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Deepwater Feeds: Mediation and Extraction at the Seafloor

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Deepwater Feeds: Mediation and Extraction at the Seafloor

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by

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ABSTRACT

Deepwater Feeds: Mediation and Extraction at the Seafloor

by

Lisa Yin Han

Dark, deep, and sparsely explored, the watery world of the seafloor is a point of convergence for ideas about technological, scientific, economic, and political frontiers. Progressive attempts to mediate this space by industry surveyors and oceanographers have resulted in enormous advances in autonomous technology, as well as sophisticated sensing, sampling, and echosounding technology. My dissertation, *Deepwater Feeds: Mediation and Extraction at the Seafloor*, explores the history and culture of these media technologies and the manner in which they are entangled with economic and political imperatives to extract hydrocarbons, mineral deposits, cultural artifacts, and other resources. Across my chapters, I develop a theory of extractive mediation, tracing its manifestations across various industries. I critique extractive mediation through the examination of feeds—a metaphor that I use to conceptualize shared pathways of nourishment, information, and meaning in multispecies terms. Each chapter focuses on a different "feed," including narrative feeds, media feeds, and resource feeds. Methodologically, I blend analysis archival oceanographic texts with media ethnography, site visits, and discourse analysis to describe the competing epistemologies and regimes of value around the seabed.

This dissertation builds on an existing body of work in critical media studies, environmental studies, and the blue humanities to think about how environmental imaginaries are constituted by processes of mediation. From nautical documentaries, to ship logbooks, to museum displays, media have always played a central role in constituting an imaginary of the deep sea for a terrestrial species. I go a step further, however, to include media beyond the popular. In particular, few ocean scholars have analyzed the influence of extractive industries in charting the course for human relation to the deep sea across both scientific and lay realms. Understanding the pervasiveness of extractive ideologies within mediation requires a cross-disciplinary perspective. Drawing from oceanography, international law, nautical archaeology, and ocean engineering, I engage with the ocean bottom as a socio-technological space. My materials were diverse, and yet there were unexpected convergences in rhetoric. My project identifies and critiques the technological fetishes of precision, transparency, coverage, and resilience that pervade industrial mediations of the seafloor, and instead argues for a multispecies perspective as a way of making the impacts of extractive mediation tangible.

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Introduction

Making Sea into Land

When I was growing up in the landlocked state of Colorado, my mother used to regale me with old stories from China, her home on the other side of the Pacific. I remember tales of mythical dragons, vengeful gods, animal spirits, and more—fearsome beings that inspired me to dream of other lands and other waters. Of the many books we read and legends she told, there was one bedtime story in particular that stuck with me, etched somewhere in an amorphous reservoir of memories. It goes something like this. A young girl named Nü Wa is playfully swimming in the Eastern Sea, when she ventures too far out and accidentally drowns. Upon her death, the girl's soul is transformed into a bird called Jing Wei. Feeling despair and resentment over the abrupt end to her previous life, Jing Wei vows to fill up the sea in order to prevent others from encountering the same fate. Day in and day out for eternity, she flies in materials from the Western Mountains and drops them into the vast ocean—stick by stick, stone by stone.

I loved this story for the way the depths of the open sea seemed to reflect a depth of human feeling: danger, sorrow, alienation, injustice, determination, and a never-ending tedium. In this myth, the ocean is a powerful agent, callous and indifferent to the life it swallows. The conflict between Jing Wei and the deep ocean paints a portrait of humanity as a species living in a world that will always exceed us; the struggle between humans and nature, water and stone, reflect a primordial balance between the elements. In many ways, stories from the United States are similar, placing monsters in the depths and casting the ocean as a dual source of fear and conquest. All around the world, oceans have shaped our stories and our values. As one group of deep sea researchers put it, “The oceans have been sources of unknown terror—both real and imagined—the means by which empires expanded and how the outcome of global conflicts was determined, and a source of vital nutrients throughout human history. Because of these intricate and innate links between humans and the ocean there has always been a strong imperative to explore it.”[1] People across the globe have imagined the sea as an entity that feeds us, connects us to each other, and calls to us to risk our lives.

What interests me most of all, however, is the underlying drive in Jing Wei’s story—that fantasy of making the sea into land. The more that I have talked to the people who spend their lives thinking about the deep ocean, the more I have come to see this fantasy of transforming fluid into solid as a widespread, environmental theme. There are instances where the Jing Wei story becomes literal, such as the building of artificial islands in the South China Sea.[2] However, I am interested in another less tangible, yet more pervasive mode of elemental transformation. In Jing Wei’s world perhaps, sticks and stones were the mediums through which this alchemy was performed. Today, we venture to the deep oceans to fill it up with media technologies: camera by camera, sensor by sensor, platform by platform.

Like Jing Wei, our efforts to visualize and extract from the seabed are challenged by the vast environment of the deep sea, the most unknown region on Earth. Occupying over 60% of the planet, deep water typically refers to anywhere between 1000-5000 meters of depth—

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[1] Jeffrey A. Karson, et al., *Discovering the Deep: A Photographic Atlas of the Seafloor and Ocean Crust*, (Cambridge: Cambridge University Press, 2015), 2.

[2] Julie Sze, *Fantasy islands: Chinese dreams and ecological fears in an age of climate crisis* (University of California Press, 2015).

the bathypelagic, abyssopelagic, and hadopelagic zones. The abyss also brings with it a distinct cultural imaginary. Ann Elias explains that all the world's oceans were once imagined to be bottomless, which made early ocean films by figures like John Ernest Williamson pleasurable for "the thrill of imagining extreme depth, and from the image of a heroic adventurer."[3] Over time however, the ocean has been partitioned legally, scientifically, and figuratively. Shallow waters have come to reassure and entertain us with their tropical reefs and vibrant colors, promising "that the eye will be able to make sense of every object."[4] By contrast, the depths have been associated with mystery, unknowability, and darkness. Over the past century, as humans have continued their endeavors to conquer the planet's final abyss, they have found new ways of making the deep sea accessible to the human senses, just as the shallows already are.

From trawlers, to sounding lines, to high definition underwater cameras, technology has enabled us to discover new species and reveal secrets about our deep ocean like never before. But our reasons for exploring the deep are premised on more than capturing the aesthetic beauty of an alien space; we see our oceans as fertile—valuable to us because of their resources. To me, these are the two values that seem to define what it means to transform the sea into land in modern day terms: the achievement of easy visual access, and the extension of extractive capitalism, wherein the extraction of profits from the earth is the primary means by which contemporary society sustains itself.[5] On this second value, the sea becomes a speculative replacement for land. As more and more of our resources above the water are

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[3] Ann Elias, *Coral Empire: Underwater Oceans, Colonial Tropics, Visual Modernity* (Durham, NC: Duke University Press, 2019): 96.

[4] Elias, *Coral Empire*, 21-22.

[5] See Saskia Sassen, *Expulsions* (Harvard University Press, 2014).

depleted, our futures are unquestionably tied to the fate of the deep ocean.[6] Offshore oil and gas exploration continues to expand, while the global demand for automobiles in addition to "green" technologies like wind turbines and solar panels is driving metal demand toward mineral deposits found on the ocean floor. The result is that our technical ability to explore and visualize the ocean depths is better than ever, which then further enables extractive capitalism in the oceans.

Deepwater Feeds intervenes by unpacking the ethical and ideological negotiations between scientists, environmentalists, and industry actors as extractive practices at the seafloor grow, and addresses how technology mediates human perceptions of the seafloor. Specifically, I will explore the technicity of seafloor mediation as it relates to imperatives to exploit mineral and cultural resources at the ocean bottom. I ask, how have global powers historically imagined ocean wilderness, and how do these ideologies influence the production, use, and regulation of underwater media technologies? What is the material impact of mediation on ocean environments, and how is seafloor data interpreted within existing social structures? To what extent do our media pipelines extend extractive relationships to deep sea space?

To describe the connections between scientific ocean mediation and a desire to extract and profit from the ocean bottom, I use the term *extractive mediation*. Extractive mediation names the primacy of an extractive power dynamic to human mediations of the environment. That is to say, it considers situations in which extraction preconditions the work of environmental mediation, and instances where mediation is understood to perform the work of extraction. For instance, extractive logics might be found in the material act of mediation,

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[6] Karson et al., *Discovering the Deep*, ixx.

in media content, in user interpretations of media, or in the long term impacts of mediation. As a broad analytic, extractive mediation attends to mediations that have participated in and perpetuated values of consumption, removal, profit, and exploitation—a point that I will elaborate later on in my discussion of deepwater feeds. For the deep sea, it also acknowledges the dual influences of extractive industries and media technology in determining the future of human-ocean relations.

Environmental Mediation

In the vein of other work in environmental media studies, this dissertation will focus on how the specificity of seabed space may proffer insights into the relationship between mediation and extraction in frontier space. As processes such as climate change, ocean acidification, and sea-level rise produce ripple effects across human and nonhuman communities, there has been a growing cohort of humanities-based research on ocean futures. However, such work tends to focus on coastal regions, popular documentaries, and literary explorations of the ocean. The seafloor has yet to be discussed explicitly within a theory of mediation that focuses on the cultural production of knowledge and uneven distribution of risks and benefits by ocean industries. My intervention is to center the role of ocean industries in the production of seafloor media. Ultimately, I see a media framework as essential to the ocean humanities, as all knowledge about the deep ocean is contingent on the use of locative, datalogical, and representational media technologies.

My approach begins with a deciphering of the term "mediation" itself. According to Raymond Williams, historical development of the mediation concept focuses on two senses of the term: the idea of an intermediary between two poles (the medium as conciliatory), and that of form—"an activity that directly expresses otherwise unexpressed relations."[7] Early theorizations of media by thinkers such as Marshall McLuhan have tended to collapse mediation with communication, emphasizing the medium's role in expression ("the medium is the message").[8] By contrast, modern philosophical treatments of mediation have grown to consider mediation beyond its instrumentality of delivering messages or information. Notably, media theorists Sarah Kember and Joanna Zylinska stress a shift from "media" to "mediation," which stresses a process of emergence, or becoming with the technological world. This includes "the acts and processes of temporarily stabilizing the world into media, agents, relations, and networks."[9] This adjustment maintains part of the core premise of mediation as a formal activity that expresses relations. However, it also implies that processes of mediation precede and exceed media, agents, relations, and networks; they include relationships between humans and the resources, infrastructures, and environmental conditions that enable the movement and dissemination of information and the creation of meaning.

Mediation ultimately adjusts scholarly focus from media as bounded material objects that carry meaning, toward an open, entangled media ecological perspective. The term "media ecology" was initially elaborated by Neil Postman alongside cybernetics and systems theory to signify a co-production of culture through humans, environments, and technologies.[10]

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[7] Raymond Williams, "Mediation," in *Keywords: A vocabulary of culture and society*, (Oxford University Press, 1976): 206-207.

[8] Marshall McLuhan and Quentin Fiore, *The Medium is the Massage: An inventory of effects,* produced by Jerome Agel (Berkeley, CA: Ginko Press, 1967).

[9] Sarah Kember and Joanna Zylinska, *Life after New Media: Mediation as a Vital Process,* (Cambridge, MA: The MIT Press, 2012), xv.

[10] Neil Postman, "The humanism of media ecology," in *Proceedings of the Media Ecology Association* 1, no. 1 (2000), 10-16.

Now, media ecological perspectives are also apparent in the works of authors like Jussi Parikka, Richard Maxwell, and Toby Miller, who attend to the entire production chain of media technology, from the use of raw materials, to the environmental impacts of e-waste. Parikka in particular has endeavored to connect the materiality of media to political and economic history by focusing on what he terms a "geology of media."[11] This work is directly pertinent to chapters 1 and 2, which address the mediating qualities of the geological record as well as the raw minerals necessary for the production of digital media technologies.

Building from these ecological theories of mediation, a central building block of my own approach is a focus on the ocean floor. Ocean environments are places that are full of movement and exchange. Theorizing media in this space requires a recognition that it is not only human technologies that perform the work of mediation. In this vein, recent work by John Durham Peters usefully extends the conceptual breadth of the word "media" to encompass natural environments themselves. Peters writes, "The old idea that media are environments can be flipped: environments are also media."[12] He continues, "If media are vehicles that carry and communicate meaning, then media theory needs to take nature, the background to all possible meaning, seriously."[13]

Peters himself is indebted to foundational media theorists such as Harold Innis, Marshall McLuhan, and Friedrich Kittler, who understand media beyond content, to include the strategies, devices, and environments through which humans make sense of and communicate information.[14] His "elemental" approach to media has pushed ecocritical

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[11] Jussi Parikka, *A geology of media* (University of Minnesota Press, 2015).

[12] John Durham Peters, *The Marvelous Clouds: Towards an Elemental Theory of Media,* (Chicago: University of Chicago Press, 2015), 3.

[13] Page number

[14] Peters, *The Marvelous Clouds*, 18.

scholarship toward a further consideration of the relationships between humans, technology, and natural landscapes.[15] Along these same lines, Alenda Chang sees natural environments as participating in infrastructural roles, as they are capable of transmission and concealment. For her, media thus "frame our understanding of the natural world."[16] My project shares a common interest in approaching mediation in terms of its component materials as well as in terms of a broad set of environmental processes, which include storage, transmission, and communication.

Material relationships between technology and environments are often made invisible to the public. Our experiences of the ocean through media are often premised on the erasure of the infrastructures, environments, and interfaces that comprise the act of mediation. This invisibility is even more of a challenge for deep sea media infrastructures, given the remoteness of the seafloor from the majority of human civilizations. Yet, those relationships between deep sea media infrastructure and their environments support much of our technological society, and it is clear that ocean industries and state actors themselves understand that breakdowns in these infrastructures would have dramatic effects on the everyday lives of people all over the world.[17] Recognizing this gap, my project starts with the interactions between ocean environments and the "thingscapes" that comprise our media technologies and infrastructures.

Scholars of infrastructure have recently contributed to bringing the social, material, and political formations around media infrastructure to light. Lisa Parks has, for example,

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[15] Also see Jeffrey Jerome Cohen, "Elemental Relations," *O-Zone: A Journal of Object-Oriented Studies* 1, (2014): 53-61.

[16] Alenda Chang, "Environmental Remediation," *Electronic Book Review*, June 6, 2015.

[17] See Nicole Starosielski, *The Undersea Network*, (Durham, NC: Duke University Press, 2015).

critically engaged with vertical media infrastructures such as satellites and drones, bringing much needed focus to the ground-level social inequalities, labor, and discordant political imaginaries that tend to get erased by empirical, top-down views of infrastructure.[18] Others like Shannon Mattern, Lisa Gitelman, and Steven Jackson highlight junk, raw material, and repurposed technology—media beyond its intended uses.[19]

For me, these approaches tend to intervene at the level of perspective, questioning the stability and objectivity of knowledge around media systems. That is to say, media infrastructural and environmental media scholarship recognize that our mediations—particularly those that involve datafication, information visualization, or imaging—have a tendency to abstract or reduce environmental and material realities and in the process, reinforce problematic impulses to control and territorialize. Many of these ideas are influenced by feminist science studies, which has emphasized a need for on-the-ground forms of knowledge as a counter to hegemonic or patriarchal scopic regimes. Donna Haraway's push for "situated knowledges," for instance, encapsulates the challenge of accounting for a dynamic, technological meaning-making process while still allowing the existence of objective knowledge in limited forms.[20]

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[18] *Down to Earth: Satellite Technologies, Industries, and Cultures,* eds. Lisa Parks and James Schwoch, (New Brunswick, NJ: Rutgers University Press, 2012).

[19] See Lisa Gitelman, "Holding Electronic Networks by the Wrong End," *Amodern 2: Network Archaeology*, October 2013; Shannon Mattern, "Mission control: A history of the urban dashboard." *Places Journal* (2015); Steven J. Jackson, "Rethinking Repair," in *Media technologies: Essays on communication, materiality, and society*, edited by Tarleton Gillespie, Pablo J. Boczkowski, and Kirsten A. Foot, (Cambridge: The MIT Press, 2014): 221-39.

[20] Donna Haraway, "Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective," *Feminist Studies* 14, no. 3 (1988): 579.

Keeping in mind a situated perspective, oceanic knowledge has a distinct cultural history that is influenced by the medium-specificity of an ocean environment. The ocean is itself a medium and an object of remediation; this dual condition is the basis for any type of subsequent ocean mediation, be that underwater video, sonar-based imaging, or sediment sampling. I draw inspiration from media scholars like Melody Jue, Stefan Helmreich, and Nicole Starosielski, who maintain a conceptual emphasis on underwater contexts for mediation, as well as recent work in the "blue humanities," which includes literary, anthropological, and historical scholarship about the ocean and its representations. Jue, in particular, has attended to the physical qualities of seawater, arguing that a conceptual displacement of media terms like "database," "inscription, and "interface" into the ocean unveils watery logics of "protean transformation," "residue," "saturation," and more.[21] Stefan Helmreich's book, *Alien Ocean*, has also been particularly instructive, as he focuses on uniquely oceanic epistemologies and modes of relation.[22] In a similar vein, I believe that a situated perspective for the seafloor is a submerged perspective that accounts for elemental, biological, and social factors specific to the deep ocean environment.

Another important component to a situated perspective for the oceans is, as I have previously alluded to, an attention to the mediations and experiences of nonhuman life. Building on Anna Tsing's mode of portraying a biodiverse natural-social landscape, I aim to

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[21] Melody Jue, *Wild Blue Media: Thinking through Seawater* (Durham, NC: Duke University Press, 2020).

[22] For instance, the word "acoustemology" is a term that Helmreich borrows from Steven Feld to describe how underwater sound imaging constitutes a specific mode of knowing. See Steven Feld, "From Ethnomusicology to Echo-Muse-Ecology," *Acoustic Ecology Institute,* June 8, 1994. Stefan Helmreich, *Alien Ocean*: *Anthropological voyages in microbial seas* (University of California Press, 2009).

"give the nonhuman species as much liveliness as the humans."[23] In their foundational article in *Cultural Anthropology*, Stefan Helmreich and Eben Kirksey define multispecies ethnography as an approach that "centers on how a multitude of organisms' livelihoods shape and are shaped by political, economic, and cultural forces."[24] Ursula Heise builds this multispecies ethics further in her proposal for "multispecies justice," which ties multispecies perspectives to differential experiences of risk from resource exploitation and extraction. As she explains it, multispecies justice "will need to be accountable not just to the ontological differences between species, but also to the cultural differences in divergent understandings of justice."[25] In line with both multispecies justice and multispecies ethnography, I envision my dissertation as addressing a coalition of human and nonhuman actors that are differentially affected by seafloor extraction. To this end, I have sought to include multispecies perspectives throughout my chapters, from hydrothermal vent shrimp, to cetaceans, to other deep sea filter feeders.

Methods

Locating resistance to extractive mediation, as my project does, necessitates thinking about the complex processes of scientific translation across human and nonhuman worlds. Science studies scholars such as Michel Callon, Bruno Latour, and Susan Leigh Star deploy critical methodologies that trace the networks and tools through which this translation is

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[23] Anna Tsing, *Friction: An Ethnography of Global Connection* (Princeton: Princeton University Press, 2004): 176.

[24] Eben S. Kirksey and Stefan Helmreich, "The Emergence of Multispecies Ethnography" *Cultural Anthropology* 25, no. 4 (2010): 545–76.

[25] Ursula Heise, *Imagining extinction: The cultural meanings of endangered species* (University of Chicago Press, 2016): 167.

accomplished. For example, Callon's "sociology of translation" includes recounting of the dissonance, power imbalances, frictions, and failures that accompany scientific knowledge. Although scientists are his guides through this narrative, Callon endows agency to nonhumans actors and emphasizes the instability and ephemerality of associations. Scientific work is painted as a deeply political, social, and even linguistic endeavor.[26]

Similarly, Susan Leigh Star and James Griesemer elaborated the frictions and cooperation inherent in doing scientific work, detailing the manner in which different actors in a group negotiate their heterogeneity. Leigh and Griesemer's mode of analysis is ecological, looking at the process of shaping and consolidating social links between humans and nonhumans in the constitution of scientific credibility. They build from Callon's notion of creating associations between actors, insisting on an antireductionist ecological model that allows for multiple viewpoints, multiple and intersecting social worlds, and simultaneous translations.[27] Each of these scholars allocates an important role for media: for Leigh and Griesemer they are "boundary objects" that synthesize meaning into coherent findings; for Callon, devices of *intéressement* that perform the work of translation within a social network.

While my interest in mediation is more capacious than this focus on media objects, my research methodologies are strongly influenced by the science studies approach to social networks, which trace meaning and experience through a web of actors. I am also indebted to the technology-focused media archaeology of researchers such as Parikka and Starosielski, who consider the social, cultural, and material histories of media technologies. My intention

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[26] Michel Callon, "Some Elements of a Sociology of Translation'." *The Politics of Interventions* (2007): 57-78.

[27] Susan Leigh Star and James R. Griesemer. "Institutional ecology, 'translations,' and Boundary Objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39." *Social studies of science* 19, no. 3 (1989): 389-390.

is to engage with the seafloor as a socio-technological space, moving beyond questions of representational accuracy, toward a viewpoint that sees mediation as acting prior to representation. That is to say, I am interested in the knowledge practices and ocean imaginaries that are facilitated and underscored by underwater media technology, as well as in the user networks that determine how they are funded, deployed, and interpreted.

To address these aims, my project combines interviews, site visits, archival research, and discourse analysis. I have talked with and learned from the oceanographic researchers who have generously shared their own expertise, attended oceanographic conferences, and visited labs and sediment archives across the country. This includes institutions such as the Woods Hole Oceanographic Institution (WHOI), Scripps Institution of Oceanography Geological Collections, the OSU Marine Sediment Sampling Group, the Ocean Observatory Initiative's Cabled Array, and University of Hawai'i Mānoa. By listening to researchers and examining video, photographs, maps, legal documents, oceanographic records, and other media objects, I was able to gain an understanding both of the technical specifics of how deep sea expeditions operate, as well as zero in on debates and discussions internal to these fields. This includes conversation topics ranging from underwater heritage, to energy security, research funding, public transparency, and environmental impact.

My method of reading across scientific, industrial, and social practices and connecting each under the framework of critical media studies is a departure from previous work on deep sea technologies, which has predominantly focused on individual fields such as nautical archaeology, marine biology, physical oceanography, or ocean engineering. While much attention is paid to scientific and engineering advancements in deep sea exploration, fewer actors acknowledge the problematic role that extractive industries play in determining what human relationships to the deep sea look like and will look like in the future. Rather than contribute to the toxic, often violent orientation toward the seafloor as a new frontier, a media and cultural studies perspective instead incorporates the substantial historical, political, and ideological context for deep sea media and technological development today.

Deepwater Feeds

Across my chapters, I mobilize the figure of the "feed," which brings to mind nourishment as well as media distribution, to critique and revise instances of extractive mediation. My use of this figure comes from our everyday encounters with media feeds—newsfeeds, audio feeds, and more. Its utility, however, is in thinking beyond the terrestrial and beyond the human. The existing body of work on offshore extraction frequently focuses on shallower coastal waters or frames human relations to the seafloor from the top down—from the perspective of surface control rooms, geopolitical debates, and legal battles rather than from the bubbling vents or sedimentary actions that produce these treasured resources.[28] In contrast, my feed approach provides room to analyze oceanic mediation from the bottom up, thinking through the unruly space of the seabed itself.

For me, "feeding" both mirrors and opposes extractive mediation. To understand the relationship between the two keywords, I must begin by further elucidating extractive mediation itself. Extractive mediation operates both at the level of theory and on the level of social and material relationships. As a conceptual term, extractive mediation describes an assumption that all mediation is extractive. That is to say, like other forms of extraction,

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[28] Jason Theriot, "American Energy: Imperiled Coast," in *Subterranean Estates: Life Worlds of Oil and Gas*, ed. Hannah Appel, Arthur Mason, and Michael Watts (Ithaca: Cornell University Press, 2015).

mediation is seen as a removal of raw material for the constitution of objects of value. To put it differently, extractive mediation requires extractions to produce meaning—a taking of a part to represent the whole (synecdoche). Second, the term has the additional utility of revealing institutional and political complicities between activities that are typically envisioned separately as extractive or mediatory processes. We can see this, for instance, in the relationship between cables and pipelines at the seafloor. These two infrastructures, one explicitly envisioned as a media infrastructure and the other an extractive one, were once confoundingly regulated in the same way. As the Maltese and Swedish diplomat Avid Pardo (also known as the "Father of the Law of the Sea Conference") wrote in 1973:

> For some reason article 2 of the High Seas Convention does not distinguish between submarine cables and pipelines although the purpose of the former (apart from cables transmitting electricity) is international communications and the purpose of the latter is essentially economic… It is surprising that, at a time when increasingly numerous pipelines are crisscrossing ever wider areas of ocean space, a distinction between cables and pipelines has not been drawn and that no norms have been proposed with regard to the construction, maintenance and protection of the latter.[29]

Here, the imbrication of extraction and mediation can be described in terms of the alignment between the development of the offshore petroleum industry and internet communications. My third and fourth chapters demonstrate this point, arguing that cables and pipelines are simultaneously extractions and mediations.

So how does feeding revise extractive mediation as a theory of media? Going back to the first sense of the concept, extractive mediation is a highly anthropocentric perspective on mediation that continues to presume an ontological separation between processes of representation and the "real" object being represented (we must extract from the real in order

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[29] A Pardo - Interventions, papers, 1973, 03-041, Box 5, United Nations Conference on the Law of the Sea Collection and Related materials, 1938-1982, University of Washington Libraries, Special Collections, Seattle, WA.

to create media representations). Feeding, by contrast, understands mediation as a vital and immediate process—a remediation of the whole itself. To riff on the popular aphorism, "you are what you eat," we transform and become-with that which we feed. Similar to Lisa Gitelman's assertion that "raw data" is an oxymoron, the feed does away with notions of "raw material" altogether, as well as the assumption that extraction is an activity that comes "prior" to the constitution of media objects. Breaking this down further, the feed contributes two additional ideas to mediation: 1. It conceives of mediation as multisensory, 2. It considers mediation from a metabolic, multispecies perspective.

First, feeding expands the sense of mediation beyond an ocularcentric worldview. The human sensorium privileges vision over the other senses as a way of making the world intelligible, and thus there is a tendency to equate mediation with visual media. But vision has never operated alone in the sea—in fact, doing so would constitute a major disadvantage. In the ocean, tactile or nonoptical forms of sensing like sonar, chemical sensors, and biological sampling are par for the course, enacting volumetric, rather than vectoral, forms of information gathering, altering the very materials from which knowledge is extracted. I find utility in the feed because it does not subsume the other senses into vision, thus opening up multiple sensory avenues into studying the cultural histories of seafloor technology. As a multisensory, experiential theory of mediation, Grusin's concept of "radical mediation" has been particularly instructive in my thinking around the feed. Grusin explains, "To understand radical mediation as affective and experiential rather than strictly visual is to think about our immediate affective experience of mediation as that which is felt, embodied, near—not distant from us, and thus not illuminated or pictured, but experienced by us as living, embodied human and nonhuman creatures."[30] Grusin argues that immediacy is always already mediation. Feeding is, in this sense, a type of radical mediation; it is a human and more-than-human experience of affective immediacy that is both an apprehension of and a becoming-with the world around us.

Second, like extractive mediation, feeding connects the processes of information capture to the intake of material resources. Feeding presumes the movement and processing of both matter and material. A feed is a pathway through which information and material is transmitted; it might include sounding lines, fiber-optic cables, and oil pipelines. However, the act of feeding can take many, nonlinear forms, and it does not happen in isolation. Examining deepwater feeds requires attending to temporalities, forms of life, and subjectivities in excess of the human while at the same time, acknowledging the undeniable fact that human beings fundamentally change and are changed by underwater landscapes.

Instead of merely referencing a media distribution process, feeding connotes a metabolic process that includes capture, consumption, incorporation, and expulsion of waste.[31] Thus, the feed is a multispecies object that brings to mind a relationship between intake and sustenance, between information and vitality. I think of filter feeders, which splay out their sensing limbs in the hopes of catching tiny morsels of food floating in the vast emptiness. For organisms like a deep sea coral, to feel is to eat; feeding is both sustenance and perception. I am reminded of the works of Donna Haraway and Karen Barad—both feminist theorists who were fascinated by the perception of tentacled beings. For instance, Barad considers the brittlestar, a photosensitive invertebrate and relation of the starfish: "Brittlestars do not have

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[30] Richard Grusin, "Radical Mediation," *Critical Inquiry* 42, no. 1 (Autumn 2015): 132.

[31] See Jennifer Gabrys, "Sink: the dirt of systems," *Environment and Planning D: Society and Space* 27 (2009): 666-681.

eyes. They are eyes… The brittlestar is a living, breathing, metamorphosing optical system. For a brittlestar, being and knowing, materiality and intelligibility, substance and form entail one another."[32] Just as the brittlestar led Barad to break beyond the anthropocentric idea of mediation as technologically mediated knowledge, I fixate on feeding in order to imply that metabolic imaginaries and life-sustaining processes, human and nonhuman, are ingrained within deep sea mediation.

Each of my four chapters fixates on a particular kind of "feed" in order to question the colonialism and extractive logics baked into existing mediations of the deep ocean. What makes these feeds similar is the way that they each exploit the seafloor for capital gain, often at the cost of human and nonhuman communities that depend on seafloor ecosystems. Each feed, in its own way, rethinks an instance of extractive mediation—whether it is the location and excavation of cultural artifacts for the purposes of national power and credibility, the extraction of oil and minerals for industrial profit, or the extraction of data into global, corporate networks. Nevertheless, it is important to note that while deepwater feeds crisscross the dissertation, my individual chapters take on extractive mediation in unique and highly specific ways. For example, while nineteenth-century sounding might have influenced the eventual deployment of cabled observatories, they are different techniques that require distinct models of organization and labor, while enabling the extraction of information particular to the scientific and industrial aims of the period. Similarly, petroleum and mineral extraction, while related, have their own technological requirements and were sometimes

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[32] Karen Barad, "Invertebrate visions: Diffractions of the Brittlestar." *The multispecies salon* (2014): 227.

rationalized differently, in the context of shifting human attitudes around the planet and climate change.

Summary of Chapters

Chapter 1, "Feeding Heritage: The Blue Archive and the Blue Frontier" lays the conceptual groundwork for the dissertation by focusing on legal, geopolitical, and cultural mediations of the seafloor space. In particular, it considers the mediated production of cultural archives from the ocean bottom through nautical archaeology, and discusses the relationship between archaeological expeditions and territorial claims on ocean space. Nautical archaeology has played a crucial role in driving the development of deep sea media technologies like side-scan sonar and Remote Operated Vehicles (ROVs). Such technologies, in turn, have led to a proliferation of blue archives through the musealization of underwater cultural artifacts. From 3D modeling to underwater color video, to Instagram feeds and Youtube channels, the very public retrievals of sunken artifacts around the world have contributed to an understanding of the deep as a repository of human technological pasts. Following Jason Groves' reminder that we must pay attention to past inundations as we face future ones, I draw from the shipwrecks of antiquity to think about the potential wreckage of our future.[33] My contention is that cultural excavations rely on a sedimentary model of history and heritage that embeds notions of human evolution, frontier conquest, and technological progress. The implications of this reach beyond the field of archaeology: these are extractive mediations because they characterize the ocean floor as an extractable database

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[33] Jason Groves, "An Anthropocene Observatory," *Open Humanities Press* (March 4, 2016). http://openhumanitiespress.org/feedback/newecologies/anthropocene_observatory/.

that belongs to humankind, thus creating a basis for future extractions. A corollary to this is the exclusion of the nonhuman from history.

While I introduce a conversation around sedimentation in Chapter 1, it is also a major theme in Chapter 2, "Feeding Sound: Sonic Pipelines in the Ocean," which turns to the location and mediation of petroleum reserves in the deep sea. Here, I focus on the history of offshore petroleum prospecting and the use of explosives to image the sedimentary layers under the seafloor. In this chapter, I focus specifically on the survey as a collection of knowledge practices that privilege an ideal of information breadth and continuity. My case studies, from TNT to airguns, demonstrate that while sound-based ocean technologies are often thought of as harmless, observational, and virtual, they were historically built on technologies of destruction and used for the purposes of extraction.

Homing in on the violent impacts of seismic surveys on cetaceans, I show that the techniques by which human beings have clarified signals from the deep have erased the materiality of seawater and marine life, leading to a characterization of much of what constitutes ocean ecosystems as noise. Echoing the larger theme of "making sea into land," the occlusion of aquatic qualities via sonar-based communication extends land-based tactics of spatial zoning and desires for broad, frictionless control over vast natural landscapes. In particular, this reduction of marine ecosystems aligns with an energy security framework that justifies the sacrifice of marine life for the sake of oil extraction. That is to say, the depletion of energy resources on land exacerbates the perceived urgency around exploiting offshore petroleum, which also justifies and normalizes the use of destructive underwater media techniques.

While my first and second chapter focus on sedimentation as the modality through which the deep seabed is likened to land, Chapter 3, “Feeding Sediment: Turbulent Mediations at Hydrothermal Vents,” revolves around turbulence as an aquatic condition that fundamentally structures human relationships to the seafloor. Hydrothermal vents are spaces that collocate several kinds of turbulence, from volcanic activity, to the extraction of polymetallic sulfides containing valuable minerals like copper and zinc. Taking a cue from Anna Tsing’s “salvage capitalism,” I dig into the deep sea mining supply chain and the environmental frictions that happen at its edges.[1] I also trace the virtual speculations around deep sea vents by the International Seabed Authority, transnational contractors like Nautilus Minerals, and by other political, technological, and scientific stakeholders of the deep sea mining industry. This foray into mining builds on my earlier chapters by offering a deeper discussion of multispecies kinships and mediations of the deep sea. Hydrothermal vents are host to unique and biodiverse ecosystems—shrimp, tubeworms, clams, and more reveal key insights into how life may have began and how it can persist under extraordinary conditions. For me, vent shrimp are canaries in the (sulfide) mine, and the way that humans mediate and often reduce nonhuman experiences of deep sea turbulences through notions of resilience determines both their futures and ours.

My final chapter ties together several themes from the earlier ones: resilience, continuity, visual transparency, global capitalism, and existential environmental crisis all coalesce in the development of cabled seafloor observatories, also referred to as “ocean fitbits.” In my estimation, no technology has done more to domesticate the oceans. Cabled observatories extend the internet onto the seafloor and aspire to transform the ocean itself into a “smart ocean.” With unlimited power, real-time, continuous data collection techniques will be able to feed into databases and portals that render data about the ocean downloadable at the click of a button, to any user around the world. To understand the widespread impact these networked seafloor observatories will have on the planet, I analyze the ocean fitbit in relation to its terrestrial analogues. The internet of things, astronomical observatory networks, and oil field surveillance all play a part in speculations about the future of ocean connectivity.

Deepwater Feeds unravels the multifaceted techniques through which contemporary societies have mediated the seafloor, and brings to light the role of extraction in structuring both knowledge and technological development in the deep sea. It mobilizes a framework for mediation that includes processes of communication, visualization, storage, and transmission beyond the flatscreen interface. It disrupts mainstream discourse about ocean media by approaching seafloor visualization and datafication not in terms of the immediacy of what we can access, but in terms of what is screened out in the process of mediation. Implicitly, our orientation towards window-like views of the ocean effaces and marginalizes another view of the exploitation and violence that has, for decades, driven human exploration of the seafloor.

The protagonists in my story are scientists, deep sea critters, politicians, community members, and industrial corporations who have acted as co-navigators and inhabitants of seabed space. It must be said that while much of the project is critical of scientific mediations of the seafloor, it also recognizes that ocean scientists are at the front lines of a climate battle that will determine the fate of the entire planet. Most ocean researchers are laboring to build a better world and to protect ocean environments, even as they simultaneously make concessions for the continuation of extractive economies. In a story as complex and wide-ranging as this, there are seldom clear lines dividing heroes from villains. As ocean scholar Teresa Shewry insists, risk and hope are entangled: "both hope and risk involve awareness of the openness of the future."[34] As we ponder multispecies futures in the context of increasingly imperiled natural environments, the challenge I pose for readers is not merely to end seafloor extraction. The challenge, instead, is to remain open to better ways of mediating and imagining the seafloor in the first place.

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[34] Teresa Shewry, *Hope at sea: possible ecologies in oceanic literature*, (University of Minnesota Press, 2015): loc 208 of 5851.

1. Feeding History: The Blue Archive and the Blue Frontier

"Oceangoing vessels invented the shipwreck, trains the rail catastrophe, fire the forest fire."

—Paul Virilio, "The Primal Accident," p. 212.

How do nations claim ownership over the seas? This is a vexed question for a space that has been ruled for centuries by the concept of a maritime commons. For the most part, it has hinged on factors such as exclusive economic zoning, exploration licenses, and shifting boundaries around territorial seas. However, there is another tactic that often goes overlooked—a form of geopolitical power and possession that derives from the past: archaeological salvage. Countries like China have used nautical archaeology expeditions to bolster claims of global dominance and ownership over ocean space through the shipwrecks that shadow its trade routes. In 2015 for instance, China launched a massive archaeological expedition to recover artifacts in the South China Sea. The press release from the Chinese State Administration of Cultural Heritage reads, "Our ancestors have been producing and living in the South China Sea since ancient times. The Xisha (Paracel) Islands are an indispensable part of the 'Silk Road on the Sea' route, leaving behind a great amount of underwater cultural heritage from various dynasties."[1] China's noticeably recent interest in nautical archaeology has focused on the discovery of relics along areas like the Xisha archipelago, part of the contested South China Sea territory, which holds oil and gas natural resources, fisheries, and is a key strategic area for military operations. Pushing back against territorial claims by Taiwan and Vietnam, Chinese press make heavy-handed assertions

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[1] Liu Jin, "Sisha 2015 underwater archaeology has officially set sail," State Administration of Cultural Heritage, April 13, 2015, http://www.sach.gov.cn/art/2015/4/13/art_722_118859.html; my translation.

connecting heritage artifacts to territorial ownership, thereby claiming sovereignty over an extended space.[2]

The Xisha expedition is not the only instance where nautical archaeology is being used to extend national boundaries. Peter Campbell points to a systematic way in which marine artifacts are exploited as political tools to broaden territories. Russia, for example, has led equally high profile expeditions, with Vladimir Putin himself participating in archaeological dives in the Black Sea to explore ancient shipwrecks near Crimea—recently the object of a territorial dispute between Russia and Ukraine.[3] Such media stunts are transparently about producing a politically advantageous narrative about the nation. Putin mentioned the purpose of the expedition was to "understand the development of ancient Rus's relations with its neighbors, as well as the development of Russian statehood."[4] Through sophisticated, state-sponsored expeditions in nautical archaeology, countries are thus able to translate the vast artifacts of exchange scattered across the seafloor over centuries into a cohesive picture of ancient trade routes—a performative endeavor that has, in many cases, clear geopolitical benefits in the present day.

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[2] This practice of using marine archaeology as a political maneuver also resounds with the nation's hotly contested island building initiatives—another way in which narrative and physical control over ocean space is associated with geopolitical power. Julie Sze, *Fantasy Islands: Chinese Dreams and Ecological Fears in an Age of Climate Crisis,* (Berkeley: University of California Press, 2015).

[3] Peter Campbell, "Could Shipwreck Lead the World to War?" *New York Times*, December 18, 2015, https://www.nytimes.com/2015/12/19/opinion/could-shipwrecks-lead-the-world-to-war.html.

[4] Roland Oliphant, "Vladimir Putin plunges into Black Sea in Research submarine," *The Telegraph,* August 18, 2015, https://www.telegraph.co.uk/news/worldnews/europe/russia/11810703/Vladimir-Putin-plunges-into-Black-Sea-in-research-submarine.html.

Archaeological salvage thus maintains a disposition toward the seafloor as a space of historical belonging that can be redeemed and used for political gain. A threshold between wilderness and civilization, this debris-strewn repository has operated as an archive from which to find and recuperate potsherds of wrecks from the past in the service of ideals about civilization, progress, power, and statebuilding. There are an estimated 3 million shipwrecks on the ocean floor,[5] from mesolithic dugout canoes, to Late Bronze Age vessels, to WWII submarines valued at $60 billion. But beyond these individual objects, the bottom of the ocean contains traces of our old shipping routes, slave trade, and harbors—a record of global conflict and imperialist expansion. The link between the seas and global capitalist exchange is what led Steve Mentz to coin the term, "Naufragocene" to describe the early modern period in which shipwreck stories captured a certain crisis in Western understandings of global culture: "Shipwreck resonantly names an epoch whose contours precede but also prestructure the arrival of fully global capitalist exchange."[6] To put it differently, Mentz's Naufragocene refers to the moment in which human beings realize that the planet is mostly ocean, deeming it the moment of global consciousness. I contend here that the so-called Naufragocene does not end with the early modern period. Rather, as politicized archaeological stunts by global powers like China and Russia demonstrate, shipwrecks continue to capture a "crisis of cultural authority" as well as the authorities with which culture subtends (political, legal, industrial, scientific) well into the twenty-first century, just

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[5] Jay Bennett, "Less than 1 Percent of the World's Shipwrecks Have Been Explored," *Popular Mechanics*, January 18, 2016, http://www.popularmechanics.com/science/a19000/less-than-one-percent-worlds-shipwrecks-explored/. "Shipwreck World," accessed June 3, 2016, http://www.shipwreckworld.com/.

[6] Steve Mentz, *Shipwreck Modernity: Ecologies of Globalization, 1550-1790,* (University of Minnesota Press, 2015): Kindle locations 275 out of 5584.

as they continue to structure global exchanges of capital and understandings of global futures. In the age of the Anthropocene, of climate change, and by proxy, of the ever more precarious geopolitical contestations for natural resources, this moment of oceanic awakening continues onward as we venture into deep waters.

In this chapter, I home in on the imaginary of the seabed as an archive of technological feats and failures, interrogating the entangled temporalities of salvage and extraction that underpin the way in which the seafloor is regulated, imagined, and ultimately transformed by anthropogenic operations. My aim is to consider the ways in which notions of heritage, of commons, and of conquest intersect with modern day exploration and extraction of seafloor resources. I ask, how has an understanding of the ocean bottom as a cultural and technological archive helped to produce the seabed as valuable and extractable? How do evolving techniques for archaeological excavation influence the ways in which this blue archive is given historical meaning? How are human perspectives on cultural and common heritage mobilized in these processes? And how might heritage and inheritance be rethought, in the context of a living (and dying) ocean?

The extraction of natural resources has been discussed by numerous scholars as a capitalist exercise of power over the environment. Macarena Gómez-Barris, for instance, refers to these "extractive zones" in terms of "the colonial paradigm, worldview, and technologies that mark out regions of 'high biodiversity' in order to reduce life to capital resource conversion."[7] Meanwhile, archaeology is a field explicitly concerned with the retrieval of artifacts of cultural heritage. I will show that far from an unproblematic academic

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[7] Macarena Gómez-Barris, *The Extractive Zone: Social Ecologies and Decolonial Perspectives (Dissident Acts)*, (Durham, NC: Duke University Press, 2017), p. xvi.

pursuit detached from capitalist endeavors, archaeological salvage has, in fact, much in common with extraction. On the one hand, archaeological pursuits in the seabed subscribe to frontier-oriented notions of progress and control over wilderness, while on the other, extractive industries like seabed mining frame themselves in terms of common heritage. Ultimately, I argue that the idea of the blue archive and the blue frontier are two sides of the same coin. Moreover, this unique understanding of the deep sea as both archive and frontier, as a reservoir for both preservation and progress, is achieved not by one actor, but by many. Archaeologists, politicians, scientists, industrial contractors, and lawmakers act together to configure the seafloor both materially and semiotically, delimiting its value to human civilizations.

Using the Guangdong Maritime Silk Road Museum and the excavation of the *RMS Titanic* as case studies, I ultimately argue that the production of archives from the seafloor is itself a contested activity which produces meaning not only in terms of common heritage, but also as an outcome of human capitalist excess. The result of this is that the blue archive itself is transformed into an resource to be mined. For me, the act of archiving is a media endeavor insofar as it entails communicating and translating information about human and natural histories. Archiving consists of porting information from one context to another; archives are simultaneously an abstraction and materialization of previous mediums. Thus, the archival process is an act of remediation, a reforming and curation of the seafloor, which is itself a natural archive and medium, as scholars such as Jay Bolter, Richard Grusin, and Alenda Chang have articulated.[8] Whether it involves filming, preservation, or musealization, archival

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[8] Alenda Chang, "Environmental Remediation" in *Electronic Book Review,* June 7, 2015, p. 5.

mediation acts as a template for important ideological, political, and industrial commitments. In the pages that follow, I create a roadmap from nautical archaeology, to frontier discourse about the seafloor, and finally to my own concept of a living archive, which rethinks the role of inheritance and heritage in structuring human relations to the ocean in regards to our pasts and futures.

I begin my argument with a discussion of nautical archaeology and what it means to see the seafloor as an archive, focusing on the ways in which wreck-related discourses of sedimentation, heritage, and lost pasts are enfolded into teleological paradigms about human progress. Next, I qualify this with a discussion of how the deep seabed is simultaneously understood as a frontier, framing politically-motivated salvage expeditions and modern day resource prospecting vis-à-vis frontier imaginaries. Bringing the two together, I then discuss the ways in which universal narratives of shared heritage act in concert with the “recovery” or extraction of seafloor resources, with particular reference to the legal regulation of the deep seabed. This leads me to posit a *salvage-extraction dynamic*, in which notions of the archive are superimposed onto the seabed’s extractive possibilities, producing it as a static reserve through which civilizing narratives about nature, culture, and heritage emerge. Finally, I end by considering the liveliness of this blue archive, gesturing towards a more responsible approach to curating futures from the seabed.

Taking a cue from science studies, this notion of a salvage-extraction dynamic interrogates the rhetoric at the heart of emergent underwater practices to consider how various actors work together to produce lasting structures for knowledge and meaning. I take an interdisciplinary approach to these mediated imaginaries of history, reading texts from nautical archaeology, international policy, and oceanography in order to understand the cultural reach of various mediated blue archives. What is worth investigating? What counts as convincing evidence of heritage? How do we interpret archaeological findings? The answers to these questions are concretized through a "negotiated order" between scientific practices, cultural and social context, and political agendas.[9]

The Blue Archive

Media archives have typically been theorized as the stuff of paper, decaying celluloid, and more recently bits and bytes.[10] The blue archive as I discuss it, however, is comprised of what is in reality a concatenation of several different kinds of archives, beginning with an understanding of the seafloor itself as a material archive. That is to say, the ocean bottom is made legible as an archival medium through its sedimentary layers—a geological record of change that can be mobilized to make historical claims. Éduoard Glissant once proposed sedimentation itself as a metaphor for historical processes at large, [11] and indeed, from a scientific perspective, the prepositional equation of a sedimentary "bottom" to temporal beginnings appears intuitive. As scientific fields like paleontology, geology, and archaeology establish, fossil records and stratigraphic data preserve and remediate information about the earth's history as well as the history of life itself.

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[9] Anslem L. Strauss, *Negotiations: Varieties, Contexts, Processes, and Social Order* (San Francisco: Jossey-Bass, 1978).

[10] See Wendy Hui Kyong Chun, "The enduring ephemeral, or the future is a memory." *Critical Inquiry* 35:1 (2008): pp. 148-171; Ernst, Wolfgang. "Dis/Continuities: Does the Archive Become Metaphorical in Multi-Media Space?" *New Media old media. New York: Routledge* (2006): 105-123; Ann Stoler, *Along the archival grain: Epistemic anxieties and colonial common sense*, Princeton University Press, 2010.

[11] Éduoard Glissant, Poetics of Relation, trans. Betsy Wing (Ann Arbor: University of Michigan Press, 1997).

To learn more about how scientists keep marine sedimentary records, I paid a visit to Professor Joseph Stoner, a paleomagnetist and geologist at Oregon State University and Director of the OSU Marine Geology Repository. Strolling through the refrigerated core repository on the OSU campus, I gazed upon stacks of long tubes of sediment, each labeled with dates, locations, and other metadata. Stoner explained to me that geological cores retrieved from the seafloor can be read like "time machines" or "a solutions manual to the Earth."[12] His perspective clearly frames these geological objects as media objects, implicit in the metaphor he offered up to me:

> What you need are records that preserve the geomagnetic field really well, that accumulate at high rates so you don't smooth out too much of the information, so you can really see a clear high fidelity picture. It's like going from an old snowy TV screen to a 5K monitor where the clarity of picture just becomes greater.[13]

Rocks become pictures, and sedimentation rates equate to fidelity. The marine core repository is thus a secondary mediation of the seafloor archive, which seeks to make legible sedimentation itself as a historical process. We dig *down* to move *backwards.* To get to the bottom of our pasts, we get to the bottom of the sea.

Preservation through sedimentation offers opportunities not only for production of geological archives, but also for cultural and anthropological ones. Like geologists, nautical archaeologists have long understood the seabed to be a palimpsest of human cultural pasts, giving the geological subject a historical corollary. That is to say, archaeological discourse largely figures the ocean as a sedimentary repository of knowledge about human civilization.

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[12] Bennett Hall, "At the Earth's Core," October 5, 2015, *Corvallis Gazette-Times.* https://www.gazettetimes.com/news/local/at-the-earth-s-core/article_ff51b324-ef97-501c-8c14-277df9a03909.html

[13] Joseph Stoner, interview with author, Oregon State University, August 16, 2018 .

I see this demarcation of the seafloor as a graveyard containing the decomposing, ossifying bodies of whales, mussel shells, gastropods, man-made trash, and of course, shipwrecks as providing the basis for a particular assertion of geopolitical power. Revising the notion of biopolitics, anthropologist and critical theorist Elizabeth Povinelli has proposed the idea of "geontopower," or the tactics in late liberalism to maintain distinctions between Life and Nonlife (*geos)*: "geontology is intended to highlight, on the one hand, the biontological enclosure of existence. And, on the other hand, it is intended to highlight the difficulty of finding a critical language to account for the moment in which a form of power long self-evident in certain regimes of settler late liberalism is becoming visible globally."[14] Povinelli's geontopower describes an anxiety that encapsulates nautical archaeology as a field that, in many respects, sees itself as dissecting death, thereby recreating a boundary between the nonliving past and the living present through the spatial boundary of surface/seafloor. We might also call this "geopower," as Elizabeth Grosz does, to describe a "capitalization of the forces of the universe" that subtends but is not reducible to political potentials.[15] In short, archaeology produces a material culture through the technical work of excavation—a culture that is "embedded in the terrain itself, facts on the ground that instantiate particular histories and historicities."[16] The underwater contexts thus mirrors the terrestrial in its perpetual obligation to save a wreck or to "get to the bottom" of its demise.

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[14] Katheryn Yusoff, Elizabeth Povinelli, and Matthew Coleman. "An Interview with Elizabeth Povinelli: Geontopower, Biopolitics and the Anthropocene." *Theory, Culture and Society* (2017).

[15] Elizabeth Grosz, Kathryn Yusoff, and Nigel Clark. "An interview with Elizabeth Grosz: Geopower, inhumanism and the biopolitical." *Theory, Culture & Society* 34, no. 2-3 (2017): 129-146, at p. 131.

[16] Nadia Abu El-Haj, *Facts on the Ground: Archaeological Practice and Territorial Self-Fashioning in Israeli Society*, (Chicago: University of Chicago Press, 2001): 13.

The very tendency to think in terms of historical sedimentation, however, also creates space for extraction, which likewise depends on the distinction between life at the surface and the geological, nonliving floor. Both archaeology and extraction justify the enactment of vertical power, from the surface to the seafloor's lowest layers. Satellite imaging, now a popular component of the archaeological gaze, is perhaps the quintessential example of media technology facilitating vertical control over environmental depths. Writing about the excavation of Cleopatra's palace, Lisa Parks argues that as archaeological tools, "satellite images frame the earth as a massive excavation site waiting to be plumbed…In treating the earth's surface as a script, archaeology imagines the planet as the raw material of the ancient past."[17] But satellites do more than just read surfaces. Increasingly, satellite sensors detect beyond the visual range with "microwave, infrared, and radar-imaging sensors" that "can pierce clouds, jungle canopies, sand, and even soils."[18] For Parks' case study, satellites did not merely improve archaeological vision, but rather enabled Western cultural discourses around Cleopatra that played up sexual spectacle and racial ambiguity.[19] In other words, by asserting human agency over sedimentary pasts, archaeologists simultaneously produce historical narratives that, in this case, strengthen hegemonic perspectives on ancient civilizations.

These terrestrial examples speak to a much longer disciplinary history in which archaeology has served as a political tool. In her examination of archaeology and the Israeli state for instance, Nadia Abu El-Haj discusses the role of archaeology in reinforcing Zionist

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[17] Lisa Parks, *Cultures in Orbit: Satellites and the Televisual* (Durham and London: Duke University Press, 2005): 110, 114.

[18] Parks, 112.

[19] Ibid., 111.

settler nationhood. Couched in a research agenda and epistemology that assumes a specific idea of nations, ethnicities, and historical emplotment, El-Haj describes archaeology as, fundamentally, a social product:

> Rooted in multiple intellectual traditions (poststructuralism, philosophical critiques of foundationalism, Marxism and critical theory, a sociology of scientific knowledge) and developed in response to specific postcolonial political movements (specifically, demands for the repatriation of cultural objects and human remains by indigenous groups in settler nations such as Australia, the United States, and Canada), this critical tradition [of archaeology] is united, at its most basic level, by a commitment to understanding archaeology as necessarily political.[20]

While the underwater context differs from the terrestrial story of Israel in its question of settler colonialism (people do not literally live underwater), this aquatic dominance nevertheless equates to an extension of national identity, political influence, and economic power over spaces that provide the livelihoods of many human and nonhuman communities. Whether digging or sensing, archaeology thus utilizes vertical mediations to assert geopower over the earth as archive. This epistemological collapse between material and informational excavation is an example of what I refer to here and elsewhere in the project as extractive mediation.

Archaeological tools and standards not only produce the archive as such, but also play a crucial social role in delimiting the credibility and competency of the professional field and establishing its privilege over alternative knowledge claims or cultural perspectives.[21] The

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[20] El-Haj, *Facts on the Ground,* 9.

[21] Lucy Suchman, *Human-machine reconfigurations: Plans and situated actions*, (Cambridge University Press, 2007), p. 263. Suchman's critique resounds with arguments by scholars like Bruno Latour, who has himself argued for reflexivity about the cultural assumptions and social negotiations within the laboratory. See Bruno Latour and Steve Woolgar. *Laboratory life: The construction of scientific facts* (Princeton University Press, 2013); Star, Susan Leigh, and James R. Griesemer. "Institutional ecology,translations' and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39." *Social studies of science* 19, no. 3 (1989): 387-420.

Institute of Nautical Archaeology asserts that expeditions are conducted to "increase knowledge of the evolution of civilization through the location and excavation of underwater sites."[22] This invocation of "evolution" is suggestive. It points to a fundamental worldview of human-nature relations in which civilization's evolution is read through progressive (as opposed to ongoing or mutually constitutive) human attempts to traverse and control natural environments, regardless of whether or not those attempts are successful. The deepest layer, then, is also the most "primitive," destined to be usurped by the more evolved technological remnants of man. Meanwhile, technological configurations capable of reconstituting the lost wreckage of the past are seen as highly evolved. The archaeological diagnosis, dissection, and analysis of deep sea ruins ultimately contributes to a growing pool of recorded historical knowledge that reinvigorates a story told by modern society about its evolution.

a. The Titanic

Take, for instance, the infamous example of the *RMS (Royal Mail Ship) Titanic*. In terms of the technologies it inspired and the social attitudes it created towards the seafloor, the 1912 sinking of the *Titanic* was a hugely influential event to the study of oceans. It marked a cultural moment in which there was widespread fear and ambivalence towards ocean depths as a whole, and of its capacity to thwart ocean travelers. As one 1932 article from the Submarine Signal Company puts it: "The bane of the mariner is really the bottom of the ocean. How to keep off it is his ever present problem…back in the mind of the shipmaster and sailor is the haunting fear that the craft they navigate will reach the bottom either by

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[22] Institute of Nautical Archaeology, "About," 2018 https://nauticalarch.org/.

sinking, through collision or storm, or by grounding in shoal water.[23] Viewed in this light, the oceanographers who helped retrieve the *Titanic* were forward-thinking heroes willing to swim towards the very heart of a watery graveyard that struck fear in the hearts of others.

Historian Joan Scott explains that historical subjects write themselves into histories in order to retrospectively stabilize identity.[24] Narrative operations around shipwrecks like the *Titanic* are a kind of fantasy, in which collective identity is secured through the resolution of antagonisms and gaps.[25] This is precisely what happens when archaeologists endeavor to reclaim what is lost—archaeological narratives include traces of the present day, either in their redemptive undertones or in their political conveniences. In a similar vein, Andreas Huyssen talks about the archaeological impulse in terms of "present pasts," where the musealization of wrecks like the *Titanic* articulate anxieties about the future displaced to the past.[26] Greg Siegel puts it well: "An accident too horrible to ignore, too devastating to discount, the *Titanic* seemed to offer startling proof of *progressus interruptus*, of forward movement 'flinched.'"[27] In this version of the story, the *Titanic* comes to serves as a warning for future generations, "a cautionary tale about the perils of human hubris."[28]

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[23] Submarine Signal Company, "The Development of the Fathometer and Echo Depth Finding," *Soundings* (April 11, 1932).

[24] Joan Scott, "Fantasy Echo: History and the Construction of Identity," *Critical Inquiry* 27 (Winter 2001):290.

[25] Ibid., 292.

[26] While originally referring to the remembrance offered by museums, the term "musealization," as used by Huyssen describes an "expansive historicism of our contemporary culture, a cultural present gripped with an unprecedented obsession with the past." Andreas Huyssen, "Present Pasts: Media, Politics, Amnesia," Public Culture 12:1 (Winter 2000): 32.

[27] Greg Siegel, *Forensic Media: Reconstructing Accidents in Accelerated Modernity* (Durham and London: Duke University Press, 2014), p. 28.

[28] "Titanic," *History,* accessed June 5, 2015, http://www.history.com/topics/titanic.

b. The Maritime Silk Road

Perhaps the most overt example of historical subjects writing themselves into history is the Chinese development of the idea of the "Maritime Silk Road," articulated most elaborately by a museum in Guangdong that opened in 2009 which showcases underwater archaeological relics related to China's foreign trade. The location of the museum overlooks the Pearl River, and is next to the waters deemed a central part of the Maritime Silk Road. The very first of these relics recovered by Chinese underwater archaeologists was the *Nanhai No. 1* shipwreck, a merchant ship transporting porcelains as far back as the Song dynasty (1127-1279). It was found in 2011 at the mouth of the Pearl River, which was then deemed the starting point of the Maritime Silk Road.[29] The ship's name, "Nanhai," translates to South China Sea. Throughout news media released about the excavation, there is a clear nationalist call to extrapolate the significance of the shipwreck, with some even comparing it in significance to the Xian terracotta warriors.[30] For instance, archaeologist Xu Yongjie maintains the Chinese perspective that *Nanhai No. 1* should be seen as synecdoche, a part of a whole: "窥一斑而知全豹," "Peering at one spot and knowing everything."[31] Xu ends with a reaffirmation of the trade route as a part of China's proud past: "We can confidently predict that as the excavation proceeds, the shipwreck will provide much more new evidence to help us appreciate the past prosperity of the maritime silk road."[32]

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[29] UNESCO, "The Guangdong Maritime Silk Road Museum (Nanhai No. 1 Museum), Yangjiang, Guangdong Province, China," Underwater Cultural Heritage, available at: http://www.unesco.org/new/en/culture/themes/underwater-cultural-heritage/about-the-heritage/underwater-museums/the-guangdong-maritime-silk-road-museum-nanhai-no-1-museum/

[30] UNESCO, "Guangdong Maritime Silk Road Museum."

[31] Yongjie Xu, "The Test Excavation of the Nanhai No. 1 Shipwreck in 2011: A Detail Leading to the Whole," *The Silk Road 13* (2015): 84-87, at p. 84.

[32] Xu, 87.

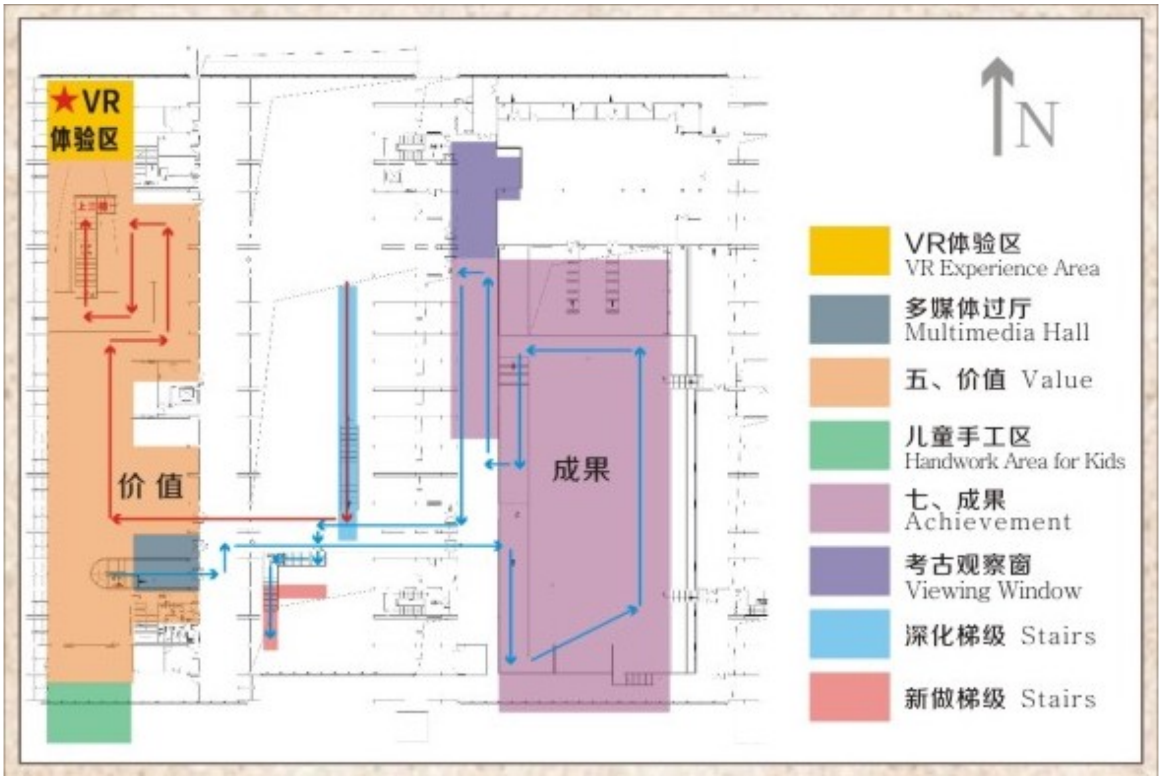

Figure 1. The layout of the Guangdong Maritime Silk Road Museum includes two VR experiences, a 3D cinema, and other multimedia experiences

It is hard not to see the present-day benefits of the historical narrative created by the museum; in 2013, China announced its modern day Maritime Silk Road Initiative (MSRI) alongside the Silk Road Economic Belt (SREB) as part of its "One Belt, One Road" project. The initiative focuses on infrastructural connectivity (highways, railways, ports, power grids, pipelines, and telecommunications networks) between China, Southeast Asia, India, Africa, and even as far as the South Pacific.[33] Whether seen as a step toward Chinese global hegemony or a step towards economic integration, the geopolitical stakes of MSRI remain high and are no doubt bolstered by the historical fantasy manifested in Chinese nautical archaeology endeavors.

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[33] Jean-Marc F. Blanchard and Colin Flint, "The Geopolitics of China's Maritime Silk Road Initiative," *Geopolitics 22*, no. 2 (2017): 223-245, DOI: 10.1080/14650045.2017.1291503

There are two theme areas to the Maritime Silk Road Museum: an exhibit area for the *Nanhai no. 1* and an area for other artifacts of the Maritime Silk Road. The layout is comprised of exhibition halls in interlinking elliptical rings, the largest palace being reserved for the shipwreck. It includes a twelve meter deep aquarium containing the steel-lined well which aims to replicate the benthic environment where the ship sank. Other exhibits show wreck parts and daily sailor's articles and trade items. Display boards and videos adorn all eight exhibition halls.[34]

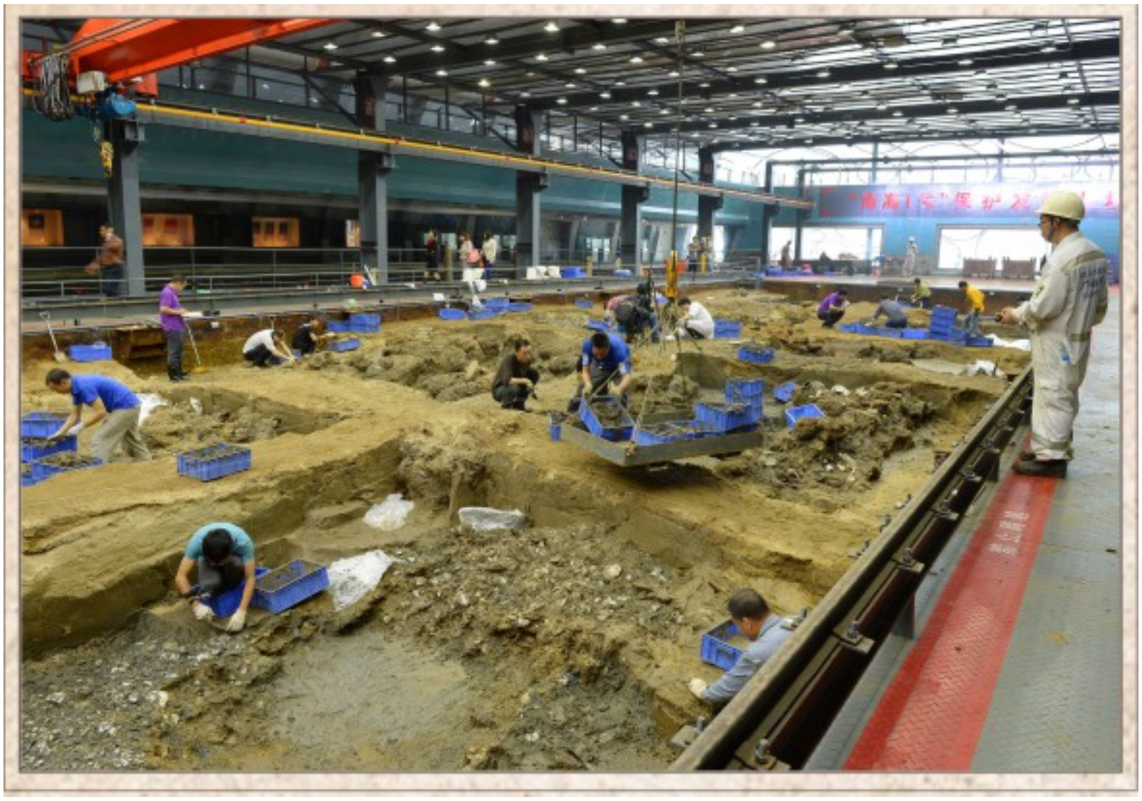

Figure 2. The excavation worksite of the Guangdong Maritime Silk Road, where audiences can observe excavation through a glass wall

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[34] "Maritime Silk Road Museum of Guangdong," Trip Advisor Reviews, accessed August 17, 2019, https://www.tripadvisor.com/Attraction_Review-g659643-d5827287-Reviews-Maritime_Silk_Road_Museum_of_Guangdong-Yangjiang_Guangdong.html; Maritime Silk Road Museum of Guangdong, accessed August 17, 2019, https://www.msrmuseum.com/Home/Enindex.

But the real draw of the museum is not necessarily the rooms full of porcelains so much as the live archaeological show, where museumgoers can watch workers sifting through the artifacts. Macao Museum director Loi Chi Pang emphasized the scale of the intact salvage process itself in an interview about *Nanhai No. 1*:

> It was not an easy exhibition to arrange. The significance was in the recovery and archaeology, a first in China. Our mission was to explain that to the public, how this had been achieved…The intact salvage of Nanhai No 1 was an enormous feat of engineering and proved extremely difficult. It involved fighting against the elements and the mud surrounding the boat thick with the sediments coming back at the speed of 10cm a month, as well as the instability of the weather. The operation was followed closely at home and abroad.[35]

Xu explains that the excavation included surveying and mapping the ship and creating a virtual test pit from the data, prior to the test pit work itself. Muds were dusted off and analyzed, artifacts were numbered and recorded, and the whole process was put under the camera from a birds-eye-view. Ultimately, in showcasing technological innovation within the archaeological field, the tone of the museum is not one of mourning; it sees the Nanhai no. 1 excavation as a national achievement.

The official Maritime Silk Road Museum website states, "The success is an unprecedented achievement and really a landmark in the history of world underwater archaeology. The wreck which has slept in the seabed for over 800 years, now revived."[36] To see the seabed as a bed where sleeping ships lie means to think of it as a frozen, static space, awaiting human intervention to be awakened or enlivened. This blue archive as constituted by the Maritime Silk Road Museum is therefore one that does not quite replicate but does

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[35] Mark O'Neill, "The Return of Nanhai No. 1," *Macao Magazine,* July 3, 2018, https://www.macaomagazine.net/history/return-nanhai-no-1.

[36] Maritime Silk Road Museum of Guangdong.

resemble older, more fearful understandings of the ocean bottom as a graveyard. Unlike Povinelli's version of geontopower which reproduces a life/death binary, Chinese nautical archaeologists are not just dissecting death at the bottom—they are recreating life, asserting the power to create continuity between past, present, and future, with of course, a particular vision of civilization in mind. While ostensibly dealing with nonhuman artifacts, this categorization of matter as inert and awaiting intervention resounds with a colonialism that likewise sees racialized bodies as extractable sources of labor awaiting activation. Kathryn Yusoff makes this point in her 2019 volume, *A Billion Black Anthropocenes or None*, in which she traces the concept of the inhuman from geology to race.[37]

However, these sedimented relics and muds need not imply such a monocultural, teleological perspective. While the idea of sedimentation, as we see in archaeological discourse, is capable of reducing narratives of historical change, it also has other affordances. For example, Stephanie Lemenager's discussion of the "rivering of time" through sediment accords both material and semiotic agency to such processes of sedimentation, and it focuses on sedimentation as the act of settling "into place over time, in ways that might transform the relations of violence bound up in settler colonialism."[38] This form of sedimentation does not enact the nature/culture divide, nor does it prescribe evolutionary paradigms. To Lemenager, there is a politics to thinking about sedimentation as resistance to extractivism, which by contrast, operates through a logic of "Do not sediment."[39] I do not see sedimentation and

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[37] Kathryn Yusoff, *A Billion Black Anthropocenes or None* (Minneapolis, MN: University of Minnesota Press, 2019), Kindle locations 209 of 1943.

[38] Stephanie Lemenager, *Veer Ecology,* eds. Jeffrey Jerome Cohen and Lowell Duckert (Minneapolis: University of Minnesota Press, 2017, Kindle Edition): Kindle Locations 3979-3980.

[39] Lemenager Kindle Locations 3962-3964

extractivism as operating on binary poles the way that Lemenager does, but she makes an important distinction between the two, casting sedimentation as the more capacious term. I will return to this later in the chapter, when I discuss the blue archive as a living, rather than static space.

Ultimately, the translation from sedimentation to extractivism in the archaeological case relies on a third term: heritage. The object of cultural heritage, be that a shipwreck or other artifact, is constantly in flux and dependent on the human mobilization of material relics through narrative. I argue next that cultural heritage is an enacted concept which accords value to that which is sedimented, redefining the seafloor as extractable.

Defining Heritage

Media theorists Wolfgang Ernst and Jacques Derrida have both suggested that the capacity to delimit what is archivable as well as what is forgettable is a constituent part of what defines the archive.[40] In other words, to see the seabed as an archive of such stories first is to have in place a structure in which objects may be defined as archivable.[41] A Derridean perspective would see the seabed itself as archivable to the extent that fields like nautical archaeology apply systems of management to it. For the seafloor, we define not only what counts as a valuable piece of heritage, but also how this piece of heritage should be preserved. It is a filtering on two levels—both in terms of narrative, as well as a material cleansing of the object itself. Ultimately, the ability to determine the contents of a such a cultural archive equates to the power to claim indexical or evidentiary truths about the past.

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[40] Jacques Derrida, *Archive fever: A Freudian impression* (Chicago: University of Chicago Press, 1996), p. 17.

[41] Derrida, 17.

Creating the archive, as in the case of recent Chinese or Russian nautical archaeological expeditions, anticipates its applications for the drawing and extension of national borders.

So what counts as part of the seafloor cultural archive? Human beings leave behind a great many traces in the ocean, but only some are deemed "cultural heritage" with "non-renewable" value, and thus worthy of "recording, preservation, and responsible management."[42] This is why in legal terms, the designation of objects as cultural heritage has become a flash point for the research community seeking to mitigate competition from opportunistic treasure hunters. In fact, the 2001 UNESCO Convention's definition of underwater cultural heritage emphasizes the relationship between heritage and property, stressing "the necessity for cultural heritage to be owned and regulated in order to be safeguarded."[43] This intersection between ownership and safeguarding is easily deployed in territorial regions to advocate for the protection of archaeological artifacts. However, in non-territorial regions like the deep sea (known in legal parlance as "The Area"), the Third UN Conference on the Law of the Sea (UNCLOS) stipulates something slightly different. Under this law, deep seabed archaeological sites can be interpreted to fall under the "'cultural' *common* heritage of mankind so as to include sites found on the seabed beyond national jurisdiction."[44] The seabed thus assumes the inheritance of something by humanity as a

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[42] Nautical Archaeology Society, "Policies and Statements," accessed June 5, 2016, http://www.nauticalarchaeologysociety.org/content/policies-and-statements.

[43] Michelle Barron, "Drowned in Law: An Examination of M. NourbeSe Philip's *Zong!* And the Regulation of Human Remains in International Waters," in *Underwater Worlds: Submerged Visions in Science and Culture*, ed. Will Abberley, (Cambridge Scholars Publishing, 2018): 160.

[44] Anastasia Strati, "Deep seabed cultural property and the common heritage of mankind" *The International and Comparative Law Quarterly* 40, no. 4 (1991): 881; Also see Anne M. Cottrell, "The Law of the Sea and International Marine Archaeology: Abandoning Admiralty Law to Protect Historic Shipwrecks," *Fordham International Law Journal* 17 no. 3 (1993): 667-725.

whole, language that is usually reserved for regulating the exploitation of natural resources in this region. Common Heritage of Mankind (CHM) is typically used to argue for the protection of mineral deposits "inherited" by humanity—a point that I shall discuss later on.

The explicit language of UNCLOS states, "All objects of an archaeological and historical nature found in the Area shall be preserved or disposed of for the *benefit of mankind as a whole*, with particular regard being paid to the preferential rights of the State or country of origin, or the State of cultural origin, or the State of historical and archaeological origin."[45] As Anastasia Stasi argues however, this stipulation is vague and prone to disputes. The parameters for what constitutes an "object of an archaeological and historical nature," or for how to determine the State of historical and archaeological origin when geopolitical territories shift over time remains unclear. Ultimately, to make a case for historical preservation, nautical archaeologists make claims about heritage that take into account present day political relationships and future profits. These debates speak to the geopolitical dimensions of nautical archaeology. As my opening examples attest, the salvaging of shipwrecks has always been a political endeavor, extending the historical relationship between oceanic mastery and colonization from the fifteenth century.

Notions of mastery depend, of course, on tools of mediation like the aforementioned satellites and cameras, as well as more hands-on methods of excavation. At sites of excavation, archaeologists, like other ocean scientists, define features and objects of relevance and then work to preserve them. Of course, some elements must be filtered out.

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[45] My emphasis. UN General Assembly, Article 149, *Convention on the Law of the Sea,* (December 10, 1982); Lowell Bautista, "Ensuring the Preservation of Submerged Treasures for the Next Generation: The Protection of Underwater Cultural Heritage in International Law," *LOSI Conference Papers,* (2012), https://www.law.berkeley.edu/files/Bautista-final.pdf.

Despite popular imaginations of the seafloor as a static space, deepwater physically transforms the objects within it. “Seawater asks us to rethink terrestrial notions of the archive or database as informed by the language of earth and sediment” writes Melody Jue, “and instead consider them in terms of seawater’s capacity for protean transformation.”[46] What do we do, for instance, about something like the 1881 Kingston shipwreck, which is now home to 48 species of corals?[47]

In the field of film preservation, the word “preservation” might include both the process of restoring content and protecting its integrity, or it might involve minimizing degradation.[48] Others, however, might retain the artifact in its found state, choosing not to pursue restoration. In the case of shipwrecks, we encounter the paradox of the ship of Theseus made literal: If Theseus’ ship is decaying and every plank is replaced with a newer and stronger timber, is it still the same ship?[49] Ultimately, what is meant by words like “preservation” that describe the transformation of seafloor debris into members of a cultural archive hinges on multiple guiding principles for both restoring the ship and minimizing future wear and tear.

Material preservation of most shipwreck artifacts is focused on both the prevention of future degradation and extensive restoration to return the artifact as close to its original (pre-wreck) state as possible. This involves scrubbing all traces of nature, or the action of natural history on the shipwreck. Specifically, a major part of shipwreck restoration involves the

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[46] Melody Jue, “Proteus and the Digital: Scalar Transformations of Seawater’s Materiality in Ocean Animations,” *animation* 9, no. 2 (2014), p. 246.

[47] Matt Bardo, “The wild world of shipwrecks,” *BBC Nature*, April 20, 2012, http://www.bbc.co.uk/nature/17706609.

[48] Paolo Cherchi Usai, “The Ethics of Film Preservation” in *Silent Cinema: An Introduction* (London: BFI, 2003), p. 66.

[49] David Lowenthal, “Material Preservation and Its Alternatives,” *Perspecta* 25 (1989): 69, doi: 10.2307/1567139

removal of salts, stains, and other mineral deposits followed by a drying process.[50] A partial restoration process, however, can also allow for other omissions. The careful cleaning and reassembling of ship anchors such as that of the *SS Clan Ranald* have at times served as metonyms for the ship itself, figuratively anchoring the wrecks in a fixed temporal place and comfortably leaving the material event of sinking behind.[51] In each case, the production of an archived shipwreck separates it from the natural fluidity and turbulence of the ocean. Salvage thus typically enacts nature/culture divides, casting seawater as a breed of vulture. From this binary perspective, salvage is also almost always a "race against time."[52] In the salvage-extraction framework, the cannibalization of artifacts by marine life is thus the index that allows us to see the passage of time, while extraction becomes an intrusion that resists this natural time.

The deep seabed as traditionally narrativized by archaeologists is thus a "ground zero" of history: a space that intertwines nature and civilization, past and future. It adheres to a teleological model of progress and expansion that is tied to a need to redeem the past for the sake of the present. With salvage-extraction, to retrieve from the archive is to remember, insofar as re-membering is a stitching of a lost moment in time back into a controlled time-space of human history. Above all, shipwrecks are understood to *already belong*, whether to

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[50] For more on conservation techniques, see Donny L. Hamilton, "Methods of Conserving Archaeological Material from Underwater Sites," *Department of Anthropology* (Texas A&M, 1999) http://nautarch.tamu.edu/CRL/conservationmanual/ConservationManual.pdf.

[51] "Clan Ranald anchor returns to Edithburgh after restoration work," *ABC*, September 22, 2014, http://www.abc.net.au/news/2014-09-22/clan-ranald-anchor-returns-home-after-lengthy-restoration/5759930.

[52] Morgan, Hiram. "A race against time to save Spanish Armada wrecks before the yare lost forever," *The Irish Times*, April 14, 2015, http://www.irishtimes.com/opinion/a-race-againsttime-to-save-spanish-armada-wrecks-before-they-are-lost-forever-1.2174364.

a nation, a company, or to mankind as a whole. Everything that is excess—rust, waste, enterprising corals, and the cyclical upheavals of nature—is discarded. As such, the archaeologist's blue archive is rendered static because of its adherence to linear human histories, and its erasure of natural ones.

And yet, even with these material cleansings, there is a foreboding twinge—a recognition that more oceanic violences and shipwrecks loom on the horizon, particularly as the seas rise with climate change. As Elizabeth Deloughrey puts it, "the ocean as medium can symbolize the simultaneity or even collapse of linear time, reflecting lost lives of the past and memorializing—as an act of anticipatory mourning—the multispecies lives of the future of the Anthropocene."[53] This specter of recurring, future wreckage gives us the pivot from thinking in terms of heritage to speculating about risky frontiers. As I demonstrate in the next section, archival practices and frontier-oriented exploration are not mutually exclusive. There are fluencies between the archaeological impulse and mineral extraction, as two related salvage-extraction activities. This is evident again in legal language, in wreck videos that both memorialize lost lives and provide anticipatory glances at a still-wild, yet resource-rich blue frontier; and in industrial resource extraction itself.

The Blue Frontier

In this section, I will highlight frontierism at the seafloor in two ways: the seafloor is both a resource frontier and a technological frontier. As I will demonstrate, both senses of the blue frontier link up to ideas about common heritage. The classical orientation of frontierism, as

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[53] DeLoughrey, Elizabeth. "Submarine Futures of the Anthropocene." "Oceanic Routes Forum," *Special issue of Comparative Literature Journal*, 69, no. 1 (2017): 36.

Jody Berland describes, is hinged to narratives of progress and evolution.[54] These ideas build from the frontier of the bygone seventeenth to nineteenth-century American West, which was largely responsible for producing notions of futurity built on colonial dominance, violence, and exploration. It was Frederick Jackson Turner who put forth the thesis that the shifting line of the frontier represents "the outer edge of the wave—the meeting point between savagery and civilization."[55] For Turner, the harsh environment of the American frontier shaped national identity, uniting citizens through the conflict and struggle against wilderness. The domination of nature and primitive men by frontier men thus acted, in Turner's estimation, as the engine of progress.

The imaginary of the deep seafloor as a lawless frontier of a similar kind has been sedimented through writings over hundreds of years, from nineteenth-century authors like Jules Verne, to present day territorial contests. Historically, the process of civilizing frontiers has often manifested in resource extraction, mining, and drilling, extending colonial capitalism and power through processes like neoliberal privatization, or the casting of natives as obstructions.[56] Indeed, we see this story play out again and again in unexplored natural spaces. Less than one-thousandth of the deep ocean has been studied by scientists,[57] yet its landscape, constellated by hydrothermal vents, seeps, mineral formations, and rich

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[54] Berland, Jody. *North of Empire: Essays on the cultural technologies of space*. (Durham, NC: Duke University Press, 2009), p. 14.

[55] Frederick Jackson Turner, *The significance of the frontier in American history*. (Penguin UK, 2008), p. 3.

[56] Sandro Mezzadra and Brett Nielson's work on *Border as Method* references this imbrication with the phrase, "primitive accumulation of modern cartography," which gestures toward the mutual production of capital and geographic border zones. Sandro Mezzadra and Brett Nielson, *Border as Method, or, the Multiplication of Labor,* (Durham, NC: Duke University Press, 2013).

[57] Antje Boetius and Matthias Haeckel, "Mind the Seafloor," *AAAS* 359:6371 (January 5, 2018): 34.

communities of clams, tubeworms, crabs, bacteria, and other organisms, has led to further exploration by industrial, scientific, and political actors alike. The existence of these rich biodiverse ecosystems has also cast the Area as a ripe frontier for resource extraction. Indeed, the old epithets of frontierism come through strongly in articles about seabed mining, which describe the deep ocean with terms like "silent worlds," "supreme tranquility," "alien ocean," "final frontier," "invisible frontier," and "new frontier."[58]

The idea of the seafloor as a global commons or a space of common heritage goes hand-in-hand with its role as a resource frontier. As mentioned in the previous section, the regulation of the seafloor stresses common ownership and common governance of natural resources and archaeological objects. Like outer space, it is a region where no nations are supposed to exert sovereignty. This concept of a maritime commons has its origins in the concept of the "freedom of the seas" or *mare liberum*, proposed by Hugo Grotius in 1609, and was accepted until the nineteenth century, when coastal state demands for customs zones, exclusive fishing rights, and resource exploitation caused conflicts with existing law. In the wake of these disputes, the third United Nations Conference on the Law of the Sea (signed in 1982) sought to standardize territorial boundaries and modernize regulation of non-territorial waters, specifically addressing concerns about offshore resource exploitation,

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[58] James Cameron, dir., *DeepSea Challenge*, National Geographic, 2014; Stefan Helmreich, Alien Ocean: Anthropological voyages in microbial seas. (University of California Press, 2009); Jacques Cousteau, *The Silent World: A Story of Undersea Discovery and Adventure*, Los Angeles: Columbia Pictures, 1953; Julian Smith, "Seafloor Miners Poised to Cut into an Invisible Frontier," *Scientific American,* August 11, 2016, https://www.scientificamerican.com/article/seafloor-miners-poised-to-cut-into-an-invisible-frontier/; Laura Hampton, "Deep-sea alliance set to probe Earth's final frontier," *New Scientist*, July 5, 2016, https://www.newscientist.com/article/2096187-deep-sea-alliance-set-to-probe-earths-final-frontier/; "Deep Sea is the New Frontier," *Outside*, December 7, 2017, https://www.outsideonline.com/2266756/deep-sea-new-frontier.

including oil, minerals, and fish.[59] As Katherine Sammler describes, "transforming the seabed from *aqua incognita* to productive metallurgist necessitated new understandings of sovereignty over the seas and re(in)scriptions of geopolitical land/sea territorial boundaries… the 1982 Law of the Sea captured the oceans in a vision of freely flowing commodities and properly fixed resources."[60] Among the outcomes of this international conversation was the creation of Exclusive Economic Zones, which extended sovereign rights to exploit underwater resources to 200 nautical miles from a coastline.

In regards to the seabed area beyond these jurisdictions, the International Seabed Authority (ISA), created through UNCLOS, is the regulatory body responsible for granting seabed mining licenses to 159 countries. This space is ruled through the principle of CHM, where it becomes simultaneously a global archive and a resource common through the construction of a universal concept of heritage for all humanity. So according to the UN Convention on the Law of the Sea, the ISA acts on behalf of "mankind as a whole" by ensuring that financial resources get split equitably and with the interests of developing states in mind, shadowing the UN's language on archaeological regulation.[61] This legislation largely responds to the fears imagined through Hardin's tragedy of the commons, or the idea that individuals, without regulation, would despoil a common landscape or common resource out of self-interest and capital accumulation.

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[59] "High seas," *Encyclopaedia Britannica*, June 19, 2017, https://www.britannica.com/topic/high-seas#ref215901.

[60] Katherine Sammler, "The Deep Pacific: Island Governance and Seabed Mineral Development," in *Island Geographies: Essays and* Conversations, edited by E. Stratford, (Routledge Studies in Human Geography, 2017), 13-14.

[61] UN General Assembly, Article 149, *Convention on the Law of the Sea,* (December 10, 1982).

Ideas about preservation, disposal, and management of circulation coexist in legal language. The commons is not pitted against enclosure, but rather gets integrated into the management of capital flows. More than merely standing in for a relationship to the past, this notion of common heritage takes into account present day political relationships and future profits. It comes as no surprise, then, that both the ISA and the United States' Deep Seabed Hard Mineral Resources Act, administered by NOAA, describes seabed mining as "commercial recovery,"[62] borrowing language resembling that of archaeology. "Exploitation" is defined explicitly by the International Seabed Authority as "The recovery for commercial purposes of mineral deposits in the Area and the extraction of minerals there from . . ."[63] Like shipwrecks, such resources *already* belong. And, in a related vein, the ISA regulations on prospecting for ferromanganese crusts ends its list of regulations with a mandate for prospectors to report "any finding in the Area of an object of actual or potential archaeological or historical nature and its location," refitting every mining expedition as simultaneously an archaeological one.[64]

Crucially however, while Common Heritage of Mankind espouses inclusivity and democratic ideals, it delimits heritage in a way that opens the seafloor up to contested claims on land and conflict with indigenous communities. A salient example of this imperialist

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[62] National Oceanic and Atmospheric Administration, "Deep Seabed Hard Mineral Resources Act," (June 28, 1980): 1401-1473; International Seabed Authority, "Protection of the Seabed Environment," March 2008, https://www.isa.org.jm/files/documents/EN/Brochures/ENG4.pdf.

[63] International Seabed Authority, "Exploitation," 2017, https://www.isa.org.jm/exploitation.

[64] International Seabed Authority, Decision of the Assembly of the International Seabed Authority relating to the Regulations on Prospecting and Exploration for Cobalt-rich Ferromanganese Crusts in the Area, Eighteenth session, 138th meeting, (Kingston, Jamaica, July 27, 2012), 6.

cooptation of CHM was the passing of New Zealand's Foreshore and Seabed Act of 2004, which declared the Crown the owner of the country's foreshore and seabed. While the act was passed in the name of "common heritage of all New Zealanders," practically speaking, it bulldozed over traditional Māori property rights and naturalized state appropriation of their lands. The Act was effectively a " 'sea grab' by the state that disenfranchised Māori from their customary title."[65] As Deloughrey observes, the construction of the seabed as a commons in this instance allowed settler colonies to erase the indigenous subject and make a claim for legitimacy. She argues that resisting this narrative would involve challenging the "(geontological) ground on which the state derives its sovereignty, including the state's claims to the strand seabed, and creatures of the ocean as a 'common heritage' and thus political territory."[66] Perhaps, as one of the few oceanographers writing rather pessimistically in 1968 about the possibility of seabed mining, Columbus O'Donnell Iselin put it best: "future uses of the deep ocean are far from being bright. It will not be easy to put them to use for the benefit of all mankind."[67] The construction of a speculative seabed archive through the language of common heritage can thus, practically speaking, become a tool of colonization. In the seabed archive, the notion of a "resource" or "cultural artifact" is invented alongside the designation of others as obstacles (ocean waste, natural turbulence, indigenous communities, environmental fragility).

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[65] DeLoughrey, Elizabeth. "Ordinary futures: interspecies worldings in the Anthropocene." *Global Ecologies and the Environmental Humanities: Postcolonial Approaches* 41 (2015): 352-372 at p. 355.

[66] Ibid. 367.

[67] Columbus O'Donnell Iselin papers, 1904-1971. MC-16, Box 4, "The Ocean Eventual Solution to Many Problems*," Encyclopedia of Marine Resources* (Jan 26, 1968), 9. Data Library and Archives, Woods Hole Oceanographic Institution. http://archives.mblwhoilibrary.org:8081/repositories/2/resources/153 Accessed July 24, 2019.

The salvage-extraction dynamic inherent in CHM thus shifts the focus of heritage from the mere preservation of objects in space to their distribution. “Extraction” becomes “recovery” at the same time that recovering objects of heritage in the seabed comes to presume a strict regime for extraction, management, and circulation. Although the traditional prerogative of cultural heritage is to preserve time and save historical artifacts from oblivion, the prerogative of common heritage is to manage extraction assuming that many actors are already competing to salvage (or recover) objects of value. The seabed archive thus becomes not simply a holding place, but a resource to be mined as well. If minerals can be reframed as part of human heritage, then heritage itself gets commoditized. With CHM, we continue to presume that the past structures the future, and that nations can manage the circulation and availability of heritage commodities. Monetary futures are enabled by the slow build of gold and copper nodules over thousands of years, and the slow recovery of valuable wreckage over centuries. Extractive temporalities of capital and temporalities of salvage thus merge.

With its universalizing of human experience and its capitalist underpinnings, CHM ultimately reproduces a paternalistic view on nature, focusing on the preservation and recovery of objects of value, while the effects of salvage or extraction in a fluid and mobile environment become secondary obstacles. Frontier narratives like that of mining tend to relegate the nonhuman or the indigenous to that which must be dominated or controlled. To men like Turner, the “outer edge of the wave” is a violent, unruly site of struggle, where wilderness is civilized. But acknowledging the role of heritage in constituting frontierism in the deep requires a rethinking of the wave itself, the zone where nature and man make each other.

Richard White speaks of two dueling imaginaries pertaining to the old American frontier: one is defined by the figure of the scout, as popularized by Buffalo Bill Cody, and the other by the figure of the farmer, shepherded by Turner. The scout is defined by conflict with native peoples, while the farmer seeks to tame the natural world; both perform a version of flag planting through acts of domination and control. White's discussion of these dominating narratives importantly emphasizes the power of the mimetic, in which the performance and reality of frontierism come to drive each other.[68] While the figure of the scout and farmer once dominated this frontier imaginary, I contend that today we are introduced to a new frontiersman of the deep sea: the archaeologist. Like the scout and farmer before him (and it is always a *him*, of course, that populates this space), the archaeologist in the story of the blue frontier has immense power in defining its reality; he is a storyteller, setting the narrative about the way in which this frontier may be integrated with existing infrastructure as well as its possibilities for commodification. Like the scout and the farmer, the archaeologist is seen as an explorer of uncharted regions.

I posit the archaeologist as supplanting the scout in order to emphasize the fact that what distinguishes the seafloor as a frontier is not only the physical specificity of its wetness, richness, or volumetric depth, but rather its relation to notions of human heritage. To construct the archaeologist as the frontiersman presumes that the frontier can be understood as an archive, and that the archive is itself a frontier. While the scout and farmer colonized frontier space and used its resources in situ, the archaeologist retrieves those resources and transports them back to land. The resource paradigm of the ocean floor overlaps with the

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[68] Richard White, "Frederick Jackson Turner and Buffalo Bill," in *The Frontier in American Culture*, James R. Grossman, ed., (Berkeley and Los Angeles: UC Press, 1994), pp. 7-66.

archival paradigm to the extent that both presume preservation of time and extractability-as-recovery. More than a resource frontier, this salvage-extraction dynamic marks the seafloor as what Anna Tsing has called a "salvage frontier, where making, saving, and destroying resources are utterly mixed up, where zones of conservation, production, and resource sacrifice overlap almost fully, and canonical time frames of nature's study, use, and preservation are reversed, conflated, and confused."[69] To better understand the seabed as a salvage frontier, we ought to remember the science of shipwreck salvage, and the way in which it already suggests notions of technological betterment, political gain, and the management and circulation of value.

The Technological Frontier

Beyond the exploitation of resources, the seafloor has also become something more—a point of cathexis for ideas about technological, scientific, economic, and political possibility. As Patricia Limerick points out, "sometime in the last century" the spirit of the American frontier "picked itself up and made a definitive relocation—from territorial expansion to technological and commercial expansion."[70] The deep sea offers a convenient space for the hybridization of the old and new frontiers, creating once more a spatial metaphor for domination through the darkness and pressure of the ocean depths, in addition to a technological one in the form of exploration via Autonomous Underwater Vehicles (AUVs), Remote Operated Vehicles (ROVs), sensors, samplers, cameras, and other novel media

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[69] Anna Tsing, "Natural Resources and Capitalist Frontiers," *Economic and Political Weekly* 38, no. 41 (2003): 5102.

[70] Richard White and Patricia Nelson Limerick. *The Frontier in American Culture*. ed. James R. Grossman, (Berkeley and Los Angeles: Universty of California Press, 1994), 88.

devices. The translation of the seafloor through a panoply of new media technologies today lies at the very core of what it means to see the seafloor as a frontier in the first place.

In the war years of 1941-1945, oceanographers at Woods Hole Oceanographic Institution were contracted by the US Navy to develop technologies for the photography of shipwrecks.[71] Dr. Maurice Ewing helmed this project, developing a groundbreaking instrument that could be lowered via cables "to any desired depth," making it possible to identify sunken ships and mines. This camera later became the prototype for all subsequent underwater cameras. But the technological innovations that came with nautical archaeology were not just visual. In the 1950s, while working with Jacques-Yves Cousteau, Dr. Harold Edgerton began developing a device to search for shipwrecks. His invention of side-scan sonar, a towed sonar device, was groundbreaking for its ability to produce a continuous image of the seafloor, and eventually helped locate countless shipwrecks, including the *Titanic* in the 1990s.[72]

This later excavation of the famous *Titanic* shipwreck by Woods Hole Oceanographic Institution (WHOI) offers an apt demonstration of how salvage can take a frontierist orientation through its technological processes. Founded in 1930, WHOI is the largest independent oceanographic research institution in the United States. Their mission is to advance "the frontiers of ocean knowledge" by developing specialized tools, supporting

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[71] "WHOI history during the war years 1941-50," MC-16, Box 31, Folder 10, Columbus O'Donnell Iselin Papers, Woods Hole Oceanographic Institution Data Library and Archives, Woods Hole, MA, accessed July 24, 2019 http://archives.mblwhoilibrary.org:8081/repositories/2/resources/153.

[72] Claire Calcagno, "Shipwreck Studies," The Edgerton Digital Collections (EDC) Project, Massachusetts Institute of Technology, http://edgerton-digital-collections.org/stories/features/fathoming-the-oceans-8-shipwreck-studies

scientific research and discovery, and educating.[73] It is no surprise then, that the act of finding and excavating the *Titanic* was a highly mediated affair—WHOI's own website describes the expedition has historically notable in driving advances in deep sea technology.[74] The journey demonstrated the technological prowess of its researchers, who used high-tech ROVs to provide detail documentation of the wreck, as well as video footage of the expedition (famously included in James Cameron's 1997 blockbuster, *Titanic*). It delivered live video from the deep to surface vessels, and groundbreaking color images at that. Such achievements remain prominent in WHOI articles and documentary featurettes about the expedition and its development.[75]

The various tools and machines constructed to retrieve wrecks are thus seen as part of a technological frontier initiated by the physical challenge of mediating and retrieving from deep waters. Innovation, as a result, was itself sustained through the production of archives of shipwrecks. Archives like these are typically seen as stable architectures in which function is latent. They prescribe to the idea of a "future simple," as Wendy Chun would say, which boils down to an ideal of programmability: the value of an archive or in a database is in its ability to construct a future by learning from the past.[76] Yet, technological development is not straightforward—it moves in fits and starts, at varying tempos, and frequently encounters dead ends. As Paul Virilio once noted, "Oceangoing vessels invented the

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[73] See WHOI website, https://www.whoi.edu/what-we-do/.

[74] Lonny Lippsett, "The Quest to Map *Titanic*," *Oceanus Magazine*, April 12, 2012, https://www.whoi.edu/oceanus/feature/the-quest-to-map-titanic.

[75] "RMS *Titanic,"* Woods Hole Oceanographic Institution, https://www.whoi.edu/know-your-ocean/ocean-topics/underwater-archaeology/rms-titanic/.

[76] Wendy Hui Kyong Chun, "The enduring ephemeral, or the future is a memory." *Critical Inquiry* 35:1 (2008), p. 50.

shipwreck."[77] The innovation precipitates the disaster. The continued inevitability of loss at sea, the *future complex* comprised of unavoidable yet unpredictable failure in the form of displaced pasts, premature abortions of technology, and lost futures are negotiated through constructed versions of pastness like archaeological videos, which show off innovation and highlight cautionary tales for the future.

More than supporting notions of progress, deep sea video has also produced a vision of what it means to archive the seafloor that is distinct from the physical musealization of shipwrecks or the extraction of geological cores. Remote sensing and videography enabled by deep submergence vehicles and satellites opened up new ideas about the deep sea as a functional space. Increasingly, the deep sea was seen not just as a mediated archive, but an accessible medium itself that could perform the work of storage and even screening. As early as the 1960s, optimism about the development of new deep sea technologies related to nautical archaeology led to wild speculations about what was possible. For instance, Senator Claiborne Pell published his speculations on this in a 1967 issue of *The World*:

> "storage of machinery in the future may be feasible in the ocean at depths below 5500 feet. We might even be able to 'mothball' ships in this manner. Certainly conventional space in rivers is growing scarcer every day. Wouldn't it be handy if we could tow our surplus warships out to sea, open their sea cocks, and stack them on the bottom until needed? At present, however, salvage techniques would be inadequate to refloat them conveniently and cheaply enough." [78]

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[77] Paul Virilio, "The Primal Accident." *The Politics of Everyday* Fear, ed. Brian Massumi. (Minneapolis: University of Minnesota Press, 1993), 212.

[78] Claiborne Pell, "The Scramble is On for Ocean Riches," *The World* (Nov 12, 1967): p. 21, MC-16, Box 29, Folder 3, Columbus O'Donnell Iselin Papers, Woods Hole Data Library and Archives, Woods Hole, MA.

Better salvage techniques, in other words, could transform what was once seen as a graveyard into a logistical storage space for the Navy, simultaneously extending national power and flaunting the power of man over the sea.

More to the point however, remote sensing and imaging enabled the seafloor itself to serve as a space of exhibition. In a video feature on the Antikythera Shipwreck, WHOI archaeologist Brendan Foley at the deep submergence lab explains: "The entire seafloor and everything on it is now accessible to us. And the Mediterranean seafloor in particular is a vast repository of human history. The biggest library, the biggest museum gallery in the whole world. And with these technologies, we have the key."[79] Foley equates the seafloor to a repository and focuses on technology in making that vision possible. With advanced underwater media, we no longer need to build a museum for our cultural artifacts; all we have to do is record the one that already exists underwater. Consequently, shipwreck excavation has become an increasingly virtual experience in the last decade. Foley tours his audiences through 3D maps, depth-scale, bathymetry—experiences that make even the most minute textures of rocks visible. With better and more robust designs for viewer participation and access to professional surveys, watching a virtual excavation, while time-delayed, becomes an equivalent experience to gazing at a museum display.

The production of technologies that enable human beings to explore the seafloor constitutes an always-shifting frontier; as we improve our ability to access the seafloor, the mediatory processes involved in archiving it continue to shift in their goalposts. From depth sounding, to 3D sonar, to color video, aspirations for the mediatized accessibility,

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[79] Dartmouth, "The Antikythera Shipwreck: Excavating the World's Richest Ancient Shipwreck." YouTube video, 1:05:42, February 3, 2015, https://www.youtube.com/watch?v=owVfI4p0zgs.

transparency, and control of seafloor space are changing. Such practices bring to mind what Joshua Neves has called "videation," or new cultures of material and imaginary intimacy produced through the diffusion of video cultures and screen interactions in everyday life.[80] Indeed, the proliferation of video and other visual images of the deep has created a new mediated intimacy with the deep ocean that relies on the same new media interfaces through which we socialize and entertain—that is, Netflix, BBC documentaries, Facebook and Instagram accounts, and YouTube videos. Often, media outreach personnel work alongside scientists, while scientists themselves take to social media to show off their own research.

Nautilus Live is one of the most visible media brands for oceanography, and focuses on the expeditions specifically aboard the *E/V Nautilus*, a vessel sponsored by famed oceanographer Dr. Robert Ballard and the Ocean Exploration Trust. Ballard himself is a pioneer in ocean telepresence, having helped discover the *Titanic* shipwreck. However, as with many research vessels, *Nautilus* is also equipped with its own communications team, sponsored by the Science Communications Fellows program. Imagery from Nautilus Live primarily comes from Remote Operate Vehicles (ROVs) Hercules and Argus, which are hooked to high definition cameras that stream images via fiber-optic cable directly to the *Nautilus* control room. This is then sent via satellite to a receiving station, then the inner space center, and finally distributed over the web.[81] Organizations like Nautilus Live, Schmidt Ocean Institute, and Woods Hole Oceanographic Institution have increasingly relied on ROVs as well as camera-equipped autonomous vehicles (AUVs) to deliver images to

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[80] Joshua Neves, "Videation: Technological Intimacy and the Politics of Global Connection," in Joshua Neves and Bhaskar Sarkar, eds., *Asian Video Cultures: In the Penumbra of the Global* (Duke UP, 2017).

[81] Nautilus Live, "The Tools of Ocean Exploration," accessed July 3, 2018. https://nautiluslive.org/tech.

scientific as well as social media platforms. One simply needs to hit subscribe to experience, in the highest possible resolutions and as if they were part of the crew, the mysterious ocean deep.

With video, there are also possibilities for a view of the seafloor beyond a nature-culture divide. Many excavation videos, including the numerous videos hosted by Nautilus Live,[82] allow the evolution of the wreck in nature to itself become part of the spectacle. The rediscovery of the USS Bugara, for instance, highlights the wreck's process of becoming a reef over the course of 46 years.[83] In the first approach video, a skeletal digital model of the wreck as a bare-bones ship is overlaid onto video footage of the actual coral-studded hulls and periscopes of the ship, situating the viewer. On its own, the wreck footage shows the viewer a ship that is almost unrecognizable as a ship. We thus require the map and the two male scientists in conversation to tell us that we are looking at the deck, or the hull, or another element of the ship. The narration explains what is missing too. Interspersed in the tour is commentary on the ship's history and how it sank. At the very end, a female voice ashore chimes in to explain what kind of rockfish appear in the video. As a whole, the experience of a virtual excavation aboard the *E/V Nautilus* relies on the documentary cues of a narrator and annotative visuals to unearth the once-human lives of what is now wholly nonhuman. Similar musealizations of manmade reefs have expanded on this notion that the ocean itself is an actor and mediator. This includes artistic projects like the Damien Hirst's

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[82] Nautilus Live, founded by Robert Ballard's Ocean Exploration Trust, records expeditions for the public aboard the E/V Nautilus. Ballard also coincidentally is known for his 1985 discovery of the RMS Titanic. See Nautilus Live, https://nautiluslive.org/category/topics/archaeology.

[83] Megan Chen, David Downing, and Linda Fergusson-Kolmes, "Rediscovering History: Submarine USS Bugara," Nautilus Live, August 25, 2017, https://nautiluslive.org/album/2017/08/28/rediscovering-history-submarine-uss-bugara

"Treasures from the Wreck of the Unbelievable," a fictional 2017 documentary about the recovery of the sunken treasures of freed slave Cif Amotan II (an anagram for "I Am Fiction"), and Ruth Wallen's 2009 *Sea as Sculptress,* a "microphotographic record of the marine life growing on sculptures" placed in the San Francisco Bay.[84]

These recent filmic and photographic projects mediate the seafloor itself as a natural material archive of human-nonhuman entanglements, exchanges, and wreckage. Also an archival process, videation acts as a compromise, acknowledging oceanic temporalities while simultaneously fulfilling the archival impulse to stabilize and to produce teleological understandings of human history. It offers the possibility for an important rethinking of the status of the wreck as belonging not only to mankind, but also to Others of the deep. Returning to Lemenager, the USS Bugara excavation is a prime example of sedimentation as settlement: as the wreck settles onto the seafloor on top of sediments, acting as its own geological layer, corals slowly settle into its crevices, creating new layers out of old rusted ones.

The Unarchivable

If salvage, in its technologically mediated and materially mediated formations, introduced the ocean floor as a field of evidence of human histories, it has also provided the justification for the ocean's uses as a resource frontier. Archaeological and legal renditions of the seabed continue to see the environment as a nonrenewable resource to be acted upon by the Enlightenment subject. Videation and educational media perhaps are initiating a shift in that

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[84] Damien Hirst, *Treasures from the Wreck of the Unbelievable,* dir. Sam Hobkinson, Netflix, 2017; Ruth Wallen, "The Sea as Sculptress—From Analog to Digital," *Digital Arts and Culture,* 2009, retrieved from https://escholarship.org/uc/item/3pm5b4jp.

perspective, allowing one to see the seabed as a changing, evolving, or perhaps unruly space in its own right. Yet, the salvage-extraction imaginary of the blue frontier continues to represent a powerful, durable, and representationally reproducible imaginary of the deep sea that serves to bolster spectacular accumulation over sustainable living and being-with the environment. This "managerial time of the deep" imposes its own ontological framework on the ocean floor, producing categories for the speculative value of seafloor objects as valuable resources, natural obstacles, and cultural artifacts.[85] Progress here is thus a mobius strip: the human act of reaching the archive suggests its mobilization and uses for the future. And as long as this framework is in place, nonhuman timescales remain subsumed within narratives that adhere to anthropogenic time.

Mentz counters this kind of monocultural temporality with his composting model of historical change, where the past is recycled and multiple presences exist in multiple states of decay at all times.[86] But while Mentz's composture is an improvement on sedimentation as a model of history, what is still missing is a stronger call to responsibility. Common responsibility, that is, must be embedded in notions of common heritage. To that end, I propose a pivot from defining heritage, to thinking about a decolonial approach to inheritance. While inheritance in its western configurations tends to signal questions of property and bloodline, the term can also offer space for a broader and more responsible approach to belonging. This sense of the term comes through in Kathryn Yusoff's essay on "Geologic Life," in which she notes that, "Inheritance, according to Derrida, requires

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[85] This is a riff on what Joshua Scannell termed "Deep Managerial Time," as neoliberalist "ontological stabilization of populations." Joshua Scannell, "Both a Cyborg and a Goddess: Deep Managerial Time and Informatic Governance," in Object Oriented Feminism, Katherine Behar ed., (Minneapolis: University of Minnesota Press, 2016): 5.

[86] Mentz, Kindle Locations 79-82.

vigilance about what is inherited and how it is carried forward: 'we inherit it, we must watch over it.'"[87] Indeed, the notion of owning parcels of land and ocean as heritage fundamentally contradicts the traditional perspectives of Oceania people at large, who see the Pacific and its "sea of islands" as a vast home "unhindered by boundaries of the kind erected much later by imperial powers."[88] Inheritance then, can be read as an active process of consultation, protection, and enactment—not just the endless accumulation of artifacts from a prelapsarian past. This perspective also resonates with traditional understandings of heritage that connect the past to present-day affective living with the environment. For instance, Karen Ingersoll talks about a "living archive" in relation to Hawaiian indigenous practices like surfing, in which local Kanaka knowledge about the oceans is rooted in history and genealogy and yet also remains organic and evolving.[89]

Inheritance, too, requires a conversation about nonhuman lives, temporalities, and that which cannot be archived. The original text of UNCLOS tells us that the seabed's artifacts and resources are "inherited" by humanity, and that its legacies must be preserved or disposed of for the benefit of mankind as a whole. This assumes, however, that all that is on the seafloor can be excavated, and reifies excavation as a necessary precursor to valuable or meaningful appraisals of heritage. For instance, writing about the *Zong* massacre and the regulation of human remains in international waters, Michelle Barron makes a case for attending to "absent bodies," or "those that are ultimately unexcavatable through maritime

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[87] Yusoff, Kathryn. "Geologic life: prehistory, climate, futures in the Anthropocene." *Environment and Planning D: Society and Space* 31, no. 5 (2013): 782.

[88] Epeli Hau'ofa, "Our Sea of Islands," in *A New Oceania: Rediscovering our sea of islands*, eds. Eric Waddell, Vijay Naidu, and Epeli Hau'ofa, (Suva: University of the South Pacific, 1993): 8.

[89] Karen Ingersoll, *Waves of Knowing: A Seascape Epistemology* (Duke University Press, 2016).

archaeology or through contemporary legal means, and instead must be figuratively reclaimed."[90] Beyond the lost human remains of drowned slaves from the *Zong* shipwreck, there is much in the realm of heritage and inheritance that is invisible, transitory, unidentifiable, or absent within the structures of property and law.

Taking seriously the charge of inheritance, we must also recognize that it is not just corals that define the material ways in which the seabed archive lives and changes. Trawling, surveying, cutting, shipping, and pumping operations transform ecosystems, adding new sedimentary layers to landscapes. Garbage and pollution in the Pacific, too, should also be enfolded into such inheritances—one could call it an inheritance of debt. The point, after all, is not simply to determine the belonging of an object, but also its disposal, as certainly, such pollutions and disruptions affect all corners of mankind. Yet, there is a lack of acknowledgement around the fact that many of the byproducts of human activity can neither be preserved of nor disposed of. The seemingly irreversible cascade of effects produced by oil spills and microplastics, for instance, has often produced more efforts to conceal and to forget than to clean-up.[91] The tendency of anthropocentric perspectives on the seabed is to take only what we can use, rather than to think about the "vital matter" that is added to the ocean and remains there.[92] Yet, resource pipelines feed back into deep sea ecosystems in profound ways, from improper sediment discharge carrying free-floating heavy metals for miles through the water column, to light and noise pollution, to other forms of waste that may

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[90] Barron, 160.

[91] Melody Jue, "Anthropocene Chemistry: Residual Media After Deepwater Horizon," talk given at UCSB, December 5, 2018. http://ejcj.orfaleacenter.ucsb.edu/2018/11/7069/.

[92] Jane Bennett uses the term "vital materialism" to foreground the creativity and political agencies of nonhuman substances within assemblages. Jane Bennett, *Vibrant Matter: A Political Ecology of Things*, (Durham: Duke University Press, 2010).

increase algae production at the surface.[93] Trash and treasure are lively, their temporalities are multiple. While we may treat the seabed as a bulwark of our past and beacon of the future, it affects our lives in ways beyond what is predictable, beyond iPhones, hybrid vehicles, and Chinese shipwrecks.

In this chapter, I have shown that salvage and extraction have acted as convergent ideas that both mobilize notions of heritage. Performing the archival process has in many senses been a performance of modernity, of human evolutions. But the time has come to envision alternative enactments of heritage. While we may still learn from the seabed, we must look to a different, more inclusive framework for this underwater landscape that does not presume that we can merely extract from an archive unproblematically. Instead, all the living things that rely on the seabed inherit it, and thus become responsible for its continuation and for its impact on others. In the deep, *geos* and *bios* are inextricable from one another, as life, death, and decay cycle between one another. Archives, like frontiers, are tumultuous and contested repositories of information and resources. As I will discuss in chapter 3, it is not just sedimentation that constitutes the seabed archive. Rather, turbulence precedes and conditions the possibility for sedimentation. In the next chapter, I will dig deeper into the mediation of the seabed by examining the history of sonar-based petroleum surveys. I will consider how this noisy pursuit of fossil fuels is shaping ocean soundscapes and ecosystems today.

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[93] See Shreema Mehta, "The Dangers of Deep Sea Mining," *Earthworks,* September 28, 2015, https://www.earthworksaction.org/earthblog/detail/the_dangers_of_deep_sea_mining#.VuNyUJMrKb8; Kathryn A. Miller et al., "An Overview of Seabed Mining Including the Current State of Development, Environmental Impacts, and Knowledge Gaps," *Frontiers in Marine Science* 4 (2018): 418.

Chapter 2: Feeding Sound: Sonic Pipelines in the Ocean

"One by one the dangers which beset the early navigator have been overcome. The chart told him the best course to take from one point to another. The mariner's compass enabled him to maintain his course when the stars were blotted out by clouds. With the sextant and chronometer he located his position; with the log and soundings he guarded himself when a sight could not be obtained."

—Columbus O'Donnell Iselin, 1932.[1]

It starts with a bang. Or, more accurately, several bangs, that together comprise a seismic survey. How it all ends, however, is uncertain. Some would say it ends with oil—others warn of extinction. It is fitting perhaps, that bangs occupy a space in our collective conscious that contains both the marking of death, as with the bangs of firearms, as well as with the violent creation of life, as read in the primordial bang itself, the bang that generated the universe—the Big Bang. Frances Dyson calls the Big Bang "a sonic event rather than a sonic continuum…The 'bang' is a noise among an overall noisiness, an identifiable sonic 'thing' or 'event' or even 'object' that stands out, protrudes into materiality, and turns noise—the generalized hum that barely enters language as a category of the sensible—into sound."[2] Indeed, the materiality of bangs both big and small seem suited for the delineation of beginnings and endings. High amplitude soundwaves are experienced as loud volumes that have a manifest materiality—they shock, they immobilize, and they penetrate into rock and earth. Violent sounds like bangs are typically standout events that stand opposed to reason; J.

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[1] Submarine Signal Company, "The Development of the Fathometer and Echo Depth Finding" *Soundings* (April 1932), Columbus O'Donnell Iselin papers, 1904-1971, MC-16, Box 31, Folder 4, Woods Hole Oceanographic Institution Data Library and Archives, accessed July 24, 2019. http://archives.mblwhoilibrary.org:8081/repositories/2/resources/153.

[2] Frances Dyson, *The Tone of Our Times: Sound, Sense, Economy, and Ecology*, (The MIT Press, 2014), 52.

Martin Daughtry calls it the “wartime acoustic sublime: the harsh euphoria of a loud close call with death.”[3] But what of the bangs that are a sonic continuum—the bangs where continuity is in fact the point?

In this chapter, I trace the transformation of underwater bangs into a landscape of petroleum. From a nineteenth-century boom era defined by the bangs of exploration, to a new age of offshore drilling, seismic surveys are material-discursive objects that have shaped and defined a culture around the geological structures that they seek to capture. Petroleum seismology as it is discussed here is part of a growing realm of sonic communication of the ocean that includes the clicks and whistles of cetacean echolocation, submarine pings, booms, and other echoic sounds.[4] But survey bangs are standout sounds within this taxonomy, speaking to a different kind of sonic ontology that stands in between noise and signal, life and death.

A 1968 position paper on ocean exploration by the National Academy of Engineering distinguishes surveying from research by its “systematic collection programs on regional or world ocean scales.”[5] In a similar vein, the Merriam-Webster definition of a survey

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[3] J. Martin Daughtry, “Thanatosonics: Ontologies of Acoustic Violence,” *SocialText* 32 no. 2 (2014): 36. Daughtry categorizes certain noises as “belliphonic” sound, “the vehicular, weapon-related, and other sounds that armed combat produces.” See J. Martin Daughtry, *Listening to War: Sound, Music, Trauma, and Survival in Wartime Iraq*, (Oxford: Oxford University Press, 2015): 5, 33

[4] Writing about the early development of sonar, John Shiga delineates a semiotic taxonomy of pings and echoes specific to underwater transmission and perception. John Shiga, “Empire, Media, and the Politics of Underwater Sound, *Canadian Journal of Communication* 38 (2013): 357-377.

[5] ICOEES Typoe Task Group, Executive Summary of Preliminary Position Paper, “An International Decade of Ocean Exploration and Assessment of the Seas,” Committee on Ocean Engineering, Jan 12, 1968, Rand (William W.) Papers ca. 1921-1968, SBHC Mss 46, Box 1, Department of Special Collections, Davidson Library, University of California, Santa Barbara.

emphasizes both broadness and precision, citing comprehensive consideration and scrutinization through measurement and data collection.[6] Seismic surveys are meant to be exactly that—expansive yet highly methodical forms of data collection, used to find the anticlines or upfolds where oil occurs and can be extracted.[7] Like other forms of sonar, hydrological surveys are accomplished by producing a series of high energy acoustic blasts that hit the seafloor and echo back to a set of transducers, which translate soundwaves into information about geological structures underneath the surface of the seafloor.[8] To achieve adequate breadth, these bursts of sounds must be repeated hundreds of times, for days, weeks, and even months. Beyond a single big bang, the use of several consecutive bangs in the simultaneously systematic and broad abstraction of a survey has minimized the sonic event itself as an object of interest as it brings other objects (like oil) into the realm of mattering.

Problematizing the fetishes of technological precision and comprehensive coverage, I seek a return to the noisy, haptic, and explosive underpinnings of seismic surveys, critiquing the erasures of animal life and oceanic materiality that they engender. Beyond wonder inducing gadgets and technics, beyond increasing efficacy and accuracy, I consider how deep-sea prospecting matters materially—how it affects the space of its interventions. As we mediate the seafloor, we also compose and delimit a space of reality that validates the

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[6] Merriam Webster, s.v. "Survey," accessed July 17, 2019, https://www.merriam-webster.com/dictionary/survey.

[7] William Whitehall Rand, "Santa Barbara Channel, Offshore Oil Exploration," to Rotary Club, 1957, p. 2. Rand (William W.) Papers ca. 1921-1968, SBHC Mss 46, Box 1, Department of Special Collections, Davidson Library, University of California, Santa Barbara.

[8] To hear a sample of a seismic airgun survey, see "Seismic Airgun Surveys," *Ocean Conservation Research,* http://ocr.org/portfolio/seismic-airgun-surveys/.

presence of certain substances like oil, while eliminating others through the calculus of noise and interference. The most spectacular illustration of this process can be read in the controversies surrounding the ecological impacts of such surveys. The bodies of marine animals, which end up on beaches or, more frequently, rain down to the seafloor in the form of "marine snow," are the forgotten companions to seismic images—inextricably linked in their shared emergence, their alienation from the sea, and their circulation through our news worlds. These nonhuman experiences of acoustic mediation lead me to ask, what are the stakes of producing informatic bodies through vibrations that simultaneously produce carcasses? This question marks a paradox of mediation: such casualties, captured in photographs and disseminated by the media, activate a moral outrage that connects activities we may otherwise ignore to the sharp relief of death; yet, it is a lust for information capture that produces this violent spectacle in the first place.

While oil extraction has been interpreted in terms of its infrastructures, its cultural legacies, and its environmental implications,[9] there has yet to be a theory of mediation that discusses oil extraction in relation to its preceding processes of imaging. My first chapter demonstrated that audiovisual abstraction of the seafloor can create the possibility for extraction by producing it as a space for the taking. While this applied to archaeological media as I discussed, it also applies to 1950s representational media about the ocean—what Nicole Starosielski calls "ocean exploitation films": "Regardless of their subject, the language of battle and hunting pervaded the reception of almost all underwater

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[9] Stephanie LeMenager, *Living Oil: Petroleum Culture in the American Century,* (Oxford: Oxford University Press, 2014); Darin Barney, "Pipelines," in *Fueling Culture: Politics, History, Energy.* Eds. Imre Szeman, Jennifer Wenzel, and Patsy Yaeger, (Fordham University, 2017): 267-270; Imre Szeman, "System Failure: Oil, Futurity and the Anticipation of Disaster, " *South Atlantic Quarterly* 106, no. 4 (2007): 805–823.

documentaries. . .Together these films configured the ocean in terms of its resources."[10] Today, tropes of exploitation also pervade scientific and industrial forms of ocean mediation. They are part of a collective staging for how Westerners relate to the ocean as a frontier. To oil men, a survey is thus far from merely a perceptual medium; it is a tool of the hunt—a form of extractive mediation that determines not only the taking of resources, but of life itself.

Throughout this chapter, I structure my discussion of seismic surveys around the idea of the "take." This term comes from legal and professional literature, which defines accidental kills of fish and other marine life as "takes." To me, the use of the word "take" to describe unintended death and injury to marine life merits pause, as it construes animals in the same terms as other substances extracted or "taken" from the ocean, occluding the matter of life and death at stake. Usefully, "take" also has connotations within film production. The word "take" in my subtitles is thus intended to invoke several interrelated functions: the imaging technologies that "take" scans of the deep sea, the connotation of repeated attempts, the physical intake of seabed resources, and in oceanographic terms, the "take" or unintended death and injury to marine life in the deep sea. Each of these takes represent parts of the whole—merely selective pieces or composites of the ocean floor. The seafloor itself contains a multitude of aspects that can therefore be subsumed, recessed, and overlooked by teleologies of extraction and monetization.

Bringing sound studies scholarship and sonic materialism to bear on the question of seafloor survey practices, I present a media historiography of reflection seismology and its

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[10] Nicole Starosielski, "Beyond Fluidity: A Cultural History of Cinema under Water," in *Ecocinema Theory and Practice,* eds. Stephen Rust, Salma Monani, Sean Cubitt (Routledge, 2012), 157.

vexed relationship to bodies of oil and the bodies of cetaceans. First, I explore the binary of noise and signal underwater by examining a series of seafloor survey technologies, from the "soundfish" to the air gun survey. This leads to a discussion of the physical effects of sound imaging on marine life, attending to listening practices as impactful sonic events in the ocean. I end with a critique of industrial and state actors, who regularly justify the expansion of seismic surveys on the basis of energy security.

The First Take: Signal and Noise

The history of seafloor sounding begins before acoustics enter the picture. "Sound" derives from the Old French *sonde*, meaning "to sink in, penetrate, pierce," or in nautical terms, "to employ the line and lead, or other appropriate means, in order to ascertain the depth of the sea, a channel, etc., or the nature of the bottom."[11] Early oceanographic research on the deep seabed was primarily understood through "sounding" techniques that involved lowering rope or wire into the depths and retrieving samples. When the HMS Challenger first explored the depths of our oceans from 1872-1876, laying the infrastructure for modern oceanography, it conducted 133 bottom dredges and 492 deep sea soundings. Modern "echo sounding" thus connotes both the sonic and physical valences of the word "sound" in a not altogether unproductive conflation. Stefan Helmreich, for instance, has appropriated the term "sounding" as a broad and abstract analytic.[12] Today, forms of echo-based sounding such as seismic imaging would do well to remember this history, as echo sounding implies a sonic

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[11] *Oxford English Dictionary*, "sound," accessed November 27, 2016, http://www.oed.com.proxy.library.ucsb.edu:2048/view/Entry/185130#eid21831455.

[12] Stefan Helmreich, *Sounding the Limits of Life: Essays in the Anthropology of Biology and Beyond*, (Princeton: Princeton University Press, 2016), 185.

materialism. The state-of-the-art tethers that transmit power and signals from control rooms to ROVs in the deep sea today began their genealogy in the lifting of ocean mud from seafloor to the surface with various types of wire.[13]

It was only with the wartime invention of sonar that ocean "sounding" took on a new, sonic register. At the turn of the twentieth century, ocean research transitioned from study within independent disciplines (as with the Challenger expedition), towards comprehensive oceanography driven by political and economic aims. As Gary Weir explains, the U-boat menace "provided the catalyst that accelerated American naval oceanographic studies, dramatically altered scientific practice, and profoundly affected the selection of new subjects for investigation."[14] The U.S. Navy had a keen interest in understanding how sound travels through seawater and sediment to meet the U-Boat threat, and thus funded much of the research on sound imaging technologies. Communications scholar John Shiga underscores the emergence of distinctly active, directional forms of detection from this wartime competition in underwater dominance, wherein the transmission of acoustic pulses and the recording of echoes became the principal mode of perceiving marine objects.[15]

There have been many iterations in the development of such ocean sounding techniques. Notably, in the early 1900s, radio expert and inventor Reginald Fessenden developed the groundbreaking Fessenden oscillator while working with the Submarine Signal Company. This was a major leap in underwater communication and detection from previous methods. Before Fessenden, navigational safety systems consisted of underwater bells located near

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[13] Stefan Helmreich, *Alien Ocean: Anthropological Voyages in Microbial Seas* (Berkeley, CA: University of California Press, 2009), 34.

[14] Gary Weir, *An Ocean in Common: American Naval Officers, Scientists, and the Ocean Environment*, (College Station: Texas A&M University Press, 2001): 6.

[15] John Shiga, "Sonar: Empire, Media."

lighthouses, which could be detected by receivers on ships.[16] At the same time, hoping to help ships detect icebergs, German physicist Alexander Behm also developed a working echo sounder in response to the *Titanic* disaster in 1912.[17] Later, the advent of World War II led to higher resolution and precision echo sounders, including the sonic depth finder (SDF) developed by US Navy physicist Harvey Hayes in 1924, which used oscillator technology to make the first bottom profiles of the ocean. Weir notes, "Hayes's SDF turned on a sonic light in a very dark room."[18]At last, sound "began to reveal what years of work with rope and wire sounding lines had only suggested."[19]

During the years of World War II, rising demand for oil to support the war effort led to a significant increase in US exploration and discovery of onshore and offshore oil fields. The simultaneous development of better sound sources and more precise methods of sonar-based communication in the ocean was an important factor in the growth in offshore oil drilling. In the 1860s, the early days of drilling for oil seeps, submarine petroleum exploration was done by divers who took core samples of the ocean bottom. But oil pioneers soon sought out techniques that could provide detailed and continuous, rather than intermittent information about bottom sediments.

Santa Barbara County, home to the earliest offshore oil rigs ever created in the 1890s, was primed to become a leader during this wartime pursuit of oil. By the mid 1940s, companies like Union Oil Company of California, Signal Oil, Shell Oil, and Macco

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[16] "The First Practical Uses of Underwater Acoustics: The Early 1900s," *Discovery of Sound in the Sea*, The University of Rhode Island: 2020.

[17] Jeffrey A. Karson, Deborah S. Kelley, Daniel J. Fornari, Michael R. Perfit, and Timothy M. Shank. *Discovering the Deep: A Photographic Atlas of the Seafloor and Ocean Crust*. (Cambridge University Press, 2015), 4.

[18] Ibid., 30.

[19] Weir, *An Ocean in Common*, 14.

Corporation were experimenting with new sounding techniques for geophysical surveys in the Santa Barbara Channel.[20] William B.W. Rand, an offshore drilling pioneer in the Santa Barbara area, was one figure involved in the development of modern survey methods. Working first for Shell Oil, then Union Oil Company of California, and later his own survey company, *Submarex*, Rand advocated for surveying as a way to delineate sedimentary structures through large numbers of observations.[21] Rand was adamant about the importance of petroleum for national well-being: "Oil companies attempt to provide for our petroleum needs in peace and war, at reasonable prices and at a profit…When the costs of finding and producing offshore domestic oil become substantially higher than such costs for foreign oil delivered locally, then other factors such as security, and national self-sufficiency in oil, must be used to justify the higher cost of domestic oil."[22] This theme of energy security would return again and again to justify the development and use of newer survey technologies.

Among the industrial survey methods used during the 1940s is a peculiar device called the "soundfish," developed by the U.S. Navy Electronics Laboratory for geophysical prospecting. The soundfish was a hybrid technology created specifically with the aim of determining seafloor composition. It consisted of a hydrophone encased in a metal container, which could be dragged along the bottom of the seafloor. Frictional noises from the scraping of the metal cylinder on the seafloor would then be picked up by the hydrophone and sent to an amplifier on the towing vessel, providing continuous information about the seafloor. Researchers explain, "Rock makes continuous loud bongs or clangs, sand makes a heavy scraping or rasping noise, and mud makes a quiet swishing noise…it is necessary for the

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[20] Rand, "Santa Barbara Channel."
[21] Rand, "Santa Barbara Channel," 1.
[22] Rand, 3.

observer to train his ear by listening while the equipment is dragged at constant speed over known types of bottom, as determined by grab sampling."[23]

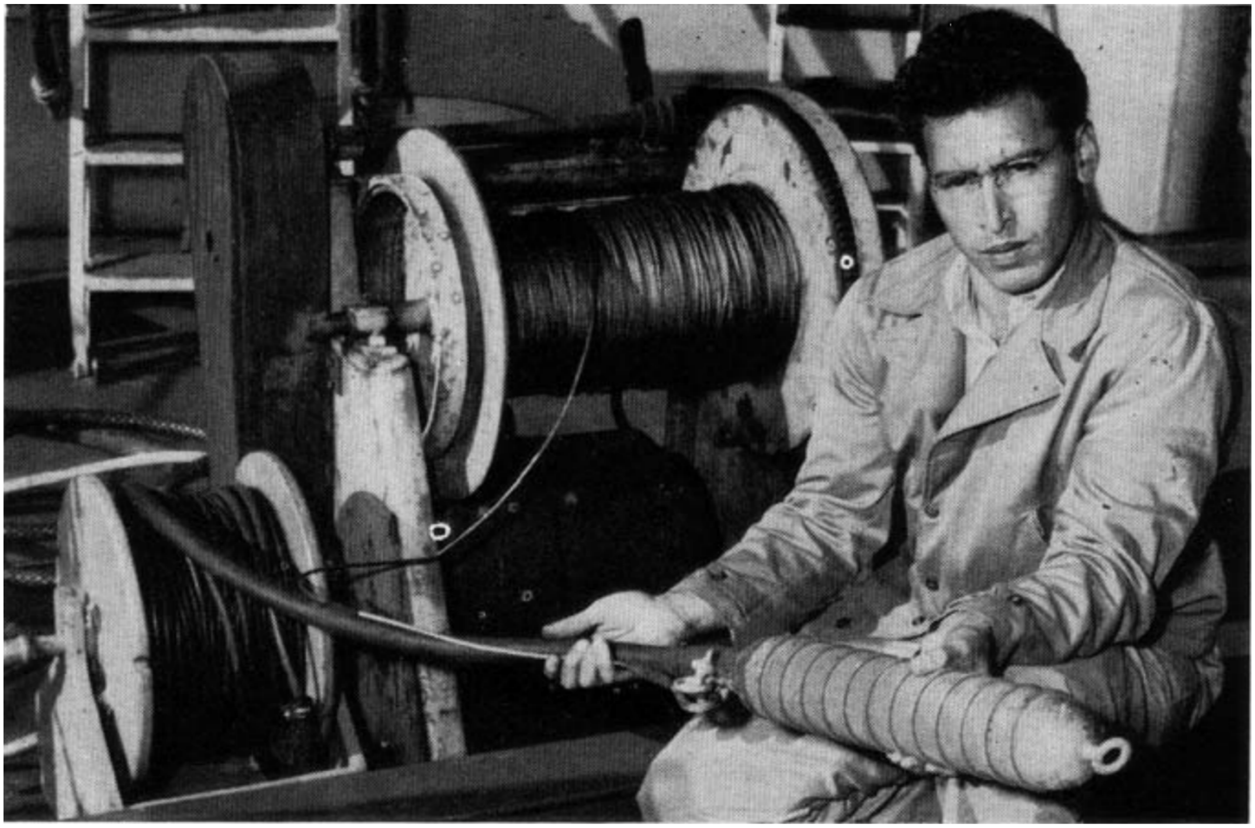

Figure 3. The "Soundfish," official US Navy photo

Variations of this method with simpler equipment have also been used concurrently, such as the dragging of a hollow metal pipe attached to a wire with an audio amplifier and microphone at the top. As the Navy researchers note, "Some information can even be obtained by listening with the ear near the wire and by feeling the wire with one's fingers. The nature of the tugging and jerking on the wire as well as the noises transmitted up the wire gives some information concerning the bottom character." [24]

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[23] E.C. LaFond, Robert S. Dietz, and J.A. Knauss, "A Sonic Device for Underwater Sediment Surveys," U.S. Navy Electronics Laboratory, Oceanographic Studies Section, San Diego 52, California, *Journal of Sedimentary Petrology* 20, no. 2 (June 1950): 108.

[24] Ibid., 110.

This mode of listening and feeling is perhaps striking for its focus on somatosensory perception, which seems to subsume audition as a sensing paradigm. Hydrophones in this case acted as a proxy for human fingertips, providing detailed transmissions of noise through a highly sensory mode of interpretation. However, the imbrication of listening with feeling here reflects the essentially haptic nature of sonic communication itself. Sound scholar Don Ihde points to the practice of shaking a closed box to hear the shape of the contents inside as just one example of the way that mute objects are given a voice through the percussive exchange between two surfaces.[25] Likewise, the soundfish makes clear a connection between haptics and sonics because the device that is used to perceive the sound (the hydrophone) is nearly the same device used to create the sound (the dragged cylinder which encases the hydrophone).

Most survey technologies that rely on dragging are limited by imprecision in location data and physical interference, and cannot achieve the level of photographic detail desired by modern oil prospectors. Nevertheless, the soundfish's premise of continuous sounding encapsulates the epistemological desire of the survey, as the ideal of continuous data streams has remained central to the development of seafloor media technologies, even today. The soundfish assumed a subject position in which the oceanographer would be responsible for filtering and interpreting streams of sensory information about the seafloor. Later advancements in deepwater imaging by the military and by shipping cartels followed suit, and focused on improving the shortcomings of dragging methods. These subsequent technologies aimed to elevate signals and reduce noise, cementing a perceived need to

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[25] Don Ihde, *Listening and Voice: Phenomenologies of Sound* (New York: State University of New York Press, 2007), 67.

manage the deep sea's materiality. Such efforts represented a shift in thinking, in which the ocean and its animals were increasingly conceptualized as forms of interference.

The progressive development of bottom sounding technologies and spatially expansive survey techniques dovetails with the classic Shannon and Weaver model of communication, which radically conceptualized communication as the success of signal overcoming noise.[26] In the ocean, this influential way of thinking about noise as interference and signal as message content is a socially significant categorization that bolstered ideas about the need to facilitate the travel of signal and eliminate the intrusion of noise. Shiga explains, for instance, that the historical division of ocean into signal and noise was achieved through the development of underwater bells, echoes, and hydrophones: "underwater sound was organized to signify symbolically through the association of hazards with the bell sound in nautical culture. Finally, the acoustic field of the ocean was divided into signal (bell ringing) and noise (everything else)."[27] Later, underwater SONAR devices diversified the number of signal sounds and meaningful sound signatures, training its listeners "to perceive the ocean through that system of sonic division."[28] This flattening of underwater space was achieved through progressive attempts by humans to eliminate the "noisy" material aspects of seawater so as to facilitate the transmission of desirable pings and echoes—a teleological pruning of sound that eventually served to erase the deep sea's unruly materiality.

The partitioning of sound into adversarial notions of signal and noise could be seen in full effect by the 1930s, when oceanographer Columbus O'Donnell Iselin identified 'the

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[26] "Shannon and Weaver Model of Communication," *Communication Theory*, https://www.communicationtheory.org/shannon-and-weaver-model-of-communication/

[27] Shiga, "Sonar: Empire, Media," 362.

[28] Shiga 365

afternoon effect,' or "the impact that diurnal conditions, specifically the changing temperature of sea water, had on underwater sound transmission."[29] The son of wealthy bankers and a graduate of St. Marks and Harvard, Iselin became a student of Henry Bryant Bigelow, the founding director of Woods Hole Oceanographic Institution, at a time when oceanography was seen as a "gentlemanly tradition."[30] Famed oceanographers like Iselin helped to further refigure acoustic transmission in terms of targeting and accuracy through the mathematical elimination of aquatic obtrusions and ocean "noise."[31] Writing on equipment developed by the Woods Hole Oceanographic Institution in 1932, Iselin's characterizes ocean life as one instance of interference:

> Unforeseen things are constantly hampering the work of each oceanographic expedition. For example, there are several kinds of marine animals which become wound around the hydrographic wire and stop the messengers…If the submarine 'devils' are not interfering with the work, the 'devils' of stormy weather are very apt to seize the opportunity to persecute the sleepy oceanographer."[32]

Ostensibly, Iselin is referring to animals such as sea turtles, seals, and dolphins—the same kinds of creatures marked as at risk of being entangled in fishing gear and debris.[33] Iselin's

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[29] Ronald Rainger, "Science at the Crossroads: The Navy, Bikini Atoll, and American Oceanography in the 1940's." *Historical Studies in the Physical and Biological Sciences* 30 no.2 (2000): 352-353. Reprinted courtesy of the History of the Sciences Society from Earth Sciences History, 2000.

[30] Henry M. Stommel, "Columbus O'Donnell Iselin," in *Biographical Memoirs v. 64*, (Washington, DC: The National Academies Press, 1994). Accessed at https://www.nap.edu/read/4547/chapter/8.

[31] Shiga, 367-368.

[32] Columbus O'D. Iselin, "Some Phases of Modern Deep-Sea Oceanography," in *Annual report of the Board of Regents of the Smithsonian Institution* (Washington: United States Government Printing Office, 1932): 258. Accessed online at http://library.si.edu/digital-library/book/annualreportofbo1932smit.

[33] NOAA Fisheries, "Entanglement of Marine Life: Risks and Response," *NOAA*, June 19, 2017, https://www.fisheries.noaa.gov/insight/entanglement-marine-life-risks-and-response.

flippant description of such creatures as "submarine devils" lessens the blow of the cruelty of entanglement, as it reduces both ocean and animal life into mere obstructions to the development of underwater communication and imaging.

Moreover, for the decades when wire sounding technologies dominated, depth remained a highly ambiguous, terrifying space for hydrographers and other ocean researchers. The requirement of a mechanical connection to the bottom with traditional sounding techniques and even with techniques like the soundfish was, in many ways, a burden that exacerbated these unwanted connections to whatever was down there, leading to an underlying desire for observation at a distance. Wireless sounding was the antidote to these fears. When echo depth sounding finally appeared, it was hailed as "a radical and brilliant step in man's mastery of the sea,"[34] emphasizing both the anxiety around the seafloor as an alien, nonhuman space, and a desire to control it from a distance.

Fundamentally, sound-based survey technologies elided the turbulent middles of transmission through the calculative production of smooth, fluid highways of sound. For echo sounding techniques, unruly noise could refer to things like environmental noise (wind, traffic, marine animals), intrinsic noise (electronic or swell noise specific to the tools being used), reverberations, as well as "statics," or variable surface conditions that could obscure or change time measurements for the reflections, a crucial element in producing accurate images.[35] In her discussion of undersea cables, Starosielski provides a basis by which we can understand how the elimination of the ocean's materiality extends to the creation of insulated

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[34] Submarine Signal Company, "The Development of the Fathometer and Echo Depth Finding," *Soundings* (April 11, 1932).

[35] Bill Dragoset "A historical reflection on reflections," *The Leading Edge* 24, no. s1 (2005): S48. https://doi.org/10.1190/1.2112392.

pipelines “designed to transform turbulent ecologies into friction-free surfaces.”[36] As she puts it, these infrastructures “produce an internal break in an ecology.”[37] I would expand on Starosielski’s point to include not only communicative mediation, but also extractive mediation. To the extent that sounding likewise constructs communication feeds that cut out ocean ecologies, surveys are a form of sonic and visual intake—a pipeline for information—that act as only a first step in a value chain that includes the creation of pipelines for oil.

The Second Take: Explosion Seismology

The answer to noise, as it so happens, was the production of more noise. The ocean is a sonic world. Beyond mathematical calculations, an important aspect of amplifying signal involved choosing the right sound source to use for reflection seismology. For all practical purposes, progressive developments of smoother underwater communication depended on loud systems of sonar-based imaging. In water, sound travels four times faster than in air and, unlike sunlight, reaches into great oceanic depths. Extreme bursts of acoustic energy have the ability to travel kilometers from a source and penetrate far into the seafloor. Thus, the higher the energy of the burst and the closer it is to the target, the more accurately surveyors were able to characterize geological structures. The dual development of noise elimination techniques and noisier technologies can be observed both in early sounding experiments and in modern-day seafloor mediation techniques.

All sound reflection experiments shared the same basic premise: first, a source transmits vibrations of a particular frequency at pulsed intervals toward the object of interest (the

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[36] Nicole Starosielski, *The Undersea Network*, (Durham: Duke University Press, 2015), Kindle edition, loc 539.

[37] Ibid.

seafloor). Then, as the seismic wave travels back to the surface, each reflecting interface bends the raypath. Different materials, whether bedrock, seawater, or piezoelectric crystals, are perturbed differently by the soundwaves, changing their ability to penetrate, echo back, or produce electric polarization. This process of energy or signal transformation is called transduction. Piezoelectric crystals, ceramics, composites, or polymers in hydrophone transducers set the limits of what can be "heard" (or transformed from vibrations into an electric signal) from the earth.[38] At maximum capacity, mechanical stress causes electric polarization, and information propagates through matter.

The first use of seismic imaging technology was the 1921 Vines Branch experiment, in which scientists used the phenomenon of echoes off of underground rock to create an image of the space below the seafloor.[39] Over the next decade, reflection seismology grew to become a proven tool for the location of marine hydrocarbons. In contemporary petroleum seismology, surveyors look out for the particular seismic responses of carbonate rocks, which are source rocks containing over half of the world's hydrocarbon reserves. Their sound signatures are unique thanks to complex pore systems, and are usually measured with ultrasonic transducers.[40] These reflections are then analyzed through various algorithmic filters to produce an image of the subsurface (rock formations below the seafloor).

Eventually, wartime developments led to the appropriation of weapons themselves for the purposes of acoustic communication. That is, explosives, from dynamite to Pentaerythritol

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[38] Huidong Li, Z. Daniel Deng, and Thomas J. Carlson, "Piezoelectric materials used in underwater acoustic transducers," *Sensor Letters* 10, no. 3-4 (2012): 679-697. http://jsats.pnnl.gov/Publications/Peer/2012/2012_Li_etal_PZT_Review_paper_Sensor_Letters.pdf

[39] Dragoset "A historical reflection on reflections," S46.

[40] Ibrahim Palaz, K.J. Marfurt, eds., *Carbonate Seismology* (Tulsa, OK: Society of Exploration Geophysicists, 1997): 40.

tetranitrate (PETN, used by the Germans in WWI), were and continue to be an important component of oceanographic surveys. Energetic or explosive materials undergo a rapid chemical reaction resulting in combustion, or the release of heat and gas as the molecular compounds break down. Detonated by a combination of heat and shockwave, high energy explosives like nitroglicerine release more energy through intramolecular decomposition—they are louder, and thus they retrieve clearer sound images.[41]

Explosion seismology was popularized by physicist Maurice Ewing, who used TNT to study the continental shelf aboard the Coast and Geodetic Survey ship *Oceanographer*.[42] Established in 1807 as the first civilian scientific agency, the U.S. Coast and Geodetic Survey is the organization responsible for surveying the US coastline and creating nautical charts for the benefit of maritime safety. After Ewing's success in revealing geological characteristics beneath the ocean floor, other USC&GS researchers also began using explosives to make seismic profiles. Electrical engineer and inventor of the Dorsey Fathometer, Herbert Grove Dorsey, chronicled experiments made by the USC&GS ships *Oceanographer* and *Lydonia* in the 1930s. In particular, he generated sound with quarter pint TNT bombs in order to test hydrophone reception at various distances and depths, measuring refraction and reflection due to changes in temperature, pressure, and salinity. These bomb signal tests, which occurred off the coast of Maryland in 1933 and Santa Barbara in 1934, would lead to the development of more accurate echo sounders.[43]

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[41] Eric Roberts, "Detonation and Combustion, Stanford, https://cs.stanford.edu/people/eroberts/courses/ww2/projects/firebombing/detonation-and-combustion.htm.

[42] David M. Lawrence, *Upheaval from the Abyss: Ocean Floor Mapping and the Earth Science Revolution*, (Rutgers University Press, 2002, Kindle edition): Loc 1535 of 3147

[43] Herbert Grove Dorsey, "The Transmission of Sound Through Sea Water. II," *The Journal of the Acoustical Society of America* 7 (1936).

Dynamite was the original seismic source for surveys because it yielded strong reflection signals and was relatively mobile and compact. But in water, dynamite also had the drawback of producing noisy bubbles of gases, which restricted surveyors to using the explosives in shallow water, further away from the target, so as to minimize the rise of bubbles. During the postwar era, these and other limitations led researchers toward alternatives to black powder as a source of explosion.[44] Safety was perhaps one of the concerns; in 1957, an attempt by oceanographers aboard the Somersworth to detonate 1/2 lb charges for Mark 3A offensive grenades resulted in catastrophe, killing three people on deck and injuring another four. The Somersworth disaster brought to light the dangers of using military explosives as signal sources, particularly without a demolitions expert.[45]

Beyond issues of safety, oceanographers saw a need for more control, "a practical, lightweight, low-frequency, high-intensity sound source, capable of being lowered to actuate at great depths, one which is unaffected by pressure."[46] This goal was eventually accomplished under the watchful eyes (and ears) of oceanographer John Brackett Hersey. A student of explosions pioneer Ewing both before and during the war, Hersey had a background in petroleum exploration, having initially worked with a seismic exploration

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[44] John Jakosky, "Characteristics of explosives for marine seismic exploration," *Geophysics* 21, no. 4 (1956): 969–991. doi: https://doi.org/10.1190/1.1438316

[45] Correspondence to Dr. Robert A. Forsch, Hudson Laboratories from Bob Westervelt, 5 August 1957, USNUSL, John Brackett Hersey Papers, MC-12, Box 9, Folder 2, Hersey J. Brackett Correspondence – U.S. Navy Underwater Sound Laboratory, 1948-1958, Data Library and Archives, Woods Hole Oceanographic Institution, Woods Hole, MA, accessed July 23, 2019, http://archives.mblwhoilibrary.org:8081/repositories/2/resources/17.

[46] Correspondence to J.B. Hersey from B. J. O'Keefe (EGG), (Nov 24, 1960): 1. John Brackett Hersey Papers, MC-12, Box 9, Folder 2, Hersey, J. Brockett Correspondence – Edgerton, Germeshausen & Grier, Inc., 1960, Data Library and Archives, Woods Hole Oceanographic Institution.

crew for Phillips Petroleum.[47] Hersey was later hired to run an underwater acoustics program for WHOI under Iselin, who by then had become the institution's new director. He is primarily remembered as a champion for towed instruments, which required sound sources with a greater degree of control. Hersey coupled newer explosive sources with hydrophone techniques to create the Continuous Seismic Profiler (CSP), a widely used technique which consisted of the repetition of echo-sounding techniques several times per minute. This introduced a time-based understanding of resolution, in which high resolution equates to the temporal length of the seismic signal.[48] The idea was to create a sub-bottom reflection that would approach a continuous line, an update on the continuity that was first available with towed hydrophone technologies like the soundfish. By the late 1960s, CSP techniques were widely deployed for offshore oil exploration, and they were used almost as universally as echo sounding.

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[47] "Memorial to John Brackett Hersey, 1913-1992," The Geological Society of America, 207-209. Accessed at http://www.geosociety.org/documents/gsa/memorials/v24/Hersey-JB.pdf.

[48] O. Leenhardt, "Analysis of Continuous Seismic Profiles," *The International Hydrographic Review* 46, no. 1 (2015). https://journals.lib.unb.ca/index.php/ihr/article/view/23959.

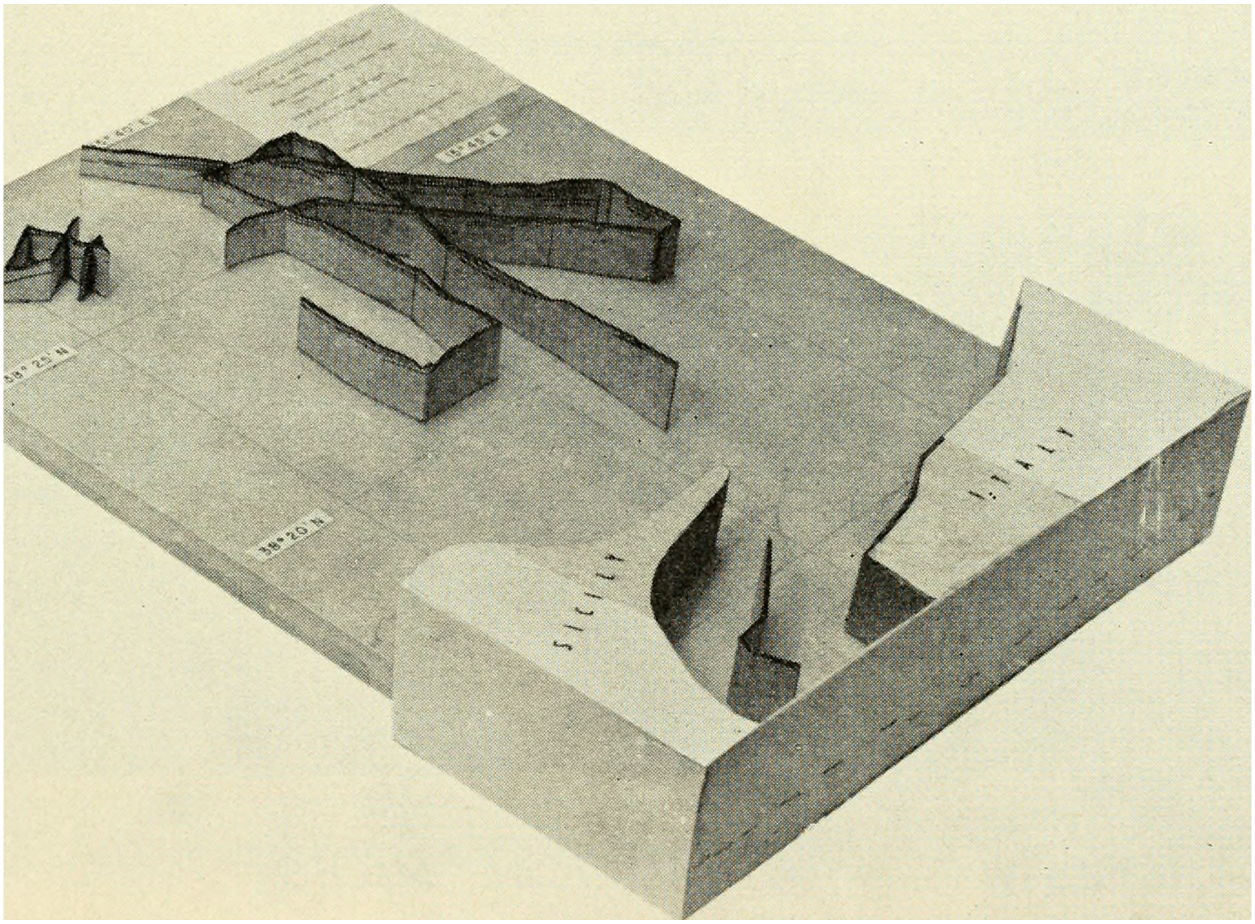

Figure 4. A model of a continuous profiler survey in the Tyrrhenian Sea, Woods Hole Oceanographic Institution. In Hill, M.N. *The Earth Beneath the Sea* (1963), p. 80.

The success of CSP ultimately revolved around increasing signal to noise ratios with controlled, acoustic sources beyond traditional explosives. Some of these alternative sound sources were electrical, creating discharge from spark plugs to generate an acoustic signals with broad sound spectrums. These could "behave somewhat like an explosion, though much weaker."[49] For instance, the "Boomer" was an eddy current generator developed by Harold

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[49] J. B. Hersey, "Sound Reflections in and under Oceans" reprinted from *Physics Today*, (Nov 1965), 17-24. John Brackett Hersey papers, MC-12, Box 16, Folder 2, Articles, abstracts reprints 1944-1982, Data Library and Archives, Woods Hole Oceanographic Institution.

Edgerton at the Massachusetts Institute of Technology. Edgerton's 1964 paper introducing the device explained that the Boomer could "be triggered often at an accurately controlled time, thus enabling the user to correlate the results of many operations on a tape or chart." It also reduced problems with noise via a digital correlation technique, and provided a large energy pulse of lower frequency sound.[50] Parallel developments also emerged from the laboratories of Socony Mobil Company, to Lamont Geological Observatory of Columbia University. At Lamont, small charges of TNT were deployed for "several nearly continuous world circling profiles."[51] Sometimes, CSP techniques involved the simultaneous use of two different kinds of sound sources.[52]

But by far the most significant development occurred in the 1970s, when Lamont and manufacturers Bolt Technologies and Texas Instruments pioneered the use of air guns, which used blasts of pressurized air as a sound source. By the mid-1970s, over 50% of marine seismic surveys relied on air guns.[53] Like dynamite, air guns also create extraneous bubbles, but this problem is remedied by the use of multiple, consecutive bangs. Specifically, differently-sized air guns are fired simultaneously in an array so that their pulses sum together and could be "tuned" to minimize the size of bubble pulses.[54] The echoes produced from these bursts are then recorded by up to 3000 hydrophones that stream from the ship.[55]

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[50] Harold E. Edgerton, "The 'Boomer' Sonar Source for Seismic Profiling," *Journal of Geophysical research* 69, no. 8 (April 15, 1964): 3033-3042. John Brackett Hersey Papers, MC-12, Box 5, Folder 2, H. Edgerton's paper, The Boomer Sonar Source for Seismic Profiling, Data Library and Archives, Woods Hole Oceanographic Institution.

[51] Hersey, "Sound Reflections in and under Oceans," p. 23.

[52] S.T. Knott, E.T. Bunce, "Recent improvement in technique of continuous seismic profiling," Deep Sea Research 15, no. 5, (1968): 638. https://doi.org/10.1016/0011-7471(68)90072-7.

[53] Dragoset, S54

[54] Dragoset, S54

[55] "Seismic Surveys," *Beachapedia*, http://www.beachapedia.org/Seismic_Surveys.

Today, air guns are typically towed from survey ships and arranged in a square array below the waterline, where they fire five or six times a minute at 200-240 decibels. When translated from an aqueous context to air, this is the equivalent of 140-180 db, which approaches the threshold for human pain and long term hearing damage.

Driven primarily by the anxiety about petroleum and hard mineral interests, Hersey and his colleagues in underwater sound thus had a distinctly extractive understanding of the seafloor and a realist perspective on the institutional funding of marine science. In a 1971 speech, Hersey stressed the importance of industry in funding marine science:

> It is worth reminding ourselves that both petroleum and hard mineral interests are already moving their experimental operations into the deep ocean. Various departments of the federal government need deep ocean capabilities. . . If my figures are not woefully dated petroleum investment at sea at all depths is a few billion per year, and the federal government spends slightly over half a billion on what is classed as marine science… Each must make his own counsel regarding this influence, but there seems little doubt that the wealth and the understanding of the oceans will need to be exploited increasingly in years to come."[56]

With a foot in both the scientific and industrial worlds, Hersey saw the link between surveying and drilling. He also understood that while air gun arrays towed from surface ships can reveal the basics, they are often still noisy and low in resolution, generating long wavefronts that limit the ability to determine small structural changes, and subjecting the signal to current distortions. This became a problem with deepwater drilling and the discovery of oil reserves inaccessible in shallow water—prospectors needed more detailed, accurate information at depth. Hersey thus realized a need for bottom profiles with "near-

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[56] John Brackett Hersey, "Speech delivered in Annapolis June 23, 1971," pp. 9-12, John Brackett Hersey Papers, MC-12, Box 16, Folder 1, Hersey, J. Brackett Speeches, 1955-1980, Data Library and Archives, Woods Hole Oceanographic Institution.

photographic detail" beyond what existing echo sounders, which he thought were "meager and rather clumsy," could do.

Responding to the growing deepwater drilling industry and problems with increased depth, the mid-1970s saw the development of ocean bottom seismographs, which could return more accurate location information with better signal-to-noise ratios.[57] Bottom technologies sought to offer more direct forms of penetration with precise energy points, by placing both the source and the receivers (hydrophones) on the sea floor instead of towing them behind a ship.[58] This allowed surveyors to retrieve precise wave velocities within thick sediment columns.[59] By 1975, deepwater drilling was in full swing, exploiting depths over 500-1000 ft or more. Bottom technologies continued to grow in their scale and sophistication as drilling interests moved towards deeper waters like those in the Gulf. [60]

Jim Broda, a researcher at Woods Hole Oceanographic Institute, led a project in 1990 called the Near Ocean Bottom Explosive Launcher (NOBEL), the first imaging system to detonate multiple high-explosive charges at the bottom. I caught up with Broda at WHOI, where he explained his experience with bottom seismographs in relation to his own invention:

> We'd make a bomb, literally, strap together 6 boxes, 8 boxes, or up to 1200 pounds of TNT, light a fuse on the back deck of the ship and throw it in the ocean… TNT was

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[57] "IPOD Site Survey Criteria: Multichannel Seismic Surveys of IPOD Sites," IPOD Site Survey Guidelines, November 1975, p. 23. Deep Earth Sampling Executive and Planning Committees, 1975-1976, College of Oceanic and Atmospheric Sciences Records, RG 173, Series II, Box 1, Oregon State University Special Collections and Archives Research Center, Corvallis, OR.

[58] Dragoset, S67.

[59] D.E. Koelsch et al., "A deep towed explosive source for seismic experiments on the ocean floor, *Marine Geophysical Research* 8 (1986): 345-346. doi: https://doi.org/10.1007/BF02084018.

[60] Frank Tursi, "A Very Brief History of Offshore Drilling, Coastal Review Online, https://www.coastalreview.org/2015/06/a-very-brief-history-of-offshore-drilling/

> the first phase, but I ended up dealing with some of the most extraordinary high energy, insensitive yet energetic materials, warhead grade. The results we got were extraordinary…. It'd be like, I used to study the moon with binoculars in a lounge chair in my backyard and now I'm standing there. That's the leap in resolution."[61]

Broda's use of a visual metaphor to describe this effect highlights the way in which sonic information is rendered and understood culturally as akin to visual media forms. Broda and other marine geologists talk about sedimentary formations in terms of resolution and clarity, equating higher energy release to higher image fidelity. The bigger the bomb, the better the picture.

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[61] James Broda, interview with author, Woods Hole Oceanographic Institution, June 25, 2018.

Figure 5. The Near Ocean Bottom Exploder, WHOI. Photo by author.

Today, as they probe seafloor muds for clues of oil, industry actors construe both acts of sounding and acts of drilling as similar forms of dimensional or deductive listening, in which the production of sound through physical contact or impact is used to construct spatial information in the absence of vision.[62] For example, in 2015, the American Petroleum Institute (API) released a report describing the oil and gas industry's desire to capitalize on unexplored reserves from the Outer Continental Shelf (OCS).[63] The report contains two contradictory statements about the nature of drilling and imaging. The first puts the onus of knowledge production on imaging: "If Congress permits the use of state-of-the-art seismic surveying technology in largely unexplored areas of the Atlantic OCS, we may discover an even greater abundance of oil and natural gas." The second, meanwhile, reverts back to drilling: "If you can't drill for oil and natural gas, you can't know how much you have."[64] Here, both drilling and surveying both serve to tell us "how much we have." The offshore oil industry thus justifies its expansion through a conflation between drilling and surveying as performing the same work of knowledge production. Given the collapse between these two practices, soundings might aptly be described as extractive mediations—media practices

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[62] On a related note, Susan Douglas speaks of "dimensional listening," a term that she coins to describe the way in which 1920s radio shows prompted its listeners to construct spatial imaginaries of three-dimensional locales, like a ballpark or a cityscape. Susan Douglas, *Listening In: Radio and the American Imagination*, (Minneapolis: University of Minnesota Press, 1999), 33.

[63] According to the Institute for Energy Research, "The Outer Continental Shelf (OCS) is the submerged area between a continent and the deep ocean. It is a rich natural resource for the deep ocean. It is a rich natural resource for the United States, containing an estimated 86 billion barrels of oil and 420 trillion cubic feet of natural gas," "Outer Continental Shelf," Institute for Energy Research, http://instituteforenergyresearch.org/topics/policy/ocs/.

[64] "Offshore Access to Oil and Natural Gas Resources" February 2015, American Petroleum Institute report. 1,7. http://www.api.org/~/media/files/oil-and-natural-gas/offshore/offshoreaccess-primer-lores.pdf.

whose fluid collection of acoustic signals preempts and mirrors the production of resource pipelines. Exploitation and extraction have produced a link between the pursuit of knowledge and the pursuit of economic wealth.

Reflection seismology, and the kind of dimensional listening that accompanies it, is an "audile technique"—a sonic practice that is informed by and impacts social contexts beyond its mere object of study. Jonathan Sterne unpacks the idea of audile technique through the example of auscultation, wherein the medical field's association of listening with knowledge and skill transforms audition into a mode of power and a marker of middle class identity.[65] Likewise, both informatic and material, seismic surveys in the ocean corporealize and operationalize landscapes according to existing social hierarchies. The event of seismology constitutes, in a sense, the event of a birth; it is the emergence of the oil reserve as a measurable body of information, energy, life, and capital. The result is both the creation of new meanings and matters, and the elision of others. But what of those properties of sound that we discard—its material existence beyond signal propagation? In what ways might we re-encounter sound underwater as deluge, as affective saturation?

The Third Take: Ecological Costs

There has been important scholarship in acoustic ecology, anthropology and history, that has pushed back against the noise/signal binary as a one-way transmissive model, finding

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[65] According to Sterne, through stethoscopes, mute bodies became sounding ones, shifting the locus of truth away from what patients say and towards what bodies reveal. Jonathan Sterne, *The Audible Past: Cultural Origins of Sound Reproduction,* (Duke University Press, 2003): 117.

ways of validating noise itself as a cultural object.[66] For instance, philosopher Michel Serres discusses noise in terms of the figure of the parasite, drawing attention to the vitality of process, propagation, and mediation: "in the beginning was the noise."[67] Building on these works, we can also contest this division of ocean into signal and noise in the bang—that object that is both noise and signal, that prompts immersive feeling while simultaneously communicating information. And bangs, importantly, lead us to nonhuman formations and the differential experience of noise in the ocean by cetaceans. Indeed, it is with a consideration of whale hearing, and with the deafening of marine inhabitants, that we can revisit sound as a haptic force that spills over the bounds of information and signal, into nausea, overload, and noise.

Cetaceans perceive the world through large auditory organs that can determine sizes, shapes, speeds, and textures of objects. Unlike human beings, whales hear just as well at depth as they do on the surface.[68] The principle of hearing by feel that characterizes the soundfish can also describe how whales experience sound. Cetaceans, who navigate, hunt, and form social groupings primarily through echolocation, hear in a haptic way. In fact, toothed whales do not hear through an ear drum and transduction through the middle ear like

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[66] Emily Thompson, for instance, talks about historical periods in which sonic culture is defined by noisy din, while Brian Larkin discusses the differential and socially layered filtering of noise and signal within urban soundscapes in Nigeria. Brian Larkin, *Signal and Noise: Media, Infrastructure, and Urban Culture in Nigeria,* (Duke University Press, 2008).

[67] Michel Serres, *The Parasite*, trans. Lawrence R. Schehr, (Baltimore: The Johns Hopkins University Press, 1982), p. 13.

[68] Maya Yamato and Nicholas D. Pyenson, "Early development and orientation of the acoustic funnel provides insight into the evolution of sound reception pathways in cetaceans," *PloS one* 10, no. 3 (2015).

humans do, but rather through the fatty tissues in their head and jaws, which connects sound vibrations to their inner ear via an acoustic funnel.[69]

This is a hapticity that fuses not the eye and the hand as Gilles Deleuze and Felix Guattari would say,[70] but the ear and the hand; it is the discovery of touching within the hearing function. A similar fusion of haptics with sonics in the hearing function is perhaps more easily grasped in the concept of something like bone conduction, in which vibrations trigger the inner ear via vibrations in the jaw. Certain types of hearing aids use this principle to bypass the ear drums completely. This is also the reason why a person's voice sounds different and perhaps fuller in their own head than it does to others at a distance. Spatial distance between the source and reception of a haptic sound, as Deleuze, Guattari, and Colin Milburn explain, does not act to separate, but rather serves as a medium of passage.[71]

Speaking to these physical processes of hearing, sound theorists such as Steve Goodman and Daughtry position sound within the framework of vibrations, accounting for aspects of sound that exceed the disembodied ideal ear. To them, vibrations instead push us to consider sound as a phenomena that is both haptic, sonic, and affective. As Goodman puts it, "sonic culture, thus situated, renders the urban audiosocial as a system of speeds and channels, dense pressure packets, vortices of attraction, basins of acoustic immersion and abrasion, vibratory and turbulent: a whole cartography of sonic force."[72] Vibrations, which radiate outwards, implicate several bodies and surfaces at once. Michael Gallagher, Anja

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[69] Yamato and Pyenson.

[70] Gilles Deleuze and Félix Guattari, "The Eye and the Hand," in *The Logic of Sense* (New York: Columbia University Press, 1990).

[71] See Colin Milburn, *Nanovision,* (Durham, Duke University Press, 2008), 85.

[72] Steve Goodman, *Sonic Warfare: Sound, Affect, and the Ecology of Fear,* (Cambridge, MA: The MIT Press, 2010), 9.

Kanngieser, and Jonathan Prior describe listening to landscapes as a vibrational exchange, arguing that sounding a landscape cannot be evaluated in terms of surface and depth: "Earth sounds, and the technologies that transduce them, situate the human subject as relatively marginal elements amongst many resounding bodies, contributing to a more disparate, relational understanding of the world."[73] Given the assemblage of actors involved in acts of sounding, it makes sense to depart from thinking in terms of discrete objects, and move toward what Alfred North Whitehead termed "superjects," "where everything—even a stone, as Whitehead would say—counts as an experiencing subject."[74] The materiality of noise can thus orient its readers towards the intimate mediatory capacities of multiple bodies, including bodies of water, land, and animals.

While noisy waters can affect whole ecosystems, cetacean takes have gained a particular notoriety. Impacts of anthropogenic noise on whales have been very well documented. According to a 2009 study by a Scripps Institution of Oceanography researcher, ambient anthropogenic noise has been doubling in intensity every decade for over 60 years.[75] In 2012, scientists measuring ambient noise levels and tracking the calls of North Atlantic right whales have estimated that right whales have lost 63-67% of their traditional communication space due to man-made noise.[76] For whales, hearing air guns is roughly like hearing gunshots

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[73] Michael, Gallagher, Anja Kanngieser, and Jonathan Prior. "Listening Geographies: Landscape, Affect and Geotechnologies," *Progress in Human Geography* (2017): 13.

[74] Alfred North Whitehead, *Process and Reality: An Essay in Cosmology* (New York: The Free Press, 1978): 29; see also Jennifer Gabrys, *Program Earth: Environmental Sensing Technology and the Making of a Computational Planet* (University of Minnesota Press, 2016): 13.

[75] John A. Hildebrand, "Anthropogenic and natural sources of ambient noise in the ocean." *Marine Ecology Progress Series* 395 (2009): 5-20.

[76] L. T. Hatch, Clark, C. W., Van Parijs, S. M., Frankel, A. S. and Ponirakis, D. W. (2012), Quantifying Loss of Acoustic Communication Space for Right Whales in and around

in sequence, or being immersed in an extremely loud rock concert. A look at how ocean bangs materially affect marine ecologies problematizes the tendency to center human perception and human values in the process of seismic imaging.

Blue whales, fin whales, gray whales, right whales, and humpbacks sing complex, locally specific songs to navigate and communicate with one another in a manner resembling dialects, constituting, as Margaret Grebowicz notes, "the largest communication network for any animals, with the exception of humans."[77] Additional noise in the ocean from shipping and sonar impacts migration, mating, and other social behaviors.[78] Many whale breeding grounds, for instance, including those of humpbacks and right whales, occur in the warm coastal waters of the South Pacific.[79] Their calves, however, are easily stimulated by noise, and thus increases in noise around these coastal areas means that key sanctuaries are being lost. The disruption to these nonhuman networks of communication puts the anthropocentric characterization of surveys in sharp relief, revealing the many ways in which our ambition to clarify one type of communication signal can interfere with the signals of others.

Bangs also raise concerns about the thresholds at which acoustic vibrations become a violent physical force. In fact, there are several instances in which the physical impacts of loud underwater sound have led to mass whale strandings. Unlike other ecological impacts, images of these strandings have circulated easily in the media and are quickly seen as

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a U.S. National Marine Sanctuary. Conservation Biology, 26: 983-994. doi:10.1111/j.1523-1739.2012.01908.x

[77] Margret Grebowicz, *Whale Song (Object Lessons)*, (New York: Bloomsbury Publishing, 2017), Kindle Edition, loc. 107 of 2251.

[78] "A Noisy Ocean: A Q&A with Dr. Leila Hatch," NOAA National Marine Sanctuaries, June 2016, https://sanctuaries.noaa.gov/news/jun16/noisy-ocean.html

[79] Cascadia Research Collective, "Summer Feeding Areas, Winter Feeding Areas and Migration," accessed July 19, 2019, http://www.cascadiaresearch.org/splash-structure-populations-levels-abundance-and-status-humpback-whales-north-pacific/summer.

tragedies because of the perceived intelligence of whales and the proximity of their social and even cultural configurations to humans. The heart-wrenching story of sonar-based technologies leading to whale beachings was most notably recounted by journalist Joshua Horowitz in his 2014 book, *War of the Whales*. Horowitz focuses on the accusation that Navy sonar is harming cetaceans and causing mass whale strandings, an issue that exploded into public consciousness in March of 2000 with the beaching of 17 whales (including several Cuvier's beaked whales, Blainville's beaked whales, Minke whales, and a spotted dolphin) on the shores of the Bahamas. It was an extraordinary and dreadful event—only two other mass strandings of beaked whales had been witnessed since 1864, and this one went down in the books as one of the largest multispecies whale strandings ever recorded.[80]

Although charges of environmental sonic violence were initially met with denial, a retrospective analysis of a string of mass stranding incidents led to a series of lawsuits against the US Navy and the National Marine Fisheries Service for the deployment of low-frequency active sonar (LFA), typically used to detect objects over long distances.[81] On August 7, 2002, the National Resources Defense Council (NRDC) filed a landmark lawsuit against the Navy and the National Marine Fisheries Service regarding the deployment of LFA. Prior to the lawsuit, LFA was permitted in 75% of world's oceans. News reporting on this controversy describes sonar as both rocket bursts ("as loud as a Saturn V rocket") which

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[80] Donald L. Evans and Gordon R. England, "Joint Interim Report: Bahamas Marine Mammal Stranding Event of 15-16 March 2000," U.S. Department of Commerce, Secretary of the Navy, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, December 2001. http://www.nmfs.noaa.gov/pr/pdfs/health/stranding_bahamas2000.pdf.

[81] Prior to the lawsuit, LFA was permitted in 75% of ocean. "Navy Agrees to Limit Global Sonar Deployment," *Natural Resources Defense Council Press* Release, October 13, 2003, http://www.nrdc.org/media/pressreleases/031013.asp.

suggests a kind of discrete targeting, and floodlights that connote dispersion effects.[82] LFA, in particular, is used for the detection of submarines over long distances of over 300 miles. In a Joint Interim Report published by NOAA after the event, it was found that the whales "experienced some sort of acoustic or impulse trauma that led to their stranding and subsequent death." The report continues, "The most significant findings, which were found in the two freshest specimens, consisted of bilateral intracochlear and unilateral temporal region subarachnoid hemorrhage with blood clots bilaterally in the lateral ventricles."[83] Simply put, the loud Navy mid-range frequency sonar caused the whales to hemorrhage, which led to cascading physical debilitation including overheating, physiological shock, cardiovascular collapse, and severe compromise of hearing and navigational abilities resulting in stranding.[84]

And it is not just whales who are imperiled by anthropogenic sound in the ocean. Even in the early days, the experimental bangs created by oil companies created controversy. For instance, in 1948, offshore seismograph surveys near the Santa Barbara shoreline led to protests and an official complaint from the County, which elaborates, "said blastings have been killing a great quantity of fish and other sea life, along said coastline, and have endangered the lives and property of the residents of said County and said blastings have further interrupted the peaceful enjoyment of the beaches and parks by the people of said County of Santa Barbara."[85] A resolution was subsequently passed, requesting that state

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[82] Andrew Darby, "Navy rejects whale blame," *theage.com.au*, October 27, 2005. http://www.theage.com.au/news/national/navy-rejects-whale-blame/2005/10/26/1130302839888.html;

[83] Evans and England, iii.

[84] Ibid.

[85] Resolution of the Board of Supervisors of the County of Santa Barbara, #8242. Passed July 19, 1948.

agencies including the Fish and Game Commission of the State of California "take appropriate action to protect the County of Santa Barbara and particularly the beaches and parks from off-shore blasting operations."[86]

Figure 6. Dynamite blast during Marine Seismograph Survey by Union Oil Company of California, 1948.

A cross-comparison with 1948 archival documents from Union Oil reveals a more precise picture of how these surveys were deployed (see fig. 6). From March 1948 to October 1948,

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[86] Ibid.

geophones and dynamite charges were suspended from surface floats four to six miles offshore as well as near the middle of the Santa Barbara channel, south of the city. Recording boats followed "shot boats," which dropped floated charges four to five feet below the surface. The crews used jetted charges, or explosives buried 10-15 feet below the seafloor by water jets, in order to minimize fish kill. Yet even with 214 jet shots, the Union Oil report estimated that the weight of fish killed by the surveys during this time was roughly 25 tons.[87]

While billed as "more environmentally friendly than explosives,"[88] modern air gun surveys which release blasts of compressed air, create pressure waves that can penetrate several hundred kilometers into the ocean floor and have a wide range of negative impacts on whales, fish, and invertebrates.[89] In close proximity, the effects are extreme. U.S. Army engineers have detailed the manner in which seismic blasting creates a physical, pre-acoustic shock which can result in everything from animal suffocation to organ damage. This happens because physical shock travels faster than the acoustic velocity of an explosive.[90] Animals near a blast can experience immediate hearing impairment, while fish eggs and larvae can be

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[87] *Marine Seismograph Survey for Union Oil Company of California of 80&81 Prospects*, United Geophysical Co., Inc, 1948, 14.

[88] Fred Aminzadeh and Shivaji N. Dasgupta. *Geophysics for petroleum engineers* 60 (Newnes, 2013): 54.

[89] Lindy Weilgart, "A review of the impacts of seismic airgun surveys on marine life," Submitted to the CBD Expert Workshop on Underwater Noise and its Impacts on Marine and Coastal Biodiversity, February 25-27, 2014, London, UK, 2013. Available at: https://www.cbd.int/doc/?meeting=MCBEM-2014-01. Also see Conservation and Development Problem Solving Team, "Anthropogenic Noise in the Marine Environment," prepared for The National Oceanic and Atmospheric Administration and the Marine Conservation Biology Institute, December 5, 2000, http://sanctuaries.noaa.gov/management/pdfs/anthro_noise.pdf; "Boom, Baby, Boom: The Environmental Impacts of Seismic Surveys," *National Resources Defense Council*, May 2010, https://www.nrdc.org/oceans/files/seismic.pdf.

[90] Thomas Keevin and Gregory Hempen, "Environmental Effects of Underwater Explosions with Methods to Mitigate Impacts," *U.S. Army Corps of Engineers* (St. Louis: August 1997): 23.

killed by the explosive pulses. Tension waves generated from explosions have been shown to be particularly harmful to fish with gas-filled swimbladders. More recently, a 2017 study on air guns showed adverse impacts to zooplankton, causing two-to threefold increases in dead adult and larval zooplankton and catastrophic death to larval krill in the air gun passage.[91] Zooplankton are crucial players in the ocean food chain; disruption to their population creates concerns for fish and marine mammals alike.

Mitigation and regulation of sound in the ocean has often been a matter of creating cartographic maps of the ocean that delineate marine protected areas.[92] For instance, Amy Propen offers a detailed discussion of the role that mapping and the invocation of boundaries between ocean biomes played in resolving the NRDC case. For both sides, the cartographic representations relegate animal takings to specific regions.[93] Propen sees maps and countermaps as *visual-material rhetorics* that freeze fluid regions in both time and space for a particular context. Their durability, reproducibility, and strategic use against each other directly influence policy and corporeal experience in the areas represented.[94] Ignoring the ocean's fluidity, high resolution images and maps of the sea are treated as synonymous with the sea itself, lending the ocean to a form of prehensive violence in which destruction is justified through its containment in abstract spatial and temporal terms.

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[91] Robert McCauley et. al., "Widely used marine seismic survey air gun operations negatively impact zooplankton," *Nature Ecology & Evolution* 1, no. 0195 (2017): 1. https://www.nature.com/articles/s41559-017-0195

[92] As Amy Propen discusses, cartographic representations of the sea are treated as synonymous with the sea itself, lending the ocean to a form of prehensive violence in which destruction is justified through its containment in abstract spatial and temporal terms. Amy Propen, *Locating Visual-Material Rhetorics: The Map, the Mill, and the GPS.* (Anderson: Parlor Press, 2012): 165-167.

[93] Propen, *Locating Visual-Material Rhetorics.*

[94] Ibid., 179.

For instance, current seismic activities are made to stop when whales are spotted up to 56 miles from the blast site, but this means little in an environment where sound can travel as far as 2000 miles. As whale researcher Scott Kraus puts it, “The mitigation strategies employed by—for all of these seismic activities are a little bit of a lipstick on a pig. That is to say they will prevent immediate mortality if a whale gets so close that it's going to get blown up.”[95] Other reactions to the controversy fell short of banning sonic technologies, and instead recommend case by case consideration and mitigation strategies. A 2002 report by the Scientific Committee on Antarctic Research (SCAR) Ad Hoc Group on the “Impact of Marine Acoustic Technology on the Antarctic Environment” recommends uses of minimum source level, careful laying of survey lines, avoidance of repeat surveying of an area in consecutive years, and the use of “‘soft starts’ whereby power is increased gradually over periods of 20 minutes or more.”[96] The idea of soft starts is essentially an animal warning, which resembles older mitigation strategies. In a 1997 report on how to mitigate environmental effects of underwater blasts for instance, engineers Thomas Keevin and Gregory Hempen recommend a combination of helicopter aerial surveys and smaller blasts from shell crackers or “seal bombs,” which would ideally “‘scare’ marine mammals from the blast zone prior to detonating the large explosion.”[97] As noise becomes the solution to noise, the induction of fear through sound becomes a matter for animal survival.

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[95] Scott Kraus, qtd. in Craig Lemoult, “Researchers Worry Right Whales Could be Harmed During Seismic Testing,” April 14, 2019, https://www.npr.org/2019/04/15/713387959/researchers-worry-right-whales-could-be-harmed-during-seismic-testing.

[96] Joanne O’Brien, Simon Berrow and Dave Wall, “The Impact of Multibeam on Cetaceans: A Review of Best Practice,” Irish Whale and Dolphin Group, March 2005, 5. http://www.ecomarbelize.org/uploads/9/6/7/0/9670208/multibeam__1_.pdf

[97] Thomas Keevin and Gregory Hempen, 74.

The portrayal of mild sonic bangs as a form of risk mediation fits neatly into the calculus of extractive mediation, centering the perspective of a knowledge-seeking human researcher as the ideal listener or ideal ear, responsible for discerning noise from signal and minimizing external impact. It largely ignores or deems negligible the production of nonhuman affects like fear, anxiety, and confusion. Evidence of such affective changes abound: whales change their vocal behaviors around seismic surveys, either calling more frequently or ending their singing around operations.[98] Meanwhile, white whales were found with increased norepinephrine, epinephrine, and dopamine levels after seismic air gun exposures, while bottlenose dolphins have shown increases in aldosterone, all indicating stress.[99] From an industry perspective, where life and death is the only binary given consideration, injury or affective violence does not matter at all. Seawater, harmful noise, and ocean currents also cease to matter in a context where their materiality is eliminated in calculations for sound propagation and in the building of sonic pipelines in the deep sea.

Building on the emphasis on vibrational sound by Goodman and Daughtry, we may consider here an expanded sense of the belliphonic beyond human pain, turning instead to its affective and physical action on nonhuman subjects. Shell crackers and seal bombs are not unlike the deployment of long range acoustic devices (LRADs) used to control bodies and crowds in the event of a protest in the human world. Such sounds extend to pre- and parasonic realms, causing temporary debilitation, panic, and confusion within a group. This

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[98] Lucia Di Iorio and Christopher W Clark. “Exposure to seismic survey alters blue whale acoustic communication.” *Biology letters* 6, no. 1 (2010), 51-4. doi:10.1098/rsbl.2009.0651 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2817268/.

[99] Chao Peng, Zhao Xinguo, and Guangxu Liu, “Noise in the Sea and Its Impacts on Marine Organisms,” *International journal of environmental research and public health* 12, no. 10 (2015): 12304–12323. doi:10.3390/ijerph121012304

"unsound" is a becoming tactile of frequencies that are both abrasive and affective. While warning blasts might reduce numbers of seismic casualties, they are predicated on incapacitation through acoustic shock, resulting in either the inducement of flight responses or the obliteration of perception.

Cetacean death, while affectively mobilizing when occasionally photographed on our beaches, remains elusive in its professional and industrial contexts. After the 2002 LFA lawsuit made sonic violence in the ocean a matter for public scrutiny, the Pentagon chose to lobby for numerous exemptions to the Marine Mammal Protection and Endangered Species Act as a means of creating justifications for continuations of harmful sonic activity. A list of active and expired military "Incidental Take Authorizations" for accidental animal killings is available on the NOAA Fisheries website and includes LFA surveillance, mine reconnaissance, and acoustic technology experiments.[100] In 2018, the Trump administration allocated five new Incidental Harassment Authorizations (a type of incidental take) for the National Marine Fisheries Service, allowing seismic air gun testing in the Atlantic by oil and gas companies and posing substantial challenges to previously hard-won campaigns to minimize such sonic violence in these waters. The move has been sharply criticized by scientists, coastal businesses, communities, lawmakers, and fishermen who argue that such blasts could be detrimental to ocean life, particularly to the North Atlantic right whale, which could be driven from endangerment into extinction.[101]

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[100] *NOAA Fisheries,* "Military Readiness: Incidental Take Authorizations," April 16, 2020, http://www.nmfs.noaa.gov/pr/permits/incidental/military.htm.

[101] National Resources Defense Council, "In a Blow to Marine Life, Trump Administration Greenlights Seismic Blasting in Atlantic," *NRDC Expert Blog,* November 30, 2018, https://www.nrdc.org/experts/nrdc/blow-marine-life-trump-administration-greenlights-seismic-blasting-

The oil and gas industry continues to avoid acknowledgment of the harmful effects of seismic surveillance in publicly available press releases, websites, and reports. Despite ample evidence and even Navy acknowledgment of these harmful effects, seismic imaging continues to be narrativized as a harmless form of surveillance by internal oil industry reports and press releases. Groups like the Petroleum Exploration and Production Association of New Zealand (PEPANZ) and the American Petroleum Institute issue blanket denials, insisting that surveying, the "first step" in oil extraction, is below a threshold of harm to the environment. To underscore its innocuous nature, API, for instance, calls these imaging processes "ultrasounds of the earth," infusing them with a maternalistic imaginary.

On a physical level, ultrasounds do operate under the same principle of echoic imaging, but of course the two sonic technologies are on different orders of magnitude and can hardly be compared in regards to actual physical safety. The invocation of a diagnostic medical technology also seems to appeal to a notion of seismic imaging as risk-minimizing technology.[102] Even if the analogy were to hold, feminist work on ultrasound has discussed the complicity of fetal imaging in anti-abortion political messages, making the point that ultrasound is not an innocent window into the fetus, as it helps to produce what it images and to some extent can dictate political and cultural debate. [103] In reflection seismology, what is

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atlantic?fbclid=IwAR2VhjFA1GbXoi5IoGAeqahCoZJ3wXI1U4LgL7pgRJRw8Uou8lo0xadA29c

[102] Logistical media is defined by Ned Rossiter as "technologies, infrastructure, and software" that "coordinate, capture, and control the movement of people, finance, and things." Ned Rossiter, *Software, Infrastructure, Labor: a media theory of logistical nightmares* (Routledge, 2016, Kindle Edition), 4-5.

[103] See Carole Stabile, "Shooting the Mother: Fetal Photography and the Politics of Disappearance," *Camera Obscura* 28, (1992): 180; Rosalind Pollack Petchesky, "Fetal Images: The Power of Visual Culture in the Politics of Reproduction," *Feminist Studies* 13, no. 2 (1987): 265; Valerie Hartouni, *Cultural Conceptions: On Reproductive Technologies + The Remaking of Life* (Minneapolis: University of Minnesota Press, 1997);

coordinated, captured, and controlled is information about oil reserves—the object that, like a fetus, is nurtured and monitored from afar. In this vein, seismic images are social technologies that likewise shape and define what they seek to capture.

The reassuring (yet often misleading) gesture by oil and gas websites towards safety and environmental mitigation is usually followed directly by an insistence that whatever is being done to the ocean by the industry is essential to the well-being of nations. For instance, in its justification for offshore oil, the API states, "in order to ensure our energy security and create economic growth it is vital that we take advantage of all our energy resources, including those safely developed in American waters."[104] Meanwhile, the Petroleum Exploration and Production Association of New Zealand insists that it performs a necessary role of "contributing billions to our national economy and providing energy security for Kiwi households."[105] Discourses of security have always been motivating factors for the production of logistical media. As Ned Rossiter explains, this spans as far back as the Cold War, when there was a symbiosis between the rise of Fordism, security discourse, and the political threat of contingency and destruction.[106] For the oil world, the idea of "energy security" seems to blend both the idea of security and the specter of resource depletion that plagues the Anthropocene.

As Imre Szeman explains it, this is the logic of *strategic realism*: "At the heart of strategic realism stands the blunt need for nations to protect themselves from energy

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[104] American Petroleum Institute, "The Offshore Energy We Need," https://www.api.org/oil-and-natural-gas/energy-primers/offshore/the-offshore-energy-we-need.

[105] Petroleum Exploration and Production Association New Zealand, "Seismic Surveys, Exploring what Lies Beneath," accessed February 1, 2017, http://www.seismicsurvey.co.nz/;

[106] Rossiter, *Software, Infrastructure, Labor,* 10.

disruptions by securing and maintaining steady and predictable access to oil." He continues, "Strategic realism sees the disaster of oil as a problem primarily for the way in which nations preserve or enhance their political status."[107] However, there is an inherent necropolitical implication to this rhetoric of exemption and political authorization, wherein large regions of animal habitation are suspended as zones of exception, deemed to operate in the service of civilization or national vitality. Takes become sacrificial acts—necessary evils that are justified through the simultaneous validation of oil as a lifegiving, nation-sustaining substance. Achille Mbembe explains, "Sovereignty means the capacity to define who matters and who does not, who is *disposable* and who is not."[108] Necropolitics, as a question of deciding what matters, can take mattering in both its literal and figurative forms. Survey work determines which objects are allowed a material body, which objects are disposable, and what can or cannot be taken. The imaging process becomes an occupation of a geographical area both physically and visually—territorializing the deep sea by allowing sovereign control over a region from a distance.

The Final Take

As land-based resources shrink, oceanic surveys and resource prospecting are becoming central to the maintenance of an industrialized, and now digitalized society. It would be dangerously naïve to dismiss this industrial exploration itself as harmless. As scientists already implicitly acknowledge, the incentive among contractors and global superpowers to hoard data about environmental impacts and minimize them is high. The little information

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[107] Szeman, "System Failure," 6, 811-812.

[108] Achille Mbembe, "Necropolitics," trans. Libby Meintjes, *Public Culture* 15, no. 1 (2003): 11-40.

that is produced about the seafloor tends to get refitted for the purposes of attracting investors. It becomes imperative to question not only the authority of these data images themselves, but the imaging process, and its potential to cause disturbances in secluded areas of the ocean before extraction even begins.[109]

Standing on the shore, stepping between the bits of tar speckling the beaches by UC Santa Barbara, there is an intuitive, affective connection to oil here—a kind of casual, emplaced petro-culture. From the shallows, our ways of seeing oil, feeling oil, and smelling oil connect us to extractive industries on a bodily level. Yet, on the level of hearing and sounding, that same kind of embodied intimacy with oil industries remains conspicuously absent. Seismic blasting is not the sort of thing people complain about on a regular basis—stories of seismic blasting disturbing the peace for human beachgoers are few. But they are becoming an increasingly common experience for cetacean communities. Sterne talks about a tendency to associate sound with interiority, subjectivity, and proximity, but, as I hope to have shown, the sounding of oil in marine contexts presumes notions of objectivity, exteriority, distance, and extraction, connecting us to this oily, watery world in caustic ways.[110] As anthropogenic noise in the ocean worsens and offshore oil extraction moves to ever deeper and more remote waters, focusing on the easy, accessible kind of environmental awareness located in sporadic and spectacular events like oil spills is not enough.

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[109] See Kathryn A. Miller, Kirsten F. Thompson, Paul Johnston, and David Santillo. "An Overview of Seabed Mining Including the Current State of Development, Environmental Impacts, and Knowledge Gaps." *Frontiers in Marine Science* 4 (2018): 418. https://doi.org/10.3389/fmars.2017.00418; Deep Ocean Stewardship Initiative, "Deep Ocean Stewardship Initiative: Advancing Science-Based Policy," http://dosi-project.org/.

[110] Jonathan Sterne, "Sonic Imaginations" in *The Sound Studies Reader*, (New York: Routledge, 2012): 9.

Although we may be situated at a distance, the stakes of acknowledging the fundamentally necropolitical and material operations of offshore seismic imaging are high. In this chapter, I have characterized the bangs of petroleum surveys as a haptic force, offering a perspective on the relationship between hearing and feeling. As Tim Ingold has stated, "the ways of acting in the environment are also ways of perceiving it."[111] This fundamentally troubles the epistemological premise of survey, which emphasizes objective, continuous perception. Yet here, the uncertainty principle is also itself a certainty—the very act of observation impacts that which is being observed.

While our dispositions towards sonic images is typically trained on the end point of informational filtering of signal from noise, thinking about the excesses of sound in an underwater environment forces us to anneal resources to their oceanic substrates, to their animal inhabitants, and to our technologies.[112] Recognizing mediation itself as extractive thus grounds human responsibility in a world that exceeds our own values and perceptual limits. In the space between noise and signal, we may encounter a world of interspecies frictions.

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[111] Tim Ingold, *The perception of the environment: essays on livelihood, dwelling and skill*, (New York: Routledge, 2002), 7.

[112] The word "anneal" is typically used to describe a process of combining substances—typically glass, steel, or DNA—through a heating and cooling process, that permanently changes the original substances in their mixing, resulting in a tougher and stronger product. My choice in using this term is meant to evoke this sense of a strengthening, essential change, constituted by the annealing of our oceanic images to the saturated bodies and materials that produce it.

Chapter 3. Feeding Sediment: Turbulent Mediations at Hydrothermal Vents

> "I share with the mountaineers a certain desire (or mania) to know high or deep places. Once asked about what I would see besides mud at the bottom of the sea, I replied, 'What does one see on a mountain top except snow.' Joking aside, one must actually go to see or send a recording system such as a camera or television pickup. And when we do send cameras down we do find many other things than mud."
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> —Harold Edgerton, "The Trench of Puerto Rico," March 15, 1960[1]

At the beginning of the oceanographic documentary, *New Explorers: The Underwater Volcanoes* (1993), narrator Bill Kurtis explains, "There is a place on earth more foreign than the surface of the moon. No sunlight has ever reached this place. The temperature of hydrothermal vents can reach 700 degrees without boiling. And yet, there is life here. Strange and bizarre creatures, unlike anything we've seen on land. They live on chemicals from hydrothermal fluids. And now, there is another creature…" A rotund, fish-like vehicle emerges from the depths and in a searing flash, bleaches the pitch black ocean with its LED lights. It is the *DSV Alvin*, a 15-ton, titanium-encapsulated deep submergence vehicle, also known as a Human Occupied Vehicle (HOV). Commissioned in 1972 through Woods Hole Oceanographic Institution, *Alvin* was one of the very first marine vehicles of its kind capable of exploring the deepest reaches of the ocean. Five years later, the *Alvin* and the crew of the Galápagos Hydrothermal Expedition discovered an entire world shimmering in cloudy blue

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[1] March 15, 1960. "The Trench of Puerto Rico." Harold Edgerton, inventor of the strobe light, professor of electrical engineering at MIT, nautical archaeologist, deep sea enthusiast. While at the M.I.T. Strobe Lab, Edgerton helped develop what he called "The Bottom Penetrator," a sonar system that gave information about sub-bottom layers. Harold Edgerton Box 1, Folder 9, Autobiographical Fragments compiled January 1988, MIT special collections.

manganese and lava. Dubbed Clambake 1 for its dense community of clams, researchers hailed this hydrothermal vent as an oasis of life in a desert.[2]

Hydrothermal vents are typically located at mid-ocean ridges where seafloor spreading occurs. Not only did their discovery provide further evidence for the plate tectonics revolution, but it also changed public imaginaries of the deep sea.[3] As discussed in my first chapter, early representations of seafloor space painted it as a quiet, static, and ancient biological and geological archive. Prior to early twentieth century innovations in underwater imaging, this area was considered a kind of tabula rasa, "a blank space, an uninhabited space, an unlived space belonging to no one and nothing."[4] As late as the 1850s, scientists continued to believe that abyssal waters were stagnant and thus lifeless—an "azoic zone" that began at roughly three hundred fathoms.[5] Later, contradicting evidence of life at depth helped to push this static view towards an association of deep space with primordial, ancient beginnings.[6] The idea of "living fossils," for instance, was popularized among naturalists in the aftermath of Charles Darwin's *On the Origin of Species,* as researchers such as Michael Sars began finding "primitive" species at the bottom of the sea that could serve as missing links in an evolutionary chain.[7]

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[2] "The Discovery of Hydrothermal Vents," printed from 25th anniversary CD-ROM, Woods Hole Oceanographic Institution, 2002, http://www.divediscover.whoi.edu/ventcd/vent_discovery/thediscovery/timeline_p.html.

[3] For a helpful historical introduction to deep sea mining, see Inhabitants, "What is Deep Sea Mining? Episode 2: Deep Frontiers," Season 1, Episode 2, written by Stefan Helmreich with Margarida Mendes, July 2018, http://inhabitants-tv.org/july2018_whatisdeepseamining_ep2.html.

[4] Ann Elias, *Coral Empire: Underwater Oceans, Colonial Tropics, Visual Modernity* (Durham: Duke University Press, 2019), 3.

[5] David Lawrence, *Upheaval from the Abyss: Ocean Floor Mapping and the Earth Science Revolution.* (Rutgers University Press, 2002, Kindle edition): loc 962 of 3147

[6] Inhabitants, "What is Deep Sea Mining?

[7] Qtd. in Lawrence, p. 83.

However, the discovery of vent and seep sites precipitated a more chaotic imaginary of the seafloor still—one in which the seabed is a space that is young, changing, and fecund; where vents, seeps, and volcanoes expel minerals and geothermal fluids upwards into the blue, to be carried and settled onto distant terrains. What's more, vent and seep formations are now understood to be more than just isolated sanctuaries of growth, but are rather critical to the well-being of all planetary life, affecting surrounding ecosystems at the seafloor, water column, and through global geochemical cycles.[8] Once perceived as silent, deserted, and recalcitrant, the muddy ocean abyss now welters with possibility, sending its signals through the human world. This turbulent landscape of vents and seeps, alien in its very liveliness, is the locus of my investigation in this chapter.

Flows of sediment, rock, seawater, and detritus found in the deep reaches of the ocean are, for many, the key to the future of human civilization. High heats dissolve basaltic rock, while the buoyance of these heated liquids causes them to rise through vents, producing the expulsion of mineral-rich fluids at geothermal hotspots.[9] The metals then precipitate out from the ocean environment and sediment onto the seafloor. And so, the discovery of hydrothermal vents was accompanied by the discovery of nodules studded with manganese, cobalt, copper, lead, zinc, silver, and gold deposits, nestled on the ocean bottom at depths of between 4500-12,000 ft.[10] With so many rare earth minerals embedded in the rock, it was not

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[8] Lisa A. Levin, Amy R. Baco, David A. Bowden, et. al. "Hydrothermal Vents and Methane Seeps: Rethinking the Sphere of Influence." *Frontiers in Marine Science* 3, no. 72*,* (May 19 2016): 1, doi:10.3389/fmars.2016.00072.

[9] "Hydrothermal Vents," New Millenium Observatory Explorer, accessed August 24, 2018, https://www.pmel.noaa.gov/eoi/nemo/explorer/concepts/hydrothermal.html.

[10] "Subsea Mining – Deep Sea Ocean Mining & Seafloor Dredging Operations," EddyPump Corporation, accessed September 26, 2018, https://eddypump.com/education/subsea-mining-deep-sea-dredging/.

long until the world began preparing for mineral extraction. The 1982 United Nations Convention on the Law of the Sea, for instance, was convened in large part to determine regulation for this prospective industry. But while the deep sea mining industry has been in the works for decades, global proposals for deep sea mining have skyrocketed in recent years, as metal demand surges in the Asia Pacific, while automobile manufacturing in the US, Germany, and Japan drives demand for rare earth minerals and metals like copper, gold, platinum, and nickel. There have, in turn, been more serious acknowledgments in popular press of deep sea mining's potentially enormous social environmental consequences.[11]

One might wonder why this chapter is entitled, "Feeding Sediment" and not "Feeding Mineral Resources." Perhaps, the most immediate reason is that sediment encompasses but is not limited to minerals. Seafloor sediments are comprised of many things: volcanic dust, sands from the coast, shells, mineral fragments, and biological debris all float downwards together to comprise the sediments of the deep. As Rachel Carson once put it, "The sediments are a sort of epic poem of the earth. When we are wise enough, perhaps we can read in them all of past history."[12] Indeed, as my first chapter has already explored, sediments are texts with many readers, and many stories to tell.

Shannon Mattern analyzes the importance of mud and clay as textual and architectural mediums in urban spaces. She explains, "For millenia, mud and its geologic analogues have bound together our media, urban, architectural, and environmental histories. Some of the first writing surfaces, clay and stone, were the same materials used to construct ancient city walls

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[11] Wil Hyton, "History's Largest Mining Operation is About to Begin," *The Atlantic* January/February 2020, https://www.theatlantic.com/magazine/archive/2020/01/20000-feet-under-the-sea/603040/.

[12] Rachel Carson, *The Sea Around Us* (New York: Open Road, 1961), 110.

and buildings, whose facades also frequently served as substrates for written texts."[13] Following Mattern's acknowledgment of mud as both textual medium and dwelling, it struck me that there is an opportunity to consider the mediation of sediment from the perspective of the natural world, where sediments do not necessarily manifest as the hard surfaces that Mattern explores. If the first chapter focused on sedimentation and efforts to stabilize the floor of the seafloor, this chapter examines the many ways in which the seafloor itself is unstable. A mudflow, to a shrimp, is thus as much a resource and a home as it is to a human being. In their movements, ocean sediments are a site of crises, of futures, and of pasts. Both amniotic and abject, cleansing and dirtying, marine sediment is activated in the paratextual realms of its circulations, encoded with meaning as it is systematically marked and unmarked by a variety of actors and actants. As they are extracted, molded, and transported, sedimentary flows have become mankind's latest medium of transfiguration.

In this chapter, I will trace mediations of seafloor sediment from vents to mining vessels. My aim is to achieve a multifaceted view on how flows and feeds of mud and mineral connect human existence to the seafloor. My research questions ask, how do actors involved in deep sea mining contend with questions of turbulence in their negotiations and social arrangements? How do notions of turbulence and resilience travel from a microbe scale, to a human scale, and finally to a planetary scale? And, to put it differently, how might thinking from the perspective of deep sea organisms help us understand how the deep sea mediates modern human life?

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[13] Shannon Mattern, "Of Mud, Media, and the Metropolis: Aggregating Histories of Writing and Urbanization," *Cultural Politics* 12, no. 3 (November 2016): 312.

This work is beholden to the scholarship of Jussi Parikka, whose text, *A Geology of Media*, importantly extends the notion of media beyond machines to their geological stories, while mobilizing a media materialism that lends ontological and epistemological agency to technologies outside of their human contexts.[14] Parikka's scholarship fixates on mobilizations and transmutations of geological matter from inert to vital contexts, as dead matter is enlivened and repurposed in mining. In this framework, media devices are zombies—undead as they emerge from raw materials, and stubbornly alive even in their obsolescence. This expanded media ecology and "paleotechnics"[15] is particularly important in the deep sea context, where gold, copper, zinc, and rare earth minerals are later used as raw materials for cell phones, electric vehicles and other devices that rely on lithium-ion batteries.[16] Roopali Phadke calls this trade off between environmentally destructive mining and environmentally destructive carbon emissions the "green energy bargain."[17] That is to say, the so-called greener future is really a browner, muddier one: the minerals within these deep sea sedimentary deposits signal to us the next way that civilization will build itself up. Not brick by brick as before, but windmill by windmill, battery by battery, Prius by Prius.

Parikka considers extraction from a terrestrial point of view. And perhaps, there is an odd sisterhood between water and rock, between deep sea mining and terrestrial mining, that precipitates from narratives around the seafloor. The Earth's crust is, after all, contiguous

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[14] Jussi Parikka, *A Geology of Media*, (Minneapolis: University of Minnesota Press, 2015): 1.

[15] Ibid., 14.

[16] Mary Beth Gallagher, "Understanding the impact of deep-sea mining," *MIT News*, December 5, 2019, accessed December 9, 2019, http://news.mit.edu/2019/understanding-impact-deep-sea-mining-1206.

[17] Roopali Phadke, "Green energy futures: responsible mining on Minnesota's iron range," *Energy research & social science* 35 (2018): 163-173.

between the land and sea. But in the deep sea context,[18] boundaries between settlement and sediment, endurance and erasure are also thrown in turbulent disarray. A simple comparison, or worse, the use of terrestrial metaphors to describe the aquatic becomes inadequate, erasing the labor of translation between the two spheres. My challenge, then, is to articulate a relationship between terrestrial humans and our aquatic brethren without losing sight of the ocean's materiality.[19]

Rather than try to produce a stationary ocean floor as we do on land, marine circulations of matter point us towards a dynamism—an active making and remaking of the seabed. Katherine Sammler makes a similar argument in her own assessment of seabed regulation and mining, pointing out the ways in which legal boundaries such as Exclusive Economic Zones (EEZs) are "created in tension" with the ocean's materiality: "The wayward physical properties of the ocean restrict neither ecosystems nor pollutants from spilling over politically and legally constructed boundaries… it generates waves, exerts buoyancy, absorbs light, transports heat, and dissolves materials which respectively limit infrastructures, afford navigation, conceal objects, propagate energy and corrode solids."[20] One could also extend this argument to animal movement, air above the surface of the ocean, and other unruly elements. Turning towards the ocean's material unruliness can also offer new historiographic analogies. In his *Shipwreck Modernity*, Steve Mentz proposes an ecologically-oriented historical model, seeking to recuperate turbulence as a historical framework: "The theoretical

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[18] The exact definition of "deep sea" varies depending on who you ask. Researchers have mentioned everything from 1000 meters to 5000 meters to me. The number is largely dependent on the type of research question being asked.

[19] Melody Jue, "Proteus and the Digital: Scalar Transformations of Seawater's Materiality in Ocean Animations," *Animation* 9, no. 2 (2014): 246.

[20] Katherine Sammler, "The Deep Pacific: Island governance and seabed mineral development" in *Island Geographies,* ed. Elaine Stratford (New York: Routledge, 2017), 19

structures I advance eschew clean transitions for messy turbulence; these historical epochs encompass a plurality that disorients, sometimes drastically."[21] Thinking about oceanic turbulence, as Mentz does, helps us to see relations of upheaval in the continuous processes of sedimentation. Turbulence and sediment together offer a theory of change that attends to catastrophe without precluding the possibilities for settlement and deep temporalities.

In what follows, I follow the turbulent flows of marine sediment between four actors, all key constituents in a multispecies community based around the seafloor: vent shrimp, who dwell in the mud; scientists who collect and read seafloor mud cores; mining contractors seeking to exploit and profit from the production of seafloor slurries; and the rest of us, who rely on the riches of the ocean floor every day without necessarily realizing it. Each of these four actors mediate the ocean floor and its resources in different ways, although they often share a language for decoding the messages in the sediment. Sedimentary cores extracted from hydrothermal sites become at once alien oases bubbling with life, and evidence of treasure troves with mineral riches yet to be activated.

To understand the plural experiences of deep sea mining, I conducted several interviews with scientists and data curators, visited sediment laboratories, attended workshops and meetings, studied archival correspondence documents, and read legal documentation. I found Susan Leigh Star's ethnography of infrastructure particularly helpful in informing my methodological approach, because she insists that we consider the imbrication of infrastructure and human organization. Star writes that the ethnographic sensibility is "an idea that people make meanings based on their circumstances, and that these meanings would

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[21] Steve Mentz, *Shipwreck Modernity: Ecologies of Globalization, 1550–1719*, (University of Minnesota Press. Kindle Edition): Kindle Locations 98-106.

be inscribed into their judgments about the built information environment."[22] Indeed, the infrastructures we produce around marine sediment contain multiplicities, playing different roles in the lives of animals, plants, and human beings.

Similarly, in his ethnographic work on marine microbiologists, Helmreich's personal perspective as an outsider experiencing the physical contortions and intake of images in the deep sea leads him to the assertion that in field work, contextual and material experiences matter in the way that they frame meanings and reflect culture. As he puts it, "the message from the mud depends not only on the media through which it is transmitted and translated but on who is reading and what sorts of interpretative habits."[23] This point was not lost on me as I engaged in my own conversations with seafloor researchers. Far from cold, objective computing agents, marine scientists draw from personal imaginaries and literary notions of frontier, from the Lovecrafts of the world to the Lovelocks, as evidenced in the evocative names of vent formations (Clambake, Garden of Eden, Hell, and Lost City, to name a few). Sediments are remediated in speculative terms—economically, biologically, geologically—as they are subjected to management operations. However, while Helmreich's messages in the mud are static, the mudflows I am interested in are in motion, engaging with agents that are human, geological, and animal. Bringing the worlds of science, industry, and ocean life together thus reveals peculiar translations between the material and economic world, manifesting the ontological entanglements between human culture and the microbial cultures in marine sediment.

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[22] Susan Leigh Star, "The Ethnography of Infrastructure," *American Behavioral Scientist* 42 (1999): 383. DOI: 10.1177/00027649921955326

[23] Helmreich, 32.

Dwellers of the Deep

As debates begin taking place around the environmental impact of deep sea mining, hydrothermal vent shrimp are just one of the many organisms put at risk by prospective mining operations, which create sedimentary upheavals and leave toxic waste water behind. These extremophiles are often recruited into discourses that either promote or object to deep sea mining.

Vent shrimp and humans first collided in 1982, when the *DSV Alvin* went down to the Galapagos Rift. Biologists Austin Williams and Fenner Chace dubbed these deep-dwelling creatures *Alvinocarididae*, for the submersible that discovered them and the Greek "karis," for shrimp.[24] Spiny, blind, pinkish in color, vent shrimp swarm together as they roam over homes dappled with tubeworms, mussels, and rugged rock. Over 30 species of *Alvinocarididae* have been found in deep-sea cold seeps and hydrothermal vents around the Atlantic, Pacific, and Indian oceans as deep as 4960 meters.[25][26] Small worms, mollusks, and crustaceans like these are common to deep reaches of the ocean, and mud dunes are good places to find clams.[27] But also curious are the sediments found at hydrothermal vents like those at Pescadero Basin, 100 miles east of La Paz, Mexico, or the Lost City field along the mid-Atlantic ridge. There, muddy sediment acts as a filter, catching the dissolved iron, zinc,

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[24] Austin Williams, and Fenner Chace, "A New Caridean Shrimp of the Family Bresiliidae from Thermal Vents of the Galapagos Rift," *Journal of Crustacean Biology,* 2, no. 1 (1982): 137.

[25] Alexander Vereshchaka, Dmitry Kulagin, and Anastasia Lunina, "Phylogeny and New Classification of Hydrothermal Vent and Seep Shrimps of the family Alvinocarididae (Decapoda) *PLOS One* 10 no. 7 (2015): e0129975.

[26] Cold seeps are also found at fissures created by the earth's tectonic plates. Like hydrothermal vents, they emit chemical and hydrocarbon-rich fluids at the seafloor, but are cooler in temperature.

[27] Cindy Dover, *The Octopus's Garden: Hydrothermal Vents and Other Mysteries of the Deep Sea*, (New York: Perseus Books Group: 1995), 3.

and copper sulfide flowing outward, and allowing clear water to emerge from the chimneys that distinguish them from their black smoker cousins. The mud here is thick with pools of methane and hydrocarbons. It acts like an oven, cooking organic material to produce carbonate chimney structures. Yet even in such temperatures life thrives in the form of tubeworms and crabs. These are regions of high biodiversity but low biomass relative to their black smoker cousins.[28]

Like all inhabitants of seafloor vents who live in such geographically restricted and dark dwellings, the heated hydrogen, sulfur, and methane-rich vent fluids are the primary source of energy for vent shrimp. Clams and other filter feeders collect nutrients that pass by through currents and fluid flow. But vent shrimp have a different tactic for receiving their nutrition. Researcher Jillian Peterson and a group of microbiologists discovered that many species of shrimp live a symbiotic existence with chemoautotrophic vent bacteria, collecting them from the sides of active smokers with their gill chambers and appendages and then ingesting them or taking up organic compounds through epidermal transfer. Meanwhile, the chemosynthetic bacteria get a prime location between vent fluids which are rich electron donors, and the nearby seawater.[29] Nearby, colonies of giant tubeworms also rely on vent bacteria to perform chemosynthesis. Unlike photosynthesis, chemosynthesis occurs in the

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[28] Nautilus Live, “Exploring Hydrothermal Vents of Pescadero Basin,” Ocean Exploration Trust, October 29, 2017, https://nautiluslive.org/blog/2017/10/29/exploring-hydrothermal-vents-pescadero-basin.

[29] Jillian Peterson et al, “Dual symbiosis of the vent shrimp Rimicaris exoculatat with filamentous gamma- and epsilonproteobacteria at four Mid-Atlantic Ridge hydrothermal vent fields,” *Environmental Microbiology* 12, no. 8 (2010): 2205. https://onlinelibrary.wiley.com/doi/pdf/10.1111/j.1462-2920.2009.02129.x; Joel W. Martin and Timothy M. Shank, “A new species of the shrimp genus Chorocaris (Decapoda: Caridea: Alvinocarididae) from hydrothermal vents in the eastern Pacific Ocean,” *Proceedings of the Biological Society of Washington* 118, no. 1 (April 2005): 196.

absence of sunlight. Instead, energy is produced through oxidation reactions with inorganic compounds like hydrogen sulfide.

Such chemosynthetic organisms, meanwhile, are linked to other, non-vent ecosystems in the deep sea, what scientists call "benthic background." That means that the chemosynthetic production performed by vent bacteria provides nutrition not only to shrimps, but also to zooplankton grazing above the plume, commercial crab species that feed on vent mussels, scavengers venturing amongst decaying shells, and bamboo corals in non-vent areas relying on the horizontal transfer of organic matter produced by vents.[30] Ecosystems are connected to one another by transition zones or "ecotones," where energy, nutrients, and other biological matter is transferred through a number of pathways that include fluid flow, gamete release, the movement of organisms, and succession.[31] And of course, predators—crabs, fish, seastars, and octopus move in and out of chemoautotrophic environments to graze, aiding in the transfer of carbon. Deep sea vents and seeps may even impact our fisheries.[32] Finally, underwater hot springs, heated up by magma and hot seawater, have important temperature impacts on the surrounding area. The ocean at large acts as a global heat sink, absorbing energy from the atmosphere. From small shrimps to planetary flows of magma, sediment, and seawater, everything has a role to play in the cycles of mass and energy between the earth and our oceans.

The remediation of vent elements through sensing, sampling, sounding, and imaging technologies is hugely important to how humans understand our own role in carbon and

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[30] Levin et. al. "Hydrothermal Vents and Methane Seeps," 5.

[31] Ibid., 1.

[32] E. M. Levy and K. Lee, "Potential contribution of natural hydrocarbon seepage to benthic productivity and the fisheries of Atlantic Canada." *Canadian Journal of Fish and Aquatic Science* 35, (1988): 349-352, doi: 10.1139/f88-041.

energy cycling. By starting with shrimp and vents, I seek to acknowledge the deep ocean's material agencies as well as a politics of relation. But speaking to a politics necessitates that we avoid reducing or equalizing nonhuman and human agents to a homogenous playing field. Sediment flows may roam and multiply as they gather material and get whipped up by currents, but they are also molded, manufactured, purchased, distributed, and disposed of by humans. I do not seek to remove the human, but I hope to maintain a perspective that has bearing on how human beings imagine their environments.[33] Thus, in the next few sections, I highlight the key ways in which scientists, industrial, and state actors are connected to the seafloor and to each other, by funding structures, technology, and sedimentary mediations. The power dynamics and contingent relationships between these actors complicate efforts to appraise turbulent deep sea ecologies from nonhuman perspectives, as necessary convergences begin to form between parties. Yet it is ultimately these conversations between human actors that will likely determine the fate of organisms like *Alvinocarididae*.

Reading Messages in the Mud

The sampling of sediments and fluid flows is an intrinsic part of both seafloor research and deep sea mining operations. Scientists and oceanographers have been reading the mud from the deep sea for about as long we have known how deep the sea is. This scientific collection of marine mud cores and ice cores has led to the production of several archives that preserve the earth's geological record and produce continuous shifts in our understanding of the planet and its fluid flows. For instance, the original green and blue

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[33] Here, I am influenced greatly by Karen Barad's *Meeting the universe halfway: Quantum physics and the entanglement of matter and meaning*. (Durham, NC: Duke university Press, 2007).

muds, amorphous clays, volcanic particles, and sands collected by the HMS Challenger have been closely catalogued in terms of the many minerals and organisms they contain. Then, in 1968, the Deep Sea Drilling Project (now the Integrated Ocean Drilling Program or IODP), became one of the most scientifically important drilling and coring projects of the era, when it provided evidence that a turbulent, youthful ocean floor had to be the result of plate tectonic movements. The discovery of seafloor spreading and plate tectonics, along with rocks sampled during this era, helped scientists to predict and confirm the existence of hydrothermal vents in 1977.[34] Today, reading the mud of the deep sea, whether the carbonate slabs from a mud volcano, or the soft muddy cores of abyssal plains, or the gentle contours of a mud dune, continues to reveal new insights on the breadth and diversity of the living world and its anthropological, biological, ecological, and geologic pasts.

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[34] Woods Hole Oceanographic Institution, "Discovering Hydrothermal Vents," accessed September 30, 2018, https://www.whoi.edu/feature/history-hydrothermal-vents/discovery/1977.html.

Figure 7. Marine sediment cores from WHOI samples laboratory. Photo by author.

During my research, I had the opportunity to examine a number of scientific sampling devices, cores, and rocky, speckled pieces of black smoker vent chimneys in the Scripps geological collections, Oregon State University's marine geological archives, and the WHOI Seafloor Sediment Laboratory. Once the cores are retrieved from the seafloor, they are taken to these labs for processing and digitization into a core repository. Cracked open, the tubes reveal long, mottled sections of soft mud. Some contain shells, seeds, ash, or even human trash. The type of metadata that gets recorded varies depending on the researcher, and often includes information such as color, grain size, chemical composition, and structure in addition to location and dating (this includes Carbon-14 dating, biomarking shells, and cosmogenic isotope dating among other techniques).

The geological archive must be rendered as part of a mechanical information system through the work of transforming marine mud through modular units, conventions, and media standards. Many of the core labs I visited, from WHOI's 14,000 sample inventory to the Pacific cores at Oregon State University actively worked to link up the natural earth archive to the logics of a digital database. Speaking to this labor, Mattern has also highlighted the "big data" work of repositories, which must struggle to maintain institutional stability and find ways of thinking across collections.[35] In each of these collections, samples and cores are inputted in a searchable (and in the best cases, app-enabled) database for reuse by other researchers and interested parties—a system that previously was built on punch cards.[36] Val Stanley adds that the process of constructing a working database requires a fair amount of translation and simplification: "geoscience can be a very descriptive science. The bread and butter of it is once you bring these cores up, you want to describe everything so that you tell a story from top to bottom. Normalizing and capturing that digitally is very tricky."[37] Alexandra Hangsterfer, the Geological Collections Manager at Scripps, adds that with the exception of the IODP, the reporting of data still lacks a true standard or true support for developing metadata standards.[38] Inevitably, some information is thus lost in translation between different collections (such as information about waste or other anomalous features).

Nevertheless, collections are important in order to maintain and preserve information for the benefit of future scientists, often without fully understanding what kinds of questions may

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[35] Shannon Mattern, "The Big Data of Ice, Rocks, Soils, and Sediments," *Places Journal* (November 2017). Accessed 17 Sept 2018. https://doi.org/10.22269/171107.

[36] Jim Broda, interview with author, Woods Hole Oceanographic Institution, June 25, 2018.

[37] Val Stanley, interview with author, Oregon State University, August 24, 2018.

[38] Alexandra Hangsterfer, interview with author, Scripps Institution of Oceanography, August 9, 2018.

arise in the future. Mediation of mud cores, rocks, and sediment samples safeguards them from external turbulence, removing them from the flows of nature and into the flows of scientific discourse. However, these core samples are finite and can be exhausted. As a result, core managers avoid sampling away whole archives from one area so as to maintain a record of the earth's history from a particular region. Core records tell geologists how the Earth has responded to a variety of perturbations, allowing them to predict how ice melts or how ecosystems respond to future perturbations, like climate change. For the underwater sediment researcher, mediation and preservation is thus about making underwater turbulence visible across deep timescales.

The irony is that the most easily funded research is not necessarily driven by deep timescale questions like climate change, but by much more immediate, human concerns around the extraction of resources. For many scientists, discovery and analysis from within an existing collection is a much cheaper option than continuously going out to sea and collecting new and fresh samples. Funding for purely exploratory research projects has progressively become more slim, demonstrating a privileging of deliverable and practical science. Joe Stoner calls it the "art of the doable." He elaborates, "Even though we have much better mapping and we can see things, and better targets for coring should be much more obvious than they were, it is hard to do anything explorative. . . the cores that already have the most information become the most valuable."[39] Hangsterfer reiterates this sentiment: "Discovery-based science isn't really something that's funded anymore…funding agencies feel more comfortable funding projects that have a higher likely success rate."[40]

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[39] Stoner.

[40] Hangsterfer.

Today, researchers turn to geological archives primarily to better understand what has already been collected, as opposed to what is still out there in the vast, unknown reaches of the seafloor. And that means that what propels novel seafloor research is the availability of funds and the likelihood of acquiring data that will be meaningful within existing knowledge infrastructures.

The Science of Deep Sea Mining

The general privileging of less risky, pragmatic oceanographic research over new discoveries and long-term scientific drivers is exacerbated by the growing influence of extractive industries. A Federal Ten Year Plan for Ocean Exploration (TYPOE) written in 1968 indicates the close relationship between scientific surveys and economic motives:

> Because of the high cost of operations at sea it is of the utmost importance that any plan be carefully coordinated to insure that areas with the highest potential interest to the most users be incorporated in a plan for an international Decade. . . It is likely that economic and political pressures will establish the type of survey and the areas of priority. These will probably focus on the mineral and living resources of the sea which in turn direct attention to the continental shelf and in areas of the deep sea where the probability of major fish resources is high.[41]

Over fifty years later, this remains an accurate portrait of the state of deep sea research. For instance, the close relationship between ocean scientists and industrial imperatives is reflected in the job funnel as those trained in the geosciences and in techniques like seafloor profiling end up becoming oil and gas prospectors. One of my interviewees working for OSU's Marine Sediment Sampling Group (MARSSAM), Mo Walczak, describes her own trajectory as a choice between a lucrative industry job and an idealistic one that serves the

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[41] ICOEES Typo Task Group Preliminary Position Paper: "An International Decade of Ocean Exploration and Assessment of the Seas," (Jan 29, 1968): 4-5. UCSB special collections, William Whitehill Rand Papers, Box 1.

planet: “It takes a special one-two combo to stay in the field now. You have to be really idealistic. It’s not about the bottom line anymore, it’s about what you want to do with your life and whether you want to help people.”[42]

However, researchers who make the choice that Walczak did find that they are not necessarily exempt from working with industry. Chandra Mukerji’s volume, *A Fragile Power*, importantly explores pure and applied research in the deep sea and concludes that scientists in both camps relate to the state as a reserve labor force.[43] This lack of scientific autonomy was supported by my own interviews and field observations. Scientists rely heavily on funding from the state to operate the expensive research vessels and tools required to explore and sample the deep sea. With the emergence of deep sea mining, research on seafloor ecologies and hot springs have become more of an applied science, springing an intellectual reserve into action and introducing more corporate money on top of traditional defense funding to scientific research.

Today, contractor studies of seafloor minerals are what have driven much of the scientific research on the seabed, particularly near places where sulfide deposits are found such as the Okinawa Trough near Southwest Japan, the Clarion-Clipperton Fracture Zone (CCFZ or CCZ), and the Woodlark Basin east of Papua New Guinea.[44] Researcher Thomas Peacock

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[42] Mo Walczak, interview with author, Oregon State University, August 17, 2018.

[43] Chandra Mukerji, *A Fragile Power: Scientists and the State*, (Princeton, NJ: Princeton University Press, 1989).

[44] As researcher Thomas Peacock noted in a recent 2018 paper, “a great deal of what is known about ecosystems and resources in the CCFZ has come from contractor-related studies.” Peacock adds that “Our expedition from San Diego, for example, was a joint program funded by the Massachusetts Institute of Technology and the Scripps Institution of Oceanography, in collaboration with the ISA, the U.S. Geological Survey and the GSR [Global Sea Mineral Resources]. In 2019 Europe’s JPI Oceans program will conduct a study with the ISA and GSR in the CCFZ.” Thomas Peacock and Matthew H. Alford. “Is Deep Sea Mining Worth It?” *Scientific American* (May 2018): 77; See also International Seabed

notes in a recent 2018 paper, "a great deal of what is known about ecosystems and resources in the CCFZ has come from contractor-related studies."[45] These contractors will conduct survey and cutting operations over the first experimental mining sites, chosen out of over 100 known sites of hydrothermal mineralization.

As mentioned in the first chapter, the International Seabed Authority (ISA), based in Kingston, Jamaica, regulates the Area (most of the ocean floor), a responsibility shared with 14 U.N. member states, excluding the United States. It allocates mineral resource contracts according to the Common Heritage of Mankind, a precept that seeks to advance equity by privileging developing nations.[46] The ISA has thus far issued 28 exploration permits from 20 countries, and requires environmental baseline studies by contractors. Notable contractors include Global Sea Mineral Resources, Japan Oil, Gas, and Metals National Corporation, and Nautilus Minerals.[47] As a country that relies heavily on imports, Japan has been a pioneer in the deep sea mining field, and is now the first nation to successfully mine the seabed.

For industrial actors, scientific samplings perform a dual role in both assessing the potential value of deep sea mining sites and evaluating the long-term impacts of deep sea

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Authority, *Polymetallic Sulphides*, Kingston, Jamaica. https://www.isa.org.jm/files/documents/EN/Brochures/ENG8.pdf; Benioff Ocean Initiative and UCSB, "Deep Sea Mining Watch," October 2016, http://deepseaminingwatch.msi.ucsb.edu/#!/intro?view=-14.9448|-159.9609|2||1124|576.

[45] Peacock adds that "Our expedition from San Diego, for example, was a joint program funded by the Massachusetts Institute of Technology and the Scripps Institution of Oceanography, in collaboration with the ISA, the U.S. Geological Survey and the GSR [Global Sea Mineral Resources]. In 2019 Europe's JPI Oceans program will conduct a study with the ISA and GSR in the CCFZ." Peacock, "Is Deep Sea Mining Worth It?" 77.

[46] Marie Bourrel, Torsten Thiele, and Duncan Currie, "The common heritage of mankind as a means to assess and advance equity in deep sea mining," Marine Policy 95 (2018): 311. http://dx.doi.org/10.1016/j.marpol.2016.07.017i. This idea has created complicated international entanglements, as companies based in wealthy nations like Canada often apply for licenses through smaller nations like Tonga.

[47] Peacock and Alford, "Is Deep Sea Mining Worth It?"

mining activity. Geologists, in particular, work with contractors to take cores, evaluate metal concentrations in new regions of the deep seabed, and help refine economic evaluations and technical models. For instance, the Blue Mining Consortium, which represents six countries and has obtained 10 million euros of funding from EU from 2014-2018, is a major organization pursuing research on resource discovery, assessment, and sustainable management for seafloor massive sulfide deposits and manganese nodule deposits. According to their 2018 report, geological modelling is crucial to the calculation of a resource potential. Their role is thus to develop project plans that include both scientific and economic work: "Mine planning covers the whole value chain—from the exploration to the scheduling of machines and from the financing of mining projects to the study of economics."[48]

Beyond basic forms of exploration and economic assessment, the need for scientific expertise largely comes from the fact that mining by Nautilus and other contractors is inevitably an act of destruction. While some articles portend this as the next gold rush, environmentalists warn of the next great extinction.[49] Given the ocean's fluidity, the questions surrounding the ecological effects and regulation of mining operations are manifold: How will mining operations at the seafloor affect the water column? How far will sediment plumes from mining spread, and what will be their impact? Who will monitor

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[48] Blue Mining, "Breakthrough Solutions for Mineral Extraction and Processing in Extreme Environments," February, 2018, 15. http://www.bluemining.eu/download/project_results/public_reports/Blue-mining-Public-Report-2018.pdf.

[49] Mehta, Shreema. "The Dangers of Deep Sea Mining." *Earthworks,* September 28, 2015, https://www.earthworksaction.org/earthblog/detail/the_dangers_of_deep_sea_mining#.VuNyUJMrKb8.

mining in international waters? What will they be monitoring for? What is the temporal scale of the environmental impact? What organisms, from jellies, to fish, to plankton, to microbes, will be affected? Each mining exploration area is enormous—up to 75000 square kilometers each. The CCFZ itself is a gigantic area that covers roughly the span of New York to California. We do not have a firm idea of the species that live in this region, nor do we understand their distribution patterns and their risks for extinction from mining.

Alvinocaridid shrimp, each colony a part of a unique and isolated ecology, are just one of the species that could be put at risk by cutting and dewatering operations from mining. Most immediately, they will be affected by the turbulent production of "slurry" proposed by Nautilus Minerals as part of the mining process. While slurry itself might be an industrial term, it is an elemental medium, acting in much the same way as what Jeffrey Jerome Cohen writes of sludge: "Produced by humans, by factories, by elements, sludge is likewise productive: of feelings, of stories, and even, perversely, of life."[50] Like grey goo, the creation of slurry relies on a violent homogenization of living, nonliving, fluid, and solid. Integrated into a supply chain, these muds or "slurries" are ontologically flat, signalling transferrable value. Circulating from seafloor to surface, slurries and sludges elude an identity as individuated objects, naming instead relations between human industrial actors, aquatic life, and rock.

So how is this slurry made? First, industrial machines called auxiliary cutters and bulk cutters grind the seafloor into a mixture of sand, gravel, and silt. Cutters are comprised of multiple toothed blades that "cut" through material as it passes, producing a homogenous

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[50] Jeffrey Jerome Cohen, "Elemental Relations," *O-Zone: A Journal of Object-Oriented Studies* 1, (2014): 58.

slurry. The muddy seawater slurry is then drawn into a collecting machine, and then pumped through a pipe to a riser and lifting system, idealized as a "clog-free vertical transport" system based on Airlift and Centrifugal Pump technology.[51] Afterwards, this material is "dewatered" as it heads to the support vessel, using centrifuges and filter presses to separate the product (seafloor massive sulfides) from other matter. This process leaves behind a discharge of sediment-laden water, which is returned to the ocean floor via a pump.[52]

In a fluid environment, the impacts of these turbulent mediations travel, as mudflows processed by mining operations come at the cost of native residents. Dissolved and fine particulate metals like copper, cadmium, zinc, and lead released from extraction could travel as a plume into the water column as far as 100-1000 s of km^2.[53] High pressures at depth additionally increase the toxic effect of each metal—all of which might be absorbed or ingested through the gills of seafloor deposit feeders who grow slowly and are energy limited. These toxicants can travel up the food chain, leading to bioaccumulation on a larger scale that is impossible to quantify. As such, the reduction of sediment plumes has been flagged as one of the most important environmental footprints of mining.[54] With deep sea mining operations quickly becoming a reality, the ISA relies on contractor studies to put

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[51] Blue Mining, "Breakthrough Solutions," 18.

[52] Nautilus Minerals, "Nautilus Minerals: Vessel dewatering detailed design contract awarded," Press Release 2015 – 20, July 29, 2015, http://www.nautilusminerals.com/irm/PDF/1633_0/Vesseldewateringplantdetaileddesigncontractawarded.

[53] Chris Hauton, Alastair Brown, Sven Thatje et al., "Identifying Toxic Impacts of Metals Potentially Released during Deep-Sea Mining—A Synthesis of the Challenges to Quantifying Risk," *Frontiers in Marine Science* 4, no. 368, (November 16, 2017): 2; Horst Oebius, Hermann Becker, Susanne Rolinski et al., "Parametrization and evaluation of marine environmental impacts produced by deep-sea manganese nodule mining," *Deep Sea Research II* 48, no. 17 (2001): 3453-3467.

[54] Blue Mining, "Breakthrough Solutions," 29.

together informed regulation for deep sea mining that takes into account existing deep sea ecosystems. By recruiting scientific partners, industry contractors are able to pursue both commodity and environmentalist credibility simultaneously.

Vent expert Cindy van Dover is one of many scientists currently working with the ISA to establish environmental baselines.[55] Originally offered a consulting role by the Seabed Authority in 2004, Dover was able to leverage the ISA to access areas where she had never before been able to get samples and conduct her own research as well. Ultimately, the ISA became a shortcut to accessing the ships and ROVs that could sample, as opposed to applying for funding from the National Science Foundation. She mentioned in an interview that her sentiment at the time was that "it's not going to happen for a long time," noting that she herself did not take the charge to mine seriously initially. Times, it seems, have changed: "there were a lot of negative views of scientists working with a mining company and I had gone to the dark side. Now, everyone is working with mining, every paper I read says that we need to do this because we need to understand the impact of mining."[56] Indeed, while organizations ranging from NOAA to the Caplan Foundation, to the EU have funded seabed projects, the vast majority of this research is done by industry contractors. Deep sea biologist Craig Smith elaborates:

> In an ideal world, maybe all the impact studies and monitoring would be done by independent bodies. One of the problems is that the resources to even do the baseline studies cost a lot of money. Deep sea expeditions to go out for a month and begin to collect baseline data costs millions of dollars, many millions actually…I do think we're stuck with the model where contractors pay for the baseline studies and probably pay for the monitoring.[57]

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[55] See also the DeepCCZ and ABYSSLINE or Abyssal Baseline Project, run by The Craig Smith Lab with the ISA. https://craigrsmithlab.com/deepccz/

[56] Cindy Dover, phone interview with author, January 16, 2018.

[57] Craig Smith, interview with author, University of Hawai'i at Mānoa, September 23, 2019.

Smith and Dover's perspectives reflect a general sentiment of surrender among scientists studying the deep seabed. Objections to the industry tend not to question the economic benefits or viability of the industry, but rather see it as inevitable. Concerned parties focus on "a lack of scientific and environmental data, a prominent and valid concern made stronger by a range of indeterminate economic factors."[58] Given this expectation of turbulence, there is no longer debate about whether or not deep sea mining can be stopped, but rather, scientists focus on communicating what we can afford to lose. Deep sea mining is thus a field that connects scientists, industry, and the state together. The success of industry is viewed as imperative to the success of the state, while the labor of scientists is used to seek out new extractive sites as well as to guide and justify policy for environmental impact assessment and enforcement.

The industry-science crosstalk means that scientists also take on much of the work of characterizing the relationship between humans and seafloor communities, following their own intuitions about deep sea mining sites. This means that reconciliations between extractive and environmentalist aims also occurs in scientific discourse, and specifically around questions of global resilience to the impacts of mining. Dover provided an example of how individual scientists might negotiate the ethics of biodiversity loss from mining. The deciding factor is often one of scale:

> I have a colleague that says if one nematode goes extinct, we shouldn't mine. I don't agree with that. But there's going to be some point where it makes a difference… It's clear to me that you could remove a square meter of the Clarion-Clipperton Zone and you would not have a long term effect on an ecosystem scale. What I don't know is how big you can destroy or degrade. How much can you do this stuff before we see

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[58] Sammler 26.

> something we care about change, like the oxygen concentration or the total biodiversity?"[59]

In aggregate, these debates chart a history of how human beings seek to mediate turbulent processes. Scientists work with industry to determine the boundaries of this resilience and the scale at which it is allowed to exist—how far can we go, how much can we destroy? Such questions always imply a planetary scale, even when they drill down to the level of microbes and nematodes. To speak of extraction in the age of deep sea mining then, is to think not only about the exploitation of natural resources, but also about the role and complicity of scientific labor in delimiting turbulence itself and articulating it to the deep sea mining industry. These political convergences and debates form the basis of a link between reading and extracting muds, where scientific readings precede the extraction of value.

Minding the Bottom Feeders

In regards to toxicity, scientists are not able to predict the full effects of metal infiltration into seawater, so some advocate instead for a Weight of Evidence (WOE) approach. With WOE, a single species, such as a type of Alvinocaridid shrimp, would be designated as a "canary species" or proxy species in order to develop a holistic overview of toxic risk. Canary species might be chosen for their role in Ecosystem Services, or, as with shrimp, because they are "biomass dominants in a local biological community."[60] In this example, shrimp would thus gain a privileged visibility as the literal canary in the [sulfide] mine. This can be seen as a form of anthropocentric mediation in which one species becomes a metonymic, sacrificial sign for an entire biological ecosystem—the canary species acquires

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[59] Ibid.

[60] Ibid., 9

recognition while its other vent brethren and symbionts are reduced to a mass. Moreover, the speculative use of organisms like shrimp as sentinels or canaries means that these organisms themselves become a sensor—a medium that perceives what the human sensorium cannot and relays that information back. The idea of a canary (or shrimp) in the mine thus imposes a technological rubric onto the animal, producing the animal as a tool for the appropriation of a novel terrain—their geographies become prospective extensions of our geographies.[61]

WOE approaches or "lethal limits" to incidental mining casualties are just one of many frameworks for regulation. The reality is that there are often multiple frameworks in play. For instance, some environmental recommendations focus on minimizing or offsetting losses from mining, while the questions that Dover articulated classify damage by identifying turbulence in distinct thresholds or tipping points of change. In the second view, turbulence becomes unacceptable when it marks a point from which there is no return—it is a question of resilience. Problematically, all of these approaches seem to ignore behavioral perturbations along with nonlethal injuries to animals. As I will explain next, industrial environmental impact statements often assume the resilience of deep sea communities, treating deep sea muds as petri dishes that can be erased and reproduced. This is a particularly egregious perspective in which present tense eradication of life matters less than the projected ability for life to grow back.

Resilience is a concept defined broadly as "a system's capacity to spontaneously reorganise itself in response to disturbance and adapt in ways that preserve its identity and

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[61] The treatment of animals as sentinels or themselves media tools for assessing medical or environmental risk is well-established. See, for instance, Council, N.R., D.E.L. Studies, C.L. Sciences, B.E.S. Toxicology, and C.A.M.E. Hazards. *Animals as Sentinels of Environmental Health Hazards*. National Academies Press, 1991.

function."[62] Melinda Cooper and Jeremy Walker's piece on "Genealogies of Resilience" identifies the way in which the science of complex adaptive systems has led to a problematic merging of the ecological concept of resilience with neoliberal doctrines of governance. This idea of a complex adaptive system is itself scalable—from individual resilience, to national resilience, to technological resilience, to planetary resilience. The underlying idea of an ecosystem's capacity to remain cohesive under perturbations has, as the authors argue, bled across security, environmental, and infrastructural contexts, which have all moved away from the charge to prevent or avoid catastrophic events and towards the capacity to adapt: "Relying as it does on the non-equilibrium dynamics of complex systems theory, what the resilience perspective demands is not so much progressive adaptation to a continually reinvented norm as permanent adaptability to extremes of turbulence…resilience risks becoming the measure of one's fitness to survive in the turbulent order of things."[63] In a sense, resilience thinking diminishes the very concept of turbulence as it incorporates it into a system and positions it as a norm. Cooper and Walker also point out that resilience has become a justification for neoliberal think tanks seeking to remove environmental protections, as the charge to create resilience appears to justify the insistence that adaptation thrives best without intervention.

In the Anthropocene, which names a new geologic epoch based around human perturbations of the natural environment, resilience thinking has become particularly

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[62] Kevin Grove and David Chandler, "Introduction: resilience and the Anthropocene: the stakes of 'renaturalising' politics," in *Resilience: International Policies, Practices and Discourses* 5, no. 2 (2017), 81.

[63] Melinda Cooper and Jeremy Walker, "Genealogies of Resilience: From Systems Ecology to the Political Economy of Crisis Adaptation*." Security Dialogue* 42, no. 2 (2012): 156.

important to debates about living with environmental risk and climate change. In their special issue on resilience and the Anthropocene, Kevin Grove and David Chandler remind us that resilience provides solace for an inescapable world in which "human life is envisioned as a geological force in and of itself."[64] But a dominant critique among this set of scholars is, as I see it, a shared concern about the ways in which resilience can be mobilized to constrain imaginaries of the future, orienting towards how to live with and even benefit from uncertainty and turbulence. This puts the onus on the evolutionary idea of survival of the fittest.[65] As Orit Halpern puts it, "It is not about a future that is better, but rather about an ecology that can absorb shocks while maintaining its functionality and organization."[66] When used to speculate about deep sea mining, resilience assumes a path that is already in motion.

Deep sea mining is an industry that is deeply indebted to the anxieties around the global depletion of natural resources in the Anthropocene, so it is no surprise that resilience plays a prominent role in regulatory discourse. The Environmental Impact Statement for Nautilus Minerals' Solwara 1 project, one of the first proposed deep sea mining projects based in Papua New Guinea, provides a useful vantage point for observing invocations of resilience and turbulence in the intersections between scientists, community leaders, Nautilus stakeholders, government entities, and benthic organisms. A Canadian company, Nautilus received its mining permits in 2009 but has found itself in a number of disputes with the Papua New Guinea government and locals, drawing media attention and community ire. It

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[64] Grove and Chandler, 81.

[65] Cooper and Walker, "Genealogies," 156.

[66] Orit Halpern, "Hopeful Resilience," *e-flux Architecture*, April 19, 2017, https://www.e-flux.com/architecture/accumulation/96421/hopeful-resilience/

nonetheless has provided a mining template for a variety of global actors, including Japan.[67] As a condition of its operation, the Solwara 1 EIS seeks to demonstrate that there has been adequate attention paid to environmental risks, and it does so through its emphasis on recolonization and resilience. Rather than deny the turbulence of mining, it frames deep sea ecosystems as naturally turbulent and thus resilient spaces that can be erased and reproduced. This happens in two main ways: 1. The mediation of vents as resilient and capable of reformation. 2. The mediation of organisms like shrimp as naturally resilient and therefore capable of recovery in the event of turbulence.

The establishment of hydrothermal vents themselves as resilient is an important precursor to insinuation of resilient life. The Solwara 1 EIS argues that "chimney structures will reform and the underlying hydrothermal energy basis will still exist for the potential re-establishment of vent-dependent and associated communities."[68] This statement seems to imply both resilience and fertility, wherein vents themselves become easily regrown infrastructures. It also insinuates biological recovery through comparisons between underwater vent life and terrestrial volcanoes, claiming that, "Recovery would occur once clean, hard surfaces emerge and new settlement occurs, as would be the case after a volcanic ash dump."[69] The report's reference to hard surfaces is an oddly static perspective, and the

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[67] As Mr. Testsuo Yamazaki, President of Japan Federation of Ocean Engineering Societies has observed, "the trial being carried out by Nautilus Minerals in Papua New Guinea would be very useful in addressing these questions." *Summary of the Authority's Workshop on Prospects for Mining Cobalt Rich Ferromanganese Crusts and Polymetallic Sulphides in the Area – Technological and Economic Considerations* (Kingston, Jamaica: International Seabed Authority, 2006): 8.

[68] Nautilus Minerals Niugini Limited, *Environmental Impact Statement: Solwara 1 Project*, Volume A Main Report CR 2008_9_v4 (Brisbane, Australia: Coffey Natural Systems Pty Ltd, September 2008): 9-20

[69] Nautilus Minerals, *Environmental Impact Statement*, 185.

equation between terrestrial and deep sea mines has also been roundly criticized by independent scientific researchers as well by the Deep Sea Mining (DSM) Campaign, an "association of non-governmental and community based organisations and citizens from the Pacific Rim Region." The review asserts, "By comparing apples to oranges, it is hardly surprising (but meaningless) that Solwara 1 is rated by EE as having a lower impact than the selected land-based mines on terrestrial values such as ground and fresh water quality, air quality, pollination, soil formation and retention, and recreational activities such as hiking and bike riding, and loss of agricultural land. [70]

More importantly, the comparison to volcanic life leads to assumptions about the natural hardiness of organisms, as Nautilus infers that "a high tolerance to metal concentrations on water and sediments would be of selective and survival value."[71] Solwara 1 mitigation proposals rely heavily on these insinuations about bottom dwellers, whose tolerance of high heat and metal concentrations are extrapolated to an idea of permanent adaptive ability. Vent shrimp are specially adapted to their environments, living in a symbiotic existence with chemoautotrophic bacteria. However, they clearly do not tolerate all kinds of extremes, and the very idea of extremes is relative. In one 2016 study, August et al. demonstrated that shrimp (*R. exoculata*) adapted to live in a metal-rich vent-field environment were still highly sensitive to copper exposure in solution. Likewise, vent mussels from the "Lucky Strike" hydrothermal vent site exposed to copper solution experienced "elevated lipid peroxidation at

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[70] Helen Rosenbaum and Francis Grey, "Accountability Zero: A Critique of the Nautilus Minerals Environmental and Social Benchmarking Analysis of the Solwara I Project," Deep Sea Mining Campaign, (September 29, 2015): 8 http://www.deepseaminingoutofourdepth.org/wp-content/uploads/accountabilityZERO_web.pdf.

[71] Nautilus Minerals, *Environmental Impact Statement*, ch. 9, p. 21.

copper concentrations in excess of 300 μg l^{-1}, indicating lipid membrane damage within these tissues."[72] The ability to live in an extreme environment in one sense thus does not presume a lack of vulnerability to all other kinds of temperature and chemical extremes—especially the turbulences produced by mining.

The report goes on to speculate, "The time sequence of recovery of fauna is not known but it is expected that, within 1 to 3 years, the major faunal elements will have re-established."[73] But the seemingly arbitrary number of "1-3 years" is misleading, particularly given warnings from scientists that full biological recovery would be effectively impossible after mining. Fundamentally, these impact statements make unfounded assumptions about the temporality of anthropogenic turbulence, which, despite its frequently rapid physical manifestations, is also a slow violence.[74] Statements such as these mark the EIS as a performative medium, as the perceived quality of its representation of the environment comes to stand in for environmental mitigation or harm reduction itself, often despite evidence to the contrary.

The reality is that deep sea ecosystems are, without question, the most non-resilient ecosystems on the planet, and for many scientists, making this point clear is an important path for limiting the areas in which mining occurs. The only way to ensure their protection is to prevent mining in the first place, or, from a legal perspective, to accord them status as Marine Protected Areas. To underscore this point, a letter to the editor of *Nature Geoscience* written by Dover and twelve other researchers, oceanographers, and lawyers warn that the

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[72] Hauton et. al.

[73] Nautilus Minerals, *Environmental Impact Statement*, 9-20.

[74] Rob Nixon, *Slow Violence and the Environmentalism of the Poor*, (Cambridge: Harvard University Press, 2011).

existing regulatory frameworks for deep sea mining industries prescribing solutions to biodiversity loss through avoidance and minimization (for instance, patchwork extraction to reduce the mining footprint), remediation (the halting or reversing of environmental damage), and offsetting (like-for-like counterbalancing of environmental impact) constitute an "unrealistic" and "unattainable goal." The authors note that biological recovery at deep sea ecosystems takes place on the timescale of decades to centuries, or nearly forever to humans given the slow rates of natural recovery.[75]

This is especially true for non-vent mining sites, such as those containing polymetallic or manganese nodules, which exist in areas where the deep sea is less naturally turbulent. Here, the ocean does not actively mix matter or transport energy, thanks to its increased density at depth leading to a more stable state.[76] Yet Peacock explains that even in these areas, "Weak background currents in the deep ocean, which move at several centimeters a second, could carry sediment particles many kilometers away from where a collector is operating…The background sedimentation rate in the deep ocean is so low, however—on the order of one millimeter per 1000 years—that biologists think trace amounts of sediment emitted by a collector could smother seafloor life even farther away."[77] Sites near mined vents could experience a similar smothering effect. This raises the question: can a centuries-long scale of recovery described as "nearly forever" by scientists really be called resilience, or does it erode the very utility of the word? Is there, in other words, a temporal limit that marks the boundary between turbulence and catastrophe?

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[75] Dover, C. L. Van, J. A. Ardron, E. Escobar, M. Gianni, K. M. Gjerde, A. Jaeckel, D. O. B. Jones, et al. "Biodiversity Loss from Deep-Sea Mining." *Nature Geoscience* 10, no. 7 (July 2017): 464.

[76] Steve Thorpe, *The Turbulent Ocean,* (Cambridge University Press, 2005): 37.

[77] Peacock et al., "Is Deep Sea Mining Worth It?" 76.

Like others of their kind, deep sea vent shrimp are omnivorous bottom feeders—some are rock scrapers, others are filter feeders, scavengers, or parasite cleaners. For me, this figure of the bottom feeder represents more than a literal description of shrimp behavior; the bottom feeder is an ecological role that has come to describe human social organization—it has practically become a shorthand slur for human opportunism. Most importantly, this cultural metaphor points us towards a naturalized link between lowly status and resilience, an association that plays an important part in the unfolding dramas of the deep seas. Resilient organisms and objects, our "bottom feeders," elude protection from speculative industries like mining because of their perceived resilience. This is where we can see the resonances of the bottom feeder to the human world, as that resilient lifeform who does not merit care. In a human context, work on resilience has touched upon its racial politics in relation to neoliberal governance, where poor, migrant communities are seen as non-resilient and thus abnormal and not worthy of saving.[78] We can also see possibilities for a different biopolitics of resilience, where the imaginary specter of the always-coming migrant is associated with the resilient bottom feeder.

To emphasize the shared metaphor, shrimp are themselves cast as a kind of environmental refugee. For instance, Nautilus' EIS also advocates the idea that communities could be saved simply by relocating one clump of organisms to other unmined areas, or "temporary refuge areas."[79] But this too implies a resilience that does not exist. Between different vent fields, biological life can be vastly different, suggesting that the habitats of

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[78] Andrew Baldwin, "Resilience and race, or climate change and the uninsurable migrant: towards an anthroporacial reading of 'race,'" in *Resilience: International Policies, Practices and Discourses* 5, no. 2 (2017): 129-143.

[79] Nautilus Minerals, *Environmental Impact Statement*, ch. 5, p. 11.

each individual vent, no matter how close they may be to each other, are unique. Not only does the refuge proposal ignore potential clashes between refugee and native communities of organisms, but scientists have argued that, like island ecosystems, individual communities are so specifically adapted to their sites that to mine one would most likely be a death sentence to the 50-60 species found only in that field. [80] In the deep sea, complex communities of species like *Alvinocarididae* are reduced to "clumps of biomass" in environmental reports, becoming what Giorgio Agamben might call bare life or zoë, that function primarily to propagate and survive.[81]

On the other hand, that which is resilient might itself become the object of speculation. Branded as extreme organisms, shrimp also become worthy of biocapital speculation. They have uniquely adapted exoskeletons, filtering abilities, and feeding capabilities. Scientists have speculated that deep sea shrimp exoskeletons might provide a template for new polymer carbonates that can withstand heat.[82] Their digestive enzymes meanwhile, are marked as potential tools for the creation of new biofuels.[83] When shrimps are not surviving, their deaths thus ensure the survival of others, and in particular, the survival of human technological society. Halpern notes that such speculative resilience "accepts the sacrifice of certain lives as necessary and justified for survival and even growth," perpetuating ecological violence and further speculation. In their uses and in their deaths, shrimp bodies become

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[80] Hauton et al., "Identifying Toxic Impacts," 4.

[81] See Giorgio Agamben, *Homo Sacer: Sovereign Power and Bare Life,* translated by Daniel Heller-Roazen (Stanford University Press, 1998).

[82] Emil Venere-Purdue, "How Deep-Sea Shrimp Survive Super-Hot Water," July 15, 2015, https://www.futurity.org/shrimp-exoskeletons-oceans-960162/.

[83] Helen Scales, "Deep-Sea, Shrimp-like Creatures Survive by Eating Wood," *National Geographic*, August 30, 2012, https://news.nationalgeographic.com/news/2012/08/120828-amphipods-oceans-mariana-trench-wood-science-animals/.

what Halpern calls "resilient hope" for human society.[84] The Nautilus EIS thus mediates the deep sea through a speculative mode that above all, treats hydrothermal vents and surrounding muds like scalable, nutrient rich environments in which cultures can be grown at will. Unlike such mediums in scientific labs, however, these cultures are not meant to communicate information about a larger world, but rather, they are the ends. They transform deep sea worlds by erasing material specificity, producing it instead as a space of virtual profits and losses.

Thus, the appraisal of ocean fluidity and turbulence is necessary, but it is not itself inherently ethical. Turbulence, like all ocean processes, is relatively defined. If catastrophe signals a radical, irreversible loss of life or identity,[85] resilience grows in the shadow of certain, yet "non-catastrophic" disaster. But what of the possibilities for preventing turbulence from radiating through deep temporalities, producing catastrophes like, for instance, extinction or irreversible sea-level rise? To think of turbulence requires that we do not simply fetishize the dynamism of environments, but also think of the ways in which massive technological interventions create radical change. A fluid environment like the ocean floor will always shift over time and experience periodic upheaval. What resilience arguments mask is the massive production of turbulence in another form, one that operates on a larger scale of disturbance than the perturbation of a single ecosystem. The production of resilient extractive infrastructure belies the creation of new turbulences, new frictions, and new problems.

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[84] Halpern, "Hopeful Resilience."

[85] See Grove and Chandler, 84.

Ultimately, the act of repurposing a complex natural ecology as an extractive site is an enclosure of life, matter, and meaning. As Deborah Cowen reminds us, logistical management of supply chains often destroys life—it frequently goes hand-in-hand with violence that can be both physical and discursive: "The entire network of infrastructures, technologies, spaces, workers, and violence that makes the circulation of stuff possible remains tucked out of sight for those who engage with logistics only as consumers."[86] The control of pipelines between the surface and seabed predominantly through resource extraction remolds vital muds in terms of their speculative value, and produces new anthropogenic mudflows. Cowen signals the way in which the life of the supply chain is valued over human rights, but this critique extends to nonhuman life. We may not think of shrimp as charismatic creatures worthy of the dramas we give to polar bears and orcas in the wake of a changing climate, but perhaps, if we can get a whiff of unfolding catastrophe in shrimp stories, we might find space to contemplate radical solutions to radical change.

Turbulence as Mediation

While much of this chapter focuses on the mediation of turbulence, I find that turbulence can also be an intervention into mediation itself. From the late Latin *turbulentus* meaning "full of disturbance or commotion,"[87] turbulence is lively in its physical meaning—it is a scientific term to describe the energetic, eddying motions found in everything from clouds, to smoke, to ocean waters. Such rotations are highly effective in dispersing material and

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[86] Deborah Cowen, *The Deadly Life of Logistics: Mapping Violence in Global Trade*, University of Minnesota Press, 2014, Kindle Locations 145-146.

[87] *Oxford English Dictionary*, "turbulent," accessed 14 November, 2018, http://www.oed.com/view/Entry/207572?redirectedFrom=turbulent#eid.

transferring energy, heat, and solutes like oxygen or nitrogen.[88] Baked into this definition is thus the role of fluids in the movement of matter and energy. Ecological definitions of media from scholars like Helmreich and Jue, position mediation as referring to the propagation of action through substances, channels, or instruments."[89] Read under this rubric, turbulence itself is a mediatory process, aiding the transduction of material from one state to another and in the transportation of signal and nutrients. This turbulent mediation can be technological or natural, and might include the sediment-laden plumes produced through mining processes as well as natural upwellings of mineral-rich fluids.

The deep sea mining industry's production of slurries diverts us from the forms of liveness and generativity that exceed our human experience. A sense of natural turbulence as itself a vital mediator, important to global and atmospheric flows of chemicals, heat, and matter is minimized. Nevertheless, understanding how metals and other life-essential chemicals circulate through mudflows of all kinds, with or without a canary species, is imperative to understanding both the anthropogenic effect on vent communities and the importance of those benthic communities to human life. As Stacy Alaimo contends, revealing the interconnections between our dry and wet spheres of life can set the stage for marine environmentalisms.[90]

Environmental impact research for deep sea mining seldom articulates the exchanges of energy, elements, and biomass between ecosystems. But these fluid exchanges mean

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[88] S.A. Thorpe, *The Turbulent Ocean*, Cambridge University Press, (Cambridge, UK, 2005): 3.

[89] Stefan Helmreich, *Alien Ocean: Anthropological Voyages in Microbial Seas* (Oakland, CA: University of California Press, 2009) 32.

[90] Stacy Alaimo, *Exposed: Environmental Politics and Pleasures in Posthuman Times.* (Minneapolis: University of Minnesota Press, 2016, Kindle edition): location 2239.

everything in the world of oceanography. In 1930, WHOI director Henry Bryant Bigelow wrote, “In a word, until new vistas develop, we believe that our ventures in oceanography will be most profitable if we regard the sea as dynamic, not as something static, and if we focus our attention on the cycle of life and energy as a whole in the sea, instead of confining our individual outlook to one or another restricted phase, whether it be biologic, physical, chemical, or geologic.”[91] Vents are important actors for the sea as a whole. They release compounds that fuel chemosynthetic production by organisms, and their geochemical footprints extend far beyond their spatially restricted sites, all the way from the seafloor to the surface. These benthic habitats are also areas of “active chemical cycling by unique bacterial and viral communities.”[92] Thus, deep sea communities participate in the carbon cycle and climate regulation globally.

Fluid flows problematize our top-down extractions of the seabed. Instead, muddy circulations are omnidirectional feeds—vital interlocutors between the biologic and geologic world, between our technologies and natural geographies, that simultaneously constitute us as environmental subjects. Our blue planet is constructed of a multiplicity of flows, many of which are unequal, some of which are violent. Our very condition of living is produced by the existence of these seabed to surface feeds. In a talk at the 2019 Frontiers in Underwater Science and Engineering Conference, Peter Girguis went a step further to assert that fluid flows are a defining feature of life itself, which requires open systems and movements of nutrients across all spatial scales, from within a cytoplasm, to the turbulence at the sea

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[91] Henry Bryant Bigelow, “A Developing Viewpoint in Oceanography,” *Science*, (January 24, 1930): 84-89.

[92] Levin, Lisa et. al., “Hydrothermal Vents and Methane Seeps,” 3, 13. doi:10.3389/fmars.2016.00072.

surface-atmosphere interface. This scientific fact, moreover, accords with new materialist perspectives within the environmental humanities. As Tim Ingold puts it, "Like all other creatures, human beings do not exist on the 'other side' of materiality but swim in an ocean of materials…The existence of all living organisms is caught up in this ceaseless respiratory and metabolic interchange between their bodily substances and the fluxes of the medium."[93] One could say rephrase this statement to say that we are all caught up in feeds—feeds comprised of metabolic exchange. Recognizing this fact can provide both incentive to treat our oceans better as well as encourage an ethical perspective on unseen deep sea communities, in which even blind vent shrimp are an intrinsic part of the human condition.

Resistance to Deep Sea Mining

Public resistance to Nautilus' logistical and economic perspective on deep sea mudflows is multifaceted, but it has hinged on emphasizing the plight of local communities and on the importance of non-Western perspectives on human-ocean relation. Few human beings have seen the seafloor nor will they ever directly encounter the ecosystems affected by mining, and yet there are those who nevertheless claim a kinship with this space.[94] Namely, indigenous Pacific cosmologies tend to contrast Western divisions of the sea and land. Tongan and Fijian writer Epeli Hau'ofa articulates a perspective from Oceania more broadly, a term encompassing the shared experiences of island communities: "Their universe comprised not only land surfaces, but the surrounding ocean as far as they could traverse and

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[93] Tim Ingold, "Materials Against Materiality," *Archaeological Dialogues* 14, no. 1 (Cambridge University Press, 2007): 7, 11.

[94] Teresa Shewry, "Gone Fishing: Activism against Deep Ocean Mining, from the Raukumara Basin to the Bismarck Sea," *The South Atlantic Quarterly* 116, no. 1 (January 2017).

exploit it, the underworld with its fire-controlling and earth-shaking denizens, and the heavens above with their hierarchies of powerful gods and named stars and constellations that people could count on to guide their ways across the seas."[95] Hau'ofa's writings constitute a decolonial perspective, pointing to the connections and relations that existed prior to the ruptures of colonialism. Likewise, Tess Shewry's work with indigenous activists against seabed mining in PNG reveals communities striving to "animate different imaginaries against a flood of high-tech corporate representations of the ocean."[96] The activists Shewry investigates often pit small-scale ecological practices like fishing against large-scale exploitative practices.

Deep sea mining is perhaps most turbulent to the lives of Pacific islanders, who are poised to absorb enormous risk, often with little benefit. Sammler remarks that experimental mining and economic plunder "are of dire concern to many Pacific peoples, who have long experienced the effects of extractive practices of ocean and island natural resources."[97] Consequently, activist groups representing indigenous communities in the Pacific like the Deep Sea Mining Campaign have voiced particular concerns about the Nautilus project and deep seabed mining in general. Their website highlights the Precautionary Principle, proposed at the 1982 UN World Charter for Nature and the rule that currently informs the ISA regulatory framework for mineral exploitation of the deep sea.[98] DSMC states, "this

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[95] Epeli Hau'ofa 31.

[96] Shewry, "Gone Fishing," 208.

[97] Sammler 30.

[98] ISA Draft Regulation in 2017 reads, "All persons engaged in activities in the Area shall apply the Precautionary Approach, as reflected in Principle 15 of the Rio Declaration, to the assessment and management of risk of harm to the Marine Environment from Exploitation Activities in the Area and where scientific evidence concerning the scope and potential negative impact of the activity in question is insufficient but where there are plausible indications of potential risks of Serious Harm to the Marine Environment." International

definition of the PP prioritizes the protection and well being of communities and the environment…Implicit in this principle is the social responsibility to protect the public from exposure to harm, when scientific investigation has found a plausible risk."[99] Like other groups representing PNG locals, DSMC makes the argument that Nautilus has failed to adequately address social and environmental impacts and denied the local community a proper seat at the negotiation table.

In addition, many activists emphasize interspecies relationships. For instance, the Māori belief *whakapapa* sees humans, flora, and fauna as sharing a genealogy, constructing "both human and more-than-human bodies and materials within a smooth framework of kinship, entanglement, correspondence, exchange, and dispersed agency."[100] Meanwhile, in PNG, videos featuring local residents do important work in subverting lingering notions of the deep sea as inaccessible and inconsequential to daily human life. One video from DSMC highlights the traditional practice of shark calling from communities along New Ireland that is being threatened by the noisy exploration practices of mining contractors.[101] Another video by New Zealand's Kiwis Against Seabed Mining (KASM) uses child testimonials on New Zealand's black beaches and waves to drive home the importance of geographic belonging

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Seabed Authority, *Developing a Regulatory Framework for Mineral Exploitation in the Area: A Discussion Paper on the development and drafting of Regulations on Exploitations for Mineral Resources in the Area (Environmental Matters)*, (Kingston, Jamaica: International Seabed Authority, January 2017): 26.

[99] Deep Sea Mining Campaign, "What is the Precautionary Principle?" Accessed June 1, 2020. http://www.deepseaminingoutofourdepth.org/what-is-the-precautionary-principle/.

[100] Katherine Sammler, "Kauri and the Whale: Oceanic Matter and Meaning in New Zealand," pp. 63-84, in *Blue Legalities: The Life and Laws of the Sea*, eds. Irus Braverman and Elizabeth Johnson (Durham: Duke University Press, 2019).

[101] Natalie Lowrey, "New Ireland locals fear Nautilus destroying shark calling," Deep Sea Mining Campaign, October 18, 2012, http://www.deepseaminingoutofourdepth.org/new-ireland-locals-fear-nautilus-destroying-shark-calling/

and the tragedies of dispossession. In direct addresses, the children offer soundbites such as, "when you hurt the beach, you hurt me too,"[102] enacting a broader ecological relationship in which the beach and self are coextensive.

This local activism has highlighted important relationships between humans and nonhuman others. However, while much of this outreach continues to rely on charismatic beings such as children and rare sharks, the definition of what is "charismatic" continues to shift. Crucially, indigenous activists are not the only people who can articulate ecologically-minded imaginaries of the ocean. Scientists, while they may be involved in extractive cultures, regularly inhabit and think from the perspective of deep timescales and nonhuman communities. I believe that ocean science is well-equipped to extend such a politics of relation through to non-charismatic subjects, including the boring, strange, or obscured aspects of ocean life—vent bacteria, shrimp, marine worms, and more. As Smith told me, the abyssal seafloor is "a reservoir of enormous biodiversity and weird animals with weird adaptations."[103] He offered up the deep sea gummy squirrel (*Psychropotes longicauda*) as an example—a bright yellow abyssal cucumber with a long, sail-like tail.[104]

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[102] Natalie Lowrey, "Children speak out against seabed mining in New Zealand," Deep Sea Mining Campaign, December 14, 2012, http://www.deepseaminingoutofourdepth.org/children-speak-out-against-seabed-mining-in-new-zealand-save-our-sands-love-our-oceans/; also see "Community Testimonies," Deep Sea Mining Campaign, October 17, 2012, http://www.deepseaminingoutofourdepth.org/community-testimonies/

[103] Craig Smith, Interview with author, University of Hawaii at Manoa, September 23, 2019.

[104] Craig Smith, "The Weird and Wonderful Megafauna of the Abyssal CCZ," June 12, 2018, NOAA Ocean Exploration and Research, https://oceanexplorer.noaa.gov/explorations/18ccz/logs/june12/june12.html

Figure 8. Gummy Squirrel (*Psychropotes longicauda*), 5100 m depth in the CCZ. Image courtesy of DeepCCZ expedition

Smith has made it part of his mission to advocate for such creatures in order to draw attention to the need to save these unique and nearly pristine habitats. Bringing these entangled relationships to the forefront of our oceanic mediations will be more important than ever in the coming years as more hydrothermal vent sites are considered for status as Marine Protected Areas.

I asked, as a final question to my scientific correspondents, what marine geologists a million years in the future might dig up from cores dating back to 2018. The responses were instructive: Alexandra Hangsterfer, the Geological Collections Manager at Scripps, speculated about the presence of plastics and the stratigraphic record of a covered-up landfill.[105] Joe Stoner pointed to radioactivity and metal traces, noting that, "I'm sure the

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[105] Alexandra Hangsterfer, interview with author, Scripps Institution of Oceanography, August 9, 2018.

magnetics would pick up all of the iron that we've been producing." Val Stanley, a curator at the OSU marine geological archives answered with a joke: "the urbanite layer." She also thought about mountaintop removal and land modification, and reiterated the presence of junk layers like plastic and Styrofoam.[106] Paul Walczak had a bleaker outlook: "I imagine that we're leaving behind some sort of lead. The leaded gas would probably be in the chemical record for a long time. Also all the nuclear testing will stick around. . . there's probably going to be a billion-year signature of that." Nick Pisias agreed with this idea: "We had cores collected by the US and Russians in the 1950s. . . and we found bomb-grade plutonium in those cores. So yeah, that stuff is in the record and they'll find it, I just don't know what the half-lives are. There's a cesium layer that we found too." [107] Each of these interviews demonstrated a heightened awareness of damaging anthropogenic effects on the planet and its oceans, and above all, the certainty that our toxic waste and pollution will stick around for a very long time indeed.

Immersing ourselves in the worlds below the surface, we may understand our own lives as indebted to this fertile dun of hydrocarbons, minerals, methane, decomposing carcasses, and detritus, depositing our own mineral layers into the earth over time. We are connected to the deep sea through what we extract from it—genetic material, rare earth minerals, signs of our past, and signals of the future. Yet, sediment flows are interwoven processes that include us, and yet often elude our control. Just as vent shrimp cannot be isolated from their symbiotic bacteria, coastal communities depend on a larger interspecies network of organisms that include vent ecosystems. Our world is comprised of fluid interchanges,

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[106] Val Stanley, interview with author, Oregon State University, August 24, 2018.

[107] Paul Walczak and Nick Pisias, interview with author, Oregon State University, August 17, 2018.

turbulent mediations, and above all, community. If we are to rely on these marine muds into our technological futures, we cannot ignore others that they feed.

4. The Unlimited Feed: How Cabled Seafloor Observatories "Take the Pulse" of the Global Ocean

"In itself, each new evidence of oceanic knowledge doesn't necessarily make a technological tidal wave. Taken together, however, they are like high cirrus clouds which tell us that a storm of fresh knowledge will break upon us before long."

—Senator Claiborne Pell, Nov 12, 1967[1]

The ocean is sick. Its waters are stricken with fever, poisoned with plastic, choked with pollution. Over the past decade, as the health of the global ocean has rapidly declined, marine scientists, engineers, and oceanographers all over the world have begun to identify as ocean doctors. Like regular doctors, ocean doctors use a variety of tools and technologies to diagnose and treat their ailing patient. In particular, seafloor observation networks from the deep sea to the coasts are now being described as "ocean fitbits," or stethoscopes which "take the pulse and vital signs" of the global ocean.[2] From SMART cables to cabled observatories, this emergent aquatic cyberinfrastructure is becoming fundamental to climate and ocean research, constituting an underwater "Internet of Things" that connects information collected by sensors and cameras into a vast network.

Given the prevalence of medical analogies for today's ocean observing systems, the figure of the feed must now be imagined differently. The UN refers to the oceans as the lungs of the world because it produces most of the oxygen on the Earth via seaweed and other aquatic plants.[3] Perhaps then, the deployment of cabled observatories discussed here can be likened to intubation—the insertion of medical tubes to help living bodies breathe. While the

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[1] Senator Claiborne Pell, "The Scramble is On for Ocean Riches," *The World* (Nov 12, 1967): 21.

[2] Ocean Networks Canada, *Oceans 2.0: An Internet of Things for the Ocean*, (Victoria, BC, Canada: Ocean Networks Canada, 2019).

[3] Vinicio Lindoso, "Ocean: The real lungs of the world," September 13, 2019, UNESCO, https://en.unesco.org/news/ocean-real-lungs-world.

analogy may be imperfect, what it acknowledges is that these distributed deepwater feeds signal a shift in how we organize and interpret knowledge about the ocean, how we imagine ourselves in relation to deep sea environments, and how we hope to avoid extinction. As seafloor cabled observatories spread across the globe, new questions arise. What becomes of the ocean's future when its survival is dictated by continuous feeds from a data firehose? What does it mean to couch the ocean's imperiled ecosystems, its rising temperatures, its salinity, and its plummeting pH in terms of fitness? Who and what does this new digital ocean network consist of? To what extent do seafloor observation networks participate in an extractive mediation?

At the recent decadal meeting of the ocean observing community, Ocean Obs'19, Scripps Institution of Oceanography researcher Karen Stocks recommended that, "The deep community should leverage existing cyberinfrastructure when feasible, and develop a coordinated communication effort to address the missing deep."[4] Currently, the most widely used global observing networks rely on satellite data, drifters, buoys, gliders, and perhaps most famously, ARGO floats—an international system of battery-powered, autonomous floats that collect temperature and salinity profiles from the upper 2000 meters of the global ocean.[5] The vast majority of these globally networked ocean observation systems collect data near the surface of the ocean.

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[4] Karen Stocks, "Observing Needs in the Deep Ocean," Ocean Obs '19 Conference, Honolulu, HI, (September 19, 2019).

[5] See "Argo Floats," Argo: part of the integrated global observation strategy, accessed April 13, 2020, http://www.argo.ucsd.edu/How_Argo_floats.html

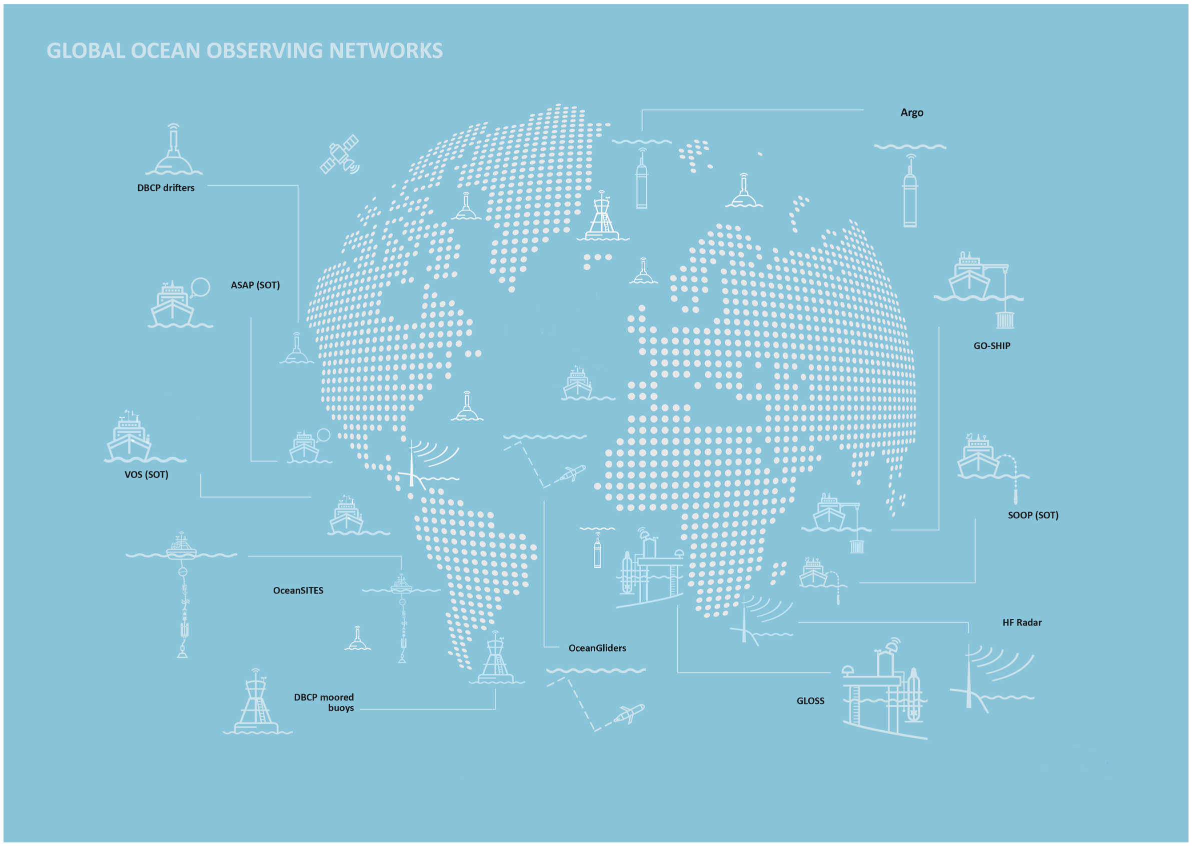

Figure 9. Ocean observing networks associated with the Global Ocean Observing System (GOOS), a UN project that connects the resources of UNESCO/IOC Member States.[6]

However, deep sea data has been conspicuously absent from much of the existing data portals for ocean research, reflecting a lack of volumetric data and a need for long-term, standardized measurements of the deep. There are, for instance, hardly any on-site, time-series observations of hydrothermal vents, frustrating our ability to understand how they grow, evolve, and are impacted by turbulent events. In the past, the ability to pursue time series research questions in the deep sea was limited by the constraints of batteries and survey ship availability. But over the past decade, scientists conducting deep ocean research

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[6] "Observations and Data," The Global Ocean Observing System, accessed April 13, 2020, https://www.goosocean.org/index.php?option=com_content&view=article&id=21&Itemid=271.

have been working to expand vertical observation capabilities. Through the repurposing, design, and installation of fiber-optic cables as a means to power ocean sensors, they are finally beginning to reap the benefits of sustained underwater observation. As Alan Chave puts it, “It would be a lot easier to explore the deep ocean, if we only had some electrical outlets and phone jacks on the seafloor. With 21st century technology, we are starting to install some.”[7]

The Charisma of In-Situ Observation

Seafloor cabled infrastructures are a site of contradiction when it comes to their global ambitions and local operations. As I will demonstrate, cabled observatories both function to monitor climate change, while extending the logic of smartness and programmability into oceanic space. Diverging from Marshall McLuhan’s notion of media as “extensions of man,” media scholar Jennifer Gabrys makes the important point that sensor networks like cabled observatories function to create new “techno-geographies.”[8] In this sense, seafloor observatories can be read as a mode of frontierist spatial and temporal occupation. Frontier thinking, as I discussed in chapter one, fuses mandates for technological innovation, spatial expansion, and domestication—each of which pits man against nature. Already, disconnected spaces in the ocean are construed as problematic gaps in a database, while rhetoric around building the smart ocean assumes that it is both necessary and inevitable. The sea is thus understood as being domesticated bit by bit through real-time control and time-series measurements.

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[7] Alan D. Chave, “Seeding the Seafloor with Observatories: Scientists extend their reach into the deep with pioneering undersea cable networks” *Oceanus* 42, no. 2, (April 2004).

[8] Gabrys, *Program Earth*, 4.

As I see it, the building of the global seafloor observation network is largely justified to the public through the undeniable charisma of in-situ ocean observation. In-situ (undersea) cameras and sensors blend entertainment and science, and they have the potential to cross social boundaries via dissemination through social media networks. In a popular media landscape where fiction films and television shows about the ocean are few and far between, documentary-style "infotainment" is a staple format for fostering ocean education and empathy. Often, such documentary formats brandish the use of liveness (temporal immediacy), or other tactics of what Pooja Rangan might call "immediations."[9] For instance, early in-situ live feeds such as critter cams or even the BP oil spillcam had a significant social and cultural impact. The spillcam, in particular, produced a sense of emergency that precipitated calls for corporate accountability, changing the way BP and the US government responded to the oil spill disaster. Nadia Bozak writes, "the Spillcam was instrumental in galvanizing media, scientists, and citizens against the criminal oil giant caught on its own surveillance video red-handed, in real time…The Spillcam 'caught' more than just BP in transgression; it caught the hydrocarbon world." [10]

Now, live feeds or camera-as-sensor assemblages have become popular choices for environmental mediation. Gabrys calls them "imagers," a form of informatic imaging that functions within distributed networks of capture.[11] However, there are drawbacks to relying on in-situ data feeds for ocean education. Cabled observatory interfaces facilitate a particular form of viewing and datalogical comprehension that resembles a gods-eye view, which ties

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[9] Pooja Rangan, *Immediations: The Humanitarian Impulse in Documentary*, (Durham: Duke University Press, 2017).

[10] Nadia Bozak, *The Cinematic Footprint: Lights, Camera, Natural Resources* (New Brunswick, New Jersey: Rutgers University Press, 2012), 153.

[11] Ibid. 57.

mediation to control and recording from a safe distance. Like other popular underwater media interfaces such as aquariums and photospheres (submarines designed for underwater photography), this continues a tradition of Western underwater observation that constrains ocean viewership to a terrestrial gaze. As Ann Elias explains, these forms of viewership "turn the world into information, not experience. It produces a viewer disposition to look and record but not necessarily to develop empathy."[12] Deep ocean live feeds can exacerbate what Elias describes as a colonial relation of exploration and conquest, reinscribing Western desires to capture and consume exotic images of ocean space. Blindingly bright LED lights flood the dark depths to reveal luminous jellies, vibrant hydrothermal vents, fluorescent squids—colorful worlds that come into being only as we reveal them. Riffing on Elias's term, "coral orientalism," we might call this an emergent *deep sea orientalism*.[13] Orientalism, as Edward Said explains it, describes European Western simplification and representation of the culture and civilization of the Orient for the purposes of domination and ruling over it.[14] Elias's use of this term to describe underwater space is a way of pointing to the othering dynamics that determine how Westerners imagine the tropical ocean; it also highlights reductive associations between coastal communities and exotic natural landscapes. By recommending the term "deep sea orientalism," I mean to suggest that in-situ images of the deep sea can be similarly reductive. Beyond the original intentions of public education or climate monitoring, captured images from the deep end up participating in an extractive

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[12] Ann Elias, *Coral Empire: Underwater Oceans, Colonial Tropics, Visual Modernity*, (Duke University Press, 2019): 51.

[13] Elias 21.

[14] Edward Said, *Orientalism*, (New York: Penguin Books, 2003): p. 3

political economy, whether in the form of oil monitoring systems, or the production and commodification of deep sea images for popular documentaries.

Importantly, these new underwater capabilities have once more made the idea of an amphibian humanity irresistible. For a long time, the notion of a *homo aquaticus* was tied to Western colonialism and the exploitation of new resource frontiers.[15] Ocean scholar Elizabeth Deloughrey mentions two perspectives: *aqua extraction*, which "largely figured the ocean and its resources as subject to the exploitation of discrete national territories," and *aqua homo,* a cultural approach to the ocean as a masculine, "historical space of transnational capital, empire, and slavery."[16] As I discussed in the previous chapters, a prioritization of material extractions in the design and implementation of undersea media technology has perpetuated both *aqua extraction* and *aqua homo* perspectives. But while cabled seafloor observatories may participate in these narratives, they also fundamentally change the terms by which we are able to occupy, exploit, and experience the seas.

While the ocean observing community increasingly acknowledges humanity's role as ocean polluters, the building of cabled seafloor observatories produces a sense that humans are one step closer to being in synch with the circulations and tempos of the sea. Where once, humans required "passports" to the sea—technologies like diving suits and vehicles that created what Melody Jue calls "conditional amphibiousness," ocean observatories promise long-term presence in water, enabled by internet technology. In this sense, cabled observatories seem to participate in a version of *unconditional amphibiousness* that goes

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[15] Jon Crylen, "Living in a World without Sun: Jacques Cousteau, Homo aquaticus, and the Dream of Dwelling Undersea," *Journal of Cinema and Media Studies* 58, No. 1, (Fall 2018): pp. 1-23.

[16] Elizabeth Deloughrey, "Submarine Futures of the Anthropocene," Oceanic Routes Forum, *Special issue of Comparative Literature Journal*, 69, no. 1 (2017): 32-44.

beyond visitation, although they fall short of imagining human beings themselves dwelling at the seafloor. One influential text by oceanographers Paolo Favali, Laura Beranzoli, and Angelo de Santis on the subject of seafloor observatories asserts, "The development of our understanding of the ocean has been hampered by our terrestrial existence as a species…However, a continuous interactive presence in the ocean, more analogous to how our knowledge and intuition about terrestrial environments has built up, has been elusive."[17] This passage suggests that technological permanence in the deep sea equates to a more-than-terrestrial existence for the human species; technologies are, for this group stakeholders, meaningful as extensions of humanity.

This type of temporal control has its origins in the terrestrial world. Referring to technologies such as computer-mediated phones, houses, cars, classrooms, and cities, Orit Halpern, Robert Mitchell, and Bernard Dionysius Geoghegan speak of "smartness" as a logic of "geographic abstraction, detachment, and exemption" that relies on the continuous production and incorporation of data into a global system. They call this the "smartness mandate."[18] The authors' case studies of smartness include a broad range of digital technologies, from home appliances to grids—all of which are linked through a shared logic of optimizing and making resilient a system of governing populations within technological zones. This logic is directly applicable to the ocean floor. Explicitly, undersea cabled observation is connected to smartness through the use of terms such as "Smart Ocean,"

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[17] Paolo Favali, Laura Beranzoli and Angelo de Santis, *Seafloor Observatories: A New Vision of the Earth from the Abyss*. Springer (2015): 5-6.

[18] Orit Halpern, Robert Mitchell, and Bernard Dionysius Geoghegan, "The Smartness Mandate: Notes toward a Critique," *Grey Room* 68 (Summer 2017): 113.

"SMART cables," and "Smart Oilfields" to describe various proposals for cabled observation.

Responding to this mandate, cabled ocean observatories transform the temporalities through which we experience large-scale events like climate change, shifting it from a perspective of catastrophe and rupture to one of continuity. Favali et. al. equate this temporal conquest to a way of *making the knowledge of the sea more like knowledge of land*. Arguably, this mode of construing the internet as continuous regardless of physical constraint simultaneously defines the internet as an abstract, even placeless technology—one that can extend anywhere at anytime.

In this chapter, I will address the temporal and spatial conquest that underpins the smartness mandate for our oceans.[19] While this smartness mandate could include a plethora of underwater platforms and technologies, my analysis will be limited to observatories that contain a specific set of characteristics as delimited by seafloor observatory engineers. Importantly, this means that I have chosen not to limit my analysis to a particular observatory purpose, focusing instead on technological design and capability (the same technology can be tailored to climate sensing, seismic detection, oil monitoring, or military surveillance). Technologies referred to by experts as "cabled seafloor observatories" typically share three essential elements: 1. Power and bandwidth through optical fiber, 2. plug-and-play capability for instruments, and 3. Regular service via human occupied vehicles (HOVs) or remotely operated vehicles (ROVs).[20]

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[19] As Halpern et. al. explain, "smartness colonizes space through the management of time." Ibid., 114.

[20] Arthur Baggeroer et. al., "Ocean Observatories: An Engineering Challenge," *The Bridge* 48, no. 3 (September 18, 2018): 19, https://www.nae.edu/195294/Ocean-Observatories-An-Engineering-Challenge

Beyond the technical feasibilities of such designs, I am interested in the ways in which cabled seafloor observatories articulate existing terrestrial ideas of network connectivity and the sociotechnological potentialities of the internet to an oceanic perspective on species futures. This includes unpacking the relationship between smartness and narratives about climate change and human-ocean futures. My intervention in this chapter is to consider how cabled observatories, construed to be near-unconditional amphibious technologies, interface with the agencies of the ocean itself—an agency that, as Deloughrey maintains, is coming into focus in the Anthropocene. As the effects of climate change have begun to imperil the seas, computation and automation have risen alongside resilience discourse as hegemonic solutions to dealing with an increasingly complex world under existential threat. This, I will argue, constitutes extractive mediation under different terms.

I will begin by introducing a brief history of cabled ocean observatories. Next, through an analysis of several observatories including the ONC's NEPTUNE observatory, the OOI Cabled Array, and the ALOHA Cabled Observatory, I take a closer look at how individual proto-networks have engaged with global aims, while contending with practical considerations around infrastructural resilience. Specifically, I interviewed scientists, examined documents related to the construction of media infrastructure, and drew from social media accounts that report on maintenance and labor efforts related to cabled observatories. In my research, I was intrigued by three practices in particular: the reuse and expansion of existing infrastructure, maintenance cruises, and negotiations around data distribution. Each of these aspects of seafloor observatory development demonstrate the environmental and social frictions that limit the potentialities of subsea media networks.

From there, I will reflect on the social and geopolitical role of observatories beyond their charge to record deep ocean space.

In documents about seafloor observatory development, terrestrial perspectives on communication, control, and spatial and temporal occupation tend to take precedence over discussions about nonhuman ocean futurities and exploratory ocean observation. This notion of extending the internet underwater naturalizes ideas about human evolution that privilege technological modernity and understand it as a universalizing force. However, looking at case studies of networked seafloor observation disrupts the idea of a unified amphibious futurity. Ultimately, I would like to suggest that the universalizing rhetoric of unconditional amphibiousness occludes the work of coalition-building and maintenance by a variety of stakeholders.[21] Situated in the uneven social and political landscapes of the Anthropocene, I demonstrate that global networked observation must contend with the material challenges of an aquatic environment as well as contestations between fragmented audiences.

A Brief History of Cabled Ocean Observatories

Proposals for long-term ocean observatories have existed for over twenty years, but the funding and implementation of these proposals among scientific communities gained momentum at the turn of this century. The Japan Meteorological Agency was one of the first innovators of this technology; it produced a cabled seafloor observing system as early as 1978 for the purposes of monitoring seismic activity.[22] This system was comprised of metal

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[21] See also Steven Jackson's discussion of "broken world thinking," in Steven J. Jackson, "Rethinking Repair." *Media technologies: Essays on communication, materiality, and society* (2014): 221-39.

[22] Hitoshi Mikada and Kenichi Asakawa. "Development of Japanese scientific cable technology," *OCEANS* (October 2008): 1 - 4. 10.1109/OCEANS.2008.5289426.

wires for signal transmission. Then in 1997, The Hawai'i Undersea Geo-Observatory (HUGO), funded by the National Science Foundation, acquired a fiber optic cable from AT&T and installed it at a depth of 1000 meters between Hawaii and the Loihi volcano in order to study the volcano's behavior in real time.[23] In doing so, HUGO became the first observatory to use an electro-optical telecommunications cable (replacing metal wires), providing proof of concept for the current generation of cabled observatories.

From there, things moved quickly. Following HUGO was the deployment of the Hawaii-2 Observatory (H2O) in 1998, which focuses on seismic activity. The first International Conference on Ocean Observing Systems occurred in 1999. And in 2000, the NSF approved the Ocean Observatories Initiative (OOI), an American national project to construct ocean observatories in the coastal and global ocean. Commissioned in 2016, OOI's five arrays[24] were envisioned to connect with a transnational regional observatory network in the Pacific that included Ocean Networks Canada (ONC), which now runs two networks: the Victoria Experimental Network Under the Sea (VENUS), and the North-East Pacific Time-Series Undersea Networked Experiments (NEPTUNE).[25] These scientific cabled observatories each power multiple kinds of instruments, including hydrophones, 3D cameras, pressure sensors, temperature loggers, seismometers, CTD instruments (conductivity, temperature, and depth),

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[23] Bruce Howe et. al., "Scientific Uses of Submarine Cables: Evolutionary Development leading to the ALOHA," *Mains L Haul: A Journal of Pacific Maritime History* 48, no. 3&4, (Summer/Fall 2012): 107.

[24] Broadly speaking, an array is a term referring to the systematic arrangement of data collecting instruments. Arrays can exist at multiple scales, and include ocean observatories as well as other complex survey infrastructures such as the towed hydrophone arrays discussed in chapter 2.

[25] Leslie M. Smith, John A. Barth, Deborah S. Kelley et al., "The Ocean Observatories Initiative," Special Issue on the Ocean Observatories Initiative, *Oceanography* 31 no. 1 (March 2018): 18.

flow meters, fluorometers, magnetometers, oxygen sensors, turbidity meters, underwater spectrometers, and more.

By making possible continuous virtual presence of human technologies in the ocean on a global scale, seafloor observatories inspire talk of a "paradigm shift." Take, for instance, this description from Ocean Networks Canada: "Smart Ocean™ Systems are a paradigm shift in how science and ocean monitoring is conducted. They address the limitation of conventional technologies to allow continuous year-round, sub-second observations with dozens of measurement types, accessible through the Internet to any audience."[26] In another example, the developers of the ALOHA Cabled Observatory write, "As new cables continue to be laid between continents, providing the fabric of interconnectivity required by our rapidly evolving technical society, an entirely new paradigm of ocean and geophysical measurements may be enabled."[27] Indeed, this narrative of techno-evolution and techno-utopianism is understandable when one considers that undersea media infrastructures have enabled views from the bottom that were previously only possible through the occasional deployment of deep submergence vehicles.

A similar narrative plays out in the NSF funding the Ocean Observatories Initiative. A 2001 paper by H. Lawrence Clark (NSF) announcing the OOI seafloor observatory networks states, "A new system of observatories, accessible to all investigators, would facilitate the 'temporal' exploration of our oceans."[28] This idea of exploration in the temporal dimension is

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[26] Ocean Networks Canada, "Smart Ocean™ Systems," 2020, https://www.oceannetworks.ca/innovation-centre/smart-ocean-systems

[27] Howe et. al. "Scientific Uses," 113.

[28] Clark, H.L., "New sea floor observatory networks in support of ocean science research." Proceedings of the Oceans 2001 MTS/IEEE Conf., Honolulu, HI (November 5-8, 2001): 5.

key—researchers are implying a transition of knowledge from ex-situ (off-site experimentation) to in-situ (on site research), from spatial expeditions outwards, to temporal explorations within. In the past, ocean knowledge was largely driven by sampling, as sensors and other instruments were limited by battery life and by the limitations of survey ship time. Continuously powered instruments, by contrast, create enormous volumes of data that allow scientists to pick the scale at which they sample information, as well as store data for an unlimited amount of time for future studies. This is particularly important for questions that require long term observation or real time data. For example, a scientist studying a typhoon season can now directly observe precipitation and temperature changes over the course of a storm, as well as compare storm data over several years, enabling better modeling and prediction.

At its heart, the desire to see ocean observation systems as revolutionary and groundbreaking projects capable of transforming human knowledge speaks to the urgency of our global ocean questions. Observatories give scientists the ability to make more minute kinds of observations that lead to better hindcasts and forecasts of internal ocean processes—things that shed light on climate change. The ability to form knowledge about multiple temporal scales and the circulation of sediment, nutrients, carbon, methane, and heat thus has bearing on our environmental futures. The irony is that the environmental risks that justify cabled observation are fundamentally caused by a “rapidly evolving technical society” itself, as data storage contributes an enormous portion of the world’s carbon emissions and electricity consumption. I will return to a discussion of this paradox later in the chapter.

Responding to this need, international initiatives like the Deep Ocean Observing Strategy (DOOS) are actively working to connect existing systems and user communities, and to redefine essential ocean variables for the deep. Such variables include temperature, salinity, sea level, carbon, oxygen, and other climate-related data. Regional observatory networks like the OOI Cabled Array and ONC NEPTUNE observatory are also designed to "contribute observations to the global system via cabled observatory and moored measurement systems."[29] The eventual target for most of these systems is the global-scale deployment of deep ocean platforms and sensors, beginning in areas of international interest.[30]

Case Studies

NEPTUNE predates the OOI Cabled Array, beginning operations in 2009. It is the largest cabled ocean observatory associated with Ocean Networks Canada, and is located in the Northeast Pacific Ocean, a dynamic region that lends itself to the study of land-ocean interactions, nutrient circulations, gas hydrates, and more. In fact, the large reach of this observatory allows for the observation of a wide range of environments, from coastal waves to deep sea hydrothermal vents. Like the Cabled Array, one of its nodes is at the Juan de Fuca Ridge, while others are fixed at the Clayoquot Slope, Barkley Canyon, the mid-plate at Cascadia Basin, and on the continental shelf at Folger Passage.[31] Peter Phibbs and Stephen Lentz, the designers of ONC's NEPTUNE Canada, have reiterated that wiring the ocean will

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[29] Smith et al., "The Ocean Observatories Initiative," 40.

[30] Deep Ocean Observing Strategy, "Background & Need," accessed March 22, 2019, https://deepoceanobserving.org/about/background-need/.

[31] "Observatories," Ocean Networks Canada, 2020, accessed April 13, 2020, https://www.oceannetworks.ca/observatories.

address a universal scientific need for continuous long time series measurements and multidisciplinary experiments.[32]

Located a bit further south on the Juan de Fuca plate, the purpose of the OOI Regional Cabled Array is to study "globally significant oceanographic processes" by tracking multiple variables in a dynamic region over a long period of time.[33] This includes studying biogeochemical cycles, fisheries, tsunamis, carbon flux, and plate tectonics. Locally however, the Axial Seamount is the most "magmatically robust volcano" on the Juan de Fuca Ridge, which makes it a strong candidate for the study of fluid-rock interactions, geodynamics, and turbulent mixing processes.[34] Notably, the part of the Cabled Array infrastructure at the Axial Seamount is able to provide live detection of seismic data, and has been called "the most advanced underwater volcanic observatory in the world ocean."[35]

Further into the Pacific, the ALOHA Cabled Observatory was developed and run by University of Hawai'i, Manoa in order to observe the abyssal environment north of the Hawaiian islands, a spot that is considered representative of 70% of the world ocean. In particular, it has studied carbon cycling and biogeochemical transformations in the context of climate change. In particular, temperature measurements from the site have contributed to the charting of repeated cold events, while video monitoring has led to the discovery of new benthic species as well as animal behaviors never before recorded.[36] Operational since 2012,

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[32] Peter Phibbs and Stephen Lentz, "Cabled Ocean Science Observatories as Test Beds for Underwater Technology," IEEE Conference, Oceans 2007-Europe (June 18-21 2007) **DOI:** 10.1109/OCEANSE.2007.4302268

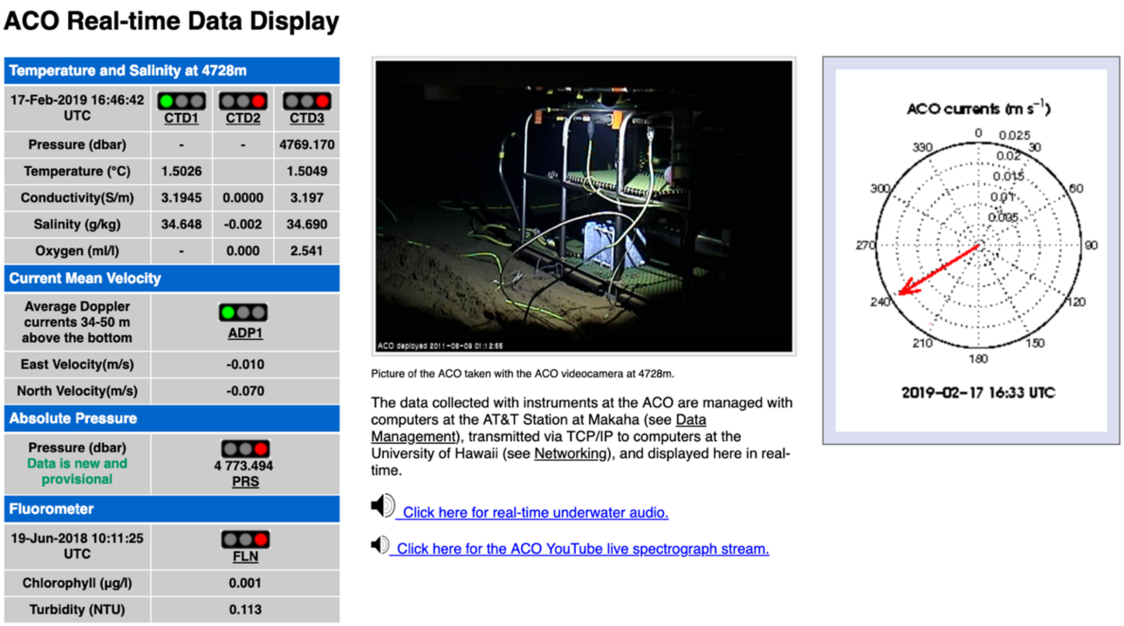
[33] Ibid., 23.

[34] "Cabled Axial Seamount," Ocean Observatories Initiative, 2018, accessed April 13, 2020, https://oceanobservatories.org/array/cabled-axial-seamount/.

[35] Smith et al., 29.

[36] Bruce Howe, "A Deep Cabled Observatory: Biology and Physics in the Abyss," *EOS* 95, no. 47 (Nov 25, 2014): 429-444.

the ALOHA Cabled Observatory is currently the deepest operating ocean observatory in the world at 4728 m, and is known for its livestreamed hydrophone data, among other sensors and instruments.



ACO Real-time Data Display

Temperature and Salinity at 4728m			
17-Feb-2019 16:46:42 UTC	CTD1	CTD2	CTD3
Pressure (dbar)	-	-	4769.170
Temperature (°C)	1.5026		1.5049
Conductivity(S/m)	3.1945	0.0000	3.197
Salinity (g/kg)	34.648	-0.002	34.690
Oxygen (ml/l)	-	0.000	2.541

Current Mean Velocity	
Average Doppler currents 34-50 m above the bottom	ADP1
East Velocity(m/s)	-0.010
North Velocity(m/s)	-0.070

Absolute Pressure	
Pressure (dbar) Data is new and provisional	4 773.494 PRS

Fluorometer	
19-Jun-2018 10:11:25 UTC	FLN
Chlorophyll (µg/l)	0.001
Turbidity (NTU)	0.113

Picture of the ACO taken with the ACO videocamera at 4728m.

The data collected with instruments at the ACO are managed with computers at the AT&T Station at Makaha (see Data Management), transmitted via TCP/IP to computers at the University of Hawaii (see Networking), and displayed here in real-time.

Click here for real-time underwater audio.

Click here for the ACO YouTube live spectrograph stream.

Figure 10. Screenshot of ALOHA Cabled Observatory web portal

In the best case scenario, adhering to big science and a data commons would facilitate scalar connections and interoperability between existing networks. The three North American prototypes that I examine are all local or regional systems that imagine possibilities for just this kind of connection. Individual networks may work together within regional networks, just as the OOI Cabled Array does with ONC’s NEPTUNE and VENUS arrays, to track meso-scale events like anomalous temperature rises, El Niño and La Niña patterns, or harmful algal blooms. Similarly, anticipating future transnational data collaborations, instruments from observatories like NEPTUNE Canada can be connected to the ALOHA Cabled Observatory (ACO) user ports, located in the deep sea off the coast of Oahu.

Imagining a FAIR network

The planetary nature of climate change, combined with the already globalized reach of cyberinfrastructure, centers discourses of global cooperation, commoning, and shared research within the ocean observing community. As most oceanographers recognize, an interdisciplinary approach to the oceans is endemic to the field, which requires knowledge of large-scale, long-term systems of interaction between land, ocean, and atmosphere. The belief becomes the lack of visibility of the seafloor is at least in part to blame for continued abuse and exploitation of ocean environments, and that continuous visibility, predictive ability, and shared knowledge can be a step in repairing our relationship to oceans and preempting our reactions to environmental changes.

While planetary research provides scientific drivers for the building of a global ocean observing system, the network itself also plays a part in reinforcing global imaginaries. In his work on global climate infrastructures, Paul Edwards considers the role of data models and technical systems in constructing ways of thinking globally: "Instead of thinking about knowledge as pure facts, theories, and ideas—mental things carried around in people's heads, or written down in textbooks—an infrastructure perspective views knowledge as an enduring, widely shared sociotechnical system."[37] Edwards' infrastructural perspective makes the point that media technologies are constitutive of culture, being, and thought—an idea shared by anthropologist Edwin Hutchins, who contends, "human cognition is always situated in a complex sociocultural world and cannot be unaffected by it."[38] Notions of the ocean as a globally connected system must therefore must be understood in the context of social and

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[37] Paul Edwards, *A Vast Machine: Computer models, climate data, and the politics of global warming.* (Cambridge, MA: MIT Press, 2010, Kindle Edition), 737.

[38] Edwin Hutchins, *Cognition in the Wild,* (Cambridge, MA: MIT press, 1995), xi.

technical systems that have also arranged marine data collection around ideals of an unlimited, globally accessible feed.

Specifically, to support the aims of climate monitoring, there is a widespread call among oceanographers to incorporate seafloor infrastructures into a data commons. This call is reflected in the FAIR Data Principles—a general (not ocean-specific) scientific guideline that emphasizes findability, accessibility, interoperability, and reusability. Endorsed by a group of stakeholders representing academia, industry, and funding agencies, a March 2016 issue of *Nature* outlines the FAIR Principles: "Importantly, it is our intent that the principles apply not only to 'data' in the conventional sense, but also to the algorithms, tools, and workflows that led to that data...The emphasis placed on FAIRness being applied to both human-driven and machine-driven activities, is a specific focus on the FAIR Guiding Principles that distinguishes them from many peer initiatives."[39] The FAIR principles thus define both humans and machines as citizens of a digital scientific ecosystem.

The FAIR principles delineate a new an environmental citizen that is dependent on shared, yet differently articulated participations of human, nonhuman, and more than human bodies. This resonates with what Gabrys has called a "becoming environmental" of computation. In her book, *Program Earth,* Gabrys seeks to describe the new forms of subjectivity that emerge from large-scale distributed sense networks. Gabrys takes up Canguilhem's notion of exterior milieus, thinking about them in a situated sense as multiple zones of transfer and inhabitation which designate spaces in communication. A milieu is not just a connection point for sensing, but "a transformative and immanent process where

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[39] Mark D. Wilkinson et. al., "The FAIR Guiding Principles for scientific data management and stewardship," *Nature* (March 2016): 1, 3, https://www.nature.com/articles/sdata201618

modes, capacities, and distributions of sense concresce through the experiences of multiple subjects."[40] As milieus connect through sensor networks, they intensify, leading to ecologies of amplification. Gabrys expands sensing beyond observation to observing proxies, which come to generate notions of distributed sense. This means that citizens, animals, and technologies can all be equal sensing subjects in a networked observatory. Indeed, while I do not focus on the use of living sensors as nodes within the ocean observing network (the focus of this chapter is limited to cabled observatories), both humans and animals have been recruited to witness within networked ocean observing configurations. Distributed sense networks shift ocean knowledge away from the epistemologies of the survey or the sample, to one where many more, continuous measurements of fixed locations are possible.

The main principles of FAIR are also related to other practical approaches to ocean infrastructure that include the "Big Science" argument, or the idea that "no single scientist or group of scientists should be given unrestricted, private access to research infrastructure of that scale…its use should be shared, optimized and audited."[41] However, this perspective has not always been mainstream. Oceanographer Deborah Kelley explains, "Growing up, you hoarded your data because that's how you made your name. Now, the evolution is data for all."[42] Helmed by researchers like Kelley, the first generation of cabled seafloor observatories now internalize mandates of access and sharing. Often, this rhetoric re-inscribes an idea of the commons in digital space—overlaying it upon the existing international commons that defines the deep sea. At Ocean Obs '19, Ambassador Peter Thomson, UN Special Envoy for

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[40] Jennifer Gabrys, *Program earth: Environmental sensing technology and the making of a computational planet*, (Minneapolis, MN: University of Minnesota Press, 2016), 52.

[41] Favali et. al., *Seafloor Observatories*, 131.

[42] Deborah Kelley, interview by author, Corvallis, OR, March 20, 2019.

the Ocean (responsible for leading UN advocacy and outreach around the sustainable use and conservation of the ocean's resources), spoke of a "fully integrated ocean observing system" freely available for the "common benefit of the people on the planet." OOI also includes this rhetoric; its system "provides 24/7 connectivity to deliver ocean observing data to anyone with an Internet connection free of charge."[43] This language contains clear echoes of Common Heritage of Mankind, the legal doctrine used to regulate deep sea mining and other extractive activities in the deep seabed. As I will contend however, the preclusion of unrestricted, private access to large-scale data infrastructure is no certainty.

What is envisioned as a shared, globally unified distributed network is challenged by the presence of fragmented material conditions and audiences. While they are imagined to partake in a global project, observatories are distinct in kinds of data they collect, the questions they are asked, and the conditions they must weather. These factors limit the degree to which we can achieve ubiquitous occupation of the oceans and thus, an amphibious human future. As digital media scholar Yanni Loukissas would say, "all data are local."[44]

Maintaining Network Resilience

Edwards' idea of infrastructure centers sustainability, endurance, and reliability in conditions of changeability. Resilience, in other words, is central to the concept of infrastructure itself. For oceanographers, discourses of resilience span multiple scales: from the logistics of individual cabled observatory development, to data resilience, to more abstract notions of resilient knowledge over generations. Physical resilience and knowledge

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[43] Smith et al., 33.

[44] Yanni Alexander Loukissas, *All data are local: Thinking critically in a data-driven society*, (Cambridge, MA: MIT Press, 2019).

resilience are connected—a resilient knowledge system requires a centralized archive from which to store and access data, and that archive must be maintained despite environmental perturbations. The additional global scale of the imagined ocean fitbit generates further speculation about its multigenerational longevity: “The complexity is so large that it is impossible for a single person or small group of people to remember everything about the system.”[45] Network resilience therefore entails producing a system that will be operational for generations.

I critiqued resilience discourse in chapter three, explaining the ways in which resilience thinking both assumes perpetual crisis and provides justification for necropolitical policies that redefine the lives of deep sea dwellers as necessary sacrifices. Outside of resource extraction, the close relationship between neoliberal governance and resilience thinking, as described by Melinda Cooper and Jeremy Walker, is also amplified through the building of smart infrastructures.[46] As Halpern puts it, “smartness enables *resilience.* This is its goal and raison d’être…we describe resilience as a state of permanent management that does without guiding ideals of progress, change, or improvement.”[47] However, creating subsea observation networks is a challenging endeavor that requires constant attention and innovation. In this vision for unconditional amphibiousness and climate resilience, what does resilience consist of on a material level?

a. Piggybacking

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[45] Favali et. al., 148

[46] Melinda Cooper and Jeremy Walker, “Genealogies of Resilience: From Systems Ecology to the Political Economy of Crisis Adaptation,*” Security Dialogue* 42, no. 2 (2012): 81.

[47] Halpern et. al., “The Smartness Mandate,” 121.

Every seafloor observatory includes primary infrastructure consisting of fiber optic cables, shore stations, junction boxes, and observatory modules, as well as secondary infrastructure, which includes the components between user ports and specific sensor instruments. The design and deployment of such delicate technologies is no easy task, and thus the resilience of observatory systems is increased through practices that take advantage of existing infrastructure. In fact, seafloor observation networks are largely possible in the first place because the global internet itself exists partially underwater. Nicole Starosielski charts this network of fiber-optic cable in her volume, *The Undersea Network,* noting the ways in which submarine internet infrastructure is made invisible to the public. Many previous generations of cable technology are now defunct, leaving miles of obsolete cabling at the ocean floor.[48] This undersea network largely provides the basis for many subsequent cabled observation projects. Proposals for an "Oceans 2.0" by organizations like Ocean Networks Canada (ONC) recommend refitting telecommunications cable infrastructure for the purposes of underwater observation. Old or decommissioned cables are also sometimes recycled by research institutions to provide support for ocean observatories. As Edwards puts it, "Infrastructure is sunk into, inside of, other structures, social arrangements, and technologies" (554). In aggregate, I refer to this cluster of infrastructure-building strategies as "piggybacking." As I began to argue in chapter 3, oceanographic research is reliant on piggybacking as a means for collecting novel data in the ocean. This is both a practical and theoretical concern—piggybacking reflects the FAIR principle of reusability as well as

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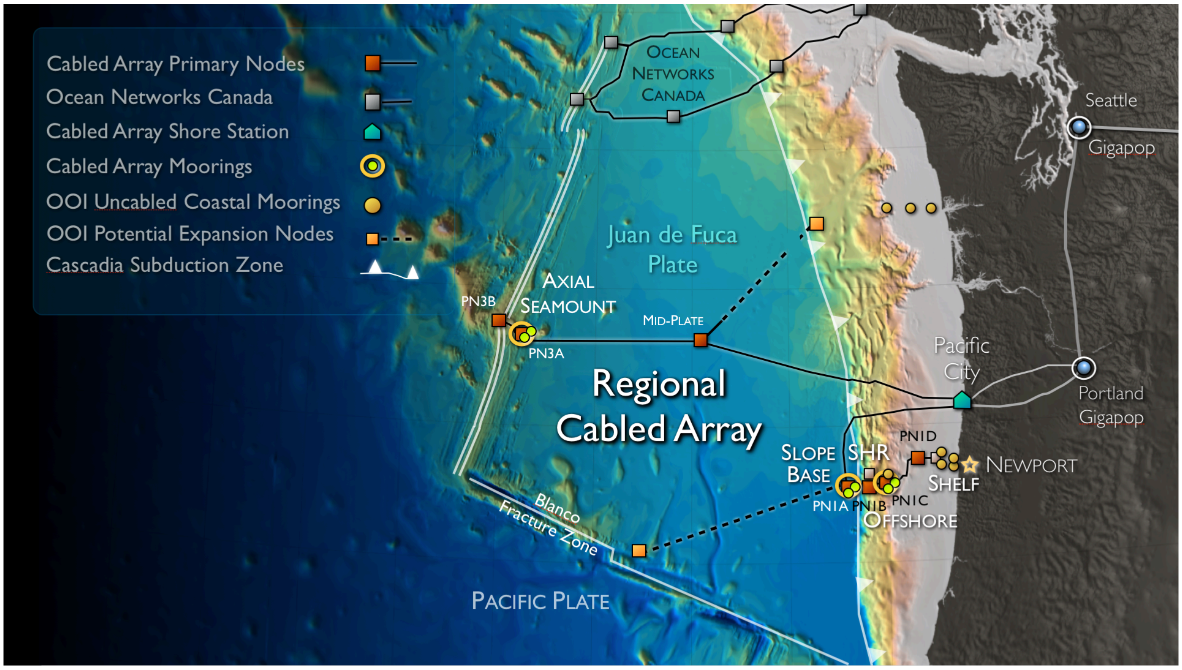
[48] Duncan Geere, "How the first cable was laid across the Atlantic," *Wired,* January 18, 2011, https://www.wired.co.uk/article/transatlantic-cables

facilitating industry collection. Thus, the prospective, globally integrated observation infrastructure will largely map onto existing internet infrastructure.

For both the ALOHA Cabled Observatory and the OOI Cabled Array, piggybacking was a necessity that required regular collaborations between scientists and industry actors. The ALOHA Cabled Observatory was piggybacked on the backbone of a decommissioned first generation telecommunications cable terminating on Oahu. The HAW-4 cable, originally owned by AT&T, had been working for 20 years prior to its repurposing.[49] The existence of an old transoceanic cable system provided a cost effective means of providing power and communications bandwidth to the observatory: "Since the cable is already in-place and is designed to operate for well beyond its commercial lifetime, costs of conversion to scientific use are substantially lower than for new systems."[50]



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[49] Marcie Grabowski, "Deepest ocean observatory celebrates 10 years of operation," *University of Hawai'i News*, April 24, 2017.

[50] Bruce Howe et al., "ALOHA cabled observatory installation," OCEANS'11 - MTS/IEEE Kona, Program Book (2011).

Figure 11. The Regional Cabled Array spans the Juan de Fuca Plate. Photo courtesy of University of Washington and Center for Environmental Visualization[51]

By contrast, the OOI Cabled Array is distinct in that its primary infrastructure was mostly built and designed from the ground up, with the exception of the shore station. Nevertheless piggybacking was a part of almost every level of production and deployment. First, the site of the Oregon cable was itself selected based on the presence of previous infrastructure—specifically, “its proximity to the historic Newport Hydrographic Line that has been sampled regularly since 1961.”[52] According to Deborah Kelley, director of the Cabled Array, the selection of OOI sites hinged heavily on not only scientific merit, but also a calculation around costs and potential conflicts and complications, determined with the help of Navy engineers, telecommunications experts, and fishermen.[53] The array was then also piggybacked on top of an abandoned shore station in Pacific City, once owned by a company that had gone bankrupt.

In 2014, a company called L3 Maripro manufactured and installed the primary infrastructure and secondary infrastructure for the OOI Cabled Array based on designs by an external telecommunications committee.[54] Running from the main shore station of the Cabled

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[51] “The Regional Cabled Array infrastructure spans the Juan de Fuca Plate with one 521 km long backbone cable connecting infrastructure located at the base (PN3A) and the summit (PN3B) of Axial Seamount (45°56’N; 129°59’N), and another southern line that connects infrastructure at the base of the continental margin (Slope Base – PN1A), the active methane seep site at Southern Hydrate Ridge (SHR) 10 km north of the Primary Node PN1B, and the Oregon Offshore (PN1C) and Shelf sites (see Figure 2). A 17 km cable connects PN1D to the shelf site. Primary cables are buried ~1 m beneath the seafloor to 1,500 m water depth. A highly expandable plan includes arrays at the Blanco Transform Fault and at the subduction zone off of Grays Harbor. A 5 km cable extends from the Mid-Plate node (5A), allowing easy expansion in the future to the Grays Harbor site.” Smith, Barth, and Kelley, 23.

[52] NSF Ocean Observatories Initiative, *OOI Coastal Endurance Array* (Woods Hole, MA: Ocean Observatories Initiative, 2018)

[53] Kelley, interview by author.

[54] Kelley, interview by author.

Array are two backbone cables: one to the Axial Seamount, and another to the base of the Cascadea subduction zone and then offshore of Newport, OR. The directors note, "The backbone cable is comprised of approximately 900 km of telecom industry subsea electro-optical cable that provides 8 kW of power and redundant 10 Gbps data communications to each primary node."[55] This does not reflect the most current fiber-optic cable capabilities. 10 Gbps was the standard bandwidth for submarine telecommunications cables in the 1990s. By 2010, the telecommunications industry was regularly using fibers that could transmit 10 times that amount.[56] The Cabled Array's primary nodes convert and distribute power and communication from the shore station to a set of junction boxes, which then extend power to a secondary infrastructure that provides access to seven observational nodes equipped with low-voltage instruments along the southern Juan de Fuca plate. Sensors include seismometers, hydrophones, pressure devices, a high-definition video camera, a long-duration fluid sampler, a mass spectrometer, benthic flow meters, and more.

Each year, OOI research teams return to the sites for maintenance purposes—an opportunity to piggyback new research questions onto the necessary ship time. Brendan Philip, a longtime OOI researcher and participant in multiple Cabled Array cruises remarks: "It's a 25-year program and you have committed to sailing every year to service your arrays." He continues, "that is a tremendous opportunity for students and researchers on board to do research that leverages the OOI instrumentation. The OOI is more than just data streaming to shore, it is also about the additional science you can do while you are out there."[57] The

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[55] Smith et al., 29.

[56] Jeff Hecht, "Submarine cable goes for the record: 144,000 Gigabits from Hong Kong to L.A. in 1 second," *ITU News*, January 5, 2018, https://news.itu.int/submarine-cable-hk-la/.

[57] Leslie Smith, "[Early Career Highlight]—Brendan Philip— From a life on the sea surface to exploration of the seafloor," Ocean Observatories Initiative (July 11, 2018),

Cabled Array thus relies on piggybacked infrastructure, while generating new opportunities for future piggybacking.

While it is a cost effective means to build ocean networks, the use of recycled cables may change, as submarine cable manufacturers adapt their telecommunications systems for scientific use. There are already proposals for Scientific Monitoring and Reliable Telecommunications (SMART) cables, which seek to add temperature and pressure sensors in addition to other kinds of instrumentation at regular intervals onto commercial submarine telecommunications cable systems.[58] These proposals would attach sensors to the cable itself, meaning cables themselves would multitask as transmission devices as well as sensing agents. In fact, there is a precedent for this in the early history of telephony. Decades before wireless telegraphy was invented, Thomas Watson, Alexander Graham Bell's assistant, first listened to natural radio waves through telephone wires, which were able to sense and transduce electromagnetic currents from the environment: "The sensitivity of the device that made it possible to hear voices also made it possible for Watson to hear natural radio."[59] More than transmitters of intentional signals, telephone wires also acted as sensors, bringing electromagnetic waves into frequencies audible to human hearing. Similarly, undersea fiber-optic cables, with the help of instrument attachments, can now act as environmental sensors.

b. Resilient Design

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https://oceanobservatories.org/2018/07/early-career-highlight-brendan-philip-from-a-life-on-the-sea-surface-to-exploration-of-the-seafloor/.

[58] Bruce Howe, "From space to the deep seafloor Using SMART submarine cable systems in the ocean observing system," Report on two NASA Workshops, September 7, 2015, http://www.soest.hawaii.edu/NASA_SMART_Cables/.

[59] Douglas Kahn, *Earth Sound Earth Signal: Energies and Earth Magnitude in the Arts,* (Berkeley: University of California Press, 2013), 27.

The overcoming of water—a medium long associated with mechanical breakdown—means that the internet itself is increasingly seen as a placeless technology. But of course, as Shannon Mattern reminds us, these aspirations of collapsing time and space are made possible by digital networks that "have a fixed geography—one that's both centralized *and* distributed, and impacted by their place within a material urban landscape."[60] However, while we now have robust technological capabilities underwater, aquatic conditions entail very different kinds of challenges than terrestrial networked infrastructure. In an aquatic environment, creating stable, long-term infrastructures is a Herculean task, and it is no wonder that oceanographers piggyback onto the telecommunications industry in order to build their observatories. The machines of man have historically been designed to avoid getting wet. Water erodes, it corrodes, and it causes rot. And so, as we continue innovating in the oceans, we devote more money and more time to resilient design, maintenance, and repair. Of course, this has not stopped efforts to design for wet environments, evidenced by the Microsoft's Project Natick, an experimental plan for subsea datacenters off the coast of Scotland.[61]

Possible problems in networked ocean infrastructure include power failure and material breakdowns. For instance, the Cabled Array and the Aloha Cabled Observatory have both contended with connector issues. Even when the ACO was first deployed in 2012, this was a major challenge, particularly in the cold, high pressure environment: "Some of the instrumentation are not working and the high pressure and near-freezing temperature,

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[60] Shannon Mattern, "Waves and Wires," in *Code and Clay, Data and Dirt: Five Thousand Years of Urban Media,* (University of Minnesota Press, 2017).

[61] Matt Burgess, "Is it a really good idea to dump data centres at the bottom of the sea?" *Wired,* June 8, 2018, https://www.wired.co.uk/article/microsoft-data-centre-orkney-sinks-project-natick.

coupled with the still-all-too-common cable and connector problems are likely factors in these failures."[62] Marine organisms also cause infrastructural breakdown. "Biofouling" is a term used by marine scientists and engineers to describe the gradual accumulation of aquatic organisms on man-made structures. In everyday life, we may think of the proliferation of barnacles on ship hulls, or the gathering of algae on underwater sensors and moorings. For all marine industries, from scientific research to fishing, biofouling costs millions every year. And so, even as we act to save aquatic ecosystems, we bemoan the seawater and the organisms that blanket our cables, weigh down our platforms, and break down our pipes.

With these multiple ongoing processes of breakdown, we then shift from imagining media interfaces as merely apertures into the virtual, to material objects that exist in time. Undersea networks all have a certain lifespan, determined not only by their design, but by their ability to weather ocean environments. So far, the estimates seem relatively modest. OOI infrastructure is meant to "provide sustained measurements for 25 years."[63] ONC's NEPTUNE observatory has a lifespan of up to 30 years.[64] The more multifunctioning a system is, the higher the risk and the lower the reliability. The main question becomes, how long can we go without having to return for an expensive maintenance trip? How do we extend the lifespans of our underwater equipment?

Resilient design starts with choosing the right materials to build with. In seawater, aluminum dissolves quickly, while copper corrodes. Titanium, which resists corrosion, is the preferred choice of metal for resilient housings.[65] Specific components, like the Cabled Array

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[62] Bruce Howe et. al., "Scientific uses of Submarine Cables," 112.

[63] Smith, et. al., 17.

[64] Chave, "Seeding the Seafloor."

[65] Kelley, interview by author.

moorings, are designed to stay in place for at least five years, optimizing maintenance costs. Meanwhile, high pressures at depth require the use of pressure tolerant housing and specially designed cables and connectors. To keep things running, observatories are equipped with alerts and alarms, backup generators, and other monitoring technologies.[66] OOI researchers explain, "System health and status for cabled infrastructure is closely monitored, 24/7 in real time from shore…Across the facility, instruments and platforms are monitored for safety, functionality, and basic data quality."[67] What is notable in this description is once again the use of medical metaphor; the health of the fitbit, like that of the ocean, must also be continuously monitored and optimized.

Meanwhile, biofouling is a unique aquatic obstacle that is dealt with through the application of several kinds of antifouling techniques. A very typical and popular antifouling technique, particularly for the bottoms of ships, is to use a special kind of coating or paint that slows biological growth. These paints are usually formulated with copper compounds or biocides. Many soft bottom paints will then release copper or zinc biocides into the water column over time. Harder paints create a kind of porous film that contains and releases biocides slowly, or use Teflon and silicon coatings to create slick, slippery surfaces.[68] [69]

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[66] Jim Potemra, interview by author, Honolulu, HI, September 20, 2019.

[67] Smith et. al., 30-31.

[68] Ramesh Tripathi, "Advances in Antifouling Coatings Technology," Coatings World, October 10, 2016, https://www.coatingsworld.com/issues/2016-10-01/view_features/advances-in-antifouling-coatings-technology/

[69] Antifouling paints, such as the ones made of copper compounds, have encountered some pushback in regards to their toxicity, the fact that they do leach extremely toxic chemicals into the water column. In 2018, Washington state actually voted to phase in a ban on copper antifouling coatings (the ban has since been delayed). Salvatore Chiavarini, Carla Ubaldi, and Sigfrido Cannarsa, "Biocides in antifouling paints: environmental concentration levels and distribution," *Energia, Ambiente e Innovazione* 52 (2014). 10.12910/EAI2014-45; https://www.marinadockage.com/washington-state-halts-ban-antifouling-copper-paints/

However, traditional antifouling paints and coatings do not work well for cabled observatories because of the sensitive and complex nature of the sensors and instruments attached to them. Antifouling paints also have their own finite lifetime, which is not ideal for a long-term system. As a result, UV antifouling systems have emerged as an alternative on the basis that they are non-contact and relatively non-toxic. These systems integrate UV-light emitting diodes into protective coating. This is used both by the Ocean Observatories Initiative and Ocean Networks Canada. The Cabled Array additionally fixes their HD camera with a small brush that periodically wipes its surface.

The myriad of antifouling practices is evidence of the extraordinary labor and money that goes into making a media interface invisible in an underwater environment, and to some extent, the inevitability of its reemergence as a material surface through its demise and breakdown. For me, biofouling points to a technological modernity that is anchored outside of water. The fouled interface is an object with multiple functions beyond information communication, including but not limited to, acting as a dwelling space for marine organisms. However, when marine industries characterize aquatic colonizers as "biofouling agents," they mark a nomadic subject which disobeys and disrupts bounded structures, and is therefore often deemed monstrous or abject.[70]

c. The Maintenance Cruise

Every smart system requires regular maintenance, but when it comes to aquatic observatories, a maintenance cruise entails enormous efforts in organization and planning.

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[70] Rosi Braidotti, "Posthuman Critical Theory," in Banerji D., Paranjape M., eds., *Critical Posthumanism and Planetary Futures*, (New Delhi: Springer, 2016).

When breakdowns happen, they cannot be fixed immediately. Jim Potemra, one of the Principal Investigators of the Aloha Cabled Observatory, spoke about the stakes of ensuring that instrumentation works in the initial stages: “If things fail they fail immediately because of the pressure. If things are working for several days, they keep running for years.” Typically, maintenance cruises happen only once a year, and the cruise schedule is cost prohibitive.[71] National Oceanographic Laboratory System (UNOLS) vessels—large ships owned by the Navy, NSF, and other oceanographic institutions—sail annually to maintain observatories like the Cabled Array. OOI researchers explain, “The degradation of mooring components, biofouling of instruments, and depletion of batteries on the uncabled profiler moorings are the main drivers of the OOI moored array maintenance schedule.”[72] Often, maintenance cruises carry ROVs to help accomplish tasks at the seafloor. In addition, the shore stations occasionally encounter issues due to large storms.

Perhaps the complexity of these cruises is the reason why maintenance expeditions are some of the most well-documented, visible aspects of oceanographic research. As I previously explained, cruises are multifunctioning—they act as opportunities to fix infrastructure, take measurements, gather data for novel research questions, and document oceanographic activities for the public. Ocean Networks Canada and the Ocean Observatories Initiative both have well maintained Instagram pages that follow the maintenance cruises and turn them into educational opportunities. The ALOHA Cabled Observatory also documented its 2011-2015 deployment cruises on Instagram, although it has not been updated since.

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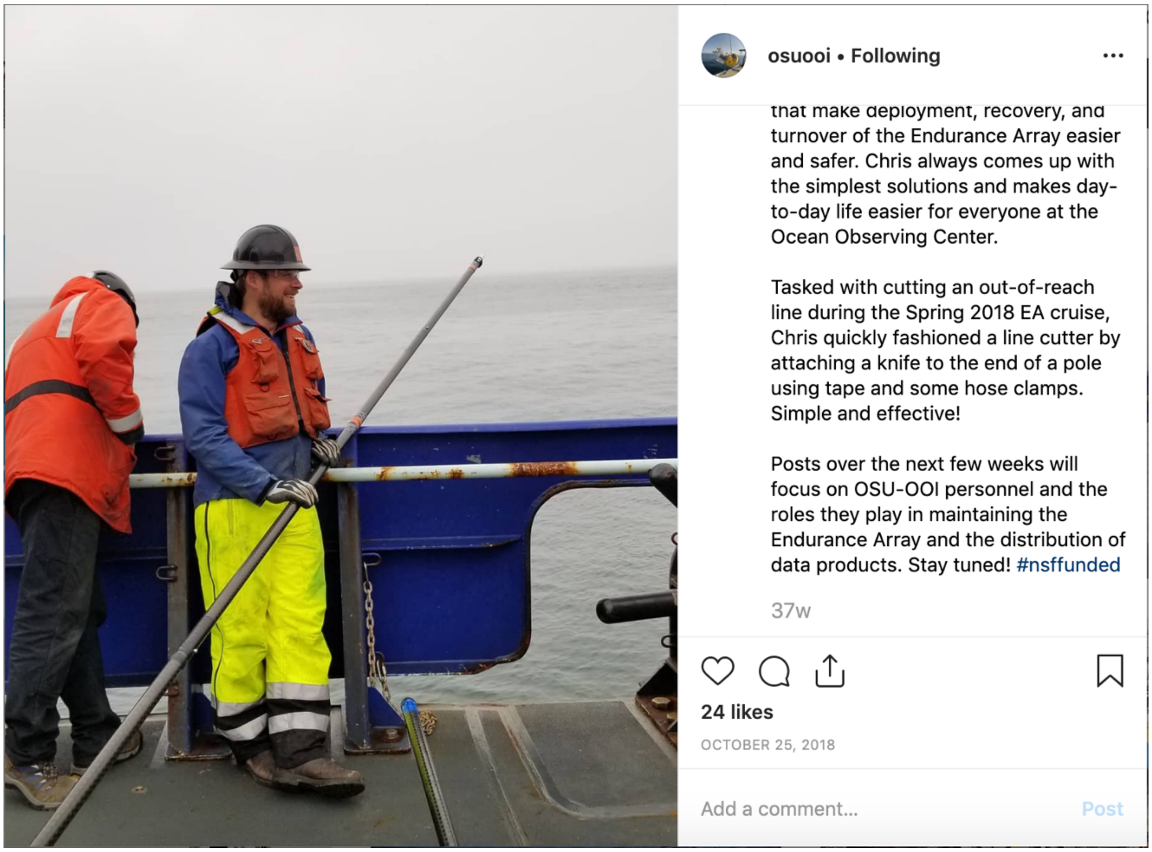
[71] Potemra, interview by author.

[72] Smith et al. 31.



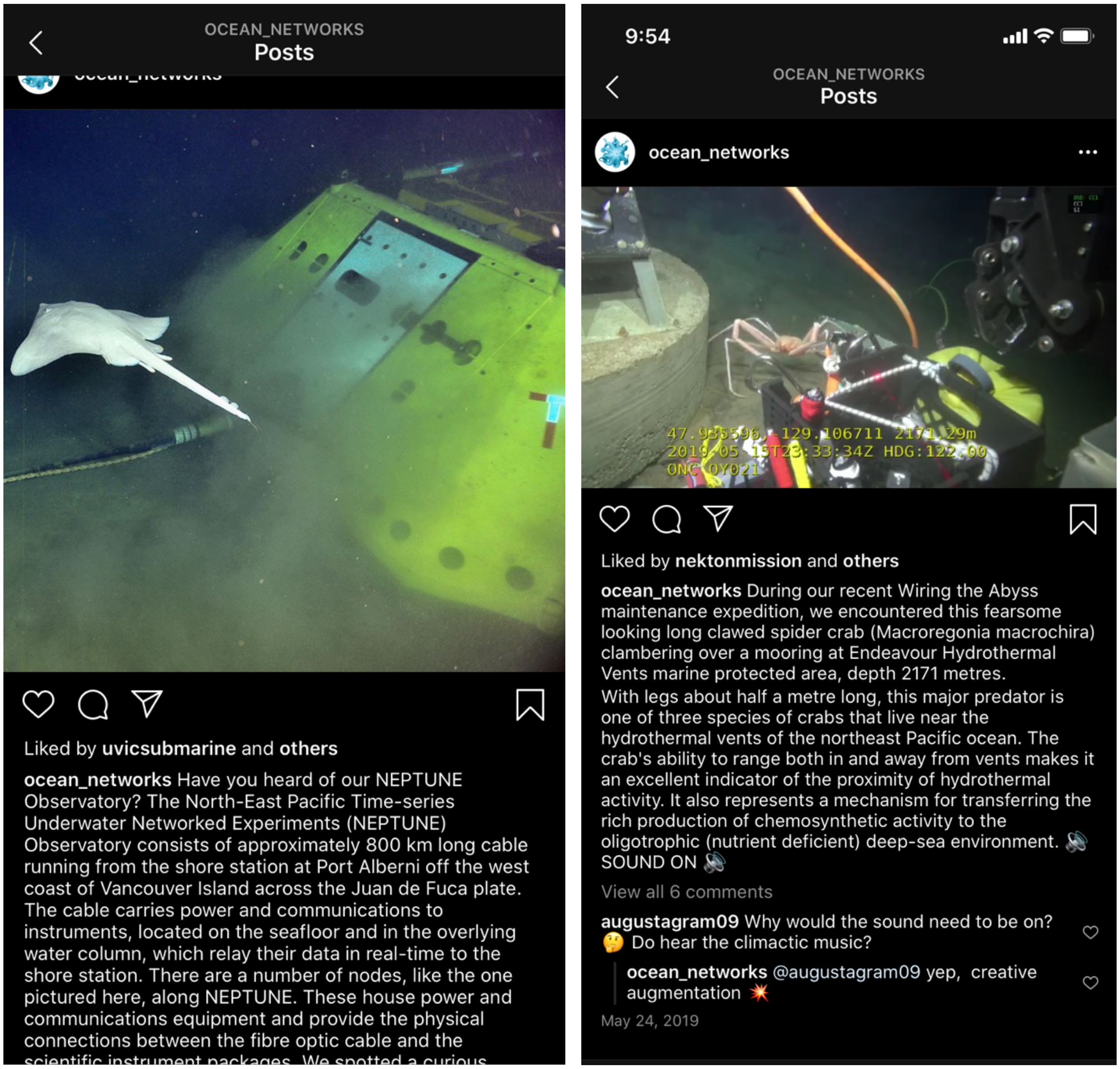
that make deployment, recovery, and turnover of the Endurance Array easier and safer. Chris always comes up with the simplest solutions and makes day-to-day life easier for everyone at the Ocean Observing Center.

Tasked with cutting an out-of-reach line during the Spring 2018 EA cruise, Chris quickly fashioned a line cutter by attaching a knife to the end of a pole using tape and some hose clamps. Simple and effective!

Posts over the next few weeks will focus on OSU-OOI personnel and the roles they play in maintaining the Endurance Array and the distribution of data products. Stay tuned! #nsffunded

Figure 12. @osuooi Instagram post about the Endurance Array (powered by the Cabled Array), October 25, 2018

ONC posts on Instagram every 2-3 days, and offers detailed descriptions of instrument deployments using hashtags such as #wiringtheabyss, #knowtheocean. These are mixed in with images of octopuses, anglerfishes, ocean perches, squids, whalefish, and other organisms. Like other ocean outreach programs, maintenance cruises provide an opportunity for oceanographers to humanize their labor, as well as introduce the general populace to deep sea ecosystems.



Liked by **uvicsubmarine** and **others**

ocean_networks Have you heard of our NEPTUNE Observatory? The North-East Pacific Time-series Underwater Networked Experiments (NEPTUNE) Observatory consists of approximately 800 km long cable running from the shore station at Port Alberni off the west coast of Vancouver Island across the Juan de Fuca plate. The cable carries power and communications to instruments, located on the seafloor and in the overlying water column, which relay their data in real-time to the shore station. There are a number of nodes, like the one pictured here, along NEPTUNE. These house power and communications equipment and provide the physical connections between the fibre optic cable and the scientific instrument packages. We spotted a curious

Liked by **nektonmission** and **others**

ocean_networks During our recent Wiring the Abyss maintenance expedition, we encountered this fearsome looking long clawed spider crab (Macroregonia macrochira) clambering over a mooring at Endeavour Hydrothermal Vents marine protected area, depth 2171 metres.

With legs about half a metre long, this major predator is one of three species of crabs that live near the hydrothermal vents of the northeast Pacific ocean. The crab's ability to range both in and away from vents makes it an excellent indicator of the proximity of hydrothermal activity. It also represents a mechanism for transferring the rich production of chemosynthetic activity to the oligotrophic (nutrient deficient) deep-sea environment. 🔊 SOUND ON 🔊

View all 6 comments

augustagram09 Why would the sound need to be on? 🤔 Do hear the climactic music?

ocean_networks @augustagram09 yep, creative augmentation 💥

May 24, 2019

Figure 13. Instagram posts from @ocean_networks (ONC), December 17, 2019 (left) and May 24, 2019 (right)

Like other ocean researchers, cabled observatory maintenance workers are accorded status as intrepid explorers and technology experts who must battle the challenges of weather, currents, and low visibility. This kind of spectacular maintenance is a means to communicate new human-ocean kinships. Such Instagram accounts serve in large part to demonstrate the biodiversity of the deep sea and foster empathy for ocean ecosystems, while simultaneously promoting underwater connectivity as a means to protect those same environments.

However, while maintenance videos provide many educational opportunities, they fail to address the central causes of ocean warming and other climate change-related ailments. In particular, the implied equation between technological resilience and environmental resilience in seafloor observatory networks is fundamentally flawed: a technological society is also one that pollutes and thus creates environmental crisis. Scholars working in environmental media studies have already started to shed light on the environmental costs of a high-tech society, which includes everything from toxic mining practices for rare earth minerals, to the massive amounts of pollution emitted by data centers.[73] As such, justifications for the smartness mandate ultimately fail when examined from the perspective of the Anthropocene, a geological timescale that accounts for human perturbations in the environment in aggregate. In the next section, I will discuss the fragmentation of stakeholders that use cabled observatory systems to further make the argument that an ocean fitbit does not itself guarantee environmental (or social) justice.

User Fragmentation

My case studies represent an early generation of deep sea cyberinfrastructure for scientific aims, and are thus largely democratic examples of how ocean observatories can work. However, there are many factors that limit the possibilities for an open and democratic use of a seafloor smart system. Researchers involved in developing cabled observatories acknowledge this in terms of data gaps, which can render a data set less useful: "If there were a weakness in the OOI for GOOS [the Global Ocean Observing System], it would be a

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[73] See Richard Maxwell and Toby Miller, *Greening the media* (Oxford University Press, 2012).

failure to report some key data openly in near-real time for societal uses…"[74] However, these data gaps are not just hypothetical. Bringing the "weakness" of ocean observatory networks to light requires asking a new set of questions around the users and uses of cabled observatories: Who builds and who pays for these systems? Who stands to benefit? One unanswered audience question at Ocean Obs'19 stood out to me in particular: "How can we build a global ocean observing system with no borders and sustained funding?"

At the NSF's Future of Seafloor Science and Engineering Conference (FUSE) in June 21-22, 2019, a Woods Hole Oceanographic Institution engineer named Anna Michel spoke at length about the economic challenges of building technologically complex seafloor systems. In her talk, she argued that ocean engineering is becoming increasingly esoteric, rendering the market for state-of-the-art, scientific monitoring infrastructure too small to be self-sustaining. The talent pool for underwater engineering is shrinking simultaneously: "Apple, Google, and Facebook are taking all the talent and then closing everything off."[75] Upon hearing this statement, the conference room resounded with agreement—private companies, it seems, are worse than the military when it comes to closing off what should be open data systems. Often, when a project gets funded, researchers who might otherwise have created a data commons lose autonomy. At FUSE, one scientist quipped: "The good news is, you're funded. The bad news is, you're funded." When I pressed for examples, however, my interviewees informed me that they were unable to provide specifics for fear of legal retaliation.

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[74] Smith et al. 40.

[75] Anna Michel, "Sensors," Frontiers in Underwater Science and Engineering (FUSE), Northeastern University, Boston, MA, (June 21, 2018).

A brochure for Ocean Networks Canada reads, "Think of it as a Fitbit for the Ocean. Made possible by world-leading Oceans 2.0 data management software, Ocean Networks Canada's (ONC) infrastructure is continuously monitoring the pulse and vital signs of our deep sea and coastal environments."[76] Upon seeing a description of ocean observation networks as wearable technology for the sea, I paused to think of its terrestrial analogue. It is significant that justifications for cabled observatories are filtered and made legible to a broad audience through references to the Internet of Things. Analogies like the fitbit are distinct choices that emerge from a Western media landscape premised on data extraction and capitalist enclosures in digital space. And, as my other chapters contest, private industry and state projects already take precedence over scientific aims of inclusion in other oceanographic contexts. The cabled observatories of the future will be no exception.

David Lyon and Zygmunt Bauman have spoken of "liquid modernity" and "liquid surveillance" as a way of specifying the fluidity and immersive qualities of modern surveillance: "Old moorings are loosened as bits of personal data extracted for one purpose are more easily deployed in another…surveillance spills out all over."[77] Indeed, it seems fitting that a culture of liquid surveillance should give rise to the surveillance of liquids. Our wearables and our phones give rise to data bodies that can be monetized, inputted into databases, and monitored from afar. Our bodies, like the body of the ocean, are now subject to what Eugene Thacker calls "biological exchange," "the ability to render the biological not only as information, but as mobile, distributive, networked information."[78]

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[76] Ocean Networks Canada, *Oceans 2.0.*

[77] Zygmunt Bauman and David Lyon, *Liquid surveillance: A conversation*, (John Wiley & Sons, 2013), 9.

[78] Eugene Thacker, *The global genome: Biotechnology, politics, and culture* (Cambridge, MA: MIT press, 2006), 7.

In fact, the fitbit, a device that collects data about individual bodies and feeds it into larger databases and user networks, is a stellar example of the smartness mandate as defined by Halpern et. al. If fitness referred to bodily optimization on an individual level, smartness is a collectively defined parameter of optimization on the level of the population. In other words, "fitness" in the twenty-first century has become a synonym for optimization—the concept that describes the underlying goal of all smart systems: "discrete data populations enable processes to be optimized (i.e., enable 'fitness' to be determined), which in turn produces new populations of data and hence a new series of potentialities for what a population is and what potentials these populations can generate."[79] Halpern et al. argue that this "optimization fever" universalizes and naturalizes the logic of algorithmic management, "so that optimization's realm can perpetually be expanded and optimization itself further optimized.[80] While the populations in question here are nonhumans, distributed sensing infrastructure at the ocean bottom extends the global ambitions of smartness itself.

Part of Halpern's critique of smartness lies in the fact that human uses of distributed sensing infrastructure are often extractive. This critique also applies to the aquatic context. Writing about undersea media infrastructure, environmental geographer Max Ritts contends: "As an increasingly resourced ocean becomes filled with sensing technologies—cabled observatories, RVs, gliders, various forms of deep-sea extraction infrastructure—so too has it re-emerged as a propitious site for the innovation of state-sanctioned capitalist social relations at the same time."[81] Ritts invokes the idea of "digital enclosure," a term coined by

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[79] Halpern et. al., "The Smartness Mandate," 117.

[80] Ibid., 119.

[81] Max Ritts, "Saturation as a Logic of Enclosure?" in *Saturation: An Elemental Politics*, edited by Melody Jue and Rafico Ruiz (Durham, NC: Duke University Press, 2020), forthcoming.

surveillance scholar Mark Andrejevic, to describe the way in which the social relations of primitive accumulation persist in marine space via novel data feeds. A central aspect of a distributed, “smart ocean” infrastructure is that the individual is eliminated as the collective pooling of data is elevated. In an oceanographic context, this means that doing science is becoming more than answering your own research questions, but rather, it has become about adding data to a larger system that can then be accessed by multiple parties and deployed for a multitude of research questions, including those driven by industry and by military forces. In this vein, the ocean fitbit aligns with an existing neoliberal system of surveillance capitalism.[82]

Despite utopian visions of a global fitbit, signs point to the continuation of a digital system that is associated with terrestrial exploitation and extraction, as smart systems are easily coopted by state and industrial actors. In fact, this is already happening. A seldom discussed aspect of cabled observatories is the manner in which they must contend with perceived security issues. For instance, while there is much applause for the OOI Cabled Array’s hydrophones, the sensitivity of these instruments is considered risky from the perspective of the state. Kelley explains, “We can detect things they don’t want us to detect.” To account for this, there is a switch at the Cabled Array shore station that allows the Navy to shunt out sensitive data. In their manual on seafloor observatories, Favali et. al. similarly recommend that military data be diverted through the use of Virtual Local Area Networks, which redirect the flow of information. In both these cases, it is unclear how military data is

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[82] See Shoshana Zuboff, *The age of surveillance capitalism: The fight for a human future at the new frontier of power* (Profile Books, 2019).

being defined—whether it refers to the passage of military submarines, or perhaps eavesdropping through subsea telecommunications cables.

Favali et. al. also recommend that cabled observatories embed privileges as part of their system: "Control will take the form of the determination of who is entitled to certain privileges on the system through the definition of roles."[83] The idea of user privileges is a term referring to the delegation of authority in computing. An exploitation of a design flaw or configuration oversight that allows elevated access to a computing technology is termed, "privilege escalation." Thinking of how this has played out in terrestrial space, where nonlinear practices like jailbreaking, hacking, or rooting are demonized practices that break copyright, one wonders, will the implementation of privileges and military diversions undermine ambitions for a seafloor data commons? Will there one day be outlaw users who escalate their privileges within these seafloor systems? Certainly, this is a question that oceanographers are still grappling with today.

While civilian networks wrestle with these questions, cabled observation networks are also being constructed specifically for military use. In fact, military actors are pioneers in this technology. In a technical sense, the first "cabled ocean observatories" were built by the military in the 1950s—sound surveillance arrays like SOSUS provided the US with acoustic surveillance of Russian submarines. Similar to their civilian counterparts, more contemporary military systems consist of "electro-optical inputs and outputs to static or dynamic subsea assets such as acoustical sensors, detection sensors, video imaging, and power/data transfer docking stations to enable new capabilities in anti-submarine warfare, mine detection and

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[83] Favali et. al., 138.

countermeasures, intelligence and surveillance, and seaport security."[84] In the South China Sea, the so-called "Underwater Great Wall" is another cabled array that is being developed for Chinese military surveillance and defense purposes. [85]

Perhaps most discordantly, the underlying technologies of cabled observation are quickly being coopted by the offshore oil industry in the form of "Smart Oilfields." Since the early 2000s, networks of sensors and cabled instruments have been deployed to provide real-time data about oil fields in areas like the Gulf and the Atlantic. In 2006, British Petroleum announced that it would spend $100 million to build the first undersea fiber-optic cable linking oil and gas platforms. Echoing the rhetoric of fitness, VP Kenny Lang asserted the main purpose is to "monitor the health of a facility during a storm." Just like civilian ocean fitbits, this data can also be shared globally—that is, by transnational oil corporations like BP, Royal Dutch Shell, and Chevron Corp.[86] There is also the DELOS project, a long-term observatory located in an oil field in the Tropical Atlantic Ocean.[87] Even OOI made recommendations for oil and gas monitoring in 2011, recommending that drilling customers

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[84] Phibbs and Lentz, 11.

[85] Catherine Wong, " 'Underwater Great Wall': Chinese firm proposes building network of submarine detectors to boost nation's defence." *South China Morning Post*, 19 May 2016. https://www.scmp.com/news/china/diplomacy-defence/article/1947212/underwater-great-wall-chinese-firm-proposes-building.

[86] "BP to Install Deep Sea Cable Network to Improve GOM Communications," Natural Gas Intel (Intelligence Press, November 3, 2006), https://www.naturalgasintel.com/articles/72758-bp-to-install-deep-sea-cable-network-to-improve-gom-communications.

[87] P.M Bagley et. al, "The DELOS project: Development of a long-term observatory in an oil field environment in the Tropical Atlantic Ocean," in *Seafloor Observatories*, pp. 325-344. (Berlin, Heidelberg: Springer, 2015).

could piggyback onto existing cabled observatories like Tsunami Warning and Early Response System in Cyprus.[88]

Thus, while ocean fitbits might increase human resilience to climate change, oil infrastructure is also contributing to climate change effects. In the grand scheme of the carbon cycle, this is antithetical to the aims of avoiding anthropogenic pollution and environmental disaster. The logic of resilience, once again, proves to be apathetic; it merely perpetuates an existing system into the future.

The Observatory as Colonialist Project

The idea of the seafloor observatory has its roots in nineteenth-century observatory science, beginning with astronomical observatories. Astronomical observatories were optical technologies that helped to reconfigure and objectivize vision during this time. This mode of representation had widespread implications. Nineteenth-century observatories brought particular techniques to prominence that took on social and cultural meaning, defining what it meant to participate in a modern world-system: precision measurements, expensive endowments, and perhaps most importantly, "the construction and maintenance of extensive networks in which observatories were key nodes."[89] Scientific observatories were progenitors

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[88] Ocean Observing Systems Committee, MTS, "A Worldwide Survey of Recent Ocean Observatory Activities: 2011 Update*, Ocean News & Technology* 17, no. 5 (June 2011): 24-28.

[89] *The Heavens on Earth: Observatories and Astronomy in Nineteenth-Century Science and Culture,* ed. David Aubin, Charlotte Big, and Otto Sibum (Durham, NC: Duke University Press, 2010), 29.

of the very idea of a network—a mode in which the observer "looks with his own eyes, but sees with the eyes of the collective."[90]

However, the technological sublime of the observatory is historically premised on the neocolonial expropriation of indigenous lands. As David Aubin, Charlotte Big, and Otto Sibum argue, observatories are spaces of scientific practice that were pillars of the state: "It is hardly worth insisting that observatory techniques—and not just the techniques of medicine and natural history that are often studied by historians of colonial science—also proved indispensable in the constitution of large overseas empires."[91] That is to say, observatory sciences such as astronomy, geodesy, hydrography, and meteorology in the nineteenth century were highly implicated in settler activities and were used for the purposes of imperialist conquest and colonial administration. This association between power and scientific networks has not diminished with time, as struggles over the construction of modern observatories both above and below water continue to define and impose a Western, hegemonic idea of technological modernity worldwide.

Notably, there has been a robust indigenous critique of astronomical observatories in Hawai'i, which also happens to be the site two pioneering ocean observatories (including the ALOHA Cabled Observatory). Tensions between indigenous Kānaka Maoli and astronomers came to a head in 2019 with the month-long protests over the Thirty Meter Telescope, a proposed, $1.4bn observatory on Mauna Kea peak. This footprint of observatories and telescopes encapsulates the settler colonial relations between Western scientists and local

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[90] Ludwik Fleck, "Schauen, sehen, wissen," 154, quoted in *The Heavens on Earth: Observatories and Astronomy in Nineteenth-Century Science and Culture,* ed. David Aubin, Charlotte Big, and Otto Sibum (Durham, NC: Duke University Press, 2010): 19.

[91] (Aubin, Big, and Sibum 31)

communities that rely on their lands and waters for everyday resources. Nonviolent resistance to the Thirty Meter Telescope has provided a template and countered narratives that normalize projects like observatories as necessary infrastructures of the future.

At Ocean Obs ’19, I saw significant pushback against the idea of a global smart ocean from indigenous delegates, as well as from Dr. Juliet Hermes of the South African Environmental Observation Network. Traditional ocean knowledges include many ways of knowing, and are often highly relational, place-based, and collaborative. Many of these epistemologies, however, do not fit in easily with the premise of cabled ocean observation networks. Indigenous methods of monitoring are also typically more qualitative, and include knowledges of species migration, travel routes, cyclical weather patterns, and unusual events. In addition, sensing is embodied, and includes touch, feel, and sight.[92] Unlike most Westerners, Kānaka Maoli also see land and sea as continuous spaces. This worldview is apparent in the traditional Hawaiian Aha Moku system of sustainable resource management, wherein water resources and land resources are treated together.[93] Paulokaleioku Timmy Bailey, an indigenous speaker at Ocean Obs’19 explained: “If you are to take a line and draw it from the heavens to the oceans, you’ll see that there are commonalities between bird and fish species. What is on land is duplicated in the oceans.”[94] Perhaps it is because of this connected perspective on the environment that in-situ ocean images do not define ocean kinships for indigenous Pacific Islanders the way that they do for Western audiences. As the

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[92] Brooks A. Kaiser et. al., “The Importance of Connected Ocean Monitoring Knowledge Systems and Communities,” *Frontiers of Marine Science* 6, (June 14, 2019) https://www.frontiersin.org/articles/10.3389/fmars.2019.00309/full

[93] See “The Aha Moku System,” https://www.ahamoku.org/

[94] Paulokaleioku Timmy Bailey, “Kupaianaha Indigenous Event,” Ocean Obs ’19 Conference, Honolulu, HI, September 16, 2019.

indigenous participants of Ocean Obs'19 made clear, not every good observation system needs to entail continuous data collection or internet-enabled sensor networks—science is not the only mode of observation that can produce documentation.

Shelley Denny, a Mi'kmaw ocean researcher, remarked that in the ocean observing community, the term "integration" is often used as a synonym for "assimilation."[95] I could not help but think back to smartness itself as a neocolonial worldview where "any change can be technically managed and assimilated while maintaining the ongoing survival of the system..."[96] By contrast, Denny's talk emphasized that incorporating indigenous voices should not be about assimilation, but rather listening. Some audience members even made the point that mediation itself conditions the possibility for extraction: we do not exploit the places that we do not know about. This is a very difficult truth to acknowledge for scientists who are trained to pursue the accumulation of more and more data. I believe that a course must be found in between these two extremes. Researchers like Denny, while celebrated in the 2019 iteration of the conference, have been historically excluded from the global ocean observing community. Now, they have emerged to courageously "show a community that thinks it knows best that it does not."[97] For Denny, Bailey, and others, an amphibious humanity does not require unconditionally amphibious technologies; we are all already connected to our oceans.

Resource frontiers like the deep sea are particularly contested social, political, and economic spaces that lend themselves to a multiscalar analysis. Tsing describes resource

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[95] Shelly Denny, "Integrating Western and Indigenous Knowledge Systems: Two-Eyed Seeing in Nova Scotia," Ocean Obs '19 Conference, Honolulu, HI, September 19, 2019.

[96] Halpern et. al. 122-123.

[97] Ibid.

frontiers as natural and social zones characterized by a variety of frictions between law and lawlessness, material realities and imagined profits, discipline and undiscipline, local disenfranchisement and capitalist expansion. In Tsing's estimation, the frontier is not a mere mish-mash of local and global sensibilities enabled by cross-cultural collaboration. Rather, it is this very collaboration and the broader aspirations of global connection and discovery that erodes or covers up the local.[98] As she explains it, this displacement or deterritorialization of the local is often experienced as a detachment of cultural practices of place and a loss of the natural. Indeed, it strikes me that what Denny expressed at Ocean Obs '19 is precisely a warning against this kind of erosion. As environmental humanist Ursula Heise explains it, ocean networks are a technique of global modernity, which facilitates an experience of staying still yet experiencing a loss of a sense of place. Heise's argument is that intimate encounters with nature on a local level cannot be recuperated from modernization, as globalization implies a change in perception, cognition, and expectations.[99] Rather than seek re-embedment, she advocates for a sense of planet—a reterritorialization at a larger, planetary scale.[100]

The dilemmas that Heise and Tsing pose around globalization and deterritorialization suggest that a binary perspective that reduces the local and global as antithetical to one another is insufficient. The questions posed by the deep sea are often planetary in nature, and the negotiations that determine the future of the seafloor happen locally, regionally, and internationally. Even while they study the dispossessions of global modernity, indigenous

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[98] Tsing 75.
[99] Heise 54
[100] Heise 56

scholars, for instance, insist that indigeneity is both local and global.[101] We can take a lesson here from the Kanaka Maoli, who see nature not as merely a local manifestation, but as an extension of the self. I see commonalities between this indigenous perspective and the sense of planet that Heise argues for: both aim to maintain environmental relation through every scale and every geography; movement across space becomes an act of both self-extension and a knowledge practice. This implies the ability for coastal or local knowledge to transgress the colonial, casting it as a multifaceted relationship to nature and to a global world.

Ultimately, my critique of the cabled seafloor observatory networks in this chapter serves not to discard their possible interventions into ocean knowledges, but rather to refuse their unifying ambitions. The history of terrestrial "smartness" offers a pessimistic, monocultural view of what an Oceans 2.0 could become. Although most seafloor sensor networks concentrate agency at the interpretive end, a truly democratic, decolonial sensing system would be heterogeneous. It would allow for autonomy and public access at every step of the process—from infrastructural production, to methods of observation, to database construction and access. This means doing away with resilience as the structuring logic of smartness, and opening up to futurities that accept catastrophic or fundamental changes to existing systems. It means accepting, with courage, a world without unlimited feeds.

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[101] Karen Ingersoll, Waves of Knowing 549

Conclusion

I am standing in the exhibit hall at Ocean Obs '19, chatting with a representative from the US Department of Energy. A small crowd has formed around a VR station that has been set up by the DOE to show a futuristic simulation of the seafloor. My curiosity gets the best of me. I put on the headset, and with a rush of bubbles, I am suddenly sinking down to the bottom of the ocean, flying through landscapes depicting aquafarms, underwater turbines, seabed mining vehicles, and more, before rushing back to the surface. There are hardly any fish in this simulation, and few aquatic plants other than the seaweed being farmed. Upon finishing the tour, I realized that what I experienced was not so much a simulation of the ocean's future, as it was an advertisement for the industrialization of the seafloor. The exhibit is entitled, "Powering the Blue Economy."

Blue economy, as it is defined by the World Bank, refers to "the sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystem."[1] It is a term that suggests a balance—an equal pursuit of both profit and environmental sustainability. This idea can be found both implicitly and explicitly in rationales for ocean media development, and is frequently embedded into mediated content about the seabed, including the DOE's VR simulation. Blue economy is just one of many global ocean frameworks that highlights the primacy of extraction to the constitution of human presence at the seafloor. As I reflect on the vast unknowns alongside the certain existential threats facing our blue planet, it occurs to me that this dissertation has served in part, perhaps, to burst the bubble on the assumption that a blue economy (at least the way the

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[1] The World Bank, "What is the Blue Economy," June 6, 2017, https://www.worldbank.org/en/news/infographic/2017/06/06/blue-economy.

UN envisions it) can be achieved. Over the last few years, my research has led me to a myriad of cultural, ideological, and political factors that inevitably reveal the blue economy "balance" to be a social battleground that is anything but certain.

While the scientific ocean observing community discusses a future in which extractive and environmental aims are pursued in tandem, history tells us that extractive industries already have the upper hand over the environmental sciences when it comes to ocean research. Knowing this, I question the present power dynamic that forces scientists to assume the benevolence of their industrial partners. Most scientists will not deny that the most effective environmental protections fundamentally limit the pace and the scope of capitalist exploitation of the oceans, and that industrial partners generally want to expand this exploitation rather than to limit it. While many ocean stakeholders continue to focus on the question of how to convince the public that economic and environmental motives are not at odds, others are ringing the alarm bell.

In this project, it has been important to identify the differences between scientific and economic mediations—between mediations that focus on discovery, and those that focus on controlling objects with predetermined value. Science-based policy acknowledges that it is inevitable that industrial expansion into the oceans will be damaging for ocean environments, and seeks to limit the scope of this expansion. However, as I have shown, each of these actors often rely on extractive documentation practices that limit the way that scientists and other stakeholders read media feeds from the ocean floor. Ultimately, care is easily rationalized away by economic mediations of the ocean that prioritize resource allocation. And so, for many, the seafloor begins to look like a classic example of the tragedy of the commons—a case in which human beings seem fated to destroy the very resources they rely on.

Nevertheless, we can come back to the idea of the commons to consider what successful alternative governance of the Area may look like. Economist Elinor Ostrom pushes back against popular models of the commons including the tragedy of the commons, the prisoner's dilemma, and the logic of collective action, arguing that they deploy constraints that predetermine the outcome of tragedy. Departing from the solutionism of big government and centralized authority that is typically offered by the tragedy of the commons model (for the deep sea it is the International Seabed Authority), Ostrom turns to successful instances of governance over a commons to argue for multiple pathways: "Instead of presuming that the individuals sharing a commons are inevitably caught in a trap from which they cannot escape, I argue that the capacity of individuals to extricate themselves from various types of dilemma situations *varies* from situation to situation."[2] In particular, Ostrom highlights an alternative solution in which participants design and enter into voluntary contracts, and members of the community monitor and conduct enforcement on each other.[3] As Ostrom discusses, the success of an alternative like self-organized collective action depends on factors such as a capacity for communication, trust, sense of common future, and the autonomy of individual actors.[4]

Already, we can see that for the oceans, there is work to be done on all these fronts. With so many challenges facing our oceans, from plastic pollution, to extraction, to ocean

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[2] Elinor Ostrom, *Governing the Commons: The evolution of institutions for collective action*. (Cambridge university press, 1990): 14, emphasis in original.

[3] Ostrom, *Governing the Commons*, 17.

[4] Ibid., 21.

acidification and warming, thinking about the seas can feel like a bewildering, emotionally taxing undertaking. But the seeds for successful collective action exist. Taking part in this research has shown me that for every entity that harms our oceans, there are many more individuals who are working to remedy these problems and find more harmonious pathways to living with our seas. And what's more, today's ocean scientists and ocean humanists share a mutual recognition that an interdisciplinary perspective is needed to aid the recovery of our ocean environments. I saw this at Ocean Obs '19, and at conferences closer to home such as the 2019 UCSB conference, "Modeling the Pacific," which was convened to bring ocean humanists and scientists into conversation with one another. Ultimately, it is not enough for media scholars to communicate scientific messages to the public; stories and lessons from ocean humanists should be widely shared and discussed by everyone from oceanographers to policymakers. I am hopeful that in the coming years, many more of us will come together to author better, more inclusive stories of for our ocean futures.

As I circulated among a community comprised largely of scientists and engineers, I often started conversations by introducing myself as a doctoral candidate in Film and Media studies. To most scientists, this understandably leads to the initial assumption that I am an ocean documentarian or filmmaker—someone who is going to communicate marine science to the public. They tell me, "we need better storytellers," lamenting a lack of understanding about the urgency of deep ocean research among the public and our politicians. I do not refute the need for these media productions—it is also clear to me that information about seafloor ecosystems as well as ocean industries needs to be communicated to the public if we are to garner any support for much needed deep sea regulations. But of course, I did not embark on this project in order to convey a scientific message. Rather, I believe that a media scholar such as myself is positioned to think through the stories that ocean industries and researchers tell each other and themselves. I chose to ask, what motivations are behind those stories? Whose stories are being promoted and why? Which stakeholders are given the opportunity, in the first place, to act as storytellers?

When I conducted interviews at oceanographic institutions, I posed questions that asked scientists to speculate about scenarios (what kind of sedimentary layer will humans leave behind in a million years?), rephrase technical principles and processes (how would you describe the information you can obtain from a bottom seismograph in layman's terms?), and expand on their feelings about their work (what motivates you to do this research? What, in your opinion, are the most important challenges that the field faces?). These questions were a way of prompting scientists to tell their own stories. Many oceanographers, to my pleasant surprise, used analogies to popular media to explain deep sea imaging and data collection processes. Most already anticipated the need to translate information for a wider audience, and emphasized the ethical, economic, and political importance of their work. In my archival research, the positionality of scientists as ocean storytellers was even more obvious, as early oceanographers were fond of using colorful metaphors, descriptive imagery, and emotional flourishes in their reports. Sometimes, the views expressed in archival documents contradicted those of contemporary oceanographers. Other times, it was easy to see the conceptual lineages within the field.

What I have presented here is merely the tip of the iceberg in terms of what is happening and what will happen in seafloor mediation. There are many more questions to be asked about the social composition of the global ocean observing community, the methods and parameters by which we evaluate ocean knowledge, the fate of offshore extractive industries, and the role of our nonhuman partners in underwater mediation. For me, it was in the final stages of my dissertation process that I began to understand just how small my slice of the picture is. My last year of research likely left me with more questions than answers, and as I extend the dissertation into a book project, I will pursue those questions through further research on contemporary ocean networks.

First, I envision building up the fourth chapter to further expand on the social and political developments around seafloor cyberinfrastructure. While observing oceanographic conferences, I became particularly interested in how developing nations are participating in the transnational production of web-enabled observatories. These issues will be most immediately relevant for Pacific Islander communities. However, organizations like Ocean Networks Canada have also already been collaborating with Ontario's First Nations, and I believe the Canadian context will also provide an important perspective into the kinds of partnerships that are being built around networked seafloor observation. Ultimately, these regional coalitions are part of coordinated international efforts to wire the abyss, and it will be necessary to maintain a multiscalar framework for this research. Building on the interdisciplinary premise of my own project, I look forward to forming further working relationships with community leaders and researchers, as well as media practitioners and environmental historians.

In addition, I plan to add a fifth chapter to the book that addresses the use of animal telemetry networks to mediate remote and inaccessible areas of the ocean, particularly in the Arctic. My dissertation as a whole attempts to center the experiences of animal others. I think that properly fulfilling this aim requires an extended discussion about the significant contributions that wildlife telemetry has made for deep sea observation. This includes near real-time ocean profiles from sharks, seals, birds, and other marine megafauna. While other media scholars have written about animal proxies or animal webcams, I am interested in thinking more about the relationships between animal mobility and networks of autonomous sensors.[5] Specifically, I would like to explore the ways in which marine animal telemetry might share a media genealogy with autonomous ocean gliders.

Finally, I will aim to include an audiovisual storytelling component to the project in order to bring these marine technoscapes to life. Following chapter 4, this will take the form of a multimedia interface that allows users to read and hear stories from a diverse coalition of researchers and observers, situated at geographical nodes within a larger ocean observing network. While I have spoken to many ocean scientists and a few policymakers about ocean observation, I have a long way to go in terms of understanding the embodied experiences of local stakeholders and fishing communities. I think it is important that these voices are heard, and rather than attempt to translate their stories into my writing, I would prefer to use my media resources to create a platform for ocean observers to tell their own stories.

I am fortunate to have many sources of inspiration for how a web project like this might look. Recently, I have been fascinated by interactive digital stories like the Ghost River Project, produced by the Concordia Ethnography Lab.[6] This particular web interface makes great use of audio soundscapes in addition to a storymap interface, and traces the hauntings of the Saint-Pierre river among embodied urban experiences and infrastructures in Montreal.

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[5] See Donna Haraway, "Crittercam: Compounding Eyes in NatureCultures," in *When Species Meet,* 249-264 (University of Minnesota Press, 2008); Jake Kosek, "Ecologies of Empire: On the New Uses of the Honeybee," *Cultural Anthropology* 25, no. 4 (2010): 650-678.

[6] See Concordia Ethnography Lab, "Ghost River Project," https://ethnographylabconcordia.ca/working-groups/hybridized-waters/ghost-project/

I am reminded also of the 2019-2020 project, *Mississippi: An Anthropocene River*, which brought together an interdisciplinary coalition across multiple campuses to journey down the length of the Mississippi River. This project had several online and offline outcomes, including short, locally situated films about the material and technical legacies and histories of river infrastructure.[7] I can see my own project engaging with a similar methodology of tracing a geographic route, and documenting sounds, stories, and feelings as various nodes. I hope that this will make visible an interdisciplinary, transnational perspective on ocean environmentalisms.

While the arguments I have presented here center on extractive mediation as opposed to close readings of media representations of the ocean, I believe that a traditional media analysis of underwater media content will continue to be an important approach to studying ocean media. Textual analysis was in fact an important part of my project, as it helped me to establish a background understanding of the current ocean media landscape. I sought to embed myself in this world by reading articles, following social media accounts, watching documentaries, and subscribing to oceanography email lists. I noticed many patterns through this ambient submersion into marine networks: among them, a sustained interest in video footage of ocean fauna, a fondness for analogies to space exploration, and references to overlapping topics such as climate change, energy security, and datafication. The selection, ordering, and display of ocean spaces in popular and scientific media is not a neutral activity; it both shapes and is shaped by social, political, and technological forces.

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[7] "Mississippi. An Anthropocene River." Haus der Kulturen der Welt, 2020. https://www.anthropocene-curriculum.org/

While vivid images of the deep ocean now abound, we are often conditioned by documentaries, visualizations, models, and other media to ignore the operations at the interface itself—a messy region that is perpetually being broken, fixed, maintained, regulated, and negotiated by humans and nonhumans. As more eyes turn to the seafloor, it is inevitable that more visuals of seafloor ecosystems will circulate through our mediasphere, from impossibly long siphonophores, to glowing jellies, prickly sea cucumbers, and recalcitrant crustaceans. We will have the impulse to make spectacles of them—to stare, to recoil, to share their likeness, and perhaps, to become their fans. But as we get to know these benthic critters, we can try to remember that retrieving those images entailed the initiation of a whole new era of interspecies experiences and encounters. What do deep sea shrimp, fishes, and crabs make of our machines, I wonder? Perhaps they feel shock, concern, or a passing curiosity. Or maybe they, too, will stop to stare and tell their friends. “What purpose do these strange creatures with their blinding lights and belching bodies have, to consume our sediments and pass over our homes? Should we fear the noisy aliens who descend from above to disturb our peace?”

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