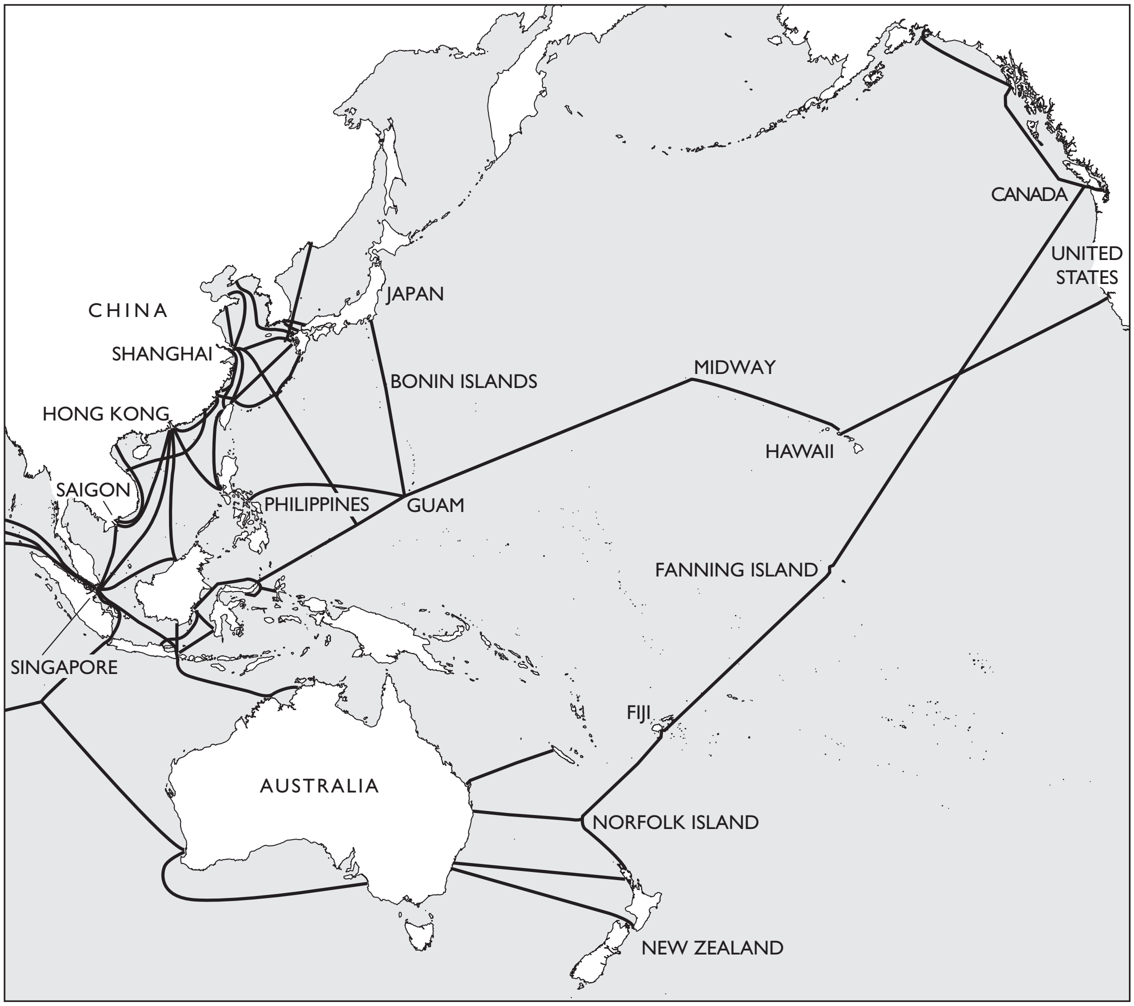
INTRODUCTION

against flow

Undersea fiber-optic cables are critical infrastructures that support our global network society. They transport 99 percent of all transoceanic digital communications, including phone calls, text and e-mail messages, websites, digital images and video, and even some television (cumulatively, over thirty trillion bits per second as of 2010).[1] It is submarine systems, rather than satellites, that carry most of the Internet across the oceans. Cables drive international business: they facilitate the expansion of multinational corporations, enable the outsourcing of operations, and transmit the high-speed financial transactions that connect the world's economies. Stephen Malphrus, staff director at the U.S. Federal Reserve Board, has stated that if the cable networks are disrupted, "the financial services sector does *not* 'grind to a halt,' rather it *snaps* to a halt."[2] As a result, the reliability of undersea cables has been deemed "absolutely essential" for the functioning of governments and the enforcement of national security.[3] Militaries use the cables to manage long-range weapons tests and remote battlefield operations. Undersea networks also make possible new distributions of transnational media that depend on high-capacity digital exchange, from the collaborations of production companies in the United States and New Zealand on the 2009 film *Avatar* to the global coordination of *World of Warcraft* players. At the same time, cable infrastructure enables modes of resistance that challenge dominant media formations. Messages produced by the Arab Spring and Occupy movements traveled between countries on undersea cables. If the world's 223 international undersea cable systems were to suddenly disappear, only a minuscule amount of this traffic would be backed up by satellite, and the Internet would effectively be split between continents.[4]

This book traces how today's digital circulations are trafficked underground and undersea, rather than by air. It follows signals as they move at the speed of light, traveling through winding cables the size of a garden hose. En route, they get tangled up in coastal politics at landing points, monitored and maintained at cable stations, interconnected with transportation systems and atmospheric currents, and embedded in histories of seafloor measurement. Cable infrastructures remain firmly tethered to the earth, anchored in a grid of material and cultural coordinates. *The Undersea Network* descends into these layers to reveal how such environments—from Cold War nuclear bunkers to tax-exempt suburban technology parks; from coasts inhabited by centuries-old fishing communities to the homes of snails, frogs, and endangered mountain beavers—continue to underlie, structure, and shape today's fiber-optic links. From this vantage point, apparently outside the network, one can see the hidden labor, economics, cultures, and politics that go into sustaining everyday intercontinental connections. Rather than envisioning undersea cable systems as a set of vectors that overcome space, *The Undersea Network* places our networks undersea: it locates them in this complex set of circulatory practices, charting their interconnections with a dynamic and fluid external environment.

As a result, the book offers what might be an unfamiliar view of global network infrastructure. Not only is it wired, but it is also relatively centralized—far from the early vision of the Internet as a rhizomatic and distributed network. Transoceanic currents of information have been fixed along fairly narrow routes through the specialized work of a small cable industry, which has navigated natural environments, built architectures of exchange, and generated new social and cultural practices, all to ensure our media and communications safe transit through the surrounding turbulent ecologies. Rather than a strictly urban system, cables are rural and aquatic infrastructures. Conservative and yet resilient, they have followed paths that are tried and true, often following the contours of earlier networks, layered on top of earlier telegraph and telephone cables, power systems, lines of cultural migration, and trade routes

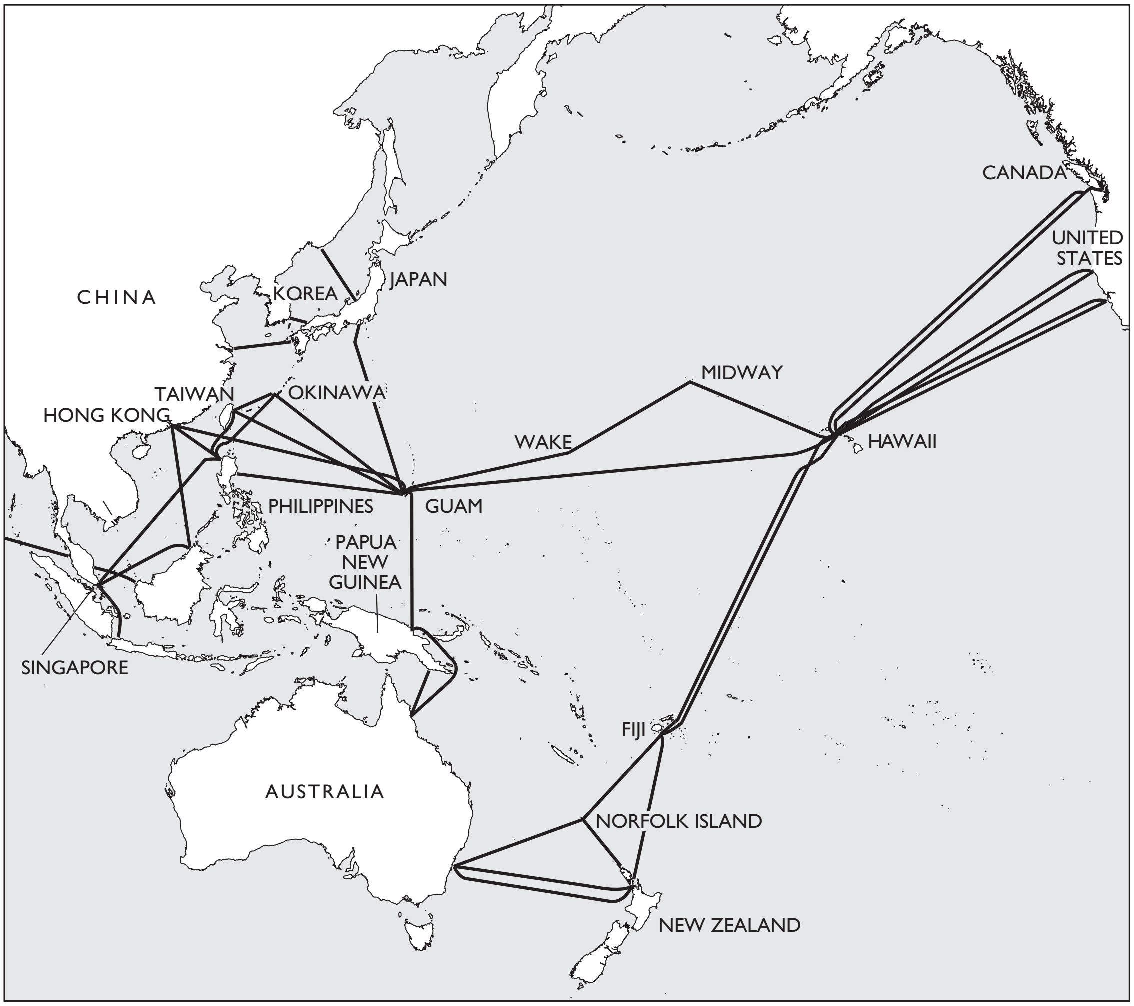


MAP I.1. Transpacific cable routes, 1922.

(figure I.1; maps I.1–I.2). All of these tend to remain outside of our networked imagination, a world defined by firmly demarcated nodes, straight and clear vectors, and graph topologies. As Alan Liu observes, a network "subtracts the need to be conscious of the geography, physicality, temporality, and underlying history of the links between nodes."[5] By bringing these geographies back into the picture, this book reintroduces such a consciousness, one might even say an environmental consciousness, to the study of digital systems.

Invisible Systems

Why have undersea cables, as the backbone of the global Internet, remained largely invisible to the publics that use them? Cable development has often been justified on the basis of cables' perceived security (as opposed to commu-



MAP I.2. Transpacific cable routes, 1982.

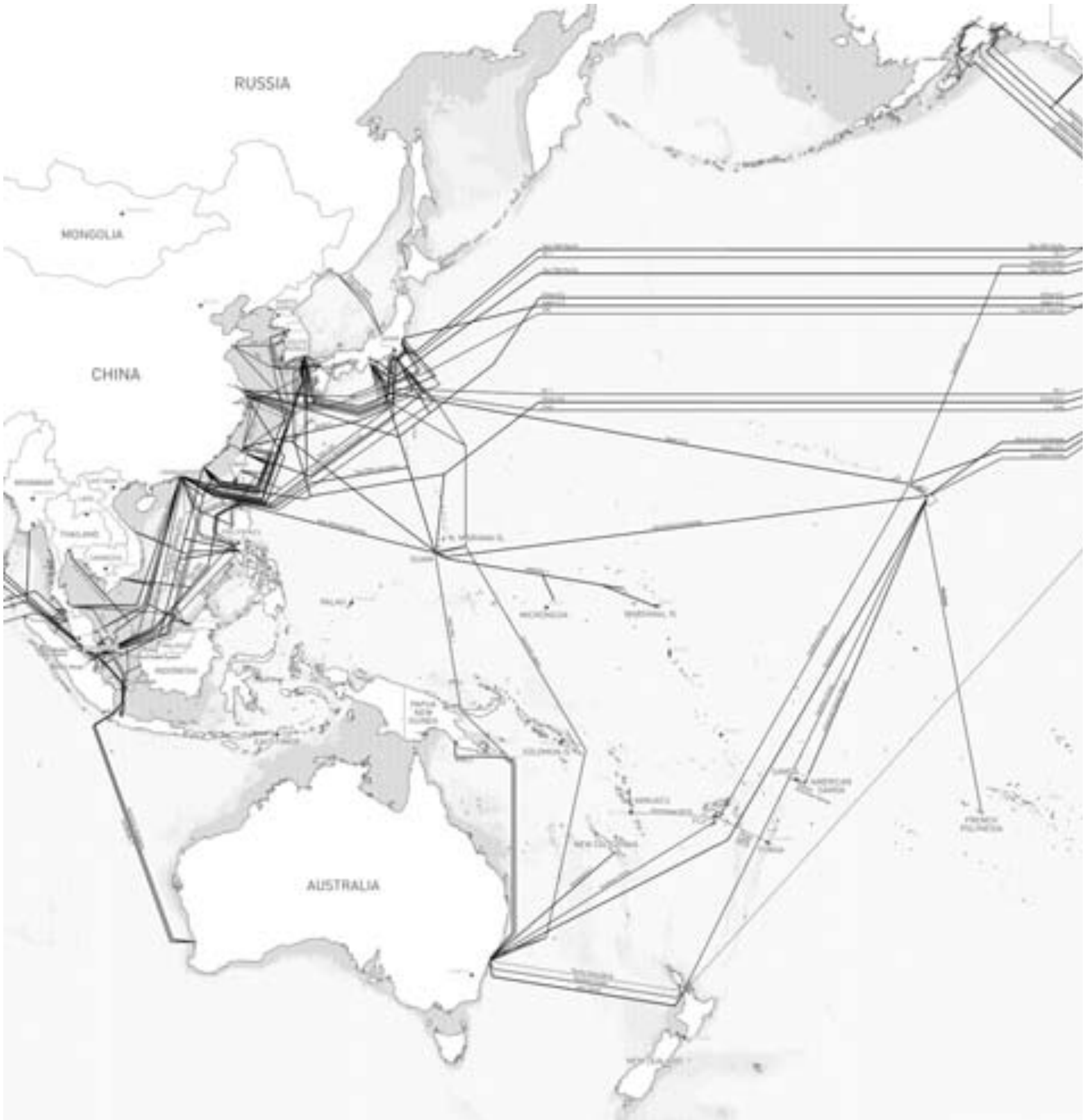
nications via satellite or radio, which are more easily intercepted) and information about the networks has often been withheld in a strategy of "security through obscurity."[6] After all, the reasoning goes, if the public doesn't know about the importance of undersea cables, they will not think to contest or disrupt them. The scarcity of facts circulated about cable systems also reflects the hesitance of a competitive international telecommunications industry to release information of commercial value. More than any intentional desire to obscure cable systems, their invisibility is due to a broader social tendency to overlook the distribution of modern communications in favor of the more visible processes of production and consumption. As Susan Leigh Star observes, infrastructure "is by definition invisible, part of the background of other kinds of work."[7] Many people in the cable industry perceive a general lack of public interest in their infrastructures. When I interviewed Stewart

Ash, who has worked for decades on undersea cable design and installation, he pressed me on my interest in making cables visible. “Why would you want to know?” he asked. “When you turn on a computer and you send an e-mail, do you really care how it works? No, you just want e-mail there, and you start drumming the table if it takes thirty seconds.”[8]

Submerged under miles of water for decades and seemingly disassociated from our everyday lives, undersea cables are particularly difficult to connect to our imagination of media and communication. When communications infrastructures are represented, they are most often wireless: handheld devices, laptop computers, wireless routers, cell phone towers, “cloud” computing, and satellites pervade our field of view, directing our attention above rather than below and reinforcing a long-standing imagination of communication that moves us beyond our worldly limitations.[9] One cable engineer I spoke with—a manager at one of Australia’s most critical cable stations—claimed that satellites are simply just “sexier” than cables. He admitted that even after his company’s communications shifted to cable, they still displayed advertising suggesting that conversations were being carried by satellites, showing signals being bounced out into orbit and then back again because that was what stuck in people’s minds.[10] Undersea cables, he claimed, are “not a technology that people find fascinating.” Leaving the station after our interview, I observed images of satellites plastered on the side of the building.

When we do see public representations of undersea cables, these tend to divert our attention away from the materiality of the network. As I describe in chapter 2, narratives about undersea cables often focus on nonoperational infrastructure: there are films about cable planning and laying, news articles at the moments of network disruption, and histories of artifacts from obsolete systems. Cable industry publications tend to focus on capacity and feature few geographic details. The typical cable map portrays the cable as a vector that indicates connectivity between major cities or even just countries (figure I.1, maps I.1–I.2). The environments that cables are laid through—the oceans, coastal landing points, and terrestrial routes—are seen as friction-free surfaces across which force is easily exerted, and where geographic barriers are leveled by telecommunications. As Philip Steinberg has observed, this conception of space is a Western ideal that has historically been linked to the expansion of capitalism.[11] Depicting the ocean and the coasts as deterritorialized naturalizes the claims of actors that might capitalize on their connective capacity, such as cable companies, and presents an obstacle to those that might claim it as a territory, such as nations.

Fiber-optic cables have also remained largely absent in the field of media



and communications studies, which has focused on the content, messages, and reception of digital media and paid less attention to the infrastructures that support its distribution. Analyses of twenty-first-century media culture have been characterized by a cultural imagination of dematerialization: immaterial information flows appear to make the environments they extend through fluid and matter less. Mark Taylor, arguing that the contemporary network economy is made possible by ever-extending dematerialization, writes that the "Internet is really nothing more than codes and protocols that enable computers to communicate."[12] When cables become an object of study, it is almost always as a form of old media. Historians of technology have carefully detailed the beginnings of telegraph cable networks in the 1850s and 1860s and the extension

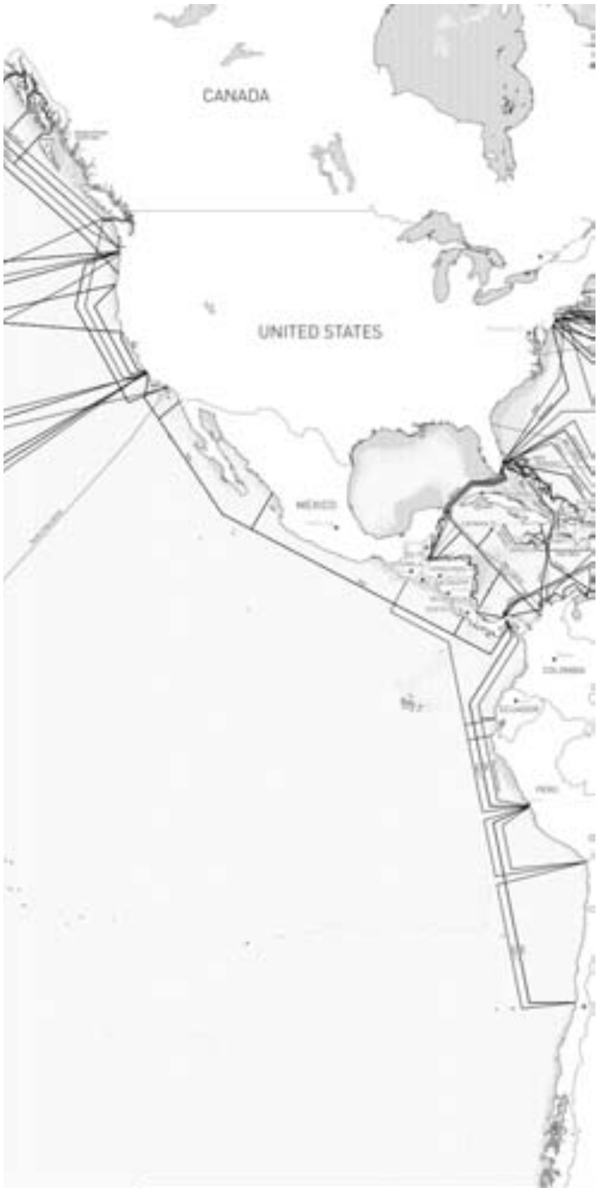


FIGURE I.1. Transpacific cable routes, 2012. Courtesy of TeleGeography, www.telegeography.com.

of these systems through the 1940s in the context of British colonial rule, conflicts between nation-states, and a global media economy.[13] There are no major studies that detail the cultural geographies of undersea coaxial cables laid between the 1950s and 1980s, the undersea fiber-optic cables of the 1990s, or the links between these newer forms and older cable systems. Cables have instead been submerged in a historiographic practice that tends to narrate a transcendence of geographic specificity, a movement from fixity to fluidity, and ultimately a transition from wires to wireless structures.

Although wired and wireless technologies are often positioned as historical competitors, cables and satellites actually have different geographic dispersions, markets, and technological affordances. Satellites, with their wide

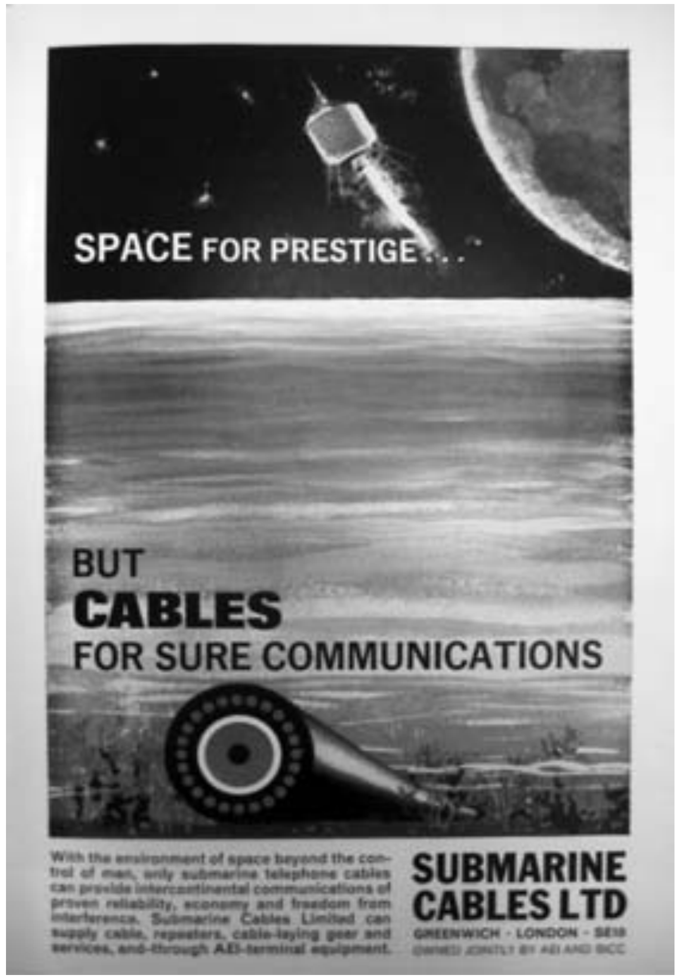


FIGURE I.2. Advertisement for Submarine Cables Ltd., 1960s. From *Zodiac*, © Cable & Wireless Communications 2013, by kind permission of Porthcurno Telegraph Museum.

field of reception, have been more useful for rural areas and islands; they have historically been used for mass communication and have been critical in the transmission of television.[14] Undersea cables, laid on the very bottom of the ocean and surfacing only at the landing points at either end, are more efficient for point-to-point routes of dense information exchange. They also have the benefit of increased security, a consideration for military and government traffic (figure I.2). Overall, the telecommunications industry has long regarded wired and wireless forms as complementary. Achieving redundancy is critical, and the best networks have multiple routes to any single destination. Therefore, even though the percentage of signals carried by wired technologies has ebbed and flowed, they have continued to support the expansion of economic, political, and cultural networking even during the eras of radio and satellite (figure I.3).

Over the past twenty years, satellites' capacity has filled up, and conditions have shifted significantly to favor fiber-optic cables.[15] Cables are now able to

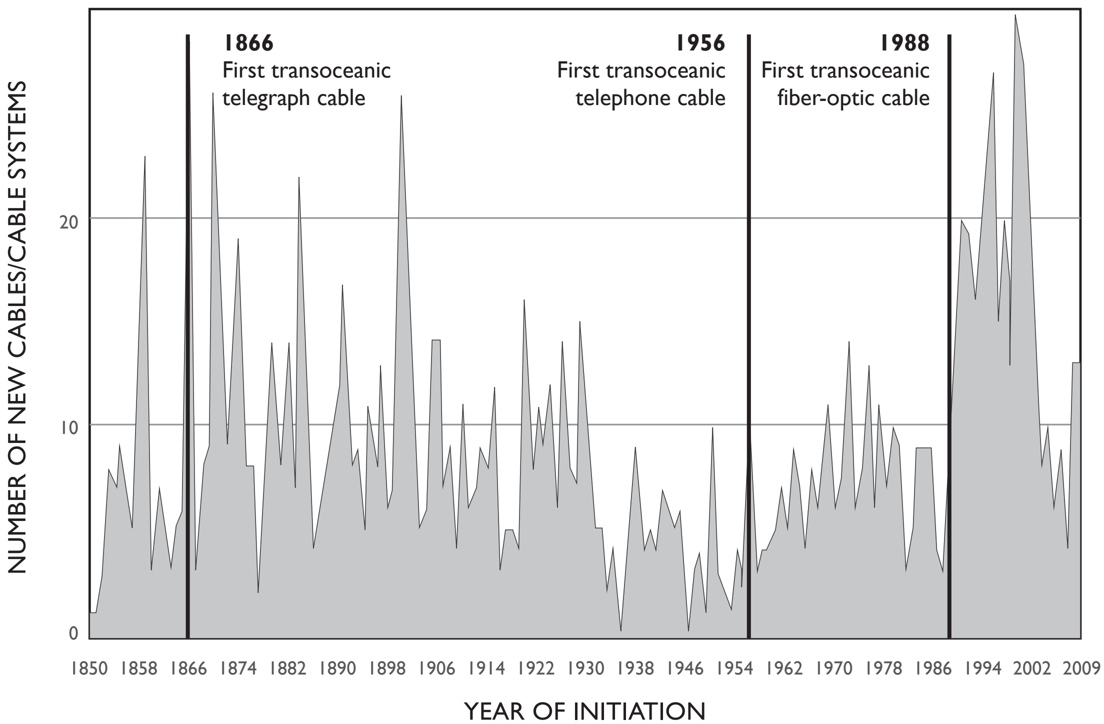


FIGURE I.3. Undersea cable systems established per year, 1850–2009. Cables remain significant even during wireless eras. Data from Burns, "History of the Atlantic Cable."

carry a greater amount of information at faster speeds and at lower cost than satellites (a signal traveling between New York and London takes about one-eighth the time to reach its destination by cable as it does by satellite).[16] With the emergence of high-definition video and high-bandwidth content on the Internet (a shift that favors cable infrastructure), the disparity between the two looks like it will only increase. Despite the rhetoric of wirelessness, we exist in a world that is more wired than ever. As Adrian Mackenzie puts it, "While the notion of wireless networks implies that there are fewer wires, it could easily be argued that actually there are more wires. Rather than wireless cities or wireless networks, it might be more accurate to speak of the re-wiring of cities through the highly reconfigurable paths of chipsets. Billions of chipsets means trillions of wires or conductors on a microscopic scale."[17] Although contemporary networking continues to depend on wired infrastructures, we lack a language—beyond terms like "a series of tubes"—to describe just how grounded these systems remain.[18]

Although telecommunications companies have long followed the rationale that keeping networks out of public view would increase their security, today this invisibility poses a threat to the cables themselves and at times to the people who use them.[19] If cables remain invisible to policy makers, government regulators, corporate customers, business managers, and politicians, then critical decisions about infrastructure funding—which could make our networks more robust and accessible—will continue to be uninformed. John Hibbard, president of the Pacific Telecommunications Council, recounted the comments of a local regulator at a cable meeting in Singapore: "Why am I here?" the man asked. "Everything comes into the country via satellite."[20] The regulator's lack of knowledge was stunning because, as Hibbard quipped, "Singapore is about the most wired country in the world. The only reason it doesn't move is because it is tied down by all of these undersea cables." The lack of awareness extends even to the highest levels of the U.S. government: President Barack Obama's 2013 executive order on cybersecurity made no specific mention of the undersea cable industry.[21]

The invisibility of cables also frustrates the industry in its attempts to gain protection or development rights from nations and state-run agencies. Fiona Beck, CEO of the Southern Cross Cable Network, told me that much of her time with investment bankers and regulatory bodies is spent dealing with the question "Isn't satellite bigger and faster and newer than cables?" and that this is an enormous block to getting better legislation.[22] As the uses of coastal and marine space have intensified, cable companies have had conflicts with fishermen and boaters, environmental advocates, and local developers, all of whom need to be informed of cable routes in order to avoid them.[23] Perhaps most significantly, millions of Internet users around the world rely on undersea cable systems for social, political, economic, and media exchanges, but have little recognition of the structures of dependency into which they are often locked. When cables are built, sold, disrupted, upgraded, and rerouted, these changes have significant consequences for their own use of the Internet.

As it traverses the material environments of cable systems, *The Undersea Network* introduces readers to the structure of cable networks, the geographies from which they have emerged and remain sedimented, and the actors responsible for their construction. In the process, the book develops a view of global cable infrastructure that is counterintuitive yet complementary to the popular understanding of networking. It is wired rather than wireless; semicentralized rather than distributed; territorially entrenched rather than deterritorialized; precarious rather than resilient; and rural and aquatic rather than urban. It is my hope that this alternative representation will give digital media users not only an understanding of their own position in a spatial and environmental Internet, as well as of its extraordinary costs, but also a ground from which to argue for new kinds of structures.

From Distributed to Semicentralized

Contemporary networks are often imagined as a distributed mesh, in which individual nodes are multiply linked in an amorphous and flexible topology.[24] These distributed systems are not simply opposed to centralized structures, but, as Alexander Galloway has noted, the "distributed network is the new citadel, the new army, the new power."[25] Indeed, the Internet's decentralized routing system often appears to be the prime example of this technological transition. From the perspective of global cable infrastructure, however, the actual geographic dispersion of signal paths is relatively limited, and the paths remain centralized in key locations. Only forty-five undersea cables extend outward from the continental United States, supporting almost all of the country's international data transactions.[26] If one groups the cables into thirty-mile stretches, one can see that international traffic enters the United States through fewer than twenty zones. This number is high if one looks around the globe. Many countries have less than five external links. This concentration of cables is partially due to the enormous capacity and expense of each system. One recent cable that connects Australia and Guam has enough capacity to carry simultaneous phone calls from the entire population of Australia—over twenty million people.[27] Large transoceanic projects might cost upward of a billion dollars. Since capacity requirements have already been met in much of the developed world, there is not always an economic incentive to diversify one's infrastructure. The concentration is also due to the traction of existing networks: there are a limited number of sites that are insulated from harmful shipping traffic and where one can interconnect with existing systems. Almost all of Australia's Internet traffic goes out through a single thirty-mile stretch, in part thanks to the cable protection zones that insulate that path.

The geography of the undersea cable system is not a distributed network in which all points easily connect to all other points. Rather, it looks more like Paul Baran's description of a decentralized system, in which there are several nodes that are all connected to a central hub and, at times, to one another.[28] When one overlays considerations of control—since a single company might be in charge of all gateways from a country—the network's geography moves further from a decentralized or distributed ideal. It is difficult to glean this from a traditional network map, which shows multiple logical pathways between endpoints but fails to reveal where these pathways use the same physical route, form bottlenecks at narrow points, or are owned and operated by a single company. In directing attention to the relative centralization in the geography and operations of cable systems, this book contributes to emerging research that documents how centralizing forces continue to permeate and underpin the extension of networks—from the U.S. investments in the Cold War to Google's domination of online searching.[29]

From Deterritorialized to Territorial

Following from the popular imagination of wirelessness and dematerialization is a common assumption that digital communications are being freed from territorial limitations. *The Undersea Network* demonstrates how cable routings have been critically shaped by territorial politics and how established political ties have facilitated the development of international communication. Early telegraph networks were mapped over colonial geographies, and the majority of companies that laid telephone cables through the 1980s were government-owned or -affiliated monopolies. These extensive investments shaped the contours of cabled environments and provided traction for Internet infrastructure. The two fiber-optic cables connecting New Zealand to the outside world, for example, are located in the same zones as telegraph cables from the early twentieth century. Takapuna (on Auckland's now suburban north shore) and Muriwai (on its rural west coast) have been landing points since 1912. Major transpacific cable hubs in the United States are located at sites established during the Cold War.

Although our digital environment appears to be a space of mobility, radically changing every few years, the backbone for the global Internet continues to be sunk along historical and political lines, tending to reinforce existing global inequalities. This geographic stasis is also a reflection of the conservative nature of the cable industry: cable technologies are designed to last twenty-five years, installation techniques have changed little since they were developed, and engineers tend to err in the direction of what has already been tested and proven.[30] Advocates for new systems are attempting to remedy this imbalanced geography. Recent moves to network previously uncabled locations, including the Interchange cable to Tonga; the Honotua cable to Tahiti; and the BRICS cable linking Brazil, Russia, India, China, and South Africa, often depend on existing territorial alliances and national governments for funding. Rather than making geography matter less, cable networks continue to be constructed in a dense web of existing territorial affiliations.

From Resilient to Precarious

Packet-switching technology, which forms the basis for the Internet's distributive operations, is often understood in terms of its potential to survive an attack: if several nodes in a network are disrupted, the system's routing can in theory move traffic around them. The relative centralization of the cable system and its embeddedness in existing territorialities make the physical networks across which these packets move far less resilient than we imagine.[31] In 2006 an earthquake near Taiwan set off an undersea landslide and snapped several cables. Another significant outage happened in Vietnam in 2007, when cable thieves pulled up several of the country's working lines. In 2011 a woman in Georgia shut down much of the Internet in Armenia when she dug up two fiber-optic lines while looking for scrap metal. Although network carriers are often able to reroute traffic, in many cases, breaks have decreased Internet connectivity. Repairing undersea networks is dependent on a limited number of specialized cable ships, and in some places, including China, Italy, and Indonesia, companies have had to wait to receive permits before they can fix their systems.[32]

Looking at moments of actual and imagined interference, this book increases awareness about the vulnerability of our networked systems. It would not be difficult for the U.S. government (or any government) to physically switch off all international telecommunications. This is not an imminent possibility, as it would cause extraordinary economic harm that would outweigh any political benefits. As one study succinctly observed, "The entire global economy relies on the uninterrupted usage of the vast undersea cable communications infrastructure."[33] To separate oneself from this economy would be disastrous for most countries, yet this is nonetheless a possibility built into our current system. This book views the narrow points where cables run together as pressure points, sites where currents can be diverted or rerouted using minimal force and where local actors have a disproportionate amount of power. This might occur not only via technological disruption, but also in the mismanagement of the banal dimensions of maintenance and upkeep, long a blind spot in studies of global and digital media. As Stephen Graham and Nigel Thrift argue, social theory has broadly focused on connection and assembly to the exclusion of the "massive and continuous work" needed to keep infrastructure systems in operation.[34] Cable systems are thus also vulnerable from within: an immense amount of time, energy, and embodied labor are required to sustain undersea networks, and without this labor, the infrastructure would soon fail.

Although the Internet is often imagined as a clean and durable technology, something that will eventually be extended everywhere at little cost, this vision fails to register the extensive financial, social, and environmental investments required to establish new systems and maintain existing ones. Taking this into consideration, we might think about the Internet not as a renewable resource but as a precarious platform, especially as moving our data to the cloud often entails increased dependence on undersea links. On one hand, this might help us make better choices about our own media consumption and content production, taking into account the potential precariousness of infrastructural systems. On the other hand, it might motivate us to push for a more genuinely distributed, resilient, and equitable network.

From Urban to Rural and Aquatic

Geographies of digital media tend to focus on the city as it has been intertwined with the development of information flows.[35] Indeed, the destination of signal traffic is often the urban user, and the city has exerted a gravitational effect on infrastructural development. Most of the undersea cable network's routes and pressure points, however, are nestled in natural environments, and the system has been profoundly shaped by the politics of rural, remote, and island locations. Much of Australia and New Zealand's cable infrastructure is routed through and shaped by the histories of Hawai'i and Fiji. A significant amount of U.S.-Asia traffic moves through Guam. On California's west coast, traffic often exits the country via remotely located hubs in San Luis Obispo and Manchester rather than Los Angeles or San Francisco. As a result, the local investments of environmentalists in California, fishermen in Southeast Asia, and deep-sea marine biologists in Canada have come to inflect cable networks in unexpected ways. Although cable traffic is often destined for larger urban areas (very little material drops off in these remote locales), the channels through which it flows nonetheless depend on investments in and reorganizations of aquatic and coastal environments—sites that have rarely been studied in relation to media distribution. As the ocean becomes subject to increasing spatial pressures, with the acceleration of shipping, underwater mining, and alternative energy projects, such environmental negotiations will continue to be integral to network development.

Turbulent Ecologies

The Undersea Network connects the evolution of cable systems with its shifting material contexts, including not only cultural practices and political formations but also atmospheric, thermodynamic, geological, and biological processes, to expose the complexity that goes into the distribution of digital media. Although early discussions about digital systems focused on their distance from the real world, over the past ten years the rise of spatially embedded systems, digital navigation, and ever-accelerating media obsolescence has drawn attention to the imbrication of digital media in its surrounding environments. Researchers have opened the black boxes of digital storage technologies, sifted through the depths of code, located hidden data centers, unearthed the electrical systems that sustain media production, and examined the materialist energy of media systems.[36] Media archaeologists have dug into history to reveal the early predecessors of digital media in predigital technologies. Scholars have documented the importance of media infrastructures and distribution—from satellites to ubiquitous computing—and revealed the lasting effects of technological networks on today's information circulation.[37] Others have examined the specificity of fiber-optic systems, unpacking their logics of control and freedom.[38] *The Undersea Network* builds on this materialist research to document "the physicality of the virtual."[39]

Tracking these changes throughout history, the book develops a new approach—what I describe as network archaeology—to historicize the movements and connections enabled by distribution systems and to reveal the environments that shape contemporary media circulation. Based on existing research in media archaeology, a network archaeological approach draws on archives and historical narratives to shed light on emerging practices and, in light of these practices, to offer new vantage points on the past.[40] To do so, *The Undersea Network* follows the paths of our signal transmissions—from the cable stations in which signals terminate, through the zones in which they come ashore, and to the deep ocean in which they are submerged. These zones, obscured in the thin lines of the network diagram, are the material geographies of cable communications, and through their excavation we can begin to understand the semicentralized, territorial, precarious, and rural natures of digital networks.

To better illustrate what this entails, let us turn to the discussion of a recently proposed undersea network, the Arctic Fibre system (figure I.4). Over the past decade, as the Arctic ice has retreated with global warming, the Northwest Passage has opened up new pathways, not only for shipping and for oil extraction, but also for cables carrying digital communications signals. The proposed Arctic Fibre cable would link London and Tokyo via the Arctic Ocean, a shorter path than the Atlantic and Pacific routes, and provide a new source of Internet connectivity for northern communities.[41] There had been a number of attempts to lay a transarctic cable prior to this, including a telegraph stretching between Alaska and Russia (before the transatlantic telegraph was laid in the 1860s) and Project Snowboard, initiated by British Telecom in the 1980s. In the 1990s the Russian Ministry of Posts and Telecommunications

FIGURE I.4. Route of Arctic Fibre's northern cable, January 2014.
Courtesy of Arctic Fibre.

even devised a plan to use a nuclear submarine to lay a fiber-optic cable under the Arctic.[42] It was not until the large-scale environmental transformation of climate change, however, that a transarctic cable route became feasible.

Between the route's endpoints in London and Tokyo lie a disparate set of environments—frigid Arctic waters in which deep oil reserves are nested, Canadian and Alaskan communities, and locations where scientific research on global warming is being conducted. Through these predominantly rural environments extend a range of human and nonhuman circulations, from atmospheric currents to the movements of container ships. Such circulations could generate friction for Arctic Fibre, a form of resistance that Anna Tsing describes as simultaneously productive and enabling.[43] The reactions of previously uncabled populations, from the indigenous people of the Canadian north to the oil companies that seek to drill off the coast, are still unknown. Icebergs scouring the coastal seafloor might disrupt shallow cables. Fishermen's nets threaten to hook and sever them. Even along well-traveled routes, environments have always generated friction for undersea networks. Throughout the telegraph era, fishermen regularly dragged their nets along the densely cabled transatlantic route, disconnecting links and scattering signal traffic.

These circulations generate interference for the system. For Arctic Fibre, the movement of ice not only threatens to break cables; in the deeper sea, it also covers much of the ocean's surface, literally interfering with the company's access to their network. In other areas around the world, cyclones, tectonic plate shifts, and rising waters threaten to physically disrupt the movement of media and communications. Interference can also be created by social and cultural phenomena and, at times, is generated as a by-product of the cable's extension. When some telegraph companies constructed cable stations in remote colonies, tensions were generated with indigenous people who would later resist communications development. The environments that cables stitch together are not always smooth spaces, but turbulent ecologies. Turbulence is a chaotic form of motion that is produced when the speed of a fluid exceeds a threshold relative to the environment it is moving through. Not an uncommon occurrence, turbulence is the "rule, not the exception, in fluid dynamics."[44] When a fluid—whether air, water, or blood—becomes turbulent, it breaks down into smaller swirling currents, called eddies, which in a cascade break down into smaller and smaller irregular flows. Turbulence is rarely a direct and purposeful opposition to flow. Rather, it describes the way that social or natural forces inadvertently create interference in transmission simply because they occupy the same environment, in the end contributing to the network's precariousness.

Cable companies go to great lengths to protect against both real and imagined forms of interference. In order to facilitate smooth and reliable signal exchanges, they develop extensive social, architectural, geographic, and discursive strategies of insulation. In this book, I define *strategies of insulation* as modes of spatial organization that are established to transform potentially turbulent ecologies into friction-free surfaces and turn precarious links into resilient ones. All along transoceanic cable routes—at the cable station, the cable landing, and in the deep sea—cable owners, manufacturers, and investors reorganize these spaces in order to enable the continuous flow of electrical and political power. A strategic organization of space, as Michel de Certeau notes, "becomes possible as soon as a subject with will and power (a business, an army, a city, a scientific institution) can be isolated . . . every 'strategic' realization seeks first of all to distinguish its 'own' place, that is, the place of its own power and will, from an 'environment.' . . . It allows one to capitalize acquired advantages, to prepare future expansions, and thus to give oneself a certain independence with respect to the variability of circumstance. It is the mastery of time through the foundation of an autonomous place."[45] Strategies of insulation are designed and financed by companies to distinguish the spaces of distribution networks as "an autonomous place" and to separate them from conflicting circulations. Approaching a historically uncabled environment, Arctic Fibre will have to fund such strategies of insulation, such as the burying or double-armoring of the cables at problematic sites, the establishment of new "no anchor" zones to keep fishermen out of the cable area, and the monitoring of icebergs via satellite.[46] Whether they are social, architectural, or discursive arrangements, strategies of insulation separate one part of an environment from the rest to stabilize the distribution of media and communication.

Local and regional circulations are not always disruptive to cable systems; in many cases, networks are planned so as to incorporate them into the circuit. For Arctic Fibre, potential users of the cable system are seen as untapped economic circulations: the regional practices and investments of the Canadian High Arctic Research Center Service, Canada's Department of Defense, and oil companies that seek to drill in the area will help to fund the network.[47] Douglas Cunningham, Arctic Fibre's CEO, argues that revenue from international traffic passing between London and Tokyo cannot in itself fund the project, and that any northern project requires either domestic demand or a government subsidy—in effect, funding that is generated in the environments on the cable's route, rather than simply at its endpoints.[48] Although coastal communities' Internet use will never financially sustain the cable alone, serving these communities also remains integral to Arctic Fibre's pitch for funding from the Canadian government, since the cable could lower Canada's costs to provide health care, education, and other government functions to the region. These interconnections highlight the continued roles of territoriality and nationalism in supporting cable networks.

In appealing to these users, Arctic Fibre seeks to develop new strategies of interconnection, modes of spatial organization that are designed to leverage local and regional circulations, or at least perceived circulations, to support its cable network. This might entail setting up actual technological points of interconnection, or gateways, where signals can be transferred between networks. Technical interconnection is an important concept in cable management: cable networks are solidified in particular locations via formal interconnection agreements, where competing companies build bridges to each other for their mutual benefit. Although the process of interconnection, critical for all kinds of networks, has been described in various ways, I use the term *strategies of interconnection* to refer to the development of fixed architectures and spatial practices through which transfers between the cable system and its surrounding environments can occur.[49] Arctic Fibre will develop strategies of interconnection to link not only to potential users of the network, but also to the existing resources in the Arctic and oceanic environment, including icebreaker ships and remote-operated vehicles that could aid in repairs. Such strategies are designed to facilitate the process of transduction—the transfer of energy, whether social, economic, biological, physical, or electric, between the system of the cable network and the cultural geographies into which it is inserted.[50]

In these cases, the network's proximate environments are not a site of interference, but a critical link in the construction of global communications, a place where signals are grounded. In electrical engineering, the movement of a current from one point to another creates an imbalance in transmission, and these circuits are made stable only by a return channel, which is termed the *ground*. Technically, for undersea cables, the ground is the ocean itself. A signal moves through the cable across the sea, and then the energy returns to its original location via the conduction of the water. As one cable report observes, powering the operation of a system "is achieved by actually using the environment—the seawater—as a conductor to complete the circuit."[51] Grounding is thus a process whereby the conductivity of existing matter—whether made up of social or natural phenomena—is harnessed to keep a current from becoming imbalanced. This metaphor highlights the fact that strategies of interconnection are not simply modes of exploiting the environments in between nodes, but also serve an important role in keeping a network in equilibrium. Today, interconnection is often facilitated by technologies, but throughout history this process has been a thoroughly human endeavor. For example, in the early remote cable stations, imbalances were created as young men moved to locations far from home and were subsequently forced to migrate between stations. Slowly the company and the cablemen developed strategies of interconnection, ranging from using local labor to arranging marriages, which helped to sustain the operators and therefore stabilize transoceanic signal traffic in remote locales. Through interconnection, energy from one system was transduced to support another's deficiencies, and equilibrium was achieved (or at least attempted).

The concepts introduced here—strategies of insulation, designed to transform turbulent ecologies into friction-free surfaces, and strategies of interconnection, designed to ground transoceanic currents in local circulations —describe the dynamics by which the infrastructures of digital media are formed in relation to their environments. Strategies of insulation shelter the movement of international signal traffic from the environments they traverse. They produce an internal break in an ecology, allowing one system to extend into and through another without being affected by it. Cables must be insulated from hurricanes and fishermen, local publics and foreign nations. This practice of intentional disconnection is integral to sustaining and securing network operations in potentially turbulent environments, and it has intensified rather than subsided as networks have become more critical to our global society. However, at the same time, the network must be grounded in some way via strategies of interconnection, the leveraging of existing circulations to support new networks. Although they appear to have opposing relationships to the environment (blocking it out versus harnessing it), insulation and interconnection are complementary strategies that regulate cable ecologies and stabilize circuits of transmission on a global scale.

Insulation and interconnection—from the establishment of cable protection zones to the channeling of local labor—reduce the threat of disruption to the cable system and make cable laying less expensive and more efficient along existing routes, a process often described as "path dependence" in studies of technology and social practice.[52] I use the term *traction* to refer to the ways that these interactions—in which cables both repel and connect to preexisting currents—anchor infrastructures in particular sites. When there have been opportunities to build new stations and remake the geography of the cable system, existing routes were typically chosen, because paths through those sites had already been negotiated. The fluidity of our information sphere is made possible only by this historical fixity of communications infrastructure. As David Morley observes, "Right at the heart of the process of globalization, somewhat counter-intuitively, we find some rather important things slowing down."[53] These slow, fixed, and disconnected spatial practices are the hidden layers that support contemporary global networks.

The challenges that Arctic Fibre faces—even at a time when distance seems to matter less and less—entail strategically developing a new path through the Arctic environment. The company must fund the acquisition of new knowledge about an uncharted aquatic and coastal landscape as well as the development of new modes of cable protection. It must generate new connections with existing actors along the cable route and cultivate new markets for cable service. The absence of networks in the area provides the cable layers with a number of challenges that their transpacific and transatlantic competitors avoid. Their ongoing costs will be high, especially since they cannot share maintenance agreements with other systems. The industry will perceive Arctic Fibre as more risky, given that the route has been as yet untested. The lack of historical precedent, all in all, will make it difficult for the company to find funding. If it succeeds in establishing the first transarctic cable, setting up critical installations, and pioneering new modes of protection, it will then be much easier and less expensive for other companies to set up shop along the same route. It is no surprise, then, that most companies build systems along routes where cables have been laid, stations constructed, "no fishing" zones established, and markets formed.

The case of Arctic Fibre, as it plans an innovative route across uncabled waters, forcefully demonstrates how networks take shape in and in turn inflect the environments around them: these are much less pressing concerns in the development of other global routes where surrounding ecologies have been managed for over a century. These ecologies, which consist of social practices, built architectures, and natural environments, have been invisibly folded into the thin lines of each network edge and the production of our intercontinental cable system. They remain hidden, however, in the common cable map. *The Undersea Network*, as it analyzes the historical negotiations and emergence of such ecologies, reveals that the creation of a stable circuit of transmission (more than simply the exchange of a single message) is always an environmental process. It involves manipulating space, from the sediment of the seafloor to the housing options of colonial cablemen, to mold contours across which signals can repeatedly and reliably move without disruption. The concepts developed here—turbulent ecologies, pressure points, strategies of insulation and interconnection, and traction—attune us to these processes, placing the geography of network infrastructure in relief.

The Undersea Network offers a new way to look at digital media systems in ecological terms. Although research on media ecology—from Neil Postman's studies of mass media to Matthew Fuller's *Media Ecologies*—understand the environment as a world of content, *The Undersea Network* extends the environment to encompass the social, architectural, and natural ecologies through which this content is distributed.[54] Here, global information flows are not positioned as equalizing, deterritorializing, and antithetical to fixed or hierarchical structures, but instead are always routed through dynamic fields made up of varied directional circulations. The challenge for networked circulations today is not how to overcome fixed barriers, but how to navigate in a world where everything is already mobile. The title of this book, *The Undersea Network*, thus refers not simply to the cables that are being analyzed, but to the book's methodological intervention: to see networks as always embedded within complex and multidirectional circulatory practices—not a static territory, but a fluid environment in which our connections must be both insulated and grounded.

Vectors

To excavate the formative role of these environments, I followed the undersea cable route.[55] This brought me to cable stations, where I interviewed telecommunications workers about cable operation and maintenance, and to landing sites, where I spoke with residents about their encounters with cable networks. I visited industry conferences and interviewed people in engineering and in marine operations as well as in sales, marketing, finance, and law about their experiences in setting up cable systems. The industry has a reputation for both secrecy and speculation; unraveling its history has involved sorting out myths and rumors and has taken me to local, national, and corporate archives.[56] As a corrective to what I see as the fundamentally limited visibility of cable systems, I have photographed cable networks throughout my travels to develop new approaches to cable representation. Cumulatively, this combination of ethnographic, archival, and artistic fieldwork offers a multivalent model for studying distribution systems, a network archaeology that connects cables' historical and technical organization to the layered cultural, political, and biological environments that surround them.

In this book, I hope to convey how the network looks to the people who build, operate, and use it. I visited cable installations in thirteen countries, as well as the offices and homes of numerous cable workers who have contributed to these systems. As a white American woman, I was unfamiliar with the culture and language in many of these places, and I relied on people who were in the industry and resided in these geographies to make the systems legible. Almost always, it was men—an analyst at a cable company in New Zealand, a distant relative in Guam, and a software developer in Yap—who broadened my mobility and helped me gain access to cable networks. While the cable industry is overwhelmingly male, many women have also been involved in the industry, particularly in labs and in project management, sales, marketing, route surveying, and legal affairs. To get to cable sites, I also relied extensively on the infrastructures of transportation (roads, boats, planes, and trains) with which the cable systems have been interconnected. My own subject position—as I traversed heterogeneous infrastructures and environments, often feeling out of place—heightened my perception of cables' ongoing requirements for interconnection as well as their vulnerabilities and need for insulation.

Each of the following chapters focuses on a distinct environment in which cables have taken shape. The first chapter, "Circuitous Routes: From Topology to Topography," gives a broad overview of the three major eras of cable development, providing the backdrop for the rest of the book. In it, I sketch out the large-scale cultural forces that affected cable networks, beginning with the copper telegraph cable's relationship to colonization from the 1850s to the 1950s, extending through the coaxial telephone cable's imbrication in postwar politics from the 1950s to the 1980s, and ending with emergence of fiber-optic cables in relation to deregulation and privatization from the 1990s on. To understand the routing of these networks, I argue that we need to move away from network topology, the analysis of the mathematical structure of connections, to topography, the analysis of how cables have been embedded into historical and geographic matrices. Counter to typical assumptions, cable geographies do not simply follow a terrestrial logic (they are often laid underwater when possible), an urban logic (they often connect suburban or rural environments), or a demand-driven logic (they often connect places that are already connected). Rather, I show how over the past hundred years transpacific cable systems have been constructed to be secure: they are deliberately routed to insulate signal flow from potential sources of natural and social interference, from a nuclear bomb to a terrorist attack. Cable routing is also driven by a competing tendency to interconnect: systems have often been routed in inconvenient and expensive ways in order to link with other systems. On the whole, this dynamic gives new routes traction in existing topographies, leaving us with a relatively centralized global network.

The second chapter, "Short-Circuiting Discursive Infrastructure: From Connection to Transmission," follows cables into the discursive environments of popular media. I argue that almost all stories about undersea cables fit into one of two narrative modes. Connection narratives trace the development and initiation of the cable, aligning this event with a transcendence of national boundaries and the easing of international conflicts. Disruption narratives focus on a cable's repair after it has been disconnected, narrating the event as a fight against broader threats to global connectivity—including nature, nations, and terrorism. Both of these narrative modes are limited: they depict the cable only when it is out of service and, as a result, exclude the enormous amount of work involved in the upkeep of global systems. Rhetorically, they function as strategies of insulation that have, until now, protected cable systems. The chapter delineates two alternative approaches that represent undersea cables as material infrastructures: nodal narratives, which focus on a node in the system and chronicle the human and nonhuman extensions through it, and transmission narratives, which move with a signal as it is transmitted through the cable. By narrating the cable past the moment of its initiation, they extend the spatial and temporal parameters for cable discourse, suggest new lines of causality in global network development, and set the groundwork for further engagement with operational cable systems. I argue that, in doing so, these narratives short-circuit the ideological power conducted by narratives of connection and disruption.

The third chapter, "Gateway: From Cable Colony to Network Operations Center," details the history of the cable station as a gateway to the network: it is a site of interconnection between national and international systems, a place where connections are made to local publics, and a zone where the border between system and environment is contested. The chapter moves through each of the three periods of cable development, documenting the shifting boundary between stations and their surrounding ecologies. In the colonial cable station, the cable worker's body was the crux of network operations and the zone to be protected and regulated. As stations were remade during the Cold War, the border between the network and environment shifted from the body to the station's built architecture. In the fiber-optic era, strategies of insulation now regulate the circulation of information. In each period, I highlight the investments in insulating the station and demarcating the inside and outside of the network, alongside the strategies of interconnection that ground the system in local micro-circulations. Looking at the network's shifting interface with local publics, the chapter also illustrates how labor and a cable community remain key support systems for information networks.

The fourth chapter, "Pressure Point: Turbulent Ecologies of the Cable Landing," analyzes conflicts at the cable landing, the zone where undersea cables emerge from the deep ocean and extend through coastal waters, beaches, and local communities before connecting with cable stations. These public spaces cannot be walled off and often become pressure points, sites where local actors can induce turbulence in the system. This chapter documents the strategies of insulation developed by cable owners, manufacturers, users, and investors that affect the cable's visibility to the publics who inhabit the landing point. Tracking these interactions in Hawai'i, California, and New Zealand, I describe how small-scale circulations at the cable network's pressure points have produced disproportionate effects across the network.

The fifth chapter, "A Network of Islands: Interconnecting the Pacific," charts how network nodes are shaped by the politics, histories, and geographies of islands across the Pacific. Although existing representations of islands and networks reinforce a conceptual opposition between the two, making it difficult to see both the interconnectedness of islands and the importance of network maintenance, this chapter recasts islands as core components of cable systems. It focuses on three critical points, past and present, in transpacific traffic: Guam, critically tied to American military extensions; Fiji, a key site for British colonization of the Pacific; and Yap, a former node in the German cable network. In these cases, I show how networks have benefited from the island's insulating properties and, in turn, how islands have become sites of interconnection, places where reciprocity can be established between oceanic, cultural, and communications currents. I argue that emerging as a network hub, becoming more than an endpoint for signal traffic, has involved triangulating existing sets of circulations, whether transpacific, regional, or local.

The last chapter, "Cabled Depths: The Aquatic Afterlives of Signal Traffic," analyzes how undersea cables exert a lasting influence on our knowledge about and inhabitation of the ocean. The chapter documents the relationship between early marine science and telegraph cable networks, which together helped chart a distinct set of transoceanic paths. During the era following World War II, these exchanges were increasingly shaped by the U.S. militarization of the seafloor, and cables took on a new function as they were mobilized for the acoustic monitoring of marine space. Today these systems feed back into the development of marine scientific research via the construction of cable-linked ocean observatories, and into new extractive relationships with the seafloor. Although the first five chapters focus primarily on the manipulation of physical sites and social practices, chapter 6 explores the institutional and epistemological interconnections that have inflected cable development. In describing how our knowledge of the ocean is thoroughly intertwined with cable histories, the chapter—like the ones before it—reveals the porous boundary between communications technologies and their environments.

These chapters offer a set of nodal narratives that illustrate the long-standing relationship between media infrastructures, environmental processes, and cultural history. Together, they show how cable companies have developed extensive strategies of insulation for network infrastructure and solidified pathways through social and natural ecologies. This process, involving both the production of knowledge about and the physical reorganization of cables' environment, has often been made possible by large-scale investments—colonial, military and corporate. At the same time, the development of transoceanic signal exchange has also involved leveraging and connecting with local and regional circulations. Weaving through these diverse geographies, the book introduces a sense of place and an environmental consciousness to our imagination of digital networks, prompting consideration of their costs, whether financial, architectural, or social. Rather than being driven by the physics of entropy—where movements are becoming ever more chaotic and interdependent—*The Undersea Network* reveals how that experience of wirelessness is accompanied by an increasing investment in wires; intercontinental connections paradoxically require numerous forms of disconnection; and our experience of global fluidity is made possible by relatively stable distribution routes that perpetuate conditions of uneven access along lines established a century ago. This book charts the movements and channels that push back against flow and ultimately shape the conditions of possibility for circulations across and under oceans.