# The Spaces In Between

## Science, Ocean, Empire

*By Michael S. Reidy* and Helen M. Rozwadowski***

**ABSTRACT**

Historians of science have richly documented the interconnections between science and empire in the nineteenth century. These studies primarily begin with Britain, Europe, or the United States at the center and have focused almost entirely on lands far off in the periphery—India or Australia, for instance. The spaces in between have received scant attention. Because use of the ocean in this period was infused with the doctrine of the freedom of the seas, the ocean was constructed as a space amenable to control by any nation that could master its surface and use its resources effectively. Oceans transformed in the mid-nineteenth century from highway to destination, becoming—among other things—the focus of sustained scientific interest for the first time in history. Use of the sea rested on reliable knowledge of the ocean. Particularly significant were the graphical representations of knowledge that could be passed from scientists to publishers to captains or other agents of empire. This process also motivated early government patronage of science and crystallized scientists' rising authority in society. The advance of science, the creation of empire, and the construction of the ocean were mutually sustaining.

> Our readers are aware that nearly three-fourths of the earth's surface are covered by the sea, and that this apparent obstacle to man's progress at the borders of which he shrank back terrified, is made by art [technology] to be to his foot what the atmosphere is to the wing of the bird. On its yielding bosom he now sails or steams quickly, and with ease, withersover he will. The great highway of nations, as the sea has in consequence been appropriately called, has its own laws, which he must study to use it advantageously for his purposes. But . . . only lately have these great phenomena been considered worthy of scientific observation.
>
> —*Illustrated London News* (1855)

PRIOR TO THE NINETEENTH CENTURY, before the oceans became an object of vigorous scientific study, a Romantic view pervaded Western conceptions of the sea. Like their mountain counterparts, the oceans epitomized the sublime. They were feared as

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a locus of anticivilization, a void between developable, potentially civilized places. Those few naturalists who took an interest in the oceans—overarching thinkers like Alexander Humboldt—rarely had control of when and where they could take measurements. Oceanic voyages were confined largely to the established trading routes, restricting scientific observations to major islands and inhabited coastlines. The middle of the oceans was understudied, and the scientific study of the sea itself remained episodic. As the *Illustrated London News* observed, mariners and philosophers had "no more thought of studying its phenomena than mail-coachmen thought of studying astronomy or natural history as they passed on the roads."[1]

That changed significantly in the nineteenth century, in a transformation of scientific perspective that conformed to the larger geopolitical ambitions of maritime nations. The change required a reconception of the ocean as a physical and intellectual space full of imperial and commercial significance. It demands of the historian an examination of the practice of science and the process of imperialism not from metropolitan and colonial positions on land but, rather, from the mostly unexplored nautical spaces in between.

As J. R. McNeill noted over a decade ago, "world regions of course may be defined by seas and oceans rather than continents"; but he lamented that historians have "not gone far" in utilizing this approach. Since then, the oceans have become a vibrant focus of study. Special issues focusing specifically on the ocean have appeared in the *American Historical Review* and the *Journal of Historical Geography*.[2] This recent scholarship, though diverse in both approach and methodology, combines to demonstrate that different cultures produce different, and often contradictory, views of the ocean, all directly linked to, and produced by, different political-economic systems. "No longer outside time," writes Kären Wigen, "the sea is being given a history, even as the history of the world is being retold from the perspective of the sea."[3]

As the ocean historian John Gillis has recently argued, "the Western eye had to learn to see the oceans and their islands." That is, oceans had to be created as known and legitimate "places." A good general definition posits that place is space to which meaning has been ascribed; it is therefore a historical and social creation.[4] How nineteenth-century scientists helped visualize the ocean through the creation of an "ocean space," one that paralleled the commercial and geopolitical trajectory of imperial powers, is a potent example of this process in action. The quest for general laws to account for the physical properties of the ocean, including the air/land/sea interface, went hand-in-hand with the

[1] [Anon.], "Review of M. F. Maury, *The Physical Geography of the Sea*," *Illustrated London News*, Saturday, 14 Apr. 1855, *26*(373), p. 363; this review is also the source of the epigraph. For background see Margaret Deacon, *Scientists and the Sea, 1650–1900: A Study of Marine Science* (1971; Aldershot, Hampshire/Brookfield, Vt.: Ashgate, 1997).

[2] J. R. McNeill, "Observations on the Nature and Culture of Environmental History," *History and Theory: Studies in Philosophy of History*, Dec. 2003, *42*(4):5–43, on p. 33. For the special issues see *American Historical Review*, 2006, *111*(3); and *Journal of Historical Geography*, 2006, *32*(3). See also W. Jeffrey Bolster, "Opportunities in Marine Environmental History," *Environmental History*, 2006, *11*:567–597.

[3] Philip E. Steinberg, *Social Construction of the Ocean* (Cambridge Studies in International Relations) (Cambridge: Cambridge Univ. Press, 2001), pp. 41–60, 98–135; and Kären Wigen, "AHR Forum: Oceans of History: Introduction," *Amer. Hist. Rev.*, 2006, *111*:717–721, on p. 717. See also, e.g., Bernhard Klein and Gesa Mackenthun, eds., *Sea Changes: Historicizing the Ocean* (New York: Routledge, 2004); Thomas Bender, "The Ocean World in American History," in *A Nation among Nations: America's Place in World History* (New York: Hill & Wang, 2006), pp. 15–60; and Daniel Finamore, ed., *Maritime History as World History* (Gainesville: Univ. Press Florida, 2004).

[4] John R. Gillis, *Islands of the Mind: How the Human Imagination Created the Atlantic World* (New York: Palgrave Macmillan, 2004), p. 109; and Yi-Fu Tuan, *Space and Place: The Perspective of Experience* (Minneapolis: Univ. Minnesota Press, 2001).

creation by scientists of visual representations of ocean space.[5] Scientists divided the ocean into interconnected zones and produced representations of its tides, currents, magnetism, atmosphere, and depths. From the hydrographic office to the printing press to every ship in the navy, this persuasive artillery in the imperial arsenal provided a synoptic view of the oceanic environment that enabled users to define the natural world in a manner commensurate with their imperial and commercial objectives.[6] The spaces in between continents—over the ocean's surface and along its currents to the deep contours at its greatest depths—sustained the advance of science in the first half of the nineteenth century and deserve the attention of historians who equate science to terrestrial science.

## ORDERING OCEANS IN THE AGE OF EMPIRE

Several nations had large navies in the nineteenth century, and their men of science investigated various aspects of the ocean, such as marine invertebrates and seawater chemistry. But two nations in particular, Britain and the United States, made scientific study of the ocean a priority. They did so to gain and consolidate economic and political power. Both nations, for different reasons, were strongly maritime in orientation through the early decades of the century. Britain's island geography necessitated its close relationship with the oceans. The young United States, even as its maritime proclivity was diluted by westward expansion, set sail to support its burgeoning shipping and whaling industries and to prove itself politically and culturally in the eyes of the civilized world. The fact that, as the epigraph to this essay shows, a popular London weekly was expostulating on the remarkable achievements of an American hydrographer was a sure sign of the meteoric rise of U.S. maritime capabilities.

Facing each other across the Atlantic, Britain and the United States pursued knowledge about the entire ocean, from the tides on its outer rim to the dark water at its greatest depths. They did so vigorously and systematically, with the aim of achieving a holistic view of global-scale oceanic phenomena. They sought to harness the methods of science and the powers of technology to define an ocean space that would enable them to traverse the immense ocean unimpeded by nature or politics. The way the Western world came to understand and use the ocean, therefore, proved significant in terms of control over vast parts of the globe—for example, the insistence on the freedom of the seas—and in proffering a heightened status to science. Science and its practitioners helped define the ocean by mapping its contours, outlining its navigable waters, and setting forth its physical laws and features.

The unprecedented interest in the world's oceans throughout the nineteenth century began as a commercial and political agenda but grew to incorporate scientific and cultural interests. It was spurred by the massive increase in British and American shipping that accompanied industrialization and by the whaling and sealing industries, especially sperm whaling, which drew ships increasingly farther from shore and away from established shipping routes. The prospect of submarine telegraphy brought further attention to the

[5] Nicolaas Rupke, "Humboldtian Distribution Maps: The Spatial Ordering of Scientific Knowledge," in *The Structure of Knowledge: Classification of Science and Learning since the Renaissance*, ed. Tore Frängsmyr (Berkeley, Calif.: Office for History of Science and Technology, 2001), pp. 93–116, esp. p. 94; and Keith R. Benson and Helen M. Rozwadowski, eds., *Extremes: Oceanography's Adventures at the Poles* (Sagamore Beach, Mass.: Science History Publications, 2007).

[6] Bruno Latour, "Drawing Things Together," in *Representations in Scientific Practice*, ed. Michael Lynch and Steve Woolgar (Cambridge, Mass.: MIT Press, 1990), pp. 19–68.

depths of the sea. Fascination with the ocean was manifested in the avid readership for new maritime novels, the rise of yachting, the increasing popularity of ocean travel, and the crazes for marine natural history and home aquaria. For the first time in Western history, people went to sea with the intent to pause rather than to cross quickly. The ocean transformed from highway to destination.[7]

As the earth's oceans became culturally, economically, and politically relevant, they attracted the attention of men of science. While mariners applied new technologies—the chronometer, iron, and steam—to ply the ocean's blue waters, and fisherman knew the ocean through work, scientists adopted the methods of Humboldt to study the ocean's physical properties. Perhaps owing to the recent spate of scholarship on Humboldt, almost all of which begins and ends in the middle of continents, it is often forgotten that Humboldt himself began with the oceans.[8] If the Western world had to learn to "see" oceans, Humboldt was the premier educator. His first tutor was J. H. Campe, a noted geographer and the translator of *Robinson Crusoe*, and Humboldt read every text on maritime exploration in his teacher's library. By the time he set sail on his own long-anticipated journey in June 1799, aboard the *Pizarro*, he was perfectly primed to appreciate what the ocean had to offer.

The currents carried the *Pizarro* along an established course so reliable and so well traveled that sailors called it "the road of Santa Cruz." The "road" itself is what first caught Humboldt's imagination. In addition to making atmospheric and magnetic measurements, he became fascinated by the ocean flora and fauna, particularly seaweed and jellyfish, and the ocean currents that carried them. The oceans connected the world physically—it would take two years and ten months, he calculated, for the water beneath his feet to travel the entire globe—and, for Humboldt, emotionally and symbolically as well. "You could not put him on any sea or shore," Ralph Waldo Emerson said of Humboldt, "but his instant recollection of every other sea or shore illuminated this."[9] Before he explored continents, Humboldt contemplated the world's oceans to formulate his global vision, more interested in how ocean currents affected mean temperatures than how atmospheric pressure affected vegetation patterns. Above all, he was interested in global patterns, in formulating an overarching synoptic vision. As a way to express the relationships among the disparate but interconnected forces in nature, he revolutionized the graphical representation of data, using "isomaps" and other unprecedented visual displays rather than tables to exhibit patterns in nature. (See Figure 1.)

Following Humboldt's creed of the interconnectedness of nature, natural philosophers became increasingly hopeful that the ocean's depth, temperature, and salinity could help answer age-old questions concerning the changes in the atmosphere (including questions about meteorology and terrestrial magnetism), the movement of the oceans (including tides, depths, and currents), and the distribution of life forms (biogeography). The earth's oceans were in many respects better suited to a Humboldtian approach than its landmasses, where mountain ranges and national borders hampered the study of meteorology and magnetism across large geographical areas. The sea, though at times forbidding and dangerous, was open and borderless. The compilation and correlation of ocean measure-

[7] Helen M. Rozwadowski, *Fathoming the Ocean: Discovery and Exploration of the Deep Sea* (Cambridge, Mass.: Harvard Univ. Press, 2005).

[8] See Aaron Sachs, *The Humboldt Current: Nineteenth-Century Exploration and the Roots of American Environmentalism* (New York: Viking, 2006); and Laura Dassow Walls, *The Passage to Cosmos: Alexander von Humboldt and the Shaping of America* (Chicago: Univ. Chicago Press, 2011).

[9] Walls, *Passage to Cosmos*, p. 51; and Ralph Waldo Emerson, quoted in Sachs, *Humboldt Current*, p. 50.

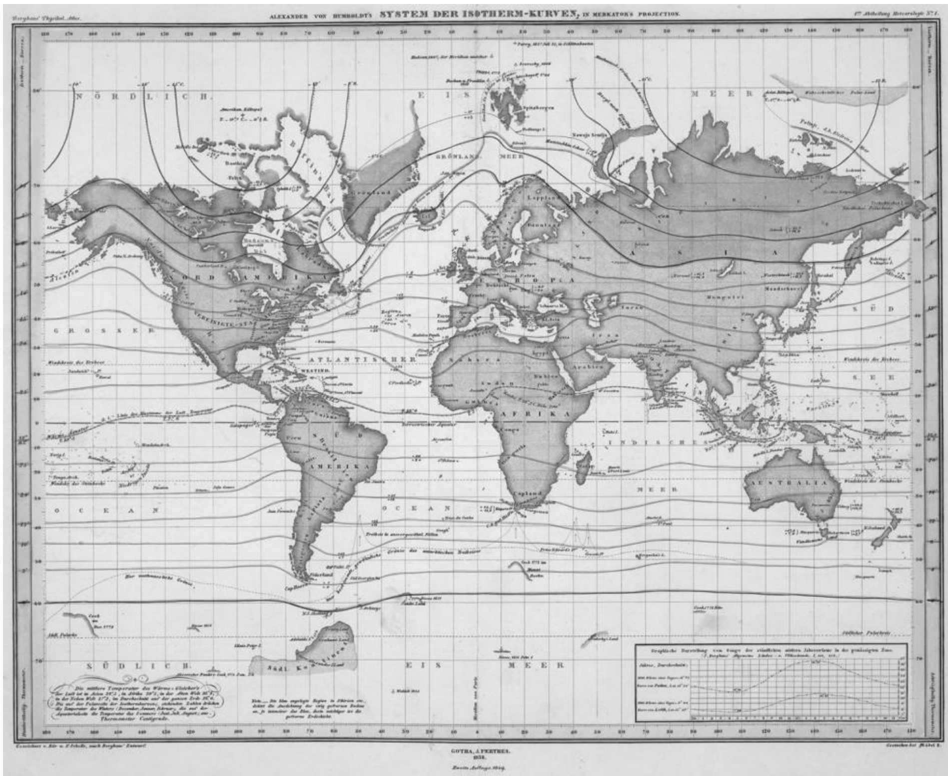


***Figure 1.*** *Alexander von Humboldt's isothermal lines over the world's oceans. From H. Berghaus,* Physikalischer Atlas, *Vol. 1, No. 1 (1849).*

ments, with attention to their spatial distribution, became the most prolific and widespread feature of the nineteenth-century study of the sea.[10] The combination of a spatial approach with detailed measurements advanced an array of sciences that are usually associated with land.

To view the ocean as a relevant scientific space required access to empirical data, and it was primarily in the nineteenth century that masses of usable data on the ocean became available, beginning with the coastline and extending far into the marine environment. As maritime trade expanded, and more and more ships were lost owing to uncharted dangers, the British government founded the Hydrographic Office in 1795. It became a clearinghouse for incoming information from overseas expeditions. After Francis Beaufort became Hydrographer in 1829, it rose to become the research and development wing of the Admiralty.[11] Beaufort's relationship with men of science, and the overarching connections

[10] Michael S. Reidy, *Tides of History: Ocean Science and Her Majesty's Navy* (Chicago: Univ. Chicago Press, 2008).

[11] G. S. Ritchie, *The Admiralty Chart: British Naval Hydrography in the Nineteenth Century* (1967; Edinburgh: Pentland, 1995); Nicholas Courtney, *Gale Force 10: The Life and Legacy of Admiral Beaufort, 1774–1857* (London: Headline, 2003); and Randolph Cock, "Sir Francis Beaufort and the Co-ordination of British Scientific Activity, 1829–1855" (Ph.D. diss., Univ. Cambridge, 2003).

between the Admiralty and the scientific community, led to increased funding for new, empirically based oceanic projects.

In the United States, Matthew Fontaine Maury performed some of the same functions for the U.S. government. After a serious leg injury, Maury resurrected his naval career by demonstrating the utility of integrating science into naval practice. From 1842 Maury directed one of several national institutions oriented toward maritime interests, the Depot of Charts and Instruments (founded in 1830), which would become the Naval Observatory. The country's maritime commercial needs drove the development of other scientific maritime institutions as well, including the Coast Survey (1807) and the Nautical Almanac Office (1849).[12] From the start of his tenure at the Depot of Charts and Instruments, Maury began mining old logbooks for data. His assistants compiled wind and current observations into charts that, along with sequential editions of his *Sailing Directions*, were greeted enthusiastically by mariners convinced that these tools reduced sailing time and rendered navigation safer.[13] The ocean catalyzed government funding of science, forging the inextricable relationship between governments and science that is still with us today.

Scientists capitalized on government interest in the science of the sea and increasingly relied on the resulting support to bring rule and rationality to the world's seemingly chaotic oceans though a myriad of research frontiers, including tides, terrestrial magnetism, meteorology, and oceanic flora and fauna. Beginning with their home waters, they went on to extend their methods out into the world's oceans, viewing the enormous spaces between continents as one connected whole. This extension enabled scientists to speak decisively about areas of the open ocean where measurements were limited.

The study of the tides illustrates the spatial turn taken by nineteenth-century scientists. When the London banker John William Lubbock resurrected the theoretical study of the tides in the 1830s after almost a century of neglect, he proposed making long-term observations at every port, an approach that would take nineteen years of observations to yield accurate tide tables. Lubbock's former tutor, William Whewell, proposed a different tack that entailed constructing a theory of the tides based on their progression across the wide extent of the world's oceans. If the course of the tides was known in the ocean and accurate tidal tables existed for one port—say, Liverpool—Whewell reasoned that a researcher could extrapolate from one port to the next and, eventually, to all ports in Europe and beyond.

This approach represented a dramatic switch in the spatial scope of tidal investigations and coincided with Whewell's coinage of the word "scientist" to describe a practitioner of such a program. As Whewell put it, "Continued observations at the same place are connected by relations of time; comparative observations at different places are connected by relations of space. The former relations have been made the subject of theory, however imperfectly: the latter have not." To undertake the spatial approach to the tides, Whewell turned to the British Admiralty for support. Beaufort extracted data from dusty archives, wrote to all his active surveyors and captains, and actively solicited the help of foreign

[12] Steven J. Dick, *Sky and Ocean Joined: The U.S. Naval Observatory, 1830–2000* (Cambridge: Cambridge Univ. Press, 2003), p. 21; Jason Smith, "'Controlling the Great Commons': Hydrography, the U.S. Navy, and the Sea in the Nineteenth Century" (Ph.D. diss., Temple Univ., 2012); Harold Burstyn, "Seafaring and the Emergence of American Science," in *The Atlantic World of Robert G. Albion*, ed. Benjamin W. Labaree (Middletown, Conn.: Wesleyan Univ. Press, 1975), pp. 76–109; and Hugh Richard Slotten, *Patronage, Practice, and the Culture of American Science: Alexander Dallas Bache and the U.S. Coast Survey* (Cambridge: Cambridge Univ. Press, 1994).

[13] Dick, *Sky and Ocean Joined*, pp. 60–117.

hydrographers, asking for observations from captains and naturalists sailing in distant waters. These combined efforts culminated in a "great tide experiment" in the summer of 1835 in which surveyors and other observers from nine countries took measurements of the tides every fifteen minutes for two weeks.[14]

Whewell's new method demanded a novel way to exhibit the data. Comparative observations, he noted, were almost impossible to reduce to calculation owing to the "extreme complexity" of forces on which they depend. "But, though the connexion of the tides in different places cannot be *calculated*," Whewell argued, "it can be *expressed*."[15] From the results, Whewell produced an isotidal map, based on Humboldt's method of data analysis, that demonstrated how the tides progressed through the Atlantic and Pacific oceans. Whewell combined a spatial approach with the power of visual representation to simplify the world's oceanic tides onto one sheet of paper the exact size of an Admiralty chart. (See Figure 2.)

These synoptic maps were powerful for the advance of similar studies in physical astronomy, copied to great effect in terrestrial magnetism and meteorology. British natural philosophers traced the varying magnetic needle, for instance, with the fervor and energy of a religious calling, causing their effort to become known as the Magnetic Crusade. Owing to the homogeneous nature of the ocean's surface, as well as its relatively stable temperature compared to air, observations made at sea suffered far less from disturbing influences than those made on land. The area of the sea also far exceeded that of the land, and thus, as the astronomer John Herschel argued, "a much wider field of observation is laid open, calculated thereby to offer a far more extensive basis for the deduction of general conclusions."[16]

Meteorology likewise benefited from investigations conducted at sea. Because the large landmass of North America made it ideally suited for charting storms and other meteorological phenomena, leaders of American science viewed meteorology as a science in which American researchers could finally advance beyond their British counterparts. Maury capitalized on the international attention garnered by his wind and current charts and spearheaded one of several midcentury international collaborations in meteorology. He orchestrated international cooperation to collect data over the ocean, earning recognition as a leader of meteorological research.[17] The sea's accessibility, geographic extent, and natural uniformity made it propitious for global geophysical investigations.

Midcentury fascination with the ocean's great depths was as tied to nationalistic and capitalist designs as was attention to the sea's surface. Investigation of the ocean's third dimension grew out of hydrographic charting activity, itself promoted by dramatic growth in the shipping and whaling industries. Under Beaufort's leadership, the British Hydrographic Office produced most of the charts used worldwide. To the maturing United States

[14] William Whewell, "Memoranda and Directions for Tide Observations," *Nautical Magazine*, 1833, *2*:665; and Reidy, *Tides of History* (cit. n. 10).

[15] Whewell, "Memoranda and Directions for Tide Observations," p. 665.

[16] John Cawood, "The Magnetic Crusade and Politics in Early Victorian England," *Isis*, 1979, *70*:493–518; and John William Herschel, "Meteorology," in *The Admiralty Manual of Scientific Enquiry* (London, 1849), pp. 113–157, on p. 113.

[17] Guy T. Houvenaghel, "The First International Conference on Oceanography (Brussels, 1853)," in *Ocean Sciences: Their History and Relation to Man: Proceedings of the Fourth International Congress on the History of Oceanography, Hamburg, 23–29 September 1987*, ed. Walter Lenz and Margaret Deacon (*Deutsche Hydrographische Zeitschrift*, Ergänzungsheft, Ser. B, no. 22) (Hamburg: Bundesamt für Seeschaffahrt und Hydrographie, 1990), pp. 330–336; and James Rodger Fleming, *Meteorology in America, 1800–1870* (Baltimore: Johns Hopkins Univ. Press, 1990).

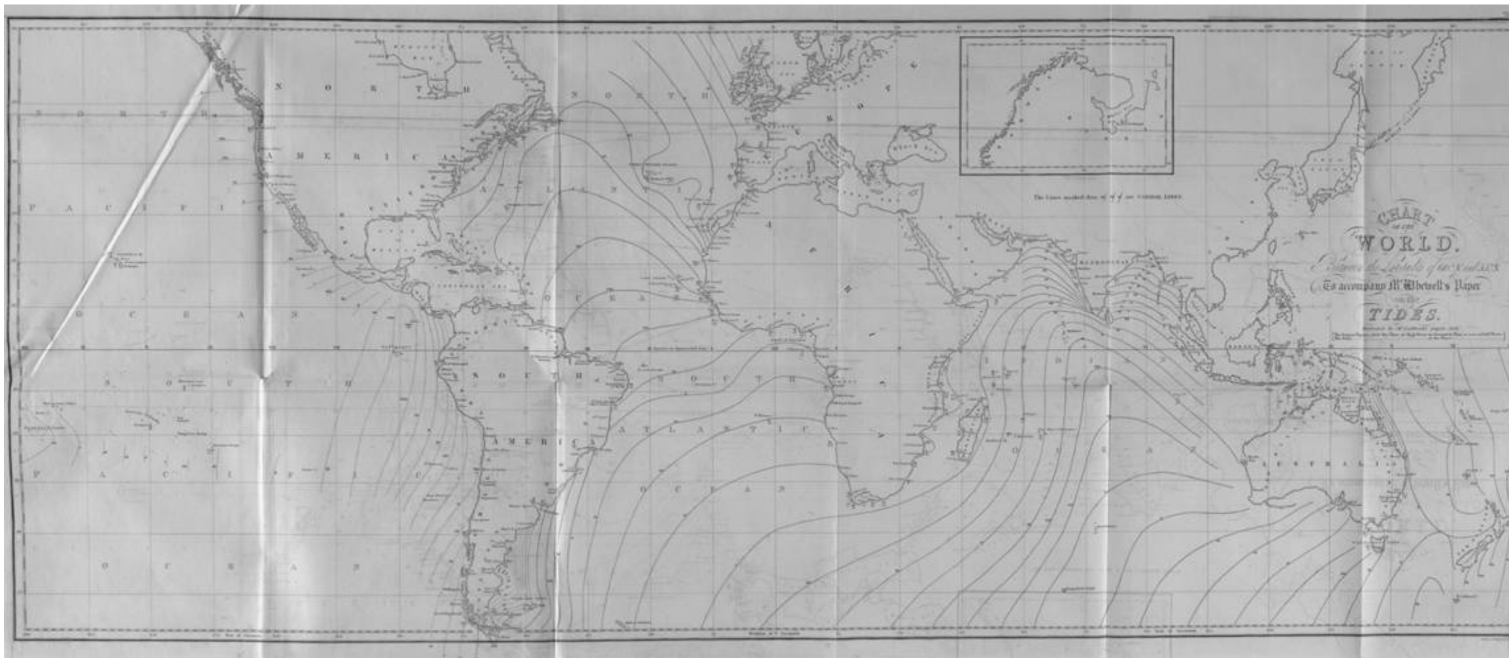


***Figure 2.*** *A chart of the cotidal lines of the world's oceans. Reproduced from William Whewell, "Essay towards a First Approximation to a Map of Cotidal Lines,"* Philosophical Transactions, *1833,* 123*:147–236. Permission of the University of Minnesota Libraries.*

at midcentury, whose shipping and shipbuilding industries, whaling fleet, and packet service rivaled even Britain's, this situation rankled. Maury complained to the Secretary of the Navy that American ships had to rely on charts from other nations not just in distant seas, but also in American waters. Although the Coast Survey had responsibility for charting harbors, anchorages, coastlines, and fishing banks, Maury asserted naval rights to chart offshore waters as well.[18]

To construct a hydrographic chart, surveyors conducted measurements inshore, then ran longer lines of soundings out to sea to record the approach to the coast. By midcentury, surveyors continued soundings out to the edge of the continental shelf, whenever possible to the 100-fathom mark.[19] The nature of seafloor sediments, recorded on inshore charts, was by that time an important navigational aid. When traversing deep water far from land, though, mariners were casual about knowing their exact position unless they were near vigias, exposed rocks or shoal areas in otherwise open seas. Clearing suspected vigias off charts boosted commerce by opening routes that navigators had previously avoided.

The deep seafloor proved a model stage for enacting Humboldtian science. Between 1849 and 1853, hydrographers working under Maury's direction transformed deep-sea sounding from sporadic, experimental efforts into systematic, routine work. As he did for wind and current observations, Maury compiled depth data to produce a bathymetric chart of the Atlantic, the first ocean-basin map, in 1853. It included shaded zones marking contours of 1,000, 2,000, 3,000, and 4,000 or more fathoms. While admitting the conjecture involved, Maury asserted that the chart conveyed "a general idea as to the shape of the Atlantic basin." (See Figure 3.) A second 1853 visual representation of the seafloor, borrowing from geographers' visual practice of land elevation profiles, contains a vertical section comparing the elevation of the Rocky Mountains to the depth of the Atlantic seafloor across to the Azores and Europe.[20] Maury also created charts of whale captures and sightings excerpted from whalers' logbooks in an effort to marry the Humboldtian approach with the promotion of industry. The title of Maury's influential book *The Physical Geography of the Sea* (1855) expresses his debt to Humboldt as well as his ambition to exercise Humboldt's vision upon and within the ocean.[21] To a young nation with designs on establishing an extensive formal empire, knowledge of the ocean's depths exerted national authority.

As with other mapping efforts, the inscription of depth measurements and types of seafloor sediments on charts supported industrial and political uses of the ocean's space and resources. The prospect of submarine telegraphy injected a new motive for deep-sea investigation. Maury's second bathymetric chart, from 1855, included more soundings (about 189 compared with 90) and focused on an area of the North Atlantic increasingly

[18] Ritchie, *Admiralty Chart* (cit. n. 11), p. 3; and Thomas G. Manning, *U.S. Coast Survey vs. Naval Hydrographic Office: A Nineteenth-Century Rivalry in Science and Politics* (Tuscaloosa: Univ. Alabama Press, 1988).

[19] One fathom is 6 feet. See Hydrographic Office, *General Instructions for the Hydrographic Surveyors of the Admiralty* (Hydrographic Department Publication 65) (1877), pp. 8, 10, 31.

[20] Matthew Fontaine Maury, *Explanations and Sailing Directions to Accompany Wind and Current Charts*, 5th ed. (Washington, D.C.: C. Alexander, 1853), pp. 238–239 (quotations), Plate XIV (bathymetric chart); and Maury, *Explanations and Sailing Directions to Accompany Wind and Current Charts*, 6th ed. (Philadelphia: E. C. and J. Biddle, 1854), Plate XV (vertical section).

[21] Matthew Fontaine Maury, *The Physical Geography of the Sea* (New York: Harper, 1855). See also D. Graham Burnett, "Matthew Fontaine Maury's 'Sea of Fire': Hydrography, Biogeography, and Providence in the Tropics," in *Tropical Visions in an Age of Empire*, ed. Felix Driver and Luciana Martins (Chicago: Univ. Chicago Press, 2005), pp. 113–134.

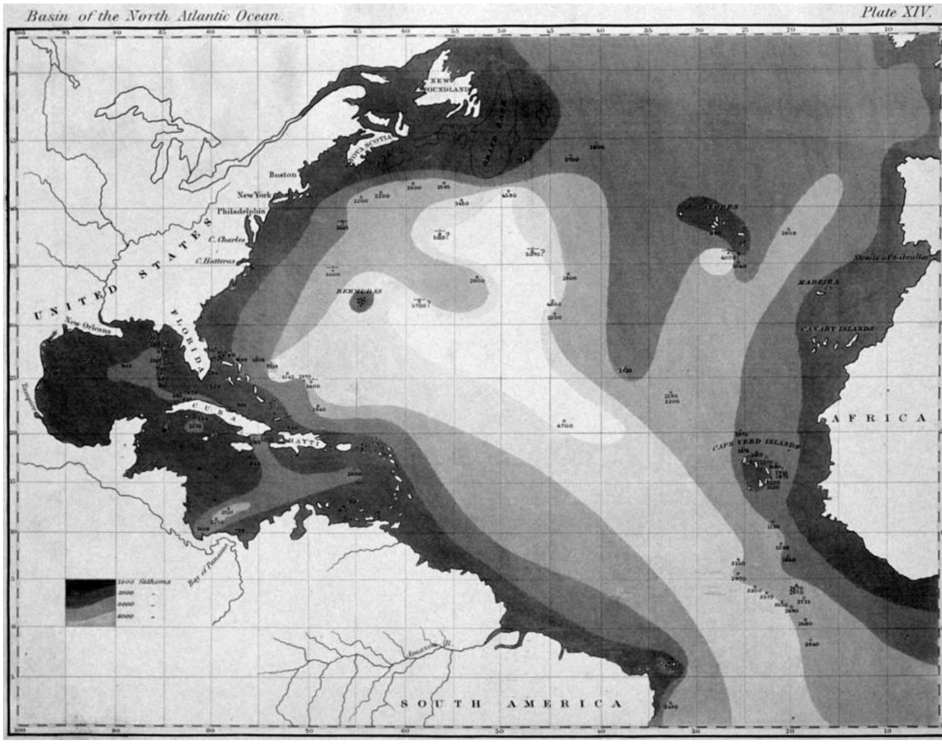


***Figure 3.*** *Matthew Fontaine Maury, "Bathymetric Chart of the North Atlantic Ocean," in* Wind and Current Charts *(1853). Courtesy of U.S. Naval Observatory Library.*

used for travel by steamships and targeted by submarine telegraph entrepreneurs. Deep-sea sounding data suggested to Maury the presence of a relatively shallow steppe, which he opportunistically christened "Telegraph Plateau." The invention of a novel sounding device by a young Maury-trained hydrographer, John Brooke, resulted in the ability to retrieve bottom samples and to confirm that bottom had been reached. Evidence from Brooke's sounder settled a debate over whether the seafloor was a safe place for telegraph cables.

The debate about the seafloor's suitability for telegraph cables intersected with a controversy about the existence of life at great depths.[22] The azoic hypothesis—that life disappeared around 300 fathoms—was articulated by the highly respected founder of marine zoology, Edward Forbes, who trained an entire community of naturalist-dredgers, including the young Charles Darwin, ensuring that an active community continued his work after his untimely death. A partnership between the Royal Society and a receptive Admiralty resulted in a series of summer research cruises on naval vessels in the 1860s that extended zoological collecting to the deepest parts of the ocean. They found life everywhere.[23] These successes inspired the voyage of HMS *Challenger*, whose scientific

[22] George C. Wallich, *The North Atlantic Sea-Bed* (London: John van Voorst, 1862), pp. 68–69; and Rozwadowski, *Fathoming the Ocean* (cit. n. 7), pp. 138–142.

[23] Edward Forbes, *The Natural History of the European Seas*, ed. and continued by Robert Godwin-Austen (London: John van Voorst, 1859); and C. Wyville Thomson, *The Depths of the Sea* (London: Macmillan, 1874) (life everywhere).

and naval crew spent three and a half years between 1872 and 1876 sailing and studying all the world's oceans, showing the flag, collecting data for future telegraph enterprises, and establishing the modern science of oceanography as the preferred way to interpret ocean space.

The *Challenger* voyage demonstrates that the nineteenth-century project of knowing the ocean was not limited to the geophysical sciences. Biogeography, like Humboldt's physical geography, depended on detailed study of the sea. Charles Darwin included two chapters on the topic in his monumental *Origin of Species*, one of which was dedicated entirely to oceans. Linking himself to Humboldt, Darwin concentrated on the correspondence between latitude and altitude, as did other naturalists of the period, including Joseph Dalton Hooker and T. H. Huxley. It was up to the co-discoverer of evolution through natural selection, Alfred Russel Wallace, to comprehend fully the role of the oceans in the distribution of the world's flora and fauna.

In his *Geographical Distribution of Animals* (1876), Wallace rejected altitudinal or latitudinal zones in favor of "zoological regions." His frontispiece, a large Mercator map of the globe, depicts these different zoological regions using numbers and colors. At first, the brightly colored landscapes come into sharp relief, but slowly the seascape also comes into view. It is likewise color coded, its blue increasing in intensity according to depth. The title of the map—"The World on Mercator's Projection shewing the ZooGeographical Regions and the Approximate Undulations of the Ocean Bed"—alerts the reader, right from the start, to the prominent place the depth of the ocean will have as either barrier or connector. (See Figure 4.) Wallace expanded on this theme in *Island Life*, where he formulated his synoptic explanation of why certain plants grow in specific areas.[24] Knowledge of the geological history of the earth, especially the depth and contour of the seabed, revealed the fifteen-mile strip of extremely deep ocean between Lombok and Bali dubbed "Wallace's Line." This zone formed a barrier between zoological regions that illuminated species distribution in ways that terrestrial or surface features could not. While biogeography is overwhelmingly associated with islands specifically, and land more generally, its origins were oceanic.

## REEXAMINING THE HISTORY OF SCIENCE THROUGH AN OCEANIC LENS

Science went through dramatic transformations in the mid-nineteenth century. It was a time of acute specialization, including the birth and astounding growth of geology and biology, the formulation of physics in its modern form, the creation of the geophysical sciences, including oceanography and meteorology, and the steady rise of both botany and zoology as subspecialties. It was also the period when naturalists became regular members of voyages of exploration. Naval and science historians alike never fail to point to Charles Darwin's monumental voyage on the HMS *Beagle* in the early 1830s as the basis for the complete overhaul of the biological sciences.

Yet this standard narrative often seems to suggest, in spite of ritual invocations of Darwin's voyage, that the extraordinary advances in the sciences were divorced from the sustained contact with the ocean as a physical space. The Royal and mercantile navies appeared to function merely as an oceanic transport system for naturalists as they contemplated the more arcane aspects of nature in the far terrestrial corners of the globe

[24] Alfred Russel Wallace, *The Geographical Distribution of Animals* (New York, 1876), pp. vi–x, 6; and Wallace, *Island Life* (London, 1880).


**Figure 4.** *"The World on Mercator's Projection shewing the ZooGeographical Regions and the Approximate Undulations of the Ocean Bed," frontispiece of Alfred Russel Wallace,* The Geographical Distribution of Animals *(New York: Harper & Brothers, 1876).*

and created their disciplines back in their offices in London or Washington, D.C. Such an interpretation is the product of a narrow focus by historians of science on individual laws, individual people, and individual discoveries. A cult of individuality has masked the far more profound change in the actual *practice* of science that took place by the mid-nineteenth century, as well as the actual physical geography of where that change took place. Though individual theories and prominent scientists were significant for the general acceptance of science in Victorian culture, the most profound change to occur in the sciences during this period was methodological. The expansion of empire enabled scientists, for the first time in history, to study topics that required the accumulation and subsequent reduction, tabulation, and graphing of large amounts of observational data from all over the globe. This essay argues that the advance of science, the creation of empire, and the construction of the ocean were mutually sustaining.

Researchers like Humboldt in magnetism, Whewell in the tides, Herschel in meteorology, Wallace in biogeography, and Maury in seafloor bathymetry all turned to the visual representation of the world's oceans as the final product of their investigation. These representations of the world's oceans rendered a forbidding environment approachable and ostensibly permitted the creators and owners of these representations safer, more effective, more predictable use of the sea. What used to be an "obstacle to man's progress at the borders of which he shrank back terrified" had been transformed, according to the *London Illustrated News*, into a "yielding bosom he now sails or steams quickly, and with ease, withersoever he will." Visual representations, then, made it possible to use ocean space in new ways to exercise power over distant lands and markets, the essence of nineteenth-century imperialism.

The imperial context had profound implications far beyond the production of knowledge about the ocean and the immediate use of that knowledge. The tone for the Western relationship with the sea was set in the mid-nineteenth century, when the ocean was systematically defined by graphs and grids. Nationalism fanned cultural claims to the sea and its resources, while the drive for imperial power prompted the extension of new industrial technologies across and into ocean space. Britain, for instance, used its advantage in deep-sea science and technology to connect its terrestrial possessions by a global network of undersea cables, while many nations employed science and technology to create industrial fisheries of unprecedented size and extent.[25] Imperial practice and ideology led to the assumption that marine resources should be exploited—maximally—by people with the knowledge and power to identify and extract them.

This essay has explored how scientists perceived, interacted with, and placed value on the ocean during the great age of European expansion and influence. Because use of the ocean in that period was suffused with the doctrine of the freedom of the seas, the ocean was constructed as a space amenable to control by any nation that could master its surface and use its resources effectively. The logic of commercial capitalism insisted that industrialization, including the shipping of raw materials and manufactured products and, as Jennifer Hubbard's contribution to this forum demonstrates, its increasingly industrialized fisheries, be unconstrained by regulation. Yet safe transportation and other uses of the sea rested on reliable knowledge of the ocean. They depended on a highly ordered ocean space, one that was bounded by isolines and bottom profiles. The history of the ocean in

[25] Daniel R. Headrick, *The Invisible Weapon: Telecommunications and International Politics, 1851–1945* (Oxford: Oxford Univ. Press, 1991); and Helen M. Rozwadowski, *The Sea Knows No Boundaries: A Century of Marine Science under ICES* (Seattle: Univ. Washington Press; London: ICES, 2002).

the nineteenth century is one in which nation-states gained control over the ocean environment—not explicit political dominance of areas of the sea or absolute control over nature but, rather, the tangible ability to use ocean space to extend imperial and industrial reach around the globe. Western, and particularly Anglo-American, knowledge of the ocean was—and remains—inextricably connected to midcentury geopolitics and the growth of modern science.