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INTRODUCTION

The Beach Philosophers

The experience of the pioneering research vessel HMS *Challenger* in the Southern Ocean in early 1874 summed up its contradictions. On the bleak Kerguelen Islands, just outside the Antarctic Circle, *Challenger* fell in with an American whaler crewed by desperate Portuguese teenagers who had escaped military conscription at home only to find themselves transported to a polar heart of darkness. Deserters from the whaling station were shot on the spot, while handwritten epitaphs marked the beach graves of those who had "drowned while fastened to a whale."[1]

Circumstances were more pitiful still for the marine wildlife of the Kerguelen Islands. The Americans had mastered the deadly art of firing bombs at surfacing whales from close range. When whales were scarce, the hunters slaughtered seals with no care for the sustainability of the colony. Breeding females and their pups were clubbed and skinned with the males. During their brief visit, the crew of the *Challenger* launched their own killing spree. In one encounter with a herd of sea elephants, they attacked the giant, floppy-nosed male with clubs and knives, then shot his cows as they fled into the water. The dying sea elephants, who had "a most enormous quantity of blood in them," stained the waters of the bay bright red.[2]

But in contrast to the whalers, where *Challenger* brought death she also discovered life—teeming, resilient, and wild.

1 Wild (1878) 65.
2 Moseley (1892) 177.

Boating in the cold waters off Kerguelen, *Challenger*'s naturalists navigated swarms of jellyfish and thick fields of kelp inhabited by never-before-seen mollusks and sea cucumbers. Their tow nets scooped up a smorgasbord of plankton—the bottom of the food chain. Then the *Challenger* trawl—designed for larger specimens—raised a stunning array of creatures from the frigid depths two miles down: gigantic glass sponges, tube-like sea squirts, skates, sea spiders, a type of worm called a sea mouse, frill-lined crabs that recalled the trilobites of the ancient ocean, and a bizarre crustacean with red-colored hexagons on its shell that looked uncannily like eyes. Seven hundred fifty species in all—not counting the plankton—two-thirds of them unique to the Southern Ocean. According to established Victorian science, life was not supposed to survive in the cold, dark abyss. But a dazzling menagerie of deep-sea animals flourished here in Antarctic waters, as they did wherever HMS *Challenger* explored the remote oceans across some 70,000 miles in the years 1872–1876.[3]

In the *Challenger* era, whaling and sealing figured among the handful of fisheries impacting the world's oceans at an industrial scale. Today, by contrast, overfishing is just one of a litany of devastating human impacts on marine life: from trawler deforestation of the seabed, to the bleaching of coral reefs, to flotillas of plastic scum twice the size of Texas. Carbon pollution is warming and acidifying the oceans, placing deadly stress on sea animals and their plant habitats that are adapted to narrow temperature windows. Since the 1980s alone, vertebrate ocean species—fish, turtles, dolphins, etc.—have declined by more than 20 percent, and the total fish population of the oceans by nearly 40 percent. *Challenger*'s meticulous inventory of deep-sea life in the 1870s thus represents the most

3 "Life is everywhere present on the sea-bed in all depths and at all distances from the shore." Murray (1896) 487.

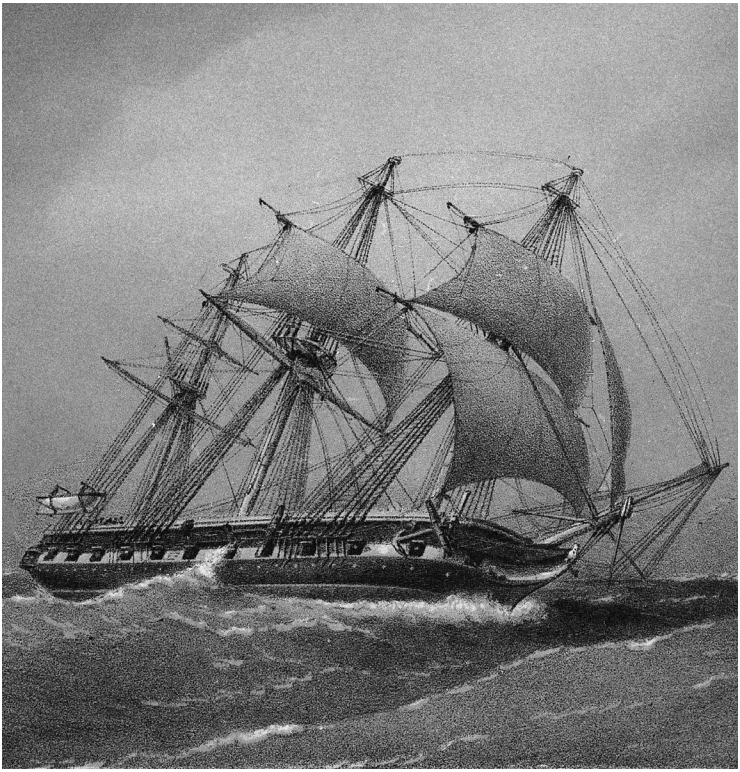

FIGURE 0.2 HMS *Challenger* in Antarctica. January 1874. Attributed to William Frederick Mitchell (1880). Courtesy of Royal Museums Greenwich.

detailed picture we have by which to compare the oceans as they were in the first stages of human annexation.[4]

The *Challenger* story begins not with the ship itself—a Royal Navy corvette converted to a floating marine laboratory—but with the global ocean it navigated. This four-billion-year

4 See McCauley (2015). If the *Challenger* voyage has a precursor, it is the global expedition of 1845–1847 sponsored by the King of Denmark, with a suite of naturalists onboard. But due to the death of the king and political turmoil at home, the 93 containers of specimens collected by *Galathea* were not properly processed, and the results remained unpublished.

history, in turn, consists of dual, interwoven threads: a geological tale of slow-drifting continents and the gradual opening of modern ocean basins, in stark contrast to a biological record of boom and bust.

The year *Challenger* set sail on her epic voyage, reports reached Europe of the most ancient sea creature yet found—*Aspidella terranovica*. An amateur naturalist had stumbled on a constellation of conical rings imprinted on a rock in St. John's, Newfoundland. Whatever the enigmatic *Aspidella* fossil might be—a kind of jellyfish or a holdfast for a soft coral or sponge—it was the first evidence of the ocean's "sudden" evolution, 600 million years ago, from an intermittently freezing anoxic basin, host only to primitive microbes, to a complex aquatic environment capable of supporting prototypes of our modern corals, anemones, and crustaceans.

The so-called Cambrian explosion that followed turned the oceans into a global aquarium of wonders—including, for the first time, vertebrate fish. But continued volcanic upheavals—accompanied by splitting continents—rendered marine life vulnerable to rapid changes in oxygen and acidity. Fish populations swelled then collapsed. Even the ubiquitous crawling trilobites vanished. From the ruins of the worst crash of all—the end-Permian extinction 251 million years ago—modern calcite-shelled plankton emerged capable of transporting carbon from the surface to the seafloor. Ocean chemistry stabilized. For nearly 200 million years, warm water oysters thrived, while reptilian monsters dominated shallow, coral-filled seas that lapped deep into continental interiors. And so might the world have remained in essentials but for a rogue asteroid that brought an end to the ocean dinosaurs and greenhouse climate of the Mesozoic. In the aftermath of this latest brutal extinction, fish repopulated the cooling seas along with a cornucopia of invertebrate marine life: from tiny plankton of brilliant design to dazzling starfish to a deepwater squid ten meters long.

The genus *Homo* emerged 2.5 million years ago to a chilly Earth with its modern continents established and a colorful marine life recognizable to us today—at least in outline. It's worth reminding ourselves, however, that HMS *Challenger* did not set sail across an untouched Pleistocene ocean. Conventional histories of the first modern humans glamorize their decimation of land megafauna, but more recent archaeology spotlights our beachcombing instincts. Human communities began harvesting coastal marine animals at least 40,000 years ago. The first Americans, for example—who travelled the so-called kelp highway via California to Patagonia—feasted on abundant shellfish. Neolithic rock paintings from Korea depict the first known whale hunts.

Ancient shell middens, found along coasts and island beaches worldwide, are the clearest evidence of our long-term dependence on marine protein. As for the written historical record, measurable impacts of human fisheries on marine life trace back at least a thousand years. In the North Atlantic, depletion of freshwater fish stocks by the eleventh century turned attention seaward to the seemingly inexhaustible bounty of herring and cod. Europeans pursued these stocks across the Atlantic to Newfoundland then New England, where they fortuitously discovered oyster beds sufficient to sustain arriving New World migrants in their hundreds of thousands. The emerging global fishery—at the vanguard of European empires—plundered sea cows in the Bering Sea, turtles in the Caribbean, sea otters off California, and seals and whales to the furthest reaches of the oceans, including both poles. By the time *Challenger* set sail, hundreds of ships prowled the world's whaling grounds, while Scotland alone—intellectual hub of the expedition—was producing 800,000 barrels of herring annually for export consumption.

But rapacious as it was, the Atlantic fishery of the Victorian age paled in comparison to what has followed. *Challenger* herself was a hybrid vessel: part sailing ship, part

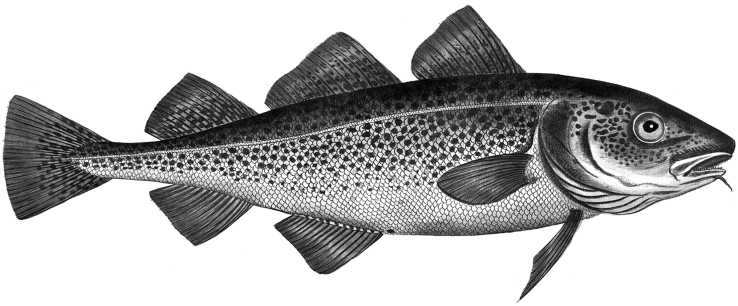

FIGURE 0.3 Centuries before the *Challenger* voyage, pursuit of the codfish drew European vessels to western Atlantic waters and the "new world." "Gadus Morhua, the Cod Fish" by Marcus Elieser Bloch (*Ichthyologie, ou Histoire Naturelle des Poissons*, vol. 1 [1796], plate 64).

steamship. With the launch in the late 1870s of the first modern steam trawlers capable of working day and night regardless of wind or tide, the fate of ocean ecosystems—our Pleistocene heritage—was sealed. Barely an inch of the world's continental shelves has escaped industrial trawling in the century and a half since, transforming millions of acres of teeming, plant-rich seabed into sandy underwater desert. For millennia, coastal human communities confined themselves to fishing well-stocked offshore waters. In the course of a short century, we have become the oceans' apex predator, eliminating an estimated 90 percent of fish in the upper levels of the food chain. By historical chance, *Challenger* set out on her global survey just prior to the industrial steam era. The naturalists who sailed with her have left us a vivid account of that marine world now lost to us.[5]

Our sense of *Challenger*'s unique value is the more acute when we realize that so ambitious a project would never have happened but for a momentary confluence of interests within a well-resourced maritime empire. The British, of course, were

5 Myers and Worm (2013).

not the first to seek to rule the waves. The islands of the world's largest ocean—the Pacific—were navigated and settled by seafaring Lapitans three thousand years ago. By the common era, the Indian Ocean played host to busy commercial traffic connecting ports in India, Africa, and Europe. Chinese traders, meanwhile, extended the "silk road of the sea" from the Southeast Asian archipelago via the Red Sea to Mediterranean markets, and Viking traders (and raiders) dominated the North Seas, venturing across the Atlantic Ocean to the Grand Banks.

These regional maritime powers flourished for centuries at a time. But no concept of a global ocean existed until the 1500s when Dutch and Portuguese navigators rounded the perilous southern capes connecting the Atlantic to the rest. Fast forward to the 1870s, and the global infrastructure of the British seagoing empire—with its well-supplied ports on major coasts in all oceans—combined with the emergence of a professional science community capable of effectively lobbying government, launched *Challenger* on her multiyear research mission. It was an unprecedented circumstance in maritime history, destined never to be repeated.

This book offers an inventory of *Challenger*'s 1870s global ocean but also of human communities under the European colonial yoke. The anonymous dockhands who filled *Challenger*'s hold with coal, and helped pilot the ship across treacherous reefs, belonged to the ranks of displaced and enslaved peoples whose labor fueled the engine of empire for centuries after Columbus. In addition to these forced human migrations, we will get a view of the coastal and island environments already ravaged in the 1870s by invasive terrestrial species, plant and animal—these were the rogue camp followers of European expansion across the globe in the nineteenth century. By activating our time-lapse imaginations, we will see how the fate of the mostly pristine Victorian ocean was anticipated in the damaged landscapes *Challenger* encountered.

Deforested coastlines in Asia and the Americas, emptied of their wild animals and long-term resident peoples, are today mirrored in devastated reef systems and a depopulated deep sea.

While Victorian colonial geography is the setting for this book, colonialism is not its subject. Marine life and its ocean habitats are the subjects. What, then, was the state of marine science in 1872, when the well-resourced *Challenger* naturalists set sail to plumb the oceans' unexplored depths? For the first half of the nineteenth century, the study of the oceans and its creatures was mostly shorebound and decidedly amateur. Like most Victorian scientific pursuits, it attracted miscellaneous intellectuals, clergymen, and eccentrics. Because empirical data on the sea was lacking, early marine science relied heavily on speculation: it was beach philosophy and little more.

By the 1870s, however, advances had been made. The coasts of Europe—and the Eastern Seaboard of the United States—had been energetically trawled for specimens. American Matthew Maury had published a compendium guide to ocean winds and currents based on the accumulated data of old ships' logs. And the richly various marine tribes—called phyla—had been organized into something like their modern form. Charles Darwin's publication of *The Origin of Species* in 1859, meanwhile, had given special impetus for exploration beyond coastal shores. The deep sea, it was speculated, might harbor missing links between extinct life preserved in fossils and contemporary plants and animals.

A generation prior to *Challenger*'s voyage, the charismatic Manx naturalist Edward Forbes had retraced Aristotle's footsteps on the shores of the Aegean, where he reflected on how little Western marine science had advanced since the Greeks. On the beaches of Lycia, he watched local fishermen hunt for cephalopods by torchlight, paddling stealthily in the rocky shallows armed with spears. From a borrowed fishing boat,

he observed the sea "filled with glancing needles of glass." The mollusk *Criseis*, with feet like butterfly wings, danced across the water, catching the sunlight on its transparent, pointed shell. Further out to sea, Forbes saw the sponge divers peering from their boats into the sunlit water just as in Aristotle's day. Holding their breath for minutes at a time, they brought up squishy masses by the basketful.[6]

For the first generation of oceanographers, data-gathering consisted of lowering a crude trawl from the stern of a fishing boat and allowing it to drag at random along the seabed—so-called dredging. From his pioneering research in the Aegean Sea, however, Forbes drew a fatefully erroneous conclusion. The mollusks, in their wild variety, studded the Aegean seafloor from the shallows to depths of several hundred feet, feeding among the seaweeds and corals. As depth increased, their shells changed: the vivid, patterned colors of the shore varieties faded to a bland whiteness. Then, beyond a critical limit—about a quarter-mile deep—the mollusk population declined to near zero, prompting Forbes to speculate that marine life was impossible in the dark, cold depths of the sea.

Challenger would definitively refute Forbes's "azoic" theory, but his ecological approach revolutionized Victorian marine science. In Forbes's official report on the Mollusca of the Aegean Sea (1843)—a publication that *Challenger*'s scientific director, Charles Wyville Thomson, hailed as "an era in the progress of human thought"—he argued that the distribution of marine life was determined by three factors: climate, water chemistry, and depth. Ocean depth, in turn, could be organized according to discrete biotic zones extending from the shore to the abyssal plain, fauna and flora changing as it went. Forbes died in 1854 having just acceded to the chair of natural history at the University of Edinburgh, a position Thomson now held. With an eye to Forbes's legacy, *Challenger*'s

6 Forbes (1843) 102.

awesome task was to extend his beach philosophy to the remotest stretches of the global ocean.[7]

Departing the Kerguelen Islands in February 1874, the *Challenger* crossed the Antarctic Circle, continuing to dredge the teeming polar deep while dodging icebergs. Tacking southward in the ice pack, the ship was the furthest distance from home in its yearslong voyage of discovery—8,500 miles. As if to signal that some physical limit had been reached, the on-deck barometer sank to a sickening low. The biting south wind off the ice freshened to a gale.

Challenger's veteran captain, George Nares, had seen enough. He had strict orders not to penetrate the ice pack and had only three months' provisions were they to get stuck—insufficient to survive the winter. The *Challenger* crew, huddled below deck, heard the long-awaited order to set sail for Melbourne, their safe haven two thousand miles to the northeast. On deck, the whipping snow stung their faces. The captain had sought shelter in the lee of an enormous iceberg, but a shift in the wind drove the ship directly toward it. Shouted orders were muffled by the howling gale, so the men simply abandoned their posts, sliding down the ice-slickened ropes to the deck. They expected any moment to hear the mainmast crashing down around them. That wild day in the Antarctic ice pack, the fate of the first global exploration of the deep sea hung in the balance.

In any ordinary naval vessel, imminent collision with an iceberg—in gale conditions with near-zero visibility—would call for all hands on deck. But on HMS *Challenger*, six able-bodied men remained below during the crisis, practically useless. John Murray—a junior scientist from Edinburgh in charge of

7 Thomson (1873a) 266. Thomson was known personally and professionally as Wyville Thomson until his knighthood in 1876, when he became Sir Charles Wyville Thomson. For this narrative, I have preferred the name by which he was known aboard *Challenger*.

skimming the sea surface with nets—complained of rheumatism in his diary while listening apprehensively to the "excitement" on deck. Ship's artist, Jean Jacques Wild, feared the worst: his leather folder full of illustrations of deep-sea wonders would surely sink without trace, along with their bottled originals. Meanwhile, the young German naturalist Rudolf von Willemoes-Suhm (whose destiny was to die in a different ocean) felt only frustration that bad weather was keeping him from his dissections in *Challenger*'s state-of-the-art workroom. As for their three senior colleagues—Wyville Thomson, Henry Moseley, and John Buchanan—one, Moseley, took to his bed with symptoms of exhaustion. But none recorded his feelings the day *Challenger* crashed the iceberg, which shattered her jib boom, sent a man plummeting from aloft, and flung a ship's boy over the side (miraculously rescued: half frozen).

In the eyes of *Challenger*'s men, these lubberly additions to the crew—nicknamed "the scientifics" or "philosophers"—were "as unlucky a shipmate as a cat or a corpse." It was because of the philosophers that *Challenger* was in Antarctica at all, having already crisscrossed the Atlantic Ocean four times in the previous year before rounding the dangerous Cape of Good Hope. Still ahead of them lay the vast coral waters of Asia and the Pacific and two more years scouring the ocean floor under all conditions, day after tedious day. Even to the *Challenger*'s officers, men of some education, their mission often seemed little more than to indulge the naturalists' unaccountable taste for wriggling critters in freezing slime.[8]

To us, however, the *Challenger* expedition, on its 150th anniversary, represents a unique nineteenth-century encounter with the sea at a planetary scale—a scale we take for granted in our era of global observation systems, deep-sea submersibles, and

8 The observation about oceangoing scientists and bad luck is from naturalist Joseph Hooker, who sailed with the Antarctic exploring expedition led by James Clark Ross (1839–43). Hooker (1877) 351.

data-rich ocean models. Without *Challenger*, we would have little notion of how much of the Victorian marine world we have since lost to overfishing, pollution, and climate change—and how much we are still in danger of losing. A century and a half after *Challenger*'s spectacular odyssey—which returned thousands of marine specimens new to science and collected groundbreaking ocean temperature data—it's worth dwelling on the sheer unlikelihood of the British government, in 1872, agreeing to send a warlike vessel, complete with seagoing philosophers, to the distant reaches of the world, far beyond all trade routes and conventional horizons. To this day, some remote stations where *Challenger* hauled up a museum's worth of spectacular sponges, starfish, and other salty wonders have never been revisited.

For a half-century before the *Challenger*'s epic voyage, a loose network of marine naturalists in Europe and the United States had been mostly shore bound, rarely venturing beyond knee-deep in the shallows, or at most a quarter mile from shore to dredge up mussels and sea stars in co-opted fishing boats. Telegraph cables—a new deep-sea technology—had awakened official interest in the ocean floor on both sides of the Atlantic Ocean. But it was a more nebulous set of circumstances—the Victorian fashion for all things marine combined with the chance influence of a few well-connected scientists—that saw study of the oceans suddenly promoted, in the imperial form of HMS *Challenger*, from shell-collecting and amateur dredging to prestige science on the global stage. *Challenger*'s cutting-edge mission would test not only how far the seafaring imagination could extend but also how deep.

The voyage of HMS *Challenger* has been extensively chronicled by ocean historians to the point of becoming a crumbling Victorian monument all its own. My new approach to the famous journey has been to de-emphasize its human actors—all white, male emissaries of empire—in favor of the global ocean itself and its creatures: those wild natives of the

global aquarium the Victorian naturalists set out to explore, and which today face mounting pressures from a rapidly deteriorating marine environment. That said, to do justice to the entire inventory of *Challenger*'s discoveries—or even a significant fraction—is a gargantuan prospect that drove its director Wyville Thomson to an early grave. The sheer volume of *Challenger*'s scientific legacy has also worked to diminish the expedition's appeal in the popular imagination.

To forestall both outcomes for this book, I have chosen a select menagerie of marine animals to tell *Challenger*'s story, each creature representing a leg of the epic journey. Interspersed with these, I recreate the major *physical* oceanographic discoveries of the voyage: these include the circulation of globe-girdling ocean currents; manganese nodules in their trillions on the Pacific Ocean floor; and the famed Challenger Deep, five miles beneath the pearl-blue surface, near Guam. I will describe, too, the remarkable phenotypic traits common to ocean organisms—such as bioluminescence, camouflage, and the daily mass vertical migration from the deep sea to the surface—that fascinated the *Challenger* philosophers, and now represent full-fledged subfields of ocean science. This book spans the nineteenth-century aqueous globe, but it also travels across time. The biography of each of my *Challenger* animals, for example, includes its evolutionary past and present existence, as well as its future prospects in a radically changing global ocean.

The oceans, it is said, are the last wilderness, and they are under existential threat. This book offers a last-chance tour of their wonders. Marine life here is the truly Other: the nonhuman in its extravagant, uncaring glory. Its gloomy habitat, the deep sea, is a wilder place than any terrestrial forest or remote highland. From a self-amputating sea star, to the endangered green turtle, to the ever-present animalcules glowing by their millions in *Challenger*'s frothy wake, the creatures of the ocean

deep make a sometimes-elegiac transit across these pages. In classic histories of oceanography, the *Challenger* expedition marks the birth of an era. But *Challenger* also signifies the end of innocence: its intrepid voyagers bore witness to the last days of the preindustrial ocean. One hundred fifty years on, we live in its wake.

But we would be wrong to project our present anxieties onto the past. The Challengers—the ship's officers, crew, and naturalists—felt no sense of loss on their journey, let alone the psychological cloud of a planetary emergency. Rather, the oceans supplied "endless novelties of extraordinary interest" to be pursued to the literal ends of the Earth. Across 1,250 days and 70,000 miles, their nets and trawls bulged with unseen marvels from the deep sea. On their return, it took twenty years to process them all and publish the results.[9]

The ocean has a different appearance and history depending on who is looking at it. The *Challenger* naturalists contemplated its mysteries through Western eyes and used ready-made tools of European scientific inquiry to describe what they saw. Some of that language is obsolete or discredited—but core insights from the mission have endured, which I detail in the chapters to follow.

I also have an argument to make. Implicit in the sprawling *Challenger* canon of early ocean research is a core environmentalist principle: that to preserve Earth's animals and habitats requires awakening our dormant biophilia—our love of nature. To save the world, we must re-enchant the world. The *Challenger* scientists' attitudes toward nature were different from ours—underwritten as they were by a belief in European superiority. But this is not the whole of their legacy. Wyville Thomson's and his colleagues' deep passion for the life aquatic is palpable on every page of their voluminous writ-

9 Thomson (1873a) 49. Imperial measures are appropriate to the period of HMS *Challenger*. Metric units will be cited from current scientific literature.

ings. Their biophilia, when separable from their prejudices, stands as a model and inspiration. In this book we will peer over the shoulders of these nature-loving Victorians at work and, through their eyes, bear witness to the undersea marvels they encountered.

Like a telescope whose sweep of the empty horizon catches a distant blur then zooms in until a single, white-sailed ship fills its entire frame, the narrative that follows tracks *Challenger* in close-up detail on her ocean-spanning travels of 1872–1876. To best capture the still urgent relevance of that journey to us, this book operates as a work of historical ecology: reconstructing the past ocean to better understand its current deteriorated state. To armchair travelers, the book offers too a unique postcard portrait of the late nineteenth-century world, when European nations maintained and extended their power through their navies and colonial settlements. As an adapted warship herself, HMS *Challenger* belonged to that colonial mission, while also pointing to an ideal that lay beyond crude imperial objectives. The goal of the *Challenger* expedition was nothing less than the first global census of deep-sea marine life.

Considered from a planetary viewpoint, my thirteen ways of looking at HMS *Challenger* add up to no more than a snapshot from the oceans' unimaginably long history. The *Challenger* expedition was, after all, just one sea voyage among millions. But it was the most ambitious, well-documented voyage ever dedicated to study of the sea. One hundred and fifty years on, HMS *Challenger*, of all ships that sailed, still has the most to tell us about our indispensable oceans—past, present, and future.

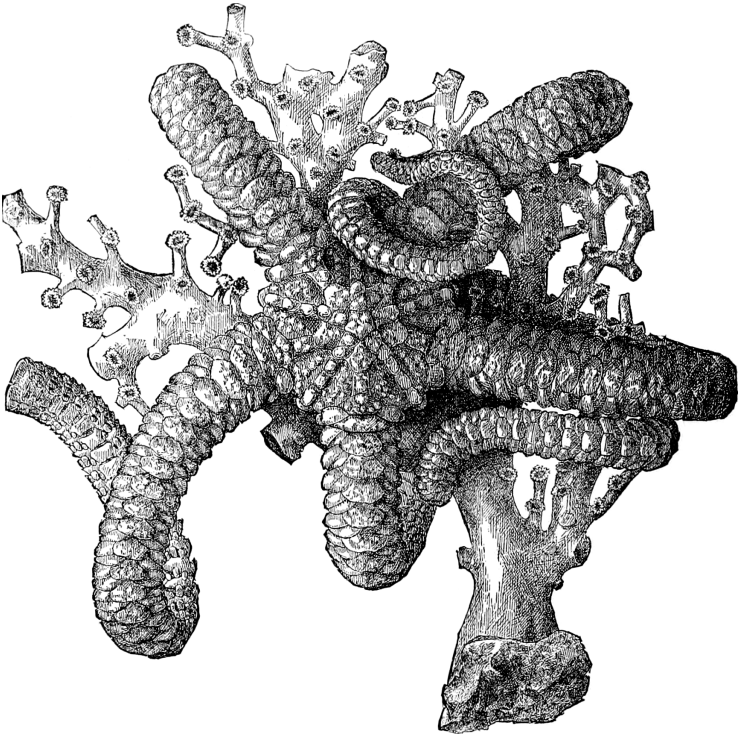

FIGURE 1.1 Brittle star *Ophiomusium lymani*. From *Bulletin of the Museum of Comparative Zoology* (1863), p. 175. (Inset) HMS *Challenger* Leg 1. Portsmouth to Gibraltar. December 1872–January 1873.

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