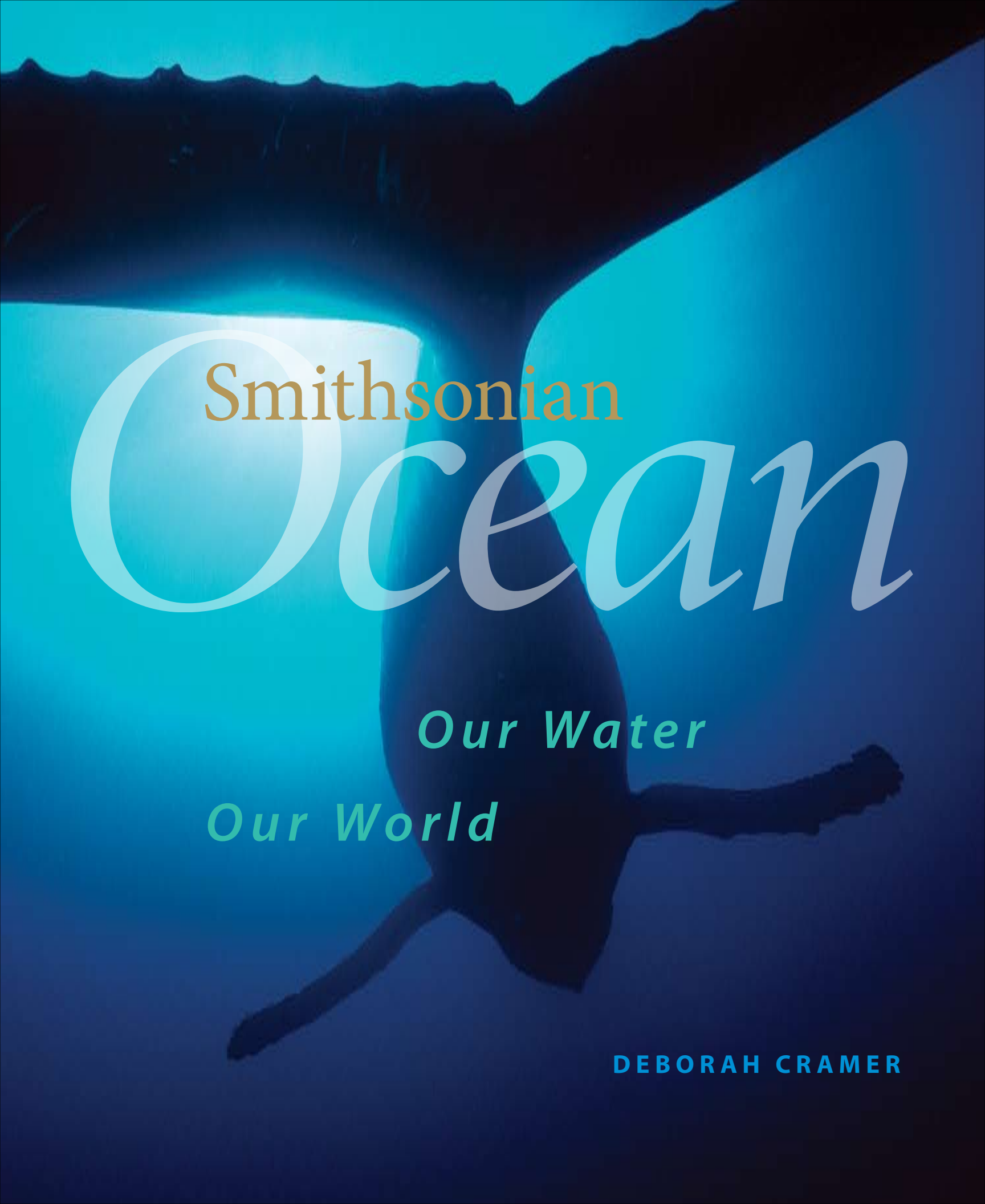
Smithsonian
Ocean
Our Water
Our World
DEBORAH CRAMER

Tarpon and jack swim in the waters of the Florida Keys National Marine Sanctuary.
FRONT COVER: A male humpback sings off the coast of Maui, Hawaii.
OPPOSITE: Close-up in a kelp forest off California's Channel Islands.

Contents

3 Circle of Water

Off the coast of Greenland, cold water sinks to form the North Atlantic's deep currents.

At the edge of the Arctic Circle, between Iceland and Greenland, lies a narrow, icy channel, the Denmark Strait. Here, hidden beneath the water's cold, inscrutable surface, unseen by human eyes, is an unexpected surprise: Earth's most spectacular waterfall. The world's better-known waterfalls are, by comparison, mere trickles. Every second, the Zambezi River pushes 1000 cubic meters of water over Victoria Falls. Niagara Falls carries twice that. The Chutes de Livingstone along the Congo River, the terrestrial waterfall with the most volume, carry 30 times more. The cataract in the Denmark Strait is on another scale altogether. There, each second, three million cubic meters of water spill into the North Atlantic, over an undersea sill of volcanic rock connecting Greenland to Iceland.

No one comes to admire the grandeur of this cascade. No one can. It is described, not by people, but by an array of current meters resilient enough to withstand corrosion and the rush of water. Its name does it little justice. The Denmark Strait Overflow is that, and so much more. Like earth's terrestrial waterfalls, it is fed by a river, a river mightier than any cutting through dry land. The ocean waterfall, and the ocean river, and its tributaries are all joined, one to another, in an endless flow of currents circling the earth. Just as the opening and closing of oceans creates land where humans dwell, and just as the sea's tiny single-celled organisms breathe oxygen into the atmosphere for us to breathe, so too does this coursing water sustain us. Currents bring oxygen to the deep water and carry the sun's heat to icy latitudes. They shape the wind, giving moisture that soaks continents with rain. On them, our lives depend.

Rhythms in the Deep

In the howling winds, bitter chill, and rough waves of Arctic and Antarctic waters, sea water begins to freeze. Thin icy slivers turn to slurry that soon hardens into thick floes. Though the sea is salty, its ice is fresh. As sea water crystallizes, the salt stays behind, turning the water below to brine. The brine, dense and cold, sinks, and spreads throughout the world. The routes of deep currents are many and varied, and the distance traveled is long, thousands of miles. From their place of birth in remote polar seas, deep currents fill the world's oceans, accounting for 90% of the sea's flowing water.

Antarctic Bottom Water slides off the continental shelf, and slowly sweeps north, slipping into the Atlantic, Indian, and Pacific Oceans, filling their deepest basins. Most of the Pacific's deep water originates from icy brines in the sea off Antarctica.

In the Atlantic, deep water flows from the cascade at the Denmark Strait. It moves south, swelling with cold, deep water from the Labrador Sea, filling deep gouges made by shifting pieces of seafloor, its path shaped by earth's moving plates. The journey is neither straight, nor direct; the current flows along the seabed, circling through deep abyssal plains, dividing and merging, winding its way south to surface off Antarctica. There, once again, the current divides, a portion circling back into the Atlantic, the rest returning to the depths, flowing as deep water into the Indian and Pacific Oceans.

For dwellers in the unlighted depths, the peregrinations of deep currents are a matter of life and death. The deep sea itself produces no oxygen. Giant squid and tiny angler-fish depend for their very existence on polar water traveling from the sunlit surface, saturated with oxygen from breaking waves and the respiration of tiny, floating plants.

Copper sharks and dolphins feed at the massive sardine "baitball" in the fertile waters of South Africa's Benguela Current.

In 1898, the Portland, *one of New England's most luxurious paddle wheel steamships, and all its passengers and crew, were drowned in a deadly nor'easter, now remembered as the "Portland Gale."*

TRACKING THE CURRENTS

Air and sea are tightly linked; pollutants wafted into the atmosphere rain out of the sky into the sea. Chlorofluorocarbons from air conditioners and aerosol propellants, and fallout from the testing of nuclear weapons give the surface water a distinctive chemical signature, enabling scientists to follow currents disappearing into the depths. Cosmic rays hitting earth's atmosphere also strike the sea. Their rate of decay, along oxygen levels in the deep water, tell scientists how long ago a current was last seen at the surface, revealing its age. Thousands of current meters, floats, and buoys chart the course of moving water, both on the surface and in the deep, mapping the path and temperament of ocean currents. Occasionally, the reverse occurs, and the currents themselves can be used to track an object lost at sea.

On the night of November 26, 1898, the steamship *Portland* left Boston on its scheduled run to Maine. It never arrived. The ship and 192 passengers and crew were lost at sea, drowned in a heavy nor'easter. No one knew where the steamer went down, and for almost 100 years, those who tried to find it failed. They were looking off Cape Cod, where debris from the wreckage and bodies of dead passengers had washed ashore the night after the storm. It was the wrong place.

A physical oceanographer from Woods Hole, using wind on the day of the gale, plotted the path and speed of ocean surface currents in the hours after the storm. Noting that the watches of the dead had stopped at 9:30, he backtracked along the currents for twelve hours, recreating the drift path of the beached bodies, empty ice cream canisters, life jackets, deck timbers, and stateroom doors, leading shipwreck explorers to the steamer's final resting place off Gloucester, Massachusetts. Its remains, now listed on the National Register of Historic Places, lie protected in the waters of the Stellwagen Bank National Marine Sanctuary.

Bridging Past and Present

Explosion of Life

For three billion years, bacteria floating in earth's ocean breathed oxygen into the atmosphere. Though they were tiny, invisible to the naked eye, and their lives were short, a matter of hours, or at most, days, their legacy endures. Breath by breath, they altered the atmosphere, opening the way for a burst of life which when it came, had never been seen before, and has never been seen since. Relative to the evolutionary quiet that preceded it, the first large animals, if indeed they were animals, emerged swiftly, seemingly from nowhere.

An Enigma

Pressed into the seaside cliffs of Mistaken Point, Newfoundland, are fossils of earth's first large organisms, the Ediacara, who once lived on the bottom of an ancient ocean.

OPPOSITE:
Ediacaran fossils are found in ancient sea floor from all over the world — from Newfoundland, Australia, Namibia, China, and the White Sea area of Russia.

Newfoundland's Avalon Peninsula, at the southeastern tip of the island, juts out into the sea, a rocky, desolate, windswept point battered by storms and waves, and often shrouded in fog. Out on the point, there's a reconstruction of the old Marconi wireless station, where, on the night of December 14, 1912, America first heard of the Titanic's fatal collision with an iceberg. A little bit north and west, there's a tiny coastal village, Portugal Cove South, that in the 1500s, used to be a fishing station for Basque, French, and English fishermen who'd come across the sea for cod. Later, when the village was inhabited year round, its residents, too, earned their living from the sea, catching cod, salting and drying it on racks on the beach. In 1991, the Grand Banks cod fishery collapsed, threatening a way of life with extinction. Though the fish are gone, and the fishermen are seeking other livelihoods, the headland remains, testament to another time in earth's history, when another way of life flourished and disappeared.

Wind, rain, and salt spray have scoured the headland, eroding the softer rock, exposing thousands of fossils. They are large, some nearly two meters long. Shaped like fern fronds, spindles, and discs, they are odd, and unfamiliar. They are the oldest large, complex fossils known anywhere in the world, but their identity continues to elude scientists. Who they were, how they lived, and where they came from is a mystery still to be solved; they share little affinity with inhabitants of today's ocean and don't easily fit into any of today's known phyla.

Cast in stone and exposed to the sun now, some 570 million years ago they lived in deep water, beyond the reach of light, below the crashing waves. They were tethered to the ocean floor by holdfasts, like seaweed clinging to rock, their bodies swaying with passing currents. Bottom currents were their lifeline, bringing oxygen and sustenance into barren water. Whether they simply absorbed nourishment, or filtered it, or were assisted by symbiotic bacteria, no one really knows. They had no teeth, no mouths, no guts.

One day, whole clusters of them died, all at once. They were lying on the sea floor, almost fully prone, bending before a current. A volcano onshore exploded, the rain of ash settled in the sea, and they were buried. None of the organisms were ripped apart, none tumbled down the slope; it was a gentle death. They died where they lived, preserved in exquisite detail.

The animals had soft bodies, and often when they were buried, they collapsed. A little further up the Avalon Peninsula, along the rocky coast of Spaniard's Bay, where they have been preserved in three dimensions, their bodies look like quilted air mattresses. The delicate design, which defies easy interpretation, is unknown in any modern organism.

Ediacaran fossils, as they are called, are found all over the world: the desert in Namibia, the English midlands, the Ediacara Hills in Australia, for which they are named, the White Sea in Russia, and the Yangtze Gorges. Their stay, 30 million years, was short, relative to the preceding 2.5 billion years of photosynthesizing bacteria; the architecture of the leaflike, quilted *Charnia*, the mysterious *Tribrachidium* with its highly unusual three part symmetry, and the ellipsoidal and controversial *Dickinsonia* were evolutionary roads not taken, way stations on a path never completed. *Kimberella* and *Spriggina* also defy easy classification, and although they too are long extinct, their legacy, bilateral symmetry, endures in our own bodies. Soft and stationary, without means to protect or defend themselves, or flee, the gentle Ediacara were unprepared for the world to come. Long before that world appeared, there were glimmers, inklings of potential for momentous change.

One way to open your eyes is to ask yourself, "What if I had never seen this before? What if I knew I would never see it again?" — RACHEL CARSON

Helmet jellyfish, Periphylla periphylla, *may live as long as 20 years. Normally a deep sea jellyfish, they live in large numbers in a fjord just north of Bergen, Norway.*

The companion volume to the Smithsonian's permanent new Ocean Hall opening September 2008, National Museum of Natural History

Our lives depend on the sea. *Smithsonian Ocean*'s stunning photography and eloquent narrative reveal the myriad ways the sea is essential to all of us, wherever we live. In the scalding inferno of deep sea hot springs, life began. The first cell, the first plant, and the first animal were born in the sea. Invisible plants in the ocean's sunlit surface give us air to breathe. The sea spawns life-giving rain; when it is withheld, entire civilizations collapse.

Author Deborah Cramer writes of the sea's seemingly boundless diversity, from the largest whales to the tiniest virus. She shows how the entire Earth is connected by the sea, how a single drop of water circling Antarctica can flood a rice field in the Ganges Delta or fill a glass of water at an American dinner table.

Seas that have come and gone created our world, and anticipate our future, making it imperative that we understand the ocean and its fate. Cramer's writing—often compared to that of Rachel Carson—will inspire readers everywhere with its powerful message of stewardship.

DEBORAH CRAMER writes about science, nature, and the environment. The author of *Great Waters: An Atlantic Passage*, Cramer is currently a visiting scholar at MIT's Earth System Initiative. She lives in Gloucester, MA.

Up-to-the-minute ocean science by a gifted writer whom AL GORE HAS "URGE[D] EVERYONE TO READ."

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