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1

Introduction

NANTUCKET IS a small island off the coast of Cape Cod, Massachusetts. Bucolic, rolling hills and sandy bluffs are dotted with million-dollar cottages. The historic downtown of the main village is lined with shingled buildings along cobblestone streets, preserving a sense of its past but with modern businesses inside. The island's beaches draw throngs of tourists in the summer, disgorged from the daily ferries arriving from the mainland. Cafes, restaurants, and bars overflow with bustling crowds. Five-star boutique hotels house visitors staying the night.

If you visited the island hundreds of years ago when the British were setting up their colonies, you never would have predicted this future for Nantucket. Its waters are not particularly navigable, limiting its use as a fishing harbor, and its land is not particularly fertile, comprised of sediment deposited by glaciers during the ice age. Yet despite its unremarkable—some might say unfavorable—constitution, it gained world renown and extraordinary wealth. How did this transformation happen?

In the late 1600s, Nantucket was agrarian, populated mostly with sheep (and their human tenders). Indeed, it was colonized explicitly for the purpose of raising sheep, as the island was inaccessible to the wolves that loved to snack on mutton. Within just a few decades, though, the island had already been overgrazed, and farming options were limited. To change their fortunes, the people of Nantucket looked to the sea that surrounded them on all sides.

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Commercial whaling was starting to take off elsewhere, fueled by rapacious demand for lamp oil, and eventually candle wax, to illuminate homes and streets. Whale oil turns out to be excellent for both. Without electricity, homes relied on flame from a wick to illuminate them, and cities were installing hundreds to thousands of streetlamps. It was an enormous and rapidly growing market.

As sheepherders, the Nantucketers didn't know how to fish for whales. So, in 1690 they invited Ichabod Paddock, a whaler living across the sound on Cape Cod and brother of Nathaniel Paddock, who lived on the island, to come over to teach them. Ichabod was already legendary, not so much as a great whaler (although he was fine at that) but for being swallowed by a whale and surviving. More than once. As the legend goes, a witch had cast a spell on the whale, and she had taken up residence inside its body; Ichabod made daily, carnal visits to the witch until his wife found out and schemed to have the whale killed.[1] Despite his reputation as a philanderer, the people of Nantucket needed Ichabod's help.

They were quick learners and clever entrepreneurs, and within a few generations this tiny island became the whaling capital of the world. It's difficult to overstate the speed and significance of this transformation. An island of just under 50 square miles and a few hundred inhabitants, Nantucket grew to have a global footprint on the ocean in just a few decades. Fueled by the high value of whale oil, Nantucket whalers sailed to distant waters in search of ever more whales. Boats from Nantucket could be found around the globe, sailing the incredibly long distance south the entire length of the Atlantic, around South America's tip at Cape Horn, and back up to the South Pacific islands in search of whales, and then sailing back home again, staying at sea for years at a time.

All this bounty created one of the wealthiest communities per capita on the planet. The village of Nantucket quickly grew into a bustling downtown. Mansions sprung up. Hotels were built to service many new visitors coming to experience the boom and the new deckhands awaiting their spot on the next transoceanic whaling trip. This wealth set in motion the future of Nantucket as a playground for the rich. Ultimately,

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the people of Nantucket had used whaling to turn the blue ocean into gold in their pockets.

Of course, commercial whaling also eventually led to the near extinction of whales.



Before commercial whaling, Inuit and Basque and Japanese communities, among others, harvested small numbers of whales for subsistence purposes for thousands of years—they ate the meat, boiled the blubber for oil, and used the bones for structures or household items.[2] Importantly, they only hunted what their local communities needed, and that small amount of harvest left global whale populations essentially intact.

By 1700, things began to change. Commercial-scale whaling was sprouting up in different parts of the world, responding to growing demand for whale oil. Today we meet energy needs with fuels like crude oil, coal, and biofuels, and with electricity from hydroelectric dams, nuclear plants, and solar and wind farms, but back then people relied on whale blubber. Blubber is the very thick layer of fat that all marine mammals, which are warm blooded, have around their bodies to keep them warm in the cold ocean water. This layer of fat can be 1–2 feet thick in some species. A single North Atlantic right whale can have as much as 28,000 pounds (12,700 kg) of blubber on it. A typical bowhead whale might have more than 80,000 pounds (36,290 kg). (It's called blubber because of the bubbling sound it makes when being boiled to make oil, a sound much like a blubbering fool makes when uncontrollably sobbing.)

Whale blubber is a dense source of oil, not immediately usable in its raw form. To process blubber and turn it into market-ready oil requires boiling it down, a messy and stinky multiday ordeal. In the early days of whaling, when whales were abundant and close to shore, whaling expeditions were day trips, and the whale carcasses were brought back to shore for processing. As whaling expanded and boats had to sail farther to find whales, they would stay at sea for months, or even more than a year, and the processing happened on the ship. This meant that

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the sailors had to tend a boiling cauldron of whale blubber on a rocking ship at sea, an arduous and dangerous task. In the end, a single whale could produce fifty barrels or more of high-quality oil, worth the equivalent in today's dollars of up to $1,000 per barrel. Whaling was extremely lucrative.

Part of what made whale oil so valuable is that it could easily be packaged and transported. It could be condensed into candles, or siphoned into jugs, bottles, or small kegs for sale. It could be sold to a neighbor, or shipped and sold in distant markets. Our modern economy is built on the ease of transporting and selling oil and gasoline in small quantities; the ease of packaging and moving whale oil was transformative to the burgeoning economies. It meant that a small whaling island could provide oil to a global market.

During the 150-year period spanning the 1700s and early 1800s, whale oil provided light to houses, buildings, and streetlamps around the world. The ubiquity of whale oil made the ocean a major source of energy. Indeed, whale oil transformed a nascent energy economy into a global one. Perhaps more than anywhere else, this was true for Nantucket. An estimated 40,000 sperm whales were killed and brought to the port of Nantucket during that 150-year period, roughly 15 percent of all sperm whales caught globally during that time.[3] Many other whale species were also brought to the port. Nantucket had emerged as the main player in what became a global-scale ocean economy. This dominance was not an accident.

Nantucket's early success as a whaling station was due to its location. The island juts out into the Gulf Stream, right in the path of migrating whales, especially the (then) abundant right whales that were the initial targets of whaling. It was easier and faster to get to the whales and bring them back to port than anywhere on the mainland. This geographic advantage would have been sufficient to maintain the island's central role for a while, but the decimation of coastal whale populations removed the advantage. If the Nantucketers had relied solely on their location, they would likely be a footnote in the history books. What really made the difference was the community of people that lived on the island.

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Nantucket is a small island, and as the prospects for agriculture were waning, there were few other options for local livelihoods. Once the local people decided to pursue whaling, the community invested and reinvested in whaling, leading to deep local expertise and experience, as well as the resources and motivation that are seeds of innovation. They developed and built the first long-distance whaling ships with onboard furnaces for oil processing, and they honed techniques for efficient and safe operations, allowing them to hunt the entire ocean. They specialized in sperm whales and the techniques to harvest spermaceti oil that is found in the whale's head, giving them a global advantage with the most valuable type of whale oil.

Equally important, many on Nantucket were Quakers, a religion that embraced tolerance and created a culture of tight-knit communities. The connection to other Quaker communities around the colonies provided strong networks for raising funds, when needed, and built-in markets for their products. With their practice of religious tolerance, there was space for Black and Native American sailors, and even captains, allowing for the most-skilled sailors to thrive. Almost all other whaling ports were less focused, less inclusive, less connected, and, ultimately, less wealthy.

The history of the global influence of Nantucket whaling is much more than a story of the success of one small island; it is a foreshadowing of the consequences of using the ocean in a globalized market. As whaling scaled up and whale oil was traded around the world, the industry eventually got too big to be sustainable. Local and regional populations of whales were nearly eliminated, and global populations were in decline. Global demand decouples markets from the limits of local ecosystems, and communities' connections to those ecosystems, as everything scales up. When you buy food in the grocery store or hook your home up to the power grid or buy the latest gadget online, there is almost no way to know precisely where that product was grown or produced and therefore how the local environment at its origin was affected by that production.

But scaling up can also be a positive driver for the changes we need. When trying to address global challenges, we need big solutions that

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act at the scale of the problem. If you need to add indoor light to a million homes, you can't do that with a few whales. Whalers were responding to the need (and the market) to provide indoor lighting for millions of homes and buildings around the world.

The story of the rise and fall of whaling is thus a warning of how unfettered greed can drive species nearly to extinction. It eventually is also a success story of groups intervening at an international scale to protect whales, interventions that turned around the fate of many whale species—an example of the resiliency of threatened ocean creatures to rebound with careful management and sufficient time. Embedded in these narratives, commercial whaling tells a story about the tension between using the ocean to support economies and communities, and overusing it to the point of environmental destruction.

The story of commercial whaling also highlights that we often don't know the consequences of our actions, given the knowledge we have at the time. We work with the best available information, and we don't know what we don't know. Sometimes that ignorance doesn't matter—the outcome might turn out great or at worst be neutral—but sometimes ignorance can be catastrophic. In hindsight, it seems obvious that whales, which reproduce slowly and are not as numerous as fishes, could not sustain industrial-scale harvest of their populations. But back then, 350 years ago at the dawn of commercial whaling, people saw the ocean as too vast to possibly be impacted by anything they could do to it. Whales, like all the fish in the sea, were thought to be inexhaustible, such that one could take and take, and the ocean would keep giving. People at the time thought they had a perpetual source of energy for the modernizing economies of the world. Commercial whalers of the 1700s had no idea whales could be exploited to near extinction.



Today we are in the midst of another rush to the ocean. Governments, companies, and conservation groups are racing to the sea to meet the needs of our burgeoning population on a finite planet. This blue gold rush—or what is commonly called the blue economy—is everywhere,

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discussed and documented in the news, in academia, and in government policies.[4] It is a rush for food, especially from rapidly expanding ocean aquaculture. It is a rush for energy, in particular from offshore wind farms. It is a rush for minerals, from vast, rich deposits on the bottom of the deep sea.

Why is this blue gold rush happening, and why is it happening now? It is not new for people to use the ocean; we have been doing so for millennia. But this movement is different. It is bigger, it is happening faster, and it is being done with the urgency of solving our global environmental problems. Moreover, many promoters of the blue economy hope the ocean will deliver us from our current planetary crises while simultaneously fueling economic development. In the green revolution of the 1950s, chemical fertilizers supercharged our ability to grow huge amounts of crops. Now, a blue revolution is being touted by many as similarly transformative and potentially lifesaving for humanity.

The high expectations for the ocean arise in part because natural resources are abundant in the vast ocean. With the ocean covering 71 percent of the planet, there is a lot out there, which can make the potential benefit seem enormous and the available space seem nearly infinite. High expectations arise too because new technologies and applications are already underway, and they are proving effective. Innovations in the food, energy, and transportation sectors, among others, are showing great promise to more sustainably tap into the bountiful resources of the ocean. Fish farming is developing novel feed components grown from microalgae and wood pulp in energy-efficient labs on land, reducing the environmental impacts on the ocean from farming fish. Indeed, the latest science has shown that many forms of aquaculture can be more ecologically sustainable than traditional agriculture.[5] Global shipping is harnessing electric motors to make fleets emission-free and even tapping into wind power to move giant ships as part of its effort to reduce fuel and emissions while saving money in the process,[6] an ironic twist of technology that looks backward in time to the days of sailing ships as much as it looks forward in time to new solutions. In response to all this potential, billions of dollars of

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investment money are pouring into the ocean economy, with much more on the horizon.[7]

But there are also plenty of stories about the damage and destruction being done to the ocean from these activities. Fish stocks like blue marlin and many Atlantic cod stocks were heavily overexploited and have yet to recover.[8] Pollution is pouring off the land, fueling massive blooms of algae along the coasts of every continent but Antarctica, which in turn create dead zones devoid of any other life.[9] Climate change is heating the waters, effectively boiling many of the creatures stuck in areas that are too hot for them to survive. Oil rigs regularly spill crude into the water, sometimes catastrophically, like the *Deepwater Horizon* oil spill in the Gulf of Mexico in April 2010, which spilled 134 million gallons of oil over a three-month period, the largest oil spill ever in the world.[10] Shrimp farms have destroyed large swaths of critical mangrove habitat in Asia and South America.[11] The ocean's outsized impact on our atmosphere, weather, and coastal populations means there is potentially outsized risk to altering the ocean at a scale that could have unpredictable, widespread, and irreversible impacts to humanity and the planet.

Our modern-era environmental challenges are of a very different nature than the ones of the 1700s. If we are going to halt and reverse climate change, or feed 8 billion people and counting, or electrify the global economy, we cannot rely on local-scale change, where one community at a time alters their interactions with the ocean. Ideas can and should spring from small places and scale up from there; but however we get there, we need the solutions to be deployed at a global scale. We need the solutions to be as big as the challenges we face if we want to have any hope of halting and reversing environmental harms to our planet.

As we scale up our use of the ocean and begin to occupy vast areas, there is so much we still don't know. Commercial fishers in the 1800s didn't think they could drive fish stocks to collapse. Coal and oil extractors of the early 1900s had no idea that running the global economy on fossil fuels could change the Earth's climate. Today we know all these things to be true, maybe even self-evident. What choices are we making

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now that will lead future generations to question how we could have gotten it so wrong?

Yet, if we wait for complete knowledge about the likely outcomes of our actions, we will never act because there is no such thing as complete knowledge. We can and must avoid making bad decisions, but equally we must not wait to make the perfect decision.

And therein lies our critical choice, an ocean crucible. Do we encourage large-scale development of the ocean in the hope that it will address our resource needs but risk overdoing it? Or, do we limit uses in order to protect the ocean but risk environmental disaster because we have not met the needs of environmental solutions quickly enough and at large-enough scales? Our decisions about expanding uses of the ocean could lead us down a path toward either sustainable use or destructive misuse of the largest environment on Earth. There is great potential either way, of risk or reward. This book will reveal the scope and consequences of our decisions, laying bare the severe test we face in the choices we make for our ocean, and in doing so ask you to reflect on the fate of the ocean and ultimately the entire planet.

The bulk of this book will explore the five ocean sectors playing the most important role in the blue economy focused on sustainability: food, energy, transport, minerals, and carbon. It will dive into the latest science and stories behind why there is so much enthusiasm for expanding these ocean uses, and what may lie in store for us in the future if, and as, we develop them to their full potential. These blue economy expansions and innovations could genuinely transform the sustainability of our planet, but we risk catastrophic outcomes if we screw it up.



There is one last part of the story of whaling in Nantucket that I want to share: it is also my story. That legendary whaler, Ichabod Paddock, is my ancestor—a distant great-granduncle, seven generations back. I only discovered this history in my twenties, after I had moved to Boston. As I was planning a vacation to visit the storied island of Nantucket, my mom (born a Paddock) told me I should visit the oldest house on the

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FIGURE 1.1. My ancestors' house on Nantucket.

island where our Paddock ancestors had lived for most of the 1700s. When I got to the island, I rented a bike and headed straight to the house, a two-story, pitched-roof structure perched on a grassy knoll surrounded by a simple farm. Each room of the house has a hearth connected to the central chimney, and standing next to the largest one in the kitchen was a park service docent. I opened my conversation with her by stating my family name and history, and she immediately started telling me tales of my ancestors and Ichabod, in particular, given the irresistible stories of his whale (and witch) encounters.

I didn't become a marine scientist because of Ichabod, but his story has both fascinated and haunted me since I first learned of it. It is humbling to think of the role my ancestor played in the rapid expansion of whaling. For a long time, I was a bit ashamed of this connection, given my passion for ocean conservation. Eventually I grew comfortable with sharing the story, highlighting the differences in my profession and his, and the irony of this legacy, and found myself wanting to learn more. I mostly ran into information walls—so little has been recorded about Ichabod and Nathaniel, and plenty of that had been elaborated and

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exaggerated through the tales of the witch and the whale. Returning again to the tale for this book, I found myself focused less on the details of his story and more on the broader narrative of why whaling, why Nantucket, and why then, and the way that it all sets the stage for our modern dilemma for how, and how much, we use the ocean.

The insights and lessons I have learned along the way are woven into the following chapters, showing how I have been pulled in different directions as I have wrestled with Ichabod's legacy—my family's legacy—and what it represents about humanity and the ocean. It is hard to not feel the need to atone for the sins of my ancestor, but Ichabod's story also highlights the potential for one person to create a cascade of events that can lead to profound (although in his case, terrible) change globally. This same potential exists for equally profound positive change, and that gives me great hope.

I have always loved the ocean as a place of inspiration. As I grew older, I became increasingly aware of the many ways humanity was damaging it, from warming oceans and coral bleaching, to overfishing and pollution, to coastal development that destroys habitats. This awareness fueled my scientific career. I have studied the many ways that human activities impact the ocean, and as part of these studies I looked for ways to protect the ocean from these (over)uses. But along that professional journey I also sought to understand how we can use the ocean to help us, and I have spent nearly two decades studying the many ways that the ocean can provide key solutions to our sustainability needs.

At the core of this book is this internal tension about what I want the ocean to be and what the ocean needs to be for humanity. That tension is rooted in the promise of sustainable solutions but also the potential peril of environmental catastrophe that comes from being able to do things at very big scales. That tension is also rooted in not knowing yet what the implications will be of doing big things in the ocean. The lessons of the past tug in opposite directions, asking us to choose a path for the future which is both uncertain and existential. In writing this book, I hoped to discover a vision for the ocean that reconciles these potentially different futures. In my research I have seen what that future can be, and I will share that vision with you in the following pages.

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In the end, I want you, the reader, to expand your view of the ocean, to connect to it in new ways, to rethink your relationship with it. I want people to slow down, pause to ponder, and acknowledge the information we have and don't have about how we could change the ocean forever. Ask yourself: What do I want the ocean to look like? What do I want it to be in my life, and in our collective lives?

I started writing without knowing where this story would end, and in sharing how I have grappled with my ideas and knowledge and feelings, both throughout my career and while writing this book, I hope to help you grapple with your own relationship with the ocean. Take the time to join me on this journey. The ocean crucible is a personal test as well as a global one.

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