TREND

Analysis of the Facts, Numbers, and Trends Shaping the World
THE PEW CHARITABLE TRUSTS

ocean

[ˈō-shən]

noun

1. the whole body of salt water that covers nearly three fourths of the surface of the earth
2. any of the large bodies of water into which the great ocean is divided
3. the largest part of Earth, essential to life on the planet

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NOTES FROM THE PRESIDENT

Standing on a beach and looking out at the crashing waves, you might think the ocean is unchanging and invincible. But looks can be deceiving. The ocean is in trouble, stressed by overfishing, pollution, and a warming climate that is altering its very chemistry. Scientists have been focused on these concerns and are advocating for 30% of the ocean to be protected and conserved by 2030. Given the urgency of that timeline, this issue of *Trend* steps back to explore how we got to this point and looks forward to what we can do to save the ocean—which makes up three-fourths of the planet, supplies food to millions, and provides half of our oxygen.

There is no better guide to the history of the ocean than Callum Roberts. An esteemed oceanographer and writer as well as a former Pew marine fellow, he explains that the ocean and humanity share a history that dates back more than 150,000 years. It is a tale of the expanding plunder of fish, but the story doesn't stop there. Today, plastic pollution has been found in the deepest corners of the seas, the acidification of the ocean's waters as they absorb more carbon dioxide is bleaching once spectacular corals, and rising waters resulting from climate change will not be stopped. As Roberts grimly summarizes: "Regardless of what we do now, a rise of six or even 10 feet in sea level is locked in based on emissions already in the atmosphere."

Pew's Winnie Lau notes that 11 million metric tons of plastic enter the ocean every year—but this is a challenge we can do something about. Lau says that the flow of plastic into the ocean can be reduced by up to 80% by 2040 if government and industry work together. She explains that Pew is launching a tool that governments can use to determine the extent of their country's plastic pollution problem and guide reforms.

Saving the ocean requires policies informed by evidence and the knowledge of Indigenous peoples who have lived near the ocean for thousands of years. Aindil Minkom, who lives on the Cocos (Keeling) Islands, an Australian External Territory in the Indian Ocean, writes in this issue that "the ocean provides so much to our community—our food, our way of life, our culture—and we look after it by fishing in a sustainable manner." In recent years, his island home—some 600 miles from any significant landmass—has been endangered by industrial fishing fleets. Fortunately, he and other islanders have worked with the Australian government to create two new marine parks, covering an area larger than Texas, to help protect local fish populations—a step, Minkom notes, that is "meaningful not just for us, but for the health of the global ocean."

As dire as the threats to the ocean are, so too are the meaningful solutions that we can achieve. Marine protected areas show that the ocean can replenish itself. Science-based fisheries management proves that depleted stocks can be restored. As altered as the ocean has been by climate change, coastal wetlands remain the planet's best carbon dioxide storehouses.

Knowing the problem is the first step to solving it. We hope this issue of *Trend* enlightens the journey toward more respect and conservation of the Earth's lifeblood, its ocean.

Susan K. Urahn, *President and CEO*

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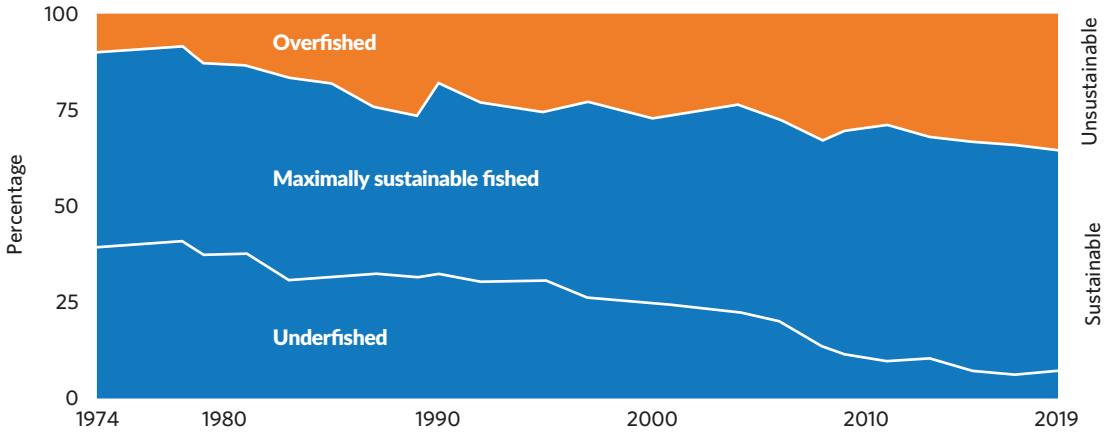
CRUNCH

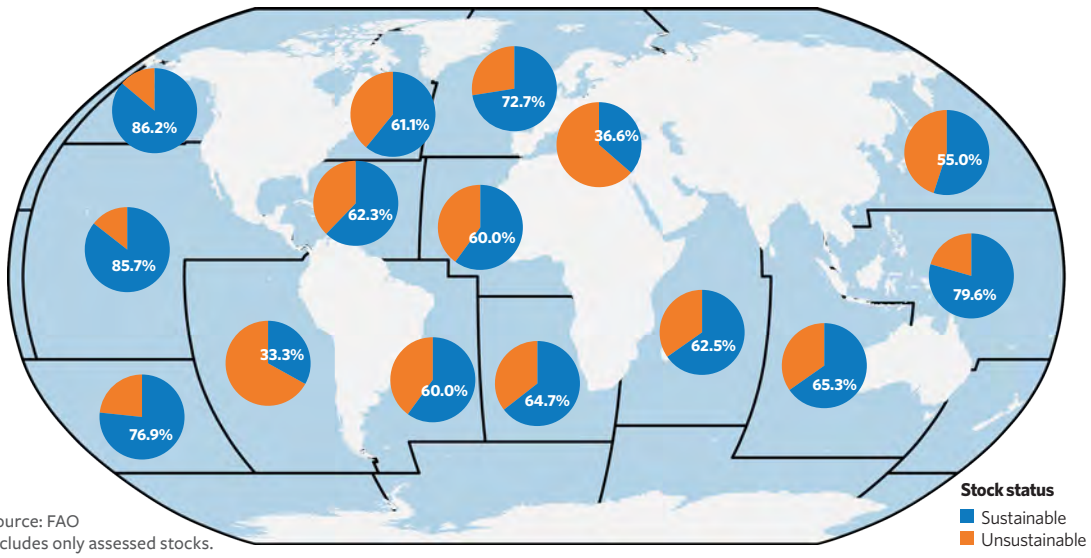
A Half Century of Overfishing the Ocean

Overfishing remains a central threat to the health of the ocean. The 2022 State of World Fisheries and Aquaculture report from the Food and Agriculture Organization of the United Nations provides the latest global statistics that help guide scientists and policymakers and shows that the percentage of stocks within biologically sustainable levels decreased 1.2% between 2017 and 2019, continuing a trend since 1974.

GLOBAL TRENDS IN THE STATE OF THE WORLD'S MARINE FISHERY STOCKS



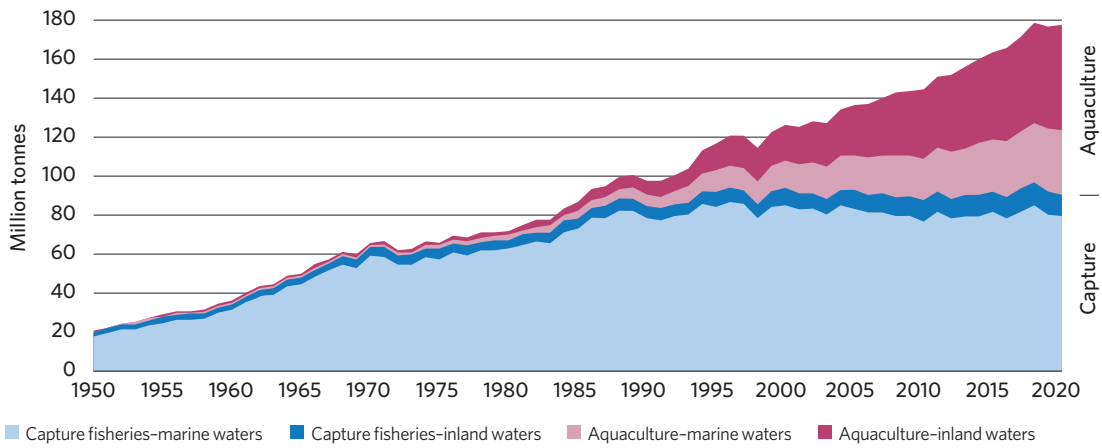
PERCENTAGES OF BIOLOGICALLY SUSTAINABLE AND UNSUSTAINABLE FISHERY STOCKS BY FAO MAJOR FISHING AREA



Source: FAO
Includes only assessed stocks.

GLOBAL FISHERIES AND AQUACULTURE PRODUCTION IS AT A RECORD HIGH

In 2020, fisheries and aquaculture produced 178 million tonnes of aquatic animals with about 157 million tonnes used for human consumption. Production is forecast to grow 14% by 2030. Average human consumption was nearly 45 pounds per capita—more than double that of the 1960s.



MORE THAN 4 MILLION FISHING VESSELS

There were an estimated 4.1 million fishing vessels in 2020, with the largest percentage—two-thirds—in Asia. Overall, the number of boats was down about 10% since 2015. But fewer boats don't necessarily mean more sustainable fishing because modern, more efficient vessels can offset any gains in fleet reduction.

MILLIONS OF LIVELIHOODS ARE SUPPORTED BY FISHING AND AQUACULTURE

Of the 58.5 million people employed in the sector, 21% are women. They constitute a disproportionately large percentage of the people engaged in the informal, lowest paid, least stable, and less skilled segments of the workforce.

FISHERIES AND AQUACULTURE

	1995	2000	2005	2010	2015	2020
AFRICA	2,812	3,589	4,159	5,032	5,562	5,641
AMERICAS	2,072	1,905	1,978	2,321	2,501	2,621
ASIA	31,632	41,265	45,693	50,401	52,079	499,425
EUROPE	476	514	463	426	375	388
OCEANIA	466	475	478	482	481	474
TOTAL	37,456	47,748	52,770	58,662	60,999	58,549

Numbers in thousands

FOREWORD

A NEW GENERATION'S OCEAN LITERACY

BY PHILIPPE COUSTEAU JR. AND ASHLAN COUSTEAU

Much of the world began to learn about the beauty in the ocean from the films and television programs by Philippe's grandfather, Jacques Cousteau, more than a half-century ago. He revealed underwater pictures of teeming fish and spectacular corals at a time when people thought the ocean was mysterious—but also bountiful. At that time, we seemed to think the water was a place that could absorb all we dumped into it and would allow us to extract all the fish and whatever else we wanted.

As a young man in the 1930s, Jacques was drawn to the depths of the ocean and motivated by a desire to share what he saw. He helped invent the Aqua-Lung—the first scuba equipment—which forever changed humans' ability to explore underwater.

Jacques' own exploring allowed him an early perspective that we all need today. The ocean is not the bountiful and invulnerable place we once thought. He saw this for himself early on. As his film and television work reached global audiences in the 1960s, he was observing the declining health of the Mediterranean Sea and knew his focus needed to change. As he began production of the "The Undersea World of Jacques Cousteau" television series, he told our family that our work was to be not about exploration—but conservation.

It is a mission we continue to pursue because the needs of the ocean have never been greater.

Today, society still lacks a basic literacy about the ocean and the issues challenging it, from overfishing to pollution to a changing climate. We must develop the care and concern among the broader public that can bring about the political, economic, and social changes necessary to protect the ocean on which the very health of the planet—and all of us—depend.

Unfortunately, as a conservation community, we've done a pretty poor job of communicating the ocean's challenges. We've also done a bad job of explaining its potential—that it is a source of hope and opportunity and is our biggest key to combating climate change.

That's because for too long we have been preaching an irrelevant message to the ocean literate, which is a too-narrow sector of the population. (Yes, dying polar bears have come to symbolize climate change for many people—yet has that shifted behavior?) We must do a better job of expanding our audience, and we must reach out to people of color and those in historically neglected communities who, tragically, also tend to be on the front lines of environmental collapse.

Those who live closest to the water, including many Indigenous communities, know firsthand the effects of overfishing, pollution, and climate change on the ocean. We have an opportunity for change—and can take hope—when we listen to their voices.

We also have hope in young people. The big ocean literacy gap we see is mainly with older audiences. Young people understand better than their elders that climate change is a looming catastrophe and that we need to protect our seas. We've never once walked into a classroom and had a student say, "Climate change? Meh." By enlisting and energizing this new generation of conservationists, we can save the ocean and the planet.

Although many activists approach climate change with a focus on land-based solutions, the ocean is the Earth's biggest and best resource. Ocean ecosystems such as mangroves and seagrass grow quickly and sequester a lot of carbon. One square acre of mangroves absorbs four to five times more carbon than a square acre of rainforest. And while a tree takes years to grow tall, kelp can grow a foot a day.

The sea, now overfished and polluted with plastics, can also restore itself—if we just leave it alone.

In Bikini Atoll, where the United States conducted nuclear testing during the Cold War—wiping some small islands off the face of the planet—the yield was 1,000 times stronger than the bombs dropped on Hiroshima and Nagasaki. Everything from coral to fish died. We went back 60 years later, and although the crater of the blast is still a desert, just a couple of feet over the rim of the blast site is a spectacular and flourishing underwater ecosystem.

Humanity threw its worst fire and brimstone at this place, but by letting this ecosystem do its own thing for 60 years, it hasn't just recovered, it is thriving. This is what happens in marine protected areas when we step back and let nature work—waters cleanse, fish return, and underwater forests grow.

And so that is why we are excited—and hopeful. We know we have tools to help restore our planet. And we have a growing, fired-up new generation. Young people are connected, switched on, and informed in ways unprecedented in history. This new community of conservationists can help communicate to the rest of the world that we must tend to and care for the ocean before it's too late.

They know, as Jacques Cousteau did, that we're all in the same boat.

The Global Ocean

ILLUSTRATIONS BY NED DRUMMOND/
THE PEW CHARITABLE TRUSTS

We are at a crossroads in human history: The consequences of our taking resources from the sea were once limited to local scales. Today, exploitation, depletion, and loss affect us all.

BY CALLUM ROBERTS

Long ago, the ocean was a barrier to human movement, a place where the land ended and further progress was impossible. But it was also a provider of nourishment, so we lived by the shore and learned the ways of the sea. Some of the earliest traces of modern humans are from coastal caves in South Africa. Shell remains dating back 164,000 years show that seafood was often on the menu.

Over time, we figured out ways to catch fish and other more elusive marine prey, using traps, hook and line, and nets. The emergence of people from Africa around 70,000 years ago appears to have been propelled by a bundle of maritime skills and technologies, enabling an almost explosive spread of people across the world. The ocean became our path for dispersal and settlement. Within 10,000 years people occupied Asia and Indonesia, and then moved onward to Australia 10,000 years later. They leapfrogged to the Americas, perhaps by following plentiful seafood on a kelp forest highway around the Pacific rim.

Oral stories that evolved into Homeric literature; frescos, painted pottery sherds; and even wooden wrecks—remarkably preserved in the anoxic, deep Black Sea—show great advances in seafaring by the time of ancient Greece. The sea had become a route to new discoveries, fame, and fortune. By the wend of the first millennium, long-distance voyaging had emerged in cultures of the Pacific, Asia, and Middle East. Our worldview expanded as the ocean and new landmasses were mapped through the great Renaissance Age of Exploration.

Exploiters of natural resources followed swiftly on the heels of explorers, drawn by tales of extraordinary wildlife abundance in faraway places. Whales, walrus, seals, seabirds, and fish became targets of industrial-scale exploitation for meat, oil, ivory, feathers, fur, and myriad other useful products derived from their carcasses (seal whiskers made excellent pipe cleaners, for example). The slaughter was so intense that seal haul-outs numbering millions of animals disappeared within the space of a few decades, and whole regions of ocean were emptied of their whales. Few places were too remote or experienced conditions too savage to save them. By the 17th century, whalers had established themselves in the Arctic, and by the early 19th century, whalers and seal hunters were attacking the fringes of Antarctica.

The impacts of such concentrated plunder were soon visible in falling catches and unprofitable voyages. A belief widely held in the 19th century was that, if there was such a thing as overfishing or hunting overkill (a point much debated) it would be self-limiting. Falling profits would cause people to abandon the pursuit and populations would recover. It didn't work out that way. By devising ever better ways to catch animals, technological innovation constantly tilted the odds in favor of continued exploitation even as populations

plummeted. And as the favored species became scarce we switched targets to others, picking off the original species whenever they were encountered. Less valuable quarry subsidized continued capture of now rare species.

Exploration and discovery led to new opportunities for trade and travel. By the early 20th century, the ocean was crisscrossed by shipping highways that connected the world, including new routes punched through the Suez and Panama canals. World trade grew in lockstep with economic growth. Today, ocean-going container ships carry 90% of internationally traded goods and have reached such monumental sizes you could fit 15 Titanics into their volume.

The ocean's role as a connector in human affairs is mirrored in its influence on the planetary environment. The greatest river in the world does not pour across any continent but runs between and around them. The global ocean conveyor is a giant current that carries the water of 20,000 Niagara Falls as it descends from the surface to the deep Atlantic, before looping the globe on a thousand-year journey that takes in the whole ocean. The surface arm of this great current is driven by winds whipped up by temperature differences between tropical and polar regions. The atmosphere and ocean moderate the climate by transporting heat poleward and cold toward the tropics. If these winds did not exist, the tropics would be so torrid as to be uninhabitable and the poles far colder.

The climate-controlling role of the sea has long been appreciated. Heat carried by the Gulf Stream leg of this circumglobal current warms the winter streets of London and Paris. At a much bigger scale, the ocean is a planetary air conditioner without which Death Valley temperatures would already be the norm almost everywhere. Since the onset of the Industrial Revolution, the ocean has absorbed 93% of the excess heat trapped by our greenhouse gas emissions. It's hard to grasp what that means, but here is a telling analogy: The rate of heat trapped by the ocean since 1871 was equivalent to the underwater detonation of one and a half atomic bombs—of the size dropped on Hiroshima—every second. Over the past two decades, the rate of heat capture has risen to three to six bombs per second.

Global warming affects everything. It powers stronger winds as there is more heat to redistribute from tropics to poles, which means larger and more powerful waves. Wave energy has increased by 31% since 1960, and the tallest waves have increased in height by more than 1 foot in just over 30 years. Such waves compound the threat from sea level rise, beating harder on our shores and now regularly inundating low-lying coral islands of the western Pacific.

There is another dimension to the ocean's climate pacifying ability. Fish and whales move carbon from the surface to the deep sea, locking it out of harm's way and slowing climate change. The biggest players in this ocean carbon shuttle are billions upon billions of tiny fish smaller than the palm of your hand. They live in the twilight zone, between 660 feet and 3,300 feet down, at night migrating toward the surface to feed and by day retreating to the depths, where they excrete surface carbon: eat shallow, poop deep. It is estimated that without them there would be 50% more carbon dioxide in the atmosphere and the planet would be oppressively hot. These fish are precious but the fishing industry, running out of other options, views them as a cheap feed for burgeoning aquaculture. Cheap they are not when it comes to their value in keeping our world habitable.

The global ocean conveyor current also ventilates the deep sea, carrying oxygen from the polar surface on its descent. The intense polar chill maximizes the oxygen payload because cold water carries more oxygen than warm. That temperature dependence also means that global warming is hindering the ocean's ability to hold oxygen, with some unexpected consequences. Lower oxygen slows the metabolism of fish and other ocean creatures, so they grow more slowly to smaller sizes. Since the number of eggs a fish spawns depends on how big it is, populations in a future warmer world may struggle to replenish themselves, hitting fisheries production just when the expanding human population needs more food.

That the ocean is a great connector is starkly visible in other ways. The beaches of the farthest

reaches of the planet are piled high with plastics, and plastic particles are embedded in the bodies of even the world's deepest inhabitants. In 2020 a new species of giant amphipod crustacean was discovered 22,000 feet down in the Mariana Trench with plastic in its gut. To mark this grim milestone, scientists named it *Eurythenes plasticus*.

Countries still look upon the ocean as a source of wealth, despite growing signs that its resources are in trouble. The high seas fishing fleet has grown rapidly in recent decades—China alone has launched 17,000 vessels—taking advantage of less exploited waters in weakly regulated international space. Fueled by national subsidies and, in some cases, geopolitical ambition, these fleets are still stripping the world of its ocean megafauna, coercing poorer nations into selling their fish too cheaply, and stealing from the waters of others.

Meanwhile, the deep ocean may soon be carved up by mining corporations for the benefit of a few at a cost that will be paid by the whole world. Deep-sea scientists reckon that removal of polymetallic nodules from the deep seabed with gargantuan underwater excavators will, at the very least, obliterate the fauna over thousands of square miles. Worse, it will probably cause the extinction of tens or hundreds of species and would release vast quantities of carbon that could accelerate global change. The island nation of Nauru, its surface long ago laid waste by phosphate miners, now wants to extend mining into surrounding seas. The country has asked the International Seabed Authority to authorize a deep-sea mining operation that has no prospect of containing damage whose magnitude we can only guess at. Experimental mining trenches dug 13,000 feet down in the deep eastern Pacific in 1989 and revisited 26 years later looked as fresh as if they were dug only months before. Life moves slowly at these extreme depths and recovery from large-scale mining is probably impossible on meaningful human timescales.

And so we find ourselves at a crossroads in human history. For most of our existence, the consequences of our resource use have been limited to local scales. Today, the impacts of resource exploitation and depletion affect us all. What one nation does in its own interests has consequences that spill far beyond its borders. If deep-sea mining goes ahead, its scars will last for thousands of years and its effects will spread with the global ocean

IN 2020 A NEW SPECIES OF GIANT AMPHIPOD CRUSTACEAN WAS DISCOVERED 22,000 FEET DOWN IN THE MARIANA TRENCH WITH PLASTIC IN ITS GUT. TO MARK THIS GRIM MILESTONE, SCIENTISTS NAMED IT *EURYTHENES PLASTICUS*.

Wikimedia Commons

conveyor current to every corner of the globe. Never has there been a greater need for the world to act as one, governing itself in the interests of all its citizens and all life on Earth.

The clear message from the ocean, and from that other global common space, the atmosphere, is that a new form of world governance is needed to rein in national self-interest in favor of collective action to safeguard our shared living space. Our struggles to regulate greenhouse gases to address climate change show we are still far off this goal. Some psychologists contend that evolution has wired our psyche for selfish tribalism, handicapping efforts to manage human affairs at the global scale. But those other great attributes of human success—intelligence, adaptability, and cooperation—make me optimistic that collective interest will eventually prevail. How long we take to get there will dictate the shape of the future for countless generations to come.

The Intergovernmental Panel on Climate Change has acknowledged in recent reports that climate change is no longer avoidable; we are in the thick of it. Some impacts are irreversible on meaningful human timescales, like sea level rise or ocean acidification from carbon dioxide dissolution. Regardless of what we do now, a rise of 6 or even 10 feet in sea level is locked in based on emissions already in the atmosphere. For some, this represents local inconvenience, for others, such as low-lying coral nations like the Maldives, it could wipe them out forever.

As some look to the stars in search of escape from earthly destruction, we should instead look deep into the sea. The ocean is the beating heart of planet Earth, which so far as we know, is the only habitable place in the universe. Although there are many reasons for concern, there is also hope. Ocean life is proving resilient and can bounce back given the right protection, as we have seen again and again when endangered species were protected from hunting and fishing, and in the resurgence of life inside newly created marine protected areas. The legacy of industrial hunting, for example, can be undone in under a century. Humpback whales off Australia are increasing at the theoretical maximum rate, while elephant seals off the west coast of North America have rebounded from a low of 100 animals early in the 20th century to over 100,000 today. Efforts to restore lost and damaged habitats like seagrass, salt marsh, and mangrove forest are growing rapidly in number and scale, in part through recognition that they are worth more to us as intact, biologically rich and vibrant habitats than reclaimed land or prawn ponds. Fisheries have recovered in the U.S. and other countries by the simple expedient of following scientific advice, rather than awarding excessive quotas for short-term political or economic gain.

It is nature that keeps Earth alive and habitable. In the past, we took for granted that this natural life support system would always ensure our own well-being. But as human agency to reshape Earth expanded, nature retreated and that assurance has crumbled. Ambitious new protected area targets at last recognize our complete dependence on the living world. They could see protection expand to 30% of Earth's surface, above and below water, by 2030, and perhaps secure half of Earth for nature by 2050. This new mindset is pushing out the old orthodoxy that conservation is a luxury affordable only to the rich. There is only one ocean, one Earth, and we are the guardians of the future.

THE TAKEAWAY

The clear message from the ocean is that a new form of governance is needed to rein in national self-interest in favor of collective action to safeguard our shared living space.

Our Ocean Is Choking on Plastic—But It's a Problem We Can Solve

A new analytical tool can show the main sources of plastic pollution and help governments determine how to best reduce the amount that is reaching the ocean.

BY WINNIE LAU

ILLUSTRATIONS BY CARA BAHNIUK/THE PEW CHARITABLE TRUSTS

Our ocean—all 140 million square miles of it—has a plastic pollution problem. This is the case in places where one might expect it—from the waters lapping at megacities to the world's most polluted river deltas—but also in areas that might surprise people, such as the deepest trenches in the sea and the world's most remote coastlines.

Some 11 million metric tons of plastic enter the ocean every year, the equivalent of a garbage truck full of plastic every minute. A 2020 Pew-authored report, "Breaking the Plastic Wave," projected that the inflow will increase to 29 million metric tons per year by 2040 without ambitious action. Unfortunately, the report showed that commitments made to date by governments and industry, such as bans on plastic bags and straws, will have only an incremental impact on those numbers. If humanity is serious about tackling this problem, we need large-scale, systemic change, with governments and businesses of all sizes doing their parts.

Among the many obstacles to raising awareness of this challenge is that most people in the world cannot see the extent of the ocean plastic pollution problem. Even while standing on a beach, we might notice a few straws, bottle caps, and long-forgotten toys at the tide line, but we can still gaze out over the ocean and conclude that it's beautiful, pristine, and thriving. What we don't see is the pervasive pollution beneath the surface or the trillions of microplastic particles, from vehicle tires, textiles, and other sources, suspended from the surface to the seafloor.

A big challenge will be to untangle our economy and daily lives from a throwaway culture. Plastic is all around us, in our homes, vehicles, food and beverage containers, personal effects, clothing, shoes, toiletries, eyewear, furniture, and much more. A 2017 report in *The Guardian* found that around the world people purchase 1 million plastic bottles every minute.

Plastic is also now in our bodies, at least temporarily. It's in the food we eat, the water we drink, and even the air we breathe. In a potentially ominous sign, a study published last year found traces of plastic in a human placenta, meaning that we are not only ingesting particles but potentially passing them on to the next generation. The human health implications of all of this are just beginning to be understood.

Our collective consumption of plastic and the cheap cost of producing goods with it compared with most other materials continues to drive production and limit large-scale action by governments to constrict the making, selling, or use of plastic.

In recent decades, many (although far from all) governments, businesses, and consumers have viewed recycling as the answer. In many communities, residents dutifully fill recycling bins, which are, in turn, dutifully emptied by waste management workers, and we believe that the problem goes away.

Except it doesn't. Worldwide, only 9% of plastic makes it to a recycling plant. And for much plastic pollution—on land and in the sea—recycling was never an economically viable option to begin with. This includes microplastics, particles 5 millimeters or less in width, such as those generated from vehicle tires and some textiles or added to liquid soaps and shampoos. In fact, microplastics are a huge part of the marine plastic pollution problem

SOME 11 MILLION METRIC TONS OF PLASTIC ENTER THE OCEAN EVERY YEAR, THE EQUIVALENT OF A GARBAGE TRUCK FULL OF PLASTIC EVERY MINUTE.

because they can mimic fish eggs and other tiny organisms and are thus consumed by sea life. Once microplastics reach the ocean, they're nearly impossible to filter out without great cost or damage to marine life, so they become a near-permanent feature of the ecosystem.

But as noted in "Breaking the Plastic Wave," humanity can reduce the flow of plastics into the ocean by up to 80% by 2040 through a set of actions led by governments and industry—the two entities with the most power to effect large-scale change. And, to reiterate an overarching finding of the report, there are no quick or simple fixes to this mass problem—but humanity can solve the ocean plastic puzzle in one generation with a concerted, broad-based, and long-term effort.

For governments, the first step is grasping where the plastic is coming from and how it is moving from production to, eventually, the ocean. And this is one of the ways that Pew can help. In the coming months, we will launch the second generation of a tool that governments can use to determine the extent of their country's plastic pollution problem and use that information to guide action.

This tool, which was originally developed by Pew and the London-based consultancy SYSTEMIQ, has now been turned into an independent software application by our partner Richard Bailey at the University of Oxford. The tool analyzes country data to show the main sources of plastic pollution and help governments determine how to best reduce the amount that is reaching the ocean.

For example, a country could enter its data into the software application and indicate where it's considering different changes—for example, by increasing recycling rates or reducing use of plastic packaging. The tool then provides bespoke guidance on which shifts would have the biggest impact on the amount of the country's plastic flowing into the ocean.

As Linda Godfrey, an ocean plastics researcher and one of our partners in South Africa, says, "We're hopeful the new model can actually provide us with trade-offs, such as saying what combination would give us the least leakage of plastic into the environment with the greatest opportunity for climate mitigation and the greatest opportunity for job creation."

Pew is looking to partner with five national governments to use the new tool to develop evidence-based policies that can both serve as models for other countries looking to tackle plastic pollution and inform international and multilateral strategies. At the same time, we are either involved in or closely watching policy action at three institutions with the stature to move the needle on this problem.

One is the European Union (EU) government, which is drafting legislation to curtail microplastic pollution. The EU, with a

Worldwide, only 9% of plastic makes it to a recycling plant. And for much plastic pollution—on land and in the sea—recycling was never an economically viable option to begin with.

population of 740 million, is among the world's major producers of plastics, and the government is working with stakeholders to explore policy options to manage "unintended microplastics" — those that are generated during use of products, such as microfibers from clothes we wear or tire particles from driving cars. The EU is considering policies to better quantify microplastics generation, increase transparency—for example, through improved labeling requirements—or capture microplastics, such as requiring installation of filters in washing machines.

At the World Trade Organization (WTO), a group of member countries launched an "Informal Dialogue on Plastics Pollution and Environmentally Sustainable Plastics Trade," known as the IDP, in 2020 to explore options for addressing this challenge—on land and in the ocean. Pew will support a subset of countries to identify and implement model trade policies and offer our expertise to members of the dialogue. Potential avenues that the IDP could take include adopting measures to reduce trade in problematic plastics, promote trade in technology that supports reduction of plastic pollution, help build capacity—for example, in countries that lack the resources needed to recycle—and improve the transparency and monitoring of plastic trade.

And on March 2 at the U.N. Environmental Assembly in Nairobi, Kenya, representatives from 175 governments adopted a landmark resolution to launch negotiations on an international binding treaty to control plastic pollution. Pew plans to share our research findings, policy options, and recommendations to inform the treaty negotiations. This resolution is a big step forward for the world in tackling plastic pollution. As U.S. Secretary of State Anthony Blinken said in relation to the treaty, "As we know, our health—our survival—is bound up in the health of our oceans. We have to do more to protect them."

The U.S. needs to be a leader in these negotiations, in no small part because of the outsize role the country has played in the plastic problem. In December, the National Academies of Sciences, Engineering, and Medicine published a report that found that, in 2016, the U.S. generated more plastic waste than any other country—and more than all EU member states combined. In fact, Americans generate 4.5 to 6 pounds of

solid waste every day, or up to eight times what people in many other countries generate. And the National Academies report noted that U.S. plastic production has consistently increased each year since the 1960s.

The report called on the U.S. to create a national strategy by the end of 2022 to address the problem, including by "substantially reducing" the amount of solid waste the country generates. The report also recommends that the U.S. establish "a nationally coordinated and expanded monitoring system" to track plastic pollution, which, in turn, should help leaders better grasp the scale of the challenge and set appropriate policies for addressing it.

Another line of work that Pew will undertake supports efforts to track plastic in the economy to better manage plastic production, use, and waste generation. Pew, in conjunction with several partners, will develop a reporting system for businesses to disclose their plastic usage and to track changes over time, much like some do now for carbon and water. This voluntary system should allow businesses to see if they're meeting their commitments and better identify where they could improve. It should also help investors identify businesses with the least risks, and better enable governments to identify where policies can accelerate actions.

And although it's clear that humanity can reduce the amount of plastic entering the ocean, no one group can do it alone. Success will require cooperation between and among governments, industry, scientists, nongovernmental organizations, and consumers, as well as between businesses at all stages of the plastic design, production, sales, use, and post-use continuum. No group can sit on the sidelines expecting that the others will move toward success without support.

For example, among the interventions we called for in "Breaking the Plastic Wave," the one with the biggest potential to reduce plastic waste is reducing plastic production and consumption. This step would require companies to redesign their products and packaging to use less plastic or reuse plastic and for consumers to adopt those changes. Such actions could potentially lessen plastic waste generation by 30% by 2040.

Also, improved recycling—mainly through product and packaging redesign and doubling mechanical recycling capacity worldwide—could yield an additional 20% drop. And manufacturers can collaborate with recyclers to redesign products for maximum recyclability.

Addressing ocean plastic pollution now can also bring numerous other benefits. In "Breaking the Plastic Wave," we found that global projected plastic-related greenhouse gas emissions could be cut by up to 25% by 2040 if the world could decrease plastic production through our modeled interventions, and that governments around the world could save $70 billion in waste management costs during that span. In this optimal scenario, the private sector could seize emerging business opportunities as well as work with governments on improved oversight and funding of the waste sector. And industry could reassess its plans to avoid lost investment in new plastic infrastructure.

Although realizing these gains will be neither easy nor simple, they are achievable—and humanity already has the technologies and policy structures needed to do so. It is work we know we must pursue, for the sake of the ocean, and the countless people—including future generations—that need a healthy marine environment to survive and to thrive.

THE TAKEAWAY

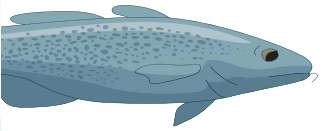
We have the technology and policy structure to reduce plastic pollution—if we have the will.

When Too Many Boats Chase Too Few Fish

The long history of government subsidies to fishing fleets has led to a decline in many fisheries over the last half-century.

BY CARMEL FINLEY

ILLUSTRATIONS BY CARA BAHNIUK/THE PEW CHARITABLE TRUSTS



In the aftermath of World War II, millions of people were starving. With this humanitarian imperative, governments set out to build fishing fleets. It was a historic change: Where once fishermen built boats, now governments would subsidize the task, a move that would lead to enormous catching capacity that soon changed the economics of fishing around the world in ways we are contending with today.

Over time, subsidies allowed fleets to grow in number, to employ new technologies, and to travel farther in quest of fish. In recent decades, the full extent of these subsidies has become clear. A 2018 study showed that without government subsidies, as much as 54% of high seas fishing grounds would be unprofitable at current fishing rates. In June, World Trade Organization members meeting in Geneva agreed to new curbs on some subsidies. It was an important turning point but also illustrated that much more is needed. Moving forward, these kinds of reforms will continue to fight the pulls of history.

That history shows the intertwined stories of competing nations, an early lack of strong science-based understanding of fish stocks, and how governance structures were not up to the task of global management of an essential natural resource.

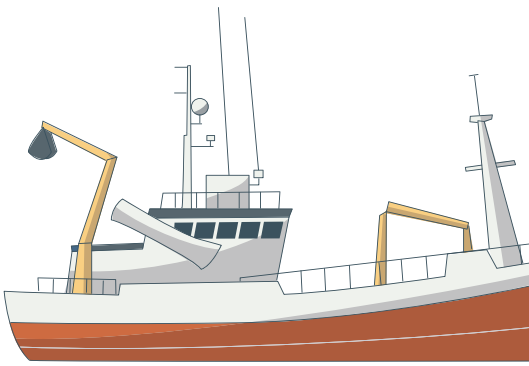
Over more than a half-century, governments have spent billions to make fishing more efficient, to find new stocks to exploit, and to facilitate the creation of new institutional agreements that laid the groundwork for fishing companies to operate easily throughout the world. Until 1976, there were no restrictions on where boats could fish.

As early as the 1950s, subsidies allowed new technologies spawned in wartime—such as radar and sonar—to be installed on fishing boats, increasing their catches dramatically. Subsidies to expand fishing have their roots in the growing industrialization of nature after 1920, as scientific concepts of industrial management were applied to natural resource systems. Fisheries that modernized and industrialized could catch far more fish more economically. Catches increased about 8% a year through the 1950s, stimulating coastal economies and providing products for export.

Iceland was one of the first nations to industrialize fishing. During the 1920s and 1930s, fishermen in rowboats caught cod just as they had for centuries. Icelandic fishermen braved the German blockades in English waters to deliver most of the fish consumed in Britain during the war. With the coming of peace, Iceland ordered 90 new trawlers from Sweden and another 30 from Britain; the vessels cost $500,000 each. An Icelandic trawler was the first in the world with a radar; by 1950, the nation's fleet was the most modern in the world.

Other larger nations quickly followed.

Japan had been the world's leading fishing nation before World War II. Under American

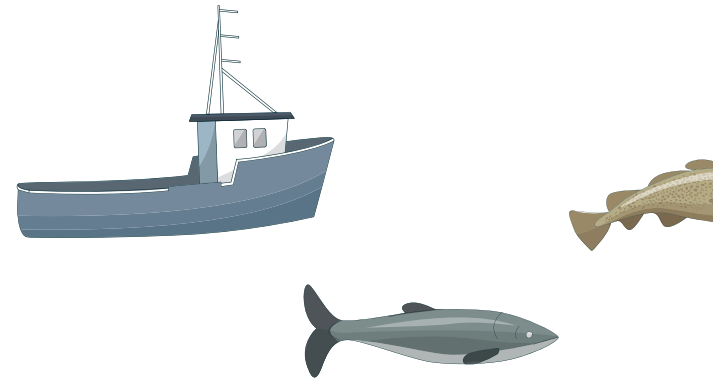


occupation and anxious to feed its people, the government wanted to get as many boats as possible fishing again. It would take the Japanese government less than two years after the war's end to rebuild the world's most capable fishing fleet, a fleet that had always been too big for its own waters. And with the signing of the Japanese peace treaty in 1951, the Japanese ships, rebuilt and with greater capacity, began to sail to the North Pacific to catch salmon and groundfish, while a rejuvenated—and also subsidized—whaling fleet also took to sea.

In those same postwar years, the Soviet Union announced a massive five-year plan to expand fishing fivefold by 1950. It built the world's largest whaling and fishing fleet, with more than 5,400 distant water vessels that amounted to at least half of the world's gross vessel tonnage for fleets of this size and type.

In 1954, a British fishing company built the world's first factory processing ship, the Fairtry, and sent it to Newfoundland to hunt for cod. It was 280 feet and carried a crew of 80 at a time when the largest British side trawlers averaged 185 feet with a crew of 20. The Fairtry transformed fishing, adopting the stern ramp from whaling ships that made it easier for crews to haul in the nets. As part of the expansion of its fleets, the Soviets ordered two dozen ships just like the Fairtry.

WHAT THIS ALL MEANT WAS THAT FISHING WAS MOVING STEADILY DOWN THE OCEAN FOOD CHAIN: AFTER TAKING THE BIG FISH, FISHERS WERE TARGETING THE SMALLER ONES, SUCH AS ANCHOVIES AND HERRING—TODAY, IT INCLUDES THE TINY KRILL OF THE SOUTHERN OCEAN—AND STEADILY REDUCING THE COMPLEXITY OF THE OCEAN ECOSYSTEM.

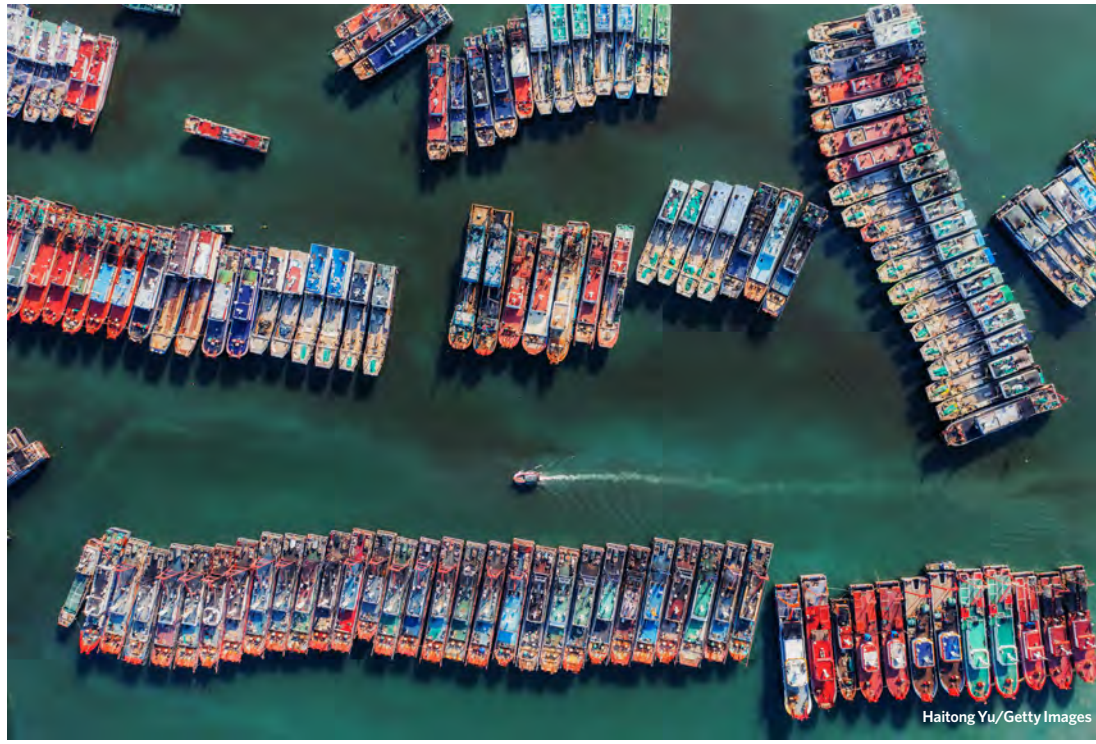


In 1961, the Spanish government began a period of generous government loans and subsidies for fishing boats. Spanish frozen fish production rose from 4,000 tons in 1961 to approximately 500,000 tons in 1972. And by the early 1970s, Spain had the third-largest fishing fleet in the world, after the Soviet Union and Japan, concentrating in hake fisheries off South Africa and on new species off South America.

Other untapped regions also became new fishing grounds. One of the fastest-growing fisheries was off West Africa, where European and Asian nations increased the catch from 1.4 million tons in 1967 to 3.7 million tons by 1976. Fishing was being revolutionized and food from the sea was playing an increasing role in the economies of Eastern Europe, Japan, Korea, and especially China.

Around the world, the overcall catch was growing—but individual stocks were in trouble. Norwegian and Icelandic herring stocks waned during the 1950s, followed by South African pilchards in 1960, Peruvian anchoveta in 1962, and Georges Banks herring in 1967. And demand for fish for oil and meal production grew, a practice that exploits young fish, including cod.

What this all meant was that fishing was moving steadily down the ocean food chain: After taking the big fish, fishers were targeting the smaller ones, such as anchovies and herring—today, it includes the tiny krill of the Southern Ocean—and steadily reducing the complexity of the ocean ecosystem.


Haitong Yu/Getty Images

Meanwhile, the market for frozen fish was expanding rapidly. The fish stick was introduced in 1953. Fish fillets could be flash-frozen in large blocks in Canada, Iceland, and Norway and shipped to the U.S., where the blocks were sliced, breaded, deep-fried, and frozen again. The sticks were uniform, simple to prepare, and, best of all, required no cooking (merely heating), totally divorcing fish sticks from the idea of messy, smelly fish that consumers had trouble cooking. Imports of fish blocks into the U.S. soared to 50 million pounds by 1956.

In that era, the sea itself was still seen as enormously resilient, capable of producing huge amounts of fish. The political apparatus to build fishing boats and create processing jobs was firmly established. How many fish could be caught? Nobody knew, but the assumptions were that the sustained harvest might be in the neighborhood of 200 million tons. The catch peaked at 86 million tons in 1996, then slightly declined.

As the technology to find fish improved, fishing became more like strip mining. There are now few areas in the world's oceans where fishermen have not been able to follow fish. Seabed mapping, global positioning systems, fish-finding electronics, and lighter, stronger nets have all allowed fishing to penetrate the deepest marine canyons. Canadian journalist Michael Harris has written that we are "using the black magic of technology to make a desert of the sea."

In the same postwar period during which subsidies were taking hold, many of the international institutions that manage fisheries and whaling were being created. Most international commissions were bilateral and multilateral organizations with very limited authority, because individual governments controlled how many boats would be allowed to fish—and those governments were propping up their fishing fleets with billions of dollars.

Just as the new tools of technology expanded the ability of fishermen to catch fish, so too did the new tools of science transform fisheries biology. Statistics, mathematical modeling, and the theories of population dynamics—aided by computers to

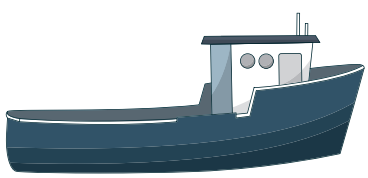
analyze large amounts of data—were shifting the science away from the traditional study of fish and how they interacted in their environment. These fish population demographics studies, used to develop fishing equations for predicting stock abundance, became the mainstay of modern American fisheries biology. In the 1950s many scientists believed that there was a balance within nature, that fishing actually created conditions that led to more fish by removing larger fish that grew more slowly, freeing up feed for smaller fish to grow more quickly. But today, scientists know the ocean as a dynamic ecosystem that is marked by complexity and uncertainty.

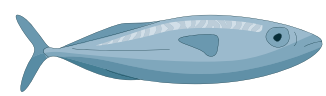
Still, it has been only in the past three decades that science has been able to show how the economics of subsidies are playing a direct role in the health of the ocean. In 2003, two researchers at Dalhousie University in Halifax, Nova Scotia, began to look past the case studies of individual fish stock declines to what was happening more broadly throughout the ocean. The researchers, Ransom Myers and Boris Worm, looked at a holistic picture of dozens of fisheries, plotting the escalating harvest throughout the world beginning in the 1950s as government subsidies began to transform industrial fishing. Their groundbreaking work changed the scale from the individual to the global. Their conclusion: The development of industrial fishing after World War II was responsible for removing up to 90% of the cod, halibut, tuna, swordfish, marlin, and other large fish in the ocean.

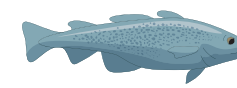
In subsequent years, researchers have steadily built the case that subsidies are a root cause for the overfishing that is threatening the livelihoods of fishers and coastal communities around the world as threatened species decline. A 2019 report commissioned by The Pew Charitable Trusts, which has sought to end the subsidies, found that governments pay their fishing industries about $35 billion a year—and $22 billion of that are considered harmful in that they allow vessels to travel farther, stay at sea longer, and catch more fish than they could normally afford to, resulting in a depletion of fish populations beyond sustainable levels.

SCIENTISTS KNOW WHAT TO DO TO RESTORE STOCKS, ESPECIALLY IN MARINE PROTECTED AREAS, BUT THE HISTORY OF GOVERNMENT SUBSIDIES AND FISHERIES MANAGEMENT STILL COMES DOWN TO THE AGE-OLD PROBLEM OF DIVIDING TOO FEW FISH AMONG TOO MANY BOATS.

Even though overfishing has been so widely studied and recognized, it will take time for the World Trade Organization's global framework to unwind the subsidies that waste so much capital and inflict damage on ocean fish stocks. The move by the WTO's 164 member governments in June will curb some harmful subsidies as well as enhance transparency and accountability on how governments subsidize their fishing fleets. More needs to be done, but we now have a path for reform. Scientists know what to do to restore stocks, especially in marine protected areas, but the history of government subsidies and fisheries management still comes down to the age-old problem of dividing too few fish among too many boats.

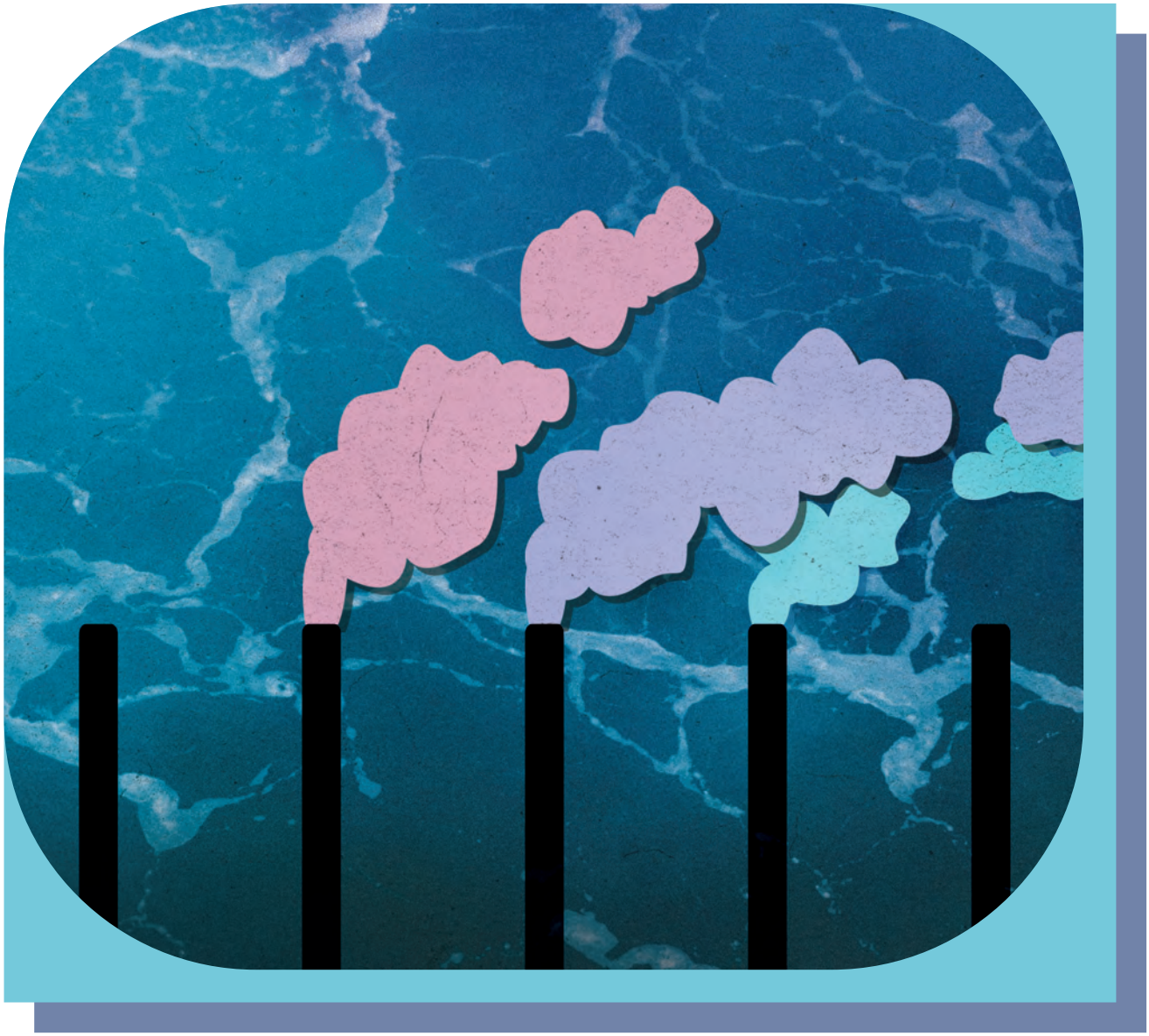






THE TAKEAWAY

A history of government subsidies to industrial fishing fleets around the globe have led to steep declines in the ocean's largest fish, showing that these expenditures must be curtailed.



How to Reverse the Ocean-Climate Crisis

BY BRAD ACK

ILLUSTRATIONS BY CARA BAHNIUK/THE PEW CHARITABLE TRUSTS

It's not enough to slow emissions of carbon dioxide into the atmosphere; we must also remove some of what's already there.

In the movie "Apollo 13," when it is clear that the astronauts are in serious trouble, flight director Gene Kranz in Houston tells his team, "Let's work the problem, people. Let's not make things worse by guessing."

For generations, the ocean has appeared to most humans as vast and impenetrable. Mysterious, dangerous, unfathomably large, but certainly not susceptible to being significantly altered by something humans might do.

But over the past century, that understanding has changed—first slowly and then more dramatically—and now, the ocean appears smaller and more fragile than we once thought. We have unimpeachable evidence that humans can have a devastating footprint on the ocean: 20th century whalers decimated global populations of blue, fin, and sperm whales over just a few decades; factory trawlers are depleting today's fisheries; agricultural runoff has created enormous dead zones in the ocean; and plastic waste litters most of the ocean.

And there is a far more dangerous human-caused stressor that has largely gotten a pass from scrutiny, even though it is creating existential threats to the ocean. That stressor is the carbon dioxide pollution we have released into the atmosphere over the past 200 years, with a significant portion finding its way into the ocean's upper layer.

Although we may not normally think of CO_2 as pollution, human enterprise since the dawn of the Industrial Revolution has emitted about 2 trillion tons of this invisible gas into Earth's atmosphere that otherwise would not have been there. Over this time, we have increased CO_2 levels by 50% in the atmosphere and by 30% in the upper layer of the ocean.

This enormous amount of CO_2 pollution has already had, and will continue to have, dangerous effects on the ocean.

The effects of CO_2 pollution on the ocean can be grouped into two large categories: thermal stress and chemical stress.

Thermal stress comes as the massive amounts of excess CO_2 we have put into the air trap an enormous amount of energy from the sun that would otherwise have dissipated into space—about 93% of all this excess heat is absorbed into the ocean. The quantity we are talking about is staggering, calculated at about 14 zettajoules of heat every year. For context, a joule is a basic measure of heat energy, and a zettajoule is that single unit with 21 zeros after it.

As that amount is still difficult to comprehend, let's give it some additional context. Researchers have translated this into an equivalent measure: the amount of heat energy released by an atomic bomb the size of the one that detonated over Hiroshima. Fourteen zettajoules of heat energy going into the ocean each year is roughly equivalent to five atomic bombs' worth of heat energy going into the ocean every second of every minute of every day, year after year. This means that, every day, 432,000 atomic bombs' worth of excess heat energy enters the ocean. And the quantity of heat has risen as atmospheric concentrations of CO_2 have increased.

All this excess heat going into the ocean is literally unraveling the fabric of the system. Warmer ocean water holds less oxygen; already, there has been about a 2% average decrease in dissolved oxygen throughout the ocean. Warmer upper layers of the ocean inhibit mixing with the middle layer of the ocean, which is a primary exchange system that brings nutrients into the

global food web. These warmer waters expand, and that expansion is causing a significant portion of the sea-level rise that coastal ecosystems and communities have been experiencing. Warmer waters also lead to marine heat waves that decimate coral reefs; we have already lost more than half of the Earth's tropical coral reefs primarily due to heating and bleaching. In addition, warmer waters are driving species that can migrate to do so; their move toward cooler water is leading to large-scale migrations of fish stocks poleward. And warmer waters mean less Arctic sea ice, which has functioned like a planetary air conditioning system that we all depend on.

Chemical stress is caused by about 25% of the total CO_2 pollution emissions being absorbed into the upper layer of the ocean, creating a chemical reaction known as ocean acidification. As the ocean absorbs this excess CO_2, it becomes increasingly acidic; today, the global ocean has become about 30% more acidic, on average, than it was in preindustrial times. As this massive shift in ocean chemistry increases, the ocean becomes less hospitable to all life that forms a shell. This notably includes many phytoplankton and zooplankton—the microscopic life forms that sit at the base of a number of oceanic food webs and are major producers of the oxygen we rely on. It also of course includes the shellfish that so many of us love to eat.

These two systemwide threats to the ocean—thermal and chemical stress caused by CO_2 pollution—outweigh, in terms of their ultimate risk, anything else that we have done or are doing to the ocean. The threats are also growing and will continue to do so as atmospheric concentrations of CO_2 and other greenhouse gases increase.

And worse, as these stresses mount, they further fuel "positive feedback loops"—reactions to ocean warming and acidification that further increase warming. For example, the loss of Arctic sea ice means that more heat is being trapped on the planet rather than reflected back into space. This is leading to thawing of permafrost, which contains enormous stores of greenhouse gases. Regional warming is also accelerating the melting of the Greenland ice sheet, which appears to be slowing a critical ocean current in the north Atlantic—altering how the waters naturally circulate.

We can now see and measure the harm that humans have done, and the conclusion is inevitable: The climate crisis is an ocean crisis, and the ocean crisis is a climate crisis. Now, the question is, what can we do about it?

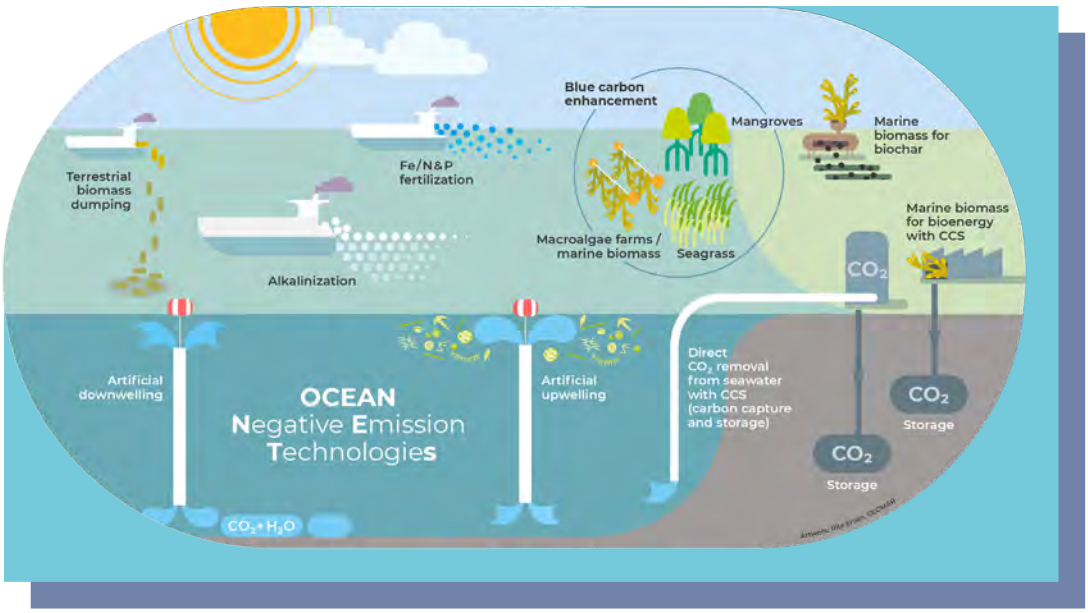
Until recently, most efforts to mitigate climate change have focused on stemming the flow of greenhouse gas emissions into the atmosphere. But the world's leading body on climate science, the Intergovernmental Panel on Climate Change, has made it clear that at this late stage, even dramatically reducing CO_2 pollution emissions won't keep global warming from exceeding 1.5 degrees Celsius, which scientists describe as the tipping point of dangerous and potentially irreversible climate disruptions. We also need to remove billions of tons of "legacy" carbon dioxide pollution that is already overheating the planet and acidifying the ocean.

This means quickly developing a host of technologies that can remove CO_2 from the air and water and safely store it as permanently as possible. These tools and techniques will range from the most natural, such as planting trees, to the most industrial, like employing direct air capture plants that operate as CO_2 removal factories and using electrochemistry to essentially strip CO_2 from the atmosphere. And there will be many other options in between, some of which have not been invented yet.

When all is said and done, cleaning up the legacy carbon pollution that we have created is essential to slowing and ultimately reversing the ocean-climate crisis. Carbon cleanup will also have to become an enormous economic sector if it is to achieve a scale relevant to the problem. And the ocean will likely have an important role to play.

Why? The ocean has enormous potential to safely draw down and sequester additional CO_2. The reasons are simple: The ocean is already the largest carbon cycler on the planet, using both biological and biogeochemical processes to move CO_2 from the air and land into the deep ocean. In fact, there is already roughly 50 times more carbon at the

bottom of the sea than in the atmosphere. If we could increase that ratio by 1% to 2%, we could have a massive impact on reducing atmospheric concentrations of CO_2 and slowing, and potentially even reversing, the climate and ocean crises.



Rita Erven/OceanNETs/GEOMAR

Ocean-based carbon dioxide removal (CDR) is a field that is in its infancy but growing up fast. Ocean-based CDR techniques essentially mimic, enhance, and/or accelerate oceanic biological and geological processes already underway.

There are five large "domains" of ocean-based CDR approaches that encompass almost every way that the ocean might be engaged to sequester more carbon:

- **Seaweed growth for carbon sequestration.** Marine macroalgae (aka seaweeds) have tremendous potential to sequester carbon given their staggering growth rates (some kelp can grow 2 feet a day!) and the fact that they do not require additional energy or nutrients to grow. Long-term CO_2 storage may be achieved by making long-lived products from biomass (biochar, bioplastics, etc.) and/or bundling and sinking the biomass into the deep ocean. Many approaches are being tested to accelerate seaweed growth for carbon removal.
- **Microalgae cultivation and carbon sequestration.** The most productive organisms in the ocean are microscopic algae (phytoplankton). As these microalgae grow, they take up carbon dioxide. Increasing their overall mass could lead to increased CO_2 fixation and, ultimately, transfer of that CO_2 into the deep ocean. Technologies being tested include using ships to distribute nutrients into nutrient-limited areas of the sea to foster growth and pumping nutrient-rich waters to the surface to fuel growth of microalgae.
- **Ocean alkalinity enhancement.** Over geological time scales, the ocean has become a major store of carbon due to the weathering of natural rocks, which washes alkaline molecules into the ocean. Ocean alkalinity enhancement technologies can speed up this natural process to sequester carbon dioxide and, at the same time, reduce ocean acidification. Many methods are under development to add alkaline material or liquid to the ocean to enhance the natural carbon cycle.

- **Direct ocean capture.** This approach is like direct air capture plants on land, using electrochemistry to essentially strip CO_2 from seawater. The acidic stream of CO_2 can be stored in deep rock layers or used to weather alkaline rocks to increase alkalinity. The resulting alkaline seawater can enhance ocean alkalinity, allowing the ocean to absorb more CO_2 from the atmosphere.
- **Blue carbon ecosystems.** Coastal ecosystems, including tidal salt marshes, mangrove forests, and seagrass meadows, fix CO_2 via photosynthesis and can trap organic carbon in their roots and the marine sediments for thousands of years. Disturbance and loss of these ecosystems has led to the release of carbon into the atmosphere. The restoration of these degraded systems can increase carbon sequestration and provide a host of other benefits for nature and people.

Technologies are being developed in each of these five domains to test the potential for permanent carbon removal and the associated economic, social, and environmental costs. For example, some people are building large autonomously operated platforms for growing seaweed in the open ocean and then using robotic harvesters to cut, bale, and sink it to the deep. Others are using wave-powered upwelling pumps that bring nutrients from the deep to the upper photic zone of the ocean to drive blooms of phytoplankton. And yet others are testing an array of ways to disperse alkaline material and liquids into the ocean to create chemical reactions that lead to CO_2 being moved to the deep. And this is just the beginning; as humans come to grips with the massive opportunity and challenge we face in cleaning up carbon, we will see a host of iterations as well as new ideas.

But we are now in a race against time. There are only two ways to reduce atmospheric concentrations of CO_2—reduction and removal—and they have to be done together.

To chart the ways forward, Ocean Visions, working with experts from around the globe, developed a series of technology roadmaps that assess the current state of various technologies that could help reduce carbon and illuminate the diverse obstacles and opportunities to quickly advance the development and testing of these technologies. The roadmaps are not just about science and engineering challenges; they also include critical policy, governance, economic, and social challenges. Work is needed in a number of disciplines and sectors for successful outcomes.

We have now turned our attention to catalyzing efforts to aid these priorities and expanding the overall investment of time, energy, and money into this emerging sector. We desperately need to engage an ever-growing cadre of scientists, engineers, managers, environmentalists, businesses, investors, and others to tackle critical obstacles and pursue key opportunities.

This work has one critical intermediate goal: to advance the development and testing of all viable approaches in the ocean and at scales significant enough to answer the critical question of whether these approaches will be able to contribute to the massive carbon cleanup and ocean regeneration challenges that we face. It is no longer a question of whether we need carbon removal; it is only a question of where society will find the most cost-efficient paths to achieving carbon removal at a climate-relevant scale. To answer these questions that are so important to our future, we must have rigorous and credible science on which climate and ocean policy can be based.

The good news is that solutions to this ocean-climate crisis are possible—if we add carbon removal as a tool in our climate toolbox and if we fully consider all the potential ways the ocean can contribute to carbon removal.

With intensified focus, expanded effort, and application of a suite of new technological tools, we can clean up the CO_2 pollution unraveling our world and regenerate our ocean and our climate so that humans and nature can thrive.

THE TAKEAWAY

The Earth's climate and ocean crises are inextricably linked, and we must quickly develop solutions that work to save them both.

Coastal Blue Carbon

Why saving our coastlines is crucial to saving the ocean—and the planet.

BY ARIANA SUTTON-GRIER

ILLUSTRATIONS BY CARA BAHNIUK/THE PEW CHARITABLE TRUSTS

The effects of climate change are now evident, threatening our lands and seas. And where the water meets the land offers some of the greatest opportunity for mitigating the rising temperatures that are warming the world.

Not only are our coastlines natural buffers to rising seas, but they are home to important seagrasses, mangroves, and other vegetation that are some of nature's best storehouses of the carbon in the atmosphere that must be absorbed to keep Earth's climate healthy. The popular name for this is blue carbon. In this case, blue is all about good. But, in fact, blue carbon is actually brown.

It might help to start with a brief, basic science lesson.

All living things are made of carbon, and all living things—you, me, animals—eat food that our bodies break down and extract energy from using oxygen through the process of respiration. A byproduct of this process is carbon dioxide. Of course, the burning of fossil fuels also releases carbon dioxide in especially large doses into the atmosphere and, to continue our color analogy, this is called black carbon.

Plants are different from other living things because they make their own food through photosynthesis. They take carbon dioxide from the atmosphere, along with water and sunlight, and make sugar that sustains them—but a small portion of that carbon also gets stored away in leaves, stems, roots, and tree trunks and is used to grow more of the plant (this carbon is called organic carbon because the carbon is now part of a living organism). So, plants make organic carbon (food for other living things) while other organisms, including people, break down this food to use for energy: A lovely transaction.

This transaction has served the world well for millennia. In fact, the current atmosphere of the modern human world has lower levels of carbon dioxide than when dinosaurs roamed the planet. That's because, over the course of history, large amounts of carbon were stored away for a long time, buried deep in the Earth. But that is changing now: The oil we extract to power our daily lives comes from those dead plants that lived millions of years ago. The burning of fossil fuels means that we are bringing back into the atmosphere more carbon than the world has seen in hundreds of thousands of years.

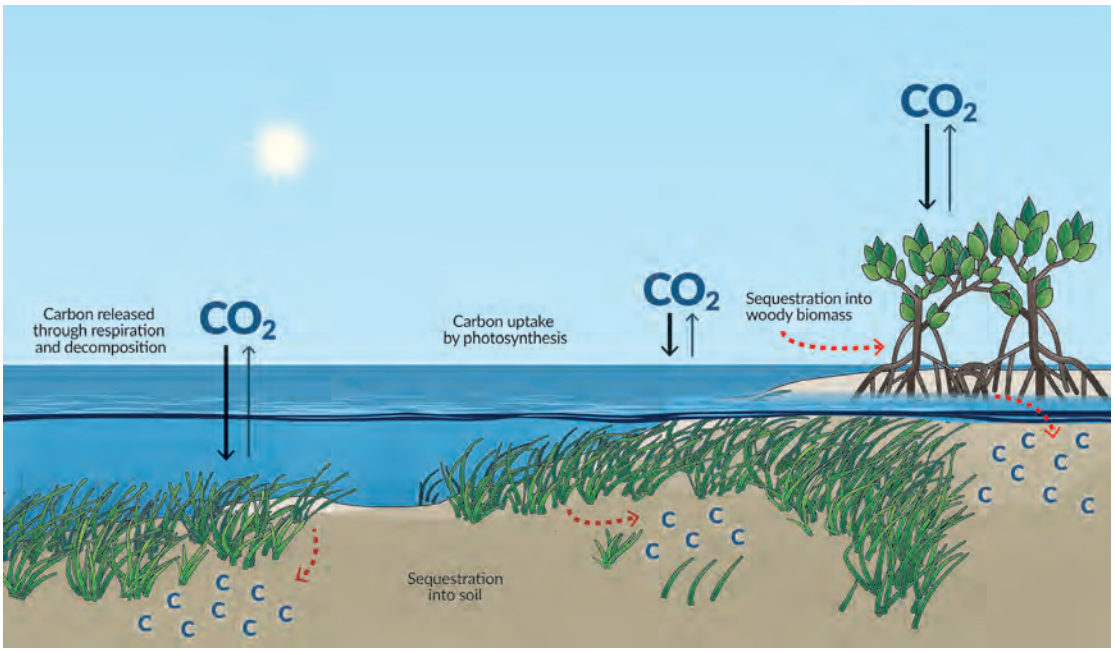
So we need to place special importance on the Earth's ecosystems that can continue to safely keep carbon out of the atmosphere—places known as natural carbon sinks.

Forests are usually the prime example of a natural carbon sink. We see grand towering trees and know that their trunks and branches are storing carbon—and that there is more stored underground in their roots.

Less visible but equally important is another critical carbon sink: the planet's coastal grasslands and wetlands.

Much is correctly made about the fact that the ocean is a great carbon storehouse. But where the ocean meets the land is especially important. Coastal blue carbon accounts for about 50% of all the carbon stored in the ocean even though coastal wetlands cover less than 1% of the ocean's area.

Mangroves, tidal marshes, and seagrasses are some of the most productive ecosystems on the planet, meaning that they take up a lot of carbon dioxide per unit area. Some of this carbon gets buried underground in the wet, tidally inundated soils. These wet soils are largely devoid of oxygen, which means that decomposition of the organic



carbon slows way down, making them the perfect place for carbon to accumulate and turning them deep—by now you've got it, right?—brown, not blue. Some coastal wetland soils are many meters thick and are storing thousands of years' worth of carbon. The amount of carbon buried in coastal wetlands over time is 10 times greater than that stored in other forest soils.

When we disturb or destroy these coastal wetlands for agriculture or development, we lose their continued sequestration ability, and when we drain them, we introduce oxygen into the soils, changing their anaerobic decomposition of carbon to the faster oxygenated process. Losing just 1 acre of coastland has the equivalent impact on carbon emissions of losing 10 to 40 acres of native forest. This is why protecting existing coastal wetlands and restoring them where they have been degraded are excellent climate mitigation strategies.

The challenge is that we have already lost more than half of the coastal wetlands around the world over the past century. These are some of the most threatened ecosystems on the planet, and today they are continuing to lose up to 3% of their global area per year. In the state of Louisiana alone, 2,000 square miles of coastal wetlands have disappeared since the 1930s. The reasons why are disheartening because they were caused by us: Natural sediment was lost when the Mississippi River was diverted to reduce flooding, the ground has subsided from oil and water extraction, and still more wetlands disappeared from the construction of pipelines and shipping lanes. And now rising sea levels due to climate change mean that even more coastal wetlands are being lost.

We lose so much coastal wetland area around the world each year that the carbon emitted from those disruptions is equivalent to the annual carbon emissions of the United Kingdom. In effect, these incredible natural carbon sinks have become *additional* human sources of greenhouse gases.

With new studies showing the Earth warming faster than previously believed, we need action that can make a difference quickly in reducing greenhouse gases in the atmosphere. That makes protecting coastal wetlands an even more attractive and necessary strategy, not just from a scientific point of view, but from the vantage

of policymakers. Not only are coastal wetlands immensely effective carbon sinks, but they are within national boundaries, allowing every coastal nation to act in its own interest and protect them—without the extensive negotiation among nations that strategies involving international waters would.

It is essential to limit development in wetlands—history has shown that is obvious. Less obvious but just as meaningful are strategies to promote and protect wetlands, including new approaches to aquaculture. For example, one promising strategy is guaranteeing higher market prices for sustainably farmed shrimp when shrimp growers retain or plant at least 50% mangrove cover over their aquaculture areas. This practice leads to larger shrimp and smaller environmental impacts and has been successfully implemented in the Mekong Delta in Vietnam.

Carbon financing can also support coastal wetland restoration. An innovative tool that places a financial value on carbon emissions, carbon financing allows companies to offset their emissions by purchasing carbon credits from sustainable projects. One successful example is the Mikoko Pamoja project in Kenya, in which the sale of mangrove carbon credits has helped the local community restore its mangrove forests and bring clean water and school supplies to villagers. The project also provides alternate livelihood options, particularly for women in the community who have been active in growing, planting, and monitoring the restored mangroves. This approach offers wins for the community, the climate, and biodiversity conservation—and could be duplicated elsewhere.

For places in the world where coastal wetland tidal flow has been affected by development, restoration is essential. Many temperate coastal salt marshes, including 27% of the coastal wetlands along the U.S. Atlantic coast, have been altered by development, including roads, bridges, or railroad tracks, which run through or directly behind these wetlands and have cut off their natural tidal cycles. These saltwater wetlands have "freshened" and now produce far more methane, a potent greenhouse gas, than they would in their natural salty state. In these areas, we can widen inlets and culverts to remove barriers and open up tidal flushing that restores the salt marshes, allowing them to play their key role in reducing greenhouse gas emissions.

WE LOSE SO MUCH COASTAL WETLAND AREA AROUND THE WORLD EACH YEAR THAT THE CARBON EMITTED FROM THOSE DISRUPTIONS IS EQUIVALENT TO THE ANNUAL CARBON EMISSIONS OF THE UNITED KINGDOM. IN EFFECT, THESE INCREDIBLE NATURAL CARBON SINKS HAVE BECOME *ADDITIONAL* HUMAN SOURCES OF GREENHOUSE GASES.

The multitude of benefits from preserving and restoring the world's coastal wetlands has become increasingly clear and must be encouraged. Of course, these coastal regions alone cannot cure climate change—that will require a range of strategies, beginning with reducing carbon emissions throughout the world. But blue carbon has shown its essential and even decisive role in protecting the planet. Every coastal nation can act to protect and nurture its wetlands—and make the future blue.

THE TAKEAWAY

Coastal wetlands hold half of all the carbon stored in the ocean, making them essential to mitigating climate change.

How We Can Help Marine Protected Areas Save Our Ocean

A new 'whole ocean' approach to ocean conservation can serve marine life and people around the globe.

BY JOHNNY BRIGGS

ILLUSTRATIONS BY CARA BAHNIUK/THE PEW CHARITABLE TRUSTS

In January 1790, a ship named The Bounty landed on a small speck of land jutting out of the Pacific Ocean. The uninhabited island, barely 2 miles long and 1 mile wide, would remain home to the crew and their subsequent generations until this very day. The fact that The Bounty dropped anchor in such a small and desolate place was no accident—its isolation was its attraction. The crew were mutineers and they never wanted to be found.

Fast forward over two centuries to 2016 and the island's mayor, an eighth-generation descendant of the lead mutineer, Fletcher Christian, was proudly announcing to the world that the Pitcairn Islands, as the archipelago is now known and which is a U.K. Overseas Territory, would house one of the world's largest marine protected areas (MPAs).

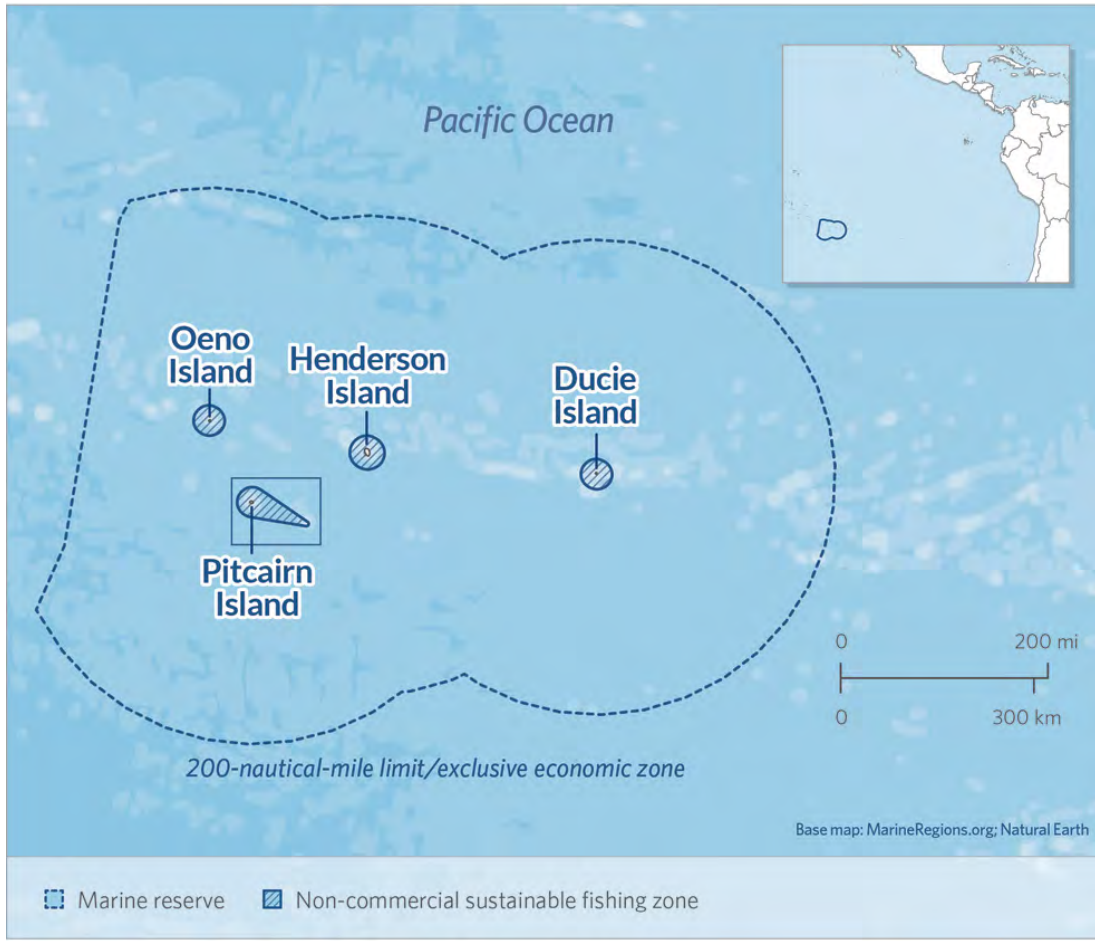
Four widely spread-apart islands make up the archipelago: Pitcairn, with a population of about 45 people; Ducie; Oeno; and Henderson, a raised coral atoll that's a UNESCO World Heritage Site.

Ducie has a distinction all of its own—it is the "closest" landmass on the planet to Point Nemo, which is known officially as "the oceanic pole of inaccessibility," that point in the ocean that is farthest away from land. Nemo is Latin for "no one," and Ducie is about 1,500 miles away. Some context for that distance: The astronauts aboard the International Space Station are about 258 miles from Earth at any given time, which means that those humans in space are often far closer to the pole of inaccessibility when they pass over it than Ducie Island is.

Under international law, a state has jurisdiction over the exploration and exploitation of marine resources within 200 nautical miles of its coastline. This means that areas such as the Pitcairn Islands have control over a huge swath of ocean. Over 836,000 square kilometers (322,781 square miles) in this case, an area more than 3.5 times the size of the landmass of the U.K. But why would the Pitcairners, so isolated and low in number, choose to fully protect more than 99% of their waters in a marine protected area? It is because those who live closest to and most intimately with the sea often know best the challenges that are facing the global ocean—and what must be done to protect it.

For millennia the ocean, covering more than 70% of our planet's surface, has provided direct benefits to the human race. Today these include providing employment for hundreds of millions of people and protein for billions more. The ocean regulates our climate, while absorbing and buffering us against the excess emissions and heat that we generate, and also offers intangible serenity through spiritual, cultural, and emotional connections. Many of these benefits, however, have come at a cost. Human activities are having a detrimental impact on the world's ocean, including decreases in biodiversity and fish stocks. Today, at least a third of fish stocks are overfished, our seas are warming and becoming more acidic, and pollution, such as plastic, is ubiquitous, found at the ocean's deepest point and in the stomachs of numerous species, including albatross and whales. At the same time, we are seeking new frontiers to exploit for oil, gas,

PITCAIRN ISLANDS MARINE RESERVE



minerals, and seafood, which could cause even further damage for decades to come.

Arresting the decline of the ocean ecosystem requires a holistic approach, incorporating the sustainable management of fisheries, the prevention of pollution, and the conservation of species and habitats. Marine protected areas such as Pitcairn's have become a key part of the contemporary marine conservation toolbox. But they are actually one of the oldest forms of fisheries management. Coastal communities have long recognized that striking a balance between exploitation and protection of a resource is critical to sustaining a healthy marine environment. French Polynesian people, for example, for centuries have applied rāhui, an integrated, community-based approach to natural resource conservation often involving the strategic closure of an area to extractive activities to allow fisheries to replenish.

According to the World Database of Protected Areas, approximately 8% of the ocean is contained within the nearly 18,000 MPAs in the world, most of which are much smaller than Pitcairn's. However, the term "marine protected area" has become a catchall for many forms of spatial ocean management, and institutions such as the Convention on Biological Diversity (CBD), the Food and Agriculture Organization of the United Nations, and the International Union for Conservation of Nature each offers a different definition and categorization. As a result, levels of biodiversity protection within these areas vary widely, ranging

from 100% fully protected (zero resource extraction permitted) to multiple-use areas (which may include commercial fisheries). Such a wide variety of MPAs makes it difficult to evaluate the conservation gains of these areas through percentage coverage figures alone.

A new publication, the MPA Guide, developed by a worldwide group of leading scientists, has tried to evaluate MPAs by each one's level of protection and what stage of implementation it is in. The guide has found that a high level of protection and enforcement, maturity, long-term sustainable financing, stakeholder engagement, and community leadership make for strong conservation benefits. But it has also determined that MPAs' effectiveness in protecting biodiversity vary substantially. In short, this means that of the 8% of the ocean now in MPAs, only 2.5% is in a highly or fully protected area, which shows just how much more work needs to be done.

To encourage the creation of MPAs by governments and stymie the decline of the ocean, international institutions have been setting global marine protection goals for the past two decades. Current targets are set by the United Nations Sustainable Development Goal 14 and the CBD's Aichi Target 11, both of which seek to effectively protect at least 10% of the ocean. And scientists, coastal communities, and more than 100 governments now agree that the global goal should be at least 30% protection by 2030 (also known as the "30 by 30" goal). Achieving this science-led goal will require a step-change in conservation. More than 8.7 million square kilometers (nearly 3.4 million square miles) of ocean must be protected per year this decade to achieve it—an area approximately the size of Brazil annually. This is daunting, but not impossible. Which all brings us back to an isolated island in the middle of the Pacific Ocean called Pitcairn.

Around 2010, the small community realized that the best way to protect its ocean heritage and to guarantee its ongoing sustainability was through the legal designation of a huge MPA. The designation, which Pitcairners alongside NGO partners including The Pew Charitable Trusts formalized over a number of years, included artisanal fishing zones up to 12 nautical miles from the coast of each of the four islands. As such, the community would fish for sustenance using handlines in perpetuity in the clear blue waters just off their coast. The rest of the exclusive economic zone was fully protected, with satellite monitoring ensuring that the waters were policed for illegal activity. With this, the Pitcairn Island community secured the long-term sustainability of its marine resource with an MPA designation.

Effectively achieving the 30 by 30 goal globally will require similar courage by other governments to forgo short-term commercial opportunity in exchange for the long-term development of sustainable blue economies. That will necessitate leadership from Indigenous and local peoples and the implementation of traditional ocean management approaches such as the proposed adoption of large rāhui in French Polynesia. It also will entail monitoring and enforcement from innovative platforms combining satellite technology

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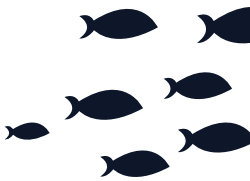


with groundbreaking science and will call for long-term sustainable financing. The technology, systems, and processes needed to meet all of these requirements for 30 by 30 are available, proven, and accessible.

A second key element will be protecting the high seas—those daunting, lonely blue spaces beyond national jurisdiction that actually comprise 64% of the Earth's surface and nearly 95% of the ocean's volume. Although seemingly impossibly isolated, the high seas are heavily exploited by international fishing fleets, some operating illegally. They also represent a frontier for the fast-evolving deep-sea mining industry, which is eyeing the rare minerals and other materials beneath the seabed. To manage such sectors requires the designation of MPAs on the high seas. Creation of those areas is dependent upon the United Nations completing the development of—and member nations agreeing on—a new treaty to protect areas beyond national jurisdiction.

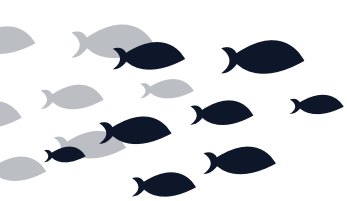
The recent precedents for marine conservation are generally positive. Over the past year, new MPAs have included France's largest fully protected area in the frigid waters of the French Subantarctic Lands, an expansion of the world-renowned Galápagos Marine Reserve, Tristan da Cunha's designation of the largest fully protected areas in the Atlantic, and a shared transboundary commitment to protect the Eastern Tropical Pacific between Ecuador, Costa Rica, Colombia, and Panama. Such a regional-network approach as proposed in the Eastern Tropical Pacific will be critical to supporting the protection and rejuvenation of the ocean.

These new Pacific MPAs are not on the scale of Pitcairn's, but their interconnectivity makes them very effective. The tenet underpinning the interconnectivity idea is simple: Ocean species, human activities, and chemical and physical oceanography transcend national marine boundaries. And highly migratory species travel thousands of miles to breed and feed; international fishing fleets encircle newly designated MPAs; and regulatory bodies with different sectoral mandates operate in the same geographical space. Interconnectivity brings a holistic regional approach to marine conversation that works to address this complex latticework of biological and human interactions.

This new approach envisages a constellation of MPAs of various sizes and levels of protection, connected by "biological corridors" shielding migratory species from human harm and underpinned by regional collaboration and good governance, equitable management, sustainable long-term financing, and effective monitoring and enforcement. Management of networks of regional MPAs allows these spaces to interconnect over huge areas and account for variables such as changing climatic conditions, economic and cultural needs, and emerging technological innovations.

Such a "whole ocean approach" also does not pit MPAs and fisheries against each other, but rather considers that protected areas and fisheries management are both important elements when making policy and allows disparate stakeholders to operate synergistically. Still, despite the scientific consensus pointing to these interconnected networks as best practice, policymakers need to be much more consistent in embracing this approach. A recent study of reefs, for example, found that a majority of corridors between key habitats remains unprotected.

We can and we must do better. Science is providing a better understanding of how to ensure a healthy and biodiverse ocean that serves both marine life and people around the globe. We know that MPAs are essential to that effort. And this regional approach to connected MPAs shows what we can accomplish by applying ambitious new ideas and collaborative policies and governance.



THE TAKEAWAY

Protecting at least 30% of the ocean by 2030 will require a "whole ocean approach"—ensuring that MPAs are interconnected by well-managed fisheries and protections of the high seas that forgo short-term commercial gain to develop long-term sustainable blue economies.

INDIGENOUS KNOWLEDGE IS ESSENTIAL FOR THE FUTURE OF THE OCEAN

COMMUNITIES AROUND THE GLOBE HAVE GENERATIONS OF EXPERIENCE IN CARING FOR THE SEAS AROUND THEM

SOMETHING HAD TO BE DONE

By Celestino Ancamil

My grandfather was one of the first settlers on the shore of the Puyuhuapi fjord in Chilean Patagonia. He arrived here in 1935, when he was only 24 years old, from the Araucanía region in central Chile. At the time, there was nothing: The town of Puerto Cisnes, where I now live, didn't exist, and there were only a couple of little houses—which could only be accessed by sailing or rowing.

Care and respect for the Earth—loving the place where I live, protecting it—is in my DNA. I was born and raised with the sea: Our house was on the coast, a few meters from the water, and I have memories of being in the house with my mom and looking out the window to see the dolphins go by. I learned to fish as a child, and my mom and I collected shellfish in baskets to cook for lunch. They were plentiful, and I liked to play with the little fish that hid under the stones. There were algae on the shore, which my father and grandfather gathered to fertilize the potato crops.

But today what little shellfish remains is contaminated. If you're lucky, you find a couple of mussels, but they can't be eaten. And where algae abounded, there are nothing but rocks.

I lived through this process of resource degradation. It started about 1985, when we

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WE LIVE AND BREATHE THE OCEAN

By Aindil Minkom

My home might be one of Australia's best-kept secrets. It's a cluster of 27 coral islands on top of an ancient seamount that forms two stunning coral atolls. Sparkling blue waters and white sands mean that our islands would be at home on the front of any tourism brochure, but our remote location has made it easy to keep them off the radar—and unspoiled.

The islands, known as the Cocos (Keeling) Islands, are an Australian External Territory in the Indian Ocean, about halfway between Perth, on Australia's west coast, and Sri Lanka.

We see an incredible array of marine life around us. Manta rays glide through the waters, and we can spot dolphins and turtles between the islands. A much-loved dugong known as Kat feeds off the seagrass in the outer lagoon.

The Islands are the only land mass within a nearly 600-mile radius, making them a crucial refuge for migratory birds and a paradise for any nature lover. They're also a wonderland for crabs—the striking purple land crab, the timid red hermit crab, and the horn-eyed ghost crab are just a few found wandering the pristine white beaches and untouched forest floors.

Only two of our islands are inhabited, with a total population of roughly 650, made up of about

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INUIT DESTINY HAS ALWAYS BEEN DEFINED BY THEIR RELATION TO THE SEA

By Kuupik Vandersee Kleist

I was born in Qullissat, a town on the east coast of the Disco Island off the west coast of mid-western Greenland, in 1958 and lived there until I and my fellow 1,500 inhabitants were relocated over a period during the 1960s when the mining industry collapsed.

During my childhood we hunted belugas and narwhals, both in the spring when the sea ice broke up and in the cold winters, where the whales occasionally would be trapped in small breathing holes in the sea ice called "sassat" in Iñupiaq: "Imayguaraat."

The hunts meant a feast, with plenty of mattak (whale skin) and meats, and secured food for a long time. When the sassat were found, be it late at night, on Sundays during church service, at any time, the storekeeper would open the doors so that the hunters could buy ammunition, rope, or whatever they needed for the big catch. It was a true community event and all the families would get their shares, whether they were hunters or not.

My whole childhood and my upbringing were closely connected to and affected by the sea ice and what seemed to be the eternal, continuous shifts of the seasons. Winter, spring, summer,

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started hearing about the red tide. In the 1990s, the red tide was everywhere in the channel that separates the mainland from Magdalena Island—coinciding with the advent of the salmon industry. Since then, nothing has been the same.

This change was very fast, over just a couple of decades, and seeing it made me realize that something had to be done to stop the decline in our environment. I was a woodworker, a carpenter, but I knew that this place's greatest attraction is the surrounding nature, and that water pollution was ruining it. My wife and I were looking for a way to bring in some extra income, and we were also worried about the environment. At the turn of the century, talking about tourism here was crazy—there was no tourism, and no tourist services, and the idea of building a tourism industry seemed like a quick road to starvation.

I never studied tourism or biology, but some colleagues and I got together and began to teach ourselves about biodiversity, responsible tourism, and marine fauna. We started taking people to tour the fjord to see dolphins and visit Magdalena Island, a national park that is home to penguins, cormorants, sea lions, and huillín—southern river otters that are endangered; scientists estimate that there are only 500 or so left in all of Chile and Argentina.

But then we understood that if we wanted this place to be cared for, we had to pass on the knowledge to our people, our own community. In addition to taking tourists to see one of the best whale-watching places in Chile, we had to take our neighbors, too. We have a beautiful national park, right here in front of us, and people don't know about it. So, we got financing from the Ministry of the Environment for a project, which we called "Educating our community to conserve the biodiversity of the Puyuhuapi fjord." It was a small

> **I imagine my community moving toward a nonextractive economy—something sustainable.**
>
> Celestino Ancamil

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600 Cocos Malays on Home Island and a smaller population—mostly of European descent—on West Island.

The Cocos Malays are the first people of the Cocos (Keeling) Islands, coming here nearly two centuries ago. In 1984, we held a referendum and voted to become a democratically run, self-governing territory of Australia.

The Cocos Malay community is like one big family. Everyone looks after each other. When we go out fishing, everyone gets some of the catch. We provide for our families, extended families, and the elderly and other people in the community who have difficulties providing for themselves.

Aindil Minkom

As part of this referendum process, the Australian Government made a commitment to preserve our culture, our traditions, and our religious beliefs.

This commitment was essential to us because our rich culture and history are at the forefront of how we live every day. Because we're an island community, the ocean is central to our lives. We live and breathe the ocean here.

The ocean provides so much to our community—our food, our way of life, our culture—and we look after it by fishing in a sustainable manner, as we always have done.

The Cocos Malay community is like one big family. Everyone looks after each other. When we go out fishing, everyone gets some of the catch. We provide for our families, extended families, and

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and fall determined our activities. The migrating patterns of the mammals, fish, and birds were so accurate that our dad would plan his fishing and hunting during the year according to the seasons of the different species.

Growing up, I realized that nature and wildlife can change dramatically. My first real recognition was when I saw with my own eyes how much the Ilulissat glacier had shrunken. It felt like my whole idea of nature being unchangeable and eternal was shaken and my whole thinking had to be evaluated and renewed. This led me to want to help protect my homeland.

I am a member of the Pikialasorsuaq Commission. Situated between the northernmost West Greenland and Northern Nunavut, Pikialasorsuaq is the biggest polynya in the Northern Hemisphere and the most biologically productive region north of the Arctic Circle. It has been home to the northernmost human settlements in the world for millennia. The year-round ice-free area is adjacent to Lancaster Sound, which recently was named a national marine protected area, partly because of an Inuit protest against future oil and gas development in Tallurutiup Tarijunga.

The first scientific report on Pikialasorsuaq was published in 1867, but Inuit have lived on the coasts near this region for at least 4,000 years. Ships from the Southern Hemisphere first came to the area during the 1300s, and European whalers have hunted there since 1500. Today, approximately 7,000 people live in the areas adjacent to Pikialasorsuaq, with an even larger number dependent on harvesting living resources and wildlife foraging and breeding. And the region has become an essential place for scientific research on climate, ice, and arctic wildlife.

Still, even among Inuit who live near Pikialasorsuaq, there is little awareness of the potential exploitation we face.

In 2016, the Inuit Circumpolar Council established the Pikialasorsuaq Commission to advance Inuit rights, interests, and shared aspirations for all the Arctic.

The commission has recommended protections for Pikialasorsuaq and the co-

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project, with a shoestring budget, but we were able to offer free workshops so that children, youth, and adults could learn about our community's biodiversity. We took them out on the water to tour the fjord and identify species with a field guide that they themselves had created.

We were quite surprised that there were some adults who, despite living their entire lives here, had never gone sailing, and had never seen a dolphin. We found it strange, but also sad, that they were the wives or children or grandchildren of artisanal fishermen and they didn't know the fjord. I think there was an entire generation that never valued what was around them; they didn't realize that not everyone has a fjord, and not everyone has the variety of fauna and native trees on their doorstep that we have here.

Three years ago, we dedicated ourselves completely to tourism, and today we combine ecotourism with environmental education for those who live here and those who come to visit. We've done a variety of things to keep the desire to learn alive in the community—such as the "Marine Ecotourism Meeting" series to which important scientists and authorities have come to speak here—and the community is grateful. Imagine this in an isolated town of 6,500 inhabitants. Before, if you wanted to immerse yourself in knowledge, you had to leave our town and participate in a symposium at a university. But not today. After these meetings, some children said they wanted to be marine biologists. Thanks to these experiences, science and environmental awareness have been gaining ground in our community.

I imagine my community moving toward a nonextractive economy—something sustainable. That's my main task. I want us to understand that we must think about the future. I see my sons following in my footsteps in ecotourism and environmental education. But if they don't, I hope they have a sustainable vision, of a different town, clean and beautiful, with people with a conscience: a community that takes care of its environment. We're part of this land. We didn't come to possess it; we're part of it, like a tree, and we have no right to abuse it. We're the ones who have to make change, our generation. The next generation won't have time. We have to do it now.

Growing up, I realized that nature and wildlife can change dramatically.

Kuupik Vandersee Kleist

the elderly and other people in the community who have difficulties providing for themselves.

This is a remote part of the world, and it can sometimes take months for supplies to arrive from the mainland. Without a healthy fish population, we couldn't survive.

For years we have been growing increasingly worried about industrial fishing. There are few places left on Earth like our waters, where the ocean is still teeming with life, where you still see populations of big pelagic fish like tuna and billfish. As fisheries around the world decline, the pressure to exploit our culturally and economically significant resources is growing.

Giant industrial fishing fleets regularly hug the exclusive economic zone surrounding Cocos, trawling the ocean for weeks or even months on end.

In March 2022, the Australian Government declared two new marine parks for the waters of the Cocos (Keeling) Islands and Christmas Island. They will cover about 287,000 square miles—an area larger than Texas.

The new marine parks will help protect our local fish populations from the threat of these industrial fleets. They are meaningful not just for us, but for the health of the global ocean. They are for everyone.

Our community and the neighboring communities on Christmas Island have been working with the Australian Government to co-design these marine parks to support our way of life and help sustain our fishing and unique environment.

These marine parks support our aspirations and empower us to sustainably manage our oceans, as we have done for so many generations. They allow us to protect our waters, our culture, and our island.

They also will deliver opportunities for our people while ensuring that our culture remains strong.

That gives us a lot of hope that we can protect our way of life for the future generations of our community and for those lucky enough to visit our beautiful, remote islands.

management of the protected area. These recommendations would ensure free travel of Inuit between Canada and Greenland and that the people in the area and Indigenous knowledge would be included in managing the area, with membership of a new management body consisting of representatives from Canada and Greenland and government people.

Once known as the "last ice area," "no man's land," and the "last frontier," the Arctic is now a hot spot whose interests are contested by the so-called "Arctic states"—Canada, Denmark, Finland, Iceland, Norway, Russia, Sweden, and the United States—that lay claims here.

There is a modern rush for the North Pole to divide the northernmost marine areas between the Arctic states, under the auspices of the United Nations Law of the Sea, to develop the area for marine transportation, extraction, tourism, and high seas fisheries. It does not take much fantasy to picture the Arctic seas as new battlegrounds between Inuit, industry, and environmental organizations.

Inuit history and Inuit destiny have always been defined by their relation to the sea. Cultural development, livelihood, as well as economic development in the Arctic, was and is dependent on harvesting from the seas. So there is an absolute need for Inuit to act now, to take the lead in shaping a new regulatory regime to manage the seas in a sustainable manner. Otherwise, the world around us is more than ready to take over and once again set the agenda for our lands, seas, and lives.

I remember as a kid when we played at the shore in the spring, the hunters were all out on the sea, and there was still frozen ice at the beach where high tide met the land ("qaanngoq"), we would throw stones and sticks at the sleeping narwhals slowly drifting alongside the coast.

The whales did not notice us; they did not even wake up. At that time the narwhals and belugas were plenty, hunters took only what they needed, and regulation of catches—and fuller protections of the sea—were not necessary. But they are today.

Michael Oppenheimer: How We Can Avoid the 'Danger Zone' of Climate Change

Michael Oppenheimer is the Albert G. Milbank Professor of Geosciences and International Affairs and director of the Center for Policy Research on Energy and the Environment at Princeton University. He is a longtime participant in the Intergovernmental Panel on Climate Change (IPCC), which won the Nobel Peace Prize in 2007.

WHAT IS THE BASIC SCIENCE BEHIND CLIMATE CHANGE?

Sunlight is absorbed by Earth's surface and warms the planet. However, some of that heat is trapped as it tries to return to space in the form of infrared radiation, a process known as the greenhouse effect. This matters because it keeps the Earth in habitable conditions; otherwise it would be a frozen desert.

Unfortunately, as gases—such as carbon dioxide from burning coal, oil, and natural gas—are emitted in increasing amounts and the carbon-absorbing capacity of forests, coastal habitats, and parts of the open ocean is undermined, greenhouse gases build up in the atmosphere and increase the natural greenhouse effect, creating a continuous warming effect. This is causing a global climate change.

WHAT IS THE OCEAN'S ROLE IN MANAGING CLIMATE CHANGE?

We experience climate as an atmospheric phenomenon, but it ties to the rest of the Earth's system. The climate both affects and is affected by the icy parts of Earth, primarily the northern and southern polar regions. Seventy percent of Earth's surface is ocean water, and not only does a changing climate affect the state of the ocean, but those changes in the ocean then affect the evolution of climate change in the atmosphere.

The ocean absorbs carbon, which has helped slow the greenhouse problem. If that weren't happening, we would add twice as much carbon dioxide to the atmosphere yearly, and it would already be a lot warmer. In addition, a lot of ice floats on the ocean in the polar regions, and that's melting as the ocean surface warms. Reflective ice is replaced by blue ocean water that absorbs yet more heat, speeding global warming. Warmer water expands and contributes, along with melting of ice on land, to sea level rise. This means that we need the ocean to stay just about like it has been or we'll experience a lot more warming and sea level rise. Unfortunately, the ocean is already evolving in harmful ways.

THAT THE OCEAN IS ALREADY EVOLVING IN HARMFUL WAYS HARKENS TO A PHRASE YOU HAVE PREVIOUSLY USED: THE "CLIMATE DANGER ZONE"—WHAT IS THAT THRESHOLD?

When the temperature increases, the ocean surface starts evaporating faster, and that combination of more heat and more humidity is deadly to people. Just at the 2-degree Fahrenheit warming that we've already seen, there's been a significant increase in the number of very hot and very humid days in many places.

If the temperature rises 3 or 4 degrees Fahrenheit (around 1.5 to 2 degrees Celsius), we tip over into a dangerous climate situation. "Dangerous" means people dying from the effects of increased heat; heightened food insecurity with lower crop yields; hot, dry zones; and flooded communities.

Ecosystems would also run into trouble at that level. Coastal areas feel greater effects of sea level rise, particularly from storms or super tides, making areas unlivable or prohibitively expensive for many countries to protect their communities from the sea.

WHAT CAN BE DONE TO AVOID THAT CRITICAL POINT?

The danger zone is already very near, too close for comfort. In order to avoid it, we have to start changing the way we behave, the way our industrial society is structured, to reduce emissions, and we have to do it quickly.

One significant step is generating energy that isn't dependent on fossil fuels—such as wind or solar energy—and using new ways of storing and transporting energy, such as smart and efficient power grids. Another big step is ending deforestation—not only does cutting and burning trees put more carbon dioxide into the atmosphere, but we rely on trees to absorb carbon. Third, we have to improve our agricultural practices, which currently release methane, nitrous oxide, and other greenhouse gases into the atmosphere. People and cities also have a big role to play in modernizing transportation—rather than using single-passenger, gas-powered automobiles, we need to turn to public transportation and electric vehicles. That will require user-friendly mass transit options, particularly in places that don't have them now.

Much of this is already underway—we are in the middle of an energy revolution. If we don't mishandle it, there's a fair chance we can get where we need to go and that other countries may get there too.

HOW DO WE BUILD MORE CONSENSUS ON THE SEVERITY OF CLIMATE CHANGE AND MAKE PROGRESS ON REMEDIES?

By giving people the facts. I was an author of a special report on the ocean by the Intergovernmental Panel on Climate Change published two years ago. The most startling number we developed was that the frequency of significant floods—those that occurred historically only once a century along the world's coastlines—would now occur at many locations once *per year* by 2050. That's only 28 years away.

Our ability to deal with large-scale flooding, or any other disaster, depends on how much time we have to recover. When you have a monumental flood event, like a Hurricane Harvey or a Hurricane Sandy, communities need years, not days or months. It's important to remember why this matters—hitting the climate change danger zone would create an ongoing disaster for societies and a biological disaster for the oceans.

But I do have some optimism. There is no silver bullet to fix the problem, but we can move quickly to improve and diffuse technologies that we know work and are already implemented in many places. Alongside that, we have to reframe the way we live as human beings so as to stop wasting so much energy. If we're going to protect the ocean, we have to take actions at not just the international and national level, but at the local level, both to be as green as we can and to reduce the vulnerability of people to coastal flooding, heat waves, and other hazards that are on the rise due to climate change. In my view, we all share the responsibility to transform our communities.

A THOUSAND WORDS

In American Samoa, corals photographed three months apart show the effects of bleaching from warmer and more acidic marine waters.

The Ocean Agency

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