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Sustainable ocean

Allianz Research

"How inappropriate to call this planet Earth when it is clearly Ocean."
Arthur C. Clarke

Foreword

The ocean, often referred to as the 'blue heart' of our planet, is a vital life source that we cannot afford to take for granted. It is a complex, dynamic system that provides countless benefits to humanity and all life on Earth. Yet, as this report by Allianz Group Economic Research vividly illustrates, our oceans are under unprecedented threat from human activities, climate change, and pollution.

This report serves as a stark reminder of the urgent need for action. It is a call to arms for governments, businesses, and individuals to recognize the critical role the ocean plays in our lives and to take decisive steps to safeguard its health and vitality. The ocean's capacity to regulate our climate, provide food, and support livelihoods is being eroded by unsustainable practices and short-term thinking.

The challenges we face are immense. Rising ocean temperatures, acidification, and sea-level rise are disrupting marine ecosystems, decreasing biodiversity, and threatening coastal communities. Plastic pollution is not only harming marine life but also impacting human health and economies. Industries that rely on the ocean are both contributing to its degradation and suffering the consequences.

This report is a roadmap for action. It highlights the need for a holistic, cross-sector approach to ocean sustainability and a vibrant Blue Economy. It underscores the importance of understanding and addressing the impacts of various industries on the ocean. It also emphasizes the potential for businesses to become a major part of the solution by adopting sustainable practices, complying with regulations, and investing in innovative solutions such as Blue Bonds and Dept-for-Nature Swaps.

The health of our ocean is intimately linked to the health of our planet and all who call it home. As an ocean activist, I firmly believe that every action counts. Every piece of plastic avoided, collected recycled, every sustainable business practice adopted, every policy implemented contributes to the preservation and restoration of our ocean.

At Allianz, we embrace collaboration to secure the future. Allianz is passionately teaming up with high-impact environmental NGOs like Sea Shepherd Global, Plastic Fischer, and Enaleia. Together, we are joining the fight against ocean pollution and overfishing, being part of the transformative change and helping to breathe new life into our precious marine ecosystems.

In the fight for ocean conservation, harnessing the power of data and technology is crucial. We still know too little about life under water, and the interconnectedness of climate, ocean, and biodiversity. By diligently collecting data, observing and monitoring, we can better understand the intricate dynamics of marine ecosystems, enabling us to manage them more sustainably and effectively safeguard our ocean to ensure a healthy planet for future generations.

Barbara Karuth-Zelle

Member of the Board of Management, Allianz SE

Content

Executive Summary


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- **Oceans play a critical role in keeping our climate stable and our world livable.** They regulate global temperatures, taking in solar energy and distribute heat around the globe via ocean currents. Additionally, oceans produce half of the oxygen we need and absorb 25% of all carbon dioxide emissions, while capturing 90% of the excess heat generated by these emissions. In fact, marine habitats could store ten times more carbon than terrestrial ecosystems per hectare.
- **Climate change poses significant risks to our planet, and the ocean is no exception.** Increasing emissions are pushing up water temperatures, leading to more severe storms and heavy rainfall events. Additionally, higher ocean temperatures facilitate the thermal expansion of the ocean which together with melting glaciers is raising sea levels. This will threaten more than 680mn people who live in low-lying coastal zones (nearly 10% of the global population). Higher temperatures are also contributing to the acidification of oceans, causing irreversible changes to habitats and a decline of species that could jeopardize the food supply and livelihoods of those living in coastal areas.
- **The enormous amount of plastic waste entering the oceans is only set to increase further.** Besides endangering marine wildlife, plastic waste also affects fishing and aquaculture, coastal tourism and the shipping industry. At current rates of production, it could lead to estimated economic damages of USD197bn by 2030 and USD434bn by 2050. But if plastic production continues to increase without the introduction of mitigation measures, these costs could escalate to USD229bn by 2030 and as much as USD731bn by 2050.
- **The production processes of the energy, industrial and consumer staples sectors have the most damaging effects on ocean ecosystem services, creating a vicious cycle that poses significant risks to industrial production itself.** Marine ecosystems are fundamental to several industries, providing essential natural capital assets such as water, species, soils, sediments and atmospheric components. If the world's oceans were an economy, it would be the seventh largest in the world, with the total value of its goods and services projected at USD2.5trn yearly. However, industrial processes such as construction activities, drilling for oil at sea and aquaculture contribute to the degradation of natural habitats, reducing biodiversity and natural capital, while byproducts such as drilling fluids, metal cuttings and accidental spillages introduce toxic chemicals into the environment. This is creating a vicious cycle, destroying the various natural capital assets that are so critical for industries.

- **Financing ocean conservation efforts is essential. But funding remains a drop in the bucket for now: the annual financing gap is estimated at USD150bn.** Though ocean conservation is enshrined in the Sustainable Development Goals, it only attracts USD25.5bn in investments per year, far below the USD174bn required. To attract both public and private investors, policymakers need to highlight the returns on investment in ocean conservation, tapping options such as conservation trust funds, insurance incentives, blue bonds and debt-for-nature swaps. Tourism could contribute to financing marine conservation, too. Charging a fee that is then invested in community-based conservation projects could provide coastal communities with the resources needed to facilitate conservation while supporting their livelihoods.
- **The emerging market for carbon dioxide removal (CDR) is another way to attract blue investments.** To reach global climate goals, CDR strategies will be essential. Several ocean-based techniques exist to harness and enhance the ocean's natural capacity to remove carbon from the atmosphere. One example is the restoration of blue carbon coastal ecosystems, such as mangroves, salt marshes or seagrass meadows, which sequester carbon dioxide at much higher rates than terrestrial forests. They also offer additional co-benefits such as flood and cyclone protection for coastal communities. These ocean-based carbon dioxide removal strategies can be used to complement land-based measures such as afforestation or Direct Air Carbon Capture and Storage (DACCS) to enable the negative carbon economy.
- **To limit the amount of plastic waste that ends up in the ocean, the most important thing is to reduce the amount of waste that is created in the first place.** Boosting the circular economy would not only improve ocean health but can also unlock substantial economic benefits, with an estimated USD4.5trn in output growth potential as early as 2030. Apart from recycling and upcycling, this comprises the use of practices such as industrial symbiosis – reusing the waste of one industry as inputs for another – or the production of renewable and biodegradable products. The central goal is to improve resource efficiency along the whole supply chain, which reduces costs, protects the environment and promotes sustainable long-term growth. To limit nutrient pollution, it will also be necessary to control and limit agricultural and industrial runoff. This involves the use of improved irrigation practices, wastewater treatment and a more controlled use of pesticides.

Ocean threats

Oceans are a key component of the climate system. They bring rain and nutrients to different regions of the world and contribute to cooling the planet. Additionally, they are an important carbon sink, capturing around 25-30% of total annual emissions and storing more than 50 times the amount of carbon that is currently in the atmosphere.

However, the effects of climate change could diminish the mitigation potential. Rising temperatures decrease the solubility of CO2 while the increased uptake of carbon in the ocean leads to ocean acidification – a process where dissolved carbon dioxide forms carbonic acid – which can endanger biodiversity and further inhibit the carbon-sequestration potential of marine organisms such as phytoplankton. Even though the impact of anthropogenic emissions on the ocean materializes more gradually, they are no less unprecedented. Ocean acidification has increased by about 30% since the start of the Industrial Revolution, with current rates of acidification not seen since before the dinosaurs (300mn years ago). While the ocean currently acts as an ally in combating climate change by absorbing increasing amounts of CO2, it may have adverse effects when global emissions start to decline. As atmospheric CO2 concentrations decrease, the natural equilibrium will prompt the ocean to release more carbon back into the atmosphere. This effect suggests that delaying the transition not only complicates emission reduction efforts but also increases overall costs.

So far climate change has already reduced nature-based carbon-capture capacities, with a -20% decrease of the land-based sequestration potential and a -7% decrease of the oceans-based sequestration potential.[1] Evaluated at the current EU ETS carbon price of EUR 70/tCO2, the 7% would translate into an annual cost of EUR49.9bn. When evaluating the lost potential at a higher and more realistic social cost of carbon of EUR 170/tCO2, this estimate increases to EUR121.2bn per year.[2]

Additionally, climate change can disrupt ocean circulation patterns, impacting carbon distribution and storage. Rising temperatures and increased freshwater influx from melting ice sheets not only lead to rising sea levels, which endanger coastal communities, but also reduce the salinity and hence density of ocean waters. As a result, important ocean currents such as the thermohaline circulation – often labeled as the ocean's conveyor belt for distributing heat, nutrients and carbon – are weakened

[1] Global Carbon Budget Report
[2] Rennert et al. (2022)

and disrupted. In the worst case this can trigger the collapse of the Atlantic Meridional Overturning Circulation (AMOC) – one of the major ocean related tipping points – that can potentially result in substantial global downside risk. Unfortunately, there is still a sizable knowledge gap in understanding the interactions of the global ocean system. Accurately evaluating potential economic costs will require further investment into ocean-based R&D.

Rising sea temperatures significantly impact global weather patterns, leading to more severe and often more frequent natural catastrophes such as tropical cyclones and flooding from heavy rainfall. A warmer ocean surface provides more energy, leading to stronger storms with higher wind speeds and heavier rainfall. Tropical cyclones alone have caused annual damages of more than USD28bn and are projected to increase in severity as climate change intensifies.[3]

Ocean ecosystems are also being seriously affected by overfishing. According to the Food and Agriculture Organization (FAO), more than 35% of fish stocks around the world are being overfished.[4] Moreover, the use of longlining, bottom trawling, and other fishing techniques is also killing an overwhelming number of non-targeted fish. Overfishing can have a catastrophic effect on ocean populations because it disrupts many aquatic species' natural habitats and eliminates important participants from food chains, which could set off a chain reaction of negative consequences.

Plastic pollution is another factor posing significant risk to marine wildlife. The UNEP report highlights that plastic accounts for 85% of marine litter. By 2040, volumes of plastic pollution flowing into marine areas are likely to nearly triple, adding 23-37mn metric tons of plastic waste into the ocean per year.[5] The extent of plastic pollution is evidenced by garbage patches, large areas of the ocean where litter, fishing gear, and other debris—collectively known as marine debris—accumulate. They are formed by rotating ocean currents called "gyres". The Great Pacific Garbage Patch is the largest, located between Hawaii and California in the Pacific Ocean. It covers an estimated area twice the size of Texas and thrice the size of France. Microplastics account for much of the debris (by count), but because they are smaller than a pencil eraser, they are not immediately noticeable to the naked eye.[6] Moreover, plastic pollution is not limited to oceans. Moreover, plastic pollution is not limited to the open oceans. As we can see from Figure 1, the Mediterranean Sea is also being affected, given its enclosed nature primarily due to its enclosed nature.

Plastic pollution has several negative impacts on marine biodiversity and human health. Fish can physically suffer by getting entangled in macroplastics and from microplastic ingestion. Humans are also at risk of ingesting plastics by eating contaminated fish or when drinking contaminated water. Seafood accounts for 20% of the total dietary intake (weight)[7] for 1.4bn people, which means a sizable share of the global population is extremely sensitive to changes in the availability, safety and quality of this food source due to plastic pollution.

Plastic pollution also leads to huge economic losses for maritime industries (fishing and aquaculture, coastal tourism and shipping). The United Nations Environment Assembly estimates that because marine trash impedes maritime commercial activity, it costs the world's population some USD13bn yearly[8]. Coastal tourism has become a vital part of the worldwide tourism sector (at least 50% of global tourism, according to UN Tourism) and has shown to be an area with particular promise to promote sustainable growth. But unsightly plastic pollution can deter tourists, lowering tourism-related income and thereby impairing coastal economies. Plastic pollution can also negatively impact recreational activities such as diving or swimming. With 2.5mn people directly employed by ocean-based tourism – which generates USD66bn in billion earnings – marine pollution can also exacerbate social inequality (Office for Coastal Management). Overall, the present value of global economic damage from marine plastic pollution is projected to reach USD197bn by 2030 and USD434bn by 2050. If plastic production continues to increase under a business-as-usual scenario, these costs could escalate to USD229bn by 2030 and USD731bn by 2050[9.]

[3] World Meteorological Organization

[4] Food and Agricultural Organization of the United Nations, "Fisheries and Aquaculture", n.d., Fisheries and Aquaculture (fao.org)

[5] Comprehensive assessment on marine litter and plastic pollution confirms need for urgent global action (unep.org)

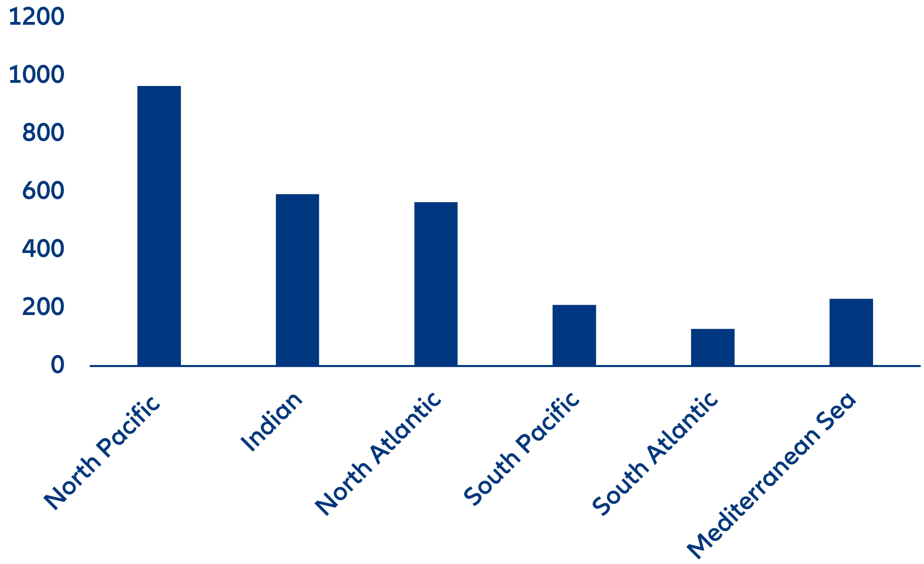
[6] Marine Debris Program - NOAA

[7] POLSOL.pdf

[8] Plastic waste causes $13 billion in annual damage to marine ecosystems, says UN agency | UN News

[9] McIlgorm et al (2022)

Figure 1: Weight of plastic particles by ocean, g x 102 tons



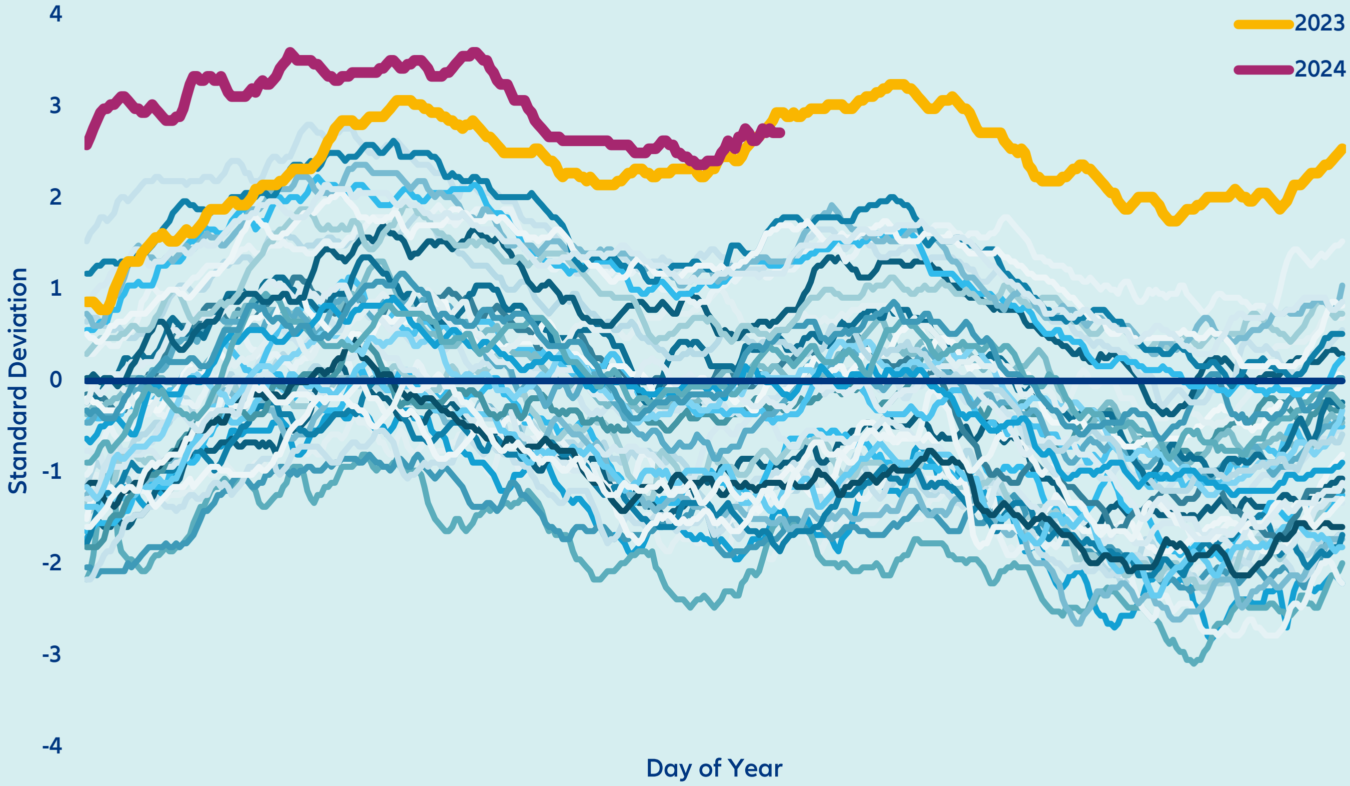
Sources: Eriksen et al. (2014), Allianz Research

Box: Marine heatwaves – an underestimated threat

Marine heatwaves (MHWs) are prolonged periods of abnormally high sea surface temperatures, similar to heatwaves on land but occurring in the ocean. These events are characterized by their intensity, duration and spatial extent, lasting from several days to months, and affecting areas from localized regions to entire ocean basins. In the past two years, sea surface temperatures have been rising at alarming speeds, with extreme uncertainties on the concrete consequences of this trend (Figure 2).

The causes of marine heatwaves are diverse. Atmospheric conditions, such as high-pressure systems, can reduce wind and cloud cover, leading to increased solar radiation and warming of the sea surface. Changes in ocean currents can also transport warmer waters into a region, contributing to elevated temperatures. Climate change, driven by increased greenhouse gas emissions, is making marine heatwaves more frequent and intense. Additionally, natural climate variability, including phenomena like El Niño and La Niña, can influence sea surface temperatures and contribute to the occurrence of MHWs.

Figure 2: Rising sea surface temperatures

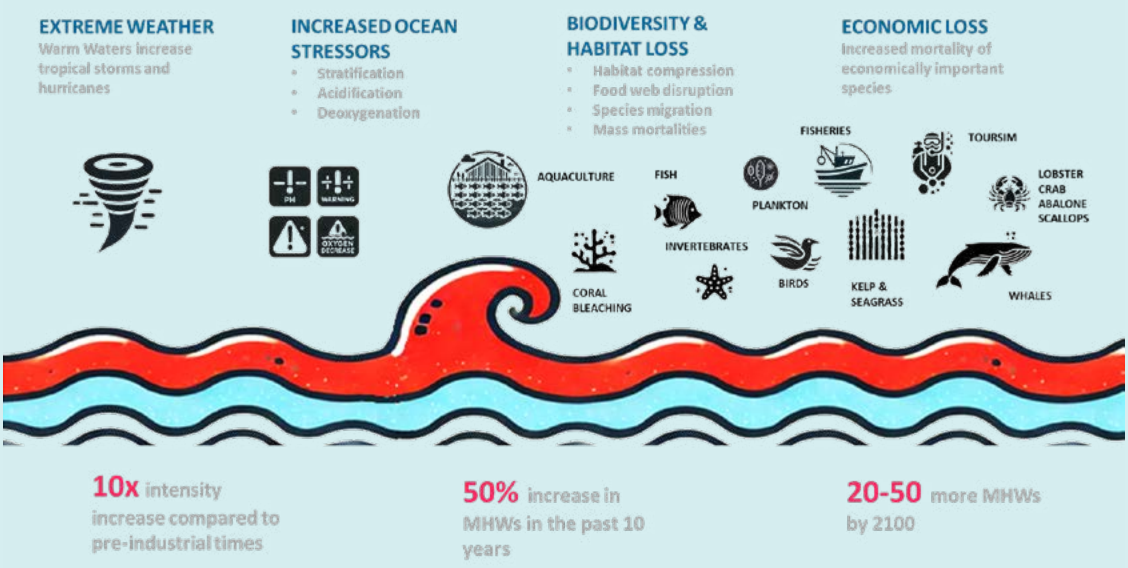


Sources: climatereanalyzer, Allianz Research

Figure 3 provides a comprehensive overview of marine heatwaves and their multifaceted impacts on marine life and human society, illustrating how extended periods of regional ocean warming have major consequences across four key areas: extreme weather, increased ocean stressors, biodiversity and habitat loss and economic loss.

MHWs contribute to the increase in tropical storms and hurricanes, and impacts currently seem to be much higher than anticipated by scientific projections. Increased ocean stressors include stratification, which is the layering of water columns that can limit nutrient mixing and oxygen distribution; acidification, which is the increase in ocean acidity that harms marine organisms, especially those with calcium carbonate shells or skeletons, and deoxygenation, which is the reduction of oxygen levels in the ocean, affecting marine life that relies on oxygen for survival. Thus, Figure 3 includes symbols indicating lower pH levels, deoxygenation and general warnings of these stressors, showcasing the deteriorating conditions within the ocean. The impacts on biodiversity and habitats are often devastating as elevated temperatures can cause coral bleaching, where corals expel the symbiotic algae living in their tissues, leading to a loss of color and potential coral death. Many marine organisms are sensitive to temperature changes, resulting in habitat compression, food-chain disruption, species migration and mass mortalities. These disruptions affect fish stocks, leading to significant economic impacts on fisheries and local communities dependent on marine resources. Beyond ecological effects, marine heatwaves also have substantial socioeconomic impacts. Declines in fish stocks and disruptions in marine food chains can lead to reduced catches, affecting food security and livelihoods in coastal communities. The degradation of marine environments, such as coral bleaching, can reduce the attractiveness of tourist destinations, impacting local economies reliant on tourism. Increased instances of harmful algal blooms can lead to seafood poisoning and other health issues. As Figure 3 indicates, tourism activities (such as scuba diving), fisheries and aquaculture are all at risk from the effects of marine heatwaves.

Figure 3: Marine heatwaves are extended periods of regional ocean warming



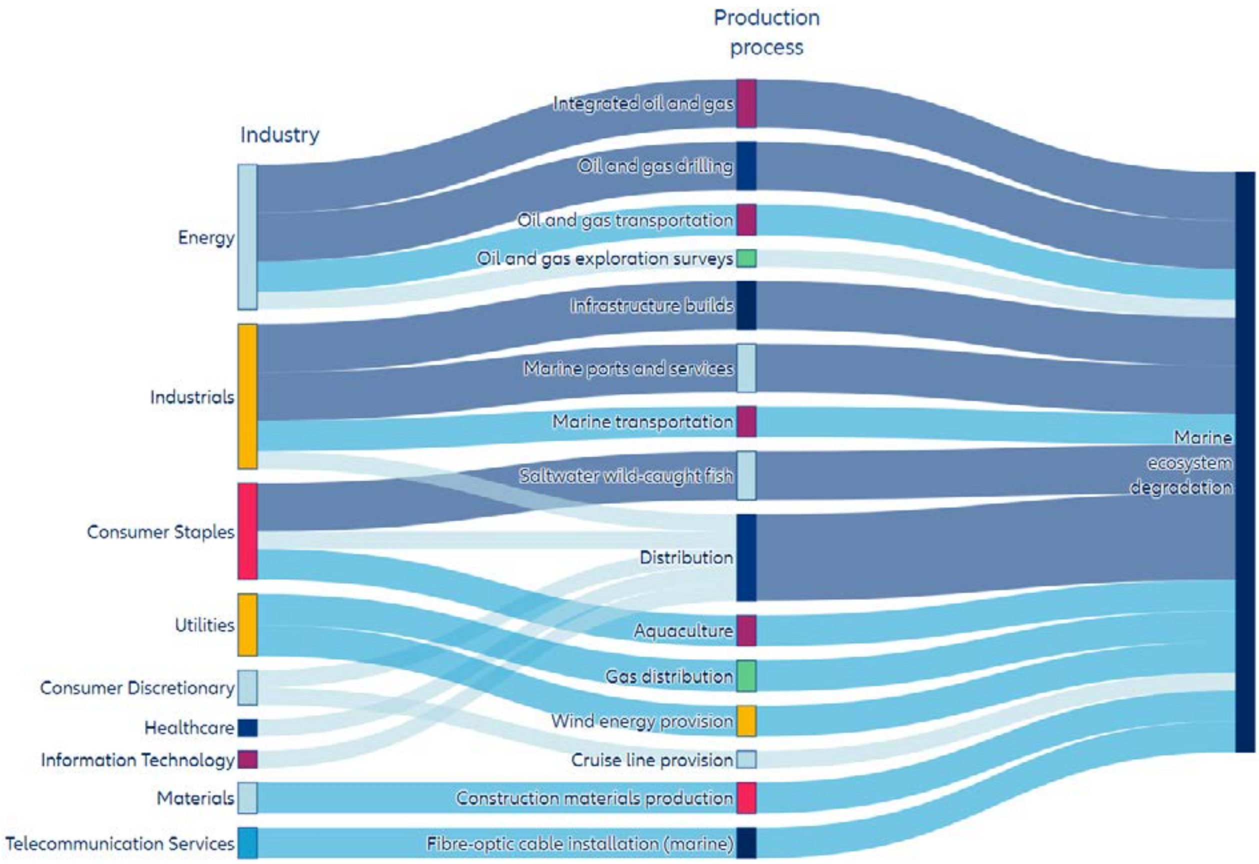
Sources: IUCN, Allianz Research

Addressing the challenges posed by marine heatwaves requires a combination of adaptation and mitigation strategies, including improved monitoring of sea surface temperatures and early warning systems. Establishing and effectively managing marine protected areas can also enhance the resilience of marine ecosystems to temperature extremes. Ultimately, reducing greenhouse gas emissions is crucial to limit the frequency and severity of marine heatwaves in the long term. Investing in research to understand MHWs and restoration projects to rehabilitate affected ecosystems can help mitigate the impacts.

The vicious cycle of "double materiality"

The energy sector, industrial sector and fishing industry are among the main contributors harming marine ecosystems. Within the energy sector, integrated oil and gas operations have profound impacts on marine ecosystems. Drilling for oil at sea disrupts habitats and introduces toxic chemicals from drilling fluids, metal cuttings, and accidental spillages. This contamination affects marine life and water quality, leading to long-term ecological damage. Oil and gas transportation infrastructure, such as pipelines, further fragments habitats and exacerbates environmental degradation. Within the industrial sector, construction activities, particularly infrastructure builds, lead to significant habitat destruction. Marine ports require regular dredging, which disturbs sediment composition and local marine life. These activities reduce biodiversity and alter marine ecosystems, making them less resilient to environmental changes. Several practices of the fishing industry also threaten marine biodiversity. For example, saltwater wild-caught fishing, especially bottom trawling, severely damages benthic environments. This method of fishing scrapes the sea floor, destroying habitats and affecting species that rely on these environments. The resulting habitat degradation has cascading effects on the broader marine ecosystem (Figure 4).

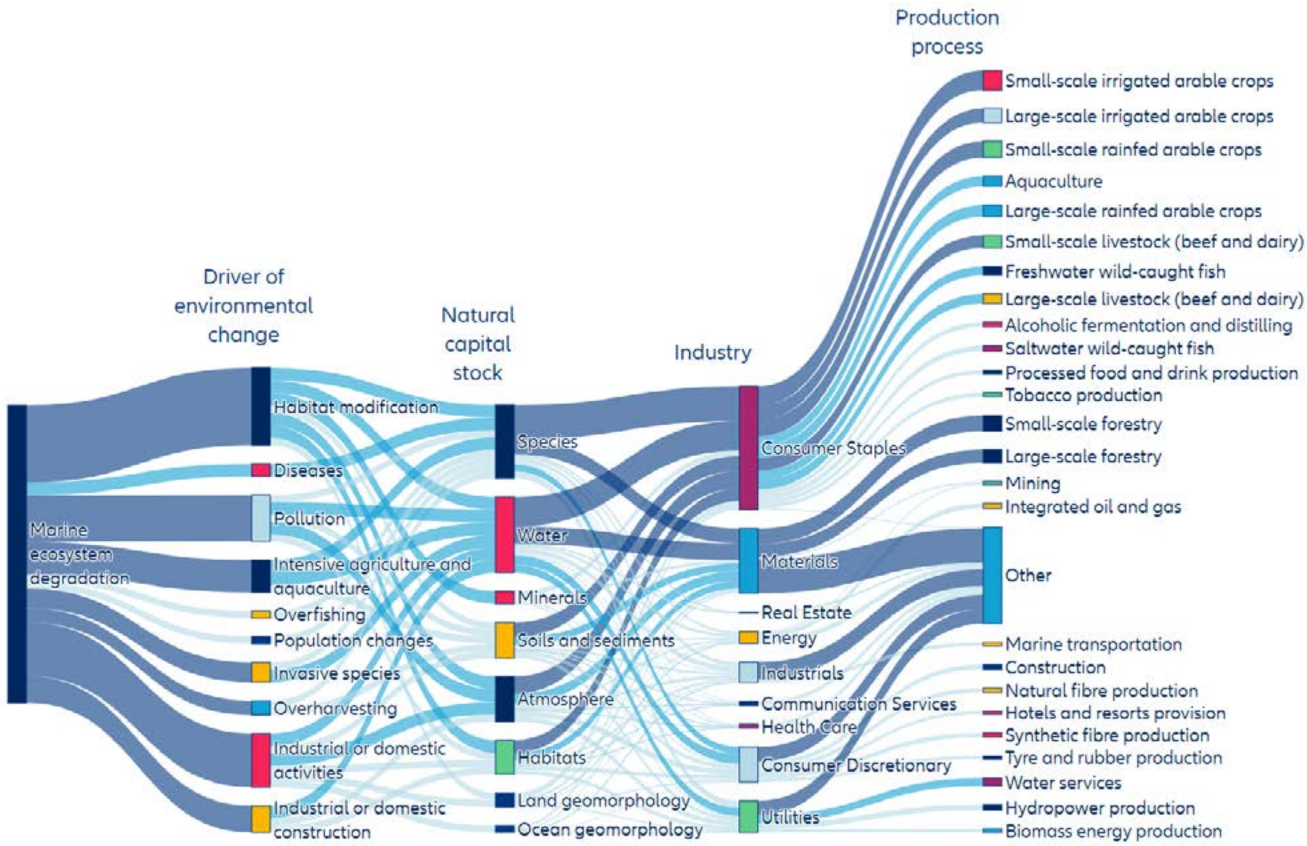
Figure 4: Impact of industrial production on the sustainability of marine ecosystems (see Appendix for more details)



Sources: ENCORE methodology, Allianz Research. See Appendix for more details.

At the same time, marine pollution creates a vicious cycle, where degraded ecosystems reduce the availability of natural capital like clean water and healthy species that are essential for industrial processes. Water quality and availability, species loss and soil and sediment health are among the main drivers that impact industrial production. Pollution from industrial activities degrades water quality, impacting industries like consumer staples and materials by increasing water treatment costs and reducing the availability of clean water for essential processes. As a result, industries dependent on large volumes of water for cooling, cleaning and production face significant operational challenges. Overfishing and habitat destruction result in declines in marine species and a loss of biodiversity, severely impacting industries that rely on marine ecosystems, such as fisheries and tourism. The disappearance of key species disrupts food webs and ecosystem services, compromising the sustainability of these sectors. For instance, declines in fish populations can drastically affect the consumer staples industry, which depends on wild-caught fish for food production. Healthy soils and sediments are crucial for agriculture and aquaculture. Marine ecosystem degradation, through erosion and pollution, leads to soil nutrient depletion and increased sedimentation, reducing land and water productivity. Industries like agriculture and construction face higher costs and lower yields due to deteriorating soil and sediment conditions. In this context, effective conservation and pollution control strategies are crucial to breaking this cycle and ensuring the sustainability of both marine ecosystems and industrial productivity (Figure 5).

Figure 5: Impact of degradation of marine ecosystems on the industrial sector's production



Sources: ENCORE methodology, Allianz Research. See Appendix for more details.

Box: The close link between marine ecosystem and agriculture

Marine ecosystems significantly impact terrestrial agriculture as well, including arable crops. This interconnectedness is often overlooked but understanding the impact channels is crucial for developing comprehensive conservation and agricultural strategies. Firstly, marine ecosystems play a critical role in regulating the hydrological cycle, which directly affects water quality and availability for arable crops. Coastal wetlands, mangroves and seagrasses act as natural water filters, removing pollutants and improving water quality. The degradation of these ecosystems can lead to increased levels of pollutants, such as heavy metals and agricultural runoffs, in freshwater sources used for irrigation. This can reduce the quality of water available for farming, impacting crop health and yield. Additionally, the loss of these natural filters can exacerbate the effects of eutrophication, leading to algal blooms that deplete oxygen levels in water bodies, further compromising water quality and endangering life under water.

The health of marine ecosystems is closely linked to terrestrial soil health through the deposition of marine sediments and organic matter. Coastal erosion, driven by the degradation of marine habitats such as coral reefs and mangroves, can lead to the loss of nutrient-rich sediments that replenish agricultural soils. This erosion not only removes fertile topsoil but also deposits saltwater and marine sediments onto arable land, increasing soil salinity and reducing its fertility. High salinity levels can inhibit crop growth, reduce yields and, in severe cases, render land unsuitable for cultivation.

The reduction of carbon-sequestration capabilities in marine ecosystems can exacerbate climate change, with consequences for agriculture. Changes in climate patterns, such as altered precipitation, the increased frequency of extreme weather events and rising temperatures, can significantly impact arable crops. Crops may face increased stress from droughts, floods and heatwaves, leading to reduced yields and increased vulnerability to pests and diseases.

Marine ecosystems contribute to the cycling of essential nutrients such as nitrogen and phosphorus, which are crucial for crop growth. Degradation of marine habitats disrupts these nutrient cycles, leading to either a deficiency or an excess of nutrients in terrestrial environments. For example, the breakdown of the coastal nutrient cycling can lead to nutrient runoff into oceans, causing dead zones where marine life cannot survive. Conversely, the reduced input of marine-derived nutrients into coastal soils can result in nutrient-poor conditions, negatively affecting crop productivity.

The biodiversity of marine ecosystems supports a range of ecosystem services that benefit arable farming. Pollinators, pest predators and beneficial microorganisms that contribute to soil health and crop productivity are all part of these interconnected ecosystems. The degradation of marine habitats can lead to the loss of these species and services, reducing the resilience and productivity of arable crops. For instance, the loss of coastal wetlands can reduce the populations of pollinators and natural pest predators, leading to increased reliance on chemical pesticides and fertilizers, which can further degrade soil and water quality.

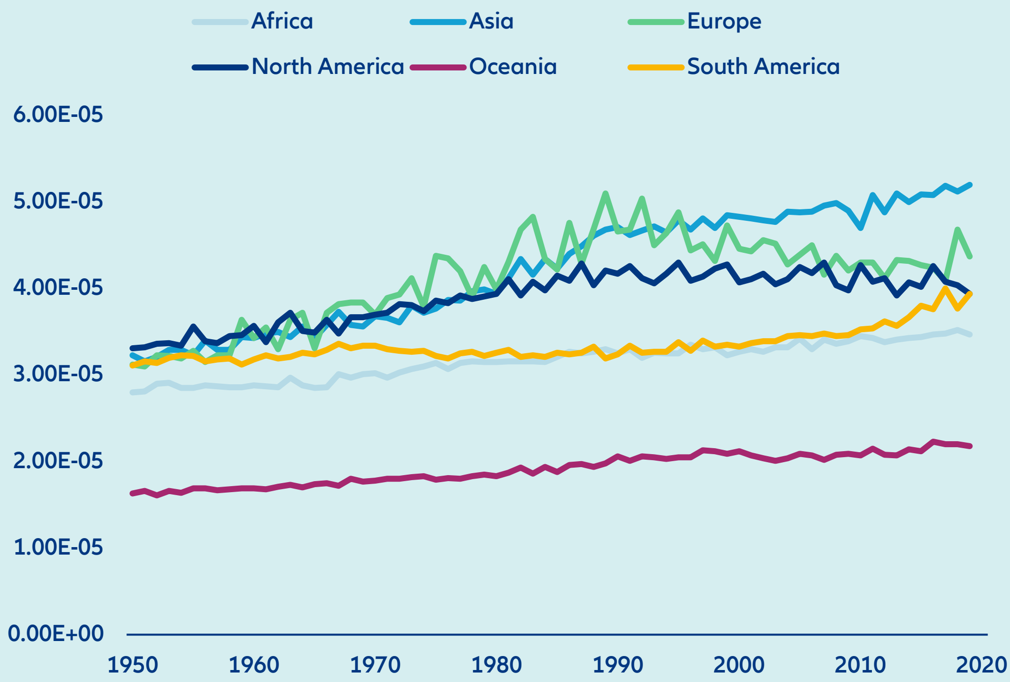
On the other hand, intensive agriculture, is also disrupting the natural nutrient cycle. The use of nitrogen-based fertilizers to boost crop growth often results in excess nitrates dissolving in water. These nitrates can then run off into nearby streams, rivers and eventually larger bodies of water such as lakes and oceans. Moreover, some manufacturing activities, such as the pulp and paper industry, significantly contribute to the nutrient load in our oceans through various pathways. Wastewater from factories, rich in nitrogen and phosphorus, often finds its way into rivers, lakes and oceans, particularly when it is not adequately treated. The air is another conduit: industrial operations emit nitrogen oxides and ammonia, which can travel vast distances before depositing back onto land and water surfaces, thus elevating nutrient levels. Additionally, industrial processes like mining and construction disturb the land, leading to soil erosion. This eroded soil, laden with nutrients, is washed into nearby water bodies and eventually reaches the oceans, exacerbating nutrient pollution.

A distorted nutrient cycle can lead to eutrophication. Nutrients like phosphate and nitrate, along with sunlight, drive the growth and energy production of phytoplankton. These tiny organisms are responsible for about 50% of all photosynthesis on Earth. Besides regulating the climate by absorbing carbon dioxide, phytoplankton (along with zooplankton) form the foundation of the entire marine food chain, promoting species richness and supporting vital sectors like marine fishing and aquaculture. However, Figure 6 illustrates the nitrogen flux from vegetation to litter across various continents, underlining the sharp increase since 1950. This trend suggests that human activities are altering the natural nutrient cycle, potentially heightening the risk of ocean eutrophication.

The most visible sign of eutrophication are harmful algae blooms. While algae are crucial to ecosystems, producing most of the oxygen we breathe and serving as food for marine life, excessive blooms can produce toxic compounds detrimental to the environment and human health. According to NOAA fisheries, in 2011, the Indian River Lagoon in Florida experienced a "super bloom" that caused a 60% loss of seagrass due to shading. Subsequent brown tides hindered seagrass recovery, with scientists estimating that seagrass contributes USD5,000-10,000 per acre annually to the local economy. This loss translates to a potential economic reduction of USD235-470mn per year. Similarly, on the US West Coast, a toxic bloom of Pseudo-nitzschia in 2015 shut down the Dungeness crab and razor clam fisheries, resulting in a USD97.5mn loss in landings compared to the previous year. Additionally, coastal communities in Washington experienced an estimated USD40mn decline in tourism spending. These values are reported in 2015 dollars. Furthermore, one study estimates the potential yearly economic losses due to eutrophication in US freshwater bodies at around USD2.2bn billion, mostly driven by the depreciation of lakefront property values[10].

[10] Dodds et al. (2009)

Figure 6: Evolution of nitrogen flux from vegetation to litter (kg m^{-2} s^{-1})



Source: ISIMIP3a

Funding for ocean conservation remains a drop in the bucket

The size of the global ocean economy, which includes fishing, shipping, offshore wind, maritime and coastal tourism and marine biotechnology is estimated to reach USD3trn. The estimated worth of major ocean assets is USD24trn overall, or 3% to 5% of the world's GDP. The value of both goods and services derived from the ocean is projected to be USD2.5trn yearly, which would make it equivalent to the seventh-largest economy in the world.

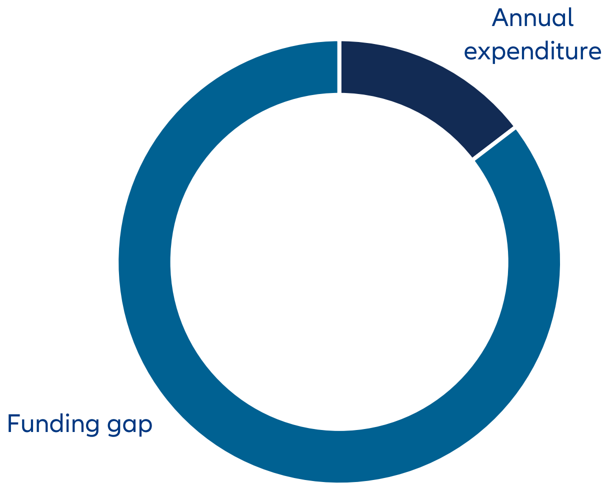
Tourism also plays a significant role in the blue economy. Accounting for 6.5mn jobs worldwide, coastal and marine tourism is the second-largest employer behind the fishing sector. Up to 80% of tourism-related activities worldwide are thought to be made possible by the ocean, and by 2030, marine and coastal tourism is expected to account for the greatest value-adding sector of the ocean economy, with global growth of +3.5%.[11]

Though ocean conservation is enshrined in the Sustainable Development Goals, it does not receive enough funding. In 2015, all United Nations members agreed on the 2030 Agenda for Sustainable Development, which includes 17 Sustainable Development Goals (SDGs) to guarantee a peaceful and prosperous future while fighting climate change and preserving land and marine biodiversity. However, SDG14 (Life Below Water) is unfortunately the one that receives less funding. Based on the estimations provided, USD174.52bn in resources will be needed yearly by 2030 to achieve this goal. But only USD25.5bn is currently being invested annually. This suggests a yearly financing gap of USD150bn.[12] (Figures 7 & 8)

[11] WEF_What_Ocean_Sustainability_Means_for_Business.pdf (weforum.org)

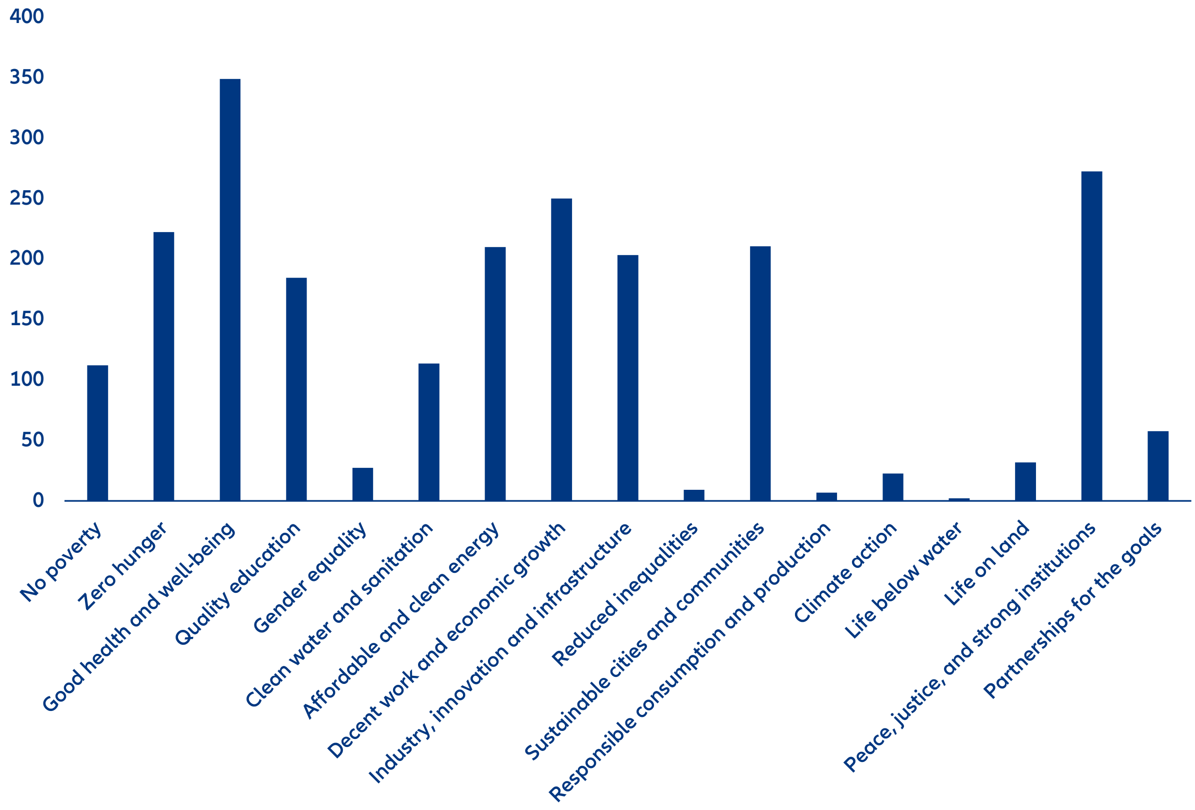
[12] The cost of saving our ocean - estimating the funding gap of sustainable development goal 14 (sciencedirectassets.com)

Figure 7: Funding gap SDG14



Sources: Johansen et al. (2020), Allianz Research

Figure 8: Aid allocation per UN SDG , 2020 US$ bn



Sources: AidData, Allianz Research

The funding gap is largely the result of limited investment data. This makes it challenging for prospective investors to find possibilities and calculate expected returns. In this context, the EU drew up the BlueInvest Investor Report, with the goal of arming investors with market intelligence on the EU blue economy to help them make informed investment choices. Certifications are another tool to facilitate investment choices. Ocean Approved was introduced in 2021 by Bureau Veritas and the Fondation de la Mer, together with the French Ministry of the Sea. The label is the first in the world to honor businesses who have made a commitment to comprehending and reducing their ocean impact.[13]

As the need for marine conservation grows, various financing mechanisms are emerging to support these efforts. Highlighting the returns on investment in ocean conservation can attract both public and private investors. Key mechanisms include conservation trust funds, insurance incentives and 'blue bonds' and debt-for-nature swaps. These methods often cover large ocean areas, including entire exclusive economic zones (EEZs).[14] Conservation trust funds (CTFs) provide long-term capital for conservation projects through endowment funds, sinking funds and revolving funds. Between 2009 and 2018, over USD2bn was paid out from CTFs globally. However, CTFs depend on investments and philanthropic donations, which can be limiting.

Insurance incentives are an innovative way to finance coastal ecosystem restoration. Coastal ecosystems save insurance companies approximately USD52bn annually by mitigating storm damage, flooding and erosion. Recognizing these benefits, the government of Quintana Roo, Mexico, purchased a USD3.8mn insurance policy in 2017, funded by tourism tax revenues, to cover 160km of coastline. The policy's payouts are dedicated to restoring and rehabilitating reefs and coastal ecosystems. Following Hurricane Delta in 2020, the first payout of USD800,000 was used for reef restoration. This approach ensures sustained funding for ecosystem recovery in the face of increasing climate-related hazards, providing a financial safety net that directly supports conservation efforts.

'Blue bonds' and debt-for-nature swaps help developing nations fund environmental protection by restructuring debt. The Seychelles, for example, made a debt-for-nature swap ensuring 400,000 km^2 of marine protected areas. Blue bonds are defined by the World Bank as a debt instrument issued by governments, development banks or others to raise capital to finance marine and ocean-based projects that have positive environmental, economic and climate benefits. The first blue bond was issued in 2018 and a good example is the Belize Blue Bond, which raised USD364mn to repay old debt and establish conservation funds. But overall, the uptake of blue bonds as an investable product has been extremely slow. There were just 26 of them between 2018 and 2022, totaling about USD5bn in value, or less than 0.5% of the market for sustainable debt. However, in 2023, the International Capital Market Association together with the International Finance Corporation, United Nations Global Compact, United Nations Environment Programme Finance Initiative and the Asian Development Bank released "Bonds To Finance The Sustainable Blue Economy: a practitioner's guide". This is a fundamental step since taxonomies of this kind are meant to play a major role in the development, standardization and use of these frameworks.

[13] The Fondation de la mer and Bureau Veritas launch "ocean approved", the first international label for ocean protection | Marine & Offshore

[14] Kaija Barisa (2023). How do we pay to protect the ocean? The finance behind saving our seas.

Box: A public-private partnership approach to marine conservation financing

Investments in marine conservation have been increasing from both the public and private sectors. In 2022, the EU established the InvestEU Blue Economy Fund, an equity fund focused on the blue economy. The objective is to raise an extra EUR500mn from the EU to support financial intermediaries making investments in the blue economy.

The German Development Bank KfW also promotes marine conservation as part of its financial cooperation with developing countries through direct and indirect projects. These initiatives aim to protect marine biodiversity, aquaculture and fisheries, and improve land-based waste management to minimize the discharge of harmful substances into the sea. Commitments have fluctuated over the years, ranging from EUR248mn in 2020, EUR238mn in 2021 and EUR108mn in 2022.

KfW is further active in the UN Sustainable Blue Economy Finance Initiative[15] and has signed the Sustainable Blue Economy Finance Principles, aligning its financing instruments with established environmental and social standards. KfW supports various funds and foundations,[16] including the eco.business Fund (EBF) (USD227mn) to promote sustainable production in Latin America and Africa; the Blue Action Fund (BAF) (EUR177.2mn in trust capital to support NGOs in marine conservation, including EUR25mn from FC funds and EUR30mn from the Green Climate Fund (GCF) for an Ecosystem-based Adaptation (EbA) program. The Caribbean Biodiversity Fund (CBF) focuses on marine conservation in the Caribbean with long-term assets of USD80mn, to which KfW contributed EUR45mn. KfW capitalized the Mesoamerican Reef Fund (MAR Fund) with EUR17mn and provided EUR23mn to strengthen conservation areas in the Mesoamerican Reef region. And in May 2023, KfW signed a grant agreement with the PACIFICO regional environmental fund for EUR10mn to protect the Eastern Tropical Pacific Marine Corridor.

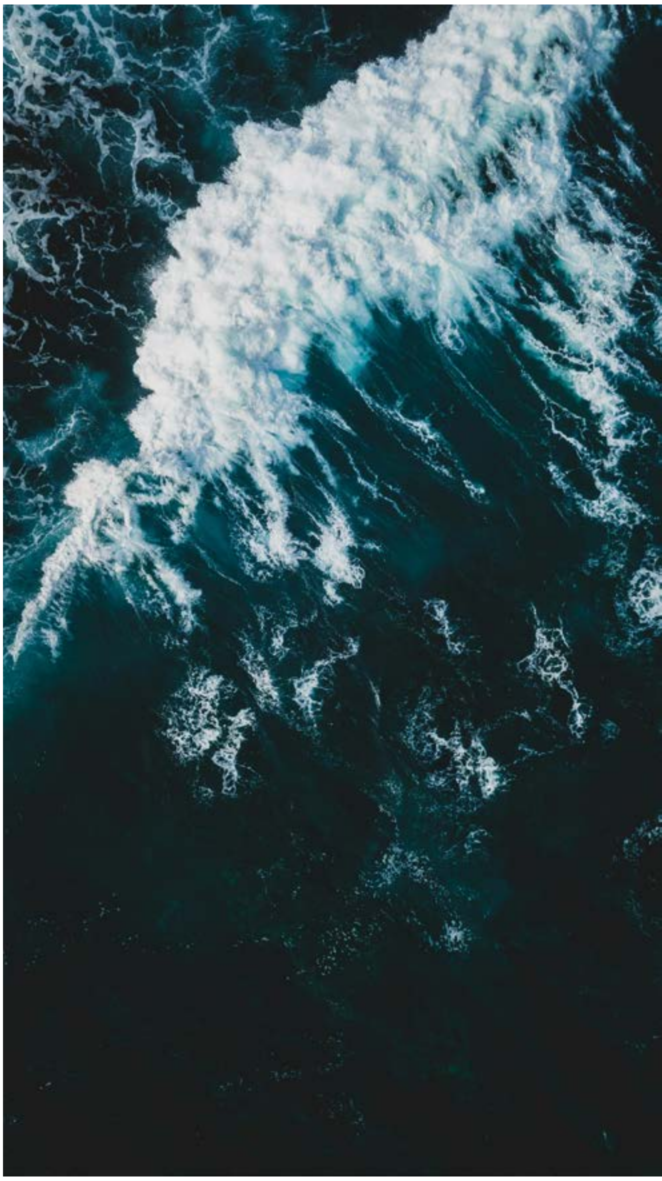
The Clean Oceans Initiative (COI), launched in 2018 by KfW, AFD, and EIB, aims to mobilize EUR4bn by 2025 to reduce plastic waste in oceans. The COI currently has commitments amounting to EUR2.bn, with KfW contributing EUR880mn across 25 projects. The initiative includes wastewater projects in Costa Rica and South Africa, rainwater management in India and waste management in Indonesia.

In June 2021, KfW signed the Sustainable Blue Economy Finance Principles, aligning its financing instruments with established environmental and social standards. Detailed information on the marine portfolio is now accessible via the BMZ Transparency Portal. KfW seeks to enhance reporting, data exchange, and scientific information sharing on marine ecosystems. By actively participating in working groups, KfW aims to support the exchange of ideas and further expand its SDG 14 portfolio.

[15] www.unepfi.org/blue-finance/the-principles

[16] Kai Wiegler, Helmut Schön (2023). Marine conservation in Financial Cooperation.

Tourism could contribute to financing marine conservation, too. Marine megafauna, such as sharks, rays and turtles, are among the world's most threatened species groups due to overfishing. Paradoxically, these species also hold significant economic value through marine tourism, with global manta ray tourism alone valued at USD140mn annually.[17] Despite this, the economic benefits from marine tourism rarely contribute directly to conservation efforts. Instead, the tourism industry typically captures these benefits, leaving coastal communities that depend on these species for food and income without significant support.[18] The costs of marine conservation often fall on these coastal communities due to restrictive regulations. For example, catch limits on endangered shark species could cost low-income Indonesian fishers up to 17.6% of their annual revenue.[19] To address this inequity, a "beneficiary pays" approach should be proposed, where tourists or tourist-focused businesses are charged a fee that is then invested in community-based conservation projects. These projects provide coastal communities with the resources needed to facilitate conservation while supporting their livelihoods. A recent survey showed that international tourists visiting two popular Indonesian holiday destinations (Lombok and Pulau Weh) would be willing to pay an average of USD10-15 per person per day to contribute towards community based marine conservation projects. This could generate USD2.3mn–6.8mn annually in Lombok and USD300,000–900,000 annually in Pulau Weh. These revenues exceed the estimated costs of community-based shark conservation in nearby fisheries.[20]

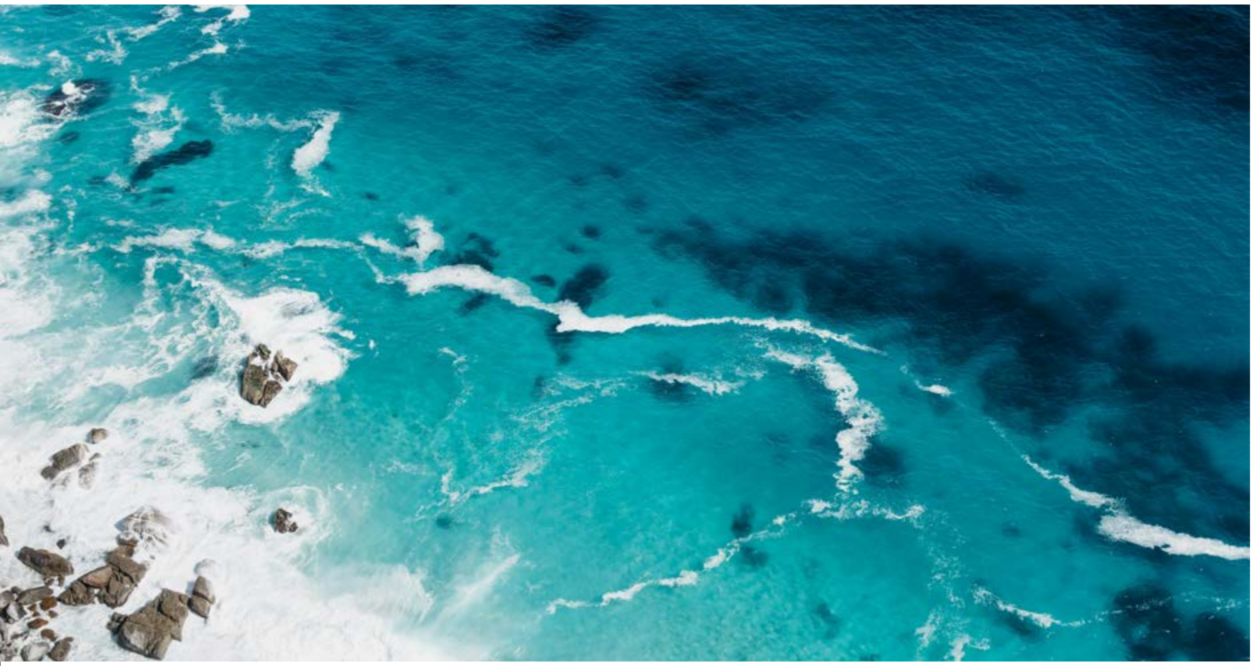


[17] Mary P. O'Malley, Katie Lee-Brooks, Hannah B. Medd (2013). The Global Economic Impact of Manta Ray Watching Tourism.

[18] Hollie Booth (2022). How to finance marine conservation without harming local communities.

[19] Hollie Booth, Dale Squires, Irfan Yulianto, Benaya Simeon, Muhsin, Luky Adrianto, Eleanor Jane Milner-Gulland (2021). Estimating economic losses to small-scale fishers from shark conservation: A hedonic price analysis.

[20] Hollie Booth, Susana Mourato, E.J. Milner-Gulland (2022). Investigating acceptance of marine tourism levies, to cover the opportunity costs of conservation for coastal communities.



The case for ocean-based carbon removal

Another avenue to attract blue investments is the emerging market for carbon dioxide removal (CDR) which will be essential to realize global decarbonization ambitions. Several ocean-based techniques exist to harness and enhance the ocean's natural capacity to remove carbon from the atmosphere. These ocean-based carbon dioxide removal strategies can be used to complement land-based measures such as afforestation or Direct Air Carbon Capture and Storage (DACCS) to enable the negative carbon economy.

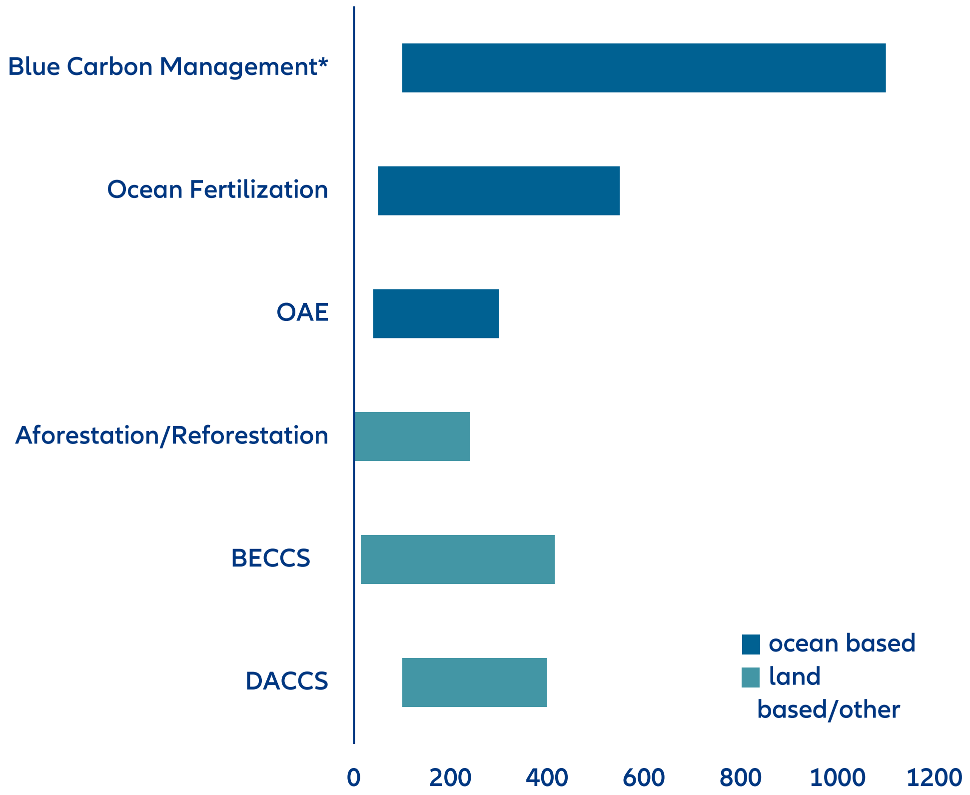
Ocean fertilization (OF) involves the targeted addition of nutrients to the ocean to facilitate the growth of phytoplankton and support the ocean's biological pump. While growing, phytoplankton take in carbon, which is then sequestered when they die and sink to the ocean floor, potentially storing carbon for extended periods in deep ocean sediments.

The restoration of blue carbon coastal ecosystems, such as mangroves, salt marshes or seagrass meadows, can add additional sequestration options to the mix. This not only helps with the direct removal of carbon but offers additional co-benefits such as flood and cyclone protection for coastal communities. Unlike terrestrial carbon, which is stored in forests, grasslands and soil, coastal carbon accumulates from sources like fallen leaves, twigs and organic matter washed up by tides. This matter is preserved under saltwater, which inhibits decomposition. These ecosystems cover only 2-6% of the area of terrestrial forests but sequester carbon dioxide at much higher rates. Coastal organic layers can reach depths of up to six meters, compared to 30 centimeters in terrestrial soils, resulting in significantly higher per square meter carbon stocks.[21] According to the Blue Carbon Initiative[22], mangroves can store up to 1,030 megagrams (Mg) of CO2 equivalent per hectare, while tidal marshes and seagrass meadows can store 920 and 520 Mg per hectare, respectively. However, the degradation of these ecosystems releases 0.15–1.02bn tons of CO2 annually.

[21] Derouin, S. (2017). Study finds that coastal wetlands excel at storing carbon.

[22] Blue Carbon Initiative

Figure 9: Cost estimates for different CDR methods (in USD/tCO2)



Source: Allianz Research, IPCC, *Blue carbon management cost are highly volatile with most applied technologies at the lower end (median cost for mangrove CDR USD 240/tCO2)

Additionally, ocean alkalinity enhancement (OAE) strategies can be employed to enhance the ocean's capability to take in CO2 from the atmosphere. In this process, alkaline substances such as crushed limestone are dissolved in ocean water, increasing the CO2 absorption potential and reducing ocean acidification, which can also help protect marine ecosystems such as coral reefs. Finally, other measures include seaweed cultivation, electrochemical processes and artificial upwelling & downwelling, all of which can help increase the ocean's capacity for carbon sequestration.

Thus far, the market for CDR has largely been focused on land-based technologies. They are currently more advanced in their development and therefore often come at a lower cost (Figure 9).

However, ocean-based methods such as OAE or the restoration of mangrove forests are becoming more cost competitive. Additionally, other methods such as DACCS currently fail to deliver on their cost-reduction promises.[23] This opens the door for a more diversified CDR market. However, to evaluate the use case for ocean-based CDR, various additional risks and co-benefits also need to be considered (Table 1).

[23] Financial Times

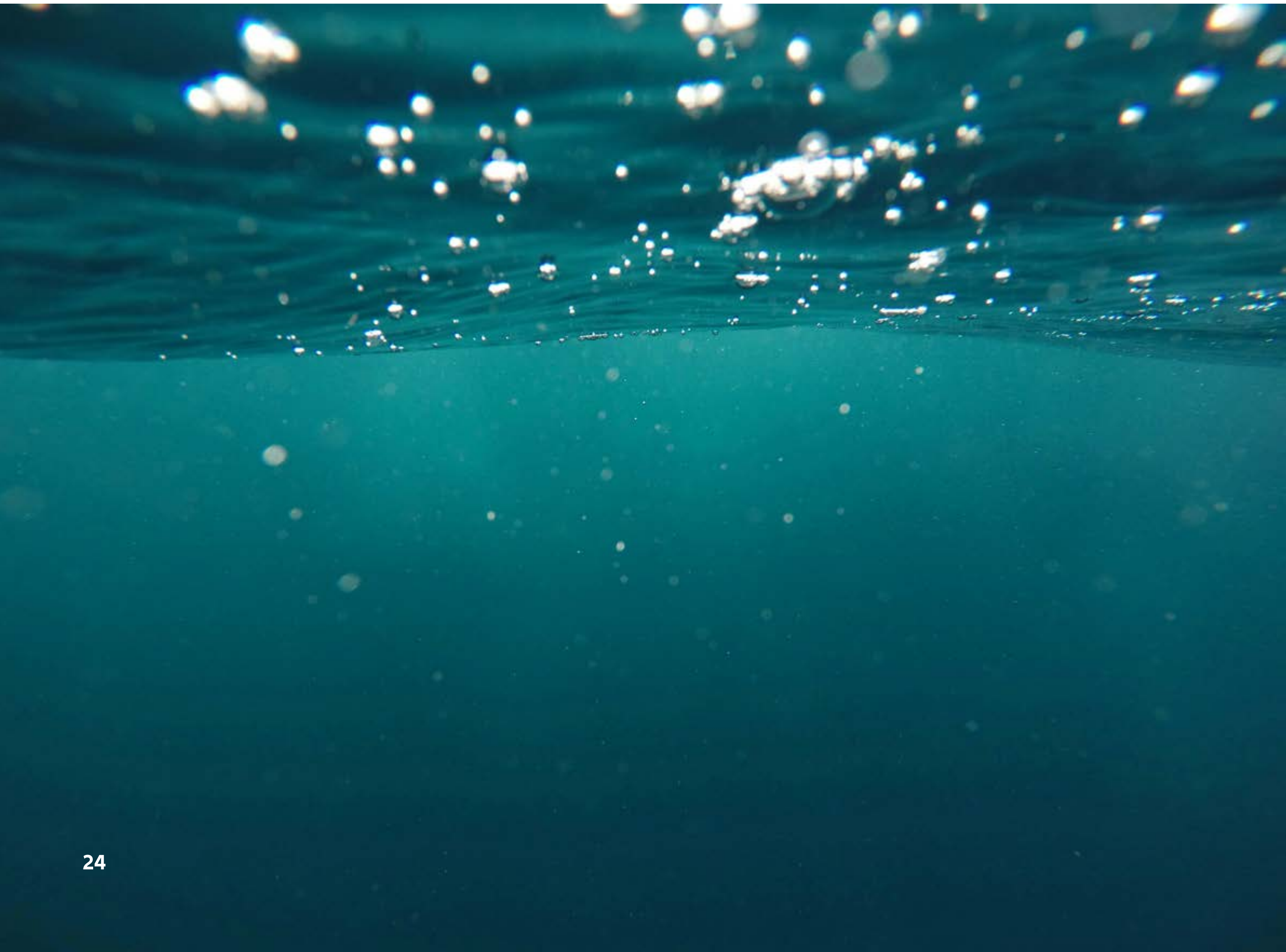
Table 1: Co-Benefits and risks associated with different carbon dioxide removal strategies

	Mitigation Potential (GtCO2/yr)	Risks	Co-benefits	Longevity
Blue carbon	<1	If destroyed release carbon back into atmosphere; Benefits take time to materialize	Coastal protection, increased biodiversity	Medium
Ocean Fertilization	1-3	Ocean acidification, deoxidization; Altered supply of macronutrients; Changes to food webs and biodiversity	Increased productivity and fisheries, reduced upper ocean acidification.	High
OAE	1-100	Potential increase in GHG emissions from mining, transport, and deployment	Reduction in ocean acidification	Very high
Afforestation/Reforestation	0.5-10	Land competition (land used for forests not available for biodiversity conservation and food production)	Enhanced employment and local livelihoods, improved biodiversity, improved renewable wood products provision, soil carbon and nutrient cycling.	Medium
BECCS	0.5-11	Land competition (land used for energy crops not available for biodiversity conservation and food production)	Reduction of air pollutants; fuel security, optimal use of residues, additional income, health benefits and if implemented well can enhance biodiversity, soil health and land carbon	Very high
DACCS	5-40	High energy requirement; Water usage (for some DACCS processes	Water produced (in isolid sorbent DAC designs only)	Very high

Source: IPCC, Bundesumweltamt ; Note: Longevity: low = years to decades; medium = decades to centuries; high = several centuries and more)

One aspect is scalability and the general mitigation potential a technology offers. This can vary widely and is subject to great uncertainty as the potential for most CDR technologies, but particularly for oceans, is not well examined. Hence, the expected potential for instance for OAE shows a wide range of between only 1 GtCO2/yr up to 100 GtCO2/yr. Only in some cases, such as for blue carbon management, can it be inferred that there are only limited mitigation opportunities. That said, the direct mitigation options are only one factor that should be considered. Blue carbon management, for instance, offers additional co-benefits such as greater coastal protection against storms and flooding, and can enhance biodiversity, which improves the wildlife and may offer a reduced risk of food scarcity for communities dependent on coastal fishing. These additional gains may very well outweigh the costs and make some CDR options viable despite a limited direct mitigation potential. Adversely, most measures also involve risks that need to be navigated. Ocean fertilization can lead to deoxygenation and similar problems as described for nutrient pollution. Land-based CDR techniques, on the other hand, increase competition for land that is then no longer available for other use (biodiversity or food production). Additionally, the use of monocultures can disrupt ecosystems and when mismanaged lead to forest dieback and an increased fire risk which reemits the stored carbon into the atmosphere. As with many technologies in the green transition there is no one size fits all solution. The effectiveness of CDR technologies is dependent on the local geographical and environmental conditions and requires careful management and oversight.

Ocean-based CDR can be a useful addition to the existing carbon removal toolkit, but more investment and research efforts are required. It is vital to reduce uncertainty to improve comparability between different options and examine which CDR methods are viable in various settings. To reduce costs, it will be key to increase investment opportunities and scale promising technologies. Here, it is important to provide credible and incentive compatible investment solutions to allow for more private sector participation. Market-based instruments such as blue bonds or blue carbon credits could achieve this if embedded into a solid regulatory framework. Finally, it should be noted that CDR technologies can only be considered complementary and do not replace direct emission reduction coming from a switch to renewable energy generation and energy-efficiency improvements.



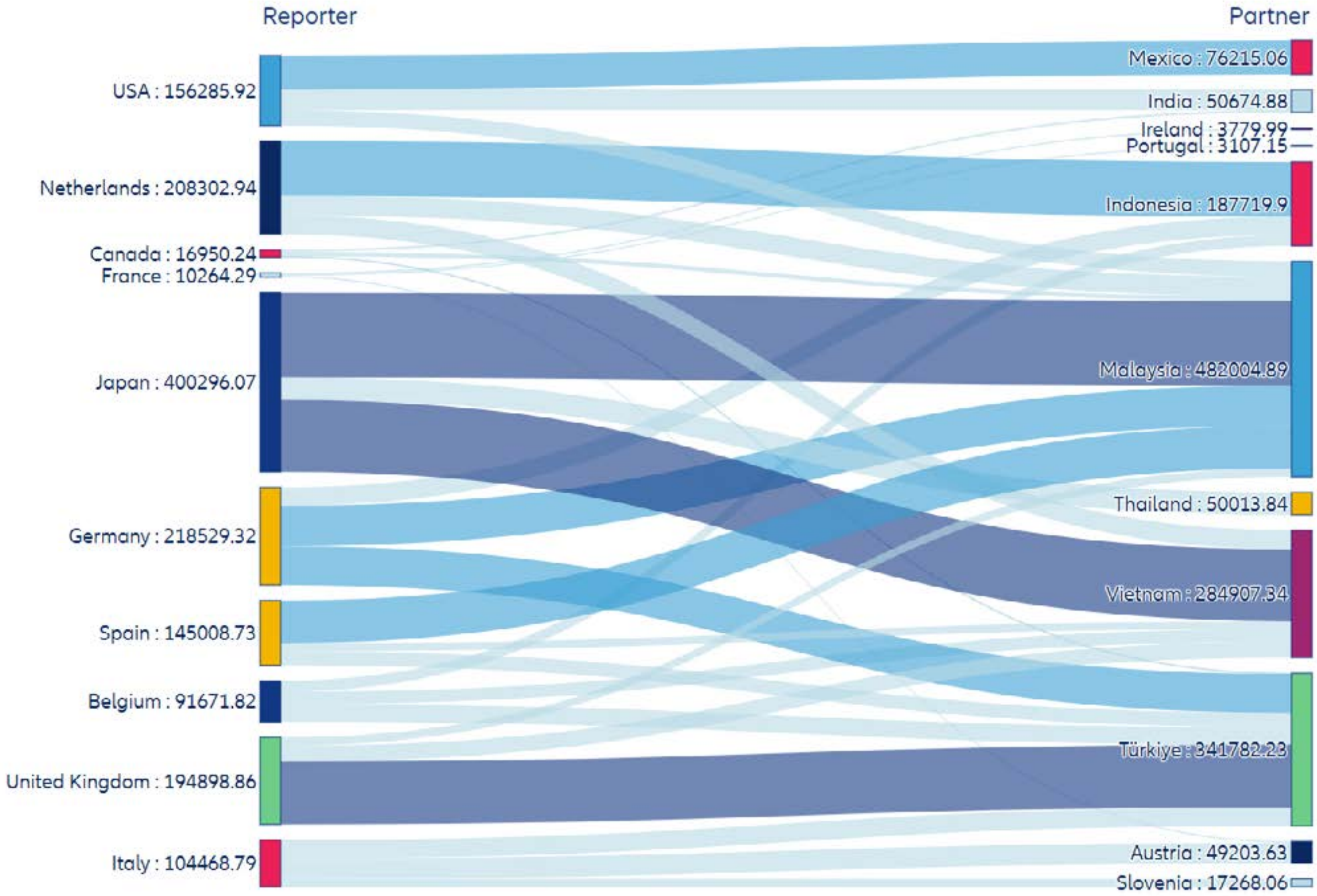
Combating ocean pollution

The most important aspect in limiting ocean pollution is the reduction of waste creation in the first place and limiting the amount of waste being disposed into the environment. This necessitates a strengthening of circular economy practices to reduce the overall resource footprint of the economy and hence the amount of residual waste needing disposal. Following circular economy guidelines would not only improve ocean health but can also unlock substantial economic benefits, with an estimated USD4.5trn output growth potential as early as 2030.[24] Apart from recycling and upcycling, this comprises the use of practices such as industrial symbiosis – reusing the waste of one industry as inputs for another – or the production of renewable and biodegradable products. The central goal is to improve resource efficiency along the whole supply chain, which reduces costs, protects the environment and promotes sustainable long-term growth. To limit nutrient pollution, it will also be necessary to control and limit agricultural and industrial runoff. This involves the use of improved irrigation practices, wastewater treatment and a more controlled use of pesticides.

[24] Accenture

Ocean protection will also require a closer monitoring of pollution practices. Today, waste trade and the outsourcing of waste disposal are widespread, with trade volumes at 5.6mn tons in 2023. This is not inherently negative as comparative advantages in different countries can make outsourcing more efficient and effective. However, it becomes problematic when it is used as an "out of sight, out of mind" solution. The responsibility here lies with the biggest waste exporters, which are primarily advanced economies (Figure 10). If waste is exported, it should be accompanied by thorough vetting and monitoring of downstream processing. Additionally, exporting waste to countries with high waste emission profiles should be avoided or paired with programs designed to mitigate waste pollution and reduce overall pollution in those countries.

Figure 10: Net plastic waste exports for top 10 exporters in 2023 by destination (in t)

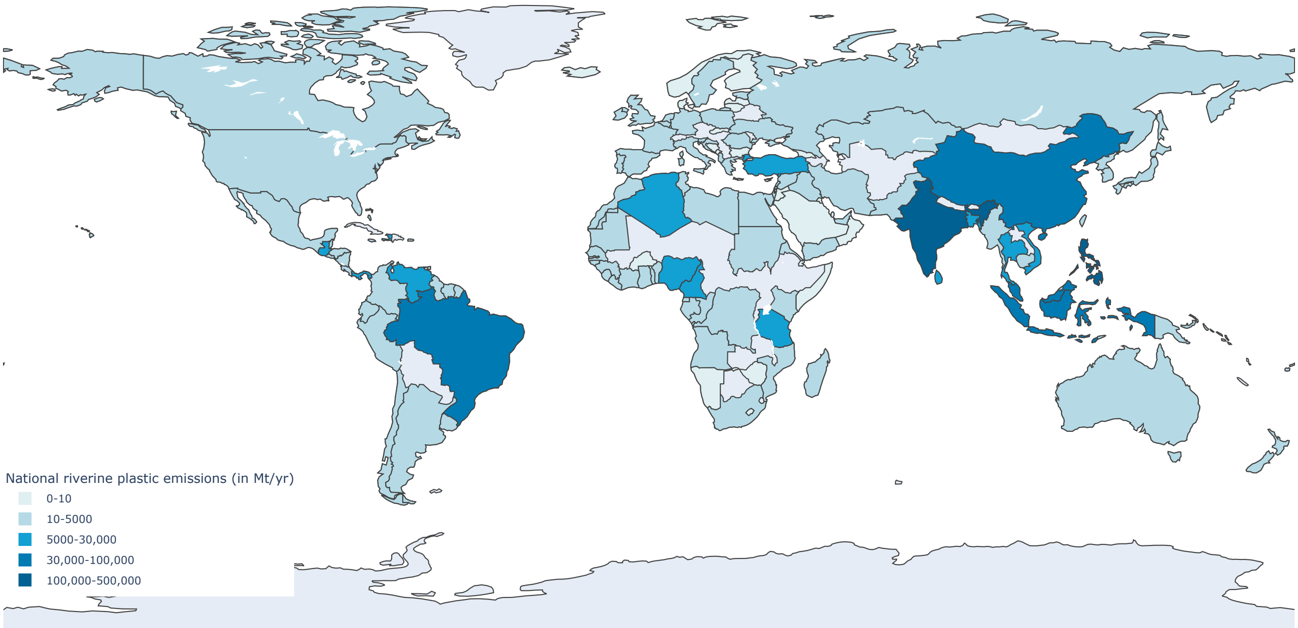


Sources: Allianz Research, UN Comtrade, Note: includes only top three export destinations; exports relationships between top 10 exporters are excluded

Importing waste goes often hand in hand with pollution. Countries such as Malaysia, Vietnam, Indonesia or Türkyie, which are major importers of waste from advanced economies, are also among the worst-performing countries when it comes to riverine plastic emissions, emitting more than 5000 Mt/year (Figure 11). While this does not apply to all waste exports to these countries, it serves as a cautionary tale to reassess such exports and rigorously inspect the quality of the local waste-disposal facilities. That said, latest trends are encouraging, with waste exports having decreased by over -50% since 2010.

However, given a doubling of plastic production between 2000 and 2019, and the projected further increase of 70% until 2040, more oversight and regulations on waste disposal will be necessary. Programs such as the currently negotiated UN plastics treaty or the EU Packaging and Packaging Waste Regulation (PPWR) are important to reduce plastics usage and improve the environmental soundness of global supply chains.

Figure 11: Riverine plastic emissions into the ocean by country (in Mt)



Source: Meijer et al. (2021)

To further mitigate pollution-related disruptions of marine ecosystems, the development of a sustainable ocean industry should be a key objective. This involves implementing environmentally friendly practices across various sectors, such as sustainable fishing, responsible tourism, and shipping. For instance, reducing the amount of ghost gear in the fishing industry – responsible for about 10% of ocean plastic pollution – could be achieved with additional trainings for those who fish and support schemes for replacing old and worn-out gear. Additionally, tightening minimum distance requirements for shipping routes could help to protect biodiversity and minimize the impact on marine habitats.

Avoiding pollution entirely will still be difficult. Ocean cleanup programs can play a crucial role in bridging the gap by significantly reducing the existing elevated levels of pollution. These initiatives not only help remove debris from the ocean but also raise awareness and promote sustainable practices to prevent future pollution. By complementing prevention efforts with active cleanup operations, we can make substantial progress towards healthier and cleaner oceans.

Box: Ocean protection efforts at Allianz

Allianz recognizes the significance of ocean conservation and has taken proactive measures towards protecting the oceans. Among these measures are the set-up of an Ocean Sustainability concept, methodology and partnerships together with Allianz entities and international marine conservation organizations to support cleaning plastic from oceans and rivers, while contributing to the circular economy.

Protecting marine wildlife with Sea Shepherd

- Sea Shepherd Global is an international non-profit anti-poaching organization dedicated to marine conservation activism. Sea Shepherd utilizes a worldwide marine fleet to patrol and protect endangered areas, with a specific focus on tackling plastic pollution caused by abandoned fishing gear.
- Allianz partnered with Sea Shepherd in 2020 and since then has been providing funding for the newly acquired ship “Sea Eagle” and its crew, which is tackling plastic pollution by removing abandoned fishing gear in the Mediterranean Sea.
- Since the launch of the partnership, 274km of nylon fishing lines, 9km ghost nets, 13.7 tons of driftnets, and 39 tons of illegal fishing gear have been collected. 1,614 illegal fish-aggregating-devices were found and 591 retrieved; 11,565 illegal octopus traps have also been retrieved.
- Additionally, the patrolling operations have led to a 70% decrease of illegal, unreported, and unregulated fishing in the Tyrrhenian Sea and reduced the number of illegal octopus traps in the Tuscan Archipelago by 50%.
- In total, 50 volunteers from Allianz sponsoring entities have participated in the campaigns and worked with the Sea Shepherd crew to achieve these results.

Supporting livelihoods and tackling plastic waste in India with Plastic Fischer

- In 2022 Allianz partnered with Plastic Fischer, an environmental social enterprise, which is taking concrete and impactful action towards cleaner and healthier rivers and oceans.
- By using simple, cost-effective technologies, involving local communities and working closely with recycling companies and the government, Plastic Fischer removes plastic from rivers, tributaries and canals of Trivandrum, India, to stop it from entering the ocean.
- Thus far, the partnership has deployed 18 Trash Boom systems, collecting more than 422 tons of waste and creating 21 local jobs, while making sure that recyclables are reintroduced into the supply chain.

Tackling marine plastic pollution and overfishing with Enaleia

- Enaleia is a social non-profit enterprise addressing marine plastic pollution and overfishing through circular and social economy solutions.
- Allianz partnered with Enaleia in 2023 to support its mission to actively reduce plastic pollution, transition to a circular economy and tackle overfishing in Spain and Greece.
- In 2023, the alliance collected 5,000kg of waste in Greece and 9,000kg of fishing gear in Spain. An estimated 55% of the collected marine plastic and used fishing gear was then integrated into the circular economy. Additionally, training sessions were conducted for more than 1,700 fishermen in both Spain and Greece, raising awareness about the risks of ocean pollution.

Appendix: Figure 4

How industrial production affects marine ecosystems

Industries involved in infrastructure builds – such as the industrial and energy sectors – have the highest impacts on marine ecosystems. Construction activities often lead to the clearing and degradation of natural habitats, reducing biodiversity and natural capital at construction sites and surrounding areas. These changes are typically long-lasting and can severely disrupt local ecosystems. In the energy sector, integrated oil and gas operations are particularly damaging. Drilling for oil at sea is highly disruptive as the construction of pipelines and infrastructure fragments habitats, while byproducts such as drilling fluids, metal cuttings and accidental spillages introduce toxic chemicals into the environment. Similarly, oil and gas drilling activities disrupt natural habitats with far-reaching environmental consequences. Saltwater wild-caught fishing methods, particularly those involving bottom trawling, severely damage benthic environments, leading to habitat degradation and significant impacts on species relying on these habitats. Marine ports and services, classified under industrials, require regular dredging to maintain operational status. This activity disturbs coastal ecosystems, affecting sediment composition and local marine life.

Marine transportation and aquaculture also have strong impacts on marine ecosystems. The consumer staples sector's aquaculture activities involve the creation of ponds and reservoirs for aquaculture, which can negatively impact coastal and marine habitats through habitat clearing and degradation. Materials production involving marine dredging alters species compositions in benthic communities due to sedimentation. This disruption can lead to the local extinction of some wild species. Marine transportation, part of the industrials sector, involves dredging to improve waterways, reducing the availability of sediments, a critical resource for many marine organisms. Oil and gas transportation involves infrastructure such as railways, roads and pipelines necessary for transporting oil and gas, which fragment marine habitats. Gas distribution, classified under utilities, has a significant spatial footprint, leading to habitat degradation and fragmentation over its life cycle. The construction of offshore wind farms under the utilities sector modifies marine habitats, impacting local ecosystems. The installation and recovery of fiber-optic cables under telecommunication services disturb the seabed, affecting habitats such as mussel beds, seagrass beds and maerl beds.

Moderate impacts on marine ecosystems are caused by cruise lines, distribution activities and oil and gas exploration. Cruise line provision within the consumer discretionary sector disrupts marine ecosystems through the movement of cruise ships, affecting natural habitats and species. Distribution activities across various sectors cause physical changes in wave movement due to ship-based distribution, leading to increased erosion along coastlines and shorelines. Oil and gas exploration surveys in the energy sector disrupt marine environments, particularly when they cover large exploration blocks. Average exploration blocks can span 250 km^2, leading to significant ecological disturbances.

Impacts on marine ecosystem use			
Sector: Sectors represent broad divisions of the economy. There are 11 sectors in the Global Industry Classification Standard. These are further broken down into sub-industries and production processes.	Production Process	Materiality Rating	Impact
Industrials	Infrastructure builds	Very high materiality rating	Construction can result in the clearing and degradation of habitats, leading to loss of biodiversity and natural capital on the construction sites and surrounding areas.
	Marine ports and services	Very high materiality rating	Ports require regular dredging to remain operational, where ports are constructed along coastlines this impacts on marine ecosystems.
	Marine transportation	High materiality rating	Dredging of marine sediments to improve waterways can reduce the availability of sediments as a valuable resource.
Energy	Integrated oil and gas	Very high materiality rating	Drilling for oil at sea is disruptive and can impact on natural habitats. Production of pipelines and infrastructure can result in
	Oil and gas drilling	Very high materiality rating	
	Oil and gas transportation	High materiality rating	Railways, roads and pipelines lead to habitat fragmentation in marine ecosystems.
	Oil and gas exploration surveys	Medium materiality rating	Oil and gas exploration surveys can disrupt marine environments, particularly when they span large exploration blocks. Block sizes vary, with some estimates citing average areas of 250 km2.
Consumer Staples	Saltwater wild-caught fish	Very high materiality rating	Certain types of fishing gear can heavily damage benthic environments (sea floor), leading to habitat degradation and associated impacts on species.
	Aquaculture	High materiality rating	Creation of ponds or reservoirs to enable aquaculture can lead to major negative impacts on coastal and marine habitats (e.g. habitat degradation or clearing).
Materials	Construction materials production	High materiality rating	Sedimentation resulting from marine dredging can result in the alteration of species compositions and populations in benthic communities. Disruption from operations can result in the loss of populations of wild species in a localised area.
Telecommunication Services	Fibre-optic cable installation (mari	High materiality rating	The burial and recovery of cables results in the disturbance of the seabed affecting habitats and species including, mussel beds, seagrass beds and maerl beds. These effects can be long term.
Utilities	Wind energy provision	High materiality rating	Construction of offshore wind farms leads to habitat modification in the marine environment.
	Gas distribution	High materiality rating	Pipelines used to distribute gas have a significant spatial footprint, which can lead to habitat degradation and fragmentation throughout the pipelines' life cycle.
Consumer Discretionary	Cruise line provision	Medium materiality rating	Movement of cruise ships is disruptive to marine ecosystems and can impact on natural habitats and species.
Consumer Discretionary	Distribution	Medium materiality rating	Physical changes in wave movement due to the distribution via ships can lead to increased erosion along coastlines and shorelines. This impact does not apply to other forms of distribution that do not take place in marine ecosystems.
Consumer Staples		Medium materiality rating	
Healthcare		Medium materiality rating	
Industrials		Medium materiality rating	
Information Technology		Medium materiality rating	

Appendix: Figure 5

How the degradation of marine ecosystems affects industrial production

High impact drivers of environmental change linked to marine ecosystems reduce industrial productivity. Agricultural expansion and intensification, including mariculture and aquaculture, can lead to habitat destruction and water pollution, which significantly impact species and water resources, both critical for industries such as consumer staples and materials. The creation of aquaculture ponds can degrade habitats and reduce water quality, affecting the health of ecosystems and the industries dependent on them. Non-agricultural human activities, such as construction and manufacturing, can cause habitat loss, pollution and changes in land and ocean geomorphology. These activities have high impacts on the atmosphere and water, essential for industries like energy, utilities and materials. Major changes in habitat composition and location due to industrial and domestic construction can lead to significant ecosystem disruptions, impacting the atmosphere, habitats, minerals, species and water. Industries such as materials, energy and consumer staples are particularly affected as habitat modification can disrupt supply chains and increase operational risks. The introduction of contaminants into the natural environment can degrade water quality, harm species and disrupt ecosystem services. Pollution has a high impact on the atmosphere and water, affecting industries like energy, utilities and consumer staples. Medium materiality impacts on habitats, soils, sediments and species further stress industrial operations by reducing resource availability and quality.

Moderate impact drivers of environmental change have also significant effects on industrial productivity. Harmful pathogens and microbes, exacerbated by human activities, can lead to significant species declines. This driver has a substantial impact on species, which are vital for industries such as healthcare, consumer staples and discretionary. The introduction and spread of harmful plants, animals and pathogens can disrupt native ecosystems and reduce biodiversity. Invasive species have high impacts on water and medium impacts on species, affecting industries that rely on healthy, diverse ecosystems. Changes in species populations over time and space can affect the availability and health of natural resources. For instance, declines in fish populations due to overfishing can impact the consumer staples sector, which relies on wild-caught fish. This driver has moderate impacts on species diversity and abundance. The harvesting of aquatic wild animals at unsustainable rates can lead to the collapse of fish populations, impacting industries reliant on marine biodiversity. Overfishing has a significant impact on species, crucial for sectors such as consumer staples and discretionary.

Marine ecosystem linked drivers of environmental change degrade natural capital assets, which in turn affects industrial production processes. Species loss and population changes affect industries such as consumer staples, materials, utilities and consumer discretionary. For example, the availability of fish for food production and the health of marine species essential for tourism and recreation can be compromised. Water quality and availability are crucial for industries such as consumer staples, materials, energy and utilities. Pollution, overuse and habitat destruction can lead to water scarcity and quality issues, disrupting industrial operations and increasing costs for water treatment and sourcing. Healthy soils and sediments support agriculture, aquaculture and construction industries. Degradation due to pollution, erosion and habitat modification can reduce productivity and increase restoration costs. The atmosphere's components and processes are vital for regulating climate and air quality. Industries such as energy, utilities and materials are impacted by changes in atmospheric conditions due to pollution and habitat modification. Diverse and healthy habitats support a wide range of ecosystem services, from water filtration to carbon sequestration. Habitat degradation affects industries reliant on these services, such as consumer staples, materials and healthcare.

Impacts of marine ecosystem degradation on natural capital assets			
Marine ecosystem degradation drivers of environmental change: Drivers of environmental change are natural or human-made pressures that can affect natural capital assets and their ability to continue providing goods and services	Materiality Rating	Natural Capital Asset: Natural capital assets are specific elements within nature that provide the goods and services that the economy depends on.	Description of natural capital asset
Habitat modification	High materiality rating	Habitats	Habitats refer to the conditions of the environment necessary for life to prosper. These conditions vary widely between species but can include such elements as water and food availability, temperature range, or absence of predators. Habitats can be defined very narrowly
Industrial or domestic activities	Medium materiality rating	Habitats	
Industrial or domestic construction	Medium materiality rating	Habitats	
Pollution	Medium materiality rating	Habitats	
Habitat modification	Medium materiality rating	Land Geomorphology	Land geomorphology describes the structure of the land, such as mountains and valleys. Land geomorphology supports the provision of
Industrial or domestic activities	Medium materiality rating	Land Geomorphology	
Habitat modification	High materiality rating	Minerals	Minerals are naturally occuring compounds not produced by living beings. They can be metallic or non-metallic and play an important supporting role in the provision of services like soil quality.
Industrial or domestic activities	Medium materiality rating	Ocean Geomorphology	Ocean geomorphology describes the structure of the marine environment such as shelfs and slopes. Ocean geomorphology supports the provision of regulatory services, like dilution by ecosystems.
Habitat modification	Medium materiality rating	Soils and Sediments	Soils and sediments are the layers of the earth's surface that support life. They comprise top-soil, sub-soil and ocean sediments and support a number of regulatory services.
Industrial or domestic activities	Medium materiality rating	Soils and Sediments	
Intensive agriculture and aquaculture	Medium materiality rating	Soils and Sediments	
Overharvesting	Medium materiality rating	Soils and Sediments	
Pollution	Medium materiality rating	Soils and Sediments	
Diseases	High materiality rating	Species	Species includes plants, animals, fungi, algae and genetic resources, which can be wild or domestic/commercial, for example livestock. Like habitats, species underpin a wide range of ecosystem services.
Habitat modification	High materiality rating	Species	
Intensive agriculture and aquaculture	High materiality rating	Species	
Invasive species	Medium materiality rating	Species	
Overfishing	Medium materiality rating	Species	
Overharvesting	Medium materiality rating	Species	
Pollution	Medium materiality rating	Species	
Population changes	Medium materiality rating	Species	
Habitat modification	High materiality rating	Atmosphere	The atmosphere is the mass of air surrounding the earth. It's components (such as oxygen) and it's processes (such as temperature regulation) support a number of essential ecosystem services.
Industrial or domestic activities	High materiality rating	Atmosphere	
Industrial or domestic construction	Medium materiality rating	Atmosphere	
Pollution	High materiality rating	Atmosphere	
Habitat modification	High materiality rating	Water	Water includes surface water, ground water, ocean water, fossil water and soil water. Water is essential for a wide range of ecosystem services.
Industrial or domestic activities	High materiality rating	Water	
Industrial or domestic construction	High materiality rating	Water	
Intensive agriculture and aquaculture	High materiality rating	Water	
Invasive species	High materiality rating	Water	
Pollution	High materiality rating	Water	

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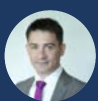

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