Blue ecosystems are our natural allies

Harnessing the ocean to help capture carbon and enhance biodiversity

What this report will cover

1 The natural potential of the blue economy

2 The case for blue carbon ecosystems (BCEs)

3 The science behind key ocean processes

4 Assessing the readiness of BCEs

5 Three ways to drive greater BCE adoption in climate plans

6 The blue economy is an untapped opportunity for progressing climate and nature-positive plans

7 How KPMG can help

1 The natural potential of the blue economy

Since the Industrial Revolution,[1] humans have emitted more than 2,000 gigatons of CO_2 ($GtCO_2$) into the atmosphere. Even the most ambitious projections acknowledge that we'll fall well short of the Paris Agreement target of 1.5 degrees global warming by 2050.[2] Simply reducing emissions won't be enough — scientists predict that up to 10 GtC will need to be removed annually from the atmosphere by 2050, with increased removal capacity up to 20 GtC per year by 2100.[3]

The ocean is a vital ally in this existential venture. Blue carbon ecosystems (BCEs) — which include mangroves, tidal and salt marshes, seagrasses as well as open ocean food webs and nutrient cycles — have enormous capacity to store carbon within the plants, animal biomass and in the sediments below for long periods of time. Estimates suggest that investments in BCEs could capture and reduce emissions of nearly 4 GtC per annum in 2030 and by more than 11 GtC per annum in 2050.[4] Conversely, when disrupted, BCEs could potentially also release carbon, which makes it even more important to conserve and restore these vital resources to aid the fight against climate change and biodiversity loss.

When compared to technological carbon removal options such as direct air capture, geological capture and biochar production, 'natural climate solutions' like BCEs are potentially more cost-effective and scalable. BCEs provide win–win solutions — sequestering carbon while improving ocean health and biodiversity as well as the livelihood of millions of people in coastal communities. BCEs are widespread, highly productive coastal habitats that host diverse ecological communities, providing food and coastal protection against erosion and sea-level rise. They also play a critical role in food supply, not just for coastal communities but also for almost all global countries as well. However, BCEs have not yet been deployed at a large scale and face barriers to widespread adoption.

In this report we will:

1. examine some of the science behind ocean systems and BCEs
2. look at the different ways they can capture carbon while promoting ecosystem resilience and regeneration
3. discuss how governments, businesses and other stakeholders can drive investment in the sector by integrating BCEs into carbon standards, influencing public policy and funding projects through the private sector.

2

The case for blue carbon ecosystems (BCEs)

By combining carbon removal with environmental rejuvenation, BCEs are a powerful solution

If we're to meet climate and societal goals, we need solutions that not only reduce emissions, but also promote the biodiversity and health of natural systems that support societies and livelihoods. There's a growing recognition of the role of natural climate solutions (NCSs) in tackling these challenges, such as through ecosystem management and reforestation.[5]

KPMG's Blue economy report suggests that carbon removal projects could capture an outsized share of the growing demand for offsets. Carbon offsets have been largely focused on terrestrial sources and through carbon capture, utilization and storage (CCU) technology advances, with 2021 a bumper year for new CCUs.[6]

However, the finite supply of land-based offset sources is likely to push up prices and benefit larger and more expensive carbon removal projects — particularly in the medium term. The world needs to remove an estimated 10 GtC per year by 2050 and 20 $GtCO_2$ per year by 2100, but tightening standards and higher environmental integrity have created uncertainty over the supply of the carbon credits that fund many carbon capture projects. The Taskforce on Scaling Voluntary Carbon Markets (TSVCM) has indicated that the 'practical' supply of carbon credits could be as low as 1 to 5 $GtCO_2$ per year by 2030 due to mobilization challenges.[7]

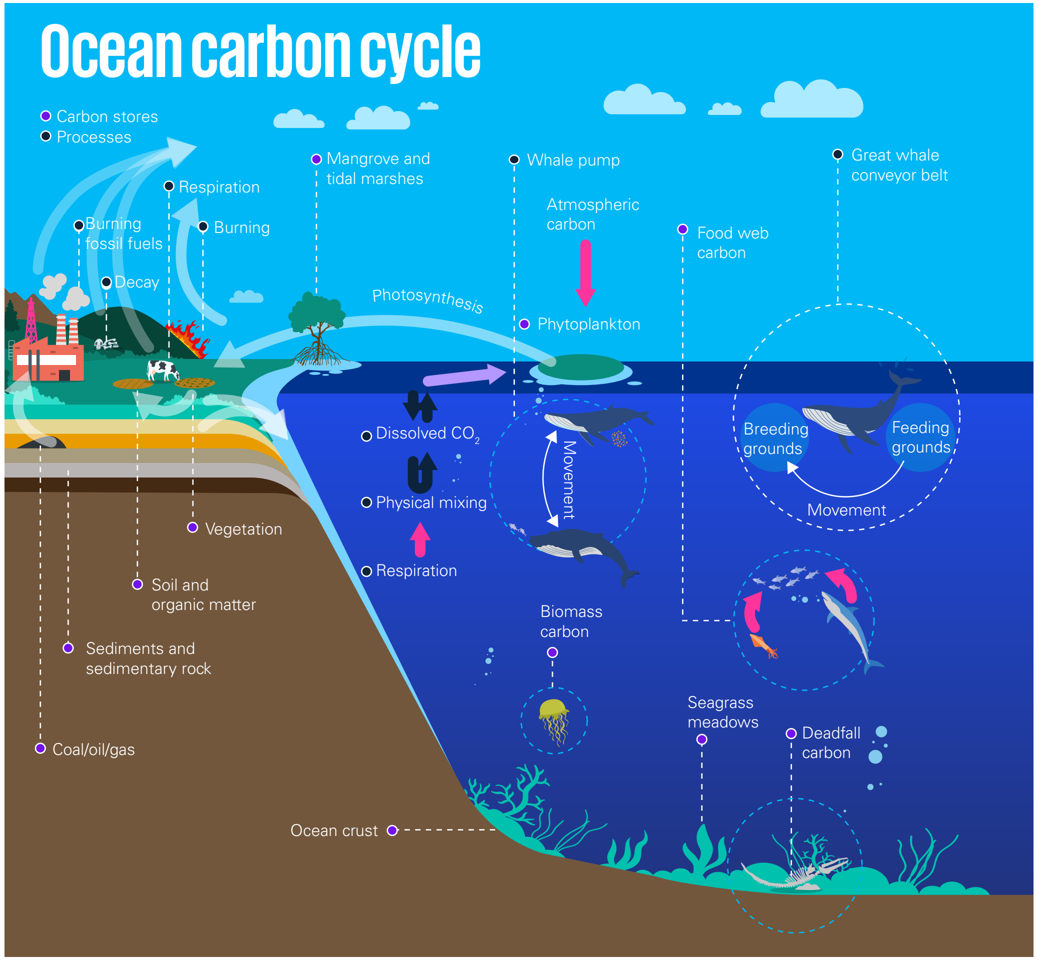
Because of their high volume of carbon capture, wider ecosystem benefits, and advances in effectiveness, NCS initiatives are growing in popularity. As the world struggles to reach climate goals through net-zero methods — particularly in sectors like agriculture and aviation — carbon capture, via NCSs, is becoming an increasingly attractive solution for countering emissions.

NCSs are in line with the headline target of protecting 30 percent of land and sea resources,[8] to reverse biodiversity loss by 2030, which in turn should exert more pressure to ramp up biodiversity reporting. The draft framework of the Taskforce on Nature-related Financial Disclosures (TNFD) is likely to spur new voluntary and mandatory requirements from policymakers and investors, following the model of the Taskforce on Climate-related Financial Disclosures (TCFD).

Initially, NCSs were based almost exclusively on green carbon (terrestrial) ecosystems, largely ignoring coastal and ocean-based opportunities for carbon capture. However, there has been increased appreciation of the potential value of BCEs as benefits, which include healthy seafood stocks, flooding and erosion protection, freshwater access as well as the regulation of global temperatures, are becoming an increasing necessity. Furthermore, BCEs are endemic to both temperate and tropical regions and can have wider impacts to countries with and without a coastline.

To give you an idea of the enormous potential ocean-based carbon removal strategies have, research has shown that the ocean contains an estimated 39,000 Gt of carbon, equivalent to 50 times the amount in the atmosphere, and is estimated to have captured 38 percent of emissions caused by humans over the past two centuries.[9] And, with its area and depth, it has a virtually limitless capacity to store carbon, especially when we look at the bottom of the ocean and the potential for natural deep sea carbon storage.[10]

This means the combination of terrestrial challenges, like limited and costly carbon capture and rising demand for wider environmental benefits, makes BCEs an especially appealing solution for investors.



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As through the worst of the COVID-19 pandemic in the lead up to COP26 in Glasgow, significant corporate momentum is helping to steer a global agenda through a time of great geopolitical uncertainty in 2022. As the Russian invasion of Ukraine diverts time and attention away from other global priorities, the global climate agenda is again coming under strain as the result of deep rifts between developed and emerging markets related to the global response to the war, a challenging economic environment, supply chain chaos, and continued uncertainty related to the trajectory of the pandemic.

The **risk of a global economic recession** looms large, threatening the ability for emerging markets to generate much-needed investment — here, BCEs have the potential to close a harrowing gap of public climate finance flows from the Global North to South while the proliferation of private sector nature-positive strategies continues. As the response to ongoing energy market turmoil and geopolitical uncertainty related to energy security has, in many instances, locked in additional fossil fuel emissions for decades to come, the demand for any and all mitigation measures — especially those, like BCEs, that offer a multitude of co-benefits — will become even more robust in country- and corporate-level climate commitments and plans.

3

The science behind key ocean processes

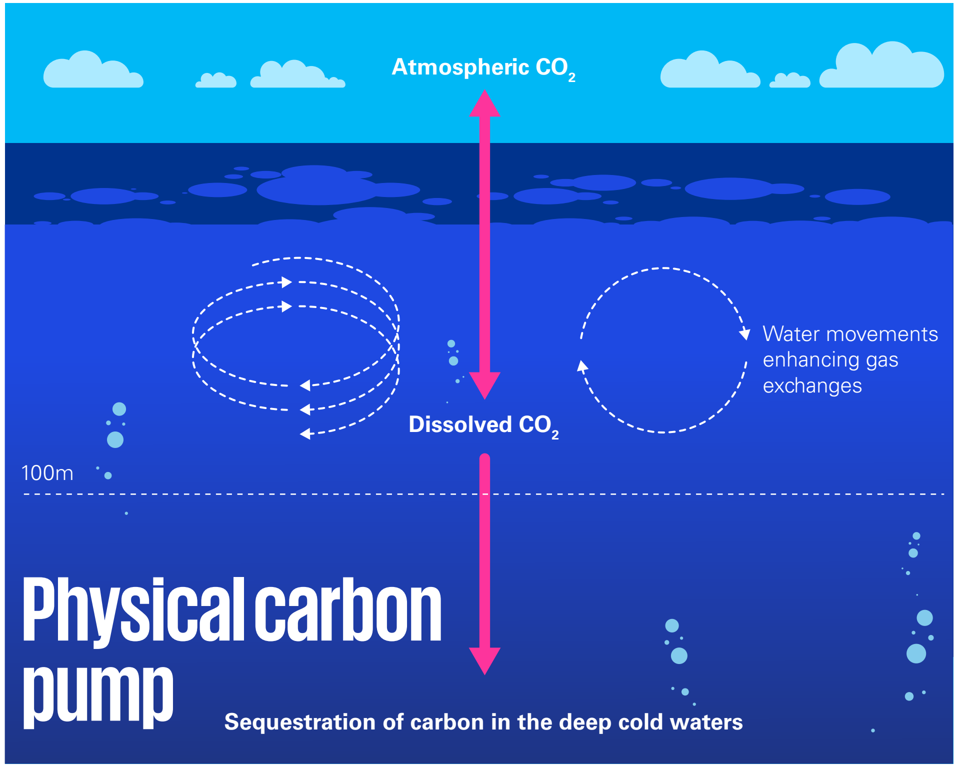
There is a physical and a biological way oceans sequester carbon and protect natural systems.

We now know the ocean is vital to our well-being and livelihood, but how does it make itself so valuable to us? Well, firstly, ocean circulations are influenced globally by polar processes and redistribute carbon across long distances and great depths. The ocean moves heat and carbon from warm, surface waters toward cool waters in its deeper layers. Winds bring cold water up from deep layers in some regions, allowing carbon exchange between the deep ocean and the atmosphere and powering biological production. This enables the ocean to regulate the climate, provide energy, capture carbon, and disseminates the essential elements of living matter.

If we focus on carbon capture specifically, temperate and tropical coastal ecosystems are significant net carbon sinks — i.e natural reservoirs that absorb and store the atmosphere's CO_2.[11] In the open ocean, carbon sink forms from two compartments: 1) Physical and 2) Biological.

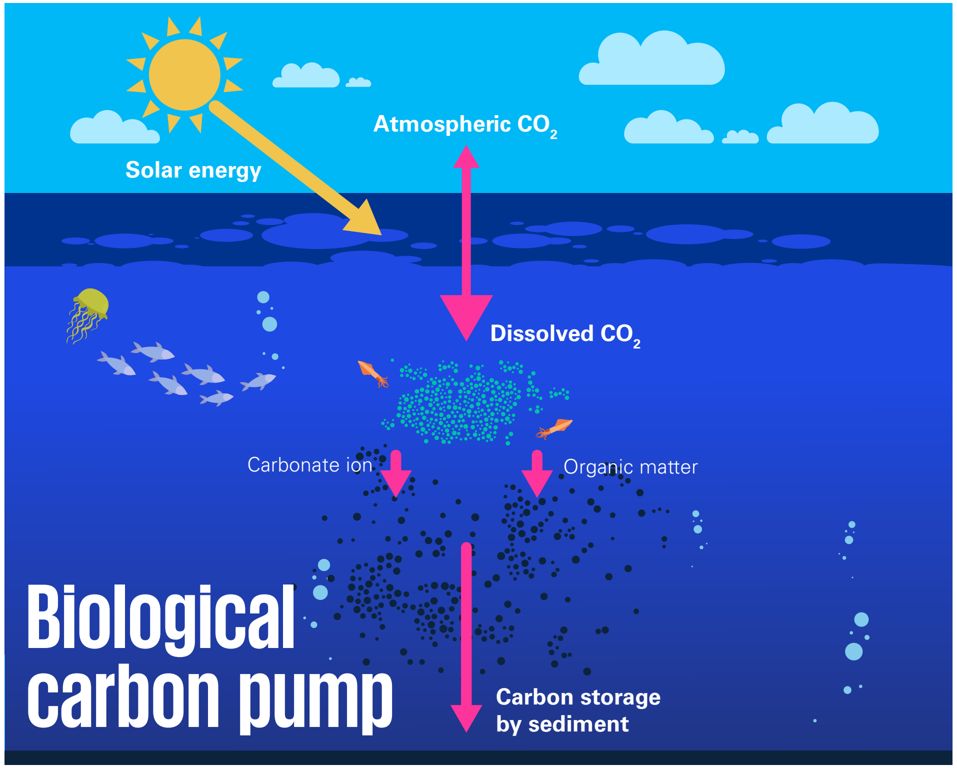
> "The ocean is less sensitive to short-term disturbances, but it is affected by disruptions over a longer-term basis (e.g. global warming). There is a strong inverse function of seawater temperature on the solubility of CO_2, as solubility is greater in colder water."

1 **Physical carbon pump:** About 90 percent of atmospheric CO_2 is transferred to the ocean as a result of ocean circulation. Gas dissolves into surface seawater, which is then transported to the deep layers of the ocean and temporarily removed from the surface cycle. It is less sensitive to short-term disturbances, but it is affected by disruptions over a longer-term basis (e.g. global warming). There is a strong inverse function of seawater temperature on the solubility of CO_2, as solubility is greater in colder water. As sea surface temperature increases (due to warmer climate/atmosphere), less CO_2 can be taken up by the ocean, therefore with the progressive warming of the oceans from global warming, the surface waters release CO_2 back into the atmosphere causing a negative feedback loop.



(Ocean and Climate Initiative Alliance)

2 **Biological carbon pump:** Some surface carbon is transferred toward the seabed via the food web through consumption, driven by photosynthesis and phytoplankton, which are the first step in the food web. Another way carbon is moved into deep ocean currents or seafloor sediments is by sinking organic matter (e.g. whale falls) — when plankton or other marine organisms eat, defecate, die, and decompose, this material, known as marine snow, begins to sink downward to the ocean floor. In total, ~10 Gt of CO_2 per year in surface waters are moved into deep-sea sediments;[12] however, this mechanism is sensitive to disturbance and relies on ecosystems' good health over the longer term similar to the physical carbon pump.



(Ocean and Climate Initiative Alliance)

4

Assessing the readiness of BCEs

The pros and cons of different ocean project approaches and their indicative readiness for investment.

The ocean offers many opportunities to address climate change, with varying levels of investment and innovation maturity.

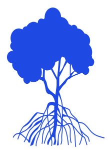
Due to cost and feasibility, no single BCE solution exists that will remove sufficient carbon to meet science-based targets. BCE solutions should consider cost effectiveness, scalability, regulatory acceptance, and wider ESG benefits. This section showcases the main BCE approaches ranked by an indicative maturity in terms of current adoption and implementation-readiness. Ecosystem benefits are highlighted to show that carbon sequestration is not the only driver for investing in each BCE solution.

1 Ocean vegetation restoration

Ecosystem Benefits: Boosts fish stocks and food security, biodiversity protection, water filtration, and coastal protection; and enhances local and open ocean fishermen's livelihoods.

Investment Readiness: High — multiple projects are proven successes and are operating in the market currently.

Coastal wetland vegetation, like mangroves, are critical to biodiversity by filtering water and providing habitats to many species, specifically during the juvenile life stage.[13] This strengthens the overall health of marine biomass, positively impacting fisheries and food security. Mangroves protect the coastline against natural disasters, with their density reducing the force of waves, and their extensive root network providing strong anchorage and wetland stability.[14] On top of this, they increase food security and economic activities for coastal communities such as fisheries and tourism.[15]



Protecting one hectare of

Mangrove

=

Up to **1,100** tons of carbon

25x more coral reef fish and threatened species

$1,079 tourism value per year

50% reduction in storm impacts

Along with protection and conservation efforts, restoration projects can increase the carbon capture capacity of natural areas. Coastal and aquaculture vegetation are excellent carbon sinks due to highly productive growth rates and the ability to store carbon for long periods of time.[16] Uniquely, mangroves store carbon predominately in the soil with relatively little in the trunks and leaves meaning the majority of stored carbon is robust as it isn't lost should the aboveground elements of mangroves be destroyed. Comparing this to most forests, there is more of an even split between above- and belowground storage (however, it should be noted there are skews in certain regions like the Amazon where the majority is stored aboveground (e.g. leaves) and boreal forests where the majority is belowground (e.g. in the soil).

As well as storing carbon, seaweed farming (macroalgae aquaculture) brings multiple benefits, notably as a source of food,[17] as well as biofuel production, fertilizer and feed to lower agricultural emissions.[18] Seaweed production, which favors small-scale farming,[19] provides an alternative source of income for fishing communities suffering from competition from large-scale commercial fishing and dwindling stocks due to overexploitation.[20,21]

❷ Ocean alkalinity enhancement

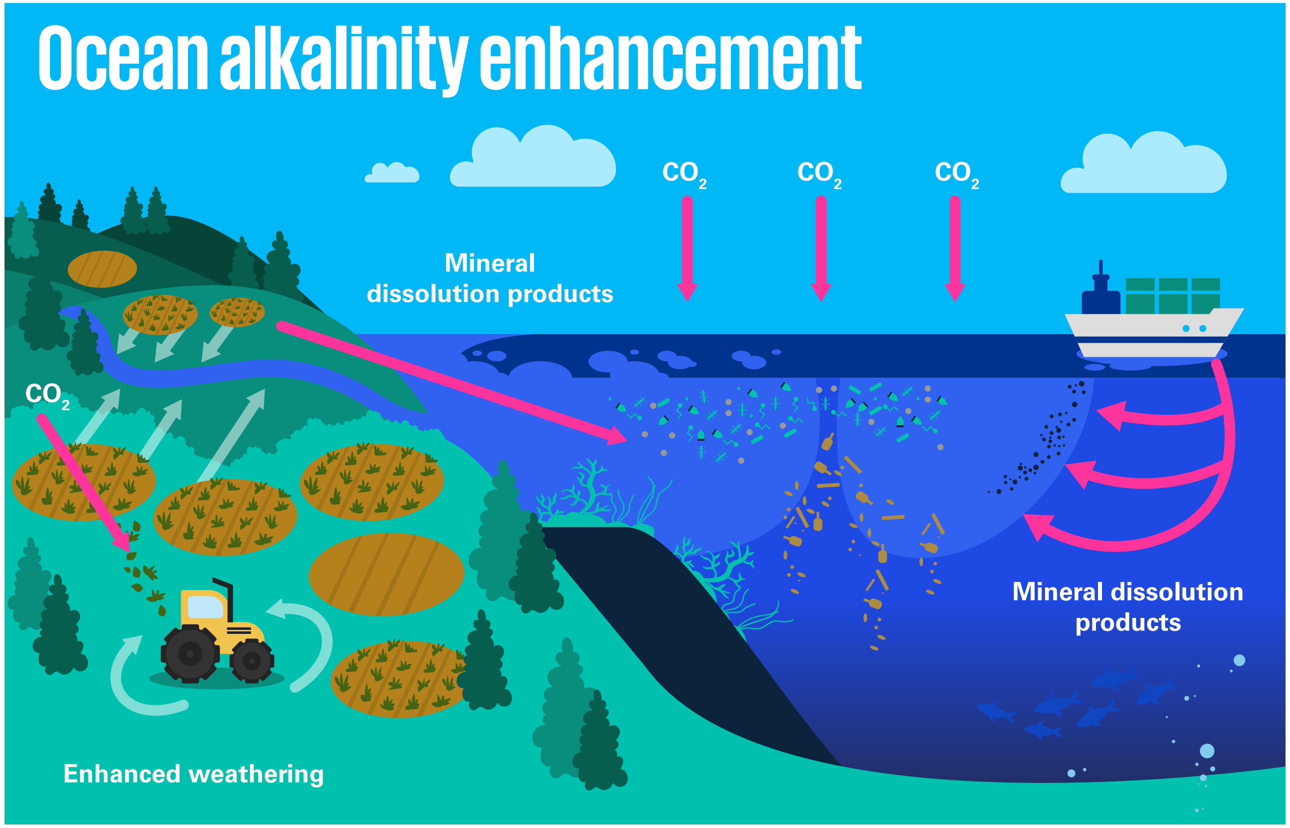
Ecosystem Benefits: Provides stability to currents and food web dynamics; promotes coral reef regeneration and protection.

Investment Readiness: Medium — currently, a few projects are ready for implementation; however, most are in impact refinement and approval states.[22]

This approach involves increasing (adding) the concentration of alkaline minerals in the ocean, which increases the volume of CO_2 removed from the atmosphere through a series of reactions that convert dissolved CO_2 into stable bicarbonate and carbonate molecules, which in turn causes the ocean to absorb more CO_2 from the air to restore equilibrium (positive feedback loop).[23]

These alkaline minerals can come from either natural sources, through enhanced weathering, or by depositing man-made alkaline-like ground carbonate or silicate rocks.[24] Encouragingly, the carbon capture here is essentially permanent because of the physical pump process that transports carbon to the deep ocean.

Research suggests that enhancing ocean alkalinity could also reduce ocean acidification, which currently harms valuable ecosystems like coral reefs by making water too toxic for animals.[25] Furthermore, certain minerals — like silicates — may provide ecological benefits, releasing nutrients that increase ocean productivity.[26] However, alkalinity enhancement is hard to scale, may be costly, and can cause indirect environmental pollution from the mining operations necessary to source the minerals.[27]



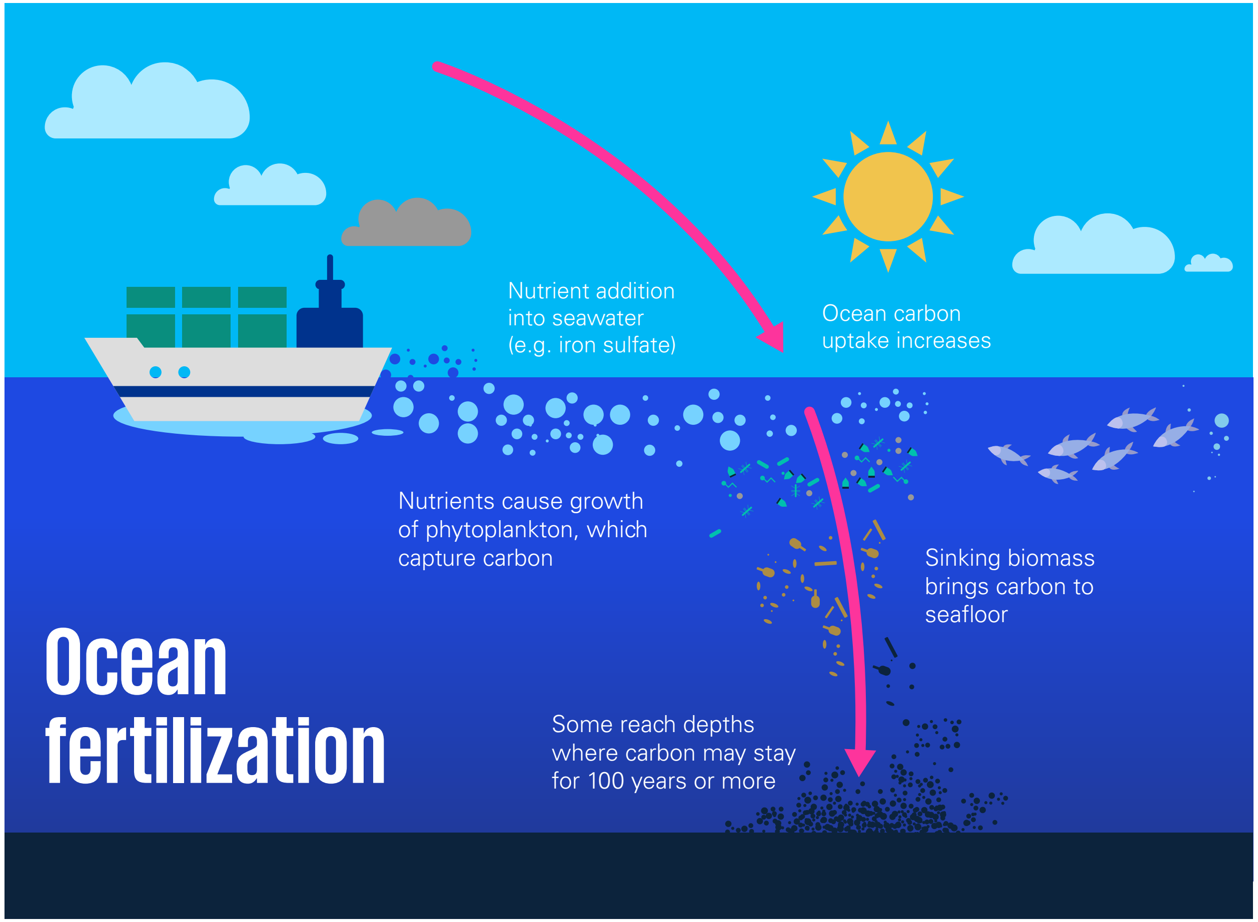
❸ Ocean fertilization

Ecosystem Benefits: Provides stability to the foundational structures of ocean food web and dynamics.

Investment Readiness: Low — Most projects are in either testing or refinement stages.[28]

By adopting the principles of biomimicry to restore and support ocean ecosystems, ocean fertilization focuses on improving the concentration of limited nutrients (iron, phosphorus and nitrogen) in the surface waters, which stimulates growth and production of phytoplankton, increasing carbon uptake and deep-sea ocean carbon capture through the natural ocean downwelling and upwelling processes (biological pump).[29] Importantly, this approach resists reversibility from both human and natural disasters, which helps ensure long-term protection and benefits.[30] Additionally, by raising phytoplankton stock, there is a potential to increase fish biomass to improve food supplies and aid the fishing industry through boosting the biomass of foundational food web species, meaning this approach can provide both biosphere and economic returns.[31]

Despite these promising benefits, local ecosystems may suffer as a result due to deoxygenation, nutrient depletion, and sub-surface ocean acidification,[32] although these concerns are uncertain, they may be dependent on both the scale and location — as research suggests that effects could be worse in shallow coastal waters. For this approach to be widely adopted, it must satisfy environmental concerns, address scalability,[33] and establish more robust cost effectiveness estimates,[34] which trial projects are currently assessing.

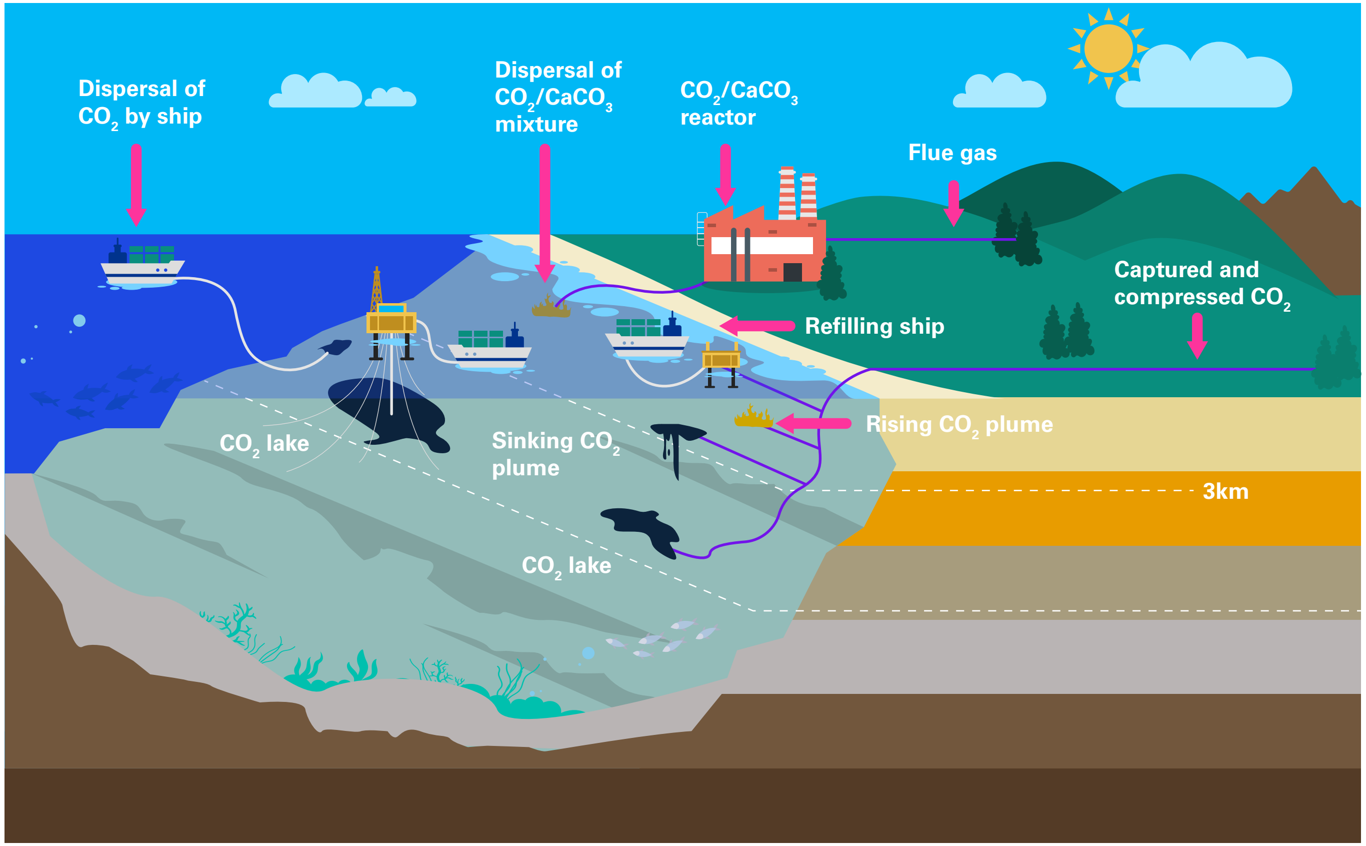


❹ CO_2 injections

Ecosystem Benefits: Prevention of CO_2 entering oceans, countering temperature rises and ocean acidification.

Investment Readiness: Low — most projects are in assessment and testing stages.[35]

To date we have seen small-scale experiments and research to evaluate the efficacy of injecting CO_2 directly into the deep ocean, effectively by-stepping the atmospheric stage, with general resistance to reversibility.[36] This approach requires significant investment to develop the infrastructure to reach such depths (which arguably offsets the 'good' it is designed to do),[37] while also increasing the dissolved CO_2 content which will perpetuate ocean acidification that would continue to harm marine life.[38] Although injection would have limited impact on surface ecosystems, the impact on the deep sea environment is unclear and needs further research, which is a key reason as to why this option is at the end of the readiness curve.[39]



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Three ways to drive greater BCE adoption in climate plans

Helping BCEs become a mainstream carbon and climate solution

Although there are several barriers that stand in the way of large-scale BCE adoption, the necessity of finding viable ecosystem solutions should be a conduit to removing these barriers. Below are three ways in which companies and governments can increase adoption of BCEs and stimulate global interest and adoption.

1 Include BCEs as part of your organization's climate strategy

Voluntary carbon markets enable businesses, governments, NGOs and investors to buy carbon credits from projects that are meaningful to their business and are proven to tackle climate change through carbon capture or emission reductions, thus providing much-needed capital for the net-zero economy. These credits — which represent volumes of reduced, avoided or removed carbon — are used to offset the emissions made by the purchasing organization (for more detail on this see our Blue Wealth of Nations report).

Understandably, investors are pursuing due diligence to evaluate project feasibility, and there is a pressing need to quantify and verify their effectiveness, given the significant sums involved and the time taken to develop new methods. Leadership from organizations can showcase the benefits of BCEs as part of their wider climate strategy (both for emission offsetting and nature positive benefits). Showcasing research and communications can also broadcast the BCE opportunity to a wider audience and make the ocean a central part of the fight against climate change and biodiversity loss.

A range of innovative carbon capture and storage projects, including BCEs, involving both the public sector and private companies, are benefiting from these investments. One example of a BCE initiative is the protection and restoration of 11,000 ha of mangrove forest in Cispatá Bay, Colombia, which will reduce potential emissions by 17,000 metric tons of CO_2 within 2 years. A tech giant is investing in the project as part of its emissions reduction strategy.

❷ Integrating BCEs in verified offset markets will allow for investors and adopters to gain a reliable financial return alongside ecosystem benefits

Carbon offset protocols provide a framework for verifying greenhouse gas emission reduction activities. Developments like the Seascape Carbon Initiative[40] and VERRA aim to generate similar standards for the BCEs, through research and measurement, to drive ocean-related capital market activity.

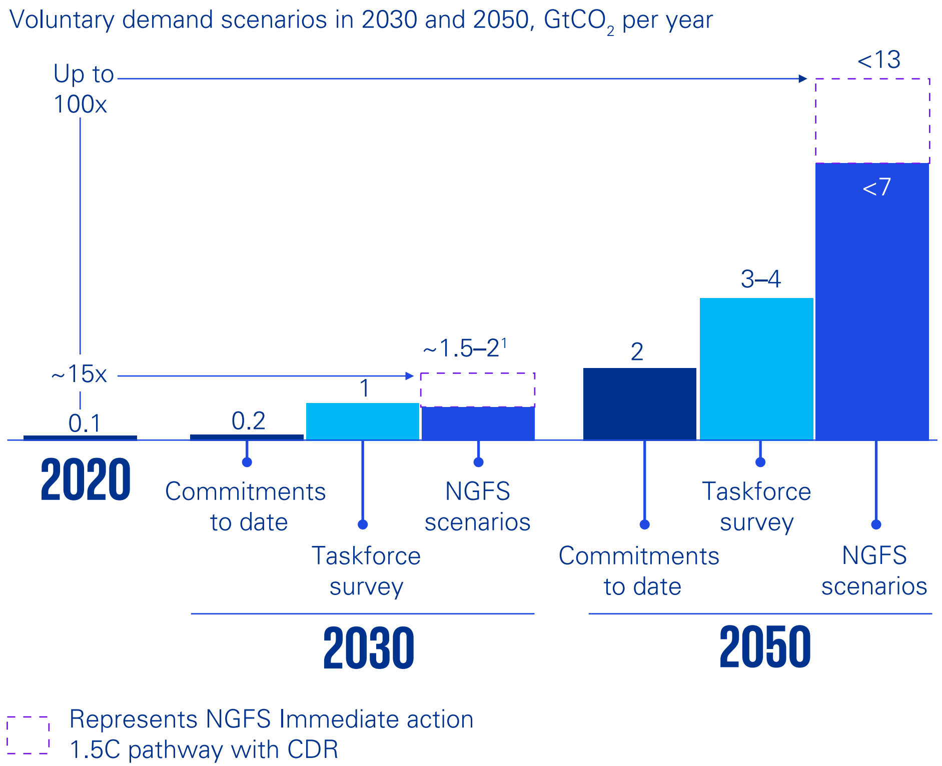
Having a carbon standard that reflects the intricacies of BCEs will be particularly valuable for emerging nations with substantial ocean footprints, such as small island states — like Madagascar and the Solomon Islands — which have lengthy coastlines and/or shallow shelves that could support extensive blue carbon habitats.

The value of voluntary carbon credit prices surged in 2021, with S&P Platts carbon price assessment rising by 900 percent,[41] as companies offset their emissions to meet formal and voluntary net-zero targets. Assessments are expanding to include carbon removal, avoidance, renewable, and methane-collection credits along with the potential to establish BCEs as an important source of carbon capture and biodiversity protection.

Demand for carbon offsets will need to increase by a factor of at least 15 by 2030

Voluntary carbon markets currently only represent 0.5 percent of the reductions pledged in Nationally Determined Contributions (NDCs) by 2030 — and only 0.2 percent of the reductions needed to limit the global temperature rise to 1.5 degrees.

The Taskforce on Scaling Voluntary Carbon Markets (TSVCM) has estimated that carbon offsets could grow in value to between **US$5 and US$50 billion by 2030.**



Analysis and visual from TSVCM Report; Network for Greening the Financial System (NGFS). Does not take into account the split of credits traded in compliance vs. voluntary markets, and does not include portions of removal/sequestration that will be funded by compliance markets and mechanisms other than offsets. Additional avoidance/reduction offsets (e.g. household appliances, avoided deforestation) are not included. Commitments to date: commitments of 700 companies and does not include likely growth. Taskforce survey: TSVCM projection of offset demand. NGFS scenarios: removal/sequestration for 1.5 and 2 degree scenarios.

Source: The blue wealth of nations, KPMG International, October 2021

❸ Integrate BCEs into countries' NDCs pledges

Another effective way to speed up BCE adoption is to include blue carbon commitments within national determined contributions (NDCs). Originating in the 2016 Paris Agreement on climate change, NDCs prioritize activities that can help lower emissions. An estimated 64 countries reference coastal and marine ecosystems in their NDCs, with a majority (45 countries) listing commitments related to mangroves, and 10 for seagrass.[42] Tidal marshes are not specifically mentioned, although many NDCs refer generally to wetlands or commit to using the Intergovernmental Panel on Climate Change (IPCC) Wetlands Supplement.[43] A few countries, such as the Bahamas and Belize, have ambitious, quantified targets for BCEs in their NDCs, but many still lack any measurable goals.[44]

The IPCC Wetlands Supplement provides guidance on how to integrate wetlands into broader national targets, including generating carbon credits for conservation and restoration. However, just three nations — Australia, the United Arab Emirates and the US — report carbon emission and removal associated with actions in coastal wetlands,[45, 46, 47] and even these are limited to a few pilot projects, mostly within mangroves. Therefore, there is much opportunity.

Countries like Australia are using existing or new frameworks to help identify blue carbon restoration opportunities, to help ensure BCEs are included within the domestic carbon accounting framework.[48,49] Standardized accounting protocols for carbon benefits should also help make projects more attractive to investors,[50] aided by low-cost data collection such as remote sensing and field sensors, to produce robust assessments of effectiveness.[51]

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In many instances, the political will — across countries and political parties — for nature-centered climate strategies is deeper and more durable than other solutions more narrowly focused on carbon mitigation. With that in mind, companies and countries that strengthen their resolve on opportunities and investments in the BCE space can contribute not just to positive climate outcomes and investments, but also to bridging an increasingly urgent political divide on climate policy in and of itself. A wider private sector view of the tangible benefits that BCEs can provide above and beyond their carbon sequestration potential can also act as a force multiplier of positive private sector action in this space.

6

The blue economy is an untapped opportunity for progressing climate and nature-positive plans

BCEs are an essential part of the global drive to counter climate change, protect biodiversity and enhance livelihoods by capturing carbon and keeping ocean and freshwater systems healthy and productive to help ensure sustainable future. BCEs provide a clear win–win situation for organizations looking to offset their carbon emissions while also investing in a nature-positive strategy.

But there's an urgent need to increase awareness by building compelling scientific and commercial arguments for faster, wide-scale adoption. At a global level, governments and other stakeholders can push the agenda of the UN Decade of Ocean Science (2021–2030) and UN Decade on Ecosystem Restoration (2021–2030).[52]

Both larger, developed countries, as well as the developing world, can address climate change through coastal restoration or habitat creation, to capture carbon and protect against rising sea levels. The main beneficiaries would be those with extensive, carbon-rich BCEs that have already experienced high rates of loss.[53]

Companies can seek to include BCE projects as part of their carbon offset program to meet decarbonization targets, leading by example, protecting oceans, biodiversity and reducing carbon. Such behavior demonstrates the win–win of blue carbon offset projects.

In building a strong case for BCE carbon capture, however, a lack of existing data to assess either the extent of BCEs or carbon stocks, particularly in the case of tidal marsh and seagrass ecosystems remains a barrier. Therefore, initiating, measuring and reporting BCE projects will create a global library of success, unlocking much-needed capital to help drive a net-zero future.

7 How KPMG can help

KPMG firms have deep experience in supporting organizations to establish their blue economy strategy. KPMG professionals can help organizations integrate blue economy considerations within their corporate and climate strategies.

We assist organizations with identifying and accessing funding for blue economy related investments and projects, aligning and reporting against the evolving TNFD, supporting and developing energy transition to integrate blue energy sources, and supporting ways to protect and promote the social aspects of the blue economy.

Our coastal and marine sector specific service offering provides expertise in climate scenario planning and assessment with additional focus on the management of fresh-water assets and infrastructure. This includes additional support with the planning and collection, monitoring, and interpretation of water use using propriety data analytics.

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