

SUSTAINABLE DEVELOPMENT

# *The ocean is key to achieving climate and societal goals*

## Ocean-based approaches can help close mitigation gaps

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The just-released Intergovernmental Panel on Climate Change (IPCC) special report on the ocean and cryosphere in a changing climate (SROCC) (*1*) details the immense pressure that climate change is exerting on ocean ecosystems and portrays a disastrous future for most life in the ocean and for the billions of people who depend on it unless anthropogenic greenhouse gas (GHG) emissions are slashed. It reinforces in stark terms the urgency of reducing carbon emissions expressed in a 2018 IPCC report (*2*). But another just-released report (*3*) provides hope and a path forward, concluding that the ocean is not simply a victim of climate change, but a powerful source of solutions. Drawing on this report organized by the High Level Panel (HLP) for a Sustainable Ocean Economy, which quantifies and evaluates the potential for ocean-based actions to reduce emissions, we outline a "no-regrets to-do list" of ocean-based climate actions that could be set in motion today. We highlight the report's analysis of the mitigation potential and the required research, technology, and policy developments for five ocean-based mitigation areas of action: renewable energy; shipping and transport; protection and restoration of coastal and marine ecosystems; fisheries, aquaculture, and shifting diets; and carbon storage in the seabed (see the figure). Make no mistake: These actions are ambitious, but we argue that they are necessary, could pay major dividends toward closing the emissions gap in coming decades, and achieve other co-benefits along the way (*3*, *4*).

These five areas were identified, quantified, and evaluated relative to achieving the 2030 Agenda for Sustainable Development. The report concludes that these actions (in the right policy, investment, and technology environments) could reduce global GHG emissions by up to 4 billion tonnes of carbon dioxide equivalents in 2030 and by up to 11 billion tonnes in 2050. This could contribute as much as 21% of the emission reduction required in 2050 to limit warming to 1.5°C and 25% for a 2°C target. Reductions of this magnitude are larger than the annual emissions from all current coal-fired power plants worldwide. Considering each action area through a technical, economic, and social/political lens, the report concluded that carbon storage in the seabed requires considerable further investigation to address concerns regarding the impacts on deep ocean environments and ecosystems, but that the other four ocean-based sectors have substantial mitigation potential and could be readily implemented or initiated with the right policies, incentives, and guidance (*3*).

### COMPREHENSIVE AND HOLISTIC

Even though all five areas have been previously proposed (*3*, *5*), there has been little traction, perhaps in part because their quantification was uneven, their collective potential impact was unclear, and challenges exist to bring each to scale. As a result, few nations have created a "to do" list for ocean-based climate action. For example, although many countries refer to coastal and marine ecosystems in their Nationally Determined Contributions (NDCs) under the Paris Agreement, only eight include quantified measures

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Mangrove ecosystems such as this stand in the Central Visayas, Philippines, along with salt marshes and seagrass beds, are powerhouses of carbon storage that could contribute substantially to mitigation of climate change.

to capture the value of these ecosystems in terms of carbon sequestration and storage (*5*) [see supplementary materials (SM)]. Only one country incorporates domestic shipping in its NDC, and only two refer to the potential of ocean-based renewable energy (SM). We believe that the HLP report's conclusions about the potential magnitude of ocean-based mitigation actions could trigger more countries, industries, and others to embrace such actions and make achievement of the Paris Agreement 1.5°C target more feasible.

The HLP report quantifies and synthesizes a comprehensive package of ocean actions that begin to construct a more complete picture of a future sustainable ocean economy. It aims to promote a pivot from theoretical discussions to actions. Already, under the guise of the "blue economy," some countries are beginning to identify and implement a range of ocean actions focused on job creation and seafood production. However, to achieve a sustainable ocean economy will require both serious attention to climate change and more integrated and holistic strategies to understand, use, and conserve the marine environment. Current uses and policies are highly siloed by sector and mostly ignore climate change. Applying a comprehensive climate lens to more holistic efforts can greatly enhance their effectiveness. It could also reveal opportunities to colocate options explored in the report and leverage additional co-benefits. For example, properly designed Fully Protected Marine Protected Areas (MPAs) can simultaneously sequester and store carbon, protect wildlife, and enhance adjacent fisheries, achieving co-benefits across multiple Sustainable Development Goals while contributing to climate goals (*6*).

Given inherent uncertainties in estimating complex developments several decades into the future, scientific research and policy development are particularly vital because many of the approaches are relatively new or require integration across sectors and policies. Consumer awareness, national targets, incentives, marine spatial planning to organize use of the marine environment, and stable economic and regulatory frameworks for stimulating the development of new energy systems will all be core elements for success.

## Renewable energy

In the short term, it is important to set clear national targets for increasing the share of ocean-based renewable energy (e.g., tidal, wave, and offshore wind) by 2030 and 2050, coupled with inclusive ecosystem-based marine spatial planning to deconflict uses of the ocean, achieve co-benefits, and ensure long-term resilience of marine ecosystems. Targets will help provide the signal and certainty that businesses and investors require to expand into new markets and compete with land-based renewable energy. In the longer term, investment should target research and development (R&D) aimed at moving technologies into deeper-water sites (e.g., floating offshore wind-energy technologies) to access larger areas of energy resources while minimizing adverse impacts on wildlife and ecosystems.

## Shipping and transportation

Achieving full decarbonization of the marine shipping and transport sector represents a substantial challenge, but one that could be incentivized and enabled with new policies and investments. Alternative fuels and decarbonized supply chains and port facilities will be required. In the short term, substantial reductions can be made by using technologies and practices available now to improve the fuel efficiency of ships. For example, the International Maritime Organization (IMO) can redesign the Energy Efficiency Design Index, which sets design requirements for new ships, to optimize vessels for minimized fuel consumption under realistic sea conditions (*3*). Policy measures could go beyond the IMO Ship Energy Efficiency Management Plan to incentivize maximum operational efficiency of the existing and new fleet by no later than 2030. Advancement of hybrid power systems including combustion engines, fuel cells, and battery technologies is an important stepping stone. In the longer term, putting a price on carbon can help close the price gap for low- and zero-carbon fuels.

## Blue-carbon ecosystems and seaweeds

Halting further loss and enabling restoration of coastal "blue carbon" ecosystems, such as mangroves, seagrasses, and salt marshes, can prevent further release of a considerable amount of GHGs such as $CO_2$ (*3*, *7*). Although these blue carbon ecosystems represent only 1.5% of the area covered by terrestrial forests, their loss and degradation are equivalent to 8.4% of $CO_2$ emissions from terrestrial deforestation, largely due to the exceptionally high organic content of the sediments that are stabilized by blue carbon ecosystems (*7*). Integration of blue carbon ecosystems into national GHG inventories and associated climate targets and plans could incentivize such efforts. The designation of MPAs by national or subnational governments or other authorities is also a key tool to achieve these goals, but they must be Fully or Highly Protected MPAs, which are well designed, implemented, resourced, and enforced (*8*). Achieving the high levels of mitigation potential identified in the report through conservation and restoration is dependent on increased investment in protection, restoration, careful monitoring, and expansion of ecosystem cover where sea level rise provides new opportunities.

Looking farther into the future, seaweeds (macroalgae) hold promise (*3*). Seaweed products might replace products with a higher $CO_2$ footprint, thereby avoiding emissions (rather than directly contributing to sequestration) in fields such as food, feed, fertilizers, nutraceuticals, biofuels, and bioplastics. The addition of seaweeds to diets of ruminant mammals (particularly sheep and cattle) could play an important role in reducing enteric methane emissions through secondary metabolites that alter rumen conditions. For example, in vitro experiments have shown that the red alga *Asparagopsis taxiformis* can reduce methane emissions from ruminants by up to 99% when constituting only 2% of the feed, and several other common species show potential methane reductions of 33 to 50% (*9*).

## Seafood in human diets

The majority of protein harvested from the ocean for human food consumption has a

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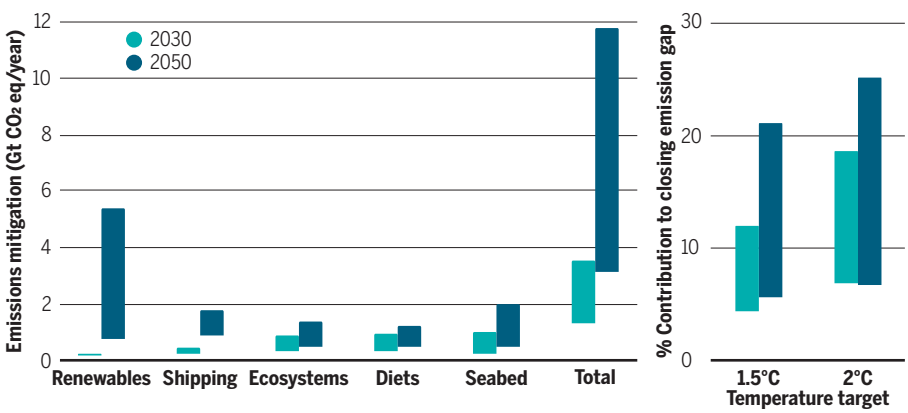
substantially lower carbon footprint than terrestrial animal-based protein, particularly ruminants (*3*). In the short term, reforming fisheries practices to reduce their carbon emissions while optimizing the amount of fish caught sustainably per fishing effort could have a substantial impact of lowering emissions as well as increasing the catch and income of wild capture fisheries (*3*, *10*, *11*). Encouraging diet shifts to include more sources of sustainable low-carbon protein from the ocean could play an important role with no additional investment in technology required. Others have pointed to the greater health and environmental benefits of more seafood in people's diets (*12*, *13*), but the potential climate benefits of low-carbon ocean-based proteins is a relatively new insight. Such large-scale shifts in food policy and behavior are daunting. The considerable climate benefits, however, should help catalyze additional motivation. In the longer term, a well-structured price on carbon, detailed full life-cycle assessments of emissions from alternative feeds, targeted investments, and information and certification campaigns would help prioritize low-emission feed options for aquaculture and catalyze a diet shift away from emission-intensive land-based sources of animal protein.

## Potential mitigation contributions of ocean-based activities

Figures reflect estimated maximum and minimum values identified in (*3*). See full report for details on data and methods. Seabed carbon storage requires further research on environmental safeguards before it should be deployed at scale.




### Seabed storage

There are substantial challenges in ensuring long-term, economically viable storage of carbon in the seabed that has minimal negative impact on deep-sea ecosystems. Although the theoretical potential is very high and there are commercial projects in operation such as the Sleipner project in Norway (*14*), this option requires resolution of these issues before it should be broadly embraced at climatically relevant scales.

### CLIMATE PLANNING

NDCs offer an important short-term opportunity for many nations to embed or elevate ocean-based mitigation opportunities into national decision-making and budget cycles. The IPCC special report on 1.5°C (*2*) found that "the chances of failing to reach a 1.5° pathway [will be] significantly increased if near-term ambition is not strengthened beyond the level implied by current NDCs." For many countries, a number of the actions outlined above could help. Countries have the opportunity to submit new or updated NDCs during 2020, setting priorities for climate action for the next 5 to 10 years. Inclusion of clear, time-bound targets, policies, and measures for ocean-based mitigation offers an immediate opportunity for governments to ensure that the potential of ocean-based actions is included in their national priorities. For example, although not specific to offshore wind, there are 162 references to generating renewable wind energy in the NDCs, indicating potential for ensuring clear targets, policies, and measures aimed at advancing offshore wind capabilities in countries where circumstances permit (SM).

Similarly, incorporation of blue carbon into NDCs is a clear path forward. NDCs, with their near-term 5- to 10-year focus, could be complemented by long-term, low-GHG emission development strategies. To date, Fiji, the Republic of the Marshall Islands, Canada, Japan, and Mexico have integrated ocean-based mitigation opportunities into their strategies (SM). The United Kingdom highlights the ocean as a key element of climate strategies and refers to the impacts on ocean health as a key reason behind its climate ambitions (SM). Seychelles, Bermuda, Curacao, and Tonga are engaged in marine spatial planning efforts that provide lessons for harmonizing ocean uses in the present while focusing on the future (SM). These strategies can provide guidance for enhancing NDCs, as countries align long-term visions with short- and medium-term actions. They can also ensure that a country's climate plans align with efforts to pursue strong, sustainable, balanced, and equitable growth (*15*). The strategies also begin to reveal the scale of change needed to bring national climate action in line with the Paris Agreement's global ambition. Across all of the ocean-based action areas, ambitious mitigation targets must be considered within local socioeconomic contexts to prevent perverse outcomes.

The findings of the SROCC bring the future of our planet and humanity into sharp focus. For far too long, the ocean has been mostly absent from policy discussions about reducing carbon emissions and meeting the challenges of climate change. The HLP report brings new insights to emphasize the potential central role of the ocean within the climate mitigation agenda. Ocean-based actions provide increased hope that reaching the 1.5°C target might be possible, along with addressing other societal challenges including economic development, food security, and coastal community resilience. ■

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### SUPPLEMENTARY MATERIALS

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