# Opportunities for Ocean-Climate Action in the United States

## Summary for policymakers

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# Introduction to the report

Addressing climate change will require reducing greenhouse gas (GHG) emissions from all sectors of the economy ("mitigation"). Mitigation measures such as renewable electricity generation and low-emissions vehicles are well known and have been integrated into U.S. policy deliberations. Yet the mitigation potential of ocean-based measures—such as offshore wind energy and reducing emissions from shipping—have not been as widely recognized to date.

To address this gap and help policymakers evaluate the relative merits of ocean-based mitigation measures, this report presents a quantitative estimate of the GHG emissions reduction potential associated with ambitious but feasible deployment of five solutions:[1]

- Offshore wind and other marine renewable energy deployment
- Coastal "blue carbon" ecosystem protection, restoration, and seaweed cultivation[2]
- Eliminating emissions from U.S. domestic and international shipping
- Fisheries and aquaculture management and production efficiency improvements as well as dietary shifts toward greater seafood consumption
- Capture of GHG emissions from point sources (e.g., industrial facilities) and storage of those emissions in geological formations below the seafloor—referred to here as carbon capture and sequestration (CCS)

We did not assess the emissions impact of a moratorium on new offshore oil and gas leases, although constraining global fossil fuel production is considered essential to achieving needed emissions reductions (Heede and Oreskes 2016).

**The report's findings suggest that investments in ocean-based climate mitigation measures can help the U.S. reduce its GHG emissions by 13.7 percent of needed reductions by 2050, or 704 Mt $CO_2$e.**[3] Through a combination of ambitious but plausible policy and financial incentives implemented today, ocean-based mitigation measures could play a major role in a low-carbon U.S. future.

These investments can also yield significant co-benefits including:

- Job creation in new industries, and providing comparable options for workers transitioning out of the fossil fuel industry
- Economic development through developing new industries and technologies, and improving American global competitiveness
- Reducing air and water pollution by replacing fossil fuel power plants, capturing emissions from heavy emitters, and avoiding oil spills
- Improving public health outcomes through reduced health burdens from air and water pollution
- Environmental justice by reducing impacts in communities disproportionately affected by the impacts of air and water pollution
- Reducing risk from coastal hazards such as extreme weather, sea-level rise, and flooding
- Environmental benefits including habitat creation, ecosystem protection and restoration, and coastal recreation opportunities

This Summary for Policymakers presents a summary of the report including:

- The need for ocean-based climate measures
- The key findings for each mitigation measure, including:
  - GHG mitigation potential of each action area
  - Co-benefits beyond mitigation potential
  - Concerns that could affect implementation
  - Recommended policy, research, and technology needs to achieve these emissions reductions

[1] Each author defined "ambitious" but plausible mitigation scenarios for each mitigation opportunity. The Paris Climate Agreement encourages "holding warming well below 2 degrees C, and pursuing efforts to limit warming to 1.5 degrees C." The U.S.'s emissions reductions efforts are currently rated "critically insufficient" by the Climate Action Tracker (an independent group that uses scientific analysis to track government climate action)—the lowest possible rating. For some mitigation opportunities, data was available to define a future scenario that is compatible with holding warming well below 2-degrees (e.g., offshore wind), but for others (e.g., blue carbon) data was not available to define a scenario that was compatible with well below 2-degrees of warming.

"Plausibility" varies by chapter and solution, and there is no universally accepted definition of a plausible deployment pathway for each of these measures. Each chapter outlines the key assumptions underpinning the analysis in the chapter, but reasonable individuals may disagree on these fundamental assumptions. These analyses should also be viewed as a snapshot in time. Market, policy, and social dynamics can affect the many assumptions that have gone into producing these analyses.

[2] The term "blue carbon" refers to GHGs, specifically carbon dioxide, that are captured by the world's ocean and coastal ecosystems. Seagrasses, mangroves, salt marshes, and seaweed along coastlines capture and hold, or "sequester," carbon dioxide, acting as a natural mechanism to remove carbon from the atmosphere—similar to trees and forests on land.

[3] This report defines "required emissions reductions" as the emissions reductions needed to put the U.S. in line with scenarios for global average temperature increase of 2 degrees Celsius of warming by 2100, as defined by the **Paris Climate Agreement**. There are numerous ways to achieve this pathway. In past international climate negotiations, the U.S. has favored emissions reductions requirements that are equal and proportional across all countries—equal per capita emissions. That is the approach used in this report, which suggests required annual emissions reductions of 2524 Mt $CO_2$e by 2030, and 5150 Mt $CO_2$e by 2050. Please see the full report for methodology details.

## The need for climate action now

**The U.S. is currently experiencing the direct effects of a changing climate. Climate impacts such as extreme weather, sea-level rise, flooding, and temperature increases are putting our economy and way of life at risk** (Behnam and Litterman 2020). The **U.S.'s Fourth National Climate Assessment** describes in stark detail the impacts of a changing climate—including its acute impacts on our coasts and oceans.[4] The assessment documents trends toward high-tide and storm surge flooding, erosion, saltwater intrusion into groundwater, greater rainfall and river runoff, increasing water and surface air temperatures, ocean acidification, and ocean deoxygenation. These changes threaten coastal businesses, real estate, fisheries, beaches, tourism, and the biogeochemical processes that help regulate our climate. Children, the elderly, households where English is not the primary language, and those in low-income communities are the most vulnerable to these threats (U.S. Census Bureau 2016). These vulnerabilities are exacerbated by the COVID-19 pandemic and the associated economic recession.

**Direct action is needed now to manage current impacts and avoid the worst effects. The Intergovernmental Panel on Climate Change (IPCC) has determined that, to avoid large-scale economic and social disruption, the U.S. must shift our current emissions trajectory within the next decade** (Masson-Delmotte et al. 2018). The U.S. is expected to lose 2.3 percent of GDP per each degree Celsius of increase in global average temperatures, primarily due to the impact of extreme weather events such as hurricanes and fires (Kahn et al. 2019). The transition to the 1.5 degree scenario outlined in the **Paris Climate Agreement** presents the best opportunity to manage the most adverse effects of a changing climate. This transition will require ambitious and coordinated solutions from all sectors of the U.S. economy, including the ocean and coastal economy.

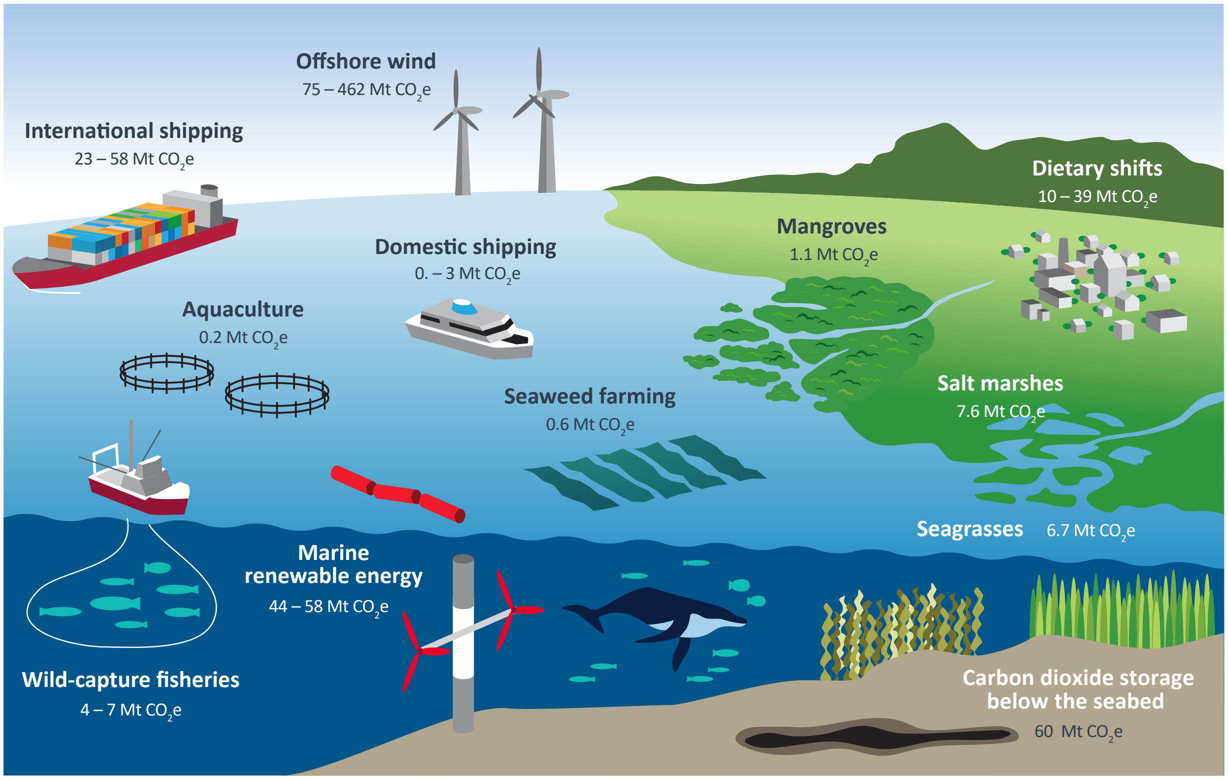
Investments in the five action areas identified here can reduce emissions by an estimated 182 Mt $CO_2e$ per year by 2030, and 704 Mt $CO_2e$ by 2050.

**Investments ocean-based mitigation measures can play a significant role in reducing emissions.** The ocean plays an important and often underappreciated role in regulating the global climate, having absorbed 93 percent of the heat from human-induced global warming to date (USGCRP 2018). Until recently, policy proposals have largely overlooked the opportunity for measures to reduce emissions in the ocean. Investments in the five action areas identified here can reduce emissions by an estimated 182 Mt of $CO_2e$ per year by 2030, and 704 $CO_2e$ by 2050—the equivalent of 7.2 percent and 13.7 percent respectively of emissions reductions required for the U.S. to achieve its contribution to a 2 degree emissions trajectory.[5]

**These investments will also contribute to economic recovery, American global competitiveness, public health, environmental justice, and ocean health.** In addition to emissions reductions, these solutions come with significant co-benefits, primarily in the form of U.S.-based jobs, economic growth, technological innovation, reduction in local air pollution and associated negative health outcomes, protection of coastal communities from sea-level rise and extreme weather events, and safeguarding the biogeochemical processes in our ocean that enable a habitable planet.

[4] The **National Climate Assessment** is a U.S. research assessment that evaluates the impacts of global climate change on the U.S.'s natural environment, agriculture, energy production and use, land and water resources, transportation, human health and welfare, human social systems, and biological diversity no less than every four years as a report to Congress and the President. The report is produced by the U.S. Global Change Research Program (USGCRP) as mandated by the Global Change Research Act of 1990. It is distinct from the **Intergovernmental Panel on Climate Change (IPCC)** reports, which assess the state of scientific, technical, and socio-economic knowledge on climate change for all UN member countries. IPCC reports are produced by scientific experts nominated by UN member governments.
[5] The percentages noted in the text above reflect the maximum contribution of ocean-based measures to the U.S.'s required emissions reductions under the 2 degree scenario with equal per capita emissions reductions.

**Figure 1. Opportunities for ocean-climate action and associated annual mitigation potential in 2050**




Graphic reproduced from Hoegh-Guldberg. O., et al. 2019 with permission from the World Resources Institute.

*Low-end mitigation potential from domestic shipping is greater than 0, but according to EIA, domestic shipping emissions have already fallen significantly, from 17.5 Mt $CO_2$ in 2008 to 6.2 Mt $CO_2$ in 2019. This is likely the result of a change in accounting methodology rather than major emission reductions in the last 11 years.

**Figure 2. Contribution of ocean-based climate solutions to mitigating U.S. emissions in 2050 (maximum Mt $CO_2$e)**

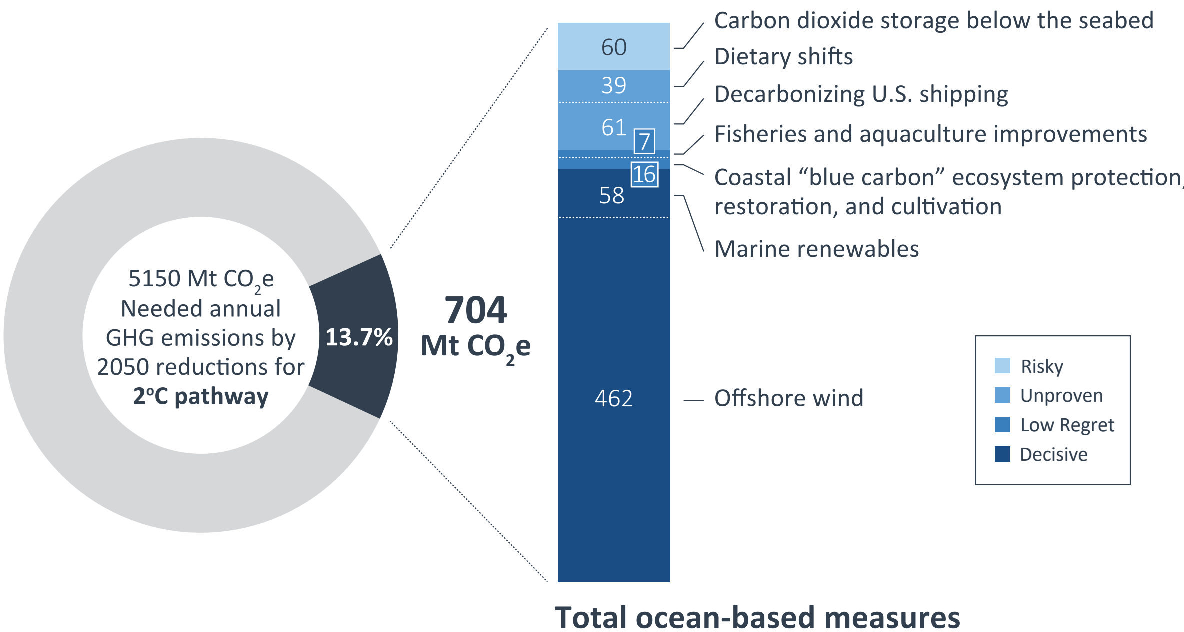


**Figure 3. Co-benefits of ocean-based climate mitigation measures**

| Measure | Co-benefit: Jobs | Economic benefits | Environmental justice and just transition | Hazard reduction | Pollution reduction | Health | Environmental benefits |
|---|---|---|---|---|---|---|---|
| **Offshore wind and marine renewables** | ✓ | ✓ | ✓ | | ✓ | ✓ | |
| **Coastal protection, restoration, and cultivation** | ✓ | ✓ | | ✓ | ✓ | | ✓ |
| **Decarbonizing U.S. shipping** | | ✓ | ✓ | | ✓ | ✓ | |
| **Fisheries and aquaculture efficiency and diets** | ✓ | ✓ | | | ✓ | ✓ | ✓ |
| **Carbon dioxide storage below the seabed** | ✓ | ✓ | ✓ | | ✓ | | |
| Offshore oil and gas moratorium* | | | | ✓ | ✓ | ✓ | ✓ |

This table presents documented and estimated co-benefits of the five ocean-climate mitigation measures and an offshore oil and gas moratorium, based on a combination of literature review and expert interviews. Check marks indicate that co-benefits are present—described more in detail in each chatper. The lack of a check mark does not necessarily indicate a co-benefit is not present, but it did not arise in our review.

*A moratorium on offshore oil and gas was not modeled, but discussed in detail in the Introduction.

# Key findings

## 1. Offshore wind and other marine renewable energy deployment

This section estimates the climate mitigation potential of offshore wind (OSW) from fixed and floating platforms, as well as other marine renewable energy (MRE) deployment such as wave, tidal, current, salinity, and thermal energy technology.

### Mitigation potential

- Total mitigation potential from offshore wind is 75 - 462 million tonnes $CO_2e$ annually in 2050, or up to 8 percent of estimated U.S. emissions. This is the single largest ocean-based mitigation measure.
- Offshore wind is a commercially mature technology with over 28 GW installed globally. U.S. installations represent less than 1 percent of this total capacity today (42 MW), but offshore wind leases, state targets, and solicitations are driving a pipeline of over 9 GW, primarily on the East Coast.
- Marine renewable energy technologies are at an early stage of development, with only 0.53 GW installed globally. Estimated mitigation potential for MRE technologies is 58 Mt $CO_2e$ annually by 2050.

### Co-benefits

- **Job creation** – an estimated 83,000 jobs annually in construction, operations, supply chain, manufacturing, and supporting industry (for 30 GW of production)
- **Economic growth** – an estimated $25 billion in annual economic output, and an overall estimated benefit-to-cost ratio of 12:1)
- **Air pollution reduction** – the potential to replace fossil fuel power plants and to reduce associated criteria pollutants such as PM2.5, NOx, and SOx
- **Public health** – reducing criteria pollutants by displacing fossil fuel power plants could yield public health benefits of $75 million to $690 million annually for the East Coast alone
- **Tax revenue** – 86 GW of OSW could provide $440 million in annual lease payments and $680 million in annual property taxes to the federal government
- **High capacity value for the electric power system** – high capacity factors and consistent production throughout afternoons and evenings; seasonal complementarity to solar
- **Just transition** – can be an option for workers employed in offshore oil and gas with experience in offshore construction operations

### Concerns

- **Higher costs than land-based wind currently** – offshore wind has a levelized cost of energy (LCOE) up to four times more than land-based wind and solar (although costs are already declining in some areas to 1.5 times)
- **Possible human use impacts** including access concerns with commercial and recreational fishing, national defense activities, and navigation
- **Possible cultural use impacts** including impacts on tribal heritage, aesthetic considerations (e.g., views)
- **Possible wildlife impacts** on marine mammals and seabirds

# Policy, research, & technology needs

## Offshore wind

- **Establish national offshore wind deployment targets combined with direct financial support** (such as investment and production tax credits) to grow the market for offshore wind similar to how the federal government and states have supported solar and land-based wind.
- **Identify sufficient sea space for the development of offshore wind through ocean planning and efficient permitting.** The Bureau of Ocean Energy Management plays an essential role in offshore wind siting. Developing national guidelines for siting and a streamlined permitting process could expedite the siting process and address the need to protect ocean wildlife and minimize conflict with other human uses.
- **Support investments in supply chain and infrastructure** through regional planning goals and funding for transmission and port upgrades to service the offshore wind sector.
- **Reduce uncertainty by supporting targeted research** that proves and optimizes large-scale floating offshore wind installations; assesses the capacity value of offshore wind and its cost effectiveness as part of electricity portfolio planning; and assesses and mitigates potential environmental or human-use impacts from turbine installations.
- **Direct funding to advance technology development**. Improvements to turbines, design standards, and integrating technology will help improve the value proposition of offshore wind as a decarbonization strategy.

## Marine renewables

- **Continue research and development** to advance MRE technologies from small-scale prototype testing to large prototype testing, demonstration, and finally early commercial stage. Augmenting funding to existing programs such as the Pacific Marine Energy Center and the Water Power Technologies Office at the Department of Energy (DOE) could support this goal.
- **Direct the DOE to identify the most promising markets for MRE** in order to right-size deployments to market needs, such as ocean observation and navigation, marine vehicle charging, aquaculture, algae farming, desalination, power for island communities, and disaster recovery efforts.
- **Apply the recommendations listed above for OSW once MRE technologies and markets are more mature.** Once MRE technology is more mature and an MRE industry is poised to launch, many of the policies we have recommended for offshore wind related to siting and permitting could be adapted to support scaling-up of MRE.

# Key findings

## 2. Coastal “blue carbon” ecosystem protection, restoration, and cultivation

This section estimates the climate mitigation potential of coastal blue carbon ecosystems via the actions of conserving and restoring mangroves, salt marshes, and seagrasses, as well as cultivating seaweed for purposes of carbon sequestration.

### Mitigation potential

- Total mitigation potential of coastal blue carbon (BC) ecosystems is **16 Mt $CO_2$e annually by 2050**.
- Conservation of existing ecosystems represents 91 percent of the total BC mitigation potential by 2050, by preventing the release of immense amounts of carbon stored in these habitats. Restoration of previously lost habitat accounts for approximately 4 percent of the total BC mitigation potential by 2050.
- Advances in technology and policy are needed to develop large-scale offshore seaweed cultivation solely for the purpose of carbon sequestration. Seaweed produced for human or animal consumption, which does not sequester carbon but which could offset higher-emissions alternatives, was not modeled.

### Co-benefits

- **Hazard reduction** – through reduced susceptibility to erosion, flooding, sea-level rise, and extreme weather events for coastal communities
- **Job creation** – restoration can create 17 - 30 jobs for every $1 million invested, which is more cost-effective than infrastructure or fossil fuels
- **Job creation** – farms could employ thousands of people permanently and seasonally, given the high labor intensity—an estimated 5 employees per 10 hectares, not including seasonal harvesting jobs
- **Coastal recreation** – new opportunities for coastal recreation and tourism through the protection and restoration of coastal wetlands
- **Improved water quality** – seagrasses and coastal ecosystems can act as filters and remove nutrients and other sources of water quality impairment while also increasing oxygen content
- **Increased aquaculture yields** – seaweed cultivation can be used in polyculture with farmed fish and shellfish (e.g., regenerative ocean farming) and boost production as a result of nutrient recycling and water oxygenation.
- **Habitat creation** – seaweed farms create new three-dimensional habitat that could also improve local marine biodiversity and fisheries
- **Pollution reduction** – constructed wetlands can act as “green infrastructure” and serve as important stormwater and sewage treatment infrastructure when properly designed and maintained

### Concerns

- **Continued habitat destruction** (exacerbated by sea-level rise and extreme weather) presents an ongoing threat to emissions reduction potential, as these habitats store significant reserves of carbon that could be released without further protection. The associated economic losses are stark: Louisiana alone is expected to lose ~2,000 square miles of land over the next 50 years, at an economic cost of $3.6 billion in infrastructure assets, $7.6 billion in lost economic activity, and at least $191 billion in storm damage.
- **Achieving the emissions reductions modeled would require major investments in protection and restoration**, as the model projects full restoration of coastal ecosystems by 2050.
- **Seaweed production is not yet economically viable** at scale in the U.S.

## Policy, research, & technology needs

### Conservation & Restoration

- **Strengthen policies to bring BC habitat loss rates to zero, such as a "no net blue carbon loss" policy** and implementing recommendations to strengthen the compensatory mitigation rule (such as a 3 for 1 offset requirement) for unavoidable habitat loss under the Clean Water Act
- **Integrate BC habitat protection and restoration into shoreline protection plans and policies** for coastal flooding and emissions benefits
- **Identify and integrate climate change impacts in conservation and restoration management plans** to ensure BC ecosystems are able to protect carbon storage and sequestration in the face of sea-level rise, coastal erosion, and wetland migration
- **Provide long-term funding for BC ecosystem conservation and restoration**, especially for continued monitoring of GHG emissions
- **Establish national governance of BC to maintain a standardized inventory**, such as the proposed Interagency Working Group on Blue Carbon that will develop and maintain a national map and inventory of BC ecosystems, identify roadblocks to restoration, assess impacts of climate change on BC ecosystems, and ensure continuity of BC data

### Seaweed Cultivation

- Fund research and development to evaluate the use of seaweed aquaculture for climate mitigation

# Key findings

## 3. Eliminating emissions from U.S. domestic and international shipping

This section estimates the climate mitigation potential of efforts to reduce emissions from U.S. domestic and international shipping through development and deployment of zero emission vessels (ZEVs) as well as operational measures to reduce emissions.

### Mitigation potential

- Fully decarbonizing the shipping sector could reduce annual emissions by 61 Mt $CO_2$ in 2050.
- Emissions from U.S. flagged shipping vessels operating both internationally and domestically totaled 75 Mt $CO_2$ in 2019. Under business as usual projections, annual shipping emissions probably will decrease modestly, by 7 Mt $CO_2$ annually in 2030, and by 14 Mt $CO_2$ in 2050.
- Reduction in emissions from international shipping accounts for the majority of mitigation potential in U.S. shipping. Approximately 8 - 21 Mt $CO_2$ in 2030 and 23 - 58 Mt $CO_2$ in 2050 can be reduced through operational measures and transitioning to zero emissions vessels.

### Co-benefits

- **Air pollution reduction** – reductions in criteria pollutants $PM_{2.5}$, NOx, and SOx that come from combustion of shipping fuel while idling in port
- **Improved public health outcomes** – the North American Emissions Control Area contributed economic benefits (primarily for health) of $110 billion in 2020, reduced premature deaths by 14,000, and reduced respiratory symptoms for 5 million Americans (annually).
- **Environmental justice** – reducing port emissions will reduce health burdens from air pollution and respiratory diseases in communities near ports, who are predominantly low-income and Black, Indigenous, and People of Color
- **Fuel savings** – speed reduction for ships (such as an average 10 percent speed decrease) could reduce fuel consumption
- **Economic competitiveness** – Alaska and Hawaii could become re-charging stops for transpacific zero-carbon vessels

### Concerns

- **Significant federal investments** would be required to spur technology development—an estimated $3.5 - 4.9 billion annually through 2050, primarily for land-based infrastructure and production of zero-carbon fuels.

## Policy, research, & technology needs

- **Leverage EPA authority to set federal emissions reduction targets in line with or exceeding IMO targets** for rapid decarbonization of the U.S. shipping sector
- **Implement National Mandatory Vessel Speed Reduction Programs** within 200 nautical miles from shore
- **Reduce localized emissions and promote environmental justice** by mandating zero at-berth emissions for ships in port
- **Establish a centralized monitoring, reporting, and verification data collection system for U.S. shipping**
- **Provide funding to the Maritime Environmental and Technical Assistance program** for research on ZEV ships and port technologies

# Key findings

## 4. Fisheries and aquaculture efficiency improvements and dietary shifts

This section estimates the climate mitigation potential of seafood through addressing key emissions sources in fishing and seafood farming and transitioning U.S. consumption toward lower-carbon proteins.

### Mitigation potential

- Total mitigation potential from **improving the efficiency of seafood and aquaculture production** is 7 Mt $CO_2$e per year by 2050.
  - Effectively managing fisheries informed by sound science, which the U.S. does under the Magnuson-Stevens Act, is a proven way to ensure carbon-efficient production. Maintaining this seminal legislation, and ensuring fisheries can be managed adaptively as the climate changes, is essential.
  - Supporting energy-efficiency measures for fishing vessels and providing incentives for the adoption of hybrid and zero-emission vessels can drive additional emissions reductions in the fishing sector.
  - Converting on-vessel refrigeration equipment to low- or no-global-warming potential technologies can further reduce GHG emissions from wild-capture fishing.
  - Aquaculture in the U.S. has low levels of emissions and mitigation potential, but reducing the carbon intensity of fish feeds could lower the emissions intensity of the production of carnivorous species.
- Total mitigation potential through **shifting consumption patterns toward a more seafood-heavy diet** is 10 - 39 Mt $CO_2$e per year by 2050.
  - Shifting diets represents the greatest opportunity for emissions reductions for seafood but has historically been the most difficult to achieve due to the challenges of influencing consumption patterns. Tax, policy, or behavioral incentives at a large scale would be required to achieve these reductions.

### Co-benefits

- **Improved fish stock health** – sound fisheries management can maintain stocks and help depleted stocks recover from overfishing
- **Increased economic value** – well-managed fisheries can increase the economic value of fishing
- **Reduced fuel costs** – through energy-efficiency improvements such as hybrid vessels, hull maintenance, and propeller upgrades
- **Jobs and economic growth** – expanding U.S. aquaculture production to 2.5 times its current level in 10 years could create 109,500 - 133,400 jobs and add $10.7 - 12.8 billion to the U.S. economy.
- **Climate adaptation** – well-managed fisheries and aquaculture systems can be more resilient to a changing climate
- **Create fishery habitat** – bivalve and seaweed aquaculture can create fishery habitat
- **Reduce pollution** – bivalve and seaweed aquaculture can utilize and store excess nutrients that pollute coastal and marine environments and cause harmful algal blooms (HABs) and eutrophied “dead zones”
- **Health impacts** – shifting to diets with less red meat can reduce the risk of cardiovascular diseases and improve the micronutrient profile of protein consumed

### Concerns

- **Fisheries management is a proven effective strategy that the U.S. is already undertaking** at a federal level, although there are more opportunities in state-managed fisheries
- **Expanding U.S. aquaculture production is likely to face intense competition** from lower-cost producers across the globe
- **Shifting diets away from red meat and toward seafood consumption would require a mix of large-scale policy, tax, and behavior change incentives** that may be challenging to implement and whose impacts are unclear, including possible impacts on red meat producers

## Policy, research, & technology needs

- **Maintain and strengthen fisheries management** by defending and strengthening the Magnuson-Stevens Act, incorporating climate adaptation into fisheries management, and managing fisheries to maximum economic yield
- **Provide grants and loan guarantees for efficiency upgrades** and for low- or zero-emission fishing vessel technology
- **Ratify the Kigali Amendment to the Montreal Protocol** and develop an implementation plan that includes refrigeration equipment for the fishing sector
- **Streamline the regulatory process for offshore aquaculture** while providing protections for the environment and other ocean stakeholders
- **Increase the recommended amount of seafood consumption in the U.S. dietary guidelines**
- **Promote American-produced seafood**

# Key findings

## 5. Carbon capture and storage in the seabed

This section estimates the emissions reduction potential of a suite of technologies and related supply chains required to capture carbon dioxide ($CO_2$) from point sources, to compress and transport the $CO_2$ into geological formations, and to permanently store it in porous rock several thousand meters below the seabed. Combined, these technologies are referred to as carbon capture and storage (CCS).

### Background on CCS

- **CCS encompasses a suite of proven technologies to capture, liquefy, and transport $CO_2$ for permanent storage** in underground geologic formations such as saline aquifers and depleted oil and gas fields.
- **Most future climate scenarios that limit warming to below 1.5 degrees include negative emissions approaches such as CCS.** The amount of $CO_2$ captured via CCS each year might have to multiply by more than 125 times by 2050 from 2016 levels to meet climate goals.
- **CCS has primarily been designed to mitigate emissions from large stationary sources (e.g., power plants, heavy industry, and refineries).** But components of CCS are also a prerequisite for the two negative emission technologies that the IPCC deems essential for meeting international climate goals: bioenergy with carbon capture and storage and direct air carbon capture and storage.
- A major advantage of offshore storage is **that most of the pore space is owned by the federal government and managed by the Bureau of Ocean Energy Management.** This avoids questions of title, ownership, and local acceptance and provides a single point of access for leasing acreage.
- **Twenty years of sub-seabed storage experience in Norway suggests that offshore CCS is technically feasible**, with relatively low risks.

### Mitigation potential

- Based on expert interviews, we estimate that sub-seabed storage in the U.S. will go online in 2025 and grow to approximately 60 million tons of $CO_2$ per year by 2050.
- **In the U.S., sub-seabed formations could store trillions of tons of $CO_2$**, equivalent to thousands of years of current emissions.
- **Low-cost CCS opportunities that are co-located with suitable offshore storage sites are mainly found in Texas and Louisiana** (approximately 15 million tons of annual $CO_2$ emissions), and onshore storage sites are ample, making it difficult to estimate offshore deployment in the near future.

### Co-benefits

- **Job creation** – an estimated 60 jobs per million tonnes of $CO_2$ sequestered per year, or an estimated 38,000 job-years between 2020-2050 under the scenario modeled here
- **Reduced local air pollution and associated health impacts** (SOx, NOx, mercury, and particulates) from heavy emitters if captured and stored
- **Extended lifetime for oil and gas infrastructure** by repurposing for $CO_2$ transport and storage
- **Just transition** – CCS is often supported by unions of power workers given ease of applicability of current skills to CCS requirements as part of a transition to a clean energy economy

### Concerns

- Under current policies, **CCS operations are only viable if costs are below $50 per ton of $CO_2$ stored**. Yet current CCS costs exceed $100 per ton of $CO_2$ for 85 percent of stationary emissions. This is significantly more expensive per ton than many other land-based sequestration measures (e.g., reforestation or agricultural practices to enhance soil carbon storage).
- Large stationary emissions in the U.S. add up to 2.6 gigatons per year of GHG emissions (almost half of U.S. emissions), currently representing the upper limit for mitigation from carbon capture. However, **CCS is currently limited to demonstration efforts that capture 1.1 million tons of $CO_2$ per year, equivalent to 0.04 percent of stationary emissions.**

## Policy, research, & technology needs

- **Enhance and extend the 45Q tax credit** by increasing the credit from $50 per ton of $CO_2$ that is captured and stored to above $65 per ton, and extend the timeframe beyond the current expiration in 2023
- **Amend the Low Carbon Fuel Standard in California to include offshore storage** and adopt a similar standard in other states
- **Conduct a national assessment of the carbon storage potential in deep seafloor environments**
- **Streamline the permitting framework** for $CO_2$ storage to accelerate technology deployment

## A note on an offshore oil and gas moratorium

- **Combustion of fossil fuels is the leading source of U.S. $CO_2$ emissions**, responsible for 75 percent of U.S. anthropogenic GHG emissions in 2018 (EIA 2018).
- **The U.S. was the top crude oil producer in 2018 and 2019, and is also one of the top five leading offshore oil and gas producers globally**, after Saudi Arabia, Brazil, Mexico, and Norway (EIA 2020). The U.S. plays a critical role in the global oil and gas markets.
- **To limit global average temperature increases to 1.5 or 2 degrees Celsius, the world will need to keep proven oil and gas reserves in the ground** (Heede and Oreskes 2016). Continued production and combustion of fossil fuels will prevent the world from meeting climate goals.
- **A moratorium on new offshore oil and gas leases in U.S. waters has broad and extensive bipartisan support**, primarily due to concerns of coastal states and communities and commercial and recreational fishing interests about the risks of oil spills such as the BP Deepwater Horizon disaster as well as public health concerns from air pollution. Offshore drilling is opposed by more than 60 percent of voters (Cooney and Kustin 2019).
- **The GHG impact of an offshore oil and gas moratorium will depend on assumptions made about the market for oil**, which is a highly globalized and volatile market. As the world's leading oil and gas producer, the U.S. has an opportunity to send a powerful signal by banning offshore oil and gas in its waters.

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