OPPORTUNITIES AND ACTIONS FOR OCEAN SCIENCE AND TECHNOLOGY (2022-2028)

A Report by the

SUBCOMMITTEE ON OCEAN SCIENCE AND TECHNOLOGY

COMMITTEE ON ENVIRONMENT

of the

NATIONAL SCIENCE & TECHNOLOGY COUNCIL

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About the Office of Science and Technology Policy

The Office of Science and Technology Policy (OSTP) was established by the National Science and Technology Policy, Organization, and Priorities Act of 1976 to provide the President and others within the Executive Office of the President with advice on the scientific, engineering, and technological aspects of the economy, national security, homeland security, health, foreign relations, the environment, and the technological recovery and use of resources, among other topics. OSTP leads interagency science and technology policy coordination efforts, assists the Office of Management and Budget with an annual review and analysis of Federal research and development in budgets, and serves as a source of scientific and technological analysis and judgment for the President with respect to major policies, plans, and programs of the Federal Government. More information is available at http://www.whitehouse.gov/ostp.

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The National Science and Technology Council (NSTC) is the principal means by which the Executive Branch coordinates science and technology policy across the diverse entities that make up the Federal research and development enterprise. A primary objective of the NSTC is to ensure science and technology policy decisions and programs are consistent with the President's stated goals. The NSTC prepares research and development strategies that are coordinated across Federal agencies aimed at accomplishing multiple national goals. The work of the NSTC is organized under committees that oversee subcommittees and working groups focused on different aspects of science and technology. More information is available at http://www.whitehouse.gov/ostp/nstc.

About the Ocean Policy Committee

The predecessor of the Ocean Policy Committee (OPC), the National Ocean Council, was established in 2010 by Executive Order 13547 to coordinate relevant Federal agency activities and implement the National Ocean Policy as described in the EO. In 2018, Executive Order 13840 created the OPC to coordinate Federal actions on ocean-related matters and collaborate with the ocean community on ocean-related matters, identify priority ocean research and technology needs, and leverage resources and expertise to maximize the effectiveness of Federal investments in ocean research. And in 2021, the National Defense Authorization Act codified the OPC and named as co-chairs the Director of the Office of Science and Technology Policy (OSTP) and the Chair of the Council on Environmental Quality (CEQ). For more information about the work of the OPC, please see the Interagency Ocean Science and Technology Website at https://www.noaa.gov/interagency-ocean-policy.

About the Subcommittee on Ocean Science and Technology

The purpose of the Subcommittee on Ocean Science and Technology (SOST) is to advise and assist on national issues of ocean science and technology. The SOST contributes to the goals for Federal ocean science and technology, including developing coordinated interagency strategies and fostering national ocean science and technology priorities. The SOST reports to both the NSTC Committee on Environment and the Ocean Policy Committee.

About this Document

This document summarizes the existing Science and Technology for America's Oceans: A Decadal Vision (2018-2028) for a broad audience and connects the five priority goals to the cross-cutting themes of climate change, resilient ocean science and technology infrastructure, and a diverse and inclusive blue workforce, all of which include connections to racial justice and equity. This document aims to enable decision-makers to better incorporate the Federal government's current key priority topics into ocean science and technology (S&T) decision-making and implementation.

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Executive Summary

As a maritime Nation, the United States relies heavily on healthy and resilient ocean, coastal, and Great Lakes ecosystems. *Science and Technology for America's Oceans: A Decadal Vision* identified pressing research needs and areas of opportunity within the Ocean science and technology (S&T) enterprise for the decade 2018-2028.[1] Each of the goals identified relies on, and contributes to, three cross-cutting themes: (1) Climate Change, (2) Resilient Ocean S&T Infrastructure, and (3) a Diverse and Inclusive Blue Workforce, all of which include connections to racial justice and equity. While the Decadal Vision lists a series of priorities to advance the U.S. Ocean S&T enterprise, this document includes additional priorities related to each of the three cross-cutting themes. The outlined priorities within each theme are intended to guide the development of future Federal ocean research implementation plans within each agency. This document also presents six immediate opportunities for ocean solutions and collaborative efforts: (1) Facilitate offshore wind energy development; (2) Coordinate coastal resilience efforts; (3) Conserve and protect critical ecosystems through the America the Beautiful initiative effort to conserve at least 30% of U.S. land and ocean by 2030; (4) Explore implementation of blue carbon solutions; (5) Support the National Ocean Mapping, Exploration, and Characterization (NOMEC) plan; and (6) Engage in the UN Decade of Ocean Science for Sustainable Development. Each of these areas further the three cross-cutting themes. The United States is well poised to embrace the national and international attention on Ocean S&T to combat the climate crisis, build modernized and resilient Ocean S&T infrastructure, and ensure the Ocean S&T community empowers a diverse and inclusive blue workforce, all while enhancing racial justice and equity.

Introduction

Healthy and resilient ocean, coastal, and Great Lakes ecosystems are fundamental to our Nation's well-being, prosperity, and security, and provide solutions to many of our society's greatest challenges, from climate change to meeting the resource needs of growing coastal populations.[2] Globally, coastal regions frequently serve as population centers, commerce and trade hubs, as well as play hosts to many national capitals, where the climate is changing at an accelerated rate and its impacts are being acutely felt by billions of people. With global impacts of the climate crisis facing current and future generations, our connection to the ocean has become more critical than ever, sustaining life on Earth and driving the climate and biosphere. In addition to our human health and well-being, the ocean supports a vast diversity of economic activities, which together compose the

[1]National Science and Technology Council, "Science and Technology for America's Oceans: A Decadal Vision." 2018, available at: https://trumpwhitehouse.archives.gov/wp-content/uploads/2018/11/Science-and-Technology-for-Americas-Oceans-A-Decadal-Vision.pdf

[2]For the purposes of this document, "ocean" includes the open ocean, coasts, estuaries, coastal watersheds, and Great Lakes.

'blue economy.'[3,4] More than 80% of the ocean is still unmapped,[5] and even more is unobserved and unexplored,[6] yet the ocean connects our planet and sustains humanity's growth and creativity.

The ocean plays a fundamental role in regulating global temperatures and must be tightly integrated into national and international plans to tackle the climate crisis and protection of our planet. Not only does the ocean absorb 93% of the heat trapped by rising anthropogenic carbon dioxide (CO_2) concentrations, but it also absorbs approximately 25 to 30% of anthropogenic CO_2 emissions that would otherwise remain in the atmosphere and increase global temperatures.[7] Ocean warming decreases the absorption of oxygen at the surface and impacts ocean mixing and circulation, leading to declines in oxygen content throughout large swaths of the ocean.[8]

The ocean is a rich source of biodiversity and ecosystem services, and conservation efforts are increasingly vital for the global community to retain such benefits.[9] The decline in health of critical oceanic habitats and loss of coastal and marine biodiversity, compounded by sea level rise, subsidence, ocean acidification, and deoxygenation, significantly threatens our ocean resources and the services they provide, such as coastal protection and food supply. Indigenous Peoples and coastal communities are especially reliant on ocean ecosystems and are among the most vulnerable to changes in the ocean. Maintaining sustainable coastal and marine ecosystems rich in biodiversity can be furthered through a fundamental understanding of the intrinsic values and cultural heritage associated with the ocean. Our global ocean is a vast natural and cultural resource that is essential to human health and well-being, providing tangible and intangible services that extend far beyond the coastline.[10]

It is more important than ever to harness the comprehensive economic and intrinsic value of seascapes to encourage conservation and cooperative use of our diverse ocean, coastal, and Great Lakes ecosystems.[11] To maintain global economic prosperity and the livelihoods that depend on the ocean, Federal and non-governmental communities need to prioritize ocean science and technology (S&T). Efforts such as the United Nations (UN) Decade of Ocean Science for Sustainable Development

[3]For example, fisheries play an enormous role in the U.S. economy. In 2018, U.S. commercial fishermen landed 9.4 billion pounds of seafood valued at $5.6 billion. Recreational anglers made 194 million marine recreational fishing trips with a catch of 359 million pounds. National Oceanic and Atmospheric Administration Fisheries, "Fisheries of the United States, 2018," 2018, available at: https://www.fisheries.noaa.gov/feature-story/fisheries-united-states-2018

[4]National Oceanic and Atmospheric Administration Fisheries, "Factsheet: Fisheries of the United States, 2018", available at: https://media.fisheries.noaa.gov/dam-migration/fus_2018_factsheet.pdf

[5]Dependent on the resolution. A "minimally mapped" area has at least 1-2 soundings per 100 m cell based on the U.S. Bathymetry Gap Analysis. National Oceanic and Atmospheric Administration Integrated Ocean and Coastal Modeling, "U.S. Bathymetry Coverage and Gap Analysis," available at: https://iocm.noaa.gov/seabed-2030-bathymetry.html

[6]National Oceanic and Atmospheric Administration Integrated Ocean and Coastal Modeling, "Progress Report: Unmapped U.S. Waters," 2021, available at: https://iocm.noaa.gov/seabed-2030/mapping-progress-report2021.pdf

[7]O. Hoegh-Guldberg and others, "The Ocean as a Solution to Climate Change: Five Opportunities for Action," World Resources Institute, 2019, available at: https://www.ourdynamicplanet.com/wp-content/uploads/2019/09/HLP_Ocean_Solution_Climate_Change.pdf

[8]D. Breitburg and others, "Declining oxygen in the global ocean and coastal waters," Science, 2018, available at: https://science.sciencemag.org/content/359/6371/eaam7240

[9]Department of the Interior, "Conserving and Restoring America the Beautiful," 2020, available at: https://www.doi.gov/sites/doi.gov/files/report-conserving-and-restoring-america-the-beautiful-2021.pdf

[10]J. Rock and M. Knapen, "What is the ocean: A sea-change in our perceptions and values?" Aquatic Conservation, 2019, available at: https://onlinelibrary.wiley.com/doi/epdf/10.1002/aqc.3257

[11]The White House, "Executive Order on Tackling the Climate Crisis at Home and Abroad," 2021, available at: https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/executive-order-on-tackling-the-climate-crisis-at-home-and-abroad/

(Ocean Decade),[12] SeaBed 2030,[13] and the broader UN Sustainable Development Goals[14] convene the global community and leverage global attention to preserve our environment and its services.

Ocean S&T integrates powerful predictive models with observational tools and research to inform preparedness, adaptation, and mitigation for future threats to ocean sustainability. Through scientific efforts to better understand and characterize the ocean, decision-makers have access to ocean predictions at finer spatial and temporal resolution, as well as a better understanding of the uncertainty of those predictions. With increased high-quality data, we can better forecast ocean-related hazards which threaten maritime interests, coastal communities, and vital infrastructure, more accurately predict severe storms and extreme drought, and make fundamental contributions to potential solutions to climate change and biodiversity loss, such as through deep-sea carbon sequestration and conservation of 30% of U.S. land and ocean by 2030.[15] Federally-funded Ocean S&T is also needed to inform the sustainable management and maintain the diversity of living and non-living marine resources within our ocean. In addition to advancing our understanding of and providing data on the impacts of environmental change, interdisciplinary Ocean S&T also offers potential solutions for managers and decision-makers navigating complex, multi-use spaces that host overlapping and rapidly evolving conservation, commercial, and recreational activities. Scientific efforts and technological advances designed and delivered with end users in mind will enable local, regional, and national communities to support and maintain healthy, resilient ocean ecosystems that allow for multiple sustainable uses of the oceans.

Many Federal agencies conduct and/or support Ocean S&T based on their perspectives, missions, and authorizations. Interagency coordination enables a whole-of-government approach that leverages the unique capabilities of each Federal agency to ensure that Ocean S&T services and products are useful, usable, and used.[16] A collaborative vision for Ocean S&T across the Federal government will enable agencies and partners to effectively implement activities that promote ocean sustainability. The Federal government and partners collaborate on foundational basic research and monitoring such as ocean observation and characterization, from satellite sea surface temperature measurements to sediment sampling and sustaining long-term monitoring of ecosystems. These coordinated efforts help us better understand the ocean and maintain the Nation's maritime security. At the same time, applied research informs human-ocean intersections, such as elucidating risks to communities experiencing the impacts of sea level rise and other coastal hazards, quantifying the effects of ocean-based toxins on human health, predicting changes to fishing opportunities based on climate-driven ecosystem changes, and regulating aquaculture[17] to support sustainable and economically viable practices.

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[12] United Nations Decade of Ocean Science for Sustainable Development, "The Ocean Decade," available at: https://www.oceandecade.org/

[13] United Nations Decade of Ocean Science for Sustainable Development, "The Nippon Foundation- GEBCO Seabed 2030 Project," available at: https://seabed2030.org

[14] United Nations, "Sustainable Development: The 17 Goals," available at: https://sdgs.un.org/goals

[15] Department of the Interior, "Conserving and Restoring America the Beautiful," 2020, available at: https://www.doi.gov/sites/doi.gov/files/report-conserving-and-restoring-america-the-beautiful-2021.pdf

[16] A. Boaz and C. Hayden, "Pro-active Evaluators: Enabling Research to Be Useful, Usable and Used," *Evaluation*, 2002, available at: https://journals.sagepub.com/doi/pdf/10.1177/13563890260620630

[17] National Science and Technology Council reports which address the Federal role in science and regulation of aquaculture: "A Strategic Plan to Enhance Regulatory Efficiency in Aquaculture" 2022, available at: https://www.ars.usda.gov/SCA/Documents/2022%20NSTC%20Subcomittee%20on%20Aquaculture%20Regulatory%20Efficiency%20Plan_Final%20508%20compliant.pdf; "A National Strategic Plan for Aquaculture Research" 2022, available at: https://www.ars.usda.gov/SCA/Documents/2022%20NSTC%20Subcomittee%20on%20Aquaculture%20Research%20Plan_Final%20508%20compliant.pdf

Cross-cutting Themes: Climate Change, Infrastructure, and a Diverse and Inclusive Blue Workforce

Science and Technology for America's Oceans: A Decadal Vision (Decadal Vision) identified pressing research needs and areas of opportunity within the Ocean S&T enterprise for the decade 2018-2028.[18] Each of the goals identified relies on, and contributes to, three cross-cutting themes: (1) Climate Change, (2) Resilient Ocean S&T Infrastructure, and (3) a Diverse and Inclusive Blue Workforce, all of which include connections to racial justice and equity. The first theme, Climate Change, is integral to the future of the ocean; "you cannot protect the oceans without solving climate change and you can't solve climate change without protecting the oceans."[19] Innovative methods such as carbon capture (including deep-sea carbon sequestration), restoring and protecting blue carbon ecosystems, enforcing marine protected areas, and sustainably expanding wind and wave energy sectors are all highly promising avenues for mitigating climate change and the constellation of related issues such as biodiversity loss.[20] A primary goal of the Administration is to promote healthy, resilient ocean ecosystems which strengthen ocean-based climate solutions and contribute to human resilience.[21]

The second theme, Resilient Ocean S&T Infrastructure, underscores the necessity of sustained investment in observational and communication infrastructure to help monitor conditions, support ocean science, and foster the development of breakthrough research. Ocean and coastal observational infrastructure such as research facilities, vessels, sensors, observing networks, and autonomous vehicles enable basic and applied research that allow maritime practitioners to better understand and safeguard ocean resources from threats such as climate change and other human impacts. To ensure consistent long-term support for ocean science, and to provide the uninterrupted, long-term data records that detection of climate change requires, development and maintenance of Ocean S&T infrastructure must be designed explicitly to collect information that will contribute to climate monitoring and resilience.

The third theme, a Diverse and Inclusive Blue Workforce, is reliant on expanding the sustainable blue economy and creating new opportunities while simultaneously ensuring equitable access to work and training opportunities in the new blue economy. This necessitates an understanding and breaking down of current barriers to employment in S&T and ocean industries, and prioritization of racial justice. Enhancing the diversity of our blue workforce is critical to sustainable solutions as historically underrepresented communities are often the most threatened by climate impacts, pollution, and continued development in low-lying areas. Increasing the influence of underrepresented communities in Ocean S&T will bring new and innovative approaches into the design and execution of critical ocean research. Additionally, a more diverse and inclusive workforce can uniquely contribute to dismantling policies and practices that have historically limited opportunities by advancing and centering equity and racial justice within the Ocean S&T community and within our work to mitigate and adapt to climate change. In addition, new uses of the ocean, such as wind energy production, will directly and indirectly impact existing activities such as fishing and conservation. These, in turn, will require support

[18] National Science and Technology Council, "Science and Technology for America's Oceans: A Decadal Vision." 2018, available at https://trumpwhitehouse.archives.gov/wp-content/uploads/2018/11/Science-and-Technology-for-Americas-Oceans-A-Decadal-Vision.pdf

[19] John Kerry, Special Presidential Envoy for Climate, "Special Guest Remarks at Ocean-climate Ambition Summit," 2021, available at: https://www.state.gov/special-guest-remarks-at-ocean-climate-ambition-summit/

[20] O. Hoegh-Guldberg and others, "The Ocean as a Solution to Climate Change: Five Opportunities for Action," *World Resources Institute,* 2019, available at: https://oceanpanel.org/sites/default/files/2019-10/HLP_Report_Ocean_Solution_Climate_Change_final.pdf

[21] D. Fiscus and B. Fath, "Foundations for Sustainability: A Coherent Framework of Life-Environment Relations," 2018, available at: https://www.sciencedirect.com/book/9780128114605/foundations-for-sustainability

to maintain their health and economic viability. Finally, reducing Federal barriers to using S&T and providing more equitable access to data and tools to inform community decision-making[22] is an important aspect of supporting a diverse and inclusive blue workforce.

The Federal agencies and the scientific community recognize the urgent need to sustain healthy, resilient ocean ecosystems, prepare our coastal communities for hazards, and ensure that decision-makers have access to relevant data, information, and tools to mitigate and adapt to our changing climate. These urgent needs are paired with great opportunity.[23] As the global community acknowledges the importance of ocean science to create a sustainable future, evident in international efforts such as the Ocean Decade, the United States is well situated to develop partnerships across the globe to further our Ocean S&T needs. The Federal government's commitment to climate, conservation, economic recovery, international cooperation, and racial justice offers the Ocean S&T community a once-in-a-generation opportunity to apply its expertise to address our society's most pressing challenges. The Federal agencies are well-poised to capitalize on the immediate opportunities in Ocean S&T to better support and inform the decision-makers who translate knowledge into action.

Intersections with Decadal Vision Goals

The Decadal Vision[24] identifies five goals to advance U.S. Ocean S&T and the Nation from 2018 to 2028: (1) Understand the Ocean in the Earth System; (2) Promote Economic Prosperity; (3) Ensure Maritime Security; (4) Safeguard Human Health; and (5) Develop Resilient Coastal Communities. Each goal is supplemented with specific objectives and actionable priorities to achieve those objectives. The first goal, Understand the Ocean in the Earth System, is the foundational perspective needed to address the ocean's greatest challenges and opportunities. The ocean serves a pivotal role in influencing many of Earth's key processes, including its ability to regulate the global climate. Land-sea and air-sea interactions (including those that intersect with sea ice and glaciers) drive biological, geophysical, biogeochemical, and thermodynamic processes that are constantly in a state of flux, and can even reach tipping points which may portend even larger irreversible changes. Thus, continuing to better understand these processes for more informed ocean sustainable use and management remains a priority for the U.S. S&T enterprise.

The second goal, Promote Economic Prosperity, has great potential in the United States since the blue economy has been growing and developing at a rate faster than the overall economy.[25] Our Nation's economic prosperity is closely linked with the natural resources from the ocean.[26] In

[22]Executive Office of the President, "Advancing Racial Equity and Support for Underserved Communities Through the Federal Government," 2021, available at: https://www.federalregister.gov/documents/2021/01/25/2021-01753/advancing-racial-equity-and-support-for-underserved-communities-through-the-federal-government

[23]Department of the Interior, "Conserving and Restoring America the Beautiful," 2020, available at: https://www.doi.gov/sites/doi.gov/files/report-conserving-and-restoring-america-the-beautiful-2021.pdf; The White House, "Executive Order on Tackling the Climate Crisis at Home and Abroad," 2021, available at: https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/executive-order-on-tackling-the-climate-crisis-at-home-and-abroad/; E. Sala and others, "Assessing real progress towards effective ocean protection," Marine Policy, 2018, available at: https://www.sciencedirect.com/science/article/pii/S0308597X17307686; Ocean Conservancy and others, "Sign On Letter: Ocean and Coastal Restoration and Resilience Funding," 2021, available at: https://oceanconservancy.org/wp-content/uploads/2021/04/30.04.2021-Sign-On-Letter-Ocean-and-Coastal-Restoration-and-Resilience-Funding.pdf

[24]National Science and Technology Council, "Science and Technology for America's Oceans: A Decadal Vision." 2018, available at: https://trumpwhitehouse.archives.gov/wp-content/uploads/2018/11/Science-and-Technology-for-Americas-Oceans-A-Decadal-Vision.pdf

[25]National Oceanic and Atmospheric Administration, "Marine economy in 2019 outpaced U.S. economy overall," 2021, available at: https://www.noaa.gov/news-release/marine-economy-in-2019-outpaced-us-economy-overall

[26]In 2019, America's marine economy, including goods and services, contributed about $397 billion (1.9%) to the Nation's gross domestic product (GDP). National Oceanic and Atmospheric Administration, "Marine economy in 2019 outpaced U.S. economy overall," 2021,

embracing an environmentally sustainable and socially equitable blue economy, so too can the Nation meet environmental and social goals.[27] The long-term viability of both consumptive and non-consumptive uses of marine resources relies heavily on resilient, biodiverse coastal and marine ecosystems. The blue economy is also dependent on a secure Nation, and the third goal, Ensure Maritime Security, shows a clear linkage between strong national security and strong maritime security.[28] The fourth goal, Safeguard Human Health, is further accentuated as research continues to provide evidence linking the health of the ocean to human health.[29] The fifth goal, Develop Resilient Coastal Communities, grows in urgency as the increase of threats to our coastal communities from sea level rise to harmful algal blooms elucidate the need to support resilient coastal zones. Nearly 40% of the world's population lives within 60 miles of the coast, and that number is only growing.[30] In the United States, coastal areas have a population density that is five times greater than that of corresponding inland counties.[31] U.S. economic activity is overwhelmingly concentrated in its ocean and Great Lakes coastal urban areas.[32] Building coastal resilience and supporting adaptation to environmental change are increasingly recognized as essential to ensure the continued well-being of coastal communities and the Nation at large.

Table 1 outlines the relationship between the five Decadal Vision goals with each of the three cross-cutting themes (1) Climate Change, (2) Resilient Ocean S&T Infrastructure, and (3) a Diverse and Inclusive Blue Workforce, all of which include connections to racial justice and equity. While the Decadal Vision lists a series of priorities to advance the U.S. Ocean S&T enterprise, this document includes additional priorities related to each of the three cross-cutting themes.

available at: https://www.noaa.gov/news-release/marine-economy-in-2019-outpaced-us-economy-overall ; Furthermore, 90% of all global trade is carried out via ocean shipping, and maritime trade volumes are set to triple by 2050, particularly with the expanding Northern Sea Route in the Arctic. Organisation for Economic Co-operation and Development, "Ocean shipping and shipbuilding," available at: https://www.oecd.org/ocean/topics/ocean-shipping/

[27]N. Bennett and others, "Towards a sustainable and equitable blue economy," Nature Sustainability, 2019, available at: https://doi.org/10.1038/s41893-019-0404-1; A. Cisneros-Montemayor and others, "Enabling conditions for an equitable and sustainable blue economy," Nature, 2021, available at: https://doi.org/10.1038/s41586-021-03327-3

[28]Department of the Navy, "A Strategic Blueprint for the Arctic," 2021, available at: https://media.defense.gov/2021/Jan/05/2002560338/-1/-1/0/ARCTIC%20BLUEPRINT%202021%20FINAL.PDF/ARCTIC%20BLUEPRINT%202021%20FINAL.PDF

[29]A. Borja and others, "Moving Toward an Agenda on Ocean Health and Human Heath in Europe," Frontiers in Marine Science, 2020, available at: https://www.frontiersin.org/articles/10.3389/fmars.2020.00037/full; S. Whitmee and others, "Safeguarding human health in the Anthropocene epoch: report of The Rockefeller Foundation–Lancet Commission on planetary health," The Lancet Commissions, 2015, available at: https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(15)60901-1/fulltext?nr_email_referer=1

[30]The Ocean Conference, United Nations, "Factsheet: People and Oceans," 2017, available at: https://www.un.org/sustainabledevelopment/wp-content/uploads/2017/05/Ocean-fact-sheet-package.pdf

[31]National Oceanic and Atmospheric Administration, National Ocean Service, "What percentage of the American population lives near the coast?" available at: https://oceanservice.noaa.gov/facts/population.html

[32]J. Rappaport and J. Sachs, "The United States as a Coastal Nation," *Journal of Economic Growth*, 2003, available at: https://link.springer.com/article/10.1023/A:1022870216673

Table 1. Relationships between the five Decadal Vision Goals and the three cross-cutting themes.

Decadal Vision Goals/ Cross-Cutting Themes	Climate Change	Resilient Ocean S&T Infrastructure	Diverse and Inclusive Blue Workforce
Understand the Ocean in the Earth System	Understanding past, present, and predicted changes in the ocean environment due to anthropogenic climate change is critical to achieving the goals of the Decadal Vision.	Robust S&T infrastructure (on shore, at sea, and in space) enables efficient observation, data collection, storage, and analysis to better understand and predict ocean and Earth-system dynamics, and impacts to wildlife, environments, and ecosystems.	Equitable access to S&T research opportunities, marine industries, inclusive S&T structures, and recruitment and long-term retention of diverse people and teams help build innovative, comprehensive information to better understand and predict environmental change.
Promote Economic Prosperity	Living and non-living ocean resources are increasingly impacted by anthropogenic climate change, and adaptation is necessary to ensure continued economic prosperity.	Innovation in sustainable Ocean S&T is critical to maintaining U.S. competitiveness in global ocean science and industry and powering the U.S. economy.	Equitable representation of people of different races, ethnicities, genders, and other elements of social identity in ocean industries fosters innovative problem-solving, enhances collaboration, and helps ensure that end products and services of the ocean enterprise meet the needs of everyone.[33]
Ensure Maritime Security	Anthropogenic climate change in ocean and coastal environments has major repercussions for maritime trade and international relations, particularly in the Arctic.	Data, modelling, and services enabled through new technologies will feed into tactical models and decision aids for marine operators and for military installation and operations planning.	Building a diverse and inclusive blue workforce enables both short-term maritime safety and security, through ocean-literate and innovative teams of people from different social and economic backgrounds, and long-term maritime security, as we invest in the next generation of ocean professionals who are representative of the Nation.

[33]A. Johnson and others, "Strategies for Increasing Diversity in the Ocean Science Workforce Through Mentoring," *Oceanography,* 2016, available at: https://tos.org/oceanography/article/strategies-for-increasing-diversity-in-the-ocean-science-workforce-through

Safeguard Human Health	Threats to human health such as marine pathogens and harmful algal blooms may be exacerbated by anthropogenic climate change.	Enhanced ocean observations, technologies, and tools that predict climate change impacts such as flooding, severe storms, and sea level rise, and harmful algal blooms are critical to reducing risk for coastal communities and understanding long-term threats.	Prioritizing equity and diversity in the blue workforce impacts workers' experiences in science and professional jobs (including immediate workplace safety) and can strengthen the outcomes of the scientific enterprise; increased diversity in personal experiences can lead to greater equity in the application of science to issues such as safeguarding human health.
Develop Resilient Coastal Communities	Impacts of anthropogenic climate change can affect the Earth's hydrological cycle, and increase the intensity of flooding and storms, resulting in infrastructure damage as well as other indirect economic and social costs that affect people throughout the country.	Infrastructure for the scientific and professional enterprises that study and manage ocean conditions and activities is central to developing long-term coastal resilience and providing decision-makers with useful, usable knowledge and predictive capabilities to understand risk and vulnerability.	Development of a diverse and inclusive blue workforce empowers all people, including Black, Indigenous Peoples, and other coastal communities of color, who are often at the forefront of climate change impacts, to co-develop the knowledge, skills, and capital needed to increase resiliency and adapt to climate change impacts.

Climate Change

The ocean plays a central role in Earth's climate system and is impacted by a multitude of climate change-related threats. However, the ocean also provides a varied suite of potential climate mitigation and adaptation strategies. Ocean-based climate solutions include marine renewable energy; improvements in ocean transportation systems such as decarbonizing shipping; ecosystem restoration of critical blue carbon environments such as mangrove forests, salt marshes, and seagrass beds; replacement of land-based protein and nutrition sources with low carbon ocean-based protein and nutrition options; and sequestration of carbon in seabed sediments.[34] These solutions have the potential to reduce Greenhouse Gas (GHG) emissions by up to 4 billion tons of carbon dioxide equivalent (CO_2e) per year by 2030, and by more than 11 billion tons of CO_2 per by 2050, or ~21% of the emissions reduction predicted to be needed to stay under a 1.5°C increase relative to pre-industrial levels.[35]

[34] O. Hoegh-Guldberg and others, "The Ocean as a Solution to Climate Change: Five Opportunities for Action," *World Resources Institute*, 2019, available at: https://oceanpanel.org/sites/default/files/2019-10/HLP_Report_Ocean_Solution_Climate_Change_final.pdf

[35] ibid. This amount of reductions is larger than the GHG emissions from all global coal fired power plants and also more than China's (the world's largest emitter of CO_2) total emissions in 2014.

Priorities

- Quantify ocean carbon sinks, sources, and fluxes to enhance a comprehensive understanding of the ocean-carbon circulation system and ocean acidification.
- Improve regional sea level rise projections for U.S. coastlines (including Great lakes water levels) and better understand high-tide flooding frequencies and storm-driven extreme water levels to better predict impacts to the built environment as well as landscape and ecosystem responses.
- Address biophysical, social, and economic impediments to marine ecosystem restoration in order to develop priorities and enhance incentives for restoring critical blue carbon habitats.
- Understand the impacts of CO_2 sequestration in deep seafloor environments, particularly on marine ecosystems.
- Explore Negative Emissions Technologies (NETs), particularly marine Carbon Dioxide Removal (mCDR), including measuring and monitoring efficacy, understanding the timescale of sequestration, assessing impacts on marine ecosystems, and integrating environmental justice and public trust considerations.
- Establish and maintain systematic monitoring of marine life to strengthen our understanding of our ability to mitigate climate change impacts on ecosystems and wildlife populations.
- Engage with decision-makers and communities across all stages of research and technology development to ensure the scientific knowledge produced is useful, usable, and used.[36]
- Incentivize innovation for ocean-based renewable energy, and research mitigating the impacts of wind and wave renewable energy development on the ocean, including impacts on living marine resources and ocean users.

Resilient Ocean S&T Infrastructure

In order to curb the Nation's GHG emissions and meet the goal of net-zero carbon emissions by 2050, Ocean S&T infrastructure needs to be modernized.[37] Rebuilding the American economy after the impacts of the COVID-19 pandemic and implementing more clean energy infrastructure requires an ambitious infrastructure plan, and one that must incorporate a multitude of conservation, commercial, and recreational ocean perspectives. Building back better will also require active consideration of the needs of diverse communities and promotion of environmental justice. Threats to Ocean S&T infrastructure include sea level rise and increased extreme weather events, which can damage observing systems, increasing the costs of operating the networks of systems needed to measure those same threats. Critical Ocean S&T infrastructure includes ships, data buoys and mooring systems, seafloor cables, borehole observatories, satellites, fixed and airborne remote sensing platforms, scientific drilling platforms, floats, gliders, Autonomous Underwater Vehicles (AUVs) and other unmanned systems, sensors (including optical, acoustic, and animal borne), submersibles, and modeling and computational infrastructure (including cloud computing) all working in concert with one another. These essential components of Ocean S&T infrastructure, aided by advanced techniques such as artificial intelligence and machine learning, are essential to improving our understanding and predictive capabilities of climate change in the ocean. Advances in resilient Ocean S&T infrastructure will likely require adoption of high-risk/high-reward efforts as the community explores opportunities for innovation.

[36] A. Boaz & C. Hayden, "Pro-active Evaluators: Enabling Research to Be Useful, Usable and Used," *Evaluation,* 2002, available at: https://journals.sagepub.com/doi/pdf/10.1177/13563890260620630

[37] The White House, "Fact Sheet: President Biden's Leaders Summit on Climate," 2021, available at: https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/23/fact-sheet-president-bidens-leaders-summit-on-climate/

Priorities

- Identify options to transform research vessels to net-zero operations.
- Design and construct resilient research and observational infrastructure, especially intended to expand our capabilities into harsh environments (e.g., polar and deep oceans) and withstand natural hazards such as sea level rise, hurricanes, and permafrost melting.
- Protect marine life with advancements to limit ship noise, marine debris (including ghost gear), and heavy fuels.
- Support and expand training for demographically diverse Ocean S&T infrastructure operators, and strengthen crosswalks into research infrastructure operation for merchant mariners and veterans.
- Enhance pathways for the translation of basic science to service delivery entities to more rapidly and effectively meet coastal community needs, particularly in helping communities reduce vulnerabilities, such as flood risk.
- Improve data management and cyberinfrastructure systems to ensure timely public access to unclassified, usable ocean data, specifically for others to further develop into more regionalized or target services and for local and underserved community needs, and for creating usable products for coastal managers to manage multi-use ocean spaces and reduce conflict among sectors.

Diverse and Inclusive Blue Workforce

As long as our blue workforce does not leverage the diversity of the U.S. population, our long-term S&T goals will not be met in a timely fashion. Contributions by people of different races, ethnicities, genders, economic backgrounds, and other elements of social identity in ocean industries will enhance innovative problem-solving, catalyze impactful collaborations, and help ensure that end products and services of the ocean enterprise meet the needs of a broad spectrum of society.[38] Who conducts ocean research impacts every stage of science development and delivery, and diverse, equitable, and inclusive research environments are needed to fully realize the goals of the Decadal Vision. Unequal access to education and jobs due to entrenched disparities in U.S. laws, policies, and public and private institutions has contributed to underrepresentation of American Indian and Alaska Natives, Black or African Americans, Hispanics, Native Hawaiians, and other Pacific Islanders in relevant disciplines that are central to ocean research.[39] While women make up a majority of the workforce in some STEM-related fields such as healthcare, other fields such as the physical sciences, computer science, and engineering remain dominated by men.[40] Racial disparities also persist across many scientific disciplines, but remain particularly stark in the geosciences. Results from one study indicate that the proportion of underrepresented minorities awarded PhDs in the geosciences was roughly the same in 2016 as it was in 1973, despite years of diversity initiatives by major institutions and

[38] A. Johnson and others, "Strategies for Increasing Diversity in the Ocean Science Workforce Through Mentoring," *Oceanography,* 2016, available at: https://tos.org/oceanography/article/strategies-for-increasing-diversity-in-the-ocean-science-workforce-through

[39] R. Bernard and E. Cooperdock, "No progress on diversity in 40 years," *Nature Geoscience,* 2018, available at: https://www.nature.com/articles/s41561-018-0116-6

[40] R. Fry and others, "STEM Jobs See Uneven Progress in Increasing Gender, Racial and Ethnic Diversity," *Pew Research Center,* 2021, available at: https://www.pewresearch.org/science/2021/04/01/stem-jobs-see-uneven-progress-in-increasing-gender-racial-and-ethnic-diversity/

universities.[41] Directly addressing these gaps in representation and ensuring long-term retention of people from diverse backgrounds is essential to cultivating a robust blue workforce capable of tackling the Decadal Vision goals. Additionally, prioritization of equity and racial justice in the development of the blue workforce will empower Americans from all backgrounds to explore and pursue marine and coastal occupations.[42]

Priorities

- Require stipends and/or living wages for internships and early career opportunities to ensure equitable access to high-quality training and jobs in ocean fields.
- Encourage programs and partners to provide paid parental leave to ensure equitable access for parents, and childcare stipends especially for graduate students, interns, and junior researchers / faculty.
- Explicitly require broadening participation and stakeholder engagement in the development of requirements and goals in grant solicitations and calls for proposals.
- Ensure policies and practices are in place to support the long-term retention of underrepresented ocean scientists and professionals in the workplace. Create a robust network of support for students and early career professionals from diverse backgrounds through targeted programs such as flexible mentoring efforts and expanded early-career awards.
- Partner with national and international Ocean S&T organizations which provide active opportunities for early career ocean professionals to attract, integrate, and retain diverse perspectives within their expert groups through knowledge sharing, training, and mentorship.
- Conduct regular, meaningful, and robust consultation with Tribal officials in the development of Ocean S&T and include Indegenous Traditional Ecological Knowledge in science approaches and products.
- Encourage agencies and partnering organizations to be as transparent as legally possible, while protecting identities, about clear sanctions and accountability at all levels.
- Improve research conditions on vessels and in the field by: requiring updated and clear codes of conduct for researchers and staff; requiring harassment, discrimination, and bystander training for all participants; clarifying accountability by including a range of clearly stated, appropriate, and escalating disciplinary consequences for violating harassment and discrimination policies; and by providing a safe and secure mechanism for reporting and seeking assistance for any incidents that may arise.
- Engage coastal communities through workforce training opportunities to build an equitable blue workforce from the bottom-up and ensure high-paying opportunities in ocean industries relevant to each unique coastal context, such as offshore wind, fisheries, and transportation, are accessible to those who live in neighboring coastal communities.
- Utilize environmental justice screening tools when developing research ideas and plans.
- Develop new and strengthen existing partnerships between Federal agencies and Minority Service Institutions (MSIs), Historically Black Colleges and Universities (HBCUs), Hispanic-Serving Institutions (HSIs), Tribal Colleges and Universities (TCUs), and Asian American and Pacific Islander Serving Institutions (AAPISIs) to create pathways for early ocean STEM engagement and retention of diverse talent.

[41] R. Bernard and E. Cooperdock, "No progress on diversity in 40 years," *Nature Geoscience*, 2018, available at: https://www.nature.com/articles/s41561-018-0116-6

[42] The White House, "Executive Order on Advancing Racial Equity and Support for Underserved Communities Through the Federal Government," 2021, available at: https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/20/executive-order-advancing-racial-equity-and-support-for-underserved-communities-through-the-federal-government/

Impacts and Expectations

The five goals described in the Decadal Vision (2018-2028), (1) Understand the Ocean in the Earth System; (2) Promote Economic Prosperity; (3) Ensure Maritime Security; (4) Safeguard Human Health; and (5) Develop Resilient Coastal Communities, remain core strategic priorities that will guide Federal government actions related to Ocean S&T. The three cross-cutting themes emphasized in this document, (1) Climate Change, (2) Resilient Ocean S&T Infrastructure, and (3) a Diverse and Inclusive Blue Workforce, add important context for these goals and help ensure that decision-makers are equipped to effectively respond to rapidly changing environmental conditions, technological advances, and societal needs. The three themes of climate change, resilient Ocean S&T infrastructure, and a diverse and inclusive blue workforce help provide Federal ocean policy experts a framework to understand connections between existing goals of the Decadal Vision and current Federal priorities (tackling the climate emergency, centering racial and gender equity, and building a strong U.S. economy). Through understanding how climate change impacts Earth's dynamic ocean systems, Federal agencies can leverage resources to better predict and adapt to environmental change while simultaneously harnessing the power of Ocean S&T to catalyze a clean energy revolution and rebuild the U.S. economy in the aftermath of the COVID-19 pandemic. By working to center equity throughout processes of science development and science application, Federal ocean policy makers can additionally play an important role in delivering a whole-of-government approach to racial justice and enhanced focus on the sovereignty of Tribal nations.

Areas of Immediate Opportunity

As shown in Figure 1, the 2018 Decadal Vision outlines five areas of immediate opportunity. These areas remain imperative, and agencies are actively pursuing the implementation of these opportunities. The second image within Figure 1 builds on these areas to present six additional opportunities for ocean solutions and collaborative efforts: (1) Facilitate offshore wind energy development; (2) Coordinate coastal resilience efforts; (3) Conserve and protect critical ecosystems through the America the Beautiful initiative to conserve at least 30% of U.S. land and ocean by 2030; (4) Explore implementation of blue carbon solutions; (5) Support the National Ocean Mapping, Exploration, and Characterization (NOMEC) plan; and (6) Engage in the UN Decade of Ocean Science for Sustainable Development. Each of these areas further the three cross-cutting themes (Table 2). These six new areas of opportunity for Ocean S&T were selected as convergence points that simultaneously advance the five goals outlined in the 2018 Decadal Vision document (Table 1), provide opportunities to showcase the three cross-cutting themes described in this document (Table 2), and help support the ambitious vision for healthy and resilient ecosystems put forth by the Administration and exemplified in Federal agency priorities. While the 2022 areas of opportunity are not an exhaustive list of priority Ocean S&T activities for the coming decade, they highlight critical entry points to begin to tackle national and international ocean issues.

Figure 1. 2018 (light blue) and 2022 (orange) Areas for Immediate Opportunity

Table 2. Relationships across the 2022 Areas of Immediate Opportunity and three cross-cutting themes.

2022 Areas of Immediate Opportunity	Climate Change	Resilient Ocean S&T Infrastructure	Diverse and Inclusive Blue Workforce
Facilitate offshore wind energy development	Offshore wind energy has the potential to reduce long-term anthropogenic CO_2 emissions that drive climate change and threaten marine ecosystems.	Diverse energy sources, including offshore wind, are critical to building resilient, sustainable coastlines and can support novel S&T infrastructure needed to understand and safeguard important marine resources.	The rapid development of offshore wind will create opportunities for thousands of new jobs. This opportunity can diversify the blue workforce throughout the Nation.
Coordinate coastal resilience efforts	A whole-of-government approach to coastal resilience enables coastal communities and ocean and coastal industries to effectively predict and adapt to climate change impacts, including loss of and changes to biodiversity.	Increased coordination of coastal resilience work helps ensure that Ocean S&T infrastructure is maintained and developed with the context of climate change.	Ongoing and new coastal resilience projects can contribute Ocean S&T to developing EJ climate screening tools as well as offer opportunities to prioritize diversity and inclusion in the blue workforce and ensure that communities most at risk from climate change impacts have equitable access to planning and jobs related to climate change mitigation and adaptation.
Conserve and protect critical ecosystems through the America the Beautiful initiative	Conserving and protecting critical habitats can not only increase natural-based carbon sequestration, but also can mitigate climate impacts such as providing habitats for migrating species or safeguarding drinking water sources. Fundamental data on climate impacts, such as ocean acidification rates, and systematic	Establishing protected and conserved areas helps delineate priority targets for baseline research and monitoring including critically important long-term observation networks.	Conservation, protection, management, and restoration of critical ecosystems calls for a blue workforce with expertise in local, Indigenous, and traditional ecosystem knowledge.

	observation of marine life shifts in the face of changing environmental conditions will in turn help preservation of critical ecosystems.		
Explore implementation of blue carbon solutions	Blue carbon ecosystems can sequester and store carbon, reducing the amount of GHGs contributing to climate change.	Establishing carbon sequestration as a priority helps build out research infrastructure in carbon cycling and related marine biogeochemical cycling, including prioritization of long-term monitoring and experimental science to determine rates of deep-sea carbon cycling.	Ongoing and new blue carbon and resilience projects offer opportunities to prioritize diversity and inclusion in the blue workforce and ensure that communities most at risk from climate change impacts have equitable access to planning and jobs related to climate change mitigation and adaptation, and habitat restoration.
Support the National Ocean Mapping, Exploration, and Characterization (NOMEC) Council	Data from ocean mapping, exploration, and characterization can help inform climate models and predictions and contextualize long-term change.	Successful implementation of NOMEC will rely on testing and deploying new and emerging platforms. In particular, autonomous tools, platforms, and technologies may provide for a more cost-effective and efficient acquisition of hydrographic mapping data, especially in shallower waters.	Mapping, exploration, and characterization data from the NOMEC Strategy can support the equitable co-development of wind power, aquaculture, and marine shipping, while also offering educational projects dedicated to growing a diverse STEM workforce to power the growing blue economy.
Engage in the UN Decade of Ocean Science for Sustainable Development	Climate is a global issue requiring global solutions, and the UN Decade provides opportunities to build upon international partnerships for coordinated mitigation and disaster responses.	International cooperation in observing networks, data sharing built by the UN Decade promote a global S&T infrastructure with distributed participation that inherently builds resilience.	A global focus on Ocean S&T for sustainable development drives growth of a workforce where every nation can be represented in the blue economy which contributes to equitable economic development across communities.

1. Facilitate offshore wind energy development

Offshore wind energy provides an opportunity for a clean, sustainable, and long-lasting alternative to traditional sources of non-renewable energy. Greater understanding of CO_2 emissions from fossil fuel combustion and its impact on anthropogenic GHG emissions and climate change has highlighted the need for better ways to power our Nation. New technologies, robust stakeholder collaborations and new partnerships, improved weather forecast models, and rigorous scientific research has allowed for the possibility of increased production of wind energy in offshore U.S. waters. Federal efforts to facilitate and support offshore wind energy efforts, in close coordination with local and State governments, the private sector, Tribal nations, and key stakeholders, will strengthen domestic energy resilience and provide employment opportunities to boost the blue economy. Further support of Federal research, development, and demonstration projects will help the industry and decision-makers overcome key barriers to offshore wind development, including the relatively high cost of energy, the mitigation of environmental impacts, the technical challenges of project installation, promotion of ocean co-uses, and grid interconnection.

2. Coordinate coastal resilience efforts

Coastal resilience requires scientific engagement and applications at the intersection of climate variability and climate change, natural hazards, natural and built environments, environmental health, offshore safety, and biodiversity. The resilience of our coastline has a direct effect on the finance, insurance, real estate, construction, transportation, tourism, recreational, and banking industries, among others. Effective service delivery requires continuous engagement with users throughout all stages of the scientific process: from seeking to answer basic science questions to feeding the outcomes of this work into actively evolving service delivery mechanisms. The scientific understanding and tools required for policy, management, and decision-making to contribute to coastal resilience spans the entirety of the natural and social science and engineering disciplines. Sustainable efforts will succeed only if environmental justice and diversity, equity, and inclusion are foundational to the work and objectives of coastal resilience practitioners. In particular, the active engagement and consultation with Tribal nations in coastal resilience coordination efforts is a key to success. Coastal resilience requires a coordinated whole-of-government approach beyond individual agency capacities and existing interagency connections, and the active inclusion of perspectives such as Indigenous, local, state, academia, and the private sector perspectives to ensure that the trusted products of Ocean S&T investments in this space are shaped by the input of these stakeholders and ultimately utilized to the fullest possible extent.

3. Conserve and protect critical ecosystems through the America the Beautiful initiative to conserve at least 30% of U.S. land and ocean by 2030

The conservation of natural resources has always been an important goal and will continue to be so over the next decade as America works towards a new ambition to conserve at least 30% of U.S. land and ocean spaces by 2030[43] and sustainably manage all waters within the U.S. EEZ.[44] This is an opportunity to mitigate, and potentially reverse, the observed decline in our Nation's ocean resources, which provide ecosystem services such as food, clean water and air, recreation, and jobs to Americans.

[43]The White House, "Executive Order on Tackling the Climate Crisis at Home and Abroad," 2021, available at: https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/executive-order-on-tackling-the-climate-crisis-at-home-and-abroad/

[44]World Resources Institute, "The United States of America Joins the High Level Panel for a Sustainable Ocean Economy," 2021, available at: https://www.oceanpanel.org/news/usa-joins-hlp

Additionally, as the climate crisis has risen to the forefront of environmental concerns, achieving this target will become increasingly paramount to preserve key ecosystem services that help to regulate the global climate, including temperature. The climate crisis elucidates the valuable role of dynamic management, as marine ecosystems and the organisms are in constant flux and the identification and evaluation of critical habitat areas should be an ongoing scientific exercise with consideration of all tradeoffs associated with a protected area. To meet these goals, the Federal government plays an important role in supporting Tribally led conservation and restoration priorities, expanding collaborative conservation and conflict mitigation of multi-use marine and coastal fish and wildlife habitats and corridors, and increasing ocean and coastal access for outdoor recreational use.[45] Significant gaps exist in our ability to document impacts of climate change on wildlife and ecosystems; these gaps can be addressed through innovative S&T and observing approaches, co-design of monitoring strategies with local communities, and support for broad global partnerships working to ensure capacity exchange and knowledge sharing.

4. Explore implementation of blue carbon solutions

With the climate crisis threatening our health and well-being, from national security to food security and biodiversity loss, the time has come for nations to consider creative solutions to reducing GHGs. One of those solutions is embracing a blue carbon storage strategy. Organic carbon can be stored in natural ecosystems such as mangroves, seagrasses, and tidal marshes, as well as can be sequestered in open ocean sediments, where it can remain for thousands to millions of years if undisturbed.[46] While marine sediments are a major carbon sink, they are also highly vulnerable to human disturbances which may potentially remineralize carbon to CO_2, and further exacerbate climate change and ocean acidification.[47] Science-based marine spatial planning can inform effective carbon storage strategies, while providing additional benefits such as meeting global targets for conservation and food security.[48] Efforts to map substrate characteristics at a high spatial resolution can fill in knowledge gaps of current marine carbon stocks to better inform protection measures. Further research is needed to explore the potential implementation of blue carbon as a climate solution, such as better understanding the degree to which GHGs are released following the disturbance of blue carbon ecosystems.[49]

5. Support the work of the National Ocean Mapping, Exploration, and Characterization (NOMEC) Council

Ocean mapping, exploration, and characterization advances maritime commerce, domestic seafood production, healthy and sustainable fisheries, coastal resilience, energy production, tourism and recreation, environmental protection, conservation, national and homeland security, among other interests. The National Ocean Mapping, Exploration, and Characterization (NOMEC) Strategy[50] presents

[45]Department of the Interior, "Conserving and Restoring America the Beautiful," 2020, available at: https://www.doi.gov/sites/doi.gov/files/report-conserving-and-restoring-america-the-beautiful-2021.pdf

[46]E. Estes and others, "Persistent organic matter in oxic subseafloor sediment," *Nature Geoscience*, 2019, available at: https://www.nature.com/articles/s41561-018-0291-5

[47]T. Atwood and others, "Global Patterns in Marine Sediment Carbon Stocks," *Frontiers in Marine Science*, 2020, available at: https://www.frontiersin.org/articles/10.3389/fmars.2020.00165/full

[48]E. Sala and others, "Protecting the global ocean for biodiversity, food and climate," *Nature*, 2021, available at: https://www.nature.com/articles/s41586-021-03371-z

[49]P. Macreadie and others, "The future of Blue Carbon science," *Nature Communications*, 2019, available at: https://www.nature.com/articles/s41467-019-11693-w

[50]Ocean Policy Committee, "National Strategy for Mapping, Exploring, and Characterizing the United States Exclusive Economic Zone," 2020, available at: https://www.noaa.gov/sites/default/files/2021-08/NOMEC%20Strategy.pdf

an ambitious multi-decadal plan to advance Ocean S&T in the United States and provide vital knowledge about climate and the ocean to better inform management of multi-use spaces. Central to the success of NOMEC efforts is close engagement and consultation with Tribal governments, including on education and workforce development, targeted outreach related to marine cultural heritage, data sharing, and use of knowledge and data for coastal community climate adaptation and mitigation. Building partnerships with the private sector, academia, and non-governmental organizations is also critical to developing and maturing new and emerging S&T. Efforts from NOMEC have the potential to better inform a multitude of solutions to ocean issues, such as ecosystem conservation efforts, renewable energy development, and sustainable coastal development.

6. Engage in the UN Decade of Ocean Science for Sustainable Development to meet its seven societal outcomes

International boundaries are meaningless to marine life and currents, to the climate and weather that the ocean drives, and to the ocean services on which humanity depends. Understanding the global ocean is necessary to understanding and effectively and equitably managing our ocean resources and ecosystems and to society's ability to adapt to and mitigate the impacts of climate change. The Ocean Decade provides an opportunity for the global community to join a highly visible, shared effort of developing partnerships and fostering energy into transforming the way ocean science is conducted and used. The Ocean Decade aims to achieve seven societal outcomes: a clean ocean where sources of pollution are identified and reduced or removed; a healthy and resilient ocean where marine ecosystems are understood, protected, restored, and managed; a productive ocean supporting sustainable food supply and a sustainable ocean economy; a predicted ocean where society understands and can respond to changing ocean conditions; a safe ocean where life and livelihoods are protected from ocean-related hazards; an accessible ocean with open and equitable access to data, information, and technology and innovation; and an inspiring and engaging ocean where society understands and values the ocean in relation to human wellbeing and sustainable development. By leveraging agency resources and formulating relationships across sectors, and particularly with new partners including international organizations, the Federal government can contribute to achieving each of these outcomes in novel, transformative ways.

Conclusion

Our ocean and coasts are economic engines for the Nation, focal regions for growth and development, and home to lands, waters, and resources of unique and national value and heritage. As our interests, investments, and influences related to the ocean have grown, accelerating rates and new modes of change are identifying the increasing the risk to coastal communities and the essential services the ocean provides. The United States is well poised to embrace the international and national attention on Ocean S&T to combat the climate crisis, build modernized and resilient Ocean S&T infrastructure, and ensure the Ocean S&T community empowers a diverse and inclusive blue workforce, all while enhancing racial justice and equity. The goals and priorities detailed in this document provide a starting point for decision-makers to incorporate these critical considerations into their work and future actions. By supporting all Ocean S&T fields and welcoming an interdisciplinary and systems-oriented lens, the Nation and global community can embrace ocean solutions to build back healthier, more sustainable, and prosperous ocean ecosystems.