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Introduction

Thank you for the opportunity to testify today regarding the important role of ocean science and technology in providing the foundational knowledge needed to understand our ocean. The National Oceanic and Atmospheric Administration (NOAA) is the lead agency in exploring, mapping, and understanding our ocean and its relationship to atmosphere and climate, as well as managing living marine resources.

Our ocean is changing at an unprecedented rate, yet we have minimal long-term records to help us establish a baseline to assess the magnitude of that change. To date, there has been a lack of awareness of the importance of our ocean and a dearth of investment in its study. By comparison, when the Nation set the goal of putting a man on the moon, we achieved that *moonshot* in less than a decade. We have dedicated incredible energy and resources towards exploring and understanding space, while much of the ocean is unmapped and unexplored. Our Nation prides itself on our drive to make new discoveries and seek out new knowledge, yet we have largely ignored exploring and fully understanding the deep ocean that makes up over 70 percent of our planet's surface and holds over 96 percent of all of Earth's water. Fully knowing our ocean is increasingly critical at a time when we are changing our planet at an unprecedented rate. We have a unique opportunity at this moment to explore the global ocean and achieve our version of a moonshot: an "ocean-shot."

Understanding our ocean requires measurements, observations, and modeling that provide information that is essential for the safety and economic well-being of our Nation. NOAA's exploration and observation enterprise collects data on past and present conditions, and provides the foundation for predicting future changes. Quality, reliable data and observations support safe and efficient management of coastal and offshore resources and serve as the critical starting point for predicting the future state not only of our ocean, but for our entire Earth system. Exploring, mapping, and observing are the first steps in our baseline understanding of the planet. From the baseline of an explored or known environment comes hypothesis-driven science essential for developing a full understanding of the ocean and our impacts on it. As we come to know and better predict the ocean environment, we improve our ability to understand and predict weather and climate. This includes improving subseasonal to seasonal forecasts, advancing knowledge of long-term global change, and using this knowledge for more accurate and timely information needed to better protect life and property.

NOAA's goals and mission align well with those of the UN Decade of Ocean Science for Sustainable Development (Decade of Ocean Science), commencing this year. As a science-to-services agency, NOAA recognizes the importance of transforming science into products and services for society, as the Decade of Ocean Science intends to do by linking ocean science to sustainable development across the globe. Within the federal government, NOAA is tasked with coordinating interagency planning for the Decade of Ocean Science. In this coordinating role, NOAA brings agencies together, facilitates dialogue on linkages to the Decade of Ocean Science challenges and societal outcomes, and works to promote synergies between relevant existing and potential federal initiatives. The start of the Decade of Ocean Science and the Nation's interest in ocean science and technology provide us with a unique opportunity to leverage multiple resources to work towards attaining an all-encompassing "ocean-shot" of fully knowing and understanding our ocean.

America's blue economy depends on understanding our ocean. NOAA's mission to share knowledge, information, and predictions regarding the Nation's climate, weather, ocean, and coasts and to conserve and manage coastal and marine ecosystems and resources, uniquely positions the Agency to support the Nation's competitiveness in ocean-related segments of the U.S. economy, which was worth nearly $373 billion GDP in 2018.[1] A healthy blue economy depends on our ocean, coastal, and Great Lakes resources. The science and management to conserve and sustainably use these resources is at the heart of NOAA's mission. Our ocean is experiencing a rise in economic importance, which in turn has strategic implications. Today, there is a need and desire to observe and understand our ocean for near-term benefit, which should be done in a manner that will preserve this resource for future generations.

[1] https://oceanservice.noaa.gov/annualreport/2020/ocm.html#gdp, https://coast.noaa.gov/data/digitalcoast/pdf/econ-report.pdf

Exploration and Mapping:

The ocean plays a critical role in supporting life on our planet, from the air we breathe and the food we eat, to weather and climate patterns, yet our understanding of the ocean remains limited. Ocean exploration is about making discoveries, finding the unexpected, and learning more about the unknown or poorly known areas of the ocean. Through ocean exploration, we collect data and information needed to address both current and emerging science and management needs so that ocean resources are managed in a sustainable way, ensuring they are around for future generations. Over the past decade, NOAA has mapped 2,037,829 square kilometers and discovered over 40 new species as we have explored the deep ocean. Hundreds of NOAA scientists have participated in this work, including with our academic partners. Thousands of people have engaged in NOAA's ship tours and in-person interactions. Millions of people have watched ROV dives via live video feeds, further engaging the public in ocean exploration and discovery and sparking their interest in the marine world.

America's economy depends on the ocean. The U.S. has the second largest Exclusive Economic Zone (EEZ) in the world, yet, 53% of US waters, including the Great Lakes, remain unmapped, with current technology. . Closing gaps in our basic understanding of the seafloor and water column within U.S. waters will facilitate growth in other sectors. Ocean exploration and mapping provides crucial information to sectors such as marine aquaculture, transportation, tourism, environmentally safe mining and energy, and others; mapping enables identification of new areas for sustainable use and areas where resources should be left undisturbed, helping to fully realize economic gains for the U.S. Exploration of the U.S. EEZ is also important for national security, allowing us to better define our boundaries and protect the American interests and ocean resources within them.

The challenges met while exploring the ocean can spur new technologies and engineering innovations that can be applied in other situations, allowing us to respond more effectively in the face of an ocean crisis, such as an oil spill. Technology enhancements in areas such as uncrewed systems, high bandwidth communications, and artificial intelligence are key to achieving our goals in the National Ocean Mapping, Exploration and Characterization, or NOMEC, Strategy.[2] For example, we expect the rapid advancement of autonomous tools and platforms to enable more cost-effective and efficient acquisition of hydrographic mapping data and site explorations, particularly in challenging regions like the Arctic. And, ocean exploration can improve ocean literacy and inspire young people to seek careers in science, technology, engineering, and mathematics.

[2] Implementation Plan for the National Strategy for Ocean Mapping, Exploring, and Characterizing the United States Exclusive Economic Zone https://iocm.noaa.gov/about/documents/strategic-plans/210107-FINALNOMECImplementationPlan-Clean.pdf

Ocean Exploration is intended to target the global ocean, in addition to closing the gap of knowledge of our own domestic ocean areas. Unlocking the mysteries of ocean ecosystems can reveal new sources for medical therapies and vaccines, food, energy, and more, as well as inspire inventions that mimic adaptations of deep-sea animals. Information from ocean exploration can help us understand how we are affecting and being affected by changes in Earth's environment, including changes in weather and climate. Insights from ocean exploration can help us better understand and respond to earthquakes, tsunamis, and other hazards.

Emerging technologies will allow us to investigate the ocean at unprecedented time and space scales that yield fundamental scientific discoveries. For example, initial studies of the midwater section of the water column known as the twilight zone, enabled by new technologies, suggest that the biomass of fish in the twilight zone may be more than in all the rest of the ocean combined. The dark and cold ocean twilight zone is one of the least understood environments on the planet, despite its importance to ecosystem services, including supporting ocean food webs and commercial fisheries, and transferring carbon dioxide to the deep ocean. Private industry, academia, and non-governmental organizations have long been, and will continue to be, valued partners of NOAA and major contributors to the marine technology developments we need in order to map and explore our ocean.

New and enhanced technologies such as underwater gliders and floats have the potential to revolutionize the quality, accuracy, and coverage of meteorological products such as hurricane intensity forecasts. Additionally, the integration of social and citizen science has led to enhanced forecast and warning methods as well as improved citizen response. Technology systems we support through partnerships with the academic community and private sector (including non-profit) partners include autonomous vehicles to explore the deep ocean and map the seafloor, and remotely operated vehicles to work at depths beyond a diver's reach.

Without adequate knowledge of our ocean and coastal realms, we cannot make appropriate decisions about their management or protection. Information about the location and composition of many resources is incomplete and can delay siting decisions, permitting processes, and investment; offshore wind capacity cannot be adequately scoped without this essential information. There are also national security and ecosystem protection considerations when other nations' investigate seabed resources in or adjacent to U.S. waters.

Monitoring & Observations

The Earth is an ocean planet, and every sector of society is affected by the ocean, either directly or indirectly. Coastal and global ocean observations and associated research are foundational to characterizing ocean and environmental changes over time. They are key to improvements in weather, climate, marine, and ocean forecasts, especially for high impact events such as El Niño, sea-ice minima, hurricanes and other storms, drought, marine heat waves, land heat waves, ocean

acidification, ocean deoxygenation, and regional weather. Ocean observations also underpin a number of the goals laid out in the Executive Order on Tackling the Climate Crisis at Home and Abroad.[3] Reliable global ocean observations and monitoring facilitate effective decision-making on time scales of hours (weather) to decades (climate). Skillful global and coastal weather and climate prediction, combined with robust marine environmental monitoring, enables informed decision making across a wide range of stakeholders and policy makers. As the volume of ocean observations grows, especially at sufficient temporal and spatial scales, so does the opportunity to apply them to ensure safety, enhance commerce, propel offshore renewable wind and wave energy generation, and understand our changing climate.

Ocean observations, in combination with atmospheric and terrestrial observations, are necessary inputs to earth system prediction models that in turn drive land-based weather forecasts and marine forecasts that enable optimization of renewable energy generation, enhance safety and fuel efficiency of trans-oceanic voyage planning, and avoidance of extreme maritime hazards that can lead to loss of life and property and costly environmental disasters. Ocean observations, including at depth, are important for initializing the state of the ocean for hurricane prediction (especially intensity) and global subseasonal to seasonal (and longer) time scales. Ocean observation systems inform daily, weekly, and seasonal weather forecasts. If you like your 7 day weather forecast, thank an oceanographer.

Through international, intergovernmental entities such as the Intergovernmental Oceanographic Commission, the World Meteorological Organization, and the International Hydrographic Organization, the U.S. is leading the advancement of common standards and frameworks for ocean and marine meteorological observations to enable broader access to information across the world's oceans.

NOAA, with the help of its federal and private sector partners, provides more than one million measurements of the ocean each day to users throughout the U.S. and across the globe. These observations are broadcast to data facilities to be screened, quality controlled, and ultimately made openly available to the global community. NOAA satellites provide remote global observations of the Earth on a near real time basis. NOAA leverages data from our international partner satellites to augment ocean observations required for activities such as tsunami monitoring, detecting the onset of the El Niño-Southern Oscillation, and tracking impact of sea surface temperature on distribution of fisheries. In addition to imagery, NOAA satellites provide important data relay from ocean buoys in difficult-to-reach and remote locations to support NOAA's ocean and coastal mission. All of this data requires stewardship and management. NOAA and partners provide archival access to large data sets to support long term assessments.

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

In terms of user services, NOAA operates the popular national Coastwatch/OceanWatch network, which makes satellite data available for users in specific geographic areas. In total, NOAA ocean observations and products improve the lives of every American, every day, however, the skillful application of new and emerging technologies can expand the boundaries of what is possible in this realm.

With advances in observing technologies, systematic observations of the chemical aspects of the ocean (e.g. ocean acidification, oxygen, carbon) are now possible. NOAA is implementing enhanced observing capabilities, such as the biogeochemical Argo program, which will allow for the collection of oxygen, nitrate, pH, and chlorophyll concentrations around the world, and Deep Argo, which will expand our range of collections to 6,000 meter depth. These technologies will help increase ocean carbon measurements, allowing NOAA to better track and understand how the ocean is absorbing carbon emissions and mitigating the short-term impacts. With these and other enhanced observing systems, NOAA can characterize how marine ecosystems change in response to ocean acidification, ocean warming, and sea ice loss. Along with new product development and advances in ecosystem modeling, these observations will be key to more sustainably managing our marine living resources, particularly in the Arctic, as well as along our Nation's highly productive and vulnerable coastlines.

Over 127 million people[4] in the United States live in coastal counties, which face a number of threats spanning from increasing storm intensity to coastal inundation and sea level rise. These growing coastal risks threaten aging infrastructure, disrupt food and water supplies, and make it difficult to plan for natural disaster response and recovery. There is an increasing need for accessible ocean data and information for decision-making in these rapidly changing communities. In order to provide this information, we need additional global ocean measurements, extensions into coastal regions, and expanded collection of marine life observations throughout the vast expanse of ocean depth and breadth. Of special importance are improved observations of the tropical, deep, and polar ocean, such as bathymetry, temperature, salinity, sea levels and sea ice cover, as well as event-related observations of storms and other extremes.[5]

One such coastal region experiencing rapid changes is the Arctic, which faces the added challenge of changing sea ice conditions. Sea ice is at the center of Arctic marine ecosystems and changes in sea ice coverage have triggered an ongoing cascade of impacts threatening the stability of Alaskan commercial fisheries, the safety of maritime shipping and transportation

[4] Economics and Demographics https://coast.noaa.gov/states/fast-facts/economics-and-demographics.html#:~:text=Coastal%20counties%20of%20the%20U.S., land%20mass%20(excluding%20Alaska).
[5]https://oceanservice.noaa.gov/facts/population.html#:~:text=Though%20home%20to%20almost%2040,people%20live%20in%20coastal%20counties.

operations, food and cultural security of Indigenous communities throughout Alaska, and the safety and security of coastal villages.

By increasing the depth and coverage of *in situ* ocean observations to more accurately capture ocean heat content, NOAA has the potential to enhance our understanding and prediction of ecosystem changes, improving coastal communities' ability to respond to the threats imposed by climate change.

Novel technologies improve our ability to monitor and observe the ocean and marine life. One such technique that NOAA is increasingly using is the field of 'Omics, or using DNA, RNA, proteins, and small molecules to monitor life in the Great Lakes and global ocean. This suite of techniques to analyze biomolecules has revolutionized biological research, benefitting fields ranging from agriculture to public health. NOAA is increasingly looking at how we can make use of this tool to further our understanding the marine life of the ocean.

'Omics is a tool that is already making contributions to fields beyond ocean science. For example, 'omics contributed to the genetic sequencing that laid the foundation to track, diagnose, and prevent the spread of COVID-19. With rapidly expanding approaches, 'Omics isimp providing new opportunities to solve previously intractable problems from improving food and water safety to sustaining fisheries to protecting vulnerable species and habitats. The marine microbiome is a relatively untapped bioeconomy resource that can benefit commercial sectors as well as the management of ecosystem resources. Although the viruses, bacteria and phytoplankton of the ocean are tiny, they control critical food webs and global cycles, including those involved in climate regulation.

Environmental DNA (or eDNA) is, stated simply, the process of collecting and sequencing DNA present in the environment, and offers an economical means to measure biodiversity at large scales. In addition to glimpsing the hidden universe of the microbial world, eDNA can identify organisms, such as fish or marine mammals, using *just seawater* (not tissue) by analyzing DNA from sloughed or excreted cells. The advantages of eDNA analysis include integration into autonomous platforms, allowing us to observe hard-to-reach areas; for example, sensitive habitats, deep ocean, and under ice.

Impact assessments fueled by the breadth and depth of 'omics information will contribute to better prediction and management of changing ocean ecosystems; for example, by providing indicators of sub-lethal stress to forewarn the risk of ecosystem collapse. 'Omics also has the potential to revolutionize the search for the causes and cures for diseases that are devastating corals and other living marine resources, solutions for algal blooms that threaten water quality, ways to mitigate climate-related threats to fisheries and aquaculture and, when combined with autonomous technologies, may provide the large scale biological mapping, monitoring, and

prediction needed to understand and prepare for changes in the ocean and Great Lakes over the next decade and beyond. NOAA is combining 'omics with uncrewed systems to protect Pacific Northwest seafood and Great Lakes drinking water from toxic algal blooms, monitor Gulf of Mexico whale populations, and characterize the biodiversity of valuable fish species and the food webs that support them in the productive currents that run along the coasts of our western states. Autonomous 'omics allow us to extend our observational reach and collect more data cost-effectively. In partnership with a variety of non-governmental engineering teams (e.g., the Monterey Bay Aquarium Research Institute and Saildrone), we are developing new tools to better forecast, monitor, and understand the ecosystems that support a variety of sectors and communities.

'Omics development and implementation require the proper capacity, tools, and expertise. As machine learning and artificial intelligence tools develop, ecosystem status and trends can be routinely delivered by automated bioinformatics pipelines. The NOAA 'Omics Strategy[6] and Strategic Plan[7] chart the course for us to harness technological advances to address priority needs.

Modeling

NOAA is among the world leaders in developing interdisciplinary Earth system models. This includes designing tools and processes to forecast high-impact weather, water, climate, ocean and ecosystem events, and transitioning science into products that meet users' current and future needs. Ocean and coastal observations and research are a foundation for advancing forecasts. Weather-climate forecasting has improved over the past several decades due, in part, to an increase in high-quality ocean observations. However, greater use of global and regional ocean monitoring and observation data is still needed to improve accuracy of models and there are still many gaps in ocean observations that must be filled to further improve forecasts to meet societal needs.

One example is the redesign of the Tropical Pacific Observing System (TPOS).[8] Monitoring and observing the tropical Pacific supports a better understanding and prediction of El Niño Southern Oscillation (ENSO), which influences temperature and precipitation across the globe and throughout the United States. The new TPOS design leverages complementary data from buoys, satellites and new autonomous instruments to contribute to the next generations of earth system models and will ensure that the U.S. continues its regional influence in the Tropical Pacific as a

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[6] 'Omics Strategy - https://sciencecouncil.noaa.gov/Portals/0/2020%20Omics%20Strategy.pdf?ver=2020-09-17-150026-760

[7] 'Omics Strategic Plan - https://sciencecouncil.noaa.gov/Portals/0/Omics%20Strategic%20Plan_Final%20Signed.pdf?ver=2021-01-19-112404-443

[8] https://tpos2020.org/

scientific leader. NOAA and our partners have made measurements in the tropical Pacific for decades and have worked to improve the forecast models that use this information. TPOS allows us to gain a greater understanding of the tropical Pacific, better address the uncertainties of climate variability, and provide improved predictions and longer forecast lead times. Improving our forecasting abilities will have a positive impact on agriculture, water management, marine ecosystems, human health, and disaster preparedness.

Our abilities to make short term forecasts, predict subseasonal to seasonal changes, and develop multidecadal to centennial scale predictions are built on our ability to model the earth system. Advancing these capacities requires constant improvements to operational models and forecast systems in order to integrate the latest user requirements, scientific research advances, and modeling developments. Just as a robust marine transportation system is crucial to a vibrant marine economy, a robust ocean and marine observation network is an essential component of safe marine transportation and, therefore, to a burgeoning Blue-Green economy. Advances in regional ocean models that are better integrated into Earth System models are needed to deliver robust projections of ocean conditions over the spatial and temporal scales relevant to living resource management, as well as to enhance both climate and weather predictions. Higher global ocean resolution for fine-scale information is needed to predict marine heat waves. Improved simulation of atmosphere-ocean interactions and forecasting is needed to advance short term forecasts and subseasonal to seasonal changes. Greater representation of ocean topography and straits is needed to improve simulation of ocean circulation and thus heat and carbon uptake in both the Northern and Southern Hemisphere. Additional advances are also needed with regard to developing and operationalizing ecological forecasts in order to provide early warnings of the possible effects of ecosystem changes on coastal systems, human health, and regional economies.

To ensure substantial progress in making NOAA's forecasts better, NOAA is working to overcome key challenges in compute capabilities, data assimilation, and hiring of skill-specific personnel. By improving data assimilation, NOAA's forecast systems will be able to fully use the increasing array of global observations from the sun to the sea, as is being done in other global centers. Upgrades to the software infrastructure will allow NOAA to enhance the value of investments in observational systems required to improve forecast guidance. An additional challenge to improving data assimilation at NOAA is finding, recruiting, and hiring experts, particularly software engineers, in this niche space.

Near-term priorities for making forecasts better include: increasing the resolution of Modular Ocean Model 6 (MOM6) to inform and improve fisheries management of commercially important species by providing high quality information on changing ocean conditions; enhancing the skill of precipitation prediction across weather and climate timescales to advance projections of precipitation extremes; improving the accuracy and reliability of hurricane

forecasts through the Hurricane Forecast Improvement Project; improve predictions of sea ice across multiple timescales (and associated weather in the Arctic and in the Lower 48), while also addressing a high-priority need for coastal communities; and ecological forecasts to provide early warnings of the possible effects of ecosystem changes on coastal systems, human health, and regional economies. All of this is driven by improved ocean observations.

Decade of Ocean Science for Sustainable Development & NOAA's Role

At the start of the Presidentially proclaimed National Ocean Month,[9] growing national and international recognition of significant threats to the ocean (pollution, acidification, exploitation, hazards), and therefore human health, has led to international consensus on the need for an Ocean Decade: a campaign for transformational ocean science that will empower and engage stakeholders, catalyze scientific advances to promote a healthy ocean for the benefit of all, and be of sufficient duration to inform solutions that make sustainable development possible. This consensus was reflected in the 2017 UN General Assembly resolution[10], which proclaimed 2021-2030 the Decade of Ocean Science for Sustainable Development. The United States, the catalyst for the prior Decade of Ocean Exploration (1971-1980), supported this resolution and has engaged vigorously in the Decade of Ocean Science thus far to influence the scope, inform our own planning efforts and optimize all potentials for successfully conducting "the science we need for the ocean we want" -- the byline for the Decade. The previous Decade of Ocean Exploration helped to inspire a global generation of marine scientists and contributed to an awakening of understanding of the role the oceans play in our lives. We have an opportunity at the start of this Decade of Ocean Science to lead the global community in observing and understanding the ocean, and inspiring the next generation to come with us at a time when the ocean is facing perilous change.

I serve as the U.S. representative to the Intergovernmental Oceanographic Commission, the intergovernmental body of 150 nations that is overseeing the Decade of Ocean Science. I served as a member of the initial planning as well as a member of the Decade Executive Planning Group.

The United States has truly been instrumental in developing the vision for the Decade of Ocean Science. American experts, selected to participate in their personal capacity, occupied six of the 20 seats on the Decade Executive Planning Group; two of the six hailed from NOAA. This demonstrates the influence that U.S. leadership has had on the formulation of the Ocean Decade, and the recognition of U.S. leadership in the field. Additional U.S. subject matter experts were involved in the regional workshops (11 regions, +1900 attendees), global workshop (+200

[9] www.whitehouse.gov/briefing-room/presidential-actions/2021/06/01/a-proclamation-on-national-ocean-month-2021
[10] https://undocs.org/en/A/RES/72/73

attendees), and several thematic meetings. These events informed the draft Decade Implementation Plan, which was reviewed by the National Science and Technology Committee Subcommittee on Ocean Science and Technology (SOST) and delivered in its final form to the UN General Assembly last fall.[11] The Ocean Decade challenges identified in the Implementation Plan represent the most immediate and pressing priorities for the Decade of Ocean Science and align closely with NOAA's priorities. For example, the Decade of Ocean Science challenges include: understanding the impacts of multiple stressors on ocean ecosystems, supporting sustainable fishing to feed the world's population, and enhancing our understanding of the ocean-climate nexus, to name a few.

During this opening year of the Decade of Ocean Science, the U.S. government responded robustly to the first call for action: 17 submissions provided by five federal agencies reflect the breadth of our interests, covering all ocean basins and all of the Decade outcomes proposed to guide us toward a clean, healthy, productive, predicted, safe, accessible, and inspiring ocean. The global community also responded to the call, submitting over 200 submissions for endorsement by the IOC to meet the goals and visions of the Decade of Ocean Science. Subsequent calls for action will be issued throughout the Decade, and the SOST is primed to ensure that the United States involvement continues to represent and advance our position as a global leader in ocean science and technology.

Last fall, the National Science and Technology Council recognized NOAA as the lead agency to coordinate interagency planning for the Decade of Ocean Science. In this role, NOAA has been joined by other federal agencies to lead an aggressive campaign to engage the breadth of federal and public expertise in addressing Decade of Ocean Science goals and challenges. Where the U.S. leads, the rest of the globe will follow, and through our engagement we inspire action and commitment that amplifies our investment many times over. Global interest has been sparked in communities, professional and technological societies, the private sector, and nongovernmental organizations. Expanded U.S. investment across the federal sector could leverage that interest to improve our understanding of the ocean and reap the societal benefits.

In addition to a robust U.S. government response to the impetus for ocean action under the Decade of Ocean Science, U.S. experts across academia, industry, civil society, and the public have also answered the call for engagement and ideas. NOAA initiated the U.S. National Committee for the Decade[12] working with the National Academies of Sciences, Engineering and Medicine Ocean Studies Board members and representatives from the Academies' Polar Research Board, the Marine Board of the Transportation Research Board, and the Sustainability Roundtable. Committee membership is complemented by four Early Career Ocean Professionals

[11] https://undocs.org/en/A/RES/75/239

[12] https://www.nationalacademies.org/our-work/us-national-committee-on-ocean-science-for-sustainable-development-2021-2030

(selected from 85 applicants) and the U.S. Youth Advisory Council for the Ocean Decade[13] as established by the Heirs to Our Ocean, and its first cohort is forty 14-25 year olds. This represents a significant achievement in involving our youth in the future of their oceans. Over the past year, more than 65 organizations have joined the Committee's Ocean Decade U.S. Nexus[14] to help contribute to and disseminate news about U.S. efforts during the Decade of Ocean Science. Proudly, we note the diverse and inclusive nature of the U.S. National Committee for the Decade has been acknowledged as a model for other nations to follow, as well as the Youth Advisory Council for the Decade of Ocean Science. We hope that as more youth become involved in ocean work and stewardship through opportunities such as these, they will gain experiences needed to join the workforce in emerging science and technological fields. The blue economy offers tremendous opportunities for young people and will benefit from the unique skills that they will bring.

The U.S. National Committee for the Decade has held three public meetings, the most recent, in February 2021, served as the U.S. Decade Launch -- notably the first country to hold such a launch. The Committee has served as an incubator of Decade actions, now in receipt of over 90 "ocean-shots," defined as audacious and transformative research ideas that draw inspiration and expertise from multiple disciplines and fundamentally advance ocean science for sustainable development.[15] The Committee is working with the SOST to explore alignment of the ocean-Shots with Administration priorities and to optimize partnerships to support the most compelling ocean-shots. If even half of these ocean-shots are fully realized, we will have achieved significant forward momentum in our goal of more fully knowing our ocean.

The Decade of Ocean Science has already motivated the ocean community into action. Federal agencies, non-governmental organizations, commercial companies, and philanthropic organizations are approaching NOAA, eager to help ensure United States Decade of Ocean Science efforts are impactful and inclusive of their respective communities, and NOAA is working to ensure the opportunities for public-private and international efforts are optimized.

Inspiring a Moonshot for the Ocean

Inspiring an ocean-shot equivalent to the moonshot of the 1960s will take American leadership and investment. We need the ocean to inspire and invite a new and diverse cadre of American youth to address the ocean challenges and face the climate crisis. American leadership is required to achieve the daunting challenge of a moonshot for the ocean. As America leads, other

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[13] https://h2oo.org/us-yac-for-un-ocean-decade/#:~:text=The%20US%20YAC%20is%20made,Territories%20and%20otherwise%20occupied%20lands.
[14] https://www.nationalacademies.org/our-work/us-national-committee-on-ocean-science-for-sustainable-development-2021-2030#sl-three-columns-bc291cc6-8db8-495b-bd04-62cb0af40a70
[15] https://www.nationalacademies.org/our-work/us-national-committee-on-ocean-science-for-sustainable-development-2021-2030/ocean-shot-directory#

nations follow. The Ocean Decade is a time for leadership in order to reach real ocean-shot objectives.

The world ocean is not fully mapped. New species are still being discovered. The marine ecosystem is understood very well in certain areas, remains a mystery in others, and is changing rapidly from the influences of climate change. We have only recently come to understand the role of the ocean in maintaining planetary stability. We need more complete information to generate lasting solutions to society's needs, while sustaining and promoting the services the ocean provides. To manage our human behavior, make sustainable societal choices, to develop a sustainable ocean or blue economy while building back better, and addressing the climate crisis, America can lead with an ocean-shot: to make the ocean transparent.

First, to make the ocean transparent, we need a complete map of the ocean. The General Bathymetric Chart of the Oceans estimates that only 19% of the world ocean has been mapped.[16] The U.S. was instrumental in creating the Seabed 2030 program through the International Hydrographic Organization and the IOC. This program seeks to map the world ocean by the year 2030. The U.S. is committed to mapping our own EEZ, and to explore and characterize the area. With this knowledge, the most appropriate uses of ocean resources can be employed and designed with minimal disruption to the natural ocean.

Discovering our marine ecosystem is the second step of making the ocean transparent. Cameras are already augmenting live capture inventories of marine species, but the sciences of molecular genetics, including 'omics and eDNA are emerging rapidly and will have the capability to render a quick assessment of all marine life - from plasmids, viruses and bacteria, to the great whales, and even the bacteria in the stomach of the whale. These technologies will enable a continuation of the decade-long Census of Marine Life[17], designed to define what did, what does, and what will live in the ocean. Today's efforts to develop a sustainable ocean and sustainable ocean economy can build on the legacy of that program and continue the discovery.

Third, the wealth of existing ocean data needs to be available, accessible, and easily usable. Exploring the ocean through big data approaches and using Artificial Intelligence and Machine Learning will accelerate human understanding of ocean biological, chemical, and physical processes, and unlock the remaining science necessary to predict the future human experience as we confront the climate crisis.

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[16] https://iocm.noaa.gov/seabed-2030.html

[17] https://oceanservice.noaa.gov/facts/marine-census.html#:~:text=The%20Census%20of%20Marine%20Life%20was%20an%20international%20project%20that,of%20life%20in%20the%20ocean.&text=The%20Census%20of%20Marine%20Life%20was%20an%20international%20project%20spanning,of%20life%20in%20the%20ocean.

Lastly, the awe, excitement, and thrill of discovery in the ocean is essential. A nation was inspired by the scientific journey to the moon. This can be experienced when someone first wears a diving mask and is inspired by the journeys of explorers diving to the deepest part of the ocean. There is life in the ocean that we are still discovering. There are medical cures from the ocean waiting to be found, the likes of which no other realm of human exploration has revealed. The technology is available for the next generation to take the helm from today's explorers and begin to make discoveries perhaps from their living rooms, and prepare America's future in science, technology, engineering, and mathematics.

American ambition and leadership are necessary to achieve the goal of making the ocean transparent, and to arrive at a sustainable ocean economy, globally. On this journey, American ingenuity and leadership will fuel the ship of discovery to take us on this journey. And if not America, who is going to replace us?

Future Directions & Concluding Remarks

As the lead oceanic and atmospheric agency, NOAA is ready to lead our Nation in coming to fully know the ocean via exploration, observation and modeling, and involvement in the upcoming Decade of Ocean Science. As the only agency with ocean exploration and mapping in our mandate, NOAA is collecting the foundational ocean knowledge needed to fully understand our ocean, and is proactively advancing and developing the technologies that will bring a new depth of understanding that our predecessors could not imagine. These technologies span from autonomous vehicles in the ocean, to providing earth observation data with the next series of geostationary and polar-orbiting satellites to advance NOAA's mission.

Evolving science and technology will improve our data collection, leading to more accurate forecast models, which will in turn enhance decision support and services. Fully knowing our ocean will allow us to create better ocean-atmosphere coupled models that will set the stage for the creation of a unified forecasting system. To achieve this, NOAA needs to improve and increase relevant observations. With quantitative measurements and observations we can understand and predict the changes to marine life and sea-ice, giving us opportunities to act before tipping points are reached. The connectedness and connectivity of ocean and land systems highlights our need for increased and improved observations to inform future predictions.

As we collect more data, we must also consider the user and how best to link this improved monitoring and scientific understanding of the ocean with the socioeconomic impacts of the use of the ocean and its resources. NOAA ocean data is collected and disseminated to be of value to decision-makers from the State and Federal level down to the individual, such as a farmer using a long-range forecast to make decisions about this year's crop season. The value of our marine ecosystem depends on sustainable management for current and future generations, and realizing

that value requires a new understanding of the ocean. Our vision is to continue to improve and transform the translation of research and observational information into human decisions that have economic value. This takes a great deal of time, resources, expertise, and practice. We are continuously improving our ocean understanding through observations and research, then communicating that to the public, private sector, and government officials. We have developed and will continue to expand upon a wide range of powerful data tools and analytics to allow for rapid, comprehensive, and precise discovery.

NOAA engages with critical federal and non-governmental partners to observe, characterize, and communicate our ocean science to many audiences, inspiring future generations to care for our ocean. NOAA will continue to leverage new technologies with partnerships between the government, academia, NGOs, and the private sector, as well as across global organizations. The Decade of Ocean Science provides an unprecedented opportunity for building these partnerships, advancing the science, and sharing knowledge. The synergies between our goals and the goals of the Decade will set the stage for further developments in the realm of ocean science and technology that will help us achieve our "ocean-shot" of fully knowing and understanding our ocean.

We're on the cusp of an ocean revolution with uncrewed systems, 'omics, computing, modeling, artificial intelligence, and machine learning advances. We need to prepare for the mountain of ocean information and data that is coming our way. As a Nation, we know that the ocean can provide us with a myriad of new discoveries, from biotechnology and pharmaceuticals, to improved food security, but there are likely additional benefits to fully knowing our ocean that are beyond our understanding. May this Decade of Ocean Science yield discoveries and results that we have yet to imagine.

Craig McLean
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Craig McLean is the Assistant Administrator for NOAA's Oceanic and Atmospheric Research (OAR). He is responsible for overseeing, directing and implementing NOAA's research enterprise including a network of research laboratories and the execution of NOAA programs including the Climate Program, National Sea Grant, Ocean Exploration, to name a few. Among a number of formal international engagements in science and technology, Mr. McLean serves as the U.S. Representative to the Intergovernmental Oceanographic Commission (IOC), and as the Co-chair of the U.S. European Union Marine Working Group.

Mr. McLean has previously served as Acting Deputy Assistant Administrator of the National Ocean Service, and was the founding Director of OAR's Office of Ocean Exploration and Research and served in uniform for nearly 25 years in NOAA's Commissioned Corps, attaining the rank of Captain. Mr. McLean served aboard hydrographic, oceanographic, and fisheries research ships and was the first commanding officer of the NOAA Ship *Gordon Gunter*. Craig led NOAA's innovation and planning for the Smithsonian Institution's Sant Ocean Hall, and achieved a National Ocean Action Plan goal of securing a permanent, dedicated ship for the National Ocean Exploration Program, the NOAA Ship *Okeanos Explorer*. Craig is also an attorney and has practiced marine resource law for NOAA. He has been awarded the Department of Commerce Silver and Bronze Medals, the NOAA Corps Commendation Medal, and Special Achievement Medal. Mr. McLean is a Fellow of the Explorers Club, and of the Marine Technology Society, and a past-president and chairman of the Sea-Space Symposium.