WRITTEN TESTIMONY OF

Margaret Leinen, Vice Chancellor Marine Sciences
Director, Scripps Institution of Oceanography
University of California San Diego

**BEFORE THE UNITED STATES HOUSE OF REPRESENTATIVES COMMITTEE ON SCIENCE, SPACE, & TECHNOLOGY
SUBCOMMITTEE ON ENVIRONMENT**

Hearing on "*To the Depths, and Beyond: Examining Blue Economy Technologies."*

Wednesday, March 26, 2025

Chair Franklin, Ranking Member Amo, and Members of the Subcommittee, thank you for the opportunity to submit testimony for this hearing titled, *To the Depths, and Beyond: Examining Blue Economy Technologies.* My name is Margaret Leinen, and I am the Vice Chancellor for Marine Sciences at University of California San Diego and Director of Scripps Institution of Oceanography (Scripps Oceanography), an academic and research division of the university.

I study ocean biogeochemistry and paleoceanography. I previously served as Dean and Vice Provost of the Graduate School of Oceanography at University of Rhode Island and Director of Harbor Branch Oceanographic Institution and Vice Provost at Florida Atlantic University. From 2000 to 2007, I was the Assistant Director for Geosciences and Coordinator of Environmental Research and Education for the National Science Foundation. I have also served as the Chief Scientist of an ocean technology start-up and the Founder of an ocean non-profit. I served as president of both of the scientific societies that represent ocean science, the American Geophysical Union (AGU) and The Oceanography Society. After coming to Scripps Oceanography I served as a U.S. Department of State Science Envoy focusing on ocean science in Latin America, East Asia, and the Pacific. I co-chaired the Decade Advisory Board for the UN Decade of Ocean Science for Sustainable Development. I have a PhD in oceanography from the University of Rhode Island, a master's degree in geological oceanography from Oregon State University, and a bachelor's degree in geology from the University of Illinois.

Institution Background

Scripps Institution of Oceanography is one of the oldest, largest, and most influential oceanographic research institutions in the world. Founded in 1903, Scripps has been a vital research partner and collaborator with the US Government. While I am here today to talk about the National Oceanic and Atmospheric Administration (NOAA), we also serve as an integrator across a number of agencies to execute scientific research that enhances their respective missions. Scripps Marine Physical Laboratory (MPL) traces its legacy to one of four major lab partners of the Department of Defense (DoD) and the US Navy during WWII. The institution has long supported our nation's needs for technology-based oceanographic research, sonar technology, and research in the undersea domain. Its innovations in submarine acoustics and ocean observation technologies have provided critical dual use advantages for a range of operations and missions. This Navy-funded academic laboratory also provides research training to students, including veterans and active-duty military officers, in areas of oceanography and ocean technology which have application to Navy requirements.

For decades, our institution has been at the forefront of oceanographic innovation, working in close collaboration with NOAA. Through this partnership, Scripps has advanced ocean science and technology applied to a host of environmental challenges across the globe and has also been instrumental in training the next generation of scientists, engineers, and industry leaders. Scripps has pioneered the development of long-term observing systems, understanding the El Niño-Southern Oscillation (ENSO) and related impacts on weather and extreme events, enhancing extreme storm prediction–including atmospheric rivers –and improving water and wild/urban fire management in the West. These fields of research have had profound implications for weather prediction, agriculture, and disaster preparedness nationally, and across the globe, and have greatly contributed to what we all know as the Blue Economy today.

Scripps hosts a range of NOAA-affiliated programs and research centers including the Southern California Coastal Ocean Observing System (SCCOOS), an Integrated Ocean Observing System (IOOS) Regional Association, the California Sea Grant College Program, the Southwest Fisheries Science Center, and key initiatives in ocean geodesy. We serve as vital collaborators in advancing our nation's oceanic and atmospheric science, climate monitoring, marine resource management, and environmental resilience. Outside of NOAA, Scripps also hosts the US Coast Guard Blue Tech Center of Expertise (BTCOE) and staff from the US Army Corps of Engineers (USACE) Engineering Research and Development Center (ERDC).

Ocean Innovation and Exploration – for research competition, national security, and enhanced weather prediction

The deep ocean is one of the least explored frontiers, offering the U.S. the opportunity to lead in exploration and innovation. Through both research and development of advanced technologies, we can ensure the U.S. maintains a competitive advantage in the era of great power competition, drive breakthroughs in weather forecasting, seafloor mapping, biotechnology and marine conservation, and uncover new resources. Supporting ocean exploration R&D enhances U.S. scientific leadership and taps into the ocean's economic potential.

I'm going to provide specific examples from UC San Diego/Scripps Oceanography of how universities partner with NOAA and industry to spur innovation and unleash exploration. These ocean R&D programs and initiatives are essential:

Uncrewed and In-Situ Observations

Uncrewed observation sensors, instruments and platforms offer a cost-effective and agile means of reaching the most remote corners of the globe, areas that are otherwise challenging or hazardous to access by traditional sea-going research vessels. Through sustained NOAA partnership and support, our institution has developed and deployed advanced ocean technologies such as the Argo program, Spray gliders, moorings, and drifting buoys which are a critical component of weather forecasting in the short-term (3-5 days), medium term (up to two weeks) and long-term (subseasonal to seasonal). NOAA, DoD, NASA, and other science agencies utilize the data from these programs for enhanced weather prediction–particularly in longer-term forecasting, understanding of extremes and hazardous weather phenomena including hurricanes, atmospheric rivers, drought, and El Nino/La Nina conditions. They are also used for satellite calibration and validation; fisheries management, harmful algal bloom monitoring,

and much more. Surface platforms can also be used in tracking oil spill response with capacity to provide wind measurements and other environmental data that feed into forecast models used by the U.S. Coast Guard for clean up efforts, while underwater gilders can be equipped with sensors to sample for the absence or presence of oil in the water column, with the capacity to continuously monitor at sea for weeks at a time.

Scripps Oceanography is part of a group of institutions funded by the National Science Foundation to develop new Argo ocean observation float program capabilities. We will add biogeochemical sensors to a third of Argo floats. These sensors allow us to see the result of biological processes in the ocean (although not the biology itself) through measurement of nutrients and oxygen used by biota. The use of biogeochemical measurements can be used in the future to validate marine carbon dioxide removal technologies by analyzing carbon uptake in the ocean. We have also developed new deep floats that can make measurements over the full depth of the ocean down to 6,000 meters (19,600 ft). These Deep Argo floats can also enhance seafloor mapping, further advancing our knowledge of the undersea domain. This underscores the critical role of university-driven research in pushing technological boundaries and ensuring the long-term viability of ocean data collection. These innovations have significantly enhanced ocean monitoring, delivering high-quality, reliable data that industry, policymakers, and coastal communities depend on. Technologies developed at universities are often licensed and commercialized to be manufactured at scale.

Ocean Mapping, Exploration, and Characterization

Four months ago, a collaborative research initiative was undertaken in Guam and Palau by a team of scientists in partnership with NOAA Ocean Exploration (Commerce), Defense POW/MIA Accounting Agency (Defense), and Bureau of Ocean Energy Management (Interior). The project aimed to support national security, battlefield documentation, and ocean resource management in the Western Pacific. Scripps Institution of Oceanography, serving as the technical and operational lead, used advanced autonomous underwater vehicle (AUV) survey technologies. This joint effort exemplifies interagency and academic collaboration in support of maritime domain awareness and environmental/resource assessments. Such partnerships help to reduce redundancies, particularly in the Second Island Chain, and align with multi-agency mandates.

The U.S. Academic Research Fleet (ARF) comprises 17 oceanographic vessels, including three operated by Scripps. This network of ships facilitates complex research in the ocean, seafloor, Great Lakes, and polar regions for scientists across the nation. The ARF is a critical part of the U.S. Oceanographic Fleet, which also includes vessels owned by NOAA, US Coast Guard, and NSF, totaling 34 vessels. Several U.S. ARF ships, including two Navy-owned, Scripps-operated vessels, are equipped for deep and shallow sonar and sampling activities, which are necessary for Exclusive Economic Zone (EEZ) mapping. It is essential to maintain and prioritize this fleet to achieve national EEZ mapping and characterization goals and to keep pace with adversaries who are outpacing the U.S. in dual-use research fleet development.

Extreme Weather Forecasting

The Center for Western Weather and Water Extremes at Scripps (CW3E) works to improve forecasts of atmospheric rivers to improve public safety and water resiliency across the U.S. West Coast. In collaboration with NOAA, Scripps co-leads the Atmospheric River Reconnaissance program, which

partners with U.S. Air Force and NOAA Hurricane Hunters to fly data-collecting missions over the Pacific Ocean, and to deploy drifting buoys that capture critical information for atmospheric river prediction at the atmosphere-ocean interface including ocean temperature, waves, wind, and barometric pressure. Partnership with both NOAA's Environmental Modeling Center and NOAA's Office of Marine and Aviation Operations is enabling the data collected to improve global forecasts in real-time, delivering significant improvements in the prediction of storm landfall location and precipitation amounts along the U.S. West Coast and to improve forecasts of downstream impacts across the continental United States. This collaboration enables public safety officials to prepare for potentially hazardous storms and flooding, and water resource managers to use these improved forecasts to more flexibly operate reservoirs to retain or release water dependent on upcoming storm activity, enhancing our nation's water supply reliability**.** This unique and successful Research and Operations Partnership is possible through collaboration with university researchers, federal agencies like NOAA and the US Army Corps of Engineers, and water agencies.

Next Generation Workforce Training, Development, and Pipeline to Industry

Universities play a crucial role in the ocean research ecosystem as the pipeline to industry. Our research institutions serve as incubators for new technologies, improving methodologies, and perfecting techniques before they transition to commercial applications, while also training the next generation of the ocean workforce with the skills and expertise necessary to sustain and advance the field. Even as artificial intelligence transforms many aspects of ocean science, we still need to invest in training future scientists, engineers, and technicians who can design, manage, interpret, and apply these technologies in dynamic, real-world environments. At the same time, we retain key capabilities within the university to continue advancing foundational research, ensuring that we can both support industry needs, prepare students for emerging careers in ocean science and technology, and push the frontiers of scientific knowledge.

Many emerging techniques and approaches present opportunities for academic institutions to provide support to government and industry in fostering expansion of our capabilities. This collaboration can contribute significantly to domestic energy security, food security, improved safety protocols, and improvements in health outcomes through the development of natural marine products for the treatment of diseases and disorders.

According to the Ocean Economy Statistics, the U.S. ocean economy supports 2.3 million jobs and contributed approximately $373 billion to the nation's gross domestic product in 2018 through tourism and recreation, national defense, offshore minerals, transportation and warehousing and resources, commercial fishing, and aquaculture. The San Diego region has a robust ocean science and technology industry, a strong innovation ecosystem, large and active port and military, an international border, and a wealth of ocean-research leadership. Just in the San Diego region, the Blue Economy supports 4,320 maritime, water and bluetech companies, 114,000 direct jobs, and $16.2 billion revenue (per 2022 *TMA BlueTech Maritime, Water, and BlueTech Economy* report).

In 2020, University of California San Diego launched the StartBlue accelerator, funded by the U.S. Department of Commerce Economic Development Administration (EDA) and led in partnership by Scripps Institution of Oceanography and Rady School of Management (Rady) at UC San Diego. It was designed to support the formation of advanced science and engineering startups tackling ocean-focused challenges and solutions integrated into science, industry, investment, and government networks. Since its

inception, it has supported 22 startups, and its success led NOAA to select StartBlue as one of four regional accelerators to expand coordination and support for ocean-based startups to scale their solutions for commercial success and grow the Ocean Enterprise.

StartBlue has a network of 80 coordinated partners including the Port of San Diego, industry groups, the Economic Development Council, Marine Technology Society, and many others. The StartBlue Ocean Enterprise Accelerator provides a coordinated continuum of support from early stage through small-medium stage for ocean-focused startups nationwide. Support includes San Diego regional assets and critical "catalyst" funding necessary to support start-ups through the challenges required to grow and attract private investment. NOAA's investment in StartBlue will capitalize on significant investments by the State, Region, and Federal government in the region that already support oceanographic research, facilities, education, and venture creation. The combined expertise, industry sector representation, and access to state-of-the-art oceanographic and atmospheric resources amidst a highly active startup ecosystem is unique and will provide an end-to-end network of partners and resources to navigate commercialization pathways.

In addition to StartBlue, Scripps has formal partnerships with over 200 companies and industry associations resulting in direct access to emerging research, technical guidance, licensing opportunities, sponsored research, demonstrations, sales, and technical forums. It also provides companies access to a student/talent recruitment portal.

Regional Partnerships for the Benefit of Society and Protection of Lives and Property

NOAA-supported research enables us to also work closely with local, regional, and state entities to address pressing ocean and coastal challenges. For example, Scripps hosts one of the eleven NOAA Integrated Ocean Observing System (IOOS) Regional Associations, the Southern California Coastal Ocean Observing System (SCCOOS), which has enabled groundbreaking progress in harmful algal bloom (HAB) forecasting. Conservative estimates say that harmful blooms cost the U.S. economy about $50 million each year through damage to public health, fisheries and coastal recreation. Thanks to partnership with NOAA and NASA, and advances in underwater imaging technology and genetic research, scientists are now unlocking the ability to predict and detect these blooms. We can now predict HAB events and are steadily increasing accuracy. A network of imaging robots, supported by NSF, NOAA and the state, is able to identify red tides, image their plankton and the diatom that produces the neurotoxin domoic acid. In 2024, scientists from Scripps Oceanography and the J. Craig Venter Institute made a groundbreaking discovery on predicting harmful algal blooms that contain high levels of the neurotoxin domoic acid. Their study is also providing new insights into the mechanisms driving this type of HAB to offer forecast predictions of when the bloom will become toxic. These forecasts help mitigate HAB impacts and protect fisheries.

Scripps Oceanography's local, regional and state partnerships enhance NOAA's capabilities. For example, we work with local municipalities, utilities, ports, and military bases to provide technical assistance, observations, monitoring and forecasting of coastal flooding events. These programs improve coastal management through flood forecasting, monitoring sand replenishment programs and actively tracking cliff erosion and collapse events. The flood forecasting system, called Resilient Futures, uses LIDAR scanning, and wave and tide modeling to deliver predictions of coastal flooding that enables local to regional governments to prepare their communities and protect infrastructure.

The program began in the low-lying coastal community of Imperial Beach, a beach community that has spectacular beaches, an estuary and marsh environment, and is located next to the US-Mexico border. This community has traditionally been a mecca for surfing big waves traveling across the Pacific and a destination for families wanting to swim its shores. But recently, a combination of regular flooding that threatens the homes along the shore during every high tide, and raw sewage and other pollution from Mexico streaming down the Tijuana River during major rain events, has caused the beaches to be closed to swimming and surfing continuously - a recent stretch of closures surpassed 1000 days. The flooding and storm related sewage create a double threat that reduces income to the community at the same time that it creates a health threat and a threat to property. The community does not have the resources to deal with this double threat to its livelihood. Our Scripps Oceanography Resilient Futures initiative has now instrumented the shoreline with equipment that allows us to predict when storm systems will combine with high tide events to threaten beach property so that the city can prepare defenses and if necessary, evacuate residents. We are able to give them 48 hours' notice so that preparations can be put in place. In addition, we have developed models of the Tijuana River pollution plume under different conditions that will allow us to identify when the river plume will make landfall at Imperial Beach rather than further north along the coast, helping them open or close beaches based on predictions rather than after the fact measurements. Our scientists are also conducting studies of how pollutants aerosolize and threaten human health through the air. This experience has shown the citizens of Imperial Beach how important ocean science is to their future and how it directly contributes to their economy.

Resilient Futures has scaled to other coastal regions and uses, including a collaboration with the US Navy, the Port of San Diego, the City of San Diego, the San Diego Regional Airport Authority, and the local utility company, San Diego Gas & Electric (SDG&E). Our collaborations with these entities, and coastal communities like Imperial Beach, exemplify the critical role of universities as NOAA's on-the-ground partners, extending the agency's impact into local decision-making and response efforts.

Summary

NOAA's investment in academic research is not just about advancing science; it is an essential driver of the blue economy. The high-quality data and technology we provide fuel commercial innovation, support maritime operations, and enhance national security. The strategic partnerships NOAA maintains with universities across the country ensure that we remain agile in responding to emerging challenges, from oceanic hazards to new economic opportunities in marine industries. And, we provide the next generation workforce to tackle new societal challenges.

As this Committee considers the future of ocean R&D, I urge you to recognize and maintain the vital role of universities in this ecosystem. NOAA's continued support for academic research not only benefits the agency but also strengthens the entire oceanographic enterprise—from education to industry.