Subcommittee on Environment
House Committee on Science, Space, andTechnology
Hearing
Defining a National 'Oceanshot':
Accelerating Ocean and Great Lakes Science and Technology

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WRITTEN TESTIMONY
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Chairwoman Sherrill, Ranking Member Bice, Members of the Subcommittee on Environment of the House Committee on Science, Space, andTechnology, I greatly appreciate your invitation and the opportunity to testify at this hearing on defining a national 'Oceanshot' as part of the U.S.'s participation and leadership in the Decade of Ocean Science for sustainable development.

I am pleased to provide my testimony as the President & CEO of Mote Marine Laboratory & Aquarium. It may also be worth noting for added context in providing my comments, that I have been blessed with a professional career full of incredibly diverse opportunities and experiences ranging from being a young assistant professor, to helping build and lead many national and international marine and coastal science initiatives during my time in service with several federal agencies here in Washington, DC and around the world, to executive leadership positions in academia. However, from a professional perspective, I feel as though I died and went to heaven when I was recruited to join the Mote family over a decade ago.

Established in 1955, Mote Marine Laboratory & Aquarium is a completely independent non-profit marine research and science education institution that for 66 years has pushed the frontiers of science for a noble cause – Conservation and sustainable use of our Oceans. Mote currently has over 260 staff, including 37 Ph.D.-level scientists conducting research at our six campuses in Florida and with partner institutions around the world. Mote's 24 research programs range from marine biomedical, immunology and microbiology; to ocean technology, sensor development and machine-learning; to fisheries and aquaculture; to marine mammals and sea turtle; to coral reefs and deep blue-hole ecology. Mote is a total "soft money" research and science education institution in that, unlike universities and agencies, we must pro-actively secure all of our annual funding through competitive research grants, contracts and cooperative agreements (over 50% of annual revenue), aquarium net positive revenue (approximately 5%) and philanthropy(balance). We also have no tenure, no guaranteed jobs, yet we have many researchers with over 30 year-careers at Mote.

Mote scientists are among the world's best and brightest minds in their respective fields. While they are extremely productive in publishing and securing competitive research grants, our experience demonstrates the power of philanthropy as the fuel that provides the freedom to pursue truly innovative and paradigm-changing science. Together with our broad community support over 66 years, Mote has accomplished so much through our research and science education enterprise. But the Mote research enterprise and our broader U.S. national ocean S&T community have incredible potential to do much more to address the grand challenges that are facing our oceans. That is why I am thrilled this Subcommittee on the Environment is focused on defining and implementing a national "Oceanshot".

Mote believes that a national "Oceanshot" should be aimed at achieving a vision we have advocated of *Oceans for All* by pushing forward the frontiers of science to develop innovative solutions for restoring, sustainably utilizing and conserving the wealth of ocean species, habitats and ecosystems, while also ensuring equity of transformational opportunities for experiential STEM education of all K-12 students and the broader public that will enhance the overall level of Ocean Literacy throughout diverse communities.

In the context of launching such a national "Oceanshot" for maximum impacts beyond just pushing the frontiers of science, my comments will attempt to weave together:

- the importance of the oceans to all of us in the U.S., no matter where we live
- the ocean science and technology development foci that are most urgently needed,
- the importance of building a more diverse, equitable, and inclusive ocean S&T enterprise that will bolster creative and collaborative solutions to the grand challenges facing our oceans,
- the vital need for enhanced levels of ocean-literacy throughout society, and
- the important role of independent non-profit institutions as full partners with government and academia.

<u>We are all connected to the Ocean</u>

The economic vitality of our Nation is connected to our oceans. For example, Florida's Blue Economy encompasses a diverse range of industry sectors that rely on and use ocean and coastal resources including, but not limited to, tourism, recreation, commercial and recreational fisheries, ports, transportation, communications, aquaculture, and energy. Analysis of 2018 data suggests in Florida the Blue Economy is worth more than $790 billion and provides enormous employment opportunities of more than one million jobs directly and indirectly created by activities that use ocean and coastal resources. Coastal and ocean ecosystems, such as coral reefs and mangroves are treasures of biodiversity that also serve as mother nature's first line of defense for coastal resiliency. Healthy coral reefs, for example, efficiently attenuate ocean wave energy and reduce coastal flooding that can lead to a coastal hazard risk reduction of $billions annually U.S.

In many coastal communities from Cortez, Florida to the Eastern Shore of the Chesapeake to the Florida Keys to the island of Ofu in American Samoa and the island of Moloka'i in Hawai'i, there are multi-generational, historical and traditional socio-cultural connections to the ocean and these connections represent a way of life that should be recognized as valuable. These

communities are particularly vulnerable to changes in marine biodiversity and natural resources because their cultural lifeways are tied directly to the quality of, and access to, these resources. Beyond economic benefits, the sharing of these resources among family and neighbors during gatherings reinforces important cultural and social relationships. The destruction or limitations on the ability to have continued use of these ocean and coastal resources can lead to the loss of cultural heritage for future generations to experience, and the potential to disrupt the socio-economic stability of coastal communities that may result in conflict among user groups with competing interests over the same limited resources.

Irrespective of the enormous economic, cultural, aesthetic and general quality-of-life values the oceans provide to each of us – everybody, everywhere in the world, no matter where you live is connected to the ocean with every breath we take. That's because over half (some estimates are as high as nearly 80%) of the oxygen we breathe comes from plants in the ocean not on the land. Therefore a national "Oceanshot" that prioritizes science-based solutions to address the most pressing challenges facing our oceans is absolutely vital to our continued existence.

Advancing technology development, including artificial intelligence, robotics, experiential STEM education, ocean observation sensors, genetic resiliency biomarkers and machine learning will be integral to achieving fundamental and applied science outcomes required for successfully addressing the following grand challenges to the restoration and long-term sustainable use of ocean species, habitats and ecosystems.

Coral Reef Research and Restoration

Worldwide, coral species are facing severe threats and have been in significant decline. Sadly, during the last 40 years, Florida's indigenous corals have declined in some areas by more than 90 percent, with some species losing more than 97 percent of their populations. NOAA recently announced new protections for coral with the listing of 20 new species as "threatened" — including several species found in the Florida Keys. These vital ecosystems are sliding into functional extinction due to past decades of pollution, poor fisheries practices, ship groundings and dredging, that have cumulatively left a severely weakened coral that are increasingly susceptible to current seascape level threats of increasing ocean temperatures, acidification and devastating coral disease that has spread like a wildfire through the Florida Keys in recent years.

Florida's coral reefs are experiencing a multi-year outbreak of coral disease. While disease outbreaks are not uncommon, this event is unique due to its large geographic range (hundreds of miles of reef tract), extended duration (4+ years), high rates of mortality (>90% on some reefs) and the number of species affected (>20 reef-building corals). The pathogen(s) has not yet been identified, but evidence suggests it may be transmitted by touch and through the water column, which makes it difficult to contain. Study of the present disease outbreak is also risky within an open multi-purpose laboratory setting, as contamination can risk the loss of other corals housed within the same facility. To enhance research capabilities, a coral disease research laboratory that is isolated and includes a 'clean room' component to reduce transmission risk, is essential.

The continued self-perpetuating existence of coral reefs in the wild has now gone past a tipping point of not being able to recover on their own. It is an environmental disaster that is urgently calling for a response to restore one of the most threatened coral reef ecosystems on Earth. With

recent advances in science, we can achieve this goal. During the summer of 2020, Mote became the first scientific organization to carry out every step of the staghorn coral sexual propagation process— from spawning and outgrowing in the laboratory, to outplanting and maintaining on the reef until they reach sexual maturity, became gravid, and spawned again to create an entire second generation of disease-resistant and climate-resilient corals.

In another breakthrough, Mote-grown mountainous star corals that were outplanted to the reef grew to sexual maturity and spawned in record-time. It typically takes several decades for these massive, reef-building species to reach sexual maturity and begin propagating in the wild. This past summer, however, colonies of these Mote-grown corals spawned on the reef in just five years after surviving two coral bleaching events, a category 4 hurricane and the exposure to deadly coral disease outbreak. This newfound accelerated growth cycle for outplanted corals makes it possible to literally shave decades off the reef restoration process. These processes, adding new genetic diversity with a new level of control, represent a critical new link in the chain of a uniquely comprehensive strategy for science-based reef restoration.

In addition, a recently created one-of-a-kind large-scale, land-based living coral gene bank is essential to serve as a "Noah's Ark" for preserving species and genetic diversity for future research, propagation and restoration. This strategy is to maintain dozens of different genotypes of at least 30 coral species per region, maintained in triplicate. These corals represent the parents of future generations, which will be used for resilience-based research and large-scale coral restoration. Implementing this vision has begun with a focus on coral species endemic to Florida and the Caribbean, and plans for expanding to include genera that are endemic to other regions around the globe. Mote's current coral genotype holdings currently consist of over 1,600 genotypes from 17 species, with approximately 3,600 additional genotypes from 3 species that will be added over next two years.

This new Coral Gene Bank facility is located in an environmentally hardened building with redundant power and re-circulating seawater systems on the 200-acre Mote Aquaculture Research Park campus ~ 20 miles inland from the coast. The current holding facility contains four separate life-support systems thus ensuring genetic preservation through independent redundancy among the raceways. It is outfitted with a separate dedicated coral spawning laboratory with the capacity to hold several ex-situ coral spawning systems. These systems are programmed to follow seasonal variations in temperature, light, and lunar cues to allow for coral spawning year-round. Complete control of these parameters provides the necessary cues to produce gametes (eggs and sperm) and elicit spawning for controlled fertilization. The ability to create sexually produced corals within a controlled environment increases the adaptive potential of populations that will be used to restore our world's coral reefs, thus increasing resiliency through these assisted reproductive events.

A strategic Florida Keys Coral Disease Response & Restoration Initiative is now being implemented through a consortium of coral research and restoration institutions, including Mote whose role is to provide 1) demonstrated experience and expertise in developing innovative technologies for coral restoration, 2) significant existing coral research and restoration infrastructure and ongoing activities in the Florida Keys, 3) ability to coordinate closely with appropriate federal and state agencies, as well as consortium partners, and 4) significant

components of local community engagement and outreach. Fully successful implementation will require landscape-scale coral reef restoration via outplanting of lab-grown and/or aquaculture-raised coral fragments representing diverse assemblages of native coral species, as well as the necessary research and development for these efforts. Specifically, the Initiative should utilize genetic strains that demonstrate enhanced resiliency to increased water temperatures, decreased pH, and coral disease, and include designs for multiyear monitoring to assess survival and ecosystem health. *Mission: Iconic Reefs*, led by NOAA, represents one of the largest investments ever undertaken in coral restoration. As a priority for a national "Oceanshot", restoring corals at seven iconic reef sites in the Florida Keys National Marine Sanctuary, and ensuring the required science support to achieve genetic resiliency, can change the trajectory of an entire ecosystem and save one of the world's most unique areas for future generations.

Harmful Algal Bloom Mitigation and Technology Development

The Gulf of Mexico is known for its beautiful beaches and coastal culture, fisheries and other ecologically and economically important marine resources. However, harmful algal blooms can deter tourists, kill fish, close shellfish harvest areas and cause beachgoers to cough and sneeze due to airborne toxins. People with chronic respiratory disorders may even end up in the emergency room. Harmful algal blooms (HABs) can cost coastal economies millions of dollars. So far, there is no tried-and-true way to combat some of the most challenging HABs — such as red tides caused by *Karenia brevis* algae — without risk to the Gulf's sensitive ecosystems. However, Gulf residents, visitors and businesses have access to powerful monitoring and forecasting tools developed by world-class scientists working to turn the tide, and there is potential for innovative mitigation of some HAB impacts. Today HABs such as *K. brevis* red tide in the marine waters off Florida's Gulf Coast, brown tides of *Aureoumbra lagunensis* algae like those in the Indian River Lagoon, and blue-green algae blooms such as those in central Florida's freshwater systems are the focus of successful and emerging research initiatives.

The fact that Florida has experienced devastating impacts from harmful algal blooms is well understood by all of us who call this region home. What is not as well understood by many is that we experienced two simultaneous but separate types of blooms. Each has their own harmful impacts to our environment, quality of life, and economy. For example, the blue-green algal bloom occurs primarily in freshwaters. It is linked to outflows from Lake Okeechobee, and for Southwest Florida flowing down the Caloosahatchee River. Blue-green algal blooms have significant negative impacts in the areas where they occur, regardless of whether a red tide event is occurring in nearby coastal ocean waters.

On the other hand, red tide blooms are naturally occurring cyclic event that are not initiated by outflows from Lake Okeechobee, nor inputs from the Caloosahatchee River. Red tide (caused by *Karenia brevis* algae) begins far offshore, deep in the Gulf of Mexico due to a number of natural interacting forcing functions. When the winds and currents move together towards the coast, our coastal communities, beaches and embayments may experience the harmful impacts these blooms can have.

Both types of algal blooms must have nutrients to survive and grow. The nutrients both algal blooms utilize come from both naturally occurring sources and from human activities. However, the specific types and combinations of diverse nutrient complexes that each algal species utilize

are different. Excess nutrients are bad for freshwater and marine systems, and they should be reduced —whether their source is from lake outflows, storm water runoff from land, or through other means.

Red tide blooms are fueled by a complex mixture of nutrients in marine waters from offshore to the coast. Many of these are from diverse coastal sources including non-point-source runoff and inputs from numerous creeks and rivers in the region that carry terrestrial nutrient runoff from rainfall. The duration of red tide events is correlated with the combination of all riverine flows, not asingle river such as the Caloosahatchee River or the outflow of Lake O. The bottom line is that red tide is indeed a naturally occurring phenomenon that existed long before Europeans came to Florida. The type of intense bloom we experienced in 2017-2019 was not "normal" but is also not unprecedented. It is also clear that excess land-based nutrients flowing into Florida estuaries and coastal watersin storm water runoff, rivers and creeks exacerbate the growth of HABs.

These are independent, objective, science-based facts, not emotional or political talking points. As we see the impacts of these blooms, we all share a blend of emotions including sadness, resolve, anger, desperation and hope for the future. A part of human nature is to sometimes believe that if only we were able to change one thing, a problem will go away. For some HABs that may be the case, but for red tide is just not that simple.

Working in cooperation with the Florida Fish and Wildlife Conservation Commission (FWC), the Florida Department of Health, the Florida Department of Environmental Protection, the National Oceanic and Atmospheric Administration (NOAA), university partners and others, Mote Marine Laboratory has led innovative HAB research for decades. These team efforts improve early alerts and forecasting, expand citizen engagement and outreach, and lay the foundation for developing mitigation technologies to help coastal residents and visitors enjoy healthy and productive days on the Gulf and its shores. Mote then proposed a vision and strategy to the State of Florida for much more that needed to be done with the knowledge we have in order to develop new technologies to actually decrease the impacts of red tide. As a result, the Florida Legislature passed, and in June 2019 Governor Ron DeSantis signed, a statute into law to establish and support the Florida Red Tide Mitigation & Technology Development Initiative as partnership between Mote and FWC. The bill provides a $3-million appropriation each year for six years ($18-million total), and FWC will award funds to Mote to achieve the goals of the Initiative. Building upon the ongoing and highly productive FWC-Mote cooperative red tide research and monitoring program, this new applied science Initiative strategically leverages state appropriations with Mote's private and federal funding in order to:

- Bring together the best and brightest scientists from Florida and around the world;
- Utilize innovative approaches and technologies to determine the most effective and ecologically sound methods for mitigating adverse impacts from red tide;
- Test technologies with combinations of lab-based, large-scale mesocosm and pilot-scale field studies ultimately leading to permitting for large-scale field testing and application;
- Develop novel detection systems to support public red tide forecasting, emergency response, and implementation of control strategies;
- Enhance public health protection with expansion of the Beach Conditions Reporting System (visitbeaches.org), local community outreach and engagement; and

- Develop new technologies for smartphone apps to engage citizen science information collaborations and commercial fisherman reporting of red tide toxin concentrations.

To date, this initiative has reviewed over 70 proposals from worldwide applicants through 3 public RFP's, has awarded funding for over 20 projects currently underway with 15 institution and business partners that have already identified and tested several promising mitigation strategies. The initiative is also developing a new field-based HPLC technology to detect HAB toxins, which kill fish and cause respiratory irritation and neurotoxic shellfish poisoning in people, and airborne drones equipped with hyperspectral sensing for HABs. Mote's Beach Conditions Reporting System (www.visitbeaches.org) provides real-time smartphone updates on Florida red tide impacts — respiratory irritation and dead fish — and other conditions at 31 Gulf-coast beaches, thanks to trained volunteer citizen scientists, and is achieving advanced technological improvement and geographic growth of the System into other states. In coming months, the initiative will expand both the number of ongoing technology development projects and partners, while also preparing for engineering transitioning of promising mitigation technologies to field testing deployments.

While we are pleased to have increased some degree of leveraging with NOAA HAB program and the Florida Sea Grant HAB Liaison, our greatest continuing challenge in advancing not only our understanding of red tide and developing technologies to actually do something about it when it does happen, is the lack of consistent, targeted extramural federal funding. A couple of years ago, I plotted the level of federal funding we have received for red tide research on an annual basis and overlaid that chart with occurrence of major red tide events. It is crystal clear - When red tide goes away, so too does federal funding. And if one were to compare annual funding from the federal government for red tide when it does occur, to the economic impacts to Florida caused by red tide, it would make you shake your head. The hotel, restaurant, amusement and retail sectors losses of 7 SW FL counties in just the relatively brief 1971 Red Tide was ~$125 million (as calculated in 2018 $$).

A question I ask you to consider is whether the federal level of extramural support to fight red tide at the front lines is an appropriate level given the economic and environmental devastation, and is that level of support having real impact? What is urgently needed is a targeted multi-year source of support for an applied science initiative focused on developing a suite of mitigation technologies to decrease impacts of red tide. A priority of a national "Oceanshot" initiative, this would help match the state's multi-year commitment and support a *Florida-based independent Red Tide Consortium* that would utilize innovative and integrated approaches for development of technologies to address the critical need for prevention, control and mitigation of red tide impacts on the environment, economy, public health and quality of life.

<u>Environmentally Sustainable Aquaculture is Good for Our Oceans and Economy</u>
The United States has lagged far behind other countries in developing a marine aquaculture industry, which has created a huge seafood trade deficit for our Nation and by extension threatens to undermine our food security. Worldwide, finfish is often the lowest cost animal protein, and the growing seafood supply gap disproportionately affects the nutrition and health of the poor. The global per capita demand for seafood has increased steadily over the last three decades. This demand has been met primarily by a rapid growth in aquaculture (farmed fish).

The production of seafood from classical fishing techniques from the oceans has been flat for almost 20 years while production from aquaculture has increased so dramatically that it now accounts for about 50% of all seafood production.

Approximately 91% of the seafood consumed in this country is imported, and more than half of that seafood is from foreign aquaculture, with China being the global leader. While aquaculture continues to grow in Asia and South America, the US represents less than 0.5% of global output. Wild fisheries capture production data is telling us the oceans around the world have been overfished. The exposure of the US seafood supply to natural and geopolitical disruptions is increasing. Because seafood tends to offer the most efficient feed conversion ratio, increasing food sustainability and reducing carbon footprints implies that seafood consumption per capita will likely continue. Future growth of US aquaculture will depend on innovation in the deployment of new technologies that are highly productive and financially rewarding.

Many of the criticisms of aquaculture are based on outdated practices that were abandoned years ago as best management practices were developed. Mote and a handful of US research institutions have been dedicated to the development and transfer of science-based technology for environmentally-sustainable seafood production that helps decrease negative pressures on current wild-caught fisheries and has positive impacts for both our oceans and our economy. There are numerous peer-reviewed scientific articles that support the development of environmentally sustainable marine aquaculture industry to provide high quality protein to feed the world's growing population. One priority area for a national "Oceanshot" should be the evolution of science-based environmentally-sustainable aquaculture, both land-based and offshore, for the good of our oceans and to help inject the economies of the US with new job opportunities.

The federal government now allows for a publicly transparent process for the permitting of offshore aquaculture leases in federal waters of the Gulf of Mexico if it can be demonstrated that no significant environmental impacts will result. A private commercial aquaculture company (Ocean Era), that has previously earned a Stewardship Council certification for socially and environmentally responsible aquaculture production, recently received the required EPA permitting for an aquaculture demonstration project to place a single net pen approximately 45 miles offshore of SW Florida in the Gulf of Mexico. The U.S. Army Corps of Engineers is currently in the process of evaluating a concurrently required permit which, if issued, would allow the project to move forward. Florida Sea Grant, the Gulf States Marine Fisheries Commission and the U.S. Department of Agriculture have provided research grants to develop hatchery technologies for maintaining Almaco jack (a native fish in the Gulf of Mexico) spawning populations at the inland recirculating seawater facilities at Mote Aquaculture Research Park in Sarasota, FL. Should the Ocean Era demonstration project be approved by the Army Corps of Engineers, Mote will be spawning and growing 20,000 fingerling Almaco jack that would then be transferred to the Ocean Era demonstration project.

This demonstration project is a vital 1st step in providing needed biological, physico-chemical monitoring and economic impacts data to enable a final decision on potentials for the development of sustainable offshore, deep-water aquaculture technologies in the Gulf of Mexico. NOAA, EPA and other federal agencies seem to be utilizing great care and science in designing

an environmentally responsible plan for moving forward in developing sustainable marine aquaculture to help meet growing demands for food.

This is an incredible opportunity the US to be a leader in developing and implementing science-based and environmentally sustainable offshore and land-based aquaculture that can help feed the world and support growth of our blue-economy. Both land-based and off-shore aquaculture efforts can have a role to play in the trajectory to sustaining our oceans and economy, and should be a priority focus for a national "Oceanshot".

Advance Electronic Monitoring Technology of Fisheries

Fisheries stock assessments require extensive data, but many are data deficient due to monitoring constraints. Only about 2% of the Gulf's snapper-grouper vessels are monitored by NOAA's on-board fisheries observers. Data from captains' voluntary discard logbooks and independent studies are also extremely important but limited in consistency and coverage. Several years ago, Mote Marine Laboratory and partners began working with commercial snapper-grouper fishers to test electronic monitoring (EM) systems on their vessels in the Gulf of Mexico with the goal of effectively/efficiently documenting fish catch and discard rates to aid sustainable fishing and fisheries management. EM—required in some U.S. fisheries, but still being investigated for the Gulf—involves deploying video cameras and sensors on fishing vessels and allowing scientists to analyze the results confidentially in the lab.

The Center for Fisheries Electronic Monitoring at Mote (CFEMM) had clearly demonstrated that EM technology can operate successfully in the Gulf. Currently, we have 17 vessels participating from FL and TX and will soon be adding several more. Over the years, CFEMM staff have amassed more than 100,000 annotated records of about 400TB of video data from more than 300 fishing trips (nearly 2,500 days at sea) describing 133 species or species groups of caught and discarded marine life, thanks to an ever-growing team of volunteer snapper-grouper vessels carrying an ever-improving suite of EM technology. With recent support from NOAA, NFWF and Net Gains Alliance, Mote is further refining and expanding its EM methods—and above all, Mote is working to transform EM data into actionable insights for fishers and fisheries managers to help ensure that Gulf snapper-grouper resources are sustainable.

A new, online, password-protected EM data portal where government, industry and science partners will be able to access EM results to inform their sustainability decisions while protecting fisher privacy is also being built. As an independent, nonprofit institution, Mote is mapping out the best pathways to feed data into government agency decisions, to the fishing industry and to individual fishers. That includes linking new EM data to existing records with different strengths and limitations, such as NOAA Fisheries Observer reports, trip tickets that FWC requires from commercial fishers selling their catch, and dockside biological sampling efforts. Mote is already sharing their EM data with fisheries management through participation in the gag grouper, greater amberjack and scamp/yellowmouth grouper working groups in the SouthEast Data, Assessment, and Review (SEDAR)—the process for fish stock assessments in NOAA Fisheries' Southeast Region.

Mote is also providing data and expertise as members of working groups including the Atlantic Coastal Cooperative Statistical Program, which aims to draft a standard or set of standards, for

fishery-dependent data derived from EM programs along the Atlantic coast, and the International Council for the Exploration of the Sea Working Group on Technology Integration for Fishery-Dependent Data, which has a diverse membership including technology service providers, academic and governmental marine institutions, and nonprofit environmental organizations, across a wide range of fisheries in Europe, the U.S., Canada, South Africa, and Chile. This group is examining electronic technologies and applications that are used to support fisheries-dependent data collection, both on shore and at sea, including electronic reporting, electronic monitoring, positional data systems, and observer data collection, and examining how they can be integrated for the benefit of industry, management, and other stakeholders.

Mote is advancing the EM data collection technology and analyses to help answer big questions of interest to fishers and fishery managers. One example: How is bycatch (unwanted species that must be thrown back) related to environmental conditions? A fishing area might yield lots of unwanted species like sharks in some seasons or environmental conditions—making it a poor target for cost-effective, sustainable fishing—while it might yield the desired snapper or grouper under other conditions. Mote scientists, with partner Waterinterface LLC, are adding a growing variety of environmental data to our EM analyses to identify such relationships for fishers and managers. We have also just become the first to integrate underwater cameras with fisheries electronic monitoring. This ongoing research effort will investigate how much the UCAM improves EM data on bycatch, discards, and depredation of targeted catch and fishing gear (damage from predatory animals such as sharks and marine mammals) during real commercial fishing trips. Additional valuable data is being obtained through the first use of a "discard chute" in the Gulf. The chute allows discarded species (including bycatch or target species of the wrong size) to be documented with photos and measured as they're released. The chute—along with added cameras on booms, viewing the vessel stern to help document if discarded species were alive or preyed upon just after release—are integrated into Mote's EM system through a partnership with NOAA Fisheries' Galveston Laboratory, Alaska Fisheries Science Center, and Saltwater Inc.

With the clear demonstration that EM technology can operate successfully, and the incredibly large quantities of monitoring video CFEMM is producing, a national "Oceanshot" initiative could build upon the initial groundwork that Mote has begun laying for future efforts to use artificial intelligence, or machine learning, systems that can be trained to recognize the presence, absence and species groups of fish in EM videos—work that currently requires a trained set of eyes.

Breaking Down the Ocean Plastic Problem

The oceans contain more than five trillion pieces of plastic, and the total is growing. Plastic debris can entangle or be ingested by marine animals, potentially killing as many as one million seabirds and 100,000 marine mammals and sea turtles yearly. Mote's Sea Turtle Rehabilitation Hospital recently treated a turtle nicknamed "Egg" for neurologic issues when the turtle passed a plastic bag through its digestive tract. Fortunately, Egg avoided complications such as digestive or respiratory obstruction, which can become fatal. While we were able to successfully return the turtle to the ocean, Egg's safety is far from guaranteed.

Unfortunately, the visible impacts of plastic might be the tip of the iceberg. Plastic in the ocean resists biodegradation but breaks into tiny microplastics less than 5 millimeters in size and even tinier nanoplastics invisible to the naked eye. The fates of those nanoplastics—and their potential impacts on ocean health—are among the most daunting mysteries in marine science today. As plastics disintegrate, they can generate nanoplastics smaller than 100 nanometers across— in theory, small enough to penetrate animals' tissues, affect their cells and even cross the blood-brain barrier. A key overarching research question remains: Are nanoplastics making their way into animals' livers, lungs, brains or reproductive organs, and if so, what are the impacts? Marine nanoplastics research is in its infancy, partially because it requires advanced technology. Some of the earliest scientific evidence of nanoplastics at sea was published as recently as 2016 and 2017. Meanwhile, lab studies have hinted that elevated concentrations of nanoplastics can be detrimental to tiny, water-dwelling animals and algae. However, no one knows the full scope of the problem.

Mote is also studying environmental contaminants associated with microplastic samples from the ocean surface. Plastics attract certain contaminants such as oil, pesticides and industrial pollutants that can collect in ocean-circulation areas called gyres—which happen to be important habitats for delicate marine life such as fish eggs and larvae. Mote scientists are investigating contaminants and the diversity of marine animal species in the uppermost layer of water from geographically diverse gyres thanks to samples collected by eXXpedition, an all-female exploratory team examining ocean plastic and contaminants.

During the 2020 Florida Oceans Day celebrations at the State Capitol, Mote announced our intent to launch a new initiative to investigate nano- and microplastic sources, properties and effects on marine animals and ecosystems. With philanthropic support to focus on emerging challenges affecting our oceans worldwide that are often difficult for government agencies to tackle. Unfortunately, the recent COVID-19 pandemic has delayed those efforts. There is no question that nanoplastic pollution in particular represents one of the most concerning, least understood, emerging consequences of rising plastic consumption. We are advocating for cutting-edge research center on nano- and microplastics that will independently advance a meaningfully exchange knowledge with key societal groups from research partners to government agencies and industry. Together we must ensure that the best available science shapes decisions about plastics—decisions that affect the oceans' future and our own. While everyone should strive to use less disposable plastic, it's unlikely to vanish entirely from modern society. It's also important to emphasizes that "not all plastics are created equal," and there is a need to collect independent data to support better societal decisions. For example, identifying the least to the most damaging plastic types to highlight better choices when selecting plastic composition for manufacturing products.

A national "Oceanshot" initiative on this important nano- and microplastics issue could focus on the following goals, with a flexible approach designed to work with supporters and partners on key emerging questions about plastics over multiple years:

- Identify specific plastic polymers which are least, and most, responsible for generating nanoplastics,
- Investigate effects of nanoplastics on ocean ecosystems, fisheries health and potential impacts on food safety,

- Identify more effective technologies for removal of nanoplastics from drinking water and wastewater systems,
- Provide science-based recommendations to plastics manufacturers to encourage industry-wide paradigm shifts in plastics production technology,
- Develop education and outreach opportunities to enhance public understanding of local and global impacts of plastic pollution, and
- Build national and international collaborations with scientific partners to strengthen U.S. ability to minimize impacts of nanoplastics in our waters.

Coastal Resiliency

With a coastline of 8,436 miles, the second longest coastline among the U.S. states and territories, Coastal Resiliency is a priority for the State of Florida. Resilience means responding quickly after hazardous events, such as hurricanes, coastal storms, flooding, and disease, and adapting to future conditions rather than simply reacting to impacts. Resilience is the ability to prevent a short-term hazard event from turning into a long-term community-wide disaster. Rebounding more quickly can reduce negative human health, environmental, and economic impact (adapted from NOAA definition). As a member of the Board of Directors for the Florida Ocean Alliance (a nonprofit, nonpartisan, private-public partnership of private industry, trade, academic and environmental organizations promoting awareness and understanding of the ocean's importance to the economy and environment of Florida), I am pleased to attribute many of my comments on Coastal Resiliency to our recent FOA report entitled "Securing Florida's Blue Economy: A Strategic Policy Plan for Florida's Oceans and Coasts."

The impacts of sea level rise associated with climate change already are visible in and around Florida. Miami Beach, Miami, Hollywood, and other coastal cities regularly experience routine flooding during lunar high tides, king tides, rain events, and periods of prolonged onshore winds. Flooding intensity and frequency have increased in Cedar Key, and wells have experienced saltwater intrusion. The Town of Yankeetown has experienced substantial tree loss from saline soil conditions, and rising water levels are leading to a decrease in available habitat for migrating and nesting birds. Today, the 16 million Floridians living in the state's coastal zone risk being affected by tropical storms and hurricanes, and a further 2.1-million Floridians are living in homes predicted to be at risk by 2100.

Furthermore, recent events may indicate global changes in the frequency and intensity of extreme weather. In 2017, Hurricane Irma caused $50 billion in damages along with extensive flooding, prolonged power outages, and sewage spills. In 2018, Hurricane Michael caused about $18.4 billion in damages to property and infrastructure in Florida. The number of billion-dollar disasters has been increasing due to population growth and continuing coastal development, as well as climate change, which is driving an increasing intensity and frequency of extreme weather events.

Cost-effective options for reducing damage to Florida's coasts include protection, restoration, and management of healthy natural habitats (e.g., coral reefs, mangroves, seagrass beds oyster reefs), or "natural infrastructure" For example, Florida's coral reefs provide flood protection to infrastructure valued at more than $600 million for storms that return on a 10-year interval, a value that rises exponentially for longer storm return intervals. These natural coastal resiliency

infrastructures can also assist in ecological adaptation to ocean acidification, temperature increase, and sealevel rise. Integrating natural with traditional grey infrastructure (e.g., seawalls) as hybrid solutions can accomplish multiple objectives. and deliver multiple benefits, including shoreline protection and environmental and ecosystems services. Unfortunately, comprehensive planning for ocean and coastal resilience and its implementation are complicated by uncertainty about the rate and extent of sea level rise.

A national "Oceanshot" should include a priority to marshal our national science and engineering research enterprise to undertake in full partnership with local and state governments a focused, sustained initiative to improve ability to predict, mitigate, and respond to the impacts of sea level rise through enhanced coastal resiliency of both natural and built infrastructure. In addition to coordinating and implementing a research program that provides science-based approaches to mitigating impacts or to adapting to sea level changes, this coastal resiliency initiative should include providing funding and other positive incentives that encourage local and state governments and industries to adopt such science-based approaches for enhanced resilience and sustainability.

Building a more diverse, equitable, and inclusive ocean S&T enterprise

Building a more diverse, equitable, and inclusive ocean S&T enterprise will bolster creative and collaborative solutions to all the grand challenges facing our oceans. Unfortunately, while ethnic diversity of university undergraduate degrees conferred in all fields of Science Technology Engineering and Mathematics (STEM) include only ~18% underrepresented minorities (URMs), geosciences, which includes marine STEM, ranks even lower with the least ethnically diverse of all STEM fields and has one of the slowest growth rates of URM participation. Only about 10% of marine STEM bachelor's degrees were awarded to URMs in 2016, a trend that has seen little growth over the past twenty years. The Louis Stokes Alliance for Minority Participation (LSAMP): Marine Science Laboratory Alliance Center of Excellence (MarSci-LACE) is an example of an innovative approach for expanding participation of URMs in marine STEM fields.

With over 15 years in the NSF research experiences for undergraduates (REU) program, Mote built on that experience and its philanthropic support to develop our successful programs to recruit, engage and retain URMs in marine STEM, such as the Research Experience for Leaders in Environmental Action for the Future Undergraduates Program (RELEAFU), Mote Research Experiences for American Samoa Undergraduates Program (MREASU), Mote Research Experiences for Undergraduates-University of South Florida Sarasota-Manatee (REU-USFSM), and Dr. Eugenie Clark Undergraduate Marine Research Fellowship-Daughters for Life. With Mote's experiential knowledge base to actively create pathways to success for URM undergraduates in marine STEM, we proposed to NSF a strategic leveraging of specialized non-degree granting STEM research institution engagement with LSAMP universities that would provide the nation with a paradigm changing approach for increasing the number of URMs in STEM fields, especially in Marine Sciences and related natural resources fields with high demands for a skilled workforce.

MarSci-LACE was founded in late 2019 through a three-year NSF grant to Mote, the only non-academic institution to receive one of seven LSAMP Center of Excellence awards in the U.S. It is co-funded by the NSF Inclusion across the Nation of Communities of Learners of

Underrepresented Discoverers in Engineering and Science (NSF INCLUDES) initiative. Partners include The College of the Florida Keys (CFK), State College of Florida, Manatee-Sarasota (SCF), Smithsonian Marine Science Station, and Perry Institute for Marine Science (PIMS). As a "nexus" training, resource, and supporting partner to other independent marine research institutions (IMRIs), degree granting institutions, LSAMP students, and science mentors and faculty, a major focus of MarSci-LACE will be to grow science mentors/faculty strategies through the development of trainings and resources that will enhance mentorship skills for IMRI institutional staff and faculty, and provide tools and resources to URM students in IMRI research experiences.

A novel aspect of MarSci-LACE lies with IMRI's being in an ideal position to provide URMs learning experiences beyond the pure research and academic aspects. Cultivated from a reality in which IRMI's lack guaranteed funding, do not have tenured faculty positions, and do not benefit from support from a larger institution, IRMI's have a distinct culture of innovation, independence, and entrepreneurship. These cultural characteristics are essential for future success in higher education research and careers in STEM fields. URM experiences in this distinctive culture will help shape how students approach future scientific endeavors. MarSci-LACE is able to leverage tremendous IMRIs resources of permanent staff, visiting scientists and focused Marine STEM scientific networks that are beyond assets of other learning environments especially for HBCUs, HACUs and community colleges that lack marine STEM programs and research opportunities but serve a significantly higher proportion of URM STEM students than non-minority serving institutions. MarSci-LACE will facilitate the transfer of the findings, resources, and best practices beyond MarSci-Lace broadly to all IMRIs, LSAMP networks and degree-granting institutions, and LSAMP students through access to web-based materials, trainings and resources for students, mentors and institutions.

MarSci-LACE may also serve as a model for a national "Oceanshot" priority in developing and implementing a new paradigm for increasing URM participation and success in marine STEM-related careers, beyond that provided by traditional degree granting institutions.

<u>Equity of transformational opportunities for experiential STEM education of all K-12 students and the broader public</u>

According to the Florida Department of Education, Title I, Part A, provides local educational agencies resources that help children gain a high-quality education and the skills to master the Florida Standards. These resources provide additional teachers, professional development, extra time for teaching, parent involvement activities, and other activities designed to raise student achievement. However, no Title 1 school in our region has advanced technology infrastructure that the new Mote Science Education Aquarium (Mote SEA) STEM teaching laboratories will be providing free of charge for approximately 70,000 K-12 students as part of the school class experiences at Mote SEA each year.

Mote SEA will be an incredible facility with ~110,000 square feet of space, nearly doubling our current aquarium space on City Island. First-year attendance will likely be near 700,000 — double the current attendance of Mote Aquarium on City Island. Forty-three million vehicles travel on I-75 past this site each year leading to expanded visibility of Mote's mission of marine research and science education. It will be the region's highly visible gateway to the SEA. Over 1

million gallons of exhibits featuring a stunning array of sharks, coral reef species, manatees, sea turtles, otters, seahorses, jellyfish and myriad other species will include glimpses of the deep sea and other remote habitats, including Mote research sites from around the world These exhibits along with advanced digital technology and augmented reality interactives will expand visitors' horizons as they are embraced with science every moment of the Mote SEA experience.

The name of our Mote SEA campaign, "***Oceans for All***", and our campaign tagline, "***Science is the Attraction***", were purposefully selected. Our current Aquarium location is not easy to get to for many of our schools in Sarasota and Manatee. As a result, many of our children from diverse walks of life are never able to have the opportunity to work with our scientists and educations, nor have the hands-on STEM education experiences that Mote provides. The location of the Mote SEA was selected to be much more accessible to all schools in the region.

Mote SEA will include 3 interactive STEM teaching labs specifically designed for K-12 students, and 2 STEM research training labs for high school and undergraduate college students. Mote will provide opportunities for every K-12 school in our region to utilize these advanced technology teaching labs at no cost, so that no child will be left behind in the chance to discover marine science and technology, first-hand. We are strategically collaborating with schools and community groups where needs are greatest. Mote will educate children who might not otherwise have access to marine STEM education.

Each year, Mote SEA will provide ~70,000 students in K-12 STEM classes throughout our region to directly engage in experiential STEM learning and provide all Sarasota and Manatee County Title 1 K-12 students (>20,000) with their families a shared Ocean Literacy experience at the new Mote SEA. No Title 1 school, nor most other schools, in our region have the advanced technology infrastructure that Mote SEA STEM teaching laboratories and Ocean Science Literacy experiences will be providing.

Families visiting Mote SEA will be immersed in STEM education from the moment they enter the building. Visitors will learn about Mote's work to discover and develop solutions for ocean conservation, sustainable use and enhanced quality of human life, including: sustainable fish farming practices to help feed the world and enhance wild fisheries, cancer- and infection-fighting compounds from the sea, technologies to mitigate impacts of red tide, understanding of marine species, rescue and rehabilitation of protected marine life, and technologies to rapidly restore dead or damaged coral reefs, the "rainforests of the sea." Visitors can become a scientist for the day, informally learning about research techniques and the importance of marine science and conservation that they will carry with them far beyond their visit.

The oceans are connected to everyone, every place in the world. Mote SEA will ignite within each visitor a greater degree of curiosity to learn more about the marine environment and to protect it. The spark for Mote SEA was ignited in 1931 when a little 8 year old girl walked in to the New York City Aquarium. The little girl was amazed at all the fish in the tanks, and imagined herself being able to swim under the sea with them. Her visit to that aquarium in 1931 sparked her interest in learning about the sea, and she fell in love with the ocean. The spark of interest from that aquarium experience led that little 8 year-old girl to become the world renown

scientist who was called the Shark Lady and the founding director of what is now Mote Marine Laboratory – Dr. Eugenie Clark.

Parent engagement is also critical to student success. When parents, teachers and school administrators work cohesively to support the student experience, then students are more inclined to achieve academic success. According to the National Association for Family, School and Community Engagement, "truly effective family engagement involves the development of genuine relationships with families, is part of the fabric of the school community and provides equitable opportunities for families to participate" in their children's education. Therefore, it is fundamental for local educational agencies and schools to create and regularly maintain an open line of communication where parents are encouraged to actively engage in their children's education. Research tells us that students with engaged parents and families, are more likely to:

- Learn to read faster (Exhibit faster rates of literacy acquisition)
- Have higher grades and test scores
- Are promoted and take more challenging classes
- Adapt better to school and have better attendance
- Have better social skills and behavior
- Graduate
- Go on to community/technical college or university

At Mote, we want the best for our community's students, and we recognize that all students learn differently. By understanding the unique needs of Title I students, we are able to identify and help overcome the challenges and issues these students face. It is for this reason that Mote will also be offering every student at Title 1 schools in Manatee and Sarasota County schools a Day Pass for the student with their parents and siblings to visit and engage together in the full guest science learning experience of the Mote SEA. A national "Oceanshot" initiative may consider utilizing the Mote SEA model to ensure equity of transformational opportunities for experiential STEM education of all K-12 students and the broader public that will enhance the overall level of Ocean Literacy throughout diverse communities.

<u>Independent nonprofit marine research institutions as partners and leveraging federal, state, private and philanthropic funding</u>

At Mote, we often refer to our foundational pillars as being – "Passion, Partnerships and Philanthropy". Passion for our science, Partnerships with our community and other research institutions around the world, and Philanthropy that gave birth to Mote and continues to nurture the growing impacts of our vital science-based mission. Mote is not automatically funded through any government process or university, so we must work hard each year to compete for local, state and federal grants and contracts. Over half of Mote's funding comes through our scientists earning grants from federal and state agencies. However, it is worth noting that the years of research breakthroughs accomplished by Mote scientists are more often than not initially fueled by philanthropy. Philanthropic support, not federal grants, enabled Mote scientists to:

- change the paradigm for coral restoration based on coral microfragmentation combined with genetic resiliency,
- identify a protein complex from the epigonal cells of bonnethead sharks that is a demonstrated source of potential therapies for 15 different types of human cancer,
- identify new antibiotics to fight MRSA resistant bacteria,

- create the ability to restore many of our wild fish populations,
- develop sustainable land-based recirculating marine aquaculture technologies to help feed the world, and
- create a real game-changer in our ability to develop innovative technologies to fight HABs.

Paradigms for funding and conducting science in the U.S. have evolved considerably since WWII, the creation of NSF, a growing role for federal funding of research in the intervening decades and now, the growing importance once again of philanthropy and independent non-profit research institutions such as Mote Marine Laboratory. Some have said that the practice of science in the 21st century is becoming shaped less by national priorities or by peer-review groups and more by the particular preferences of individuals with huge amounts of money. Others believe that setting national priorities by the very peer-review groups who established current paradigms of science will inhibit federal support for proposals for what some call "high risk" and the National Science Board termed potentially transformative research.

Independent non-academic nonprofits research institutions, such as Mote Marine Laboratory, are the most nimble and entrepreneurial, and least bureaucratic of any nonprofit including academic institutions. Philanthropic support enables us to remain completely independent, serves as the fuel for an entrepreneurial spirit of innovation that allows Mote to leverage agency support and provides the freedom for our scientist to thrive in pursuing potentially transformative ocean science and technology development. Nevertheless, in 2014 the National Science Board status and trends report *Science and Engineering Indicators* found that while Academic institutions (i.e., universities) had generally received steadily increasing federal research support over the previous decade, "Other Nonprofits" (other than academics and federally funded research and development centers [FFRDCs]) declined in R&D expenditures by 2.6%.

In a book entitled "Science, Money and Politics", Daniel Greenberg has stated that Donald Kennedy once remarked (*paraphrasing here)* that academia is bound by a set of policies and practices that favor the present state of affairs over any possible future, and that it is a portrait of conservatism, perhaps even of senescence. Given the somewhat unique role of independent nonprofit research institutions, such as Mote Marine Laboratory, in terms of, *inter alia*:

- innate entrepreneurial spirit of entirely soft-money research enterprise with a mission of translating and transferring research results,
- minimal bureaucratic challenges and hurdles to the conduct of science,
- the lack of political influences on research conducted and the scientific freedom provided through significant philanthropic support to leverage competitive grants from federal and state agencies and conduct potential transformative research,

and especially with respect to a national "Oceanshot" initiative, the ocean focused research/technology development and ocean STEM education model of such institutions like Mote may provide insights on more effective and efficient use of ocean science investments. Our Nation's federal research enterprise may be well-served to reconsider the critical value of independent nonprofit research institutions such as Mote Marine Laboratory, and the vital niche role they play in enabling the U.S. to stay at the forefront in the global research and innovation enterprise.

Dr. Michael P. Crosby
President & CEO of Mote Marine Laboratory

Dr. Crosby has over 35 years of diverse research, teaching, science management and leadership endeavors. He has developed, managed and conducted major multi-disciplinary research project and partnerships with numerous universities, national and international science and resource management agencies, programs and committees. Many of these endeavors focused on improving the "synthesis, translation and transfer" of science and technical information between research, public policy and stakeholder communities. He has secured over $60 million in research funds, published over 50 science manuscripts, edited several books, and his past appointments include: Associate Vice President, Research and Economic Development, George Mason University; Vice Chancellor for Research, University of Hawai'i, Hilo; Executive Director, National Science Board of the National Science Foundation; and Senior Advisor for International Science Policy, National Oceanic and Atmospheric Administration. Dr. Crosby has been named as one of the 25 most influential executive leaders in life sciences for the State of Florida, is also Past-President for Sigma Xi-The Scientific Research Society, past Chairman for the U.S.-Israeli Binational Science Foundation, and currently serves as Chair of the Florida Institute of Oceanography Council, the Board for Southeast Coastal Ocean Observations Regional Association (Past-Chair), the Association of Marine Laboratories of the Caribbean Board of Directors (Past-President), the Pacific Congress on Marine Science and Technology Board of Directors (Past-President), the Institute for Venture Science Board of Advisors, and Board of Trustees for Doctors Hospital of Sarasota.