WRITTEN TESTIMONY OF
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LEGISLATIVE HEARING ON
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BEFORE THE
HOUSE COMMITTEE ON NATURAL RESOURCES

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Chairman Bentz and Members of the Committee, thank you for this opportunity to testify today on important legislation for our Nation. I speak in strong support for reauthorization of HABHRCA and of the amendments contained in H.R. 6235.

I am Donald M. Anderson, a Senior Scientist in the Biology Department of the Woods Hole Oceanographic Institution, where I have been actively studying harmful algal blooms (HABs) for over 45 years. I am here to provide the perspective of an experienced scientist who has investigated many of the HAB phenomena that affect coastal waters of the United States and the world. I am also Director of the U.S. National Office for Harmful Algal Blooms, a former co-Chair of the National Harmful Algal Bloom Committee, and have been actively involved for many years in formulating the scientific and legislative framework and the agency partnerships that support and guide our national program on HABs. This includes working on the first iteration of the Harmful Algal Bloom and Hypoxia Research and Control Act of 1998 (HABHRCA), the law for which amendments are on the floor for the Committee's consideration today.

My testimony today will summarize the national scale of the HAB and hypoxia problems in the U.S., notably their distribution, impacts, and trends as well as the emerging challenges facing those responsible for monitoring and managing these phenomena. I will also highlight recent research accomplishments and partnerships made possible by investments in the HABHRCA, as well as developments that are needed to improve the national response to HABs and hypoxia. Finally, I will provide my perspective on the programmatic, legislative, and funding needs of the national HAB program given emerging issues and challenges, and offer some comments about the Committee's draft legislation for the reauthorization of HABHRCA.

Background. HABs and hypoxia are national problems that require a comprehensive national research, monitoring, and mitigation strategy. The increasing frequency, intensity, and spread of HABs adversely affect the health and economy of communities, states, tribes, and regions around the nation. Similarly, hypoxic zones are expanding throughout U.S. coastal waters, and worldwide. Smaller areas experiencing periodic hypoxia can grow into "dead zones" if contributing factors are not addressed. Indeed, dead zones have spread exponentially since the 1960s and have been reported in more than 400 receiving waters worldwide, nearly half of which are in the U.S. As the name implies, most forms of marine life cannot survive such low oxygen conditions.

Congress has responded by increasing HAB and hypoxia funding for some agencies, in particular for NOAA's base and competitive programs, which is essential if we are to improve our understanding of how these phenomena develop and identify strategies to mitigate their impacts. These increases, however, do not fully restore major funding cuts made in previous years when the national HAB and hypoxia problems were much smaller than what we face now. Clearly, sustained funding at a higher level is a critical need. Enhanced support is also needed for HAB programs in the EPA, USGS, and multiple other agencies with mandates that include HAB and hypoxia issues.

I want to start by highlighting the challenge that HABs and hypoxia pose to our nation. HABs are accumulations of microscopic and macroscopic algae (seaweeds) that cause harm in myriad ways. There are many species and types of HABs that occur in both marine and freshwater environments, leading to wide-ranging impacts on people and ecosystems. Some species produce compounds that are among the most potent natural toxins known. Either because of these toxins or the sheer biomass of the dense accumulations of the algae (hence the common term "red tide"), impacts can be significant, including illness and death of humans who consume contaminated shellfish or fish; mass mortalities of fish, seabirds, and marine mammals; and even irritating aerosolized toxins that cause respiratory irritation and drive tourists and residents from beaches. To provide a glimpse of the scale of some of these phenomena, a few years ago a massive and highly toxic HAB occurred along the U.S. west coast, stretching from Washington to California. A few years later on the east coast, much of the west coast of Florida was impacted by major HAB events in 2018 and 2021 that devastated the Florida Gulf Coast marine ecosystem, tourism, and fishing industries. Millions of fish and hundreds of sea turtles, dolphins, and manatees perished, while driving residents and tourists away from beaches and coastal waters. Socioeconomic studies estimate approximately $184 million in losses in the tourism sector from the 2018 outbreak, and, because of the consequent contraction to the rental market, the loss of nearly 2,900 jobs. These describe just two of many small- and large-scale marine HAB events that occur nationwide every year.

Freshwater HABs are primarily caused by cyanobacteria or blue-green algae. These create serious problems, first due to the reduction of light and depletion of oxygen in the water, and second, through the production of potent toxins. Freshwater HABs can affect humans through recreational exposure and drinking water, and also affect fish, wildlife, and domestic animals. In 2014 a cyanoHAB near Toledo severely impacted Ohio's drinking water intake source in Lake Erie resulting in 500,000 water customers being advised not to drink their tap water for nearly three days. A similar event occurred in Salem, Oregon in 2018, affecting a similar number of people but for a longer interval. The scale of these blooms can be massive, evidenced by the largest bloom in recorded history in western Lake Erie in 2015—an event that produced a surface scum that covered nearly 300 square miles.

Hypoxia can also have a wide range of detrimental impacts on human and animal health. Low concentrations of dissolved oxygen, often linked to high concentrations or biomass of algal cells, can be lethal to aquatic species. Increases in hypoxia events have led to increased frequencies and magnitudes of fish kills and mass-mortality events. HABs and hypoxia are often linked in a positive feedback loop that further reinforces harmful conditions, such as when hypoxia in an aquatic ecosystem reduces the populations of algae-controlling fish species, allowing algal blooms to proliferate unchecked.

Ocean conditions, such as those along the Pacific Northwest Coast, are affected by changes in winds that drive upwelling ocean currents that pull deep, oxygen-poor waters onto the shallow continental shelf. Stronger winds from climate change have accentuated the risk and severity of low-oxygen events. In recent years, the synergistic effects from HABs and hypoxia have repeatedly led to the closure of entire Dungeness crab fisheries along the Pacific Northwest Coast. As the result of low-oxygen waters being upwelled into coastal waters, oxygen levels can drop so low that Dungeness crabs suffocate in the pots of fishermen before they can be brought to market. This has led to massive die-offs of crabs impacting the region's most valuable fishery.

As noted above, HAB and hypoxia events have wide ranging economic impacts, including the costs of conducting routine monitoring programs to keep dangerous shellfish and other affected resources off the market, short-term and permanent closures of harvestable shellfish and fish stocks, reductions in seafood sales (including the avoidance of "safe" seafoods as a result of "overreaction" to or uncertainty with health advisories), mortalities of wild and farmed fish, shellfish, submerged aquatic vegetation and coral reefs, impacts on tourism and tourism-related businesses, and hospital treatments for people who fall ill. Furthermore, regional studies show that HABs and hypoxia cause losses in tourism, housing, and general business revenue that can amount to hundreds of millions of dollars annually. For example, the 2015 West Coast Dungeness crab closures and delayed openings mentioned earlier resulted in over $97.5 million lost from commercial landings compared to the previous years, and coastal communities in Washington lost an estimated $40 million in tourism spending for recreational activities.

National HAB and Hypoxia Programs. The diverse nature of HAB and hypoxia phenomena and geographic variability associated with outbreaks throughout the U.S. pose a significant constraint to the development of coordinated national programs. Nevertheless, in large part because of HABHRCA, the combination of planning, coordination, and highly compelling topics with great societal importance has led to integrated research and response communities that include scientists, federal and state agencies, Tribes, and industry. In the past, many of these individuals and groups worked independently and with little exchange of ideas and data. The networks that now exist in many parts of the country are active and productive, and are a major factor in the growing capabilities of the national programs.

Our national HAB "program", or strategy, is viewed by many of my colleagues in other disciplines and other countries as a model program that has succeeded because of its organization and partnerships. Given the diversity of HAB a impacts across different regions of the U.S., sustained national support is critical to allow agencies to respond to the inevitable outbreaks that will occur in different locations in future years. Historically, NOAA was often the only federal agency addressing this issue for our nation. The Interagency Working Group (IWG) on HABHRCA was then established by Congress in 1998 as an interagency task force, and today, it has over 16 member agencies, leveraging the expertise and capabilities of the federal government to prevent, mitigate, and even control these diverse phenomena. The IWG should be sustained, and in my opinion, NOAA has done an excellent job leading that group and should continue in that role.

Partnerships are key to our success and help us point science in the right direction. The IWG-HABHRCA enhances federal coordination of activities that span agencies' jurisdictions to leverage capabilities where possible. For instance, CyAN, a satellite-based cyanobacterial monitoring network, is a collaboration between NASA, NOAA, USGS, EPA and USACE that provides near real-time cyanobacterial bloom data for more than 2000 lakes in the United States. Each agency alone would not have the expertise, technology, development tools, or funding to complete a project of that nature. Collaborative methods and technologies like CyAN help state and local officials make informed decisions on where to focus their limited time and capacity for testing and mitigation efforts.

HABHRCA has been instrumental in providing the framework and enabling environment to move many of these federal partnerships forward. The academic research community strongly relies on federal funding through these programs to conduct our research across a very broad spectrum. Reflecting the diverse nature of HABs and their impacts, over the last 25 years the national HAB program has evolved into a comprehensive strategy that addresses all of the major elements of HAB research and management. Many of these program elements are authorized in HABHRCA. What follows is a brief summary of the individual scope of these research programs that complement each other and produce a comprehensive national strategy:

- ECOHAB (Ecology and Oceanography of HABs) is a critical, core program that is needed to address the fundamental processes underlying the impacts and dynamics of HABs. Knowledge of how different factors control the initiation, development, and decline blooms is a critical precursor for advancing HAB management nationwide.
- ECOHAB research results have been brought into practical applications through MERHAB (Monitoring and Event Response of HABs), a program formulated to transfer technologies and foster innovative monitoring programs and rapid response by public agencies and health departments.
- Similarly, PCMHAB (Prevention, Control and Mitigation of HABs) is a program dedicated to advancing research on effective strategies for HAB prevention, control, and mitigation.
- Now, the new federal Social, Cultural and Economic Assessment of Harmful Algal Blooms (SEAHAB) Program will further address critical gaps in assessing the socioeconomic and cultural impacts of HABs.
- Additionally, the National Science Foundation and National Institute of Environmental Health Sciences jointly fund research on marine-related health issues through the Centers for Oceans and Human Health program that is bringing HAB scientists together with the public health community to understand human exposure to HAB toxins, to develop methods to detect, quantify and forecast ocean-related health threats, and to identify relationships among parameters of climate change and increased human exposure to toxins.

This suite of programs has been a major part of the success and productivity of HAB research in the U.S., and therefore I fully support having them highlighted in HABHRCA and having other federal agencies participate in them where possible.

Directly authorized by HABHRCA, the Coastal Hypoxia Research Program (CHRP) is a competitive research program focused on advancing the scientific understanding and management capabilities needed to assess, predict, and mitigate hypoxia events. The program brings together researchers, federal experts, blue industry, and stakeholders to address impacts of hypoxia on local communities and natural resource managers. For example, in 2022 CHRP provided academic researchers with funding to work with Oregon's Dungeness commercial crab fishery to cooperatively implement a hypoxia detection and monitoring program. The project team will deploy dissolved oxygen sensors on commercial crab pots in collaboration with commercial fishermen. The information collected with these sensors will supply hypoxia exposure data that will allow the fishing fleet to adapt to the onset of hypoxia events and the Oregon Department of Fisheries and Wildlife Shellfish Program managers to conduct in-season management of the fishery. The project will also help the fishing fleet to adaptively manage the crab fishery in response to hypoxic events by providing recommendations to bolster its multi-stressor readiness plan.

All of these programs serve important topic areas, and collectively form the basis for what I believe has been an extraordinary pace of national progress addressing both HABs and hypoxia.

Emerging problems. Since the last reauthorization of HABHRCA, and as is evident from the diverse and expansive nature of the national HAB and hypoxia problems described above, managers responsible for the protection of human health and coastal resources are facing a growing and daunting challenge. Many regions now experience multiple HAB species, with many blooming at different times of the year, affecting multiple resources. State monitoring programs that used to focus on a single HAB poisoning syndrome are now struggling to cover two, three, and even four different threats, sometimes concurrently, greatly stretching scarce personnel and financial resources. In some cases, this has led to blanket harvesting closures in which entire coastlines are quarantined for months at a time on an annual basis, even though the affected resources may not be toxic across that entire expanse and time.

Climate change will also almost certainly influence HABs and hypoxia since many critical processes governing their dynamics are influenced by climate, such as temperature, water column structure, water circulation patterns, and nutrient inputs. This is not a future problem, but one that faces us now. 2023 was the warmest year on record, and three other recent years fall in the top 10 of the warmest years recorded. This underscores the need for reauthorization of HABHRCA legislation, as there is no doubt that the rapidly changing climate is bringing us new and different challenges going forward. We know, for example, that climate change is causing increasing frequency and severity of marine heatwaves and general warming of surface and near-shore bottom waters that are already affecting the distribution and abundance of HAB species. Climate change is expected to exacerbate the HAB problem in some regions and shift species distributions geographically. In the Gulf of Maine, where I have done much of my HAB field research, we are watching with great concern a massive region or blob of exceptionally warm ocean water in the northwestern Atlantic near Labrador and Nova Scotia. The seawater in that area is as much as 15°F warmer than long-term averages. We know that the region is important in the development of blooms of a HAB species that causes the human poisoning syndrome called amnesic shellfish poisoning (ASP), and that changes in regional currents and water circulation can affect the paralytic shellfish poisoning (PSP) problem as well. The presence and persistence of a huge oceanographic feature of this type needs to be studied to better understand the changes that might happen with HAB phenomena in the region. Indeed, 2023 already proved to be a highly unusual year for the PSP problem in the Gulf of Maine, as there was virtually no toxicity observed throughout the bloom season across the entire region, a truly rare occurrence in the long history of annually recurrent, wide-scale outbreaks. Similar anomalies and heat waves are occurring in other areas of the U.S. coast, and the HAB implications are the same.

A warming ocean also gives rise to oxygen-poor (or hypoxic) zones. This is because warmer waters hold less dissolved oxygen and stratified warmer waters on the surface of the ocean act to slow the replenishment of oxygen from the atmosphere to the deep ocean. The low-oxygen zones that we experience today are more severe and closer to shore than what can be seen in historical records that go back seven decades. Just as we have wildfire seasons that start earlier and spread farther on land because of climate change, Oregon and other states now have hypoxia seasons that return to those coastal waters each year. Similarly, freshwater cyanoHABs are expected to worsen as temperatures rise. The cyanobacteria that cause many of these outbreaks thrive under warm temperatures and outcompete many more beneficial groups of algae.

One area where global warming is of particular and immediate concern is in the Arctic which is warming nearly four times faster than the global average. With present-day warming leading to major reductions in ice cover and changes in regional hydrography, biogeographic boundaries of a wide range of marine species at all trophic levels are being impacted, particularly in summer ice-free shallow waters. There is now clear evidence that multiple HAB toxins are accumulating on a recurrent basis within the Arctic food web at dangerous levels, and I firmly believe that the problems will worsen as waters warm. For example, as a result of these warming trends, historically dormant, deepwater cysts of one of the country’s most dangerous HAB species are now germinating and blooming in the Arctic and sub-Arctic waters of Alaska, producing massive quantities of toxins that can move through virtually every level of the marine food web. As this occurs, human health and ecosystems are threatened in a region where traditional monitoring programs for toxins in shellfish, fish, or other animals are not feasible, and where the Alaskan native communities that rely on many different marine animals and plants for subsistence have no prior exposure to these toxins. The ecosystems that are critical to the survival of these communities are also threatened by HAB toxins, as these can lead to animal illnesses and deaths that raise food security issues as well. I am thus supportive of the amendments to HABHRCA that expand applied research to a wider range of impacts, such as subsistence impacts on rural and Tribal communities that rely on marine resources for their cultural, nutritional, and economic well-being.

Technological developments. Of necessity, research advancements have had to keep pace with the expanding needs and complexity of HAB and hypoxia problems. In recent years, research has led to the development of operational forecasts for specific HAB types in certain regions, such as the NOAA HAB forecasts in Lake Erie and the Gulf of Maine. An operational HAB forecast is like checking the weather to see what the water conditions are at a given moment, up to several days in advance. Similarly, research has led to the development of innovative and powerful HAB sensors that can be deployed autonomously at key sentinel locations and on a variety of fixed and mobile platforms. For example, one new instrument is a submersible microscope that takes hundreds of thousands of high-resolution images of microscopic algal cells every day and, with the aid of artificial intelligence, software then identifies and counts the HAB species that are present. When deployed at key locations, these new technologies can provide states, Tribes, management agencies, and tourism, aquaculture and wild and farmed fisheries industries with HAB early warning. Equally importantly, these instruments can supply data that can be assimilated into HAB forecast models, making them more accurate, just as arrays of weather instruments supply data that improve the accuracy of weather forecasts.

These HAB sensors are now being deployed throughout the country, but Alaska once again gives a clear example of the value of these new technologies. The communities mentioned above that rely on subsistence harvesting are scattered throughout the Alaskan Arctic, often in remote and rugged areas along the coast. Since these areas are far from the population centers that have infrastructure for toxin monitoring and measurement, new region-specific approaches are needed to provide early warning of blooms as they occur. Efforts are thus underway to deploy autonomous instruments in several locations so that the instruments can sample the water three times every hour, 24/7, with results communicated via the internet on a near real-time basis. Locals are being trained to operate the sensors, and generators and StarLink Internet connections established to keep the systems operating and communicating despite frequent power outages and limited bandwidth. This nascent Arctic HAB observing system is just one element of the critically important National HAB Observing Network (NHABON), which will allow states and industries to deploy and maintain sensors to meet their specific needs. I am thus supportive of the clear mandates introduced in these amendments for both sustaining operational forecast capabilities at the national level, and also for a National HAB Observing Network (NHABON).

HAB Control. Many of the technologies and research programs described above are helping to prevent and mitigate HABs and their impacts, but one of the most challenging frontiers of HAB science is the development, scaling, and ultimate deployment of bloom control or suppression technologies. Once again, the diverse nature of HAB species and their impacts dictates that no single control strategy will work for all HABs, and therefore, many different approaches are under investigation, ranging from chemical algaecides to biocontrol using naturally occurring bacteria and viruses, and even to the dispersal of simple clay minerals that aggregate with each other and with HAB cells, sinking the cells and their toxins to bottom sediments. Research progress has been rapid in this area, but state and federal regulatory requirements are a major obstacle to transitioning technologies from the lab setting into the field when blooms are happening, even for small-scale field trials. NOAA's NCCOS program has taken a major step to help with these challenges by creating a National HAB Control Technologies Incubator that will provide one-time seed money to promising but risky technologies for proof of concept studies, as well as a clearinghouse of state and federal regulations to help investigators navigate that difficult landscape. I am highly supportive of the inclusion of the National HAB Control Technologies Incubator in this version of the HABHRCA bill to address this growing need.

Event Response. Finally, when unexpected or unusual HAB events occur, there are immediate needs for short-term observations of where a bloom is, where it will go, and how severe it might be. This information is needed for assessments of impacts and formulation of management responses, as well as economic assistance. NOAA has maintained a modest HAB Event Response Program for over a decade, and it has been very effective, but given the growing diversity and scale of the problems described above, a much larger program is needed. The amount of money available for distribution to those requesting immediate assistance throughout the country is small, both in terms of the size of individual awards, but also in the number of awards that can be granted. This bill includes modifications to the Harmful Algal Bloom and Hypoxia Events of National Significant provision that make it more effective for both short-term and long-term response, and creates a funding mechanism that will allow monies to be provided quickly to affected states.

Summary. Let me close by saying that it is vitally important to reauthorize HABHRCA so that we can maintain the highly productive momentum that we have built up for addressing the growing problems of HABs and hypoxia. The U.S. has strong and highly respected programs, and from the perspective of one who has been an active investigator in the HAB field for over four decades, I have seen a clear acceleration of outcomes and benefits from the sustained research support covered by HABHRCA. Furthermore, these amendments clearly support the collaborative interagency effort that is needed to respond to and manage HABs and hypoxia across a diverse array of federal agencies and mandates. Together, these efforts are leading to greatly enhanced understanding of the mechanisms underlying HABs and hypoxia and their impacts, as well as the development and implementation of practical tools, technologies, and approaches that can assist state and federal managers and others on the front lines to protect public health, fisheries, tourism, and other economic and social interests at the national, state, and community levels.

Thank you for the opportunity to offer information that is based on my own research and policy activities, as well as on the collective wisdom and creativity of numerous colleagues in the HAB and hypoxia fields. I would be pleased to answer any questions that you or other members may have.

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