University Corporation for Atmospheric Research
Consortium for Ocean Leadership
Incorporated Research Institutions for Seismology
Lamont Doherty Earth Observatory, Columbia University
Woods Hole Oceanographic Institution
Scripps Institution of Oceanography, University of California San Diego
National Association of Marine Laboratories
Association of Public and Land-grant Universities
SRI International
University of California System
Texas A&M University
Oregon State University
University of Colorado
University of New Hampshire
University of New Mexico
University of Connecticut
University of Wisconsin – Madison
Florida State University
University of Delaware
University of Nebraska-Lincoln
University of Massachusetts Dartmouth
Michigan Technological University
University of Hawaii at Manoa
University of North Carolina at Wilmington
University of Oklahoma
University of Rhode Island
Skidaway Institute of Oceanography, University of Georgia
The University of North Carolina at Chapel Hill, Institute of Marine Sciences
Great Lakes WATER Institute, University of Wisconsin-Milwaukee School of Freshwater Sciences
Humboldt Marine and Coastal Science Institute, Humboldt State University
Moss Landing Marine Laboratories
Grice Marine Laboratory, College of Charleston
University of South Florida - College of Marine Science
Center for Marine Sciences and Technology – North Carolina State University
Louisiana Universities Marine Consortium
American Anthropological Association
Soil Science Society of America
Bigelow Laboratory for Ocean Sciences, Maine
Friday Harbor Laboratories, College of the Environment, University of Washington
American Geosciences Institute

Testimony Regarding Fiscal Year 2016 Funding for
The National Science Foundation and the Geosciences
Submitted to the
Subcommittee on Commerce, Justice, Science and Related Agencies
Committee on Appropriations,
United States Senate
March 27, 2015

Dear Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to present testimony in support of strong and balanced funding for the National Science Foundation. This testimony is submitted on behalf of the organizations listed in the left margin that are concerned with funding for NSF and the geosciences

We want to thank the Subcommittee for the vital support it provided NSF in the FY 2015 process. For FY 2016, the Administration is requesting $7.7 billion for NSF – an increase of 5.2% over the FY 2015 level provided by this Subcommittee and, ultimately, the Congress. We strongly endorse the NSF proposal for FY 2016, and hope the Subcommittee will be able to continue to provide the leadership and support that it has in the past for NSF.

Within the NSF request we draw your attention to the request for the Geosciences Directorate (GEO), which is $1.36 billion, 4.7% above the FY 2015 level. As it did last year, we hope the Subcommittee will once again provide the GEO budget request.

GEO provides about 61% of the federal funding for basic research at academic institutions in the geosciences. Geoscientists work to understand and predict natural disasters that regularly plague the Earth, including earthquakes, volcanoes, tornados, hurricanes, tsunamis, floods, drought and solar storms, saving countless lives and billions of dollars in property damage. Better weather prediction and hazard mitigation, as well as improved public weather and warning systems, are a direct result of such research. Comprehensive, state-of-the-art observing systems help grasp the complexity of large-scale concerns, such as the acidification of oceans, the occurrence of solar activity and the quantity and quality of surface and groundwater resources.

Geoscientists also provide valuable knowledge on sustaining biological diversity and ocean resources, conserving soil for agricultural productivity, finding and sustaining adequate supplies of minerals and natural resources, facilitating environmental cleanup, and understanding global climate patterns. Through this work, the geosciences have strengthened national security and public safety, while educating the next generation of geoscientists. This work informs government officials, industry and the public, helping to ensure that solid science guides the nation's conservation,

National Association of Geoscience Teachers
American Meteorological Society
Marine Biological Laboratory
Seismological Society of America
College of the Environment, University of Washington
College of Earth and Mineral Sciences, Penn State University
Department of Geography and Meteorology, Valparaiso University
The College of Arts and Sciences, Valparaiso University
Metropolitan State University of Denver
Saint Louis University Department of Earth & Planetary Sciences, The Johns Hopkins University
Oregon Institute of Marine Biology University of Oregon
Annis Water Resources Institute – Grand Valley State University
The Institute of Earth, Ocean, and Atmospheric Sciences at Rutgers University
Whitney Laboratory for Marine Bioscience, University of Florida
Seahorse Key Marine Laboratory, University of Florida
Marine Science Research Institute-Jacksonville University
Galbraith Marine Lab, Eckerd College
Western Washington University, Shannon Point Marine Center
Belle Baruch Institute for Marine and Coastal Sciences, University of South Carolina
University of California, Davis
University of Maine
Michigan State University
Dauphin Island Sea Lab, Dauphin Island, Alabama
Desert Research Institute, Nevada
The University of Kansas
University of Minnesota
The Institute at Brown for Environment and Society, Brown University
The University of Texas at Austin

management, safety and security strategies to meet societal and global challenges.

As the Subcommittee moves ahead with the FY 2016 appropriations process, the institutions listed in the margin of this testimony would like to provide information that tries to demonstrate how investing in the geosciences is inextricably linked to furthering innovation, increasing productivity, raising the standard of living of our citizens, creating more jobs, and ensuring the safety of our citizens. We hope the examples contained in this testimony will ensure full and balanced funding by the Subcommittee for NSF and strong support for the geosciences.

Geoscience Graduates – Source of Technical Talent for Oil and Gas Industry

The geosciences research that NSF funds also helps educate and train the next generation of geoscientists. According to the Bureau of Labor Statistics (BLS), there were a total of 296,963 geoscience jobs in 2012, and this number is expected to increase by 14% by 2022 to a total of 339,737 jobs. Approximately 143,000 geoscientists are expected to retire by 2022, but over the next decade, approximately 51,000 students will be graduating with their bachelor's, master's, or doctoral degrees in the geosciences. Therefore, according to the American Geosciences Institute's (AGI) *Status of Recent Geoscience Graduates 2014*, assuming minimal non-retirement attrition from the geoscience workforce, there is expected to be a deficit of approximately 135,000 geoscientists by 2022. Texas leads the nation in the number of geoscience undergraduates and graduate students enrolled within geoscience departments.

The AGI report, *Status of the Geoscience Workforce 2014,* says that the oil and gas industry hires more geoscience graduates than any other industry. The survey showed that 36% of graduates with bachelor's degrees in geosciences in 2014 went on to high-paying positions in the oil and gas industry. Another 21% found employment in the environmental services industry, and 11% found employment in the mining industry. The survey also found that 74% of master's graduates were employed by the oil and gas industry. At the doctoral level, 22% were employed by the oil and gas industry. Other industries hiring geoscientists include: manufacturing or trade, construction, information technology services, and agriculture. NSF's support for the geosciences contributes significantly to the education and training of these individuals via NSF's programs in research, graduate student support, and undergraduate student support.

Improved Hurricane Prediction Saves Lives

While an estimated $60 billion in losses can be attributed to Superstorm Sandy, the ability we had at that time to make such a forecast probably saved thousands of lives. Imagine the quality of the forecast and the impact of such a storm if it had hit just fifteen years ago. Hurricane advisories extended only two or three

days into the future. Forecast models did not yet reflect the fact that oceans were the source of heat and energy that fueled such storms – a fact vital for accurate hurricane forecasts that came from basic ocean sciences research. Without such information embedded in the models, forecasters would never have seen Sandy's last minute westward hook into New Jersey. We did not have the sophisticated weather information system that made it possible for the nation's weather enterprise to make the call and subsequent updates on Sandy as early, as often, and as accurately as was done which enabled residents, businesses, and public officials to prepare and take shelter. While still not perfect, these modern forecasts allowed for nearly a week of preparations by cities, businesses, institutions, and families – and undoubtedly made a life or death difference for thousands of people.

How did we acquire such a sophisticated and important weather forecast system? The short answer is that we – led by this Committee, the Congress and ultimately the taxpayers – continuously invested in science, technology, engineering, mathematics, and education. These investments supported basic research in mathematics and physical sciences, computer sciences, and the geosciences to the development of sophisticated models, satellites, radar, and parachute-borne instrument packages that could make the key observations. Those investments also allowed us to develop an understanding of how the earth, the oceans, and the atmosphere collectively impact our weather and the environmental conditions that ensued. They enabled us to develop and run forecast models on advanced computing systems that turned massive amounts of raw data into "actionable intelligence". This was coupled with investments in education and training that created the talented and dedicated workforce needed to put it all together. And it was a host of innovative technologies that allowed all of this information to be presented in a manner that most people—with or without smart phones—could understand.

<u>The Oceans, the Coasts, and the Great Lakes - Drivers of the U.S Economy</u>

Over 8.5 million people reside in the 100-year coastal flood hazard area. More than half of the United States population lives in 673 coastal watershed counties, and these counties generate 58% ($8.3 trillion) of the Nation's gross domestic product (GDP)—even though they comprise only 25% of the Nation's land area. Every day, the marine environment supplies a multitude of products and services that enhance and support the lives and livelihoods of citizens. In 2011, Americans, on average, ate 15 pounds of fish and shellfish per person – 4.7 billion pounds all together – making the U.S. second in the world in total seafood consumption. The United States has jurisdiction over 3.4 million square miles of oceans – an expanse greater than the land area of all 50 states combined. This vast marine area offers many environmental resources and economic opportunities, but also presents threats such as damaging tsunamis and hurricanes, industrial accidents and outbreaks of water borne pathogens. The 2010 Gulf of Mexico *Deepwater Horizon* oil spill, the 2011 Japanese earthquake and tsunami, and the 2012 Superstorm Sandy are vivid reminders that our understanding of our oceans, coastal areas, and the Great Lakes is far from complete. Developing sufficient capabilities to sustain ocean-based economies and protect our coasts and coastal communities from natural and man-made hazards will require a sustained investment in research, infrastructure and education and training.

The Great Lakes region boasts a massive geographic footprint, and is a major driver of the North American economy. With economic output of $4.7 trillion in 2011, the region accounts for 28% of combined Canadian and U.S. economic activity. By comparison, the region's output ranks ahead of Germany, France, Brazil and the U.K., and it would rank as the fourth largest economy in the world if it were a country, behind only the U.S., China and Japan. The Great Lakes are responsible for nearly 1 million manufacturing jobs; 217,000 jobs in tourism and recreation; over 100,000 in shipping; over 110,000 in agriculture, fishing and food production and about 10,000 related to mining. Understanding the complexity of the Great Lakes is vital for the future health and well being of this region of the country.

Research Underlying Fracking Technology Yields Economic Benefits

Investment in the geosciences provided the fundamental understanding of geologic structures and processes necessary to utilize hydraulic fracturing (fracking) processes to release oil from shale formations. The ability of U.S. companies to develop these natural resources is built upon decades of fundamental research and technology development in the earth sciences. According to a 2013 report from U.S. Chamber of Commerce's 21st Century Energy Institute, fracking has created a job boom even in states that don't actually have shale deposits, with 1.7 million jobs already created and a total of 3.5 million projected by 2035.

Conclusion

It is important to appreciate that the NSF's investments in the geosciences have addressed other important national and global challenges, spurred new economic sectors, and led to the development and implementation of advanced technologies that save lives, protect property, and support our economy. We appreciate the difficult decisions Congress must make within the constraints of the budget environment. Additionally, we believe the future of the nation is well served by a strong and sustained investment in the full scope of our research enterprise, which includes a central role for the geosciences. Thank you for the opportunity to present these views.