Robert Cowen, President, National Association of Marine Laboratories

Robert Dickey, Chairman, Public Policy Committee, National Association of Marine Laboratories

NATIONAL ASSOCIATION OF MARINE LABORATORIES

Annual Public Policy Meeting

March 4 and 5, 2018

1201 New York Avenue NW, Suite 400

Washington, D.C. 20005

Prepared by Joel Widder and Meg Thompson, Federal Science Partners

Briefing Book for NAML Meeting

March 4-5, 2018

Washington, D.C.

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National Association of Marine Laboratories
Winter Meeting
1201 New York Avenue NW
4th floor Ocean Leadership Conference Room
Washington, D.C.
March 5 and 6, 2017

Sunday -- March 4, 2018

Location: **Washington Plaza Hotel, 10 Thomas Circle NW, Washington, D.C. 20005**

2:00PM **Opening Remarks – Robert Cowen**

- **New Member(s)**
- **Reciprocal Membership of Consortium for Ocean Leadership**
- **Executive Board Membership**

2:15PM **Briefing on the Federal Science Budget and Policy Environment – Joel Widder and Meg Thompson, Partners, Federal Science Partners and Consultants to NAML**

2:45PM **Discussion of NAML Public Policy Agenda and Related Activities – Robert Dickey**

- **NAML FY 2019 Public Policy Agenda – Approval Requested**
- **Testimony for FY 2019**
- **Coastal Roundtable Statement**
- **COL, NAML, and SOST – Webinar Review of SOST Plan**
- **Congressional Briefing – Topic and Member Participation – Collaborate with Coastal Roundtable**
- **General Discussion**

3:45PM **NAML Business Meeting – Committee/Workgroup Reports**

- **Treasurer** — **Billie Swalla**
- **Membership** — **Brett Burk**
- **Education Committee** — **Jan Hodder**
- **Data Integration WG** — **Steve Weisberg**
- **Science Communication WG** — **Karina Neilsen**

4:15PM **Regional Meetings: WAML; SAML; and NEAMGLL**

5:00PM **Regional Meetings report out**

5:30PM **Reception – Washington Plaza Hotel**

6:30PM **Dinner (on your own)**

Monday – March 5, 2018

Location:	**Consortium for Ocean Leadership, 1201 New York Avenue NW, Suite 400 Conference Rooms A, B &C**
8:00AM:	**Coffee and continental breakfast**
8:30AM:	**Robert Cowen, President, NAML** **Robert Dickey, Chair, Public Policy Committee**
8:45AM:	**Dr. William Easterling, Assistant Director, Geosciences, National Science Foundation and Dr. Rick Murray, DD for Ocean Sciences to accompany Bill Easterling**
9:45AM:	**Break**
10:00AM:	**Mr. Kolo Rathburn, Majority Staff, Senate CJS Appropriations Subcommittee**
10:45AM:	**Break**
11:00AM:	**Speaker: Novim Report: *Warning Signs* – American Climate and Environmental Research and Policy at the Crossroads: Dr. Ari Patrinos, Mr. Kei Koizumi**
12:00PM:	**Break**
12:15PM:	**Lunch & Speaker: RDML Timothy Gallaudet, Deputy Administrator, NOAA**
1:30PM:	**Break**
1:45PM:	**Panel: Future of the Sea Grant Program:** **Dr. Jon Pennock, Director National Sea Grant College Program** **Dr. James Hurley, President, Sea Grant Association and Director, Wisconsin Sea Grant;** **Dr. Amber Mace, Chair, Sea Grant Advisory Board**
2:45PM:	**Break**
3:00PM:	**University Federal Relations and NAML Labs; Moderator Ms. Jennifer Poulakidas, APLU; Speakers: Ms. Ellyn Perrone, University of Texas; Mr. Brent Burns, Michigan Technological University; Ms. Gabrielle Serra, Oregon State University**
4:15PM:	**Jon White, President and CEO, Consortium for Ocean Leadership: COL and NAML Future Collaborative Activities**
5:00PM:	**Summing Up/Next Steps**

Biographical Sketches of Speakers
NAML Public Policy Meeting
Washington, D.C.
March 4 and 5, 2018

Dr. William Easterling, Assistant Director, Geosciences, National Science Foundation -- William E. Easterling began his tenure as Assistant Director of the Directorate for Geosciences at the National Science Foundation in June 2016. Dr. Easterling comes to NSF from Penn State, where he has been dean of the College of Earth and Mineral Sciences since 2007. As dean, Dr. Easterling led strategic planning for research initiatives focusing on the food-energy-water nexus, clean carbon energy, additive manufacturing, big data challenges in forecasting, risk and uncertainty in environmental decisions, and more. In 2001, he became the founding director of the Penn State Institutes of Energy and the Environment, the focal point for interdisciplinary research in energy and environmental science and engineering at Penn State. GEO provides about 61 percent of the federal funding for basic research at academic institutions in the geosciences. These investments improve our understanding of the many processes that affect the global environment, including the planetary water cycle, geologic interactions that cross the land-ocean interface, and the behavior of ice sheets. A self-described enthusiast of multiple disciplines of science, Dr. Easterling served as professor of geography and earth system science at Penn State since 1999. He has written or co-authored nearly 100 peer-reviewed papers, reports and books. He has served on numerous committees, panels and boards for NSF, the National Research Council and other organizations, and has been a principal investigator on dozens of highly competitive federal awards. He has won numerous awards and honors, including election to the American Association for the Advancement of Science in 2010 for his contributions to climate change and food security science. He was a coordinating lead author on the Intergovernmental Panel on Climate Change for its 1999-2001 and 2005-2007 reports, having been nominated by the White House Office of Science and Technology Policy.

Dr. Rick Murray, Division Director, Ocean Sciences, National Science Foundation – Rick Murray is Division Director, Ocean Sciences, at the National Science Foundation, on a four-year IPA position beginning January, 2015. Murray is a Professor of Earth and Environment at Boston University (BU), where he has been located since 1992. He was the Director of the BU Marine Program from 2006-2009 and served as Chair of the Department of Earth Sciences from 2000-2005. After receiving his Ph.D. from the University of California at Berkeley, he was a post-doctoral scholar at the Graduate School of Oceanography (University of Rhode Island). Murray's research interests are in marine geochemistry, with an emphasis on sedimentary chemical records of climate change, as well as modern oceanographic processes in the tropics. He has authored or co-authored over 70 peer-reviewed scientific research papers. Murray's research funding has been provided by the National Science Foundation, the Ocean Drilling Program and Integrated Ocean Drilling Program (IODP), the U. S. Geological Survey, and other agencies. Murray is a Fellow of the Geological Society of America, a former Trustee of the Sea Education Association (resigning upon accepting the NSF position) and helped initiate and manage the Link Foundation's Ph.D. Fellowship Program in "Ocean Engineering and Instrumentation". As a seagoing oceanographer, he has participated on many research cruises in various capacities, including Co-Chief Scientist on the "Asian Monsoon" IODP expedition and

Chief Scientist on the last full research cruise of the *R/V Knorr*. Rick Murray is a resident of the coastal community of Scituate, Massachusetts, where he has lived since 1998. He was an elected Selectman from 2006-2014 (a position he resigned upon accepting the NSF position), and served as Chair, Vice-Chair, and Clerk of the Board of Selectmen at various times. In his capacity as Selectman, Murray took a special interest in coastal issues, worked closely with stakeholders from the coastal community, and also addressed commercial fishing, media relations and outreach.

Mr. Kolo Rathburn, Professional Staff, Senate Appropriations Subcommittee on Commerce, Justice, and Science -- Charles Kolo Rathburn is a Professional Staff Member -- Majority for Senate's Committee on Appropriations on the Commerce, Justice and Science subcommittee under the leadership of Senator Richard Shelby. His portfolio includes the Department of Commerce and related trade and science agencies including the National Oceanic and Atmospheric Administration (NOAA). Prior to serving on the Appropriations Committee, Mr. Rathburn was a Legislative Assistant to Senator Roger Wicker from 2011 to 2013. In 2010, Mr. Rathburn was a Sea Grant Legislative Fellow in Senator Wicker's office. Mr. Rathburn received an M.S. in Marine Biology from the College of Charleston in 2009.

Dr. Ari Patrinos, Chief Scientist, Director of Research and Chair of the Science Advisory Board at Novim – Dr. Patrinos was previously Deputy Director, Research, NYU Center For Urban Science & Progress, Brooklyn, NY. Prior to that, he was President of Synthetic Genomics Inc., and Director of the Office of Biological and Environmental Research in the Department of Energy's Office of Science, where he oversaw human and microbial genome research, structural biology, nuclear medicine and health effects and global climate change. He is well known for his leading roles in the development of the U.S. Global Change Research Program and the U.S. Human Genome Project. In addition, Dr. Patrinos helped create the Joint Genome Institute and developed and launched the Genomes to Life Program, a research program dedicated to developing technologies to use microbes for innovative solutions to energy and environmental challenges. He received his undergraduate degree from the National Technical University of Athens, and Ph.D from Northwestern University.

Mr. Kei Koizumi, Visiting Scholar, American Association for the Advancement of Science and Co-Author for *Warning Signs – American Climate and Environmental Research and Policy at the Crossroads* -- Kei Koizumi, former assistant director for federal research and development at the White House OSTP, has also recently joined AAAS as a visiting scholar. He served in the White House for the entirety of the Obama administration. Before joining OSTP, Koizumi served as the director of AAAS' Research & Development Budget and Policy Program. He was also named a AAAS Fellow, an honor that the organization bestows upon members who have made significant efforts to advance science or its applications. During his term as a visiting scholar, Koizumi will work to enhance the capacity of the community to bring together science and public policy and the public in interesting ways. He would also like to help build relationships between universities and non-profit organizations in the broader science community. During his term, Koizumi will work with multiple departments within AAAS, including the Executive Office, the Office of Government Relations and Center of Science, Policy, and Society Programs.

RADL Timothy Gallaudet, Deputy Administrator, National Oceanic and Atmospheric Administration -- Timothy Gallaudet, Ph.D., was confirmed by the U.S. Senate on October 5, 2017, as the assistant secretary of commerce for oceans and atmosphere for the Department of Commerce in the National Oceanic and Atmospheric Administration. Dr. Gallaudet was previously a rear admiral in the U.S. Navy, where his most recent assignment was Oceanographer of the Navy and Commander of the Navy Meteorology and Oceanography Command. During his 32 years of military service, Dr. Gallaudet has had experience in weather and ocean forecasting, hydrographic surveying, developing policy and plans to counter illegal, unregulated and unreported fishing, and assessing the national security impacts of climate change. He has led teams of Navy sailors and civilians performing such diverse functions as overseeing aircraft carrier combat operations, planning and conducting humanitarian assistance and disaster response efforts, assisting Navy SEAL Teams during high visibility counter-terrorism operations, and developing the Navy's annual $52 billion information technology, cyber security and intelligence budget. Dr. Gallaudet holds a bachelor's degree from the U.S. Naval Academy and master's and doctoral degrees from Scripps Institution of Oceanography, all in oceanography.

Dr. Jonathan Pennock, Director, National Sea Grant College Program, National Oceanic and Atmospheric Administration – In 2016, Dr. Pennock was named as the Director of the National Sea Grant College Program. Prior to coming to NOAA to serve as Sea Grant Director, Dr. Pennock served as the head of the New Hampshire Sea Grant Program for 10 years. Dr. Pennock has been the deputy director of the School of Marine Science and Ocean Engineering at the University of New Hampshire. While there he was also an active member of the National Association of Marine Laboratories (NAML). He previously worked with both the Delaware and Mississippi-Alabama Sea Grant programs, served as president of the National Sea Grant Association, and served on the NOAA Research's Senior Research Council as the SGA representative. While earning a bachelor's in biology from Earlham College in Indiana, he did a semester of study on the west coast of Florida. He received a master's in marine studies and a Ph.D. in oceanography from the University of Delaware. His connection and appreciation of Sea Grant goes back to his graduate school days when he received Sea Grant support for his doctoral research on how estuaries are affected by nutrient runoff from our land use.

Dr. James Hurley, President, Sea Grant Association and Director, Wisconsin Sea Grant -- Dr. James Hurley serves as the President of the Sea Grant Association for the 2017 to 2018 term. The Sea Grant Association (SGA) is a non-profit organization dedicated to furthering the Sea Grant program concept. The SGA's regular members are the academic institutions that participate in the National Sea Grant College Program. SGA provides the mechanism for these institutions to coordinate their activities, to set program priorities at both the regional and national level, and to provide a unified voice for these institutions on issues of importance to the oceans and coasts. The SGA advocates for greater understanding, use, and conservation of marine, coastal and Great Lakes resources. By day Dr. Hurley is director of the University of Wisconsin (UW) Aquatic Sciences Center, which houses the UW Sea Grant Institute and the UW Water Resources Institute. Both programs are federal-state partnerships which support research, outreach and education in support of sustainable uses of the state's natural resources. He is an Associate Professor of Civil and Environmental Engineering at UW, Madison and chair of the Environmental Chemistry and Technology Program. Dr. Hurley's recent research has

centered on cycling of mercury in the aquatic environment. His past research has also focused on natural organic compounds in lakes and rivers. He is particularly interested in developing research projects that build on our experiences studying natural aquatic pigments (chlorophyll, carotenoids and other accessory pigments) and gaining better insight into processes responsible for production of key algal toxins in Wisconsin waters.

Dr. Amber Mace, Chair, National Sea Grant Review Board, Deputy Director of the California Council on Science and Technology -- Amber Mace, PhD is Deputy Director of the California Council on Science and Technology (CCST) and is a Policy Fellow with the UC Davis Policy Institute for Energy, Environment and the Economy. Mace devotes her time to building new and revitalizing existing programs and organizations that are dedicated to increasing the impact and value of science-informed decision-making. Prior to this, Mace served as the Associate Director of the UC Davis Policy Institute for Energy, Environment and the Economy. She also served as the executive director of the California Ocean Protection Council (OPC) and assistant secretary for coastal matters at the California Natural Resources Agency. In this role she applied her background in ocean policy and marine ecology and collaborative leadership skills to guide the state in developing policies that promote the sustainable use of California's ocean ecosystem. Prior to that, she served in the dual roles of science advisor to the OPC and executive director of the California Ocean Science Trust, a non-profit whose mission is to provide objective, high-quality science to decision makers. She learned firsthand about the challenges of public policy-making at the federal level as a Knauss Fellow in the U.S. Senate Commerce, Science and Transportation Committee, and at the state level as a California Sea Grant state fellow at the California Natural Resources Agency. Amber was recognized as a Coastal Hero by Sunset magazine in 2011 and her California coastal research experience includes piloting a submersible with the Sustainable Seas Expedition. She earned a bachelor of arts in geography from UC Berkeley and a doctorate in ecology from UC Davis and the Bodega Marine Laboratory.

Mr. Jennifer Poulakidas, Vice President for Government Affairs, Association of Public & Land Grant Universities (APLU) -- Jennifer Poulakidas joined APLU in 2006 as Vice President for Congressional and Governmental Affairs. In this role, she works closely with the leadership of APLU's more than 230 member universities to promote public higher education's positions to Congress and the Executive Branch on science and research, student affordability and access, innovation and competitiveness, and internationalization, among other issues of importance to major public universities. Before APLU, Poulakidas was legislative director for science at the University of California's Washington, DC office. During her 11 years with UC, she enjoyed active engagement with the federal science and research advocacy community. A San Francisco native, her career in Washington began on Capitol Hill where she served her hometown as an aide to Congresswoman Nancy Pelosi. Jennifer received a B.A. in Sociology from UCLA and an MPA from the University of Texas at Austin's LBJ School of Public Affairs.

Ms. Ellyn Perrone, Senior Associate Vice President for Research, University of Texas -- R. Ellyn Perrone was joined the University of Texas as associate vice president for research at the University of Texas in 2005. She focuses on raising the university's national research profile and increasing funding from federal agencies and Congress. Ms. Perrone is UT's liaison among university researchers, the U.S. Congress and state and federal agencies and conduct strategic program development planning to enhance research. She works closely with the University of

Texas System Federal Relations Office and The University of Texas at Austin's Office of the Vice President for Institutional Relations and Legal Affairs. Ms. Perrone had been vice president for government relations at Ohio State University where she coordinated all aspects of the university's relationship with federal, state and local government officials, representatives and agencies. She was formerly the vice president for governmental affairs at Texas A&M University. Ms. Perrone represents the university on several national organizations, including the American Association of Universities Council of Federal Relations and the Science Coalition.
She is a native of Bryan, Texas and received her undergraduate degree from Stephen F. Austin University. She earned a master's degree in public administration from Texas AandM University.

Mr. Brent Burns, Director of Federal and Industry Relations, Michigan Technological University -- Mr. Burns leads the University's federal relations efforts, working with elected officials and leaders in Washington D.C. to advocate for the University's interests in both education and research. Brent Burns also serves as the primary point of contact for any general or strategic industry inquiries and is responsible for leading the connection of the interests from companies with appropriate campus initiatives/constituents. Prior to Michigan Tech, he served as a Systems Engineer for General Dynamics Land Systems and has a B.S. in Mechanical Engineering from Michigan Tech, Masters of Engineering from the University of Wisconsin-Madison, and is currently pursuing his PhD in Environmental and Energy Policy from Michigan Tech.

Ms. Gabrielle Serra, Director, Federal Relations, Oregon State University -- Gabrielle Serra joined Oregon State University's Government Relations team in Fall of 2014 to serve as Director of Federal Affairs. In her role, Gabrielle works with the Administration and federal agencies, federal legislators, as well as national partner organizations. Her focus is to engage federal policy makers and program officials on issues and opportunities important to the success and potential of OSU and our community, including priorities ranging from student access, fundamental and applied research, to outreach and extension. Gabrielle began her career with the U.S. Department of Agriculture where she served for nearly 7 years in several capacities related to federal food and nutrition policy. Gabrielle then went to the House of Representatives where she served for the 111th Congress as a policy advisor to the Chairman of the Committee on Education and Labor. During this time, Gabrielle oversaw the development and enactment of comprehensive legislation authorizing the federal child nutrition programs. And, after leaving the Hill, Gabrielle oversaw federal government relations for a national non-profit organization focused on public health. Originally from Florence, Oregon, Gabrielle graduated from OSU in 2003 with a degree in public health. She holds a master's degree in food policy and economics from Tufts University, the Friedman School of Nutrition Science and Policy.

Suggested Questions to Raise with NAML Speaker and Panelists

Dr. William Easterling, Assistant Director for Geosciences
Accompanied by Dr. Rick Murray, National Science Foundation

Without a Presidential Science Advisor, describe the day to day relationship NSF and the other agencies have with OSTP. For months the interagency Subcommittee on Ocean Science and Technology has been working on a new plan for Federal priorities in the ocean sciences. What can you tell us about that forthcoming plan? When can the community expect to have a chance to review and comment upon it?

Please describe the key priorities the Directorate for Geosciences will be pursuing during your tenure at Assistant Director for Geosciences? How have those priorities been impacted by the new budget agreement and the additional $2.2 billion the Administration is proposing for NSF that would bring the NSF budget back up to the FY 2017 level. How will the Geosciences and particularly the core research programs in GEO benefit from the proposal? Can we expect to see funding for the core ocean sciences and other related programs benefit from that significant budget adjustment?

When the NAS released *Sea Change,* we learned from that report that marine laboratories were classified as either a *critical* or *important* for the research prioritized by the Decadal Survey (page 68 of *Sea Change*). What recommendations would you have for our community to maximize the role envisioned for marine labs in *Sea Change*? In particular, given the recommendations contained in *Sea Change*, how does the ocean sciences benefit from the additional $2.2 billion added back by the Administrations as the FY 2019 budget was released?

We were delighted to see that the Administration decided to provide NSF with an additional $2.2 billion at the last minute to bring the NSF budget back up to the FY 2017. We also understand the Foundation is looking to move ahead with some of the Big Ideas with one being the Future of Work at the Human-Technology Frontier and the other being Harnessing Data for the 21st Century. In what ways with the Geosciences participate in these two Big Ideas and how will the funding for the Big Ideas impact the core of NSF's research and education programs.

There are two other Big Ideas contained in the NSF plan relevant for NAML and some of our members – mid scale infrastructure and the arctic. How does the FY 2019 address these initiatives and at what cost will these big ideas come to base programs important to the NAML membership?

NAML has been discussing with COL the possibility of holding some kind of public roundtable event with the leaders of SOST to discuss the forthcoming SOST plan for federal ocean sciences. Of course, we don't yet know when that report will be released nor what it will propose, but in principle, how do you want to involve the community with respect to that forthcoming plan?

Mr. Kolo Rathburn, Professional Staff Member,
Senate Appropriations Subcommittee on Commerce-Science-Justice

Can you give us a sense of the FY 2019 budget constraints the Congress will be confronting and how those pressures may impact the research and education programs important to NAML?

What does the new budget agreement for FY 2019 non-defense spending mean for the CJS subcommittee and the ocean and coastal programs under your jurisdiction?

Can you give us any advice as how NAML can effectively interact and educate new decision makers on both ends of Pennsylvania Avenue?

Can you give us advice as what NAML can do to help Chairman Shelby and the CJS Subcommittee maintain strong support for research and education?

How can we go about increasing bipartisan support for the ocean, coastal and Great Lakes enterprise and what can NAML members do to expand awareness of and support for ocean research and education?

What is the likelihood that an infrastructure initiative will include research infrastructure such as rehabbing research facilities and or cyber infrastructure to support research and education? What role will your subcommittee play in any infrastructure initiative?

Dr. Ari Patrinos and Mr. Kei Koizumi
***Warning Signs* – American Climate and Environmental Research and Policy at the Crossroads**

What has been the reaction from the science community so far to this report?

As you said during the presentation, the report was based on the FY18 request – one that is one its way of being nearly ignored by the Congress.

How would you like the community – such as the one represented by the members of NAML – to make use of the report?

What is the message and rationale being conveyed by this report?

Will Novim be regularly reporting on federal support for environmental science?

Do you anticipate Novim getting involved in commenting on the Administration's long expected report in which the authors of the report are billing the report as a road map for federal ocean science priorities. Will that be something Novi might consider commenting upon?

How does Novim go about selecting issues to focus upon? What was the driving factor that led to Warning Signs?

How will you go about continuing to educate policy makers when this report focuses on FY 2018 and we are now in the thick of the FY 2019 process?

RDML Timothy Gallaudet, Assistant Secretary of Commerce for Oceans and Atmosphere and Acting Under Secretary of Commerce for Oceans and Atmosphere

Both the Department of Commerce and NOAA make aquaculture a key priority. At the same time, the Administration is proposing to eliminate the Sea Grant program and its nearly $10 million extramural competitive merit-based research effort in marine aquaculture – despite the fact that Sea Grant proactively developed nearly two years ago a ten-year vision for the role of Sea Grant in aquaculture research. We also see the aquaculture program in NMFS is level funded. How does that square with aquaculture being an Administration priority? Why is the Administration eliminating Sea Grant and in particular its cost-shared highly leveraged marine aquaculture research program? Does the elimination of the Sea Grant program also eliminate the Knauss program? How many former Knauss fellows are now working in NOAA and elsewhere in the ocean/coastal enterprise? Has the Knauss program been successful?

In addition to Sea Grant, aquaculture research and the Knauss program, the NOAA budget proposes substantial reductions in many other extramural ocean, coastal, and Great Lakes programs such as the Prescott program, NOAA education programs, arctic research, coastal resilience grants, and NERRS. On top of that, NOAA is seeking authority (see p. Exhibit 32-1 of the Department of Commerce, National Oceanic and Atmospheric Administration Justification of Estimates to the Committees on Appropriations) "to… receive and expend funds made available on a consensual basis from... any…international or intergovernmental organization, public or private organization, or individual…" This would exacerbate a problem created by the proposed termination of many NOAA extramural programs by enabling NOAA to compete against many of the lab directors in this room for scarce non-federal and private sector support. Can you help us understand NOAA's rationale for these program and policy proposals?

NAML is strongly supportive of NOAA and the critical partnership role it plays in providing valuable environmental information that enables marine labs to conduct research and carryout vital education activities in the coastal areas where we are located. NAML members want very much to be active supporters of NOAA as we communicate with our local elected officials. NAML weighed in early with key Senators in support of both your nomination and that of Mr. Myers to be NOAA Administrator and we intend to continue to be strong active supporters of NOAA. Wouldn't you agree, however, that NOAA makes our job harder by the nature of the ocean and coastal proposals in the FY 2019 budget request? How can NAML be helpful to NOAA in making the case to decision makers on both ends of Pennsylvania Avenue?

With the new budget agreement in place for FY 2019 should we expect NOAA will be working with the Congress under these increased spending levels to re-visit the budget request and should we expect those discussions will bode well for extramural ocean, coastal, and Great Lakes programs?

According to the FY19 budget request, NOAA is seeking a total of $450 million for R&D (see p R&D-1 of the Department of Commerce, National Oceanic and Atmospheric Administration Justification of Estimates to the Committees on Appropriations). How does this compare with FY 2017? And can you give us a sense of the portion of this R&D total that will support extramural activities such as those carried out by NAML labs?

Future of the Sea Grant Program
Dr. Jonathan Pennock, Director, National Sea Grant College Program
Dr. James Hurley, President, Sea Grant Association
Dr. Amber Mace, Chair, National Sea Grant Advisory Board

What actions will SGA be taking to reverse the Administration's proposal to terminate Sea Grant?

Does the proposal to terminate Sea Grant also terminate the Knauss program?

Sea Grant has been particularly focused at collecting data to demonstrate the impact of the program at the state, local and regional level. How has that date been used and what sort of impact has such data (on job created, acres of wetlands restored, etc.) had on decision makers in leadership positions in NOAA, in DOC, and in OMB?

Can you talk a bit about SGA's success at building and maintain the considerable bipartisan support the Sea Grant program enjoys?

Dr. Mace, can you describe the role the advisory board plays with respect to interacting with the NOAA leadership and Commerce Department Leadership?

The biennial report published by the National Advisory Board often contains very useful information on the contributions made by the Sea Grant program. How is that report used and disseminated?

With Admiral Gallaudet on board and Mr. Myers' nomination still awaiting Senate approval, a number of key policy officials have been appointed to serve in the Office of the Administrator. Many of these policy officials have close ties to Sea Grant. How do you expect those pre-existing relationships to impact on the furfure of the Sea Grant program?

Can you talk about how Sea Grant works with the other programs within NOAA and more generally with your stakeholders at the state and local levels?

Does Sea Grant participate in the Coastal Roundtable often chaired or convened by NOS leadership? Does OAR participate in the Coastal Roundtable?

What suggestions to you have for NAML so that we might engage effectively and in support of Sea Grant with our locally elected officials? What message do you wish us to carry?

University Federal Relations and NAML Labs
Moderator Ms. Jennifer Poulakidas, APLU;
Ms. Ellyn Perrone, University of Texas;
Mr. Brent Burns, Michigan Technological University;
Ms. Gabrielle Serra, Oregon State University

As you may know, NAML is an association of approximately 100 marine and Great Lakes laboratories. Many of us, but not all, are associated with universities. Some of us constitute a campus within our university systems. Can you give us some suggestions that would enable us to have productive relationships with our university's or college's federal relations or external relations office?

Can you give us some insight into how universities develop their own set of public policy priorities? Do you each primarily represent the President or Chancellor when you are here in Washington?

How does the senior leadership at your respective institutions set priorities for federal relations -- is it done annually or as part of some overall strategic planning process? Is it reactive to the proposals coming from the Administration and/or federal agencies?

Given the way the agenda or priorities are developed on your respective campuses, what advice would have for us lab directors as to the best way to our message incorporated into the university's agenda? Are there certain universal "do's" and "don'ts" that we should know about?

What information can we provide you and your counterparts that would help you help us?

Jennifer – this one is for you specifically – APLU has its Board on Ocean, Atmosphere, and Climate or BOAC. Is that a forum that would be friendly towards NAML's interests in ocean, coastal, and Great Lakes research and education? Can you talk a bit about BOAC and how it fits into the overall APLU advocacy structure?

Jonathan W. White, RADM (Ret.), USN
President and CEO
Consortium for Ocean Leadership

On behalf of all the Members of NAML, we would like to thank you and your members for the invitation for NAML to be an associate member of the Consortium for Ocean Leadership. You should know that yesterday in the NAML business meeting, we approved a similar membership for COL within NAML. We look forward to strengthening our collaborative activities to more effectively support ocean sciences research and education. We know there has been a very preliminary discussion with your staff about a joint COL/NAML roundtable meeting with the leaders of SOST to discuss and comment on the forthcoming federal ocean sciences priorities update report. What is your view about such a joint event? Is that something your members would consider a valuable service provided by COL for its members and the community?

In light of the Administration's FY 2019 budget request for NOAA, NSF, ONR etc – what is your view on the requests? Is COL concerned that the so called "Addendum" document failed to include NOAA, DOI, EPA, etc? What efforts will COL be making in the coming weeks and months to inform policy makers of your members' views? Are there ways NAML could help amplify that message?

Earlier today we heard from Acting NOAA Administrator Tim Gallaudet. We expressed our concerns regarding the reductions and terminations NOAA is proposing for extramural ocean, coastal, and Great Lakes science, education, and conservation programs. We talked with him about the proposal to terminate Sea Grant and along with that is the termination of the Knauss program. What is COL's view on such proposals and what actions will you and your members be taking?

February 26, 2018

Honorable John Culberson
Chairman
Subcommittee on Commerce, Justice, and Science
Committee on Appropriations
House of Representatives
Washington, D.C. 20515

Honorable Richard Shelby
Chairman
Subcommittee on Commerce, Justice and Science
Committee on Appropriations
United States Senate
Washington, D.C. 20510

Honorable Jose Serrano
Ranking Minority Member
Subcommittee on Commerce, Justice, and Science
Committee on Appropriations
House of Representatives
Washington, D.C. 20515

Honorable Jeanne Shaheen
Ranking Minority Member
Subcommittee on Commerce, Justice and Science
Committee on Appropriations
United States Senate
Washington, D.C. 20510

Dear Chairman Culberson, Chairman Shelby, Ranking Member Serrano, and Ranking Member Shaheen:

Much of the Federal extramural nondefense, non-biomedical support for research and education is provided by these Subcommittees. Within that overarching enterprise, the Subcommittees are uniquely responsible for the health and vitality of our ocean, coastal, and Great Lakes enterprise through your support for NSF, NOAA, and NASA. In so doing, the Subcommittees are positioned to impact the Nation's economic growth, national security, and public safety by your decisions to support research and education and training. Year after year, under your leadership these Subcommittees have generously embraced that challenge and for that the National Association of Marine Laboratories (NAML) is deeply grateful.

Now that a new budget agreement is in place that provides additional resources for nondefense spending for FY 2018 and FY 2019 and as House and Senate conferees move to resolve their differences within the FY 2018 Commerce-Justice-Science Appropriations Bill, NAML would like to urge your maximum support for the ocean, coastal, and Great Lakes research and education programs under the jurisdiction of this Subcommittee as outlined below.

The ocean, coastal, and Great Lakes network of NAML laboratories, is a vital part of the nation's research and education enterprise. That enterprise is a critical contributor to the economic and environmental health of the nation. The nation is faced with a widening gap between the actual level of federal funding for research and education and the required investment to sustain the U.S. as the world's leader in innovation. Accordingly, NAML urges the Conferees to take the following actions:

- Conferees should build on the Federal investment in research to develop the knowledge, people, and technologies that power the ocean and coastal economies, create jobs, improve health, strengthen our national security, and support the U.S. as the global innovation leader. Some of key programs that support this goal include:

- *NSF funding for research, training, infrastructure, and education much of which is supported by the Directorates for Geosciences and Biological Sciences;*
- *Extramural funding provided by NOAA including funding the National Sea Grant College Program at $80 million, marine aquaculture NOAA's cooperative institutes related to ocean, coastal and Great Lakes issues, and restoration of the Prescott Marine Mammal Rescue Assistance Grant Program;*
- *NOAA National Estuarine Research Reserves at $27 million in FY 2018 and National Centers for Coastal Ocean Science; and*
- *NASA Earth Sciences.*

- This investment should include ocean observations, data integration, and related cyber and physical infrastructure; monitoring, research, and response to changing environmental conditions such as:

  - *NSF's Field Stations and Marine Laboratories (FSML) at $6 million;*
  - *NOAA Integrated Ocean Observing System program at $43 million;*
  - *Research and Monitoring for Ocean Acidification; and*
  - *NSF's Long Term Ecological Research program and HBCU Research Infrastructure for Science and Engineering (RISE)*

- Renew the commitment to improve the quality of STEM education and re-energize efforts to attract, recruit, support, and retain women, minorities and others not currently well represented in the science and technology workforce through the following programs:

  - *NSF's Research Experiences for Undergraduates (REU), its Alliances for Minority Participation, the graduate and post graduate fellowship programs at NSF, NOAA, and NASA; and*
  - *Reject the Administration's proposal to terminate the NOAA and NASA Offices of Education*

These time-tested programs, that support the extramural research and education community via competitive, merit-based research, provide cost-effective impressive returns on investment, leverage additional resources to meet science and management priorities, and distribute economic and societal benefits over a broad array of communities. With new spending guidelines in place, we hope the Subcommittees will continue to be the leading voice for the health of the Nation's research enterprise via the decisions it makes in finalizing the FY 2018 Commerce-Justice-Science Appropriations Act.

NAML is grateful for the opportunity to provide this information to the Subcommittees.

Sincerely,

Robert K. Cowen
President
National Association of Marine Laboratories

FEB 21, 2018 DRAFT

NATIONAL ASSOCIATION OF MARINE LABORATORIES – FY 2019 PUBLIC POLICY AGENDA

The National Association of Marine Laboratories (NAML) advocates for the importance of marine and freshwater science and education to America's health, security and productivity. Drawing from the NAML membership and the broader scientific community perspectives contained in two important reports from the National Academies, *Sea Change: 2015-2025 Decadal Survey of Ocean Sciences*; and *Enhancing the Value and Sustainability of Field Stations and Marine Laboratories in the 21st Century*, NAML's public policy objectives for FY 2019 are:

- To champion the national value of marine and Great Lakes research, monitoring, education, and outreach;
- To advocate for robust merit-based federal funding programs to address societal needs, and;
- To enhance the capabilities and networking of marine and Great Lakes laboratories to serve the Nation's needs thoroughly and efficiently.

The Value of Marine and Great Lakes Laboratories in America's Research and Education Enterprise

The national network of Marine and Great Lakes science laboratories are vital national assets. Their geographic reach includes estuaries, the coastal zone, the Great Lakes and inland watersheds, all the oceans of the world including polar regions, and the sea floor. They connect scientists, students, public and civic leaders with leading edge science, environmental intelligence, and professional training that contributes to the management and stewardship of our oceans, coastal zones and Great Lakes. NAML institutions share common mission elements and broad expertise:

- To produce and assimilate knowledge of world oceans, coastal zones, Great Lakes and watersheds;
- To train future generations of marine and freshwater scientists, resource managers, and civic leaders;
- To inspire public and civic understanding and stewardship of marine and freshwater resources; and
- To inform preservation, restoration, management and utilization of marine and freshwater resources.

The intersection of ocean, coastal zone and Great Lakes natural resources and U.S. economic activity is complex and highly interdependent. The U.S. depends on healthy marine and freshwater resources, yet many economic activities have the potential to damage these resources, putting jobs, wages and gross domestic product (as well as human health and well-being) at risk. Marine Laboratories operate at this interface of human socioeconomics and the natural aquatic world. They provide access to the full spectrum of marine and Great Lakes habitats. Often affiliated with universities, marine laboratories are research, monitoring and placed-based teaching platforms that support faculty scientists, graduate and undergraduate students, and public/civic outreach activities to promote stewardship and informed environmental and business management practices. Programs such as NSF's ocean, earth, polar, and biological research programs, NOAA's ocean and coastal programs, Sea Grant, EPA's Wetlands, Oceans and Watersheds, and other mission agency programs rely on marine and Great Lakes laboratories to contribute access, knowledge, data, and technologies to help improve management of these natural assets and sustain their development as socioeconomic drivers.

Marine and Great Lakes science laboratories play a vital role in the decadal science priority themes identified in *Sea Change: 2015-2025 Decadal Survey of Ocean Sciences*. They are *critical* or *important* for several of the priority questions, including studies of coastal food webs, ecosystem biodiversity, and human impacts on coastal environments. NSF support of field stations and marine laboratories has provided much-needed infrastructure and capital improvements that have enhanced the quality of scientific research and engagement with the public. Recent efforts by NSF to promote networking and data sharing among field laboratories will provide further opportunities for research and education. *Sea Change* identifies marine and Great Lakes laboratories as having a high degree of relevance towards priority research questions with lower costs than other marine infrastructure.

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The Economic Value of Our Oceans, Coasts, and the Great Lakes

The economic productivity and security of the U.S. is dependent on coastal, ocean and Great Lakes natural resources:

- Fourteen percent of U.S. coastal counties produce 45% of the nation's gross domestic product (GDP), with close to one in 45 jobs directly dependent on the resources of the oceans and Great Lakes;
- In 2014, six economic sectors that depend on the ocean and Great Lakes, the ocean economy, contributed more than $352 billion to the U.S. GDP and supported 3.1 million jobs; and
- Offshore mineral extraction represents 43%, and tourism and recreation account for 31%, of the ocean economy contributions to GDP. Tourism and recreation account for 72% of the ocean economy jobs.

The oceans are a primary source of food for over one billion people; a globally significant regulator of the earth's weather and climate; the basic source of water for the hydrologic cycle; a cleaning agent that absorbs carbon dioxide and generates oxygen; and home to thousands of flora and fauna, many with pharmaceutical value. A wide gulf often separates science from the people who need it to protect and support them.

The ocean and coastal economy depends on science and technology that can meet critical, fast-rising needs across many sectors of society. In 2014, the ocean economy employed more people in the U.S. than the telecommunications, crop production, and building construction industries combined. Additionally, if the nation's coastal counties were considered an individual country, they would rank number three in global GDP, behind only the U.S. and China. The Great Lakes alone generated nearly $5 trillion in economic output or about 30% of combined U.S. and Canadian economic production.

The United States is the leading global importer of fish and fishery products, with 91% of the seafood we eat originating abroad – half of which is from aquaculture. Driven by imports, the U.S. seafood trade deficit grew to over $14 billion in 2016. NAML entities are leaders in developing and supporting innovative methods that will improve and encourage sustainable U.S. aquaculture products that complement, not compete with, existing US commercial fisheries. Additionally, the U.S. marine transportation system is an essential driver of the U.S. economy and its impact reaches into the heartland of the nation. America's seaports are crucial generators of economic development and well-paying jobs, regionally and nationally, throughout all supply chains that use the ports. Long-term sustainability of such critical ocean-front infrastructure in the wake of shifting - and dynamic - environmental conditions is a key concern addressed by marine laboratories, which themselves typically share the same geographic proximity to the water.

U.S. Leadership in Science and Technology

Innovation builds new knowledge and technology, contributes to national competitiveness, improves living standards, and furthers social well-being. Research and development (R&D) is a major driver of innovation and R&D expenditures reflect a nation's commitment to expanding capabilities in Science & Engineering (S&E), which in turn drives innovation. On January 18, the National Science Board released the biennial *Science and Engineering Indicators 2018*. The report finds that the world's nations are continuing to accelerate the growth of their technology-intensive economies. It documents how the S&E landscape — historically concentrated in the U.S., Europe, and Japan — is rapidly shifting as China and other countries continue to increase their R&D investments. It also makes clear that while the U.S. remains the global leader in many S&E measures, China has continued its rapid rise in the rankings.

Global R&D expenditures have more than doubled since 2005, growing at an average rate between 6.3 and 7 % per year. The U.S. remains the world leader in overall R&D spending, growing an average of 4% per year between 2000 and 2015. However, Asian economies surpassed both the U.S. and Europe as having the largest concentration of R&D spending, rising from 25% of the global share in 2000 to 40% in 2015. China has seen by far the largest R&D growth, accounting for almost one-third of the global increase over that period, reaching 21% of the global total in

2015 and an average growth rate of 18% per year. At the same time, North America and Europe saw their global shares decrease to 28% and 22%, respectively.

The rapid growth of S&E economies in China and other Asian countries also contrasts with the relative stagnation in U.S. R&D intensity - a measure of R&D expenditure as a percentage of GDP. Although U.S. R&D intensity has stayed relatively stable, hovering near 2.7% in recent years, it dropped in global ranking from eighth place in 2009 to eleventh place in 2015. Meanwhile, China and South Korea's R&D intensities have doubled since 2000. *Indicators* notes that while federal R&D funding has generally increased annually since the 1950s, the government's share of total U.S. R&D spending has steadily declined, reaching a historic low of 24% in 2015 – far below the peak of 67% in 1964.

In science, technology, engineering, and mathematics (STEM) education, China has more than quadrupled the number of S&E degrees conferred since 2000, where they comprise nearly half of all bachelor's degrees awarded in China. The number of S&E bachelor's degrees in China increased from 359,000 in 2000 to 1.65 million in 2014. At the same time, U.S. S&E bachelor's degrees, which comprise one-third of U.S. bachelor's degrees awarded, increased from 400,000 in 2000 to 650,000 in 2015. The U.S. remains the world leader in the production of S&E doctoral degrees, however, awarding 40,000 in 2014. China is close on the heels of the U.S., having rapidly increased production of S&E doctoral degrees from 8,000 in 2000 to 34,000 in 2014. In 2007, China surpassed the U.S. as the largest producer doctoral degrees in the natural sciences and engineering.

Another indicator tracked the growth of academic R&D expenditures by technical field. The average annual growth rate for *the geosciences* in the U.S. from 1997 to 2006 was 3.8%. From 2007 to 2016 it was just 0.1%, *the lowest growth rate of all assessed fields.* By comparison, engineering grew 3.2% from 2007 to 2016, down 4.8% from 1997 to 2006. Women in 2015 constituted just 28% of U.S. workers in S&E occupations. For the category of Earth scientists, geologists, and oceanographers, the number was 22.7%, and for physicists and astronomers, it was 18.4%.

Priority Ocean Science Questions with Significant Societal Impact

Marine and Great Lakes science laboratories play a vital role in the decadal science priority themes identified in *Sea Change*. They are *critical* or *important* for several of the priority questions, including studies of coastal food webs, ecosystem biodiversity, and human impacts on coastal environments. The overarching critical research questions in *Sea Change* are:

- What are the rates, mechanisms, impacts, and geographic variability of sea level change?
- How are the coastal and estuarine ocean and their ecosystems influenced by the global hydrologic cycle, land use, and upwelling from the deep ocean?
- How have ocean biogeochemical and physical processes contributed to today's climate and its variability, and how will these systems change over the next century? How does the changing atmosphere affect the chemical stability of the ocean resources (e.g. increasing ocean acidification)
- What is the role of biodiversity in the resilience of marine ecosystems and how will it be affected by natural and anthropogenic changes?
- How different will marine food webs be at mid-century? In the next 100 years?
- What are the processes that control the formation and evolution of ocean basins?
- How can risk be better characterized and the ability to forecast geohazards like mega-earthquakes, tsunamis, undersea landslides, and volcanic eruptions be improved?
- What is the geophysical, chemical, and biological character of the sub-seafloor environment and how does it affect global elemental cycles and understanding of the origin and evolution of life?

Based on questions posed in *Sea Change* and other pressing ocean science needs, NAML members have identified the following priorities for advancing scientific discovery and providing critical science-based guidance addressing societal needs, economic development, and national security:

- **Increase comprehensive understanding of:**
  - Living marine and Great Lakes ecosystems, derived services, resilience, and vulnerabilities in coupled and uncoupled social and ecological systems;
  - Watershed, sediment, and nutrient flows and impacts on coastal ecology and habitats;
  - Climate and sea level change to inform risk management of critical infrastructure along U.S. coastlines;
  - Biogeochemical and physicochemical contributions to climate change, variability, and implications for equilibrium of aquatic systems (e.g. ocean acidification);
  - Deep-ocean and sub-seafloor biogeochemical, physicochemical, and biological connectivity to in-shore ecosystems, cycles, and resource services (e.g. energy extraction);
  - Ocean and coastal circulation patterns to understand physical and biological systems connectivity and implications for defense and technology development;
  - Marine and Great Lakes biodiversity, genetics and "nanotechnology" to support advances in biomedical science and pharmaceutical development, understand ecological aspects of disease occurrence/prevalence, and identify human health implications.

- **Develop and implement:**
  - Selection of aquatic species, technologies and methods for off-shore and shore-based aquaculture systems to increase domestic protein sources and enhance natural marine stocks in decline;
  - Advanced physical, chemical, biological, and socioeconomic data gathering technologies to improve monitoring;
  - Networking and integration of existing and future data/information collections from monitoring programs;
  - Improved holistic modeling of marine ecosystems to inform status and trends and adaptive management to sustain services, e.g. U.S. commercial and recreational fisheries;
  - Advanced acoustics research and development to enhance bathymetric surveys for maritime transportation, improve on sub-bottom profiling techniques for resource exploration, and expand applications for target (natural or man-made) identification and acquisition;

NAML's Recommendations to Policy Makers

US leadership in science and technology is being challenged by our international competitors. Investing in research and education that relates to our oceans, coasts, and Great Lakes contributes to coastal security, seafood security, energy security, and natural resource management security.

The Administration said in the R&D Chapter of the FY 2019 Budget Request, "Innovation in science and technology has been a cornerstone of America's economic progress since the founding of this nation." In OMB Memo M-17-30, the Administration said, "…leadership in science and technology is critical to achieving this Administration's highest priorities…Federal funding of research…programs and research infrastructure can play a crucial supporting role."

In light of these priorities and the new budget agreement for FY 2019, NAML strongly urges policy makers to continue to significantly strengthen the Federal Government's investment in extramural merit-based, competitive research and education programs at NSF, NOAA, NASA, EPA, DOI, and other relevant agencies to develop the knowledge, the people, and the technological innovations needed to power the nation's economy, create jobs, improve health, and strengthen our national security.

March 2018

FEB 21, 2018 DRAFT

APPENDIX TO NAML FY 2019 PUBLIC POLICY AGENDA
FY 2019 Overview of the Administration's Budget Request
for Agencies Important to the Ocean, Coastal, and Great Lakes Research and Education Community

On February 12, the administration released its FY2019 Budget Request. The President's budget features significant increases in DOD and other defense programs, a plan for a $1.5 trillion public-private multi-year infrastructure initiative with a proposed $200 billion in Federal funding, and, once again, dramatic reductions in specific non-defense programs (such as NIH, NSF, NOAA, and EPA).

OMB Budget Adjustments Due to Bipartisan Budget Agreement for FY2018 and FY2019 -- As OMB finalized the FY 2019 Budget, the Congress reached a bipartisan agreement to significantly raise the defense and non-defense discretionary spending caps in FY2018 and FY2019, and the President has signed these new caps into law. In light of the BBA, the administration also transmitted an "Addendum to the President's FY2019 Budget to Account for the Bipartisan Budget Act of 2018."

> *"As reflected in the FY2019 Budget, the Administration strongly supports the overall defense spending levels included in the bipartisan cap deal. However, given the current fiscal situation, the Administration is not proposing a Budget at the new non-defense caps. The Administration does not believe these non-defense spending levels comport with its vision for the proper role and size of the Federal Government. However, we believe it is prudent to lay out the Administration's roadmap for how to account for these higher non-defense spending levels in a responsible manner. This addendum includes additional funding for a limited set of Administration priorities…"*

The administration requests total defense discretionary spending of $716 billion, the same as the newly raised defense cap. The defense budget is expected to track with the National Defense Strategy which emphasizes strategic competition with China and Russia means which calls for investing in advanced capabilities, rather than solely increasing the size of the force. Similarly, the strategy's language on force employment suggests a recalibration in favor of preserving readiness at the expense of some presence activities that are not focused on improving the military's ability to deter or respond to conflict.

For non-defense spending, the administration requests $540 billion, the addendum adds $75 billion to the FY2019 Budget, but this is still $57 billion below the newly raised non-defense cap agreed to last week that allows non-defense spending of $605 billion. The request for non-defense programs brings total non-defense spending to about the FY2017 level.

The President's budget also contains workforce reduction plans for many agencies. These plans rely on hiring freezes, buyouts, and provisions making it easier for agencies to release or terminate the employment of Federal employees.

Similar to the FY2018 request a large number of non-defense discretionary programs are proposed for elimination including: Sea Grant and other ocean and coastal grant programs, and the NOAA Office of Education, a reduction of some $273 million; the Advanced Research Projects Agency - Energy (a reduction of $305 million); the USAID Global Climate Change Initiative; and five Earth Science Missions at NASA including Radiation Budget Instrument (RBI), Plankton, Aerosol, Cloud; ocean Ecosystem (PACE), Orbiting Carbon Observatory-3 (OCO-3), Deep Space Climate Observatory (DSCOVR) Earth-viewing instruments, and Climate Absolute Radiance and Refractivity Observatory (CLARREO) Pathfinder (a savings of $133 million).

Agencies slated for closure in the proposed budget include the Corporation for National and Community Service, Corporation for Public Broadcasting, Institute of Museum and Library Services, the National Endowment for the Arts, and the National Endowment for the Humanities. The FY2019 Budget moves the Agency for Healthcare Research and Quality to within the National Institutes of Health, but reduces the funds currently supporting AHRQ.

With the new spending caps in place for FY2019 and this being an election year, Congress can be expected to oppose many of these reductions.

For the **National Science Foundation** (NSF), the administration's addendum would provide an additional $2.204 billion to NSF, bringing the FY2019 NSF request to a total of $7.472 billion, the same as the FY 2017 appropriated amount. The Administration's budget shows that without the addendum, it would have requested a reduction of 30% below the FY2017 level. With the addendum, Research and Related Activities increases by 2%, while NSF Education and Human Resources would remain at the FY2017 level. Funding for the Major Research Equipment and Facilities Construction account would decline by 56% or $120 million.

The increase for the Research & Related Activities account will allow NSF to invest in priority areas centered on accelerating focused, cross-disciplinary efforts around two of the NSF Big Ideas - The Future of Work at the Human-Technology Frontier, and Harnessing the Data Revolution. The requested increase would also support beginning construction on the Antarctic Infrastructure Modernization for Science project. The reduction for the Major Research Equipment & Facilities Construction account is largely due to the support for two new Regional Class Research Vessels.

For the **National Oceanic and Atmospheric Administration** (NOAA), the Administration is requesting $4.6 billion NOAA which is $1.1 billion or 19% below the FY 2017 level. NOAA is not included as one of the "add backs" in the addendum. Notable terminations in the NOAA budget include: Sea Grant, Coastal Zone Management Grants and Regional Coastal Resilience Grants, the National Estuarine Research Reserve Systems, NOAA Education programs, arctic research, the Prescott grant program, the reef fish stock assessment program, the Big Earth Data project, and the Research Transition Acceleration Program. Those programs proposed for substantial reductions include: elimination of the climate competitive research activity (this was a $60 million program in FY 2017); the ocean exploration program, reduction in the IOOS program of $11 million; reduction in the tsunami warning system ($11 million); reduction in numerical weather prediction models and the national water model; reduce the ocean acidification research activity by $2.4 million; regional climate centers would be reduced by $2.4 million; and reduce the marine debris program by nearly $500,000.

Areas or programs where NOAA is proposing modest increases despite an overall bottom line that declines by nearly 20% include: restore core capabilities at the National Weather Service; support increased costs for NOAA aircraft facility; improve disaster preparedness; strengthening NOAA's future satellite capabilities; maintenance of core geospatial and oceanographic data and products; and facilitate commercial space marketplace.

With respect to aquaculture, a priority area for the Department of Commerce and NOAA, support for NOAA's Office of Aquaculture is proposed to be $9.3 million, an amount equal to the FY 2017 level. The aquaculture research component within Sea Grant (approximately $9 million in FY 2017) is eliminated as part of the Administration's proposal to terminate the Sea Grant program. Also eliminated via the Sea Grant proposal would be the Knauss Fellowship program and other Sea Grant education activities.

NOAA Research (Office of Oceanic and Atmospheric Research - OAR) would decline in this budget proposal to a level of $321.7 million which is about 37% below the comparable FY 2017 level. In addition to the proposed termination of Sea Grant and other ocean and coastal grant programs, other notable reductions include:

- $60 million reduction in various climate research activities;
- $14 million reduction for weather related cooperative institutes and laboratories;
- $9 million to eliminate the joint technology transfer initiative;
- $16 million reduction to ocean exploration;
- $2.4 million reduction to ocean acidification - from $10.4 million in FY 2017 to $8 million in FY 2019.

The **National Ocean Service (NOS)**, in the FY 2019 budget request would decline by nearly 30% from the FY 2017 level. In the Navigation, Observations, and Positioning program support would decline by $7 million via the

elimination of a single-year grant to the joint ocean and coastal mapping center in Mississippi and the elimination of geospatial modeling grants. The IOOS Regional Observations program would decline by about 30% or $11 million to a level of $19.4 million. The $10 million competitive research program in Coastal Science and Assessment would be eliminated. The Coastal Science, Assessment, Response and Restoration would increase relative to FY 2017 by $773,00 to a level of $74 million. Coastal Zone Management Grants and the National Estuarine Research Reserve System programs would be terminated. Sanctuaries and Marine Protected Areas would be funded at $49.7 million which is about $1 million below the FY 2017 level.

The **National Marine Fisheries Services (NMFS)** would decline to $837.3 million which is about 15% below the FY 2017 level. Under this proposal NMFS would terminate the Prescott Marine Mammal Stranding program, Interjurisdictional Fisheries Grants, Cooperative Enforcement Program with coastal states and territories to enforce marine conservation law; and reef fish stock assessments in the Gulf of Mexico. NOAA's Enforcement Program is proposed to decline by $18 million or 26% below the FY 2017 level. Such a reduction could adversely impact NOAA's efforts to detect and deter Illegal, Unreported and Unregulated (IUU) fishing and enforce restrictions on imports of illegally-harvested and improperly-documented seafood.

The **National Weather Service** is requesting $1.1 billion which is virtually equal to the FY 2017 level. Within this budget, NWS would increase its support for the restoration of core capabilities; increase by $5 million its Advanced Weather Interactive Processing System (AWIPS) updates; and enhance the resilience and reliability of integrated dissemination program applications. Areas slated for reduction include $15.5 million to reduce surface and marine observations by reducing the National Mesonet Program; reduce the tsunami warning program by $11 million; reduce the investment in the National Water Model; reduce the NWS information technology workforce by $10 million through consolidation of IT support services; reduce the NWS workforce by nearly 250 positions by implementing the Operations and Workforce Analysis plan; save $2 million by terminating aviation science research to operations efforts; save $1.2 million via the consolidation of the Climate Prediction Center and Weather Prediction Center; reduce investment in numerical weather prediction modeling by $5 million; terminate NWS support for the COASTAL Act which among other things produces detailed post-storm assessments in the aftermath of severe storms; reduce by $3 million support for the National Water Model;

The **National Aeronautics and Space Administration (NASA)** budget request for FY2019 is $19.9 billion, an increase of about 1.2% over the FY2017 level; these numbers include the addendum that added $300 million to NASA's request. NASA's Science Account would be funded at $5.9 billion which is 2.3% over the FY2017 level. The addendum specifies that the additional $300 million in the Science account would support lunar science research and technology development of future power systems for solar system exploration. Within the funding for the Science Account, Earth Science would decline to $1.784 billion which is 7% below the FY2017 level. Earth Science would see the cancellation of five Earth Science Missions at NASA including Radiation Budget Instrument (RBI), Plankton, Aerosol, Cloud; ocean Ecosystem (PACE), Orbiting Carbon Observatory-3 (OCO-3), Deep Space Climate Observatory (DSCOVR) Earth-viewing instruments, and Climate Absolute Radiance and Refractivity Observatory (CLARREO) Pathfinder.

The **Department of Defense (DOD)**-- The FY 2019 Budget Request for DOD's Base Budget is $647 and an additional $69 billion for the Overseas Contingency Operations (OCO) account for a total budget of $716 billion (Base +OCO). Total DOD Research, Development, Test, and Evaluation level is $92.4 billion. Of this amount, $18.6 billion is slated for the Navy which represents an increase of 8.3% over the FY 2017 level. Within the **Navy**, basic research would grow to $597 million, an increase of 6%. Within the 6.1 program, Defense Research Sciences would increase to $459 million which is an increase of 8.5%. At the same time, University Research Initiatives would decline by almost 2% (down to $119.4 million). Navy applied research (6.2) and Navy advanced technology development (6.3) would each decline by 9%.

For the **National Institutes of Health**, the Budget requests a total of approximately $34.8 billion, plus supplemental funding to help address the opioid epidemic. This includes the additional $9 billion included in the addendum. However, the administration's proposal would consolidate the activities of the Agency for Healthcare Research and

Quality (AHRQ) into a National Institute for Research on Safety and Quality (NIRSQ) under the auspices of NIH. Similarly, programs currently administered by the Centers for Disease Control and Prevention (CDC), such as the National Institute for Occupational Safety and Health (NIOSH) are also shifted into the NIH portfolio. Thus, while the overall NIH budget would appear to increase, many programs across the Institutes and Centers could be adversely impacted by those consolidations.

At the **Environmental Protection Agency** (EPA) Categorical grants to help fund State environmental program offices and activities for such activities as the Clean Air Act, Clean Water Act, and Safe Drinking Water Act. The administration proposes to reduce many of these grants and eliminate others declining by $469 million from the FY2017 level of $1 billion. In the addendum, the administration adds $724 million to EPA: an additional $327 million to the Hazardous Substance Superfund account largely for the Superfund Remedial program, and an additional $397 million to the State and Tribal Assistance Grants account for the Clean Water and Drinking Water State Revolving Funds (SRF). The Administration is proposing to terminate most the Geographic Programs such as the Gulf of Mexico, Lake Champlain, Puget Sound programs. For the Great Lakes Restoration Initiative funding would drop from $300 million to $30 million. The National Estuary program would be reduced to zero from its FY 2017 level of $27 million. Beach and fish programs would also be zeroed out. Water Quality Research Projects, worth a total of $12.6 million that were added in by the Congress in FY 2017 would be terminated. Overall R&D at EPA would decline by 37% under this budget proposal. EPA is not included in the "add back" contained in the Administration's Addendum to the FY 2019 Budget Request.

For the **U.S. Geological Survey (USGS)**, the Administration is requesting $860 million, $223 million or 25% below the FY 2017 level. The 2019 budget provides $92.3 million for Core Science Systems. This is $23 million below the FY 2017 level. The budget includes $50.9 million for the National Geospatial Program, a reduction of $16 million. Within that $16 million reduction is a proposed reduction of $7.3 million for 3DEP. The National Cooperative Geological Mapping Program would be funded at $23 million, a reduction of $2 million from the FY 2017 level. The request provides for continued collection of high-resolution elevation (3DEP) and hydrography data for the Nation, including modernizing maps for Alaska and complete national lidar coverage by 2033. The budget also includes $22.4 million for leveraged geologic mapping activities in coordination with States, which are important for infrastructure, resource development, and mitigation of hazards. Support for Earthquake Hazards would decline by nearly $13 million below the FY 2017 level. USGS is not included in the "add backs" contained in the Administration's Addendum to the FY 2019 Budget Request.

The **Bureau of Ocean Energy Management (BOEM)** is slated to receive $129 million in appropriations (an increase of $17 million) plus $50 million in offsetting collections from offshore rental receipts and other cost recoveries. In 2019, BOEM will continue to advance renewable energy through a leasing program and streamlining of its permitting and National Environmental Policy Act processes. The BOEM continues to support renewable energy development spurred by the renewable energy goals of coastal States. BOEM is not included in the "add backs" contained in the Administration's Addendum to the FY 2019 Budget Request.

Department of State's **Oceans and International Environmental and Scientific Affairs** (OES) program would be funded at a level of $65.9 million, an amount similar to FY 2017. Funds will be used to support countries to phase out ozone depleting substances under the Montreal Protocol to protect U.S. citizens from skin cancer and cataracts and support global market-leading U.S. companies by promoting global adoption of advanced air conditioning and refrigeration technology. Funds will also be used to meet the annual commitment to Pacific Island partners, which secures access for U.S. vessels to lucrative fishing grounds thus supporting economic opportunities for Americans. OES is not included in the Administration's "add backs" contained in the Administration's Addendum to the FY 2019 Budget Request.

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The National Association of Marine Laboratories (NAML) is a nonprofit organization representing the ocean, coastal and Great Lakes interests of member laboratories that employ thousands of scientists, engineers and professionals nationwide. NAML labs conduct high quality research and education in the natural and social sciences and translate that science to improve decision-making on important issues facing local, state, regional, national and international entities.

Overview of the Administration's FY2019 Budget Request for Selected Federal Agencies' Science and Engineering

Prepared by Joel Widder and Meg Thompson
Federal Science Partners LLC
February 14, 2018

On February 12, the administration released its FY2019 Budget Request. The President's budget features significant increases in DOD and other defense programs, a plan for a $1.5 trillion public-private multi-year infrastructure initiative with a proposed $200 billion in Federal funding, and, once again, dramatic reductions in specific non-defense programs (such as NIH, NSF, NOAA, and EPA).

OMB Budget Adjustments Due to Bipartisan Budget Agreement for FY2018 and FY2019 -- As OMB finalized the FY 2019 Budget, the Congress reached a bipartisan agreement to significantly raise the defense and non-defense discretionary spending caps in FY2018 and FY2019, and the President has signed these new caps into law. In light of the BBA, the administration also transmitted an "Addendum to the President's FY2019 Budget to Account for the Bipartisan Budget Act of 2018."

> *"As reflected in the FY2019 Budget, the Administration strongly supports the overall defense spending levels included in the bipartisan cap deal. However, given the current fiscal situation, the Administration is not proposing a Budget at the new non-defense caps. The Administration does not believe these non-defense spending levels comport with its vision for the proper role and size of the Federal Government. However, we believe it is prudent to lay out the Administration's roadmap for how to account for these higher non-defense spending levels in a responsible manner. This addendum includes additional funding for a limited set of Administration priorities…"*

The administration requests total defense discretionary spending of $716 billion, the same as the newly raised defense cap. The defense budget is expected to track with the National Defense Strategy which emphasizes strategic competition with China and Russia means which calls for investing in advanced capabilities, rather than solely increasing the size of the force. Similarly, the strategy's language on force employment suggests a recalibration in favor of preserving readiness at the expense of some presence activities that are not focused on improving the military's ability to deter or respond to conflict.

For non-defense spending, the administration requests $540 billion, the addendum adds $75 billion to the FY2019 Budget, but this is still $57 billion below the newly raised non-defense cap agreed to last week that allows non-defense spending of $605 billion. The request for non-defense programs brings total non-defense spending to about the FY2017 level.

The President's budget also contains workforce reduction plans for many agencies.

These plans rely on hiring freezes, buyouts, and provisions making it easier for agencies to release or terminate the employment of Federal employees.

Similar to the FY2018 request a large number of non-defense discretionary programs are proposed for elimination including: Sea Grant and other ocean and coastal grant programs, and the NOAA Office of Education, a reduction of some $273 million; the Advanced Research Projects Agency – Energy (a reduction of $305 million); the USAID Global Climate Change Initiative; and five Earth Science Missions at NASA including Radiation Budget Instrument (RBI), Plankton, Aerosol, Cloud; ocean Ecosystem (PACE), Orbiting Carbon Observatory-3 (OCO-3), Deep Space Climate Observatory (DSCOVR) Earth-viewing instruments, and Climate Absolute Radiance and Refractivity Observatory (CLARREO) Pathfinder (a savings of $133 million).

Agencies slated for closure in the proposed budget include the Corporation for National and Community Service, Corporation for Public Broadcasting, Institute of Museum and Library Services, the National Endowment for the Arts, and the National Endowment for the Humanities. The FY2019 Budget moves the Agency for Healthcare Research and Quality to within the National Institutes of Health, but reduces the funds currently supporting AHRQ. With the new spending caps in place for FY2019 and this being an election year, Congress can be expected to oppose many of these reductions.

For the **National Science Foundation** (NSF), the administration's addendum would provide an additional $2.204 billion to NSF, bringing the FY2019 NSF request to a total of $7.472 billion, the same as the FY 2017 appropriated amount. The Administration's budget shows that without the addendum, it would have requested a reduction of 30% below the FY2017 level. With the addendum, Research and Related Activities increases by 2%, while NSF Education and Human Resources would remain at the FY2017 level. Funding for the Major Research Equipment and Facilities Construction account would decline by 56% or $120 million.

The increase for the Research & Related Activities account will allow NSF to invest in priority areas centered on accelerating focused, cross-disciplinary efforts around two of the NSF Big Ideas – The Future of Work at the Human-Technology Frontier, and Harnessing the Data Revolution. The requested increase would also support beginning construction on the Antarctic Infrastructure Modernization for Science project. The reduction for the Major Research Equipment & Facilities Construction account is largely due to the support for two new Regional Class Research Vessels.

For the **National Oceanic and Atmospheric Administration** (NOAA), the Administration is requesting $4.6 billion NOAA which is $1.1 billion or 19% below the FY 2017 level. ***NOAA is not included as one of the "add backs" in the addendum***. Notable terminations in the NOAA budget include: Sea Grant, Coastal Zone Management Grants and Regional Coastal Resilience Grants, the National Estuarine Research Reserve Systems, NOAA Education programs, arctic research,

the Prescott grant program, the reef fish stock assessment program, the Big Earth Data project, and the Research Transition Acceleration Program. Those programs proposed for substantial reductions include: elimination of the climate competitive research activity (this was a $60 million program in FY 2017); the ocean exploration program, reduction in the IOOS program of $11 million; reduction in the tsunami warning system ($11 million); reduction in numerical weather prediction models and the national water model; reduce the ocean acidification research activity by $2.4 million; regional climate centers would be reduced by $2.4 million; and reduce the marine debris program by nearly $500,000.

Areas or programs where NOAA is proposing modest increases despite an overall bottom line that declines by nearly 20% include: restore core capabilities at the National Weather Service; support increased costs for NOAA aircraft facility; improve disaster preparedness; strengthening NOAA's future satellite capabilities; maintenance of core geospatial and oceanographic data and products; and facilitate commercial space marketplace.

With respect to aquaculture, a priority area for the Department of Commerce and NOAA, support for NOAA's *Office of Aquaculture* is proposed to be $9.3 million, an amount equal to the FY 2017 level. The aquaculture research component within Sea Grant (approximately $9 million in FY 2017) is eliminated as part of the Administration's proposal to terminate the Sea Grant program. Also eliminated via the Sea Grant proposal would be the Knauss Fellowship program and other Sea Grant education activities.

NOAA Research (Office of Oceanic and Atmospheric Research – OAR) would decline in this budget proposal to a level of $321.7 million which is about 37% below the comparable FY 2017 level. In addition to the proposed termination of Sea Grant and other ocean and coastal grant programs, other notable reductions include:

- $60 million reduction in various climate research activities;
- $14 million reduction for weather related cooperative institutes and laboratories;
- $9 million to eliminate the joint technology transfer initiative;
- $16 million reduction to ocean exploration;
- $2.4 million reduction to ocean acidification – dropping from $10.4 million in FY 2017 to $8 million in FY 2019.

The *National Ocean Service* (NOS), in the FY 2019 budget request would decline by nearly 30% from the FY 2017 level. In the Navigation, Observations, and Positioning program support would decline by $7 million via the elimination of a single-year grant to the joint ocean and coastal mapping center in Mississippi and the elimination of geospatial modeling grants. The IOOS Regional Observations program would decline by about 30% or $11 million to a level of $19.4 million. The $10 million competitive research program in Coastal Science and Assessment would be

eliminated. The Coastal Science, Assessment, Response and Restoration would increase relative to FY 2017 by $773,00 to a level of $74 million. Coastal Zone Management Grants and the National Estuarine Research Reserve System programs would be terminated. Sanctuaries and Marine Protected Areas would be funded at $49.7 million which is about $1 million below the FY 2017 level.

The *National Marine Fisheries Services* (NMFS) would decline to $837.3 million which is about 15% below the FY 2017 level. Under this proposal NMFS would terminate the Prescott Marine Mammal Stranding program, Interjurisdictional Fisheries Grants, Cooperative Enforcement Program with coastal states and territories to enforce marine conservation law; and reef fish stock assessments in the Gulf of Mexico. NOAA's Enforcement Program is proposed to decline by $18 million or 26% below the FY 2017 level. Such a reduction could adversely impact NOAA's efforts to detect and deter Illegal, Unreported and Unregulated (IUU) fishing and enforce restrictions on imports of illegally-harvested and improperly-documented seafood.

The *National Weather Service* is requesting $1.1 billion which is virtually equal to the FY 2017 level. Within this budget, NWS would increase its support for the restoration of core capabilities; increase by $5 million its Advanced Weather Interactive Processing System (AWIPS) updates; and enhance the resilience and reliability of integrated dissemination program applications. Areas slated for reduction include $15.5 million to reduce surface and marine observations by reducing the National Mesonet Program; reduce the tsunami warning program by $11 million; reduce the investment in the National Water Model; reduce the NWS information technology workforce by $10 million through consolidation of IT support services; reduce the NWS workforce by nearly 250 positions by implementing the Operations and Workforce Analysis plan; save $2 million by terminating aviation science research to operations efforts; save $1.2 million via the consolidation of the Climate Prediction Center and Weather Prediction Center; reduce investment in numerical weather prediction modeling by $5 million; terminate NWS support for the COASTAL Act which among other things produces detailed post-storm assessments in the aftermath of severe storms; reduce by $3 million support for the National Water Model;

The **National Aeronautics and Space Administration** (NASA) budget request for FY2019 is $19.9 billion, an increase of about 1.2% over the FY2017 level; these numbers include the addendum that added $300 million to NASA's request. NASA's Science Account would be funded at $5.9 billion which is 2.3% over the FY2017 level. The addendum specifies that the additional $300 million in the Science account would support lunar science research and technology development of future power systems for solar system exploration. Within the funding for the Science Account, Earth Science would decline to $1.784 billion which is 7% below the FY2017 level. Earth Science would see the cancellation of five Earth Science Missions at NASA including Radiation Budget Instrument (RBI), Plankton, Aerosol, Cloud; ocean Ecosystem (PACE), Orbiting Carbon Observatory-3 (OCO-3), Deep

Space Climate Observatory (DSCOVR) Earth-viewing instruments, and Climate Absolute Radiance and Refractivity Observatory (CLARREO) Pathfinder.

The **Department of Defense** (DOD)-- The FY 2019 Budget Request for DOD's Base Budget is $647 and an additional $69 billion for the Overseas Contingency Operations (OCO) account for a total budget of $716 billion (Base +OCO). Total DOD Research, Development, Test, and Evaluation level is $92.4 billion. Of this amount, $18.6 billion is slated for the Navy which represents an increase of 8.3% over the FY 2017 level.

Within the Navy, basic research would grow to $597 million, an increase of 6%. Within the 6.1 program, Defense Research Sciences would increase to $459 million which is an increase of 8.5%. At the same time, University Research Initiatives would decline by almost 2% (down to $119.4 million). Navy applied research (6.2) and Navy advanced technology development (6.3) would each decline by 9%.

DARPA would grow by nearly 17% to $3.4 billion. Basic research within DARPA is proposed to increase to $470 million which is a 12% increase. DARPA applied research (6.2) grows by 15% and DARPA advanced technology development (6.3) increases by 18%.

For the **National Institutes of Health**, the Budget requests a total of approximately $34.8 billion, plus supplemental funding to help address the opioid epidemic. This includes the additional $9 billion included in the addendum. However, the administration's proposal would consolidate the activities of the Agency for Healthcare Research and Quality (AHRQ) into a National Institute for Research on Safety and Quality (NIRSQ) under the auspices of NIH. Similarly, programs currently administered by the Centers for Disease Control and Prevention (CDC), such as the National Institute for Occupational Safety and Health (NIOSH) are also shifted into the NIH portfolio. Thus, while the overall NIH budget would appear to increase, many programs across the Institutes and Centers could be adversely impacted by those consolidations.

At the **Environmental Protection Agency** (EPA) Categorical grants to help fund State environmental program offices and activities for such activities as the Clean Air Act, Clean Water Act, and Safe Drinking Water Act. The administration proposes to reduce many of these grants and eliminate others declining by $469 million from the FY2017 level of $1 billion. In the addendum, the administration adds $724 million to EPA: an additional $327 million to the Hazardous Substance Superfund account largely for the Superfund Remedial program, and an additional $397 million to the State and Tribal Assistance Grants account for the Clean Water and Drinking Water State Revolving Funds (SRF). The Administration is proposing to terminate most the Geographic Programs such as the Gulf of Mexico, Lake Champlain, Puget Sound programs. For the Great Lakes Restoration Initiative funding would drop from $300 million to $30 million. The National Estuary program would be reduced to zero from its FY 2017 level of $27 million. Beach and fish programs would also be

zeroed out. Water Quality Research Projects, worth a total of $12.6 million that were added in by the Congress in FY 2017 would be terminated. Overall R&D at EPA would decline by 37% under this budget proposal.

For the **U.S. Geological Survey** (USGS), the Administration is requesting $860 million, $223 million or 25% below the FY 2017 level. The 2019 budget provides $92.3 million for Core Science Systems. This is $23 million below the FY 2017 level. The budget includes $50.9 million for the National Geospatial Program, a reduction of $16 million. Within that $16 million reduction is a proposed reduction of $7.3 million for 3DEP. The National Cooperative Geological Mapping Program would be funded at $23 million, a reduction of $2 million from the FY 2017 level. The request provides for continued collection of high-resolution elevation (3DEP) and hydrography data for the Nation, including modernizing maps for Alaska and complete national lidar coverage by 2033. The budget also includes $22.4 million for leveraged geologic mapping activities in coordination with States, which are important for infrastructure, resource development, and mitigation of hazards. Support for Earthquake Hazards would decline by nearly $13 million below the FY 2017 level.

The **Bureau of Ocean Energy Management** (BOEM) is slated to receive $129 million in appropriations (an increase of $17 million) plus $50 million in offsetting collections from offshore rental receipts and other cost recoveries. In 2019, BOEM will continue to advance renewable energy through a leasing program and streamlining of its permitting and National Environmental Policy Act processes. The BOEM continues to support renewable energy development spurred by the renewable energy goals of coastal States.

Department of State's **Oceans and International Environmental and Scientific Affairs (OES) program** would be funded at a level of $65.9 million, an amount similar to FY 2017. Funds will be used to support countries to phase out ozone depleting substances under the Montreal Protocol to protect U.S. citizens from skin cancer and cataracts and support global market-leading U.S. companies by promoting global adoption of advanced air conditioning and refrigeration technology. Funds will also be used to meet the annual commitment to Pacific Island partners, which secures access for U.S. vessels to lucrative fishing grounds thus supporting economic opportunities for Americans.

18. RESEARCH AND DEVELOPMENT

Innovation in science and technology has been a cornerstone of America's economic progress since the founding of this nation. The most recent estimate of total U.S. research and development (R&D) spending was about $495 billion, an amount greater than any other country and more than a quarter of the global total.[1] While the private sector funds and performs the majority of U.S. R&D, the Federal government has an important role in funding R&D in areas that industry does not have a strong incentive to invest in and in areas of critical importance to national and economic security. The Federal government has been the leading source of support for basic research and provides more than 25 times the amount funded by state and local governments in total R&D.[2] Prior Federally funded R&D has greatly advanced human knowledge, and applications of that knowledge permeate our lives—from the phones we carry, to the cars we drive, to the medicines that return us to health. Recognizing the critical importance of fostering innovation to promote America's interests, including competitiveness, economic and job growth, and national security, the 2019 Budget continues support of investments in basic research, early-stage applied research, and technology transfer efforts that will lead to the breakthroughs of the future.

The President's 2019 Budget provides $118.1 billion for Federal R&D, including the conduct of R&D and investments in R&D facilities and equipment (see Table 18-2). This figure applies a change to the R&D definitions introduced in July 2016 per OMB Circular A-11. Under the former R&D definitions, the President's 2019 Budget provides $156.8 billion for R&D, a $2.8 billion (or 2%) increase over the FY 2018[3] level, and includes an $18.1 billion increase for Defense-related R&D. Detailed R&D definitions and a discussion of the definition change are available in Section II. Table 18-1 shows a breakout of FY 2019 R&D funding by major funding agencies at the bureau or account level.

[1] National Science Board. 2018 Science and Engineering Indicators. January 2018.

[2] NSF National Center for Science and Engineering Statistics (Dec. 2017). InfoBrief - NSF 18-306.

[3] Because an appropriation for FY 2018 was not passed by the time this chapter went to print, the chapter calculates FY 2018 estimates using an annualized version of the FY 2018 Continuing Resolution.

Table 18–1. TOTAL FEDERAL R&D FUNDING BY AGENCY AT THE BUREAU OR ACCOUNT LEVEL

(Mandatory and discretionary budget authority[1,2], dollar amounts in millions)

	2017 Actual	2018 Annualized CR	2019 Proposed	Dollar Change: 2018 to 2019	Percent Change: 2018 to 2019
By Agency					
Agriculture	2,585	2,487	1,914	–573	–23%
Agriculture Research Service	1,298	1,289	855	–434	–34%
Animal and Plant Health Inspection Service	40	39	34	–5	–13%
Economic Research Service	87	86	45	–41	–48%
Forest Service	282	281	235	–46	–16%
National Agricultural Statistics Service	9	9	9	0	0%
National Institute of Food and Agriculture	869	783	736	–47	–6%
Commerce	1,794	1,833	1,361	–472	–26%
Bureau of the Census	232	237	165	–72	–30%
National Institute of Standards and Technology	750	746	564	–182	–24%
National Oceanic and Atmospheric Administration	804	839	619	–220	–26%
National Telecommunications and Information Administration	8	11	13	2	18%
Defense[3]	49,197	43,616	57,156	13,540	31%
Military Construction	155	37	53	16	43%
Military Personnel	410	439	455	16	4%
Defense Health Program	1,452	336	362	26	8%
Research, Development, Test, and Evaluation	47,180	42,804	56,286	13,482	31%
Education	254	243	240	–3	–1%
Institute of Education Sciences	226	219	216	–3	–1%
Office of Postsecondary Education	3	0	0	0	0%
Office of Special Education and Rehabilitative Services	23	24	24	0	0%
Office of Career, Technical, and Adult Education	2	0	0	0	0%

Table 18–1. TOTAL FEDERAL R&D FUNDING BY AGENCY AT THE BUREAU OR ACCOUNT LEVEL—Continued

(Mandatory and discretionary budget authority[1,2], dollar amounts in millions)

	2017 Actual	2018 Annualized CR	2019 Proposed	Dollar Change: 2018 to 2019	Percent Change: 2018 to 2019
Energy	14,896	15,006	12,685	–2,321	–15%
Fossil Energy Research and Development	399	419	292	–127	–30%
Science	5,438	5,307	4,127	–1,180	–22%
Electricity Delivery	144	144	46	–98	–68%
Nuclear Energy	764	955	754	–201	–21%
Energy Efficiency and Renewable Energy	1,445	1,492	524	–968	–65%
Advanced Research Projects Agency--Energy	306	295	0	–295	–100%
Cybersecurity, Energy Security, and Emergency Response	0	0	40	40	n/a
Defense Environmental Cleanup	28	28	28	0	0%
National Nuclear Security Administration	6,357	6,351	6,859	508	8%
Power Marketing Administration	15	15	15	0	0%
Environmental Protection Agency	497	496	269	–227	–46%
Science and Technology	481	480	256	–224	–47%
Hazardous Substance Superfund	15	15	12	–3	–20%
Inland Oil Spill Programs	1	1	1	0	0%
Health and Human Services	34,222	33,772	24,742	–9,030	–27%
Administration for Children and Families	16	5	89	84	1680%
Centers for Disease Control and Prevention	511	464	296	–168	–36%
Centers for Medicare and Medicaid Services	278	19	17	–2	–11%
Departmental Management	116	131	158	27	21%
Food and Drug Administration	390	410	410	0	0%
Health Resources and Services Administration	30	30	22	–8	–27%
National Institutes of Health[4]	32,881	32,713	23,750	–8,963	–27%
Homeland Security	724	672	548	–124	–18%
National Protection and Programs Directorate	6	6	48	42	700%
Science and Technology	597	527	371	–156	–30%
Transportation Security Administration	5	5	21	16	320%
United States Coast Guard	38	38	21	–17	–45%
United States Secret Service	3	2	3	1	50%
Management Directorate	3	3	3	0	0%
Countering Weapons of Mass Destruction Office	72	91	81	–10	–11%
Interior	953	964	759	–205	–21%
Bureau of Indian Affairs and Bureau of Indian Education	5	5	5	0	0%
Bureau of Land Management	23	23	23	0	0%
Bureau of Reclamation	72	104	83	–21	–20%
Bureau of Safety and Environmental Enforcement	27	27	21	–6	–22%
Department-Wide Programs	6	3	0	–3	–100%
National Park Service	27	26	24	–2	–8%
Office of Surface Mining Reclamation and Enforcement	1	1	1	0	0%
United States Fish and Wildlife Service	32	15	15	0	0%
United States Geological Survey	687	683	503	–180	–26%
Bureau of Ocean Energy Management	73	77	84	7	9%
National Aeronautics and Space Administration	10,704	10,243	10,651	408	4%
Science	5,668	5,666	5,820	154	3%
Aeronautics	517	508	488	–20	–4%
Low Earth Orbit and Spaceflight Operations	2,542	2,166	1,727	–439	–20%
Safety, Security and Mission Services	269	262	257	–5	–2%
Deep Space Exploration Systems	976	937	1,392	455	49%
Construction and Environmental Compliance and Restoration	52	22	54	32	145%
Exploration Research and Technology	680	682	913	231	34%
National Science Foundation	5,938	6,030	4,177	–1,853	–31%
Research and Related Activities	5,314	5,412	3,821	–1,591	–29%
Education and Human Resources	409	410	290	–120	–29%
Major Research Equipment and Facilities Construction	215	208	66	–142	–68%
Patient-Centered Outcomes Research Trust Fund	463	501	622	121	24%

Table 18–1. TOTAL FEDERAL R&D FUNDING BY AGENCY AT THE BUREAU OR ACCOUNT LEVEL—Continued

(Mandatory and discretionary budget authority[1,2], dollar amounts in millions)

	2017 Actual	2018 Annualized CR	2019 Proposed	Dollar Change: 2018 to 2019	Percent Change: 2018 to 2019
Transportation	904	929	826	–103	–11%
Federal Aviation Administration	433	439	351	–88	–20%
Federal Highway Administration	317	311	334	23	7%
Federal Motor Carrier Safety Administration	11	9	9	0	0%
Federal Railroad Administration	43	43	24	–19	–44%
Federal Transit Administration	0	28	22	–6	–21%
Maritime Administration	0	1	0	–1	–100%
National Highway Traffic Safety Administration	63	60	62	2	3%
Office of the Secretary	17	17	13	–4	–24%
Pipeline and Hazardous Materials Safety Administration	20	21	11	–10	–48%
Smithsonian Institution	251	242	271	29	12%
Veterans Affairs	1,346	1,338	1,345	7	1%
Medical Services	673	669	618	–51	–8%
Medical and Prosthetic Research	673	669	727	58	9%

[1] This table shows funding levels for Departments or Independent agencies with more than $200 million in R&D activities in 2019.

[2] The Experimental Development definition is used in this table across all three fiscal years.

[3] Unlike previous years, totals for Experimental Development spending in FY 2017-2019 do not include the DOD Budget Activity 07 (Operational System Development) due to changes in the definition of development. These funds are requested in the FY 2019 Budget request and support the development efforts to upgrade systems that have been fielded or have received approval for full rate production and anticipate production funding in the current or subsequent fiscal year.

[4] The FY 2019 Budget proposes to consolidate the activities of the Agency for Healthcare Research and Quality (AHRQ) within NIH. The NIH total includes R&D funding that previously occurred in AHRQ.

I. PRIORITIES FOR FEDERAL RESEARCH AND DEVELOPMENT

The President's Budget provides support for Federal R&D to enhance our national security, increase American economic prosperity, create well-paying American jobs, and improve the national science and technology enterprise. This section highlights key areas of R&D funding in the 2019 Budget.

Protecting the Homeland against Physical and Cyber Attacks

Worldwide advances in technology mean that the threats to our national security are changing. Nations best able to employ precision-guided weapons, track enemy movements in real-time, disrupt communications, and work seamlessly in the fight will prevail. The President's National Security Strategy affirms the importance of peace through strength, reiterating that U.S. military strength remains a vital component of our nation's security, and renewing calls for American military overmatch. Historically, Federal R&D investments in military technology have led to the development of breakthrough technologies with tremendously useful civil applications, and the President's 2019 Budget encourages programs with dual-use potential to be leveraged for Federal nonmilitary advancements.

The Department of Defense (DOD) will invest more than $84 billion in research, engineering, and prototyping activities in 2019 to maintain technical superiority and promote U.S. national security innovation. For example, DOD is the centerpiece of a government-wide effort to outinnovate competitors and bolster the U.S. engineering and design communities in the area of trusted microelectronics, semiconductors, and future computing. Electronics, such as computer chips and their integrated circuits, are in everything from cell phones to jet aircraft. The Defense Advanced Research Projects Agency (DARPA) announced its Electronics Resurgence Initiative, investing more than $150 million per year —not including matching funds from industry – toward chip innovation. In addition, DOD is investing in hypersonics research for non-nuclear weapons, which can deter our potential adversaries and are able to strike any point on the globe within an hour. DOD will also support intelligence, surveillance, and reconnaissance along with kinetic and non-kinetic technologies that will disrupt and defeat missiles prior to launch. The 2019 Budget provides $6.8 billion for R&D efforts at the Missile Defense Agency to develop missile defeat, detection, and defense capabilities to protect the United States, our deployed forces, allies, and partners from missile attacks.

Beyond DOD, the 2019 Budget also supports a number of critical investments to protect the homeland at the Department of Homeland Security (DHS) and the Department of Health and Human Services (HHS). In particular, at DHS, the President's Budget requests $80.4 million in R&D funding to detect radiological and nuclear threats in order to defend against weapons of mass de-

struction, $25 million for biodefense-related R&D, $71.1 million in R&D to improve border surveillance and law enforcement capabilities to detect and interdict illegal activity, including the smuggling of contraband, and $70.6 million for cybersecurity R&D. In alignment with the President's National Security Strategy call to bolster transportation security, the 2019 Budget will also invest $20.6 million in R&D at the Transportation Security Administration to counter emerging threats to our aviation, surface, and intermodal transportation systems. At HHS, the Budget also provides $1 billion to develop enhanced medical countermeasures to respond to potential public health emergencies.

Improving Preparedness for and Response to Natural Disasters

In the wake of natural disasters, including a devastating hurricane season and catastrophic forest fires, it is more important than ever to invest in the tools necessary to predict, protect against, mitigate, respond to, and recover from natural disasters. The Budget supports investments in high-priority Earth observations that contribute to the nation's ability to predict the weather and respond to natural disasters. Within the National Aeronautics and Space Administration (NASA), the Budget provides $1.8 billion to maintain progress toward satellite missions and research that will improve our understanding of the Earth, including natural hazards. The joint NASA-Indian Space Research Organization Synthetic Aperture Radar (NISAR) mission will provide unprecedented, detailed views of Earth and will enhance our understanding and response to hazards such as earthquakes, tsunamis, and landslides. The Budget also supports National Oceanic and Atmospheric Administration (NOAA) research on seasonal to subseasonal atmospheric behavior to improve our ability to understand, predict and communicate information associated with hazardous weather. The Budget also funds the U.S. Geological Survey to conduct research to quantify earthquake likelihoods and to develop a nationwide capability to release aftershock advisories during major earthquake sequences. The Budget also continues to support space weather-related R&D, since space weather can affect not just the nation's satellites and space explorers, but can potentially cause significant damage to our electrical grid and electronic systems.

Expanding Human Exploration and Commercialization of Space

The Budget supports more innovative and sustainable approaches for exploration with commercial and international partners to enable the return of humans to the Moon for long-term exploration and utilization, followed by human missions to Mars and other destinations. As it pioneers the space frontier, NASA will support growth of the nation's space economy, increase understanding of the universe and our place in it, and advance America's aerospace technology.

This Budget continues investments to once again launch Americans into space from American soil. Additionally, it initiates new industry partnerships for landing robotic missions on the surface of the Moon in the next few years, paving the way for a return of our astronauts—this time not just to visit, but to lay the foundation for further journeys of exploration and the expansion of our economy into space. The Budget supports a space exploration program that we can be proud of—one that reflects American ingenuity, ambition, and leadership. One key to an affordable and dynamic exploration program is the development of new technologies and the Budget spends over $750 million on exploration technology. The Budget also provides $150 million for a program to expand commercial activities in low Earth orbit, with a focus on developing and deploying commercial space stations that can be used by NASA and other customers as a successor to the International Space Station.

Harnessing Artificial Intelligence and High Performance Computing

The development of artificial intelligence (AI) is advancing at a rapid pace, and the 2019 Budget invests in fundamental AI research and computing infrastructure to maintain U.S. leadership in this field. AI holds the potential to transform the lives of Americans through improved technology integration in the workplace and enhanced standards of living at home. The Budget funds basic research related to AI at the National Science Foundation and applied R&D in the Department of Transportation for the further development of autonomous and unmanned systems. In defense applications, DOD is working to deliver AI-driven algorithms to warfighting systems, which can rapidly turn volumes of data into decision-quality insights. And in the health realm, NIH is supporting the use of high performance computing to analyze large data sets to drive cancer research forward.

The Budget also funds high performance computing through supporting investments in computing infrastructure, which hold the potential for AI technology use and other purposes. The Budget provides $811 million to the Department of Energy's Advanced Scientific Computing Research Program to support research and facility upgrades to supercomputing infrastructure at Argonne and Oak Ridge National Laboratories, including the development of exascale high performance computers. These supercomputers will rank among the fastest and most powerful in the world, and will leverage strong partnerships with industry and academia in their development and use.

Combating Drug Abuse and the Opioid Overdose Epidemic

The Administration is committed to combating drug abuse and the opioid overdose epidemic, which poses an urgent threat to public safety and public health. The Administration's declaration of a nationwide public health emergency on October 26, 2017 highlighted the need for improved R&D to prevent and treat drug addiction. The President's Commission on Combating Drug Addiction and the Opioid Crisis provided recommendations for related research to the President. In addition, the White House Office of Science and Technology Policy is convening an

interagency body to facilitate efforts across agencies on health science and technology in response to the opioid crisis, and to develop an R&D roadmap designed to enhance the national opioid response.

The 2019 Budget supports a number of important R&D efforts at agencies to understand and fight this critical problem. For instance, the Budget invests in research into the biological and social-behavioral basis of drug addiction to improve the fundamental understanding of opioid addiction, and in the development of technologies to measure brain function, which can potentially improve our understanding of addictive behavior, brain systems, and related phenomena. In addition, NIH has launched an initiative in partnership with innovator companies and the Food and Drug Administration (FDA) to address the urgent need for non-addictive alternatives to opioids for pain relief. With the 2019 Budget's investment of $100 million, this public-private partnership will facilitate the development of new treatments for addiction, overdose-reversal, and non-addictive therapies for pain. Furthermore, the 2019 Budget supports R&D at DHS to develop cost-effective detection systems to rapidly collect information useful for detecting opioids and fentanyls at land borders and international mail handling facilities - enhancing efforts to prevent illicit drugs from entering the country.

Stimulating Biomedical Innovation for American Health

Encouraging biomedical innovation is key to preventing, treating, and defeating disease and maintaining America's global leadership in healthcare. Achieving these goals requires effective and efficient transfer of research results from bench to bedside. To ensure that the work of the National Institutes of Health (NIH) continues to drive biomedical innovation that improves health, the 2019 Budget supports the expansion of policies that promote technology transfer, including policies that encourage investigators to seek intellectual property protection for their inventions. The Budget also supports the highest priority research at NIH to continue to make progress on finding cures for major diseases and illnesses.

Integrating Autonomous and Unmanned Systems into the Transportation Network

Autonomous and unmanned systems, such as drones and self-driving cars, can provide novel, low-cost capabilities across a broad range of commercial sectors, including transportation. In order to leverage these benefits, research is needed on how these systems and technologies can be safely integrated into the existing transportation network.

The 2019 Budget provides $17.3 million to the Federal Aviation Administration for R&D related to the integration of unmanned aircraft systems (UAS) into the national airspace system. The Budget will also provide $57 million to NASA for research on further development of the UAS traffic management system and UAS operating standards. This funding will allow NASA to complete its current UAS-related projects, which will contribute to the integration of UAS into the national aerospace system. The Budget also proposes accelerating the start of advanced autonomous systems research to ensure the safe integration of autonomous vehicle systems, such as advanced UAS and passenger-carrying urban air mobility aircraft, into the national airspace.

The Budget provides $10 million to the National Highway Transportation Safety Administration's Automated Driving Systems program for critical research that will assist the agency in the development of an advanced regulatory approach for a new generation of transportation technologies. The Budget also provides $100 million to the Federal Highway Administration's Intelligent Transportation Systems program to support R&D on connected and autonomous vehicles and related technologies.

Leveraging Biotechnologies for Agriculture and Rural Prosperity

The report from the President's Interagency Task Force on Agriculture and Rural Prosperity called for an increased focus on leveraging agricultural biotechnology to further improve agricultural efficiency and the quality of food products. Therefore, the Budget prioritizes the U.S. Department of Agriculture (USDA) research portfolio by providing formula funding at the FY 2017 Enacted level for research and extension activities at land-grant universities and competitive research through the Department's flagship competitive research grant program, the Agriculture and Food Research Initiative. The Budget also proposes over $800 million for in-house basic and applied research conducted by the Agriculture Research Service.

The Budget also proposes to transfer operational responsibility of the National Bio-and Agro-Defense Facility (NBAF) from the Department of Homeland Security to USDA. NBAF is a laboratory facility designed to study diseases that threaten the animal agricultural industry and public health, and given that USDA is already responsible for the research programs that will be conducted at this facility once construction is completed, it makes sense for USDA to manage the facility itself.

Unleashing an Era of Energy Dominance through Strategic Support for Innovation

The United States has among the most abundant and diverse energy resources in the world, including oil, gas, coal, nuclear, and renewables. The ability of our entrepreneurs and businesses to commercialize technologies that take full advantage of those resources is paramount to promoting U.S. economic growth, security, and competitiveness. That is why the Budget invests approximately $1.7 billion across the applied energy offices at the Department of Energy (DOE) for early-stage research and development that will enable the private sector to deploy the next generation of technologies and energy services that usher in a more secure, resilient, and integrated energy system. Through balanced support across generation types and fuel sources, the Budget helps usher in a new era of US energy dominance.

II. FEDERAL R&D DATA

R&D is the collection of efforts directed toward gaining greater knowledge or understanding and applying knowledge toward the production of useful materials, devices, and methods. R&D investments can be characterized as basic research, applied research, development, R&D equipment, or R&D facilities. The Office of Management and Budget (OMB) has used those or similar categories in its collection of R&D data since 1949. Starting with the FY 2018 Budget, OMB implemented a refinement to the categories by more narrowly defining "development" as "experimental development" to better align with the data collected by the National Science Foundation on its multiple R&D surveys, and to be consistent with international standards. An explanation of this change is included below. Please note that R&D cross-cuts in specific topical areas as mandated by law will be reported separately in forthcoming Supplements to the President's 2019 Budget.

Background on Federal R&D Funding

More than 20 Federal agencies fund R&D in the United States. The character of the R&D that these agencies fund depends on the mission of each agency and on the role of R&D in accomplishing it. Table 18-2 shows agency-by-agency spending on basic research, applied research, experimental development, and R&D equipment and facilities.

Basic research is systematic study directed toward a fuller knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications towards processes or products in mind. Basic research, however, may include activities with broad applications in mind.

Applied research is systematic study to gain knowledge or understanding necessary to determine the means by which a recognized and specific need may be met.

Experimental development is creative and systematic work, drawing on knowledge gained from research and practical experience, which is directed at producing new products or processes or improving existing products or processes. Like research, experimental development will result in gaining additional knowledge.

Research and development equipment includes acquisition or design and production of movable equipment, such as spectrometers, research satellites, detectors, and other instruments. At a minimum, this category includes programs devoted to the purchase or construction of R&D equipment.

Research and development facilities include the acquisition, design, and construction of, or major repairs or alterations to, all physical facilities for use in R&D activities. Facilities include land, buildings, and fixed capital equipment, regardless of whether the facilities are to be used by the Government or by a private organization, and regardless of where title to the property may rest. This category includes such fixed facilities as reactors, wind tunnels, and particle accelerators.

Comprehensive government-wide efforts are currently underway to increase the accuracy and consistency of the R&D budget via a collaborative community of practice of Federal agencies which have been working to identify best practices and standards for the most accurate classification and reporting of R&D activities. For example, to better align with National Science Foundation R&D surveys and international standards, starting with the FY 2018 Budget OMB has narrowed the definition of development to "experimental development." This definition, unlike the previous definition of development, excludes user demonstrations of a system for a specific use case and pre-production development (i.e., non-experimental work on a product or system before it goes into full production). Because of this recent change, the experimental development amounts reported are significantly lower than the development amounts shown in past Budgets. In particular, the change in definition of experimental development reduces R&D spending compared to what it would have been under the previous definition by approximately $38.7 billion in FY 2019.

III. OTHER SOURCES OF FEDERAL SUPPORT FOR R&D

The President's 2019 Budget seeks to build on strong private sector R&D investment by prioritizing Federal resources on areas that industry is not likely to support over later-stage applied research and development

Table 18–2. FEDERAL RESEARCH AND DEVELOPMENT SPENDING

(Mandatory and discretionary budget authority[1], dollar amounts in millions)

	2017 Actual	2018 Annualized CR	2019 Proposed	Dollar Change: 2018 to 2019	Percent Change: 2018 to 2019
By Agency					
Defense[3]	49,197	43,616	57,156	13,540	31%
Health and Human Services	34,222	33,772	24,742	–9,030	–27%
Energy	14,896	15,006	12,685	–2,321	–15%
NASA	10,704	10,243	10,651	408	4%
National Science Foundation	5,938	6,030	4,177	–1,853	–31%
Agriculture	2,585	2,487	1,914	–573	–23%
Veterans Affairs	1,346	1,338	1,345	7	1%
Commerce	1,794	1,833	1,361	–472	–26%

Table 18–2. FEDERAL RESEARCH AND DEVELOPMENT SPENDING—Continued

(Mandatory and discretionary budget authority[1], dollar amounts in millions)

	2017 Actual	2018 Annualized CR	2019 Proposed	Dollar Change: 2018 to 2019	Percent Change: 2018 to 2019
Transportation	904	929	826	–103	–11%
Interior	953	964	759	–205	–21%
Patient-Centered Outcomes Research Trust Fund	463	501	622	121	24%
Homeland Security	724	672	548	–124	–18%
Smithsonian Institution	251	242	271	29	12%
Environmental Protection Agency	497	496	269	–227	–46%
Education	254	243	240	–3	–1%
Other	561	629	490	–139	–22%
TOTAL[2]	125,289	119,001	118,056	–945	–1%
Total (using the former definition of Development)	***154,983***	***153,932***	***156,777***	***2,845***	***2%***
Basic Research					
Defense	2,215	2,244	2,284	40	2%
Health and Human Services	16,701	16,859	12,114	–4,745	–28%
Energy	4,802	4,601	3,398	–1,203	–26%
NASA	3,607	3,713	4,150	437	12%
National Science Foundation	4,739	4,818	3,402	–1,416	–29%
Agriculture	1,119	1,038	921	–117	–11%
Veterans Affairs	538	538	540	2	0%
Commerce	234	232	197	–35	–15%
Transportation	.....	.....	.....	.....	.....
Interior	54	54	40	–14	–26%
Patient-Centered Outcomes Research Trust Fund	.....	.....	.....	.....	.....
Homeland Security	49	53	31	–22	–42%
Smithsonian Institution	224	220	225	5	2%
Environmental Protection Agency	.....	.....	.....	.....	.....
Education	34	28	28	0	0%
Other	11	11	11	0	0%
SUBTOTAL	**34,327**	**34,409**	**27,341**	**–7,068**	**–21%**
Applied Research					
Defense	5,276	5,101	5,239	138	3%
Health and Human Services	17,356	16,685	12,348	–4,337	–26%
Energy	6,491	6,693	5,885	–808	–12%
NASA	2,476	2,517	2,713	196	8%
National Science Foundation	778	773	546	–227	–29%
Agriculture	1,070	1,055	904	–151	–14%
Veterans Affairs	780	774	779	5	1%
Commerce	979	961	733	–228	–24%
Transportation	594	602	497	–105	–17%
Interior	745	744	580	–164	–22%
Patient-Centered Outcomes Research Trust Fund	463	501	622	121	24%
Homeland Security	184	179	125	–54	–30%
Smithsonian Institution	.....	.....	.....	.....	.....
Environmental Protection Agency	420	418	228	–190	–45%
Education	133	135	132	–3	–2%
Other	403	421	317	–104	–25%
SUBTOTAL	**38,148**	**37,559**	**31,648**	**–5,911**	**–16%**
Experimental Development[2]					
Defense[3]	41,545	36,219	49,579	13,360	37%
Health and Human Services	27	35	35	0	0%
Energy	2,488	2,533	1,865	–668	–26%
NASA	4,569	3,991	3,734	–257	–6%
National Science Foundation	.....	.....	.....	.....	.....
Agriculture	174	173	163	–10	–6%
Veterans Affairs	28	26	26	0	0%
Commerce	303	322	191	–131	–41%

Table 18–2. FEDERAL RESEARCH AND DEVELOPMENT SPENDING—Continued

(Mandatory and discretionary budget authority[1], dollar amounts in millions)

	2017 Actual	2018 Annualized CR	2019 Proposed	Dollar Change: 2018 to 2019	Percent Change: 2018 to 2019
Transportation	275	293	296	3	1%
Interior	152	164	137	–27	–16%
Patient-Centered Outcomes Research Trust Fund	.....	.....	.....	.....	.....
Homeland Security	491	440	392	–48	–11%
Smithsonian Institution	.....	.....	.....	.....	.....
Environmental Protection Agency	75	75	41	–34	–45%
Education	87	80	80	0	0%
Other	149	199	157	–42	–21%
SUBTOTAL	50,363	44,550	56,696	12,146	27%
Subtotal (using the former definition of Development)	***80,057***	***79,481***	***95,417***	***15,936***	***20%***
Facilities and Equipment					
Defense	161	52	54	2	4%
Health and Human Services	138	193	245	52	27%
Energy	1,115	1,179	1,537	358	30%
NASA	52	22	54	32	145%
National Science Foundation	421	439	229	–210	–48%
Agriculture	222	221	–74	–295	–133%
Veterans Affairs	.....	.....	.....	.....	.....
Commerce	278	318	240	–78	–25%
Transportation	35	34	33	–1	–3%
Interior	2	2	2	0	0%
Patient-Centered Outcomes Research Trust Fund	.....	.....	.....	.....	.....
Homeland Security	.....	.....	.....	.....	.....
Smithsonian Institution	27	22	46	24	109%
Environmental Protection Agency	2	3	0	–3	–100%
Education	.....	.....	.....	.....	.....
Other	–2	–2	5	7	–350%
SUBTOTAL	**2,451**	**2,483**	**2,371**	**–112**	**–5%**

[1] This table shows funding levels for Departments or Independent agencies with more than $200 million in R&D activities in 2019.

[2] The total uses the new Experimental Development definition across the three fiscal years.

[3] The totals for Experimental Development spending in FY 2017-2019 do not include the DOD Budget Activity 07 (Operational System Development) due to changes in the definition of development. These funds are requested in the FY 2019 Budget request and support the development efforts to upgrade systems that have been fielded or have received approval for full rate production and anticipate production funding in the current or subsequent fiscal year.

that the private sector is better equipped to pursue. A key means of stimulating private sector investment and bridging Federal government research with industry development is through the transfer of technology. Federal technology transfer seeks to help enable domestic companies to develop and commercialize products derived from government-funded R&D, which can lead to greater productivity from U.S. R&D investments and ultimately promote the nation's economic growth. Recognizing the benefits of this mechanism, the 2019 Budget sustains funding for technology transfer efforts where appropriate. The Administration will also be launching a new initiative to enable and enhance the Federal government's transition of discoveries from laboratory to market as a Cross-Agency Priority Goal.

Because much of the Federally funded R&D is conducted outside of the government, the Administration seeks to reduce the associated burdens to funding recipients and partners in order to promote greater effectiveness and efficiency in our Federal spending. A significant effort to reduce the administrative and regulatory burdens associated with Federal R&D funding is currently underway through new interagency groups. One of these, an interagency working group on research regulation (as required by the Research and Development Efficiency Act), is examining ways to reduce the administrative burden on those performing Federally funded research. The Administration remains committed to reducing administrative burdens for all Federal grant recipients - not just those for R&D. Specifically, OMB plans to take actions on the recommendations outlined in the DATA Act Section 5 Pilot report, which identified specific opportunities to reduce recipient reporting burden.

The Federal Government also stimulates private investment in R&D through tax preferences. Historically, dating back to the 1950s, the private sector has performed the majority of U.S. R&D. As of 2015, businesses performed 72% of total U.S. R&D.[4] The research and experimentation (R&E) tax credit, which was made permanent through the Protecting Americans from Tax Hikes Act of 2015 (P.L. 114-113) and modified in the Tax Cut and Jobs Act of 2017 (P.L. 115-97), essentially provides a credit to qualified research expenses. R&E tax credit claims have at least doubled over the past two decades, growing from an estimated $4.4 billion in 1997 to $11.3 billion in 2013.[5] The manufacturing and the professional, scientific and technical services sectors account for about 70% of total claims in 2013.

[4] NSF National Center for Science and Engineering Statistics (Dec. 2017). InfoBrief - NSF 18-306.

[5] IRS Statistics of Income Division (August 2017). 1990-2013 Corporate Returns Data.

Novim

Warning Signs:
Effects of Proposed Federal Funding Cuts to Environmental and Climate Research and Development Programs

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Effects of Proposed Federal Funding Cuts to Environmental and Climate Research and Development Programs

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Foreword

The White House's Office of Management and Budget (OMB) has prepared the president's proposal for the *Budget of the U.S. Government Fiscal Year 2018 (FY 2018)* request which includes significant reductions to many agency programs. Especially noteworthy are the suggested cuts to climate and environment related research and development efforts.

Early signals from Congress indicate a strong reluctance to go along with many of the proposals. At this time, it is unclear how final FY 2018 appropriations will emerge and whether any or all of the reductions will be sustained. Nevertheless, the administration, through guidance from the OMB, has signaled to many federal agencies that the FY 2019 request will contain most of the same cuts proposed for FY 2018.

Novim believes that a rigorous assessment of the impacts of these changes on government scientific climate and environment programs is a necessary undertaking. This study will inform the general public, the scientific community and policymakers in both the administration and Congress of what the impacts may be.

Novim is a nonprofit scientific research group based at the University of California, Santa Barbara, that specializes in issues of global controversy. Novim is proud of its ten year history of summarizing the science behind these controversies without advocacy. Novim is grateful to the team of experienced scientists and research managers who have worked diligently to produce a report that will hopefully help guide future decision making.

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Executive Summary

Problems facing the United States today range from a changing climate to population growth; from urbanization and social change to reliable access to safe food, water, and energy. How the country responds to these future choices as a democracy is reflected in the annual budget decisions made by its government.

Climate and environment research and development (CE R&D), including continued investment in research, observations, modeling, assessments, workforce development, and working effectively with other nations are a part of meeting these challenges. This report documents the risks and impacts to our national, economic, societal, and environmental security and leadership if cuts to CE R&D included in the current administration's fiscal year FY 2018 budget proposal become a reality.

This study and resulting report provide an overall summary of the proposed FY 2018 reductions and an agency-by-agency detailed analysis. The president's FY 2018 budget proposes $7.86 billion for CE R&D, a roughly $2 billion or 21 percent reduction between FY 2017 and 2018, with significant reductions to most of the thirteen agencies in the climate and environmental portfolio.

The study focused on:

- Dismantling of programs designed to protect the health, economic prosperity, and safety of U.S. citizens.
- Disruptions in the continuity and integrity of ongoing and future observation and research infrastructure that contribute to climate and environmental modeling.
- Degradation of the country's ability to detect and understand critical climate and environmental trends and their influences on natural resources, including knowledge needed to manage future energy, water, food supply, and consumption.
- Reductions to programs used to train the next generation of scientists, resource managers, and decision makers who can work together to translate science into effective climate and environmental policies and approaches.
- Missed opportunities from past CE R&D investments.
- Reduction to the U.S. Global Change Research Program (USGCRP), which was initiated to

ensure the coordination and prioritization of federal CE R&D and report to Congress on the consequences of climate change.

- Diminution of the country's ability to meet legal and international climate and environmental commitments.

As this report was being written, Congress has been drafting appropriations legislation that may reject some of these reductions and may even restore programs to levels close to FY 2017 funding levels. However, final decisions have yet to be made by Congress for FY 2018. Nevertheless, the current administration has directed all federal agencies to build their FY 2019 budgets based on the fiscal plans laid out in the president's FY 2018 budget. As a result, the analysis in this report is as relevant for FY 2019 as it is for FY 2018.

Given the concerted efforts of federal agencies over the past thirty years to coordinate and responsibly steward federal resources, the CE R&D agency portfolio has focused on agreed to priorities with limited redundancy. Cuts of the scale proposed will have impacts that could be difficult, if not impossible, to reverse.

Introduction

The president's proposed fiscal year FY 2018 budget proposes $7.86 billion for climate and environment research and development (CE R&D), a roughly $2 billion or 21 percent reduction between FY 2017 and 2018, with significant cuts to most of the thirteen agencies in the CE R&D portfolio. This report examines the societal and environmental impacts and consequences of the FY 2018 budget proposal on federally-sponsored CE R&D, including: physical, life, engineering, and social science. The study also looks at particularly important policy or operational programs critical to climate and environment observations and support for international agreements. The report does not address clean energy technologies, general climate- and environment-related education programs, or routine operational climate and environment data and observation programs (e.g., operational weather satellites). While very important and also experiencing proposed cuts, these programs were not included in this study.

This report documents the impacts to the well-being of society and the environment should these CE R&D-related budget proposals become a reality. As this report was being written, the House and Senate were actively developing FY 2018 appropriations legislation for these CE R&D agencies and programs. Current draft appropriations legislation is rejecting some of the more dramatic reductions and may even restore some programs to levels close to their FY 2018 requested funding level. While promising, final congressional decisions on appropriations for FY 2018 will likely not be known until later in calendar year 2017 or early in calendar year 2018. These proposed budget reductions and decision delays are taking a significant toll on these programs, and uncertainties are hampering federal program managers' ability to make prudent fiscal decisions. Even relatively small reductions can have severe and irreversible impacts when they come late in a fiscal year.

Despite these congressional actions, on July 7, 2017, the Office of Management and Budget (OMB) issued a memorandum[1] to all federal agencies stating that the FY 2019 president's budget should continue to build on the fiscal plans laid out in the proposed FY 2018 budget. Should this happen, then federal support for CE R&D will continue to be under duress in the coming years. In this scenario, the impacts of such budget reductions will remain very real possibilities.

This report examines the potential impacts of the FY 2018 budget on all federal CE R&D, and includes a particular focus on the following five high-level themes:

- **Investment and Capacity.** Dramatic reductions in federal CE R&D support erode the U.S.'s ability to turn observations and modeling into understanding and innovation, resulting in missed opportunities from past investments. The erosion of the USGRCP and the inability of federal

[1] https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/memoranda/2017/M-17-28.pdf.

CE R&D agencies and program managers to move forward negatively impacts their ability to protect the health, economic prosperity, and safety of U.S. citizens and the environment.

- **Observations and Modeling.** Potentially irreversible breaks in continuity and integrity of ongoing and future CE R&D observations and research infrastructure needed for climate and environmental modeling.
- **Adaptation and Assessments.** Reductions or terminations to programs that translate CE R&D into impact assessments and adaptation and resiliency approaches, including the ability to detect and understand trends and influences on natural resources and manage future energy, water, and food supply, and consumption.
- **Workforce.** Reductions to programs that are training the next generation of climate- and environment-related researchers, and scientists, resource managers, and decision makers who can work together to translate science into effective climate and environmental policies and approaches.
- **International Commitments.** Diminution of the U.S.'s ability to meet legal and international climate and environmental commitments.

Summary of Agency Analysis

Table 1: Climate and Environment R&D Budgets by Agency (Dollars in Millions)[2]

	FY 2016 Enacted	*FY 2017 Estimate*	*FY 2018 Proposed*	*FY 17-18 Dollar Change*	*FY 17-18 Percent Change*
Department of Defense (DoD)	351	332	347	15	5%
Department of Energy (DOE)	315	305	124	-182	-60%
Department of Health & Human Services—National Institutes of Health (HHS-NIH)	770	792	593	-199	-25%
Department of Homeland Security (DHS)	72	66	59	-7	-10%
Department of the Interior (DOI)	741	741	600	-142	-19%
Department of State U.S. Agency for International Development (DOS-USAID)	693	760	102	-658	-87%
Environmental Protection Agency (EPA)	1,182	1,114	676	-438	-39%
National Aeronautics and Space Administration (NASA)	1,927	1,906	1,754	-154	-8%
National Oceanic and Atmospheric Administration (NOAA)	596	721	672	-49	-7%
National Science Foundation (NSF)	2,233	2,248	2,032	-216	-10%
Smithsonian Institution	766	766	766	0	0%
U.S. Army Corps of Engineers (USACE)	22	22	16	-6	-27%
U.S. Department of Agriculture	124	128	117	-11	-9%
Total	**$9,791**	**$9,903**	**$7,858**	**-$2,046**	**-21%**

Table 1 shows budget data for the thirteen agencies involved in CE R&D. Under the administration's FY 2018 proposed changes, a significant number of programs are targeted for cuts of more than 50 percent, including the Environmental Protection Agency's (EPA) air and energy research, sustainable communities, water quality research and support grants, and regional science and technology programs; U.S. Agency for International Development (USAID) Clean Technology Fund,

[2] Budget of the U.S. Government FY 2018; FY 2018 budget justifications; FY 2017 omnibus appropriations bill and reports; and FY 2018 agency spending plans. Totals may not add due to rounding.

Strategic Climate Fund, and Global Climate Change Initiative (GCCI); the Fish and Wildlife Service's (FWS) Landscape Conservation Cooperatives (LCC) and science support; and the Department of Energy's (DOE) atmospheric system research, terrestrial system research, subsurface biogeochemical research, climate model development and validation, regional and global model analysis, earth system modeling, integrated assessment, and data management programs.

Since the late 1980s, most of the agencies in Table 1 have contributed to the U.S. Global Change Research Program (USGCRP) and worked to improve the coordination and prioritization of federal global change research. The USGCRP was codified into law in 1990[3] to increase the effectiveness and productivity of federal global change research, with the requirement to report to Congress every four years on the environmental, economic, health, and safety consequences of climate change. The agency analysis below highlights the reductions and terminations impacting the USGCRP contributions.[4] Given the concerted efforts of the agencies over the past thirty years to responsibly steward federal resources through careful coordination, the USGCRP portfolio has very little redundancy. As a result, cuts of the scale proposed will have a particularly devastating and long-lasting impact.

In addition to the effects on the USGCRP, the following is a brief summary of the impacts and consequences of the president's FY 2018 CE R&D proposal utilizing the five high-level themes mentioned above.

Investment and Capacity

The cuts proposed would result in a significant reduction in the number, size, and duration of CE R&D program awards (e.g., grants, contracts, etc.) in both the intramural (i.e., occurring in laboratories or other facilities and major instruments owned by agencies, such as EPA laboratories, DOE national laboratories, Department of Interior [DOI] field installations, and National Aeronautics and Space Administration [NASA] satellites) and extramural CE R&D programs (i.e., occurring in laboratories and facilities not owned by agencies, such as universities and private-sector and not-for-profit laboratories).

These cuts will also have a significant impact on research facilities and infrastructure. For example, reductions in the National Science Foundation (NSF) budget will result in approximately 800 fewer awards, adversely impacting the careers of an estimated 2,500 senior scientists, postdoctoral students, graduate and undergraduate students, and a reduction of nearly 50 percent in the academic research fleet (supported by several federal agencies) by 2030 absent further investment. Proposed cuts to EPA would entirely eliminate its support to universities and industry. For the National Institutes of Health (NIH), the 2018 budget would reduce the number of new National Institutes of Environmental Health Sciences (NIEHS) research awards to universities by 20 percent,

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[3] https://www.govtrack.us/congress/bills/101/s169.

[4] This is not meant to be a recreation of the USGCRP crosscut. Agencies develop the USGCRP crosscut based on specific definition and will be reported some time in 2018 in the annual USGCRP "Our Changing Planet" report.

reduce the average size of a new NIEHS awards by 20 percent, reduce the success rate for all new NIH awards from 18 percent in FY 2016 to 14 percent, and reduce intramural NIEHS research by at least 20 percent. These cuts would result in a dramatic reduction of federal support of environmental health sciences research, including research to improve the understanding of contaminants that are dangerous to humans. If sustained, such reductions will result in a loss of new knowledge, the possible closure of federal labs and academic centers, and a decline in the education and training of the next generation of environmental scientists.

Reductions of 17 percent to the National Oceanic and Atmospheric Administration's (NOAA) Oceanic and Atmospheric Research (OAR) programs and 18 percent to the U.S. Geological Survey's (USGS) CE R&D will result in dramatic reductions in climate research carried out by NOAA and USGS laboratories and at academic institutions across the country. At the same time, the budget proposes to eliminate NOAA education programs related to environmental literacy and all the FWS programs for youth. The budget also eliminates NASA's Office of Education that supports the space grant program, a unique activity within each state. The proposed termination of DOI's LCCs and termination of four Climate Adaptation Science Centers (CASC) will result in a significant impact on cost-effective resource management options and, because these are collaborations with universities, the cuts will also have a significant impact on the training of students.

Observations and Modeling

Long-term, continuous, and consistent observational records are essential for testing hypotheses quantitatively and are a cornerstone of CE R&D modeling activities. These records are dependent on a variety of research observing networks and facilities, including satellites, ocean buoys, long-term ecological research, streamgage and groundwater monitoring, the academic research fleet, marine laboratories, and field stations. Most of these networks and facilities are being stressed significantly by the FY 2018 budget proposals. For example, four key NASA CE satellite missions (i.e., Plankton, Aerosol, Cloud, Ocean Ecosystem [PACE], Orbiting Carbon Observatory [OCO-3], Climate Absolute Radiance and Refractivity Observatory [CLARREO], and the Radiation Budget Instrument [RBI]) would be terminated. These missions are part of a coordinated approach for initiating and enabling long-term global observations of the land surface, biosphere, atmosphere, cryosphere, and oceans, and provide the continuation of key measurements needed for understanding critical earth system processes. These programs were also designed to overlap with earlier missions, enabling calibration of the data and ensuring a continued flow of vital information. Cuts to NSF's support to the National Center for Atmospheric Research (NCAR) may result in eliminating or significantly scaling back programs in atmospheric chemistry, climate and global dynamics, computational and information systems, climate modeling, earth observing, high-altitude observing, meteorology, and its research applications program.

For NOAA, the FY 2018 budget would terminate several surface and marine observations carried out by the National Weather Service (NWS) including the tsunami warning system and mid-range weather outlook. For DOE, cuts to climate modeling that range from 58 percent to complete

program termination will slow progress towards using exascale computers for models with greater certainty of predictions and at regional scales, where such information can inform planning and adaptation strategies. The likely result of these cuts at NOAA, NSF, NASA, and DOE will be to cede U.S. leadership in climate modeling over the next few years to other countries, and the loss of modeling capabilities to help local leaders incorporate climate change into their planning. This has both national security and economic implications.

Adaptation and Assessments

The loss of the critical measurements mentioned above will limit the ability of governments, businesses, and citizens to improve their decision-making processes for both short and long-term environmental issues. These types of global data are critical for addressing societal challenges in food, water, and, energy security. They inform decisions on how best to mitigate and adapt to the effects of environmental change for the general well-being of society.

NOAA provides competitive funding to assist communities in their efforts to strengthen their resilience in the face of severe weather and other environmental changes. Many of these efforts to support adaptation and assessments will be weakened by the FY 2018 budget proposals. Energy and water are interdependent—energy use is water-intensive and water treatment and delivery is energy-intensive. In addition, the food supply is entirely dependent upon the availability and quality of water and energy. DOE has been a leader in integrated assessments of this energy-water nexus using data, modeling, and analysis to improve understanding and inform decision-making about energy and water for a broad range of users and at multiple scales. In the proposed FY 2018 budget, the DOE energy-water nexus program is being cut by 87 percent, and put on the path to termination by the end of the fiscal year, reducing the national capacity to prepare for and meet coming increased demand for food, energy, and water. The information, modeling, and tools produced by the USGS are used by the government and private sector to support adaptive management efforts, such as managing forests during severe droughts; anticipating changes in permafrost, glaciers, and wildfire patterns in the Arctic; and understanding flood-related risk. The cuts to these programs will severely impact the nation's ability to adapt and respond to our changing environment, including extreme weather events.

Workforce

Federal research funding fuels our ability to conduct important research and educate and train the next generation of scientists and engineers. Reduced academic research funding will have a short-term impact on individual projects, but will have longer term effects on the technical workforce. Students' decisions to follow a career path are influenced by their perceptions of future funding and support of the field or industry. Given the time investment required for training for skilled jobs in climate and environment fields, shortages in the workforce cannot be recovered overnight. If proposed reductions in R&D funding in the climate and environment agencies are implemented, fewer undergraduates will have the opportunity to gain hands-on research experiences to prepare them for scientific careers. Graduate students may also be forced to leave school without earning their degrees given the lack of financial support to carry out the research

required for degree completion. According to the American Geosciences Institute,[5] the geoscience community is already facing a shortage of 135,000 geoscientists by 2022, including exploration geophysicists, hydrologists, petroleum geologists, and economic geologists. This shortage will become more pronounced with reductions in research and research training support.

Cuts at NSF will reduce support for up to 2,500 individuals, including senior scientists, post-doctoral students, graduate and undergraduate students. A 22 percent cut at NIH will dramatically reduce the number of workers trained in hazardous materials-related activities. These workforce cuts are occurring as some of the greatest economic competitors of the U.S. are moving aggressively into the green economy (mitigation and adaptation strategies and adopting renewable energy sources).

International Commitments

The Department of State U.S. Agency for International Development (DOS USAID) would be impacted by the largest decrease in both dollars ($658 million) and percentage (87 percent) of all the climate and environment programs highlighted in this report. While the DOS USAID does not fund CE R&D programs, it does support diplomatic and financial mechanisms to help influence, shape, and implement international CE policies and agreements. This happens through two significant processes: (1) supporting international efforts to provide the latest science related to CE policy issues, and (2) funding efforts to help implement international climate and environment agreements. The proposed DOS USAID reductions and terminations threaten the nation's ability to meet these legal and international climate commitments, many of which have resulted from more than twenty years of U.S. leadership and complex negotiations with allies and other nations around the world. This could result in distrust towards the U.S. on any subsequent international agreements.

Reductions to key NASA satellite programs will also impact ongoing commitments the U.S. has with other countries on climate and environment observational systems, the open sharing of data, and the ability to monitor key measurements that are critical parts of international climate and environment agreements. The EPA also has a range of CE R&D efforts supporting international agreements that are targeted for reductions or terminations. Funding reductions would also reduce NASA, NSF, DOE, DOI, and NOAA's research support for the interagency USGCRP. This will hinder the nation's ability to contribute to major international negotiations regarding changing climate conditions and the necessary and appropriate adaptation measures that must be undertaken. The proposed 2018 budget would: reduce support for Clean Air Allowance Trading Programs; all-but-eliminate the U.S. Greenhouse Gas Reporting Program; diminish EPA's capacity to prepare the statutorily mandated annual Inventory of U.S. Greenhouse Gas Emissions and Sinks; end several environmental partnership programs, including: ENERGY STAR, and the Global Methane Initiative; reduce EPA's ability to set National Ambient Air Quality Standards (NAAQS) for ambient pollutants; and eliminate U.S. government funding for the Multilateral Fund for the Implementation of the Montreal Protocol (MFIMP) on stratospheric ozone.

[5] http://sites.agu.org/careers/files/2014/10/Predicted-Workforce-Shortage.pdf.

Agency-by-Agency Analysis

Department of Defense (DoD)

Table 2: DoD CE R&D Funding by Program (Dollars in Millions) FY16[6]

	FY 2016 Enacted	*FY 2017 Estimate*	*FY 2018 Proposed*	*FY 17-18 Dollar Change*	*FY 17-18 Percent Change*
DoD-wide Programs					
Strategic Environmental Research & Development Program (SERDP)	54	65	72	7	10%
Environmental Security Technical Certification Program	51	52	55	2	4%
Department of the Army					
Environmental Quality Technology—Applied Research	20	22	22	-1	-2%
Environmental Quality Technology—Demonstrations	15	11	10	-1	-6%
Environmental Quality Technology—Demonstration/Validation	8	8	10	3	34%
Defense Research Sciences/Army					
Environmental Research (H67), Battlefield Env & Sig (53A), Single Investigator Basic Research (H57): Basic Research in Environmental Sciences, Environmental Science Basic Research (T25)	13	13	12	-1	-9%
Department of the Navy					
Environmental Protection	19	20	20	-0	-1%
Ocean Warfighting Environmental Applied Research	69	43	42	-0	-1%
Defense Research Sciences/Navy Atmosphere and Space Sciences	25	24	26	1	5%
Ocean Sciences	73	70	75	5	7%
Undersea Warfare Applied Research/ Marine Mammals	3	3	3	-0	-3%
Total	**351**	**332**	**347**	**15**	**4%**

[6] Budget of the U.S. Government FY 2018; DoD FY 2018 Budget Estimates (Research, Development, Test & Evaluation, Defense-wide, Justification Book Vol 3 of 5; Research, Development, Test & Evaluation, Army, Justification Book Vols. 2-4; Research, Development, Test & Evaluation, Navy, Justification Book Vols. 1-2 of 5). Totals may not add due to rounding.

DoD CE R&D funding falls under two major DoD-wide programs and within two of the four services, namely the Army and the Navy. As Table 2 shows, the FY 2018 request is up $14.7 million to $347 million, an increase of 4.4 percent over the FY 2017 enacted levels. Of the $14.7 million increase requested, $9 million is allocated to programs that focus on improving regulatory compliance and pollution prevention at military installations and $5.7 million is for military-related environmental research. DoD is not a member agency of USGCRP.

For context, the $347 million in CE R&D captured in Table 2 is less than 1 percent of the $54.3 billion requested in FY 2018 for DoD's R&D budget. The reported totals represent a lower limit on the DoD's CE R&D expenditures since a potentially large number of small projects are funded, but not explicitly referenced, through programs with an "environmental" label. Projects singled out for inclusion in the narrative are likely to be the subject of heightened oversight interest. The marine mammal research program reported under the Navy's Undersea Warfare Applied Research program is one example.

Pollution Prevention and Regulatory Compliance

DoD's largest department-wide program is the Strategic Environmental Research & Development Program (SERDP). SERDP is jointly planned and executed by the DoD, DOE, and the EPA, with strong participation by other federal agencies, industry, and academia. The program develops technologies that improve energy and water efficiency and increase the use of renewable energy on DoD installations; cleanup soil, sediment, and water contaminants; remediate military munitions on U.S. lands and water; manage DoD's natural and cultural resources; and reduce pollution from the manufacture, maintenance, and use of weapons systems.

In addition to the SERDP, DoD's Environmental Security Technical Certification Program (ESTCP), another department-wide program, supports demonstration projects that document the cost and performance of innovative environmental technologies deployed at DoD installations. Projects must target technical or programmatic risks that serve as barriers to adoption, so formal test and evaluation plans with rigorous technical reviews are required.

The administration's proposed budget continues the funding profiles for both programs as planned by the last administration. The FY 2018 budget request would increase these two programs by $8.8 million, an increase of 7.5 percent to a total of $126 million. The significant shifts in resources are within ESTCP from the Installation Energy Test Bed Initiative, reduced by $2.9 million, to technology demonstrations focused on groundwater restoration sites, underwater unexploded ordnance, and environmentally benign surface engineering technology at larger scales, all increased by $5 million.

The Army's largest climate and environment-related R&D program, Environmental Quality Technology (EQT) program, focuses on maintaining regulatory compliance while limiting future Army liability to installation operations and training, and maintaining resilient and adaptive ranges. The program spans three budget elements: applied research, demonstrations, and demonstration/validation projects. Topics include life cycle of military materials in the environment,

environmental effects of advanced materials and nanotechnology, risk prediction and decision technologies, as well as pollution prevention. The applied research program component develops tools to integrate climate change forecasts and data to assess impacts to installation decision metric values that affect Army enterprise planning decisions. The FY 2018 request for the three budget elements increases by $1.5 million to $42.6 million, with a positive adjustment to the base budget for pollution prevention technology demonstration/validation projects. A new program is being started for insensitive munitions wastewater treatment.

Analogous to the Army's EQT program, the Navy's Environmental Protection (EP) program focuses on environmental compliance, but is informed by the Navy's broad remit to operate in U.S., foreign, and international waters air, space, and land areas while complying with environmental laws, regulations, executive orders, and international agreements. Major program elements include projects that improve shipboard waste management, pollution prevention for base operations and maintenance activities, and marine mammal research. The president's FY 2018 budget requests $20.2 million for the EP program, with $3 million redirected to start a new project in accordance with a settlement agreement under the Marine Mammal Protection Act.

Military-Related Environmental Research

The Navy is the source of nearly half of all CE R&D in the DoD, and more than 85 percent of the Navy's environmental R&D is military mission related. The Navy's Ocean Warfighting Environmental Applied Research (OWEAR) program supports research on the natural sea environment that provides new or enhanced warfare capabilities for the Navy by measuring, analyzing, modeling, and simulating the natural environment for fleet operations and current or emerging weapons systems. Research activity is focused on the sources, distribution, and natural variability (concentration and properties) of optically important matters in the coastal ocean; marine mammals and biology, with a particular emphasis on adverse effects of underwater noise exposure; marine meteorology; ocean acoustics; physical oceanography; and the Navy's investments in the National Oceanographic Partnership Program (NOPP). Funding for the OWEAR research program is essentially unchanged from FY 2017 at $42 million in the FY 2018 budget request.

Environmental R&D is nearly a quarter of the Navy's $458 million Defense Research Sciences (DRS) budget—$103 million in the FY 2018 request, or approximately 23 percent. The atmosphere and space sciences program and the ocean sciences programs are two of the fifteen basic research areas supported within the Navy's overall DRS program. The atmosphere and space sciences program emphasizes understanding of the marine atmosphere, the tropics, polar regions, the ionosphere, while the ocean sciences program supports work in littoral geosciences and optics, marine mammals and biology, physical oceanography and prediction, and ocean acoustics. The FY 2018 budget request proposes an increase of $5.9 million, or 6 percent, to these basic environmental research efforts.

Environmental R&D is a small component of the Army's $264 million DRS budget—just $12.2 million in the FY 2018 request or approximately 5 percent. The FY 2018 budget request proposes

a $1.2 million, or 8.6 percent reduction to these efforts. Most of the reduction in the environmental sciences research components are attributable to a reduction in funding requested for the single investigator basic research program element.

Department of Energy (DOE)

Table 3: DOE CE R&D Funding by Program (Dollars in Millions)[7]

	FY 2016 Enacted	*FY 2017 Estimate*	*FY 2018 Proposed*	*FY 17-18 Dollar Change*	*FY 17-18 Percent Change*
Office of Science–Biological and Environmental Research—Earth and Environmental Sciences (EES)					
Atmospheric System Research*	26	26	12	-14	-54%
Environmental System Research Terrestrial Ecosystem Science*	40	40	10	-30	-75%
Subsurface Biogeochemical Research	23	22	10	-12	-55%
Climate and Earth System Modeling Climate Model Development and Validation*	15	10	0	-10	-100%
Regional and Global Model Analysis*	30	30	13	-18	-58%
Earth System Modeling*	36	35	13	-23	-64%
Integrated Assessment*	18	15	2	-13	-87%
Climate and Environmental Facilities Atmospheric Radiation Measurement (ARM) Research Facility*	65	65	34	-31	-48%
Environmental Molecular Sciences Laboratory (EMSL)*	43	43	25	-18	-42%
Data Management*	7	7	1	-6	-86%
SBIR/STTR Set-Aside	11	11	4	-7	-60%
Total, Office of Science—EES	**315**	**305**	**124**	**-182**	**-59%**

**Note: Elements marked with an asterisk are part of DOE's programmatic contribution to the U.S. Global Change Research Program.*

[7] DOE FY 2018 budget justifications and FY 2017 budget execution numbers provided to Congress. Program elements that are part of the USGCRP budget crosscut are marked with an asterisk. Totals may not add due to rounding.

In DOE, CE R&D is principally supported through the Earth and Environmental Sciences (EES) subprogram[8] of the DOE Office of Science. EES plays a leading role in federal climate change research, especially in understanding atmospheric and terrestrial ecosystem processes, advancing modeling of climate change, and analyzing the impacts and interdependencies of climatic change with energy production and use. Its work in climate model development and analysis focuses on two of the most critical areas of uncertainty in contemporary climate science—the impacts of clouds and aerosols—with data provided by the Atmospheric Radiation Measurement Climate Research Facility (ARM).[9]

A current strength of EES is its integration with the broader DOE efforts to advance high-performance computing to the next generation, termed exascale computing, after the prefix exa, which means a billion times a billion. EES also funds research on subsurface biogeochemical processes involved in nutrient cycling, radionuclide fate and transport, and water cycling.[10] Recent external scientific review of the subprogram has validated that it is well managed and funds high-caliber scientists producing high-quality science, with significant and internationally respected impact.[11]

As shown in Table 3, EES is slated for an overall funding cut of 59 percent in the FY 2018 proposed budget—the largest cut within the Office of Science. The high rating from external reviews of the program makes it unlikely that there is a substantive rationale for these cuts. The following are the impacts of the proposed DOE CE R&D budget reductions, grouped by the key themes of this report:

Loss of Past Investments and Capacity The EES program has built, over the years, significant facilities to study questions important to the understanding of earth system processes in the atmosphere (the Atmospheric Radiation Measurement Research Facility, or ARM), terrestrial ecosystems (the AmeriFlux network and major long-term ecological studies), and issues at the interface of energy and biology that relate to DOE's missions as they affect the environment (the Environmental Molecular Science Laboratory, or EMSL). These are national scientific user facilities and are unique and critical capabilities that can only be built and operated at the federal level. These past facility investments are significantly impacted by cuts proposed for FY 2018. ARM has established fixed sites for long-term measurements in Alaska, Oklahoma, and the Azores. It also has three mobile facilities that can deploy to other sites and collect focused measurements. Under the FY 2018 proposed budget, ARM will have to limit its observations in the Azores and

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[8] The title given to this program in the detailed FY 2018 budget for the DOE is used here—it was previously titled (and is sometimes referred to in DOE FY 2018 documentation) as "Climate and Environmental Sciences."

[9] DOE. FY 2017 Budget Request, p. 111.

[10] Ibid.

[11] DOE, Biological and Environmental Research Advisory Committee. 2016. "Report of the Committee of Visitors—Climate and Environmental Sciences Division, Office of Biological and Environmental Research, Office of Science, U.S. Department of Energy: Findings and Recommendations from a Review of Fiscal Years 2013-2015," available at https://science.energy.gov/~/media/sc-2/pdf/cov-ber/2016/BER_COV_2016_CES_Report.pdf.

put two of its three mobile facilities "in reserve," retaining only one mobile facility for targeted observations in the Southern Ocean.[12] The highly regarded AmeriFlux network, which measures ecosystem carbon dioxide, water, and energy fluxes at 110 sites in a wide variety of major climate and ecological biomes,[13] will be placed in "maintenance only" mode. EMSL has provided facilities and instrumentation for experimental and computational research in biological systems science, hydrobiogeochemistry, ecosystems science, vegetative emissions and aerosol chemistry, and interfacial chemistry and surface science relevant to EES's activities. It will be cut back by 42 percent, eliminating user access to facilities for research related to climate feedbacks and carbon, and a broad array of environmental science – from contaminant transport to molecular biology.[14]

The FY 2018 request also cuts, by 86 percent, funding to obtain maximum utility from the rich set of data and observations that result from EES activities, funding only the minimum required data archiving.[15] By ending funding for data curation, integration, and analysis, the FY 2018 request fails the test of good financial stewardship by allowing the trove of data accumulated by past EES research support to lie fallow and inaccessible.

Loss of Observations and the Basic Science and Modeling to Understand Observed Changes The budget cuts that will reduce the use and capability of past facility investments by DOE will also negatively affect the continuity and integrity of climate and environment observations and research to understand the implications of observed changes. EES research on atmospheric sciences which addresses two major areas of uncertainty in earth system models—the transmission, absorption, and balance of radiative energy in the atmosphere and the role of clouds and the effects of aerosols on precipitation—will be cut by 54 percent from FY 2017 funding, forcing DOE to cut funding of analyses of the role of anthropogenic aerosols and black carbon as climate-forcing agents.[16] These cuts—coming on top of the 48 percent cut in funding for ARM—will impede better understanding of clouds and aerosols as contributors to climate change, and thus, reduce the ability of decision makers to develop climate change mitigation and adaptation strategies

A different loss of continuity of observations will result from the 75 percent funding cuts to terrestrial ecosystem science,[17] including cuts to the AmeriFlux network. This will hamper efforts to better understand the effect of global warming on the terrestrial biosphere and its ability to act as a sink for CO_2—a key knowledge gap.[18] Subsurface biogeochemical research—which

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[12] DOE. FY 2018 Budget Request, p. 136.

[13] Lawrence Berkeley Laboratory. 2017. "About AmeriFlux: About the AmeriFlux Network," available at http://ameriflux.lbl.gov/about/about-ameriflux/ (last accessed July 2017).

[14] DOE. FY 2018 Budget Request, p. 136.

[15] Ibid., p. 137.

[16] Ibid., p. 134.

[17] Ibid.

[18] Ibid., p. 125.

illuminates the physical, chemical, and biological processes controlling the terrestrial component of the carbon cycle,[19] and helps the DOE manage and remediate contamination at sites where it previously conducted nuclear weapons-related research and manufacturing—will be cut by 55 percent. These cuts are likely to have negative consequences on food production, the understanding of the role of soil in reducing the impacts of carbon emissions, and on data collection related to cleanup and management of DOE's enormous group of contaminated sites.

A suite of three programs relating to improving climate models are slated for cuts ranging from 58 percent to outright program termination. These programs seek to inform national energy decisions by providing the tools that enable scenario evaluation (e.g., what are the global implications of various energy futures?). They do this by capturing a state of the science understanding of the function and interaction of various Earth systems, (especially those areas targeted by DOE research programs), and atmospheric and terrestrial ecosystem processes. These cuts will slow progress towards harnessing the next generation of exascale computers to develop new models that can provide greater certainty of predictions—especially at regional levels, where such information can inform planning and adaptation strategies of states and local government and businesses. While DOE will maintain support—at a greatly reduced level—for developing its Energy Exascale Earth System Model, it will end its joint effort with the NSF to advance the current leading U.S. climate model, the Community Earth System Model (CESM). The likely result of these cuts will be to cede U.S. leadership in climate modeling over the next few years to other countries that are not reducing their investments in cutting-edge modeling, leaving the U.S reliant on other countries to provide the most robust analyses of future scenarios.

Adaptation and Assessments Energy and water are interdependent—energy use is water-intensive and water treatment and delivery is energy-intensive. DOE has been a leader in integrated assessments of this energy-water nexus that use data, modeling, and analysis to improve understanding and inform decision-making about energy and water for a broad range of users and at multiple scales.[20] In the FY 2018 budget, integrated assessment activity is very hard hit, with an 87 percent cut, and appears to be placed on a glide path to termination at the end of that fiscal year, reducing the national capacity to prepare for and meet coming challenges in this area.

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[19] DOE. FY 2017 Budget Request, p. 125.

[20] Ibid., pp. 112-113.

Department of Health and Human Services (HHS)/ National Institutes of Health (NIH)

Table 4: HHS/NIH by Program CE R&D Funding by Program (Dollars in Millions)[21]

	FY 2016 Enacted	*FY 2017 Estimate*	*FY 2018 Proposed*	*FY 17-18 Dollar Change*	*FY 17-18 Percent Change*
National Institute of Environmental Health Sciences (NIEHS)					
Environmental Health Sciences	693	714	534	-181	-25%
NIEHS Superfund Appropriation	77	77	60	-17	-22%
Total	**770**	**792**	**593**	**-199**	**-25%**

NIH is the primary federal agency supporting biomedical and health sciences research. Within NIH, the National Institute of Environmental Health Sciences (NIEHS)—one of twenty-seven NIH institutes and centers—is the primary institute supporting CE-related R&D through its support of environmental health sciences research to fulfill its mission "to discover how the environment affects people in order to promote healthier lives."[22] NIEHS research focuses on diseases and other health conditions with a strong environmental component; although other NIH institutes support some environmental health research, they are not considered in this report. A key part of the NIEHS portfolio is its Superfund research program, focused specifically on environmental health research relevant to EPA's Superfund environmental-cleanup program. As Table 4 shows, the 2018 budget would cut NIH support of environmental health sciences research by 25 percent compared to the 2017 appropriation.

NIH is a relatively small but important sponsor of environmental sciences research. NIH supports 7 percent of all federal funding of environmental sciences research and 15 percent of all federal funding for environmental sciences research at universities, but NIH's share is considerably higher for the subfield of environmental health sciences.[23]

The following are the impacts of the proposed NIH CE R&D budget reductions in the key report themes:

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[21] AAAS, from Budget of the U.S. Government FY 2018; NIH 2018 budget justifications; FY 2017 omnibus appropriations bill and report. Note: Totals may not add due to rounding.

[22] NIEHS Mission Statement, "About NIEHS," https://www.niehs.nih.gov/about/index.cfm (accessed July 2017).

[23] National Science Foundation, National Center of Science and Engineering Statistics, *Survey of Federal Funds for Research and Development Fiscal Years 2015–17*, Data Tables, 2017. https://ncsesdata.nsf.gov/fedfunds/2015/ (accessed July 2017).

Reduce Investment and Capacity in Environmental Health Sciences Research NIEHS' core research program (non-Superfund) aims to prevent disease resulting from exposure to harmful aspects of the environment primarily through extramural competitive research grants to universities, alongside other extramural funding mechanisms and intramural research. Unlike past budgets, the 2018 budget does not provide programmatic details of the potential impacts of the proposed 25 percent cut to NIEHS core research.[24] Extrapolating from budget information for all of NIH,[25] the 2018 budget would reduce by at least 20 percent the number of new NIEHS research awards, reduce by at least 20 percent the average size of a new NIEHS award (in part due to a proposed 10 percent cap on indirect cost payments for all NIH awards), reduce the success rate for all new NIH awards (including NIEHS) to 13.7 percent from approximately 18 percent in FY 2016, and reduce NIEHS intramural NIEHS research by at least 20 percent. These cuts would result in a dramatic reduction of federal support of environmental health sciences research.

The NIEHS Superfund research program supports academic research on human health and environmental issues related to hazardous substances designed to improve understanding of environmental contaminants, which may lead to lower environmental cleanup costs in programs such as EPA Superfund, reduced risk of exposure, and improvements in human health.[26] The 22 percent cut to the NIEHS Superfund proposed in the 2018 budget would dramatically reduce university-based research on environmental contaminants.

Cut Key Workforce Training NIEHS Worker Training Program (WTP) As part of NIEHS Superfund, the NIEHS WTP awards grants focused on training workers engaged in activities related to hazardous materials and waste removal, containment, transportation, and emergency response. The 22 percent cut to the NIEHS Superfund proposed in the 2018 budget,[27] if allocated proportionately to WTP, would dramatically reduce the number of workers trained in hazardous materials-related activities.

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[24] Department of Health and Human Services, National Institutes of Health, *Congressional Budget Justification for the National Institute of Environmental Health Sciences (NIEHS) FY 2018 Budget*. May 2017.

[25] Department of Health and Human Services, National Institutes of Health, *Justification of Estimates for Appropriations Committees, Fiscal Year 2018, National Institutes of Health – Volume I: Overview*. May 2017.

[26] Department of Health and Human Services, National Institutes of Health, *Congressional Budget Justification for the National Institute of Environmental Health Sciences (NIEHS) Department of the Interior and Related Agencies Appropriations Superfund-Related Activities*, FY 2018 Budget. May 2017.

[27] Ibid.

Department of Homeland Security (DHS)

Table 5: DHS CE R&D Funding by Program (Dollars in Millions)[28]

	FY 2016 Enacted	*FY 2017 Estimate*	*FY 2018 Proposed*	*FY 17-18 Dollar Change*	*FY 17-18 Percent Change*
Coast Guard					
Research, Development, Test & Evaluation	25	20	19	-1	-5%
Waterways Management and Environmental Response (non-add)	*4*	*3*	*4*	*0.8*	*26%*
Arctic Operations (non-add)	*3*	*2*	*2*	*0*	*1%*
Science & Technology					
Apex Flood	5	5	5	0	0%
USCG/EPA Wide Area/Vessel Decontamination Project	0	0	3	3	100%
National Hurricane Technology Regional Resilience Assessment	1	1	1	0	0%
Technology Modernization	1	1	2	1	220%
University Programs	40	40	30	-10	-25%
Centers of Excellence R&D (non-add)	*36*	*36*	*26*	*-10*	*-28%*
Total	**72**	**66**	**59**	**-7**	**-11%**

DHS has a broad mission spanning domestic security, emergency response, border control, and customs enforcement. Some of the well-known units of DHS include the Coast Guard, the Federal Emergency Management Agency (FEMA), the Transportation Security Administration, the Secret Service, and the Immigration & Customs Enforcement Agency (ICE). DHS's Science & Technology Directorate (S&TD) manages research for the department's operational components and the nation's first responders. CE R&D at DHS, carried out by the Coast Guard and the S&TD, is a very small and declining component of the department overall. As shown in Table 5, DHS programs that support CE R&D are estimated to total $59 million in the FY 2018 budget request, less than 0.1 percent of the total agency request, and are down $7 million, or 11 percent, compared to the FY 2017 enacted level.

[28] Budget of the U.S. Government FY 2018; DHS FY 2018 Congressional Justifications (U.S. Coast Guard: Research, Development, Test, and Evaluation and Science & Technology: Research and Development); FY 2017 omnibus appropriations bill and report. Totals may not add due to rounding.

Coast Guard

The Coast Guard has eleven statutory missions: port and waterway security, drug interdiction, aids to navigation, search and rescue, living marine resources, marine safety, defense readiness, migrant interdiction, marine environmental protection, ice operations, and law enforcement. Although many of these missions have a significant environmental component, the Coast Guard itself is not a research-intensive agency. Coast Guard research activities total $18.6 million out of a total FY 2018 request of $10.7 billion for the agency. In addition, several Coast Guard research, development, test, and evaluation (RDT&E) programs include partnerships on a reimbursable basis with other parts of DHS, DoD, and other federal and private research organizations.

Within the Coast Guard's RDT&E budget, primary climate and environment-related R&D activities include waterways management and environmental response and research supporting Arctic operations. The waterways management and environmental response program supports R&D related to spill response technologies, non-indigenous species, fisheries management, marine safety, and aids to navigation. The Arctic Operations Program is focused on development of the next generation arctic navigation safety information systems and spill response technology concepts for ice. The FY 2018 request increases funding for these two activities 14 percent from $5.3 million to $6.1 million.

Aside from its research expenditures, the Coast Guard is recapitalizing its heavy polar icebreaking fleet. This is particularly important for the NSF, which relies upon Coast Guard heavy icebreakers for the annual resupply of Antarctica's NSF-operated McMurdo Station. The icebreaker acquisition program entered the "need" phase in July 2012, and transitioned to the "analyze/select" phase in June 2014. Currently, the Coast Guard is completing the required documentation to transition to the "obtain" phase planned for early FY 2018.

Science and Technology Directorate

This directorate conducts R&D in support of the missions of its sister organizations within DHS. The FY 2018 request for the S&TD is $144.4 million, or 19 percent below the FY 2017 enacted level, with the R&D cut more deeply at 21 percent than the operations and support line cut by 15 percent. The S&TD proposes closing three laboratory facilities in FY 2018: the National Urban Security Technology Laboratory (NUSTL), the Chemical Security Analysis Center (CSAC) and the National Biodefense Analysis and Countermeasures Center (NBACC) operations. Closure plans for Plum Island Animal Disease Center continue in preparation for the transition to the National Bio and Agro-Defense Facility (NBAF) in 2023. The proposed reductions in the operations and support line would eliminate forty-nine civilian DHS positions totaling twenty-five full-time equivalents alone if enacted with an unknown number of positions eliminated as a result of the proposed R&D cuts.

CE R&D within the S&TD is no less than 3 percent of the directorate's budget. Despite the overall negative outlook for DHS R&D, the FY 2018 budget requests $11 million for four environmental research efforts, an increase of $4.4 million (66 percent) over FY 2017 enacted levels. These efforts include: (1) the Apex Flood program focused on flood disaster resilience and flood prediction;

(2) the National Hurricane Technology program that develops decision support tools to increase responders' understanding of forecasting uncertainties and potential impacts of storm surge, winds, and inland flooding; (3) the Regional Resilience Assessment Technology Modernization effort to identify, develop, test and transition to operational use new tools to increase resiliency; and (4) a new USCG/EPA Wide Area/Vessel Decontamination project to rapidly characterize contamination, conduct decontamination, and manage waste, including wash water, to avoid a wide area release of *Bacillus anthracis* spores.

The University Programs Centers of Excellence (COE) R&D is slated for reductions in the FY 2018 budget request. The COE program would be cut from $36.3 million in FY 2017 to $26.3 million in FY 2018. The $10 million reduction, a 28 percent cut, will result in the elimination of three COEs: the Maritime Security COE, the Cross Border Threat Screening and Supply Chain COE, and the Counterterrorism COE. Of the seven COEs remaining, there are three environmentally-relevant COEs: The Center for Homeland Security Quantitative Analysis, which focuses on both security threats and natural hazards; the Arctic Domain Awareness Center; and the Center of Excellence for Coastal Resilience. The proposed cuts do not appear to significantly impact these three environmentally-relevant COEs.

Department of the Interior (DOI)

Table 6: DOI CE R&D Funding by Bureau (Dollars in Millions)[29]

	FY 2016 Enacted	*FY 2017 Estimate*	*FY 2018 Proposed*	*FY 17-18 Dollar Change*	*FY 17-18 Percent Change*
U.S. Geological Survey	573	572	471	-101	-18%
Fish and Wildlife Service	30	30	0	-30	-100%
Bureau of Land Management	48	48	38	-10	-20%
Bureau of Ocean Energy Management	68	68	74	6	9%
Bureau of Reclamation	22	24	16	-7	-31%
National Park Service	*	*	*	*	*
Total	**741**	**741**	**600**	**-142**	**-19%**

**National Park Service environmental research activities are commingled with other activities at the most detailed level presented in the DOI budget, so a numerical estimate is not provided.*

[29] DOI FY 2017 and FY 2018 Budget in Brief documents. Budget numbers for activities in FY 2017 are FY 2017 amounts under the continuing resolution in effect when the FY 2018 budgets were transmitted. Totals may not add due to rounding.

DOI is both the custodian of most of the public land owned by the federal government, and the pre-eminent funder and user of CE R&D relating to the use and stewardship of those lands, including research on the functioning of their ecosystems. The environmental science developed by DOI bureaus is essential to the proper management of the natural, biological, and cultural resources found on, and ecosystem services provided by, public lands.

As shown in Table 6, the president's FY 2018 budget for the DOI would impose a 19 percent overall cut in environmental research activities, for a total loss of research support of more than $140 million. Some important research activities would be eliminated under the budget request. The proposed cuts to the environmental R&D programs across DOI will disrupt the collection of environment- and climate-related data. This will forego a comprehensive understanding of how these lands, the ecosystems in which they are found, and the Earth's climate system are being altered by human influences—at the level of detail that enables the formulation of local and regional impact assessments and adaptation plans. CE R&D is conducted by the DOI bureaus in the following list.

U.S. Geological Survey (USGS)

The USGS is a scientific agency of DOI and conducts much of the department's CE R&D. This research is conducted by programs in several of the USGS's mission areas including Land Resources, formerly Climate and Land Use Change; Ecosystems; Water Resources; Environmental Health; and Natural Hazards. While the FY 2018 budget would cut the overall USGS budget by 13 percent from the FY 2017 continuing resolution baseline level,[30] the CE R&D-related programs would be cut by 18 percent.[31] The cuts to CE R&D across the USGS mission areas will impact the collection of long-term data sets and the ability to detect and understand environmental trends and influences on natural resources at integrated geographic levels (e.g., watersheds, coastal zones, ecosystems) as the following examples describe:

- The FY 2018 budget request of $112.8 million for Land Resources, $26.9 million below FY 2017,[32] would terminate or reduce several programs, including the closure of the National Civil Applications Program (NCAP) and four national and regional Climate Science Centers (CSC). The NCAP is a unique resource for the civil science agencies. It is the primary source of classified and commercial imagery and information to the civil agencies for research and operations. These cuts would also end long-term monitoring of more than 500 environmental sites around the globe that have been watched since the late 1990s using classified sensors. Cuts to the national and regional CSCs would impact the ability to provide on-the-ground observations and research required to understand how changes in climate, land uses, and associated changes in land cover are affecting the nation's natural resources and associated populations of fish and wildlife species essential to the nation's natural heritage.

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[30] DOI. 2017. Fiscal Year 2018 – The Interior Budget in Brief: May 2017 [FY 2018 Budget in Brief], p. BH-54.

[31] U.S. Department of the Interior [DOI]. 2017. Budget Justifications and Performance Information: FY 2018 – U.S. Geological Survey [USGS Budget Justification – FY 2018], p. A-2, available at https://www.doi.gov/sites/doi.gov/files/uploads/fy2018_usgs_budget_justification.pdf (last accessed July 2017).

[32] DOI. 2017. Fiscal Year 2018 – The Interior Budget in Brief: May 2017 [FY 2018 Budget in Brief], p. BH-55.

- Cuts to USGS CE R&D would likely result in cuts to the USGS contributions to USGCRP.
- In terms of maintaining continuity of measurements and observations, the proposed FY 2018 budget continues to develop the ground systems for Landsat 9 and prepare for a launch date in fiscal year 2021. The Landsat Program has run continuously since 1972 and this long-term data set has a wide range of uses, including tracking urban sprawl, monitoring the effects of climate change, and measuring the effect of deforestation on surrounding landscapes.
- For ecosystems, the FY 2018 budget request includes $132.1 million for ecosystems programs, $27.8 million below 2017.[33] The request focuses on nationally significant priorities, to detect and respond to invasive species, and to ensure the network of forty Cooperative Research Units (CRUs) at universities in thirty-eight states remains responsive to needs of state and federal resource managers. The request includes decreases for species-specific research and for focused research and monitoring in specific ecosystems. The proposed reductions would jeopardize the integrity of comprehensive long-term data sets that enable the U.S. to understand long-term environmental and ecological trends.
- The FY 2018 budget request includes $173.0 million for water resources, $37.2 million below 2017.[34] The request provides the capacity to conduct research on water use and drought, conduct water budget and water availability studies, and develop regional-scale water quality models and model-based decision support tools. The reductions will impact the ability to understand and manage future water availability and consumption at the local, regional, and national level.
- Since 1889 the USGS has operated a National Streamflow Information program that today includes 8,200 streamgages. The network provides data for flood forecasting, flood-control operations, and disaster mitigation and recovery, and the data are crucial to the reliability of the National Weather Service's river and flood forecasts. Although the proposed FY 2018 budget maintains support for this program, it would not allow for strengthening the network.
- The reductions would also suspend research on how contaminants move through the environment and whether they pose a risk to human or aquatic ecosystem health.

Fish and Wildlife Service (FWS)

Several FWS programs have a role in improving the use of science in conservation, but two specific efforts in the FWS have an identifiable focus on environmental research initiatives: LCCs and Science Support. The FY 2018 budget request would terminate all activities under these two programs,[35] including all staff associated with the 22 LCCs.[36] Environmental research initiatives in the FWS have

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[33] DOI. 2017. Fiscal Year 2018 – The Interior Budget in Brief: May 2017 [FY 2018 Budget in Brief], p. BH-55.

[34] Ibid.

[35] U.S. Department of the Interior [DOI]. 2017. Fiscal Year 2018—The Interior Budget in Brief: May 2017 [FY 2018 Budget in Brief], pp. BH-64.

[36] DOI. 2017. Budget Justifications and Performance Information: FY 2018—U.S. Fish and Wildlife Service [FWS Budget Justification – FY 2018], p. CLC-1, available at https://www.fws.gov/budget/2018/FY2018-FWS-Greenbook.pdf (last accessed July 2017).

been seen in the past as developing the high-quality science that allows FWS managers and their external stakeholders and collaborators to develop cost-effective management strategies, resolve and avoid conflicts, and strengthen the quality of the Department's public trust stewardship of the nation's lands and waters.[37] The National Academies reviewed the LCCs and concluded that, "The nation needs a landscape approach to conservation... [O]nly the LCC Network is designed to address this need at a national scale for all natural and cultural resources, and to bridge from research to management."[38] The loss of the cooperative environmental science activities under the LCCs, as well as funding for their integration into land management decisions by the host of entities responsible for managing federal and adjoining lands, will impede the development of cooperative and collaborative strategies aimed at better management outcomes for these lands. The termination of investment and capacity of science support efforts in the FWS will deprive it of the sound science on several emerging and high-impact questions relating to threats to fish and wildlife resources and will impede the development of scientific observations and modeling, tools, and techniques that could be applied to anticipate, monitor, and adapt to environmental changes and their effects on the lands. The result will be both the loss of science that could better ground such decisions, as well as the likelihood that future scientific research and projects undertaken by entities that had been cooperating in the LCCs will experience lack of coordination and duplication.

Bureau of Land Management (BLM)

Because the BLM programs also need to apply scientific research to attain conservation and management goals, this bureau carries out some environmental research activities. In recent years, three specific BLM activities have involved a greater emphasis on research activities: Assessment, Inventory and Monitoring program; Rapid Ecoregional Assessments (REA); and the National Seed Strategy for Rehabilitation and Restoration (NSSRR). The 20 percent cut to the resource management, assessment, and monitoring program rests most heavily on environmental monitoring research, as the program will

> "reprioritize [its] efforts to focus on the expansion of energy and mineral activities, including coal, oil and gas, and infrastructure development activities in support of the Administration's 'America First Energy Plan,' as well as the planning, monitoring, and assessment of other Administration priorities. This change in focus will result in fewer ongoing planning efforts in offices without potential for energy development or transmission."[39]

The REA and NSS have been funded in a cross-cutting manner, so while specific funding levels cannot be identified in the BLM budget, the FY 2018 budget request makes clear that the REA will be terminated and that there will be less funding for the NSSRR. BLM's termination of regional assessments and the loss of ready access by the public to the scientific reports from past assessments represents a loss in the ability to anticipate and intelligently manage the consequences

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[37] DOI. 2016. Fiscal Year 2017 – The Interior Budget in Brief [FY 2017 Budget in Brief], p. DH-55.

[38] National Academies of Sciences, Engineering, and Medicine. 2016. A Review of the Landscape Conservation Cooperatives (Washington, DC: The National Academies Press), p. 7, available at https://doi.org/10.17226/21829.

[39] DOI. 2017. Budget Justifications and Performance Information: FY 2018 – Bureau of Land Management [BLM Budget Justification – FY 2018], p. II-8, available at https://www.doi.gov/sites/doi.gov/files/uploads/fy2018_blm_budget_justification.pdf (last accessed July 2017).

of climate change and other human-caused disturbances in key landscapes in the U.S. What may also be lost is the opportunity to identify priority areas where ecosystem transition may be rapid, as well as elements of these landscapes that may be resilient to climate change and other stressors.

Bureau of Ocean Energy Management (BOEM)

BOEM has developed and used science as a foundation for managing offshore energy and mineral resources in an environmentally and economically responsible way. BOEM has a clear statutory mandate for its environmental programs and these programs are fundamental to decisions about offshore mineral leasing.[40] The budget increase proposed for BOEM environmental programs in FY 2018 is related to efforts by the Department to formulate a new five-year Outer Continental Shelf (OCS) Oil and Gas Leasing program for 2017-2022 to replace the current one, approved by the prior administration in January 2017. BOEM will undertake environmental analyses, including observations and modeling, in areas that previously were not under consideration. For this reason, the FY 2018 budget request has, within the overall totals for environmental programs, an increase of $8.6 million targeted to the new five-year OCS Oil and Gas Leasing program, with offsetting reductions of $1.5 million and $1.0 million in the budget lines for Environmental Studies Programs and IT Development.[41] While this represents a change in the geographic distribution of areas being studied under BOEM's environmental programs, it probably does not represent a meaningful diminution of this overall BOEM's scientific effort.

Bureau of Reclamations (BoR)

The BoR's $1.1 billion annual budget is focused on the operation of its facilities, large ecosystems restoration projects, and settling claims by Native Americans to water resources in the western U.S. Within the budget there are R&D activities that are environmental in nature. Some of the research has a very applied emphasis, but in recent years the research has also provided more fundamental work to strengthen the scientific basis of understanding of phenomena important to the bureau's operations. R&D related to climate change and variability has been aimed at improving the ability to predict, and effectively adapt to, the risks and impact of climate change and variability on western water resources. This is important because water in the western U.S. is expected to be significantly impacted by climate change.[42] In FY 2018, the overall Science and Technology Program is slated to be cut by 40 percent. Within that amount, it appears that the climate-related water resources research is being completely phased out.[43]

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[40] Outer Continental Shelf Lands Act, section 20 (a) and (b); 43 U.S.C. 1346(a) and (b), and FY 2018 Budget in Brief, p. BH-20, which states that "BOEM decisions and management of OCS oil and gas, marine minerals, and renewable energy development will continue to be informed through the environmental assessments, studies, and partnerships conducted through BOEM's Environmental Programs."

[41] DOI. FY 2018 Budget in Brief, p. BH-22.

[42] U.S. Global Change Research Program (2014) Climate Change Impacts in the United States: U.S. national climate assessment (http://purl.fdlp.gov/GPO/gpo48682).

[43] DOI. 2017. *Budget Justifications and Performance Information: Fiscal Year 2018—Bureau of Reclamation*, p. Bureauwide-57.

National Park Service (NPS)

Several NPS activities have a CE R&D component, the bulk of the research can be found in park management and stewardship. This funding provides park and resource managers with knowledge gained through systematic and critical investigations involving theoretical, taxonomic, and experimental investigations or simulations; responsive technical assistance; continuing education for park personnel; and cost-effective research programs that address complex landscape-level management issues. Research activities are commingled with other restoration and conservation activities, so funding numbers reflecting research alone cannot be derived from the DOI budget documents. Of the total $131.8 million reduction in the FY 2018 budget request for NPS park and program operations, $13.1 million would be taken from Natural Resource Stewardship. This represents a 6 percent decrease in funding from FY 2017 levels, which would affect all activities, including research and the ability to translate research into adaptation and resilience approaches at the park level, and would result in fewer natural resource conservation staff at the park level. Due to this decrease in investment and capacity, the NPS expects the percentage of acres managed in a natural condition that are in a desired condition could decrease 3.6 percent, the percent of acres infested with invasive plants which are controlled could decrease 0.3 percent, and the park populations of exotic invasive animal species effectively controlled could decrease 1.0 percent.[44]

Department of State–U.S. Agency for International Development (DOS–USAID)

Table 7: DOS–USAID CE R&D-Related Funding by Program (Dollars in Millions)[45]

	FY 2016 Enacted	*FY 2017 Estimate*	*FY 2018 Proposed*	*FY 17-18 Dollar Change*	*FY 17-18 Percent Change*
Global Environment Facility (GEF)	168	168	102	-66	-39%
Clean Technology Fund (CTF)	171	170	0	-170	-100%
Strategic Climate Fund (SCF)	50	60	0	-60	-100%
Green Climate Fund (GCF)	0	0	0	0	0%
Global Climate Change Initiative (GCCI)	304	362	0	-362	-100%
Total	**693**	**760**	**102**	**-657**	**-87%**

[44] NPS Budget Justification—FY 2018, p. ONPS-ResStew-4.

[45] Budget of the U.S. Government FY 2018; DOS 2018 budget justifications; FY 2016 and 2017 omnibus appropriations bills and reports. Totals may not add due to rounding.

DOS is the lead U.S. foreign affairs agency and the lead institution for the conduct of American diplomacy. Through DOS annual funding, the U.S. is the world's leading financial contributor to the United Nations Framework Convention on Climate Change (UNFCCC) and to the Intergovernmental Panel on Climate Change (IPCC)—the principal international organization for the assessment of scientific, technical, and socioeconomic information relevant to the understanding of climate change, its potential impacts, and options for adaptation and mitigation. Recent DOS contributions to these organizations provide substantial support for global climate observation and assessment activities in developing countries. DOS also works with other agencies in promoting international cooperation in a range of bilateral and multilateral climate change initiatives and partnerships.

USAID's climate change and development strategy calls for enabling countries to accelerate their transition to climate resilient, low emission sustainable economic development through direct programming and integrating climate-change adaptation and mitigation objectives across the agency's development portfolio. USAID leverages scientific and technical resources from across the U.S. government—for example NASA, NOAA, United States Department of Agriculture (USDA), USGS—as it applies its significant technical expertise to provide leadership in development and implementation of low-emission development strategies, creating policy frameworks for market-based approaches to emission reduction and energy sector reform, promoting sustainable management of agriculture lands and forests, and mainstreaming adaptation into development activities in countries most at risk. USAID bilateral programs work in key political and governance areas where multilateral agencies cannot.

The DOS and USAID do not support CE R&D directly. Their roles are largely to support diplomatic and financial mechanisms to help influence science-based international environmental and climate policies and agreements, including: (1) supporting UNFCCC efforts to provide the latest science related to environmental and climate policy issues like the IPCC, and (2) funding Climate Investment Funds (CIFs) to help implement international climate and environment agreements. In 2010, the Obama Administration created the GCCI to integrate climate change considerations into U.S. foreign assistance through a range of bilateral, multilateral, and private-sector mechanisms to promote sustainable and climate-resilient societies, foster low-carbon economic growth, and reduce greenhouse gas (GHG) emissions from deforestation and land degradation.

The current administration has promised to cease payments to the United Nations for climate change programs, and the administration has also articulated concerns about the overlap between these programs and whether the U.S. is paying an unfair share to support these international efforts. As shown in Table 7, the administration has proposed to significantly reduce funding for the GEF and eliminate the CTF and the GCCI—an overall 87 percent reduction to these programs.

International Commitments

The CTF, SCF, and GCF are designed to help implement current climate agreements like the 2015 Paris Accord signed by 195 countries to keep global warming to below two degrees Celsius.

Developed countries are largely responsible for the GHG emissions and subsequent warming of the planet since the industrial revolution. These funds are designed to help developing countries move away from fossil fuel-based economies since most of these countries have not significantly contributed to current warming and will disproportionally suffer given projected warming through the end of the century. The elimination or reduction of these efforts could: (1) unravel the more than twenty years of challenging yet productive international diplomacy relative to both climate and environmental issues, and (2) relegate civilization to another lost decade before addressing the issues facing future generations relative to a changing climate.

Environmental Protection Agency (EPA)

Table 8: EPA CE R&D Funding by Program (Dollars in Millions)[46]

	FY 2016 Enacted	*FY 2017 Estimate*	*FY 2018 Proposed*	*FY 17-18 Dollar Change*	*FY 17-18 Percent Change*
Science and Technology					
Clean Air	109	117	86	-31	-26%
Indoor Air and Radiation	6	6	3	-3	-44%
Enforcement	14	14	10	-3	-24%
Homeland Security	37	33	23	-10	-30%
IT/Data Management/Security	3	3	3	0	-12%
Operations and Administration	71	68	79	11	16%
Pesticides Licensing	6	6	5	-1	-17%
Research: Air and Energy	104	92	31	-61	-67%
Research: Safe & Sustainable Water Resources	115	106	69	-38	-36%
Research: Sustainable Communities	154	134	54	-80	-60%
Research: Chemical Safety & Sustainability	129	127	84	-43	-34%
Water: Human Health Protection	4	4	4	0	4%
Water Quality Research & Support Grants[46]	10	4	0	-4	-100%
Total, Science and Technology	**764**	**714**	**451**	**-263**	**-37%**
Environmental Programs and Management (selected programs)					
Clean Air	293	273	143	-130	-48%
Regional Science and Technology	2	2	0	-2	-100%
Science Advisory Board	4	4	4	0	-8%
Toxics Risk Review and Prevention	87	93	65	-27	-30%
Water Quality Research and Support Grants[47]	13	13	0	-13	-100%
Total, Environmental Programs & Management	**399**	**384**	**212**	**-172**	**-45%**
Superfund (selected programs)					
Science and Technology	19	15	12	-3	-20%
Oil Spill Response (research)	1	1	1	0	-24%
Total	**1,182**	**1,114**	**676**	**-438**	**-39%**

[46] Budget of the U.S. Government FY 2018; EPA 2018 budget justifications; FY 2017 omnibus appropriations bill and report. Totals may not add due to rounding.

[47] Funded out of EPA Science and Technology Account.

[48] Funded out of the EPA Environmental Programs and Management Account.

EPA is the primary environmental regulatory agency in the government, with a mission of protecting human health and the environment. EPA administers over a dozen major environmental laws, including the Clean Air Act; Clean Water Act; Solid Waste Disposal Act and Resource Conservation and Recovery Act; Comprehensive Environmental Response, Compensation, and Liability (or Superfund) Act; Toxic Substances Control Act; and the Federal Insecticide, Fungicide, and Rodenticide Act.

In executing its mission, EPA supports CE R&D and supports programs to utilize science and technology for environmental protection. Most of EPA's CE R&D is conducted by the Office of Research and Development (ORD), the principal scientific and research section of EPA supported primarily by the Science and Technology (S&T) account, through a network of EPA intramural laboratories. EPA also supports extramural research, and programs in Superfund research and oil spill response research. As Table 8 shows, the 2018 budget would cut EPA support of CE R&D and related activities by 39 percent compared to the 2017 appropriation.

EPA is a small but important sponsor of CE R&D, and an important sponsor of life sciences research and engineering, particularly environmental engineering.[49] EPA is also a contributor to the multi-agency USGCRP, contributing approximately $20 million annually from its Research: Air and Energy portfolio.[50] The following are the impacts of the proposed EPA CE R&D budget reductions in the key report themes:

Across-the-board Cuts to Environmental R&D Investments, Workforce, and Capacity

EPA supports intramural and extramural CE R&D and other disciplines related to EPA's environmental regulatory, cleanup, and enforcement missions. The 2018 budget would reduce funding for EPA's Science and Technology account—the primary funding source for EPA R&D and related science and technology activities—by 37 percent to $451 million.[51] Much of this funding supports the ORD, EPA's primary research office. Federal budget documents state:

> "At lower funding levels for the Office of Research and Development, the EPA would prioritize intramural research activities that are either related to statutory requirements or that support basic and early stage research and development activities in the environmental and human health sciences."[52]

The 2018 budget would eliminate EPA's extramural research support, primarily through the EPA

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[49] National Science Foundation, National Center of Science and Engineering Statistics, Survey of Federal Funds for Research and Development Fiscal Years 2015–17, Data Tables, 2017. https://ncsesdata.nsf.gov/fedfunds/2015 (accessed July 2017).

[50] U.S. Global Change Research Program. 2016. Our Changing Planet: The U.S. Global Change Research Program for Fiscal Year 2017. Washington, DC, USA, p. 42.

[51] See United States Environmental Protection Agency, FY 2018 EPA Budget in Brief, May 2017.

[52] Office of Management and Budget, Budget of the U.S. Government Fiscal Year 2018: Major Savings and Reforms, 2017, p.88.

Science to Achieve Results (STAR) grants program, resulting in dramatic reductions in research capacity for environmental R&D at academic institutions.

Federal government data show that roughly half of EPA's R&D funding is used by EPA's intramural laboratories, with the remainder allocated to industry and by universities and colleges.[53] If the proposed 2018 cuts are allocated as stated in EPA documents, then EPA support for university and industry CE R&D could be eliminated entirely. EPA budget documents state that the cuts to EPA S&T would result in a reduction of 715 work years, primarily of scientific and technical personnel inside and outside EPA.[54]

Other impacts would include: elimination of the Indoor Air Program; the S&T Homeland Security: Critical Infrastructure Protection Program; and all research programs labeled as climate change research, thereby eliminating EPA financial contributions to the USGCRP. The 2018 budget would also substantially reduce most EPA R&D efforts, including: sustainability and healthy communities research; computational toxicology; and drinking water research.

Reduce Science-based Environmental Programs that are Vital for Meeting U.S. Legal and International Commitments

EPA supports several science-based clean air programs, many with a connection to climate change monitoring and mitigation, most of the funding for which would be reduced dramatically in the 2018 budget. The 2018 budget would: reduce support for Clean Air Markets programs; all-but-eliminate the Greenhouse Gas Reporting Program; diminish EPA's capacity to prepare the statutorily-mandated annual Inventory of U.S. Greenhouse Gas Emissions and Sinks; end several environmental partnership programs, including ENERGY STAR, and the Global Methane Initiative; reduce EPA's ability to set NAAQS for ambient pollutants; and eliminate U.S. government funding for the MFIMP on stratospheric ozone.[55] These cuts would dramatically reduce the ability of the U.S. government to collect data on greenhouse gas emissions and jeopardize the ability of the U.S. to meet its environmental legal and international commitments.

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[53] NSF, Federal Funds Data.

[54] United States Environmental Protection Agency, Fiscal Year 2018 Justification of Appropriation Estimates for the Committee on Appropriations Tab 03: Science and Technology, May 2017.

[55] United States Environmental Protection Agency, Fiscal Year 2018 Justification of Appropriation Estimates for the Committee on Appropriations Tab 04: Environmental Programs and Management, May 2017.

National Aeronautics and Space Administration (NASA)

Table 9: NASA CE R&D Funding (Dollars in Millions)[56]

	FY 2016 Enacted	*FY 2017 Estimate*	*FY 2018 Proposed*	*FY 17-18 Dollar Change*	*FY 17-18 Percent Change*
Earth Science Research	478	462	407	-55	-12%
Earth Science Research and Analysis	347	333	288	-45	-13%
Computing and Management	131	130	119	-11	-8%
Earth Systematic Missions	915	928	779	-149	-16%
GRACE FO	60	34	21	-13	-39%
Other Missions and Data Analysis	855	894	758	-136	-15
Earth System Science Pathfinder	234	209	265	56	27%
Venture Class Missions	151	147	199	53	36%
Other Missions and Data Analysis	83	62	65	3	5%
Earth Science Multi-Mission Operations	192	205	197	-8	-4%
Earth Science Technology	61	63	60	-3	-4%
Applied Sciences	48	39	48	9	22%
Total, NASA Earth Science	**1,927**	**1,906**	**1,755**	**-151**	**-8%**

NASA is the largest federal sponsor of environmental sciences research. Primarily through the Earth Science Program (ESP) within the Science Enterprise, NASA funds approximately 29 percent of all federal CE R&D. NASA's ESP has the predominant responsibility for the development, deployment, and operation of satellite and airborne missions for environmental research.[57] These missions provide critical measurements initiating and enabling long-term global observations of the land surface, biosphere, solid Earth, atmospheres, cryosphere, and oceans. In addition, the NASA ESP conducts and sponsors basic and applied research to advance scientific understanding of the Earth including: how the global earth system is changing, what causes these changes now, and what will happen to the earth system in the future.[58]

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[56] NASA FY 2018 budget justifications and FY 2017 budget estimates provided to Congress. Totals may not add due to rounding.

[57] National Science Foundation, National Center of Science and Engineering Statistics, Survey of Federal Funds for Research and Development Fiscal Years 2015-2017, Data Tables, 2017 https://ncses.data.nsf.gov/fedfunds/2015/ (accessed July 2017)

[58] NASA Website https://www.nasa.gov/topics/earth/index.html.

The NASA FY 2018 budget includes $5.7 billion for the Science account, which includes Earth Science. While the Science FY 2018 budget would represent only a 0.9 percent reduction from the FY 2017 appropriation, the reductions are selective and focused primarily on Earth Science, one of the five major portfolios in Science. As shown in Table 9, Earth Science would decrease by 8 percent below FY 2017-enacted levels to $1.8 billion. The request proposes the elimination of three future climate missions all already in development: PACE, OCO-3, and CLARREO Pathfinder. The budget proposes to stop future work on the RBI, being built as part of the Joint Polar Satellite System 2, and the Carbon Monitoring System (CMS) being designed to enable assessment of greenhouse gas emissions from forests and other natural carbon stocks. The budget request includes no funding for the NASA-provided instruments, the Earth Poly-Chromatic Imaging Camera (EPIC) on the Deep Space Climate Observatory (DSCOVR) mission, which has been in operation since 2015. EPIC is a 10-channel spectroradiometer on board NOAA's DSCOVR space observatory. This instrument enables views of the Earth during sunlit time. Data obtained from the global spectra images are being used in science applications to measure aerosol levels, cloud dynamics, vegetation properties, and ozone, providing important data for climate science and also hydrology, biogeochemistry, and ecology.

Finally, the budget would reduce the Earth Science Research and Analysis Program account that supports a competitive merit-reviewed grants program for climate and environment research, including research utilizing data from the projects above.[59] More details on these programs can be found in the appendix.

The following are the impacts of the proposed NASA CE R&D budget reductions in the key report themes:

- **Observations and Modeling.** PACE, OCO-3, CLARREO, and RBI are being developed now to enable new, enrich, and/or maintain ongoing systematic measurements deemed essential by the research community for continued and further understanding the Earth's system. These missions are part of a coordinated approach for long-term global observations of the land surface, biosphere, atmosphere, cryosphere, and oceans, and provide the initiation of new and the continuation of key measurements needed for the advancement of research. One aim, where measurements already exist, is for the new missions to overlap with the older technologies enabling calibration of the data and ensuring a continued flow of vital information. In some cases, the instruments provide better data than previously generated. Termination will result in the lapse of critical data. These lost data cannot be obtained by starting new missions later in time. Instead, there will always be missing gaps in the knowledge base. Moreover, CLARREO is not only measuring the amount of reflected solar radiation emitted from Earth—which sheds light on radiation forcing, climate responses and feedback that are important variables within climate models—but also will be able to calibrate sensors of other

[59] NASA 2018 Budget Estimates https://www.nasa.gov/sites/default/files/atoms/files/fy_2018_budget_estimates.pdf

satellites that cross its path to ensure the integrity of the data. Elimination of these projects now in development will negatively impact the advancement of U.S. earth system models and the nation's ability to predict climate, weather, and natural hazards.

- **Adaptation and Assessments.** The loss of key measurements that would be provided from the previously mentioned missions along with the termination of the unique earth images obtained from DSCOVR will negatively impact the ability of the U.S. to assess the results of earth and climate variability on the health of oceans, water resources, and vegetation. In addition, the budget request proposes the possibility of terminating all existing awards and any future activities for the development and verification of the CMS. The anticipated outcome of the CMS is the development of products that will be useful in accurately measuring carbon emissions on a global level and to providing new information to better understand carbon emissions. Without this ability to monitor, understand, and assess change through these types of measurements and carbon accounting, the U.S. will be hindered in its ability to determine whether existing policies and practices are effective. NASA data being generated from their extensive observation network and their models are now being used by a broad range of interested parties, including policy makers, water managers, public health officials, wildfire teams, and others to inform decisions in a timely and sound manner. These types of global data are critical for addressing societal challenges in food, water, and, energy security. They inform the decisions on how best to mitigate and adapt to the effects of climate change for the general well-being of society.

- **Workforce.** Proposed reductions in the number of merit-reviewed grants that NASA awards will affect production of new scientific knowledge and reduce the number of researchers and trainees, including undergraduates, graduates and post-doctoral fellows who will be supported. Fewer undergraduates will have the opportunity to gain hands-on research experiences that have been shown to contribute to their career decisions, including continuation of education for advanced degrees.[60] There will also be fewer new graduate students admitted to academic programs in NASA-related fields, and existing graduate students may also be forced to leave without their degrees given the lack of financial support to carry out the research. Moreover, data have shown that students' decisions to enter fields are impacted by their perceptions of future funding opportunities.[61] Given the duration of time required for training for these skilled jobs, shortages in the workforce cannot be addressed overnight. The FY 2018 budget also proposes to eliminate NASA's Office of Education, which supports programs and activities focused on attracting and increasing the diversity of students in science, technology, engineering and math (STEM) fields. Many of the NASA-supported students find positions in government laboratories, aerospace, and geoscience-related industries as well as academia. In addition, the

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[60] Russell, Susan H., Mary P. Hancock, and James McCullough. "Benefits of Undergraduate Research Experiences." *Science*, Vol. 316, No. 5824 (27 April 2007), pp. 548-549. Available at http://www.sciencemag.org/content/316/5824/548.summary.

[61] Homer A. Neal, Tobin L. Smith, Jennifer B. McCormick. Beyond Sputnik: U.S. Science Policy in the Twenty-first Century, University of Michigan Press, 2008 (pp. 285-286).

cancellation of the RBI is one example where the decision could cause immediate termination of about one hundred employees of the contractor.[62]

- **International Commitments.** NASA has developed strong international agreements and cooperation to share its observations, data, and capabilities with the entire world. NASA's open data policy enables researchers from all over the world to use NASA measurements; in return, U.S. scientists and ultimately the American people benefit from data generated by observations systems monitored by other countries. NASA is an active participant in the Group on Earth Observations (GEO), an international body which promotes the open sharing of data among 105 member governments.[63] A main function of GEO's mission is to build the Global Earth Observation System of Systems (GEOSS). GEOSS is envisioned as a "coordinated, independent Earth observation, information and processing systems that interact and provide access to diverse information for a broad range of users in both public and private sectors. GEOSS links these systems to strengthen the monitoring of the state of the Earth."[64] In addition, NASA has signed a letter of agreement with the U.K.'s National Centre for Earth Observation (NCEO) in support of CLARREO, which is expected to be housed on the International Space Station (ISS) in the 2020 time frame. OCO-3 is already planned to be installed as a stand-alone payload on the Japanese module of the ISS after a launch in 2018. As noted earlier, the budget request also ceases the CMS, which could be used by any nation to understand its own carbon emissions and storage. To evaluate the effectiveness with which each country is achieving its goal requires accurate and precise measurements. Moreover, in the last ten years, carbon financial markets for trading of CO_2 emissions have emerged and are now valued in the billion-dollar range. The CMS could also contribute to the global economy since its successful deployment would provide reliable data for carbon trading activities.

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[62] http://www.journalgazette.net/news/local/20170526/budget-cut-would-end-local-work-for-nasa

[63] https://www.earthobservations.org/pos.php

[64] https://www.earthobservations.org/geoss.php

National Oceanic and Atmospheric Administration (NOAA)

Table 10: NOAA CE R&D Funding by Program (Dollars in Millions)[65]

	FY 2016 Enacted	*FY 2017 Estimate*	*FY 2018 Proposed*	*FY 17-18 Dollar Change*	*FY 17-18 Percent Change*
National Ocean Service	77	68	59	-9	-13%
National Marine Fisheries Service	77	68	56	-13	-19%
Oceanic and Atmospheric Research	395	422	350	-72	-17%
National Weather Service	22	20	13	-7	-33%
Nat'l Satellite, Data, & Info Service	26	22	29	7	34%
Mission Support		5	0	-5	-100%
Office of Marine & Aviation Ops		117	164	47	40%
Total	**596**	**721**	**672**	**-49**	**-7%**

Through its mission of science, service, and stewardship, NOAA advances the understanding of and ability to anticipate changes in the Earth's environment by improving society's ability to make scientifically informed decisions, and by conserving and managing ocean, coastal, and Great Lakes resources. Science at NOAA is the systematic study of the structure and behavior of the ocean, atmosphere, and related ecosystems; integration of research and analysis; observations and monitoring; and climate and environment modeling. Science provides the foundation and future promise of the service and stewardship elements of NOAA's mission. Service is the communication of NOAA's research, data, information, and knowledge for use by the nation's businesses, communities, and people's daily lives. Stewardship is NOAA's direct use of its knowledge to protect people and the environment, as the agency exercises its authority to regulate and sustain marine fisheries and their ecosystems, protect endangered marine and anadromous species, protect and restore habitats and ecosystems, conserve marine sanctuaries and other protected places, respond to environmental emergencies, and aid in disaster recovery.

For FY 2018, NOAA is requesting a budget of $4.8 billion, a reduction of nearly $1 billion from FY 2017. Within this budget, NOAA has protected support for its current generation of polar orbiting satellites, at-sea monitoring infrastructure, management of commercial and recreational

[65] Amounts for NOAA Environmental R&D are based on NOAA's estimates for *Research and Development Investments* contained within NOAA's annual Budget Estimates Submitted to the Congress. FY 2017 Estimate is based on amounts contained in NOAA's FY 2017 current (spending) plan submitted to House and Senate Appropriations Committees in June 2017. Totals may not add due to rounding.

fisheries, and domestic seafood production via aquaculture. NOAA-owned laboratories and centers are emphasized at the expense of extramural programs such as the National Sea Grant College Program. Sea Grant provides more than $65 million in support to thirty-three land grant colleges and universities for ocean, coastal, and Great Lakes research, extension, and outreach. Sea Grant outcomes in FY 2015-16, helped generate an estimated $575 million in economic impacts; created or sustained nearly 21,000 jobs; provided 534 communities with technical assistance on sustainable development practices; worked with about 1,300 industry, local, state and regional partners; and supported the education and training of almost 2,000 undergraduate and graduate students. Other extramural NOAA programs proposed for termination or severe reductions include: the Prescott Marine Mammal Stranding Grant Program and university-based cooperative research institutes; and competitive climate research grants.

As reflected in Table 10, NOAA's CE R&D is proposed to decline by an estimated 7 percent or $49 million. If ship and aircraft acquisition costs carried out in the Office of Marine and Aviation Operations (OMAO) are excluded from the R&D totals, the reduction in support for CE R&D in NOAA's program offices would be $96 million—a 16 percent reduction. The programs and facilities proposed for termination or reduction related to NOAA CE R&D are described in the appendix to this report.

The following are the impacts of the proposed NOAA CE R&D budget reductions in the key report themes:

- **Loss of Investment and Capacity.** Under the Administration's FY 2018 budget plan, OAR would decline to $350 million, a 17 percent reduction compared to the FY 2017 funding level. By way of example, this would dramatically reduce NOAA's support for climate research carried out by NOAA's own laboratories and at academic institutions across the country. At the same time the budget proposal eliminates NOAA education programs related to environmental literacy. If sustained, such reductions will result in a loss of new knowledge, the possible closure of one or more NOAA laboratories and/or university cooperative institutes, and a decline in the education and training of the next generation of geoscientists.

- **Observation and Modeling.** NOAA plays a critical role in sustained observations and dissemination of various forms of environmental data. The FY 2018 budget would terminate several surface and marine observations carried out by the NWS including the tsunami warning system and mid-range weather outlook. The FY 2018 budget request would reduce competitive funding on such data and modeling activities as: atmospheric chemistry; Carbon Cycle and Climate (AC4) program; and the Modeling, Analysis, Predictions and Projections (MAPP) data archive.

- **Adaptation and Assessments.** NOAA's climate activities, which include state-of-the-art models, observations, and outlooks, result in data, tools, and information that enable people to understand and prepare for climate variability and change. NOAA also provides competitive funding to assist communities in their efforts to strengthen their resilience in the face of severe

weather and other environmental changes. Many of these efforts to support adaptation and assessments will be weakened via the FY 2018 budget proposals.

National Science Foundation (NSF)

Table 11: NSF CE R&D Funding by Program (Dollars in Millions)[66]

	FY 2016 Enacted	*FY 2017 Estimate*	*FY 2018 Proposed*	*FY 17-18 Dollar Change*	*FY 17-18 Percent Change*
Biological Sciences	724	747	672	-75	-8%
Engineering[67]	184	184	168	-15	-10%
Geosciences	877	875	783	-91	-7%
Polar Programs	449	441	409	-32	-10%
Total	**2,233**	**2,248**	**2,032**	**-216**	**-10%**

NSF's annual budget represents 27 percent of the total federal budget for basic research conducted at U.S. colleges and universities, and an estimated 63 percent of all federal support for academic CE R&D. In many science and engineering fields NSF is the primary source of federal academic support.

NSF addresses CE R&D issues by funding merit-reviewed research proposals, submitted largely by the academic community, that seek to advance the frontiers of knowledge; providing state-of-the-art instrumentation, facilities and observatories; developing new analytical methods; enabling cross-disciplinary collaborations; and educating a diverse, highly-trained workforce. As shown in Table 11, under the FY 2018 budget proposed by the administration, NSF support for CE R&D would decline by nearly 10 percent from the FY 2017 level. A more detailed assessment of the impact of such a budget reduction on NSF is contained in the appendix to this report.

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[66] FY 2017 Estimate is based on amounts contained in NSF's FY 2017 current (spending) plan submitted to House and Senate Appropriations Committees in June 2017. With the exception of the amounts shown in Engineering, the amounts displayed in this table are the total for each disciplinary directorate at NSF. Unless otherwise noted, these amounts come from the annual Budget Estimates NSF provides to the Congress. Totals may not add due to rounding.

[67] This amount is the Division of Chemical, Bioengineering, and Transportation Systems Research (CBET) within the Directorate for Engineering. CBET provides a substantial amount of the support for environmental R&D in the Engineering Directorate.

Much of NSF's support for CE R&D is focused on understanding fundamental processes involved in physical, biological, and human system interactions. Examples include research in the areas of ecosystem dynamics, atmospheric chemistry, biogeochemical cycles, coastal ocean processes, population biology and physiological ecology, Earth system history, and solar influences. NSF also supports research activities across all scientific and engineering disciplines to address issues related to the preservation, management, and enhancement of the environment. Areas of interest include air and water quality, biodiversity, environmental technology, natural disaster risk reduction, water and watersheds research, and risk assessment.

The following are the impacts of the proposed NSF CE R&D budget reductions on the key report themes:

- **Investment and Capacity.** NSF has long invested in the development of new knowledge and the physical infrastructure necessary for cutting-edge research, most of which is conducted at U.S. colleges and universities. The proposed budget reductions in FY 2018 will reduce funding opportunities in CE R&D, leading to an estimated 800 fewer awards in FY 2018 compared to FY 2017. By way of example, such budget constraints will reduce research opportunities via the academic fleet. The academic fleet, with its unique research capabilities developed via sustained investments by NSF, the U.S. Navy, NOAA, and other entities, is facing a reduction from thirty-five vessels in FY 2015 to eighteen vessels by 2030 absent further investment. Funding reductions would also reduce NSF's research support for the interagency USGCRP. This will hinder the nation's ability to contribute to major international negotiations regarding changing climatic conditions and the necessary and appropriate adaptation measures that must be undertaken.

- **Observation and Modeling.** Long-term, continuous, and consistent observational records are essential for testing hypotheses quantitatively and are a cornerstone of NSF CE R&D activities. NSF supports a variety of research observing networks and facilities for example, ocean observing, long-term ecological research, the academic fleet, marine laboratories, and field stations that complement, and are dependent on, the climate and environment monitoring systems maintained by its federal partners. NSF also supports major national centers, such as NCAR, that develop and provide models that aid the research community in predictions such as severe weather, hydrological cycles, and climate change. The proposed budget reductions will reduce the opportunities to gather necessary CE data and observations. For example, NCAR with its unique high-performance computing capabilities, modeling, and observing capabilities has already had to significantly scale back one of its laboratories. NCAR laboratories have programs in atmospheric chemistry; climate and global dynamics; computational and information systems; earth observing; high-altitude observing; mesoscale and microscale meteorology; social science, and a research applications program.

- **Workforce.** The FY 2018 budget reductions, in addition to a loss of approximately 800 fewer awards for CE R&D, would also reduce support for up to 2,500 individuals, including senior scientists and post-doctoral, graduate, and undergraduate students. Fewer funding

opportunities and awards will discourage potential graduates from pursuing careers in the geosciences. According to the American Geosciences Institute, the geoscience community is already facing a shortage of 135,000 geoscientists by 2022[68]—including exploration geophysicists, hydrologists, petroleum geologists, and economic geologists. This shortage will only become more pronounced with reductions in research and research training support.

Smithsonian Institution

Table 12: Smithsonian Institution CE R&D Funding by Program (Dollars in Millions)[69]

	FY 2016 Enacted	*FY 2017 Estimate*	*FY 2018 Proposed*	*FY 17-18 Dollar Change*	*FY 17-18 Percent Change*
Smithsonian Tropical Research Institute	191	191	191	0	0%
Smithsonian Environmental Research Center	32	32	32	0	0%
National Zoo	208	208	208	0	0%
National Museum of Natural History	335	335	335	0	0%
Total	**766**	**766**	**766**	**0**	**0%**

The Smithsonian Institution is the world's largest museum and research complex, consisting of nineteem museums and galleries, the National Zoological Park, and nine research facilities. The Smithsonian was created as a result of a bequest to Congress. It is a charitable trust administered by a board of regents and a secretary (private side), and also receives federal appropriations (public side). The Smithsonian funds its environmental and climate R&D activities with both federal and nonfederal funds. The federal funds are essential to the continued ability of the Smithsonian to serve society with world-class science in organismal biology, genetics, ecology and conservation. For example, its insect collections are essential to the understanding of the transmission of Zika, West Nile virus, and other mosquito-borne diseases. The Smithsonian is a founding partner in the USAID-funded Emerging Pandemic Threats Program, which helps public health officials avoid the next major pandemic.

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[68] http://sites.agu.org/careers/files/2014/10/Predicted-Workforce-Shortage.pdf

[69] Smithsonian FY 2018 budget justifications and FY 2017 budget estimates provided to Congress. Note: Totals may not add due to rounding.

All of the Smithsonian's R&D activities are characterized as basic research and are performed intramurally by its more than 500 scientists, and its facilities are used by scholars and students from around the world. The Smithsonian is strongly connected with the overall research enterprise of the federal government. Researchers from at least a dozen other federal entities work at the National Museum of Natural History (NMNH). Some of the museum's economically important collections such as parasites and other organisms that affect agriculture are housed at research facilities of the U.S. Department of Agriculture and other entities.

Smithsonian climate and environment research is done in support of the Smithsonian Grand Challenges Consortia. The grand challenge, Understanding and Sustaining a Biodiverse Planet, states that "the Smithsonian will use the resources of its scientific museums and research centers to significantly advance the knowledge and understanding of life on Earth, respond to the growing threat of environmental change, and sustain human well-being."[70]

The challenge includes a research goal: The Smithsonian advances and synthesizes knowledge that contributes to the survival of at-risk ecosystems, and an access goal: The Smithsonian inspires all generations of learners to turn knowledge of life on Earth into awareness and action aimed at improving sustainability. The Smithsonian supports hundreds of undergraduate and graduate students and postdoctoral fellows. The units primarily associated with this Grand Challenge are:

- **Smithsonian Tropical Research Institute (STRI)** The STRI is located in Panama and is, along with the National Museum of Natural History, the principal U.S. organization dedicated to advancing fundamental scientific discovery and understanding of biological diversity in the tropics. STRI hosts more than 1,400 resident and visiting international scientists annually.

- **Smithsonian Environmental Research Center (SERC)** The SERC is on the Chesapeake Bay and supports research on the ecological interconnections of aquatic, terrestrial, and atmospheric components of complex landscapes, with comparative studies on regional, continental, and global scales. Key areas of research are water quality, fisheries, invasive species, conservation, land use, toxic chemicals, and global change.

- **National Zoo** The Zoo provides leadership in animal care, conservation science, education, sustainability, and visitor experience. The zoo includes the **Smithsonian Conservation Biology Institute**, headquartered in Front Royal, Virginia, which facilitates and promotes research programs at six centers.

- **NMNH** The NMNH includes a museum on the National Mall and also scientific collections of well over 145 million biological specimens, many housed in a state-of-the-art collections storage

[70] Smithsonian Institution Fiscal Year 2018 Budget Request to Congress https://www.si.edu/sites/default/files/about/fy_2018_cjb_linked_table_of_contents.pdf

facility in Suitland, Maryland; a marine science research facility in Ft. Pierce, Florida; and field stations as far away as Belize, Alaska, and Kenya.

Each of the units in this grand challenge is proposed to be level-funded. While level funding compares well to the proposed 2018 budgets of most other federal science entities, the Smithsonian is dealing with chronic underfunding relative to the demands for its facilities and knowledge. Many positions such as curators at the NMNH have been unfilled for years. The Smithsonian budget requests notes, "Currently, the Institution has vacancies within our collections staff, impacting our ability to provide optimal care for collections. These vacancies hinder our ability to strengthen and share our collections with diverse national and international audiences."[71] The potential consequences of a static budget include slower responses to new diseases that can potentially kill people, other animals, and plants; reduced capacity to understand how climate and other types of environmental change affect people and ecosystems; and reduced ability to develop techniques to protect endangered and threatened species. The impacts by the five report themes are:

- **Investment and Capacity** The Smithsonian's scientific collections and research facilities are an essential part of the nation's scientific infrastructure. Chronic underfunding has limited the rate that records of scientific collections can be digitized and made more easily accessible to other researchers.

- **Workforce** The Smithsonian is essential for training future conservation biologists and species experts. The lack of capacity of scientists to discover and describe the world species is a chronic issue[72] that limits development of biologically-based products and in general the ability to describe and protect life on Earth.

- **International Commitments** The Smithsonian houses the world's largest collection of biological specimens, which are used by researchers worldwide. The knowledge generated by scientists at the STRI and the NMNH is essential to protecting the world's tropical rainforests—the most biodiverse ecosystem on Earth and critical to moderating the world's climate and weather. The U.S. is party to international conventions protecting the world's biodiversity.

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[71] Smithsonian Fiscal Year 2018, p. 8. https://www.si.edu/sites/default/files/about/fy_2018_cjb_linked_table_of_contents.pdf

[72] Systematics Agenda 2000. Systematics agenda 2000: charting the biosphere. Technical Report. New York: Systematics Agenda; 1994. pp. 1–34.

U.S. Army Corps of Engineers (USACE)

Table 13: USACE CE R&D Funding by Program (Dollars in Millions)[73]

	FY 2016 Enacted	*FY 2017 Estimate*	*FY 2018 Proposed*	*FY 17-18 Dollar Change*	*FY 17-18 Percent Change*
Civil Works, Total	5,989	6,038	5,002	-1,036	-17%
Research and Development	22	22	16	-6	-27%

As the nation's environmental engineer, the USACE Civil Works program manages several federal environmental missions: restoring degraded ecosystems; constructing sustainable facilities; regulating waterways; managing natural resources; and cleaning up contaminated sites from past military activities.

Climate and environment-related R&D activities are focused on navigation research to improve the efficiency, reliability, and capacity of the nation's complex, aging transportation/power network; flood and coastal storm damage reduction research that responds to demands for emergency management, water supply, and recreation; and environmental research related to USACE's regulatory responsibilities on more than eleven million acres of land and water resources.

As Table 13 shows, the total civil works request is more than $1 billion below the FY 2017 enacted funding level. As many analysts of USACE budgets will note, administrations traditionally propose reductions to the USACE knowing that Congress will reject the cuts. Against this baseline expectation, the Trump Administration's FY 2018 request for the USACE is approximately $400 million more than the Obama Administration's last request for FY 2017 and is consistent with President Trump's emphasis on infrastructure investments.

[73] Budget of the U.S. Government FY 2018; USACE 2018 budget justifications, Volume II – Remaining Items; FY 2017 Consolidated Appropriations Act (House Committee Print, Book 1, Divisions A-F, H.R. 2029); FY 2018 House E&W Appropriations (H.Rpt. 115-230, H.R. 3266). Totals may not add due to rounding.

U.S. Department of Agriculture (USDA)

Table 14: USDA CE R&D Funding by Program (Dollars in Millions)[74]

	FY 2016 Enacted	*FY 2017 Estimate*	*FY 2018 Proposed*	*FY 17-18 Dollar Change*	*FY 17-18 Percent Change*
Agricultural Research Service	203	202	189	-14	-7%
National Institute of Food and Agriculture	147	152	130	-22	-15%
U.S. Forest Service	291	290	259	-31	-11%
Total	**641**	**644**	**578**	**-76**	**-12%**

The USDA has broad responsibilities in the areas of farm services; food safety; food, nutrition, and consumer services; marketing and regulatory programs; rural development; natural resources and environment; and research, education and economics. The USDA Research, Education, and Economics (REE) mission area is conducted through the Agricultural Research Service (ARS) and is primarily intramural; the National Institute of Food and Agriculture (NIFA) which is primarily extramural, the Economics Research Service (ERS), and the National Agricultural Statistics Service (NASS). The USDA Natural Resources and Environment (NRE) mission area is conducted through the U.S. Forest Service (USFS). Climate and environment research at USDA is conducted through ARS, NIFA, and the USFS.

The FY 2018 request for discretionary budget authority to fund the USDA programs and operating expenses is about $21 billion, approximately $4.8 billion less than FY 2017. The budget proposes $2.5 billion for agricultural research and related activities. As shown in Table 14, a total of $578 million is proposed for CE R&D, a reduction of $76 million, or 12 percent from FY 2017.

Agricultural Resource Service

The ARS is the USDA's chief in-house scientific research agency. Less than 20 percent of the ARS budget is focused on the environment. Environmental stewardship is under the Natural Resources and Sustainable Agricultural Systems National Program. ARS research programs in environmental stewardship "emphasize developing technologies and systems that support profitable production and enhance the nation's vast renewable natural resource base."[75] The ARS budget proposes

[74] USDA FY 2018 Budget Summary (https://www.obpa.usda.gov/budsum/budget_summary.html); USDA FY 2018 Budget Justification (https://www.obpa.usda.gov/budsum/fy18budsum.pdf)

[75] https://iapreview.ars.usda.gov/pandp/locations/NPSLocation.htm?modecode=02-02-00-00

the termination of many intramural and extramural research projects and the closure of seventeen laboratories, locations, or worksites. The budget requests $189 million for Environmental Stewardship, a reduction of $13.7 million, or 7 percent from FY 2017. The budget would include a decrease of $17.5 million from twenty-three ongoing research projects at sixteen USDA facilities. The reductions include projects related to water, soil, rangelands, forage, cropping systems, genetics, climate change, air quality, and bioenergy.[76]

The National Institute of Food and Agriculture

NIFA is the USDA's major extramural research agency, spanning the biological, physical, and social sciences related to agricultural research, economic analysis, statistics, extension, and higher education. NIFA provides funding for projects conducted in partnership with state agricultural experiment stations, state cooperative extension system, land-grant universities, colleges, and other research and education institutions, as well as individual researchers. More than half $854 million of the NIFA FY 2017 budget of $1.5 billion goes to research and education. An additional $475 million goes to extension programs. Less than 20 percent of the NIFA research budget is classified here as CE R&D. NIFA administers USDA's primary competitive research grants program, the Agriculture and Food Research Initiative (AFRI), which supports investigator-initiated research with the strong potential to contribute to major breakthroughs in the food, agricultural, natural resource, and human sciences.

The FY 2018 budget requests approximately $1.3 billion in discretionary funding for NIFA, including nearly $350 million for AFRI. NIFA would experience a net decrease of $48.5 million for research and education activities for a total of $769.6 million. About half of the proposed decreases equaling $22 million are in climate and environment research, including in AFRI, the Sustainable Agriculture Program, and McIntire-Stennis Cooperative Forestry Grants.[77] However, the budget cuts may be greater as six former AFRI challenge grant areas that included climate change, sustainable bioenergy, and water—which totaled $64 million in FY 2017—will be consolidated with three non-climate and environment areas (nutrition, food safety, and food security) in a new program called Sustainable Agricultural Systems with a total budget of $65 million.

U.S. Forest Service

USFS manages 154 national forests and twenty grasslands encompassing 193 million acres of land; 439 wilderness areas totaling more than thirty-six million acres of land; twenty national recreation areas; six national scenic areas; six national monument areas; two national volcanic monument areas; and two national historic areas. These lands are managed under the principles of multiple-use and sustained yield. Multiple-use includes the extraction of timber and other forest products; forage of livestock; mineral extraction; outdoor recreation; conservation of watershed, wildlife, fish and other natural resources; and other purposes.

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[76] 2018 President's Budget Agricultural Research Service https://www.obpa.usda.gov/18arsexnotes2018.pdf

[77] 2018 President's Budget National Institute of Food and Agriculture https://www.obpa.usda.gov/19nifaex-notes2018.pdf

Research and development by the USFS supports the sustainable management of the nation's forests and rangelands. Approximately 6 percent of the overall budget of the USFS, which is $4.8 billion discretionary, is devoted to CE R&D. For FY 2018, $259 million is proposed for Forest and Rangeland Research, a net decrease of $31.4 million or 11 percent, including drastic 16 percent cuts for all programs other than inventory and monitoring.[78]

The primary impacts of the proposed cuts at ARS and NIFA will fall upon farmers, ranchers, and the agricultural industry that depend upon USDA research to better understand the impacts of environmental change on agricultural production and to develop strategies to sustain agricultural production without damaging the soil and water systems that are the basis for cropping systems. The proposed reductions in USFS research will hurt the sustainable management and resilience of forests and their water, air, soil, and fish and wildlife resources. The cuts would reduce the ability of forest managers to protect forests and nearby communities from fire and invasive species.

The aggregate impacts of these proposed cuts could lead to more forests and homes damaged by fire, more erosion, reduced air and water quality, more flooding, and more outbreaks of disease and pests, resulting in potentially higher prices for food and lumber and reduced human health and nutrition.

[78] FY 2018 Budget Justification USDA Forest Service https://www.fs.fed.us/sites/default/files/usfs-fy18-budget-justification.pdf

Appendix 1—Additional Agency Details

Department of Energy (DOE)

The work of the DOE in environmental research has its origin in studies of the distribution and fate of radionuclides released during atomic weapons tests. The atmospheric circulation studies of that era were the forerunners of modern climate models.[79] As the nuclear era developed, it was also recognized that radioisotopes could provide significant insight into other large-scale global processes—for example, the seminal paper on the use of radium-226 as an oceanographic tracer was published in the 1958 Proceedings of the Second Geneva Conference on Peaceful Uses of Atomic Energy.[80]

DOE's support for research at the nexus of energy and the environment grew with the developing appreciation of the interconnection of energy production, energy use, and the environment, with an emphasis on bringing to bear the capabilities developed by the DOE in other arenas (e.g., high-performance computing). As a result, DOE, through the EES subprogram[81] of the DOE Office of Science, plays a leading role in federal climate change research, especially in understanding atmospheric and terrestrial ecosystem processes, advancing modeling of climate change, and analyzing the impacts and interdependencies of climatic change with energy production and use. EES works in climate model development and analysis using models developed by the broad scientific community, notably the CESM, the Energy Exascale Earth System Model (E3SM, previously known as the Accelerated Climate Model for Energy), and the Global Change Assessment Model (GCAM). These leading U.S. models are used to address two of the most critical areas of uncertainty in contemporary climate science—the impacts of clouds and aerosols—with data provided by the Atmospheric Radiation Measurement Climate Research Facility (ARM).[82]

A current strength of EES is its integration with the broader DOE efforts to advance high-performance computing to the next generation of exascale computing (the prefix "exa" means a billion times a billion). Exascale computing systems are envisioned to carry out at least one exaFLOPS, or a billion times a billion floating point operations per second. This represents a thousand-fold increase in computing power over the first petascale computer that started

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[79] U.S. Department of Energy [DOE]. 2016. Department of Energy FY 2017 *Congressional Budget Request: Volume 4—Science and Advanced Research Projects Agency—Energy* [FY2017 Budget Request], p. 111.

[80] R.F.C. Mantoura, "Opening Statement," *Isotopes in Environmental Studies: Aquatic Forum 2004* (Vienna: International Atomic Energy Agency, 2006), p. 4.

[81] The title given to this program in the detailed FY 2018 budget for the DOE is used here – it was previously titled (and is sometimes referred to in DOE FY 2018 documentation) as "Climate and Environmental Sciences."

[82] DOE. FY 2017 Budget Request, p. 111.

operating in 2008. Exascale computing will provide a new level of capability to model the earth system and climate change. Many climate models that have been run on previous generations of high-performance computers have operated at coarser geographic scales, and phenomena such as atmospheric turbulence could be left out of the modeling without great consequence. As climate models improve to address smaller geographic scales—needed to provide regional and local predictions—phenomena like turbulence must be factored into the modeling. Incorporating phenomena like turbulence into models, though, is both complex and computationally intensive. Getting to a new level of capability in climate modeling, then, requires a transition to exascale computer architectures. For this reason, the EES program works closely with the main program in the Office of Science that is developing exascale computing, the Advanced Scientific Computing Research (ASCR) Program. For example, the ASCR program provides processing hours on the highest-performance computers in the DOE national laboratories to projects that advance the state of the art in computer modeling across a range of scientific disciplines. In FY 2017, climate and earth-system computational projects are receiving a combined total of 247 million processing hours in these leadership computing facilities, as part of the ASCR program's Leadership Computing Challenge.[83]

Linkage to the U.S. Global Change Research Program

The portion of the EES subprogram that relates to climate change is included in the overall federal budget coordinated through USGCRP and reported to Congress as required by the Global Change Research Act of 1990. Within the USGCRP, this program is the fourth largest of the ten agencies reporting climate-related research in the USGCRP's Budget Crosscut.[84] Among federal programs in this interagency research effort, the EES subprogram plays a special and important role in supporting research on atmospheric processes, terrestrial ecosystem processes, climate change and environmental modeling, and analysis of impacts and interdependencies of climatic change with energy production and use. The subprogram has provided leadership among federal agencies in advancing the understanding of the physics and dynamics governing clouds, aerosols, and atmospheric GHGs, as these represent the more significant weaknesses of climate prediction systems. EES has also supported multidisciplinary climate and environmental change research to advance experimental and modeling capabilities necessary to describe the role of the individual (terrestrial, cryospheric, oceanic, and atmospheric) component and system tipping points that may drive sudden climate change.[85]

In addition to its climate-related work, the EES subprogram also funds research on subsurface biogeochemical processes involved in nutrient cycling, radionuclide fate and transport, and water

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[83] DOE. 2017. "ASCR Leadership Computing Challenge (ALCC): Current Awards," available at https://science.energy.gov/ascr/facilities/accessing-ascr-facilities/alcc/alcc-current-awards/ (last accessed July 2017).

[84] U.S. Global Change Research Program. 2016. *Our Changing Planet: The U.S. Global Change Research Program for Fiscal Year 2017*, p. 42.

[85] DOE. 2016. "Biological and Environmental Research (BER): Research," available at https://science.energy.gov/ber/research

cycling.[86] These topics are important to understanding energy-environment interconnections, but are not principally related to climate change and are not part of the USGCRP Budget Crosscut.

External Reviews

The EES subprogram was reviewed by an external Committee of Visitors in 2016, focusing on program activities during FY 2013 to FY 2015. The committee found that the subprogram was well managed, that the principal investigators in the various projects funded by the subprogram were high-caliber scientists, and that the science produced by the subprograms was of high quality. The committee judged the EES subprogram to have made significant impacts on the respective scientific fields it was funding, and that observed that it was well respected by the national and international scientific community.[87]

Budget Changes in FY 2018 Budget Request

A summary of recent budgets and the FY 2018 Budget request are shown Table 15. The 59 percent cut in overall funding for the EES program from FY 2017 to FY 2018 is the largest budget cut within the Office of Science in the president's FY 2018 request. Two overarching effects of these cuts will be evident throughout the discussion of the EES subprogram that follows. First, the special role that EES plays in supporting continuous, high-resolution, and long-term observations in areas that relate to energy and climate will be curtailed. Second, the future ability to understand the significance of these observations and the changes that they are documenting of the operation of the Earth's climate system and to major ecosystems will be impeded.

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[86] DOE. 2016. "Biological and Environmental Research (BER): Research," available at https://science.energy.gov/ber/research

[87] DOE, Biological and Environmental Research Advisory Committee. 2016. "Report of the Committee of Visitors—Climate and Environmental Sciences Division, Office of Biological and Environmental Research, Office of Science, U.S. Department of Energy: Findings and Recommendations from a Review of Fiscal Years 2013-2015," available at https://science.energy.gov/~/media/sc-2/pdf/cov-ber/2016/BER_COV_2016_CES_Report.pdf (last accessed July 2017).

Table 15: DOE CE R&D Funding by Program (Dollars in Millions)[88]

Office of Science—Biological and Environmental Research—Earth and Environmental Sciences (EES)	*FY 2016 Enacted*	*FY 2017 Estimate*	*FY 2018 Proposed*	*FY 17-18 Dollar Change*	*FY 17-18 Percent Change*
Atmospheric System Research*	26	26	12	-14	-54%
Environmental System Research Terrestrial Ecosystem Science*	40	40	10	-30	-75%
Subsurface Biogeochemical Research	23	22	10	-12	-55%
Climate and Earth System Modeling					
Climate Model Development and Validation*	15	10	0	-10	-100%
Regional and Global Model Analysis*	30	30	13	-18	-58%
Earth System Modeling*	36	35	13	-23	-64%
Integrated Assessment*	18	15	2	-13	-87%
Climate and Environmental Facilities					
Atmospheric Radiation Measurement (ARM) Research Facility*	65	65	34	-31	-48%
Environmental Molecular Sciences Laboratory (EMSL)*	43	43	25	-18	-42%
Data Management*	7	7	1	-6	-86%
SBIR/STTR Set-Aside	11	11	4	-7	-60%
Total, Office of Science—EES	**315**	**305**	**124**	**-182**	**-59%**

**Note: Elements marked with an asterisk are part of DOE's programmatic contribution to the U.S. Global Change Research Program.*

Atmospheric Sciences Research

EES research on atmospheric sciences—which addresses two major areas of uncertainty in earth system models: the transmission, absorption, and balance of radiative energy in the atmosphere and the role of clouds and the effects of aerosols on precipitation—will be cut by 54 percent

[88] DOE FY 2018 budget justifications and FY 2017 budget execution numbers provided to Congress. Program elements that are part of the USGCRP Budget Crosscut are marked with an asterisk. Totals may not add due to rounding.

from FY 2017 funding (see Table 15), forcing DOE to cut funding of analyses of the role of anthropogenic aerosols and black carbon as climate-forcing agents.[89] In addition to these program cuts, EES's ARM facility, which provides unique, multi-instrumented capabilities for continuous, high-resolution, and long-term observations that inform atmospheric science analyses, will be cut by 48 percent. These cuts—which will reduce the continuity of ongoing and future observations, and the ability to understand the significance of these observations through modeling—will impede better understanding of clouds and aerosols as contributors to climate change.

These cuts matter because there is a wide uncertainty band around the currently accepted values for describing the contribution to climate change of aerosols and black carbon (i.e., radiative forcing). In the most recent IPCC Fifth Assessment Report, the best estimate for the radiative forcing due to aerosol-radiation interactions was given as -0.35 W m^{-2}, with a 5 percent to 95 percent uncertainty range of –0.85 to +0.15 W m^{-2}.[90] The atmospheric radiative forcing for black carbon was estimated to be +0.40 (+0.05 to +0.80) W m^{-2}, with an additional forcing of +0.04 (+0.02 to +0.09) W m^{-2} due to its effects of reducing albedo on snow and ice.[91] The climate forcing effects of black carbon could be on the range of methane (CH4) as a greenhouse gas (0.48 ± 0.05 W m^{-2}),[92] but with much larger uncertainties, so further research to understand its impact on climate change is important.

Terrestrial Ecosystem Science

A different loss of continuity of observations will result from the 75 percent funding cuts to terrestrial ecosystem science,[93] reducing to "maintenance only" the highly regarded AmeriFlux network, which measures ecosystem carbon dioxide (CO2), water, and energy fluxes at 110 sites in a wide variety of major climate and ecological biomes.[94] This will hamper efforts to better understand the effect of global warming on the terrestrial biosphere and its ability to act as a sink for CO_2—a key knowledge gap.[95]

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[89] DOE. FY 2018 Budget Request, p. 134.

[90] Myhre, G., D. Shindell, F.-M. Bréon, W. Collins, J. Fuglestvedt, J. Huang, D. Koch, J.-F. Lamarque, D. Lee, B. Mendoza, T. Nakajima, A. Robock, G. Stephens, T. Takemura and H. Zhang, 2013: Anthropogenic and Natural Radiative Forcing. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)] (New York: Cambridge University Press, 2013), p. 662.

[91] Ibid., pp. 683, 685.

[92] Ibid., p. 678.

[93] DOE. FY 2018 Budget Request, p. 134.

[94] Lawrence Berkeley Laboratory. 2017. "About AmeriFlux: About the AmeriFlux Network," available at http://ameriflux.lbl.gov/about/about-ameriflux/ (last accessed July 2017).

[95] DOE. FY 2017 Budget Request, p. 125.

Subsurface Biogeochemical Research

Subsurface biogeochemical research—which illuminates the physical, chemical, and biological processes controlling the terrestrial component of the carbon cycle,[96] and helps the DOE manage and remediate contamination at sites where it previously conducted nuclear weapons-related research and manufacturing—will be cut by 55 percent. DOE will try to maintain research in the fate and transport of subsurface elements and hydrological cycling, uptake, and acquisition by plants and microbes. This is intended to improve integration with the Terrestrial Ecosystem Science activities and facilitate multi-scale, very high-resolution process modeling from the bedrock to the canopy.

Climate Model Development and Validation/Regional and Global Model Analysis/Earth System Modeling

A suite of three programs relating to improving climate models are slated for cuts ranging from 58 percent to outright program termination. These cuts will slow progress towards harnessing the next generation of exascale computers to develop new models that can provide greater certainty of predictions—especially at regional levels, where such information can inform planning and adaptation strategies.

The programs being cut include specific scientific analyses to address uncertainties in current models or to bring greater scientific depth and spatial resolution to the treatment of important climate-related phenomena, especially at the regional level. For example, this program has funded work that significantly improved the predictability of clouds and precipitation in climate models, by combining field observations from the ARM Research Facility and laboratory data to develop a better understanding of the secondary organic aerosols that serve as cloud-condensation nuclei.[97]

The utility of other topics that have been addressed recently by this activity within the EES subprogram is illustrated by the FY 2017 budget request, which included proposals to develop and analyze a new set of high-resolution simulations of extreme events, with a focus on extremes that could influence the interdependence of energy and water; analysis of the causes and distributions of droughts; biogeochemical controls on abrupt climate change; and the roles of cryospheric features (i.e., sea ice, ice sheets, glaciers, and permafrost thaw) in Arctic climate, sea level rise, and large-scale modes of variability.

While DOE is proposing to maintain support in FY 2018, at a greatly reduced level, for developing its Energy Exascale Earth System Model, it will end its joint effort with NSF to advance the current leading U.S. climate model, the CESM. The likely result of these cuts will be to cede U.S. leadership in climate modeling over the next few years to other countries that are not reducing their investments in cutting-edge modeling.

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[96] DOE. FY 2017 Budget Request, p. 125.

[97] DOE. FY 2017 Budget Request, p. 118.

Integrated Assessment

Similar to other FY 2018 cuts to federal environmental research programs, there are major reductions to DOE's activities that shed light on the real-world economic threat posed by changes to coupled social-environmental systems, particularly the "energy-water nexus." Energy and water are interdependent. Energy use is water-intensive; water treatment and delivery is energy-intensive. DOE has been a leader in integrated assessments of the energy-water nexus that use data, modeling, and analysis to improve understanding and inform decision-making about energy and water for a broad range of users and at multiple scales.[98] In the FY 2018 budget request, the Integrated Assessment activity is very hard hit, with a 87 percent cut, and appears to be placed on a glide path to termination at the end of that fiscal year, reducing the national capacity to prepare for and meet coming challenges in this area.

Data Management

The EES subprogram results in the collection of a rich set of observations and other data, whether through dedicated field experiments, routine and long-term observations accumulated by the subprogram's user facilities, or model-generated information derived from climate modeling platforms.[99] Up until the current budget request, the data management activity in EES included a climate and environmental data analysis and visualization activity that made good use of this trove of data by coupling high-resolution earth system models with interdependent components involving energy and infrastructure sector models, field observations, raw data from environmental field experiments, and analytical tools for system diagnostics, validation, and uncertainty quantification.[100]

In the FY 2018 budget request, the data management activity will be cut back by 86 percent to just $1 million in funding. Most activities to obtain maximum utility from the rich set of data and observations that result from all EES research activities will be terminated, funding only the minimum required data archiving. By ending funding for data curation, integration, and analysis,[101] the FY 2018 request fails the test of good financial stewardship by allowing the trove of data accumulated by past EES research support to lie fallow.

Environmental Molecular Science Laboratory (EMSL)

EMSL, located at Pacific Northwest National Laboratory, is a user facility that supports the broad mission of Biological and Environmental Research (BER), including in areas of biology and energy that are outside the scope of the EES subprogram. As a DOE user facility, EMSL provides a suite of advanced instrumentation and state-of-the-art facilities for use by scientists from other institutions around the world who have interests in energy, environmental, and biological

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[98] DOE. FY 2017 Budget Request, pp. 112-113.

[98] Ibid., p. 125.

[100] Ibid., p. 112.

[101] DOE. FY 2018 Budget Request, p. 137.

research.[102] Within the EES subprogram, EMSL provides facilities and instrumentation for experimental and computational research in biological systems science, hydrobiogeochemistry, ecosystems science, vegetative emissions and aerosol chemistry, and interfacial chemistry and surface science relevant to EES's activities. Its facilities include a new ultra-high-resolution mass spectrometer to analyze, among other things, the composition of aerosol samples.[103]

In the FY 2018 Budget Request, EMSL's budget in EES will be cut by 42 percent. EMSL will maintain user access to instrumentation such as its new mass spectrometer, but the funding cut will eliminate user access to EMSL facilities for research related to climate feedbacks and carbon.[104]

Department of the Interior (DOI)

The Department of the Interior (DOI) is both (1) the custodian of most of the public land owned by the federal government, and (2) the pre-eminent funder and user of environmental research relating to the use and stewardship of those lands, including research on the functioning of their ecosystems. The environmental science developed by DOI programs is essential to the proper management of the biological resources found on, and ecosystem services provided by, those lands. These resources are an essential part of the recreational values of DOI lands, and contribute to hunting and fishing opportunities on state and private lands that depend on the role that federal lands play in the health of their ecosystems and the lifecycle of migratory species. The president's FY 2018 budget request for DOI will impose a 19 percent overall cut in environmental activities, for a total loss of research support of over $140 million (see Table 6 on page 19). Some important research activities will be completely eliminated under the FY 2018 budget. A more detailed analysis of changes in environmental research for each DOI bureau that conducts a significant amount of such research is given below.

U.S. Geological Survey

The USGS is the scientific arm of the DOI. The USGS FY 2018 budget request is $922.2 million, $137.8 million below the FY 2017 Continuing Resolution (CR) baseline level. Environmental and climate research is conducted in programs in several of the USGS mission areas including Land Resources (formerly Climate and Land Use Change Program); Ecosystems; Environmental Health, Water Resources; and Natural Hazards. Given the number of USGS environmental programs that were cut, the analysis is only of a subset of the impacted programs. Table 16 shows selected areas and programs from the overall DOI budget and the proposed impacts of the FY 2018 proposed climate and environmental budget, and includes more details than shown in the higher-level numbers in Table 6 on page 19.

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[102] Pacific Northwest National Laboratory. 2017. "About EMSL," available at https://www.emsl.pnl.gov/emslweb/about (last accessed July 2017).

[103] DOE. FY 2017 Budget Request, pp. 131-132.

[104] DOE. FY 2018 Budget Request, p. 136.

Table 16: Department of the Interior (Dollars in Millions)

USGS – Selected Programs for Environmental Research	*FY 2016 Enacted*	*FY 2017 Estimate*	*FY 2018 Proposed*	*FY 17-18 Dollar Change*	*FY 17-18 Percent Change*
Land Resources Mission Area	140.0	140.0	112.8	-27.2	-19%
National Land Imaging	72.2	72.1	76.1	-4.0	-6%
Land Change Science	41.3	41.3	19.3	-22.0	-53%
Climate Adaptation Science Centers	26.4	26.4	17.4	-9.0	-34%
Ecosystem Mission Area	160.2	159.9	132.1	-27.8	-17%
Status and Trends	20.4	20.4	16.8	-3.6	-18%
Fisheries	20.9	20.8	15.9	-4.9	-24%
Wildfire	45.8	45.7	35.5	-10.2	-22%
Environments	38.4	38.3	29.3	-9.0	-23%
Invasive Species	17.3	17.3	17.3	0	0%
Cooperative Research Units	17.4	17.3	17.3	0	0%
Environmental Health	21.4	21.4	17.1	-4.3	-20%
Contaminant Biology	10.2	10.2	8.2	-2	-20%
Toxic Substance Hydrology	11.2	11.2	8.9	-2.3	-21%
Water Resources Mission Area	211.0	215.0	173.0	-42	-20%
Water Availability and Use Science	42.1	42.0	30.4	-11.6	-28%
Groundwater and Streamflow Information	71.5	71.4	68.2	-3.2	-4%
National Water Quality	90.6	90.4	74.5	-15.9	-18%
Water Research Program	6.5	6.5	0	-6.5	100%
Natural Hazards Mission Area					
Coastal/Marine Hazards and Resources Program	40.5	40.4	35.8	-4.6	-11%
Total	**572.7**	**571.7**	**470.9**	**-100.8**	**-18%**

Sources: DOI FY 2017 and FY 2018 Budget in Brief documents. Budget numbers for activities in FY 2017 are FY 2017 amounts under the continuing resolution in effect when the FY 2018 budgets were transmitted.
Note: Totals may not add due to rounding.

Land Resources Mission Area

The Climate and Land Use (CLU) Mission Area has been renamed and refocused in the president's FY 2018 budget—it is now called the Land Resources Mission Area (LRMA). The DOI's explanation was that "[t]he renaming of this mission area reflects its actual problem-solving focus on meeting the practical science needs of land managers."[105] Notwithstanding this name change, CLU science remains essential to improve the understanding of past and present change; to develop relevant forecasts; and to identify those lands, resources, and communities that are most vulnerable to earth system change processes.[106]

Since the passage of the U.S. Global Change Research Act of 1990, the USGS (predominantly through CLU) has made substantial scientific contributions to understanding the interactive living and nonliving components of the earth system. This work has led to advances in observing and understanding climate and land-cover change and the effects these changes have on ecosystems, natural-resource availability, and societal sustainability. Science plays an essential role in helping communities and resource managers understand the local-to-global implications of a changing world and how it affects natural resources, livelihoods, and communities. The research funded by the USGS in this area helps these communities and managers anticipate the effects of change, prepare for change, and reduce the risks associated with decision making in a changing environment.[107]

The FY 2018 budget provides a total of $112.8 million for the LRMA programs, $27.2 million below FY 2017. The FY 2018 budget proposes to organize the program into three sub activities:[108]

- **The National Land Imaging Program** (NLI) sub activity would deliver the remote sensing observation capacity, data, and research required to understand how landscapes and associated natural resources are changing at grand scales.
- **The Land Change Science Program** (LCSP) sub activity would conduct research required to understand the forces that shape landscapes and their potential uses, to distinguish between land surface change resulting from natural forces and those that are associated with land use decisions, and to provide the scientific bases for land use decisions that affect the safety of communities, economic prosperity, and natural resources of the nation.

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[105] DOI. 2017. "President proposes $922 million FY18 budget for USGS," Press release, May 23, 2017, available at https://www.usgs.gov/news/president-proposes-922-million-fy18-budget-usgs (last accessed July 2017).

[106] Burkett, V.R., Kirtland, D.A., Taylor, I.L., Belnap, Jayne, Cronin, T.M., Dettinger, M.D., Frazier, E.L., Haines, J.W., Loveland, T.R., Milly, P.C.D., O'Malley, Robin, Thompson, R.S., Maule, A.G., McMahon, Gerard, and Striegl, R.G., 2013, U.S. Geological Survey climate and land use change science strategy—A framework for understanding and responding to global change: U.S. Geological Survey Circular 1383–A, p. 1.

[107] DOI. 2017. "Climate and Land Use Change," available at https://www.usgs.gov/science/mission-areas/climate-and-land-use-change?qt-mission_areas_l2_landing_page_ta=0#qt-mission_areas_l2_landing_page_ta (last accessed July 2017).

[108] USGS Budget Justification—FY 2018, p. B-1.

- **The National and Regional Climate Adaptation Science Centers** sub activity would be the organizing entity within USGS for the National Climate Adaptation Science Center and DOI's regional CASCs. These centers would deliver the on-the-ground observations and research required to understand how changes in climate, land uses, and associated changes in land cover are affecting the Nation's natural resources and associated populations of fish and wildlife species essential to the nation's natural heritage.

The proposed FY 2018 budget provides $76.1 million for the NLI program, including an increase of $22.4 million to continue to develop the Landsat 9 ground systems and prepare for a launch date in fiscal year 2021. The budget eliminates direct finding for the National Civil Applications Center ($-4.8M) and associated USGS research, monitoring, and data collection activities using classified remote sensing imagery, as well as its acquisition of imagery on behalf of other civil agencies. Both USGS secure compartmentalized information facilities (Reston, VA and Denver, CO) would be closed.

The budget includes $11.1 million in reductions to the LCSP related to climate research and development and $1.5 million in net reductions for other LCSP activities, including localized studies. The budget terminates biological carbon sequestration research and reduces geologic carbon sequestration research, a reduction of $7.9 million. The termination of the Biological Carbon Sequestration Program (-$5.2M) eliminates projects to develop methods for the inventory and tracking of carbon stored in ecosystems in the U.S., to understand processes that control carbon sequestration and release in different ecosystems, to design strategies to enhance carbon stored in National Wildlife Refuge ecosystems, to model carbon flux in ecosystems, and to create a standard methodology for the inventory of biological carbon sequestration for the entire U.S. The budget proposes to transfer $1.5 million to the Energy Resources Program to promote fossil fuel resource recovery. Reductions to the Geologic Carbon Sequestration Program (-$2.6M) greatly curtails work to monitor and evaluate induced seismicity associated with geologic CO_2 storage, evaluate the geochemistry of produced groundwater and the potential for CO_2 leakage from the injection zones, develop economic models for CO_2 storage in saline formations and associated with enhanced oil recovery operations. The termination of Landscape Science Projects (–$1.5M) eliminates projects to develop methodologies for incorporating remote sensing products in landscape analyses. The termination of Climate Research and Development Activities (-$11M) eliminates investigations of changes in land cover and interactions between land use, land change and regional climate, research to identify processes related to carbon in soils, studies of arid vegetation response to extended drought, and investigations of heat exchange beneath polar ice sheets.

The budget proposes $17.4 million for the National and Regional Climate Science Centers, which will focus on adaptation research to respond to stressors across broader geographic regions and at a national level. The budget terminates support for the National Phenology Network (-$250K), eliminating work on a 10-year retrospective linking changes in climate to changes in timing of natural events, such as bird nesting, blooming of flowers and hatching of fish eggs. The budget reduces funding for the National and Regional Climate Adaptation Science Centers (-$8.5M). This

reduction would eliminate four (of eight) regional CASCs, refocusing work on the highest priority needs of Interior bureaus and States, supporting their development and adaptation of fish and wildlife management plans, and natural resource adaptation science needs.

Ecosystems Mission Area

Scientists in the Ecosystem Mission Area (ECO) conduct research and monitoring on freshwater, terrestrial and marine ecosystems and the fish and wildlife within them. Federal and state natural resource managers use USGS scientific information to protect, restore and enhance our natural resources, and ensure that healthy ecosystems, and the services they provide, will be here for generations to come.[109]

ECO is comprised of five sanctifies:

- **The Status and Trends Program** provides credible information about the status and trends of natural resources required at a variety of spatial and temporal scales to detect changes that may signal degradation or improvement of natural systems, or to identify new or emerging conditions that signal the need for management action or further investigative research.[110]
- **The Fisheries Program** conducts research that leads to the protection and restoration of our nation's fisheries and aquatic resources, the habitats that support them, and the services they provide. The program priorities include species conservation, habitat restoration, energy development, and water quantity and quality needs.[111]
- USGS scientists in the **Wildlife Program** are developing advanced tools for disease diagnosis, surveillance, risk assessment and control. USGS research on diseases at the interface of wildlife, domestic animals, and humans support public health and domestic animal health. USGS disease ecologists are also examining how climate change, invasive species, and landscape changes are impacting disease dynamics.[112]
- **The USGS Invasive Species Program** develops tools, technologies, and decision support systems to detect, monitor, assess risk, and control aquatic and terrestrial invasive species, including invasive wildlife diseases, across the U.S. and its territories.
- **The CRU Program** enhances graduate education in fisheries and wildlife sciences and facilitates research between natural resource agencies and universities on topics of mutual concern. CRUs conduct research on renewable natural resource questions, participate in the education of graduate students, provide technical assistance and consultation on natural

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[109] DOI. 2017. "U.S. Geological Survey—Ecosystems: About," available at https://www2.usgs.gov/ecosystems/about.html (last accessed July 2017).

[110] DOI. 2017. "USGS—Ecosystems: Status and Trends," available at https://www2.usgs.gov/ecosystems/status_trends/index.html (last accessed July 2017).

[111] DOI. 2017. "USGS—Ecosystems: Fisheries," available at https://www2.usgs.gov/ecosystems/fisheries/index.html (last accessed July 2017).

[112] DOI. 2017. "USGS—Ecosystems: Fish and Wildlife Disease," available at https://www2.usgs.gov/ecosystems/disease/disease.html (last accessed July 2017).

resource issues, and provide continuing education for natural resource professionals.[113]

The proposed FY 2018 budget terminates and cuts a number of the programs and projects in ECO. The major changes include a cut to Unconventional Oil and Gas Research (-$1M) and discontinuation of the development of indicators of environmental stress that can be used by resource managers, public health agencies, and other responders to detect and respond to leaks and reduce risks to fish, wildlife, and humans. The reduction to Species-Specific Fisheries Research (-$3.5M) will reduce the science that supports the DOI and other federal, state, and tribal agencies' management of species under their authority.

The proposed FY 2018 budget terminates the Whooping Crane Propagation Program (-$1.5M), eliminating the largest dedicated captive breeding effort for Endangered Species Act—listed cranes and eliminates capacity within Interior for avian studies that require controlled studies with large, rare birds. Changing Arctic Ecosystems Research and Monitoring is also reduced (-$1.6M), decreasing science support for management and policy decisions and reduces, among other things, the availability of information related to transmission of avian influenza by migratory waterfowl passing through Alaska that could infect other wildlife or poultry in the contiguous U.S. Species-Specific Wildlife Research is cut (-$8.6M), reducing the science that supports the DOI and other federal, state, and tribal agencies' management of species under their authority. Cuts to the Greater Everglades (-$5M) and Chesapeake Bay Research and Monitoring (-$3M) programs discontinues research and monitoring and development of management plans in these two important ecosystems.

Environmental Health Mission Area

The Environmental Health (EH) Mission Area works to safeguard the nation's health, economy, and resources by supporting scientific research to understand and minimize exposures to toxicological and infectious disease agents in the environment. While the scope of the EH program has encompassed all environmental hazards, some of its recent work has included hazards that are made worse by climate change impacts, such as algal blooms.[114]

The Mission Area consists of two programs:[115]

- **The Contaminant Biology Program** develops and applies advanced laboratory methods and field investigations to understand potential biological health effects from exposures to chemical and microbial hazards in the environment.

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[113] Cooperative Research Unit. 2017. "Cooperative Research Units--Education, Research and Technical Assistance for Managing Our Natural Resources," available at https://www.coopunits.org/Headquarters (last accessed July 2017).

[114] DOI. 2017. "Satellite Imagery Used to Measure Harmful Algal Bloom Frequency—Steps Toward Understanding Exposure Risk," available at https://toxics.usgs.gov/highlights/2017-06-19-satellite_imagery_habs.html (last accessed July 2017).

[115] DOI. 2017. "USGS – Mission Areas: Environmental Health," available at https://www.usgs.gov/science/mission-areas/environmental-health?qt-mission_areas_l2_landing_page_ta=0#qt-mission_areas_l2_landing_page_ta (last accessed July 2017).

- **The Toxic Substances Hydrology Program** develops and applies advanced analytical methods, field investigations, laboratory studies, and modeling capabilities to understand the sources, movement, and exposure pathways of chemical and microbial hazards in the environment.

The reduction to Contaminant Biology Research ($1.9M) decreases scientific information, such as sampling and analysis used to determine actual rather than perceived health risks of legacy and emerging contaminants to humans, fish, and wildlife. This loss of information would impact specific regions of the nation (e.g., the Chesapeake Bay watershed and the Great Lakes) as well as lands managed for recreational hunting and fishing, tribal subsistence, or other recreational purposes. Termination of the Contaminant Science in Support of Water and Land Stewardship, Energy, and Wastewater and Drinking Water Infrastructure (-$1.6M), would result in a loss of specialized expertise needed in studies that provide science to understand and address health hazards posed by environmental contaminants in tap waters, recreational waters, and fisheries.

Water Resources

The Water Resources Mission Area collects and disseminates reliable, impartial, timely information needed to understand the nation's water resources.

This mission area is made up of four major programs:[116]

- **The Water Availability and Use Science Program**[117] provides accurate assessments of the status of the U.S. water resources; assists in the determination of the quantity and quality of water that is available for beneficial uses; identifies long-term trends in water availability; and develops the basis for an improved ability to forecast the availability of water for economic, energy production, and environmental uses.[118]
- **The Groundwater and Streamflow Information Program** monitors groundwater and streamflow, including floods and droughts, related to groundwater resources at regional and national scales. At the core of the program is a set of streamgages positioned across the country that are continuously operated and the data is provided real time to the NWS to forecast floods.[119]
- **The National Water Quality Program** provides an understanding of the water-quality conditions; whether conditions are improving or degrading; and how natural features and human activities affect these conditions.[120]

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[116] DOI. 2017. "USGS—Water Resources of the United States: About Water Resources," available at https://water.usgs.gov/about_WRD.html (last accessed July 2017).

[117] Initiated in 2015 in response to the SECURE Water Act, passed by Congress in 2009.

[118] DOI. 2016. "USGS Water Availability and Use Science Program," available at https://water.usgs.gov/wausp/ (last accessed July 2017).

[119] DOI. 2016. "USGS – Mission Areas: Groundwater and Streamflow Information Program," available at https://www.usgs.gov/science/mission-areas/water/groundwater-and-streamflow-information?qt-programs_l2_landing_page=0#qt-programs_l2_landing_page (last accessed July 2017)

[120] DOI. 2017. "USGS – Mission Areas: National Water Quality Program," available at https://www.usgs.gov/science/mission-areas/water/national-water-quality-program?qt-programs_l2_landing_page=0#qt-programs_l2_landing_page (last accessed July 2017).

- **The National Water Research Program** conducts research to develop and disseminate science-based information and tools needed for a fundamental understanding of the processes that affect the availability, movement, and quality of the nation's water resources. The program includes work on water availability, water and climate, water, energy and food, and water and ecosystems dynamics.[121]

The FY 2018 proposed budget would terminate several WR programs/projects:

- Two aquifer assessment programs—**Mississippi Alluvial Plan Aquifer Assessment Project** (-$1M) and **U.S.-Mexico Transboundary Aquifer Assessment Project** (-$1M). This information supports sustainable agriculture in Mississippi, Louisiana, Arkansas, Alabama, and Tennessee and, in partnership with states provides, new information and a scientific foundation for state and local officials to address water-resource challenges along the U.S.–Mexico border.
- **Water Use Data and Research** (-$1.5) eliminates cooperative agreements with states to improve the availability, quality, compatibility, and delivery of water-use data used to manage long-term water supplies.
- **Focus Area Studies** (-$1.6M) eliminates collaborative studies in the Upper Rio Grande, the Red River, and the Coastal Carolina Basins with state and local partners to provide data, models and decision-support tools, such as water availability estimates, snow melt information, and groundwater and surface water models to improve water resource management.
- **Groundwater Model Development, Maintenance and Sustainability** (-$1M) eliminates maintenance and improvements on existing groundwater software tools.
- **NPS Cooperative Water Partnership** (-$1.7M) would eliminate water-quality science support to the NPS, eliminating research on the occurrence of emerging contaminants, harmful algal blooms, endocrine disrupting compounds, harmful algal blooms, and mercury and other metals in park waters.
- **National Atmospheric Deposition Program** (-$1.6M) would eliminate USGS participation in a collaborative effort to measure atmospheric inputs of nutrients, acidic compounds, mercury, ammonia, and other chemicals to aquatic and terrestrial ecosystems.
- **Water Resources Research Act Program** (-$6.5M) eliminates a grant and cooperative agreement program for land grant universities and would end USGS involvement in coordination and administrative support for all grants to Water Resource Research Institutes.

In addition to the terminations listed above, several programs/projects would also receive reduced funding. Proposed reductions to the National Groundwater Monitoring Network (-$1.7M) reduces cooperative agreements with states that support national and local groundwater

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[121] DOI. 2017. "USGS –National Research Program: Welcome to the National Research Program," available at https://water.usgs.gov/nrp/index.php (last accessed July 2017).

databases. Reductions to the National Water-Quality Assessment Project Lower Mississippi Stream Quality Assessment (-$4M) would eliminate the planned study to characterize sources of water quality and aquatic ecosystem impairment and ecological conditions in streams to determine the relative effects of these stressors on the health of aquatic communities and to identify which human and natural factors are most critical in controlling stream quality. Reductions to the National Water-Quality Assessment Project Trends Assessments (-$2.6M) would delay studies to determine and explain which natural and human factors are most important in influencing long-term trends in surface water and groundwater quality. The proposed reduction to program operations would slow the improvement of the national streamgage and ground water monitoring networks and would slow activities assessing the current and future quality of the nation's freshwater resources, evaluating which human and natural factors are driving observed geographic patterns and trends, and developing tools and models water resource managers and drinking-water suppliers can use to forecast short and long-term changes to water quality, such as forecasting harmful algal blooms or decadal-scale changes in groundwater quality.

Several aspects of the National Research Program would also be cut.

These include:

- Reductions to research in the San Francisco Bay Delta, Klamath Lake, the Florida Everglades, and Chesapeake Bay to improve operational forecasting of water availability and ecological health. This reduces localized, regional, and national studies examining how changes in water budget components impact water availability.
- Reductions to research on water quality and the development of effective remediation strategies.
- Suspension of studies in Arizona, California, Colorado, and Minnesota that focus on how contaminants move through the environment and whether or not they pose a risk to human or aquatic ecosystem health.

Natural Hazards Mission Area

Within the Natural Hazards Mission Areas, the USGS proposes to change the name of the Coastal and Marine Geology Program to the Coastal/Marine Hazards and Resources Program (CMHRP). This change reflects the connection between the critically important hazards-related activities such as offshore earthquake and tsunami hazards as well as coastal changes due to extreme storms. This also highlights the priority work conducted in the program addressing offshore resources, including work related to identifying the extended shelf of the U.S. and evaluating methane hydrates as a potential energy source. CMHRP provides surveys, knowledge and tools to characterize the hazard and resource potential of the nation's offshore and coastal landscapes. CMHRP provides managers with the information and tools to anticipate and reduce the risk of natural hazards and coastal change, and to assess and manage marine and coastal resources to meet current needs and to respond to changing demands.

The president's FY 2018 budget would eliminate two programs: Marine Habitat/Resource Mapping and Ocean and Glacier Studies to Inform Resource Management (-$1.6M) and Elevation Model Development and Regional Coastal Resource Assessments (-$2.5M). These reductions would eliminate monitoring, research, and model development to forecast the impacts on coastal waters, ecosystems and fisheries due to ocean acidification and changing fluxes of nutrients, freshwater, and sediment from retreating glaciers and the development of "user ready" regional onshore/offshore elevation models for regional restoration of San Francisco Bay, the Pacific Northwest, and the Northern Gulf of Mexico and Florida.

Fish and Wildlife Service

FWS manages the largest network of lands in the U.S. dedicated to conservation.[122] As noted in DOI chapter above, it could be said that all FWS programs have some role in improving the use of science in conservation, but two specific FWS budget lines have an identifiable focus on environmental research initiatives (LCCs and Science Support). The FY 2018 proposed budget would terminate all activities under these two programs, as shown in the below table. Support for these environmental research initiatives in the FWS has been seen in the past as developing the good science that allows FWS managers and their external stakeholders/collaborators to develop cost-effective management strategies, resolve and avoid conflicts, and strengthen the quality of the department's public trust stewardship of the nation's lands and waters.[123] The changes in these two specific programs are discussed below, followed by a discussion of environmental research activities that are incorporated into other FWS programs, but not called out with specific lines in the budget.

[122] U.S. Department of the Interior [DOI]. 2017. *Fiscal Year 2018—The Interior Budget in Brief: May 2017* [FY 2018 Budget in Brief], pp. BH-59, BH-60.

[123] DOI. 2016. *Fiscal Year 2017—The Interior Budget in Brief* [FY 2017 Budget in Brief], p. DH-55.

Table 17: Department of the Interior (Dollars in Millions)

Mission Area/Program	*FY 2016 Enacted*	*FY 2017 Estimate*	*FY 2018 Proposed*	*FY 17-18 Dollar Change*	*FY 17-18 Percent Change*
Fish and Wildlife Service–Selected Programs for Environmental Research					
Landscape Conservation Cooperatives	13.0	13.0	0.0	-13.0	100%
Science Support					
Adaptive Science	10.5	10.5	0.0	-10.5	-100%
Service Science	6.5	6.5	0.0	-6.5	-100%
Total	**30.0**	**29.9**	**0.0**	**-29.9**	**-100%**

Sources: DOI FY 2017 and FY 2018 Budget in Brief documents. Budget numbers for activities in FY 2017 are FY 2017 amounts under the continuing resolution in effect when the FY 2018 budgets were transmitted.
Note: Totals may not add due to rounding.

Landscape Conservation Cooperatives

DOI launched the LLCs program in 2009, "to improve science integration and application to address natural hazards and other landscape-scale issues."[124] The LCCs constitute a network of twenty-two individual, self-directed conservation areas that collectively cover all of the U.S., including Pacific and Caribbean islands, as well as ecologically related parts of Canada and Mexico.[125] The LCCs bring together federal, state, tribal, and local governments, as well as non-governmental organizations and academic institutions, to collaborate, coordinate, and integrate efforts to conserve lands of common interest within the broad area covered by each LCC. The LCCs provide a network of scientists and resource managers to develop and integrate science into a holistic approach to land management, including identifying best practices, gaps in scientific knowledge, and ways to avoid duplication among cooperating partners.[126]

The LCCs serve, in part, as a complement to the USGS CASCs and many of the CASCs participate in activities of LCCs within their respective regions. That said, the LCCs themselves place a significant focus on environmental science research as part of their mission.[127] In 2015,

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[124] Ibid., p. DH-57.

[125] Landscape Conservation Cooperative Network. 2015. "New LCC Network Map," available at https://lccnetwork.org/news/new-lcc-network-map (last accessed July 2017).

[126] Ibid., pp. DH-57, DH-58.

[127] Landscape Conservation Cooperatives. 2014. LCC Network Strategic Plan (Falls Church, VA: Landscape Conservation Cooperative Network), pp. 10-11, available at http://lccnetwork.org/strategic-plan (last accessed July 2017)

the LCC Network published the first edition of its *LCC Network Conservation Science Plan*, which laid out a strategic framework for addressing scientific issues in landscape conservation.[128] Many individual LCCs also have region-specific science plans. While a number of science-related activities supporting the LCCs are funded under the "Science Support" program line described below, core LCC funding through this budget line also funds environmental research, such as developing efficient monitoring programs to measure species and habitat outcomes across landscapes.[129]

In 2016, the National Academies of Sciences, Engineering, and Medicine released a congressionally-mandated review of the LCC program. The National Academies noted that "progress has been made toward the LCC Network's goal to advance science; a considerable amount of scientific work has been funded and disseminated to resource managers" and that several stakeholders had informed the National Academies "that a number of tools and research results have already improved resource management decisions and helped develop more cost-effective management options."[130] The academies also placed the LCCs in a broader context, stating that

> "Conservation scientists conclude that working at landscape scales is likely to be more effective for addressing current threats to biodiversity, such as widespread conversion of native landscapes for human use (e.g., agriculture, energy development, and urbanization), human population growth, and climate change. This focus on landscapes and seascapes in conservation of natural and cultural resources is prevalent throughout the world today, including within federal agencies, nongovernmental organizations (NGOs), and local land-use planning agencies, and in the global movement toward ecological networks, such as the Natura 2000 network in Europe."[131]

The academies concluded that,

> "The nation needs a landscape approach to conservation. Implementing landscape approaches in the United States is challenging because of the multitude of federal, state, local, and tribal jurisdictions, as well as numerous private landholders and stakeholders… [O]nly the LCC Network is designed to address this need at a national scale for all natural and cultural resources, and to bridge from research to management."[132]

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[128] Landscape Conservation Cooperatives, Science Coordinators Team. 2015. LCC Network Conservation Science Plan Version 1.0 (Falls Church, VA: Landscape Conservation Cooperative Network), available at https://lccnetwork.org/sites/default/files/Resources/LCC_Network_Conservation_Science_Plan_Version_1.0.pdf (last accessed July 2017).

[129] DOI. 2016. Budget Justifications and Performance Information: FY 2017 – U.S. Fish and Wildlife Service [FWS Budget Justification – FY 2017], p. CLC-5, available at https://www.fws.gov/budget/2016/FY2017_FWS_Greenbook.pdf (last accessed July 2017).

[130] National Academies of Sciences, Engineering, and Medicine. 2016. A Review of the Landscape Conservation Cooperatives (Washington, DC: The National Academies Press), p. 6, available at https://doi.org/10.17226/21829.

[131] Ibid., pp. 9-10.

[132] Ibid., p. 7.

Despite the value of the efforts of the LCCs in the development and application of environmental science to land management, the president's FY 2018 budget request terminates all funding for the LCC program, asserting that other unnamed "longstanding programs" in the department will "continue to work with external stakeholders to support conservation efforts, share information, and help natural communities thrive."[133] This funding termination includes all staff and funding previously provided to the twenty-two LCCs.[134] The loss of the cooperative environmental science activities under the LCCs, as well as funding for their integration into land management decisions by the host of entities with responsibility for managing federal and adjoining lands, will impede the development of cooperative and collaborative strategies aimed at better management outcomes for these lands. It may result in a retreat from the more effective modalities of resource conservation—implemented through voluntary, non-regulatory partnerships—that are increasingly being practiced around the world. Defunding such voluntary, non-regulatory, and local partnerships is somewhat at odds with the Interior secretary's comment, when releasing the FY 2018 budget request for the department, that "Being from the West, I've seen how years of bloated bureaucracy and D.C.-centric policies hurt our rural communities."[135]

Science Support

The FWS Science Support Program's stated purpose is

> "to coordinate internal and partner efforts developing and applying science for conservation outcomes by ensuring science products are high quality, non-duplicative, and accessible to fish and wildlife managers and decision makers. Science Support staff are responsible for leading Service efforts in high priority scientific research, information quality, scientific integrity, peer review, and science adaptation to inform management decisions."[136]

The program consists of two elements: Adaptive Science, which supports the needs of LCCs for conservation science; and Service Science, which supports the needs of FWS programs for scientific information to improve decision-making for refuge management, endangered species conservation, and other priorities.

In the FY 2018 budget request, all activities in the Science Support program will be terminated. The termination of activities under the Adaptive Science activity will impede the development of scientific information, tools, and techniques that could be applied to anticipate, monitor, and adapt to environmental changes and their effects on the lands managed by the entities cooperating on a voluntary basis in the LCCs. The result will be both loss of science that could better ground such decisions, as well as the likelihood that future scientific research and projects undertaken by entities that had been cooperating in the LCCs will experience duplication and lack of coordination. The termination of activities under the Service Science activity will deprive other elements of the FWS

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[133] DOI. FY 2018 Budget in Brief, p. BH-62.

[134] DOI. 2017. Budget Justifications and Performance Information: FY 2018 – U.S. Fish and Wildlife Service [FWS Budget Justification – FY 2018], p. CLC-1, available at https://www.fws.gov/budget/2018/FY2018-FWS-Greenbook.pdf (last accessed July 2017).

[135] DOI. "President Proposes $11.7 Billion Budget for Interior in FY2018," Press release, May 23, 2017, available at https://www.doi.gov/pressreleases/president-proposes-117-billion-budget-interior-fy2018 (last accessed July 2017).

[136] DOI. FWS Budget Justification – FY 2018, p. SS-1.

of the best science on several emerging and high-impact questions relating to threats to fish and wildlife resources. These include efforts to understand and combat White-Nose Syndrome in bats, emerging wildlife health issues (such as the *chytrid* fungus that has caused mass mortality of amphibians, globally, and the *B. salamandrivorans* fungus that threatens North American salamander populations), efforts to understand and forestall the decline in monarch butterflies, and partnerships with states to prevent the listing of species as endangered species and to cooperate in the recovery of endangered species.[137, 138]

Environmental Research Contributions of Other FWS Programs

Several of the major programs in the FWS also conduct environmental research in the course of their activities. While the specific funding levels for these programs are not detailed in budget documents, the role that these programs play in advancing our understanding of the environment is considerable.

Examples of past scientific efforts in these programs include the following programs:

- **National Wildlife Refuge System—Wildlife and Habitat Management—Inventory and Monitoring** About 10 percent of the funding for FWS Wildlife and Habitat Management goes to species and habitat inventory and monitoring activities that collect and manage scientific data that inform wildlife management and conservation strategies in the National Wildlife Refuge System.[139]
- **Migratory Bird Management—Conservation and Monitoring** Monitoring activities are an essential component of bird conservation activities in the FWS, especially as it relates to the status of Birds of Management Concern. The FWS conducts extensive migratory game bird population and habitat surveys across North America on an annual basis. This data is used to manage the various FWS programs, including those that affect hunters, and also provides insight into environmental science issues such as the shift in populations due to climate change and other factors.[140]
- **Fish and Aquatic Conservation—Aquatic Habitat and Species Conservation** The FWS fisheries offices, under this program element, work at the intersection of science and management to understand the biology, ecology, and economics of major U.S. fisheries and to develop approaches to manage them sustainably.[141] In FY 2018, the FWS will reduce the funding of management, restoration, inventory, and monitoring activities for fish and other aquatic species by $1.1 million.[142]
- **Fish and Aquatic Conservation—National Fish Hatchery System—Fish Technology Centers and Fish Health Centers** The seven Fish Technology Centers and nine Fish Health

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[137] Ibid., p. SS-4.

[138] DOI. FWS Budget Justification – FY 2017, pp. SS-9, SS-11.

[139] DOI. FY 2018 Budget in Brief, p. BH-60.

[140] DOI. FWS Budget Justification – FY 2017, p. MB-4.

[141] Ibid., p. EX-18.

[142] DOI. FWS Budget Justification—FY 2018, p. FAC-13.

Centers that operate under the National Fish Hatchery System provide the science base for FWS fish recovery and restoration programs. Their work covers areas that fall under the definition of environmental research—such as animal culture biology, genetics, ecological physiology, and the detection and monitoring of disease-causing pathogens and invasive species—as well as more applied technology-oriented work.[143] In 2016, it was estimated that the FTCs had published nearly 1,000 papers in peer-reviewed journals over the preceding thirty years.[144]

In FY 2018, the budgets for all the elements above that contain these activities will be cut. While the portion of the cuts that will fall on these environmental research program is not specified, it is reasonable to assume that there will be impacts to all of them.

Bureau of Land Management

The BLM administers more land than any other federal agency—245 million surface acres of public land. While all BLM programs have the need to apply scientific research to attain conservation and management goals, and in the process, carry out some activities that would fall under the broad description of environmental research, in recent years three specific activities have involved a greater emphasis on research activities. They are listed in Table 18, but two of the activities have been funded in a cross-cutting manner, so specific funding levels cannot be identified from the BLM's budget. Recent budget documents do discuss negative trends in these environmental research programs, though.

[143] Ibid., p. FAC-6.

[144] DOI. FWS Budget Justification—FY 2017, p. FAC-6.

Table 18: Department of the Interior (Dollars in Millions)

Mission Area/Program	*FY 2016 Enacted*	*FY 2017 Estimate*	*FY 2018 Proposed*	*FY 17-18 Dollar Change*	*FY 17-18 Percent Change*
Bureau of Land Management—Selected Programs for Environmental Research					
Resource Protection and Maintenance					
Resource Management Planning, Assessment, and Monitoring	48.1	48.0	38.4	-9.6	-20%
Crosscutting Programs					
Rapid Ecoregional Assessments	—	—	0.0	—	
National Seed Strategy	—	—	—	—	—
Total	**48.1**	**48.0**	**38.4**	**-9.6**	**-20%**

Sources: DOI FY 2017 and FY 2018 Budget in Brief documents. Budget numbers for activities in FY 2017 are FY 2017 amounts under the continuing resolution in effect when the FY 2018 budgets were transmitted.
Note: Totals may not add due to rounding.

Resource Management Planning, Assessment, and Monitoring

In recent years, the BLM's Resource Management Planning, Assessment, and Monitoring sub activity has included two elements related to environmental research. The first program element has focused on developing assessment and monitoring protocols that would provide current data on the status and trends in terrestrial and aquatic systems and about the location and extent of natural and human-caused disturbances. Such basic information is needed to carry out informed decision making and adaptive management of public lands, as well as to comply with monitoring commitments that the BLM has made (e.g., the Greater Sage-Grouse Conservation effort).
To be able to gather such information reliably, BLM has funded research to develop core indicators, standardized field methods, remote sensing, and statistically valid study designs to provide nationally consistent and scientifically defensible environmental information. The second sub activity has focused on supporting the deployment of the Enterprise Geographic Information System (EGIS), which BLM deemed critical in its FY 2017 budget request to help make "a generational leap forward in [BLM's] geospatial capabilities." The EGIS was envisioned as working with the information, core indicators, and standard methods developed in the assessment and monitoring protocols element, as well as digitizing legacy data so that it could also be used in analyses supporting decision making.[145]

[145] DOI. 2016. *Budget Justifications and Performance Information: FY 2017—Bureau of Land Management* [BLM Budget Justification—FY 2017], pp. II-5, II-6, available at https://www.doi.gov/sites/doi.gov/files/uploads/FY2017_BLM_Budget_Justification.pdf (last accessed July 2017).

As shown in the above table, the overall budget for the Resource Management Planning, Assessment, and Monitoring sub activity is being cut by 20 percent in the FY 2018 budget request. This budget cut, though, rests most heavily on environmental monitoring research, as the sub activity will

> "reprioritize [its] efforts to focus on the expansion of energy and mineral activities, including coal, oil and gas, and infrastructure development activities in support of the Administration's 'America First Energy Plan,' as well as the planning, monitoring, and assessment of other Administration priorities. This change will result in fewer ongoing planning efforts in offices without potential for energy development or transmission."[146]

The benefits of better understanding of the environmental effects of natural and human-caused disturbances on terrestrial and aquatic systems in federal lands, both for better federal decision-making and for the benefit of external stakeholders interested in the multiple uses of these lands will be lost.

Rapid Ecoregional Assessments and Other Regional Assessments

Recognizing that federal lands will be affected by climate change and other environmental factors, in recent years the BLM has conducted several REAs to improve its understanding of how conditions on the landscapes it manages may be altered by both environmental changes and land use demands. These assessments were called "rapid" because each one was aimed at being completed within eighteen months—much faster than more traditional land-use studies.[147]

The REAs result in peer-reviewed science products that synthesize existing information (including a significant amount of non-BLM data) about resource conditions and trends. REAs provide the BLM with information about current and projected resource conditions, as well as information on science gaps and key opportunities for resource conservation, restoration, and development. The geographic scope of these assessments makes them useful for the landscape management approach that BLM was evolving towards in the prior administration.[148] By 2015, BLM had published ten of the fifteen REAs and was planning to publish the remainder by the end of 2017. The REAs were considered to be living documents that would be updated and refreshed by BLM and the other agencies and partners with which it was coordinating.[149]

Because the REAs and other regional assessments were science activities that cut across the BLM, their funding is not specifically called out in BLM budget documents. But, it is clear that these activities are slated for termination in FY 2018, if not before. There is no mention of REAs anywhere in the detailed BLM budget justification document, and web pages previously on the

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[146] DOI. 2017. Budget Justifications and Performance Information: FY 2018 – Bureau of Land Management [BLM Budget Justification – FY 2018], p. II-8, available at https://www.doi.gov/sites/doi.gov/files/uploads/fy2018_blm_budget_justification.pdf (last accessed July 2017).

[147] The Wilderness Society. 2012. "Rapid Ecoregional Assessments" available at http://wilderness.org/article/rapid-ecoregional-assessments (last accessed July 2017).

[148] DOI. BLM Budget Justification – FY 2017, p. IV-20.

[149] Ibid., p. IV-24.

BLM website describing the program have been removed.[150] BLM's termination of its REAs and other regional assessments, and the loss of ready access by the public to the scientific reports from past assessments, represents a loss in the ability to anticipate and intelligently manage the consequences of climate change and other human-caused disturbances in key landscapes in the U.S. that can no longer be avoided. What may also be lost is the opportunity to identify priority areas where ecosystem transition may be rapid, as well as elements of these landscapes that may be resilient to climate change and other stressors.

Science Underlying the National Seed Strategy for Rehabilitation and Restoration

After the extensive wildfires of 1999 and 2000, the effort to replant burned areas with native plant materials was significantly impeded by a lack of the seeds for these plants. In response, Congress directed the BLM and the U.S. Forest Service to develop a long-term program to provide a stable and economical supply of seeds for native plants that might be used to restore and rehabilitate public lands. The current NSSRR guides this program for ecological restoration across large landscapes of the U.S., and has broadened its initial focus on restoration of lands damaged by rangeland fires to include lands damaged by invasive species, severe storms, and drought.
The strategy, for which BLM is the lead element in DOI, involves environmental research to achieve its goals.[151] The funding for the National Seed Strategy is not a specific line item in the BLM budget, but is part of the overall BLM Wildlife Management program. The prior administration's budget request for FY 2017 indicated an intention to increase funding for the National Seed Strategy by $5 million, some of which would met the environmental research objectives outlined in the 2015–2020 strategy document. In contrast, the FY 2018 BLM budget request identifies the National Seed Strategy as receiving reduced funding from enacted FY 2017 levels. These funding reductions will affect implementation of the environmental research that is part of the National Seed Strategy.

Bureau of Ocean Energy Management

BOEM is responsible for managing development of energy and mineral resources on the U.S. OCS.[152] BOEM's activities include oil and gas leasing, marine mineral leasing, and renewable energy development (e.g., offshore wind generation of electricity)—all supported by economic

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[150] Among prior links to BLM webpages on the program that are now decommissioned are "Rapid Ecoregional Assessments" (www.blm.gov/wo/st/en/prog/more/Landscape_Approach/reas.print.html), "An Introduction to Rapid Ecoregional Assessments" (https://www.blm.gov/style/medialib/blm/wo/Communications_Directorate/public_affairs/landscape_approachPar.84084.File.dat/REAintroduction.pdf), "Questions and Answers: Rapid Ecoregional Assessments (https://www.blm.gov/style/medialib/blm/wo/Communications_Directorate/public_affairs/landscape_approach.Par.95370.File.dat/QsandAs_REAs.pdf), as well as a number of the scientific reports generated by specific past assessments, including those for the North Slope, Sonoran Desert, and Madrean Archipelago ecoregions.

[151] DOI. 2015. National Seed Strategy for Rehabilitation and Restoration: 2015-2020, pp. 4, 7, available at https://www.blm.gov/sites/blm.gov/files/program_natural%20resources_seed%20strategy_quick%20link_seed%20strategy.pdf (last accessed July 2017).

[152] U.S. Department of the Interior [DOI], Bureau of Ocean Energy Management. (n.d.) "The Continental Shelf," available at https://www.boem.gov/The-Continental-Shelf/ (last accessed July 2017).

analysis and rigorous environmental review and studies.[153]

For many years, BOEM and its predecessor entity in the DOI (the Minerals Management Service) have developed and used science as a foundation for managing offshore energy and mineral resources in an environmentally and economically responsible way. BOEM has a clear statutory mandate for its environmental programs and these programs to decisions about offshore mineral leasing.[154] BOEM's recent budgetary proposal states that

> "BOEM decisions and management of OCS oil and gas, marine minerals, and renewable energy development will continue to be informed through the environmental assessments, studies, and partnerships conducted through BOEM's Environmental Programs. Through its environmental assessments and environmental studies, BOEM will continue to integrate science needs across programs and resources in order to provide effective and timely information to decision makers."[155]

A summary of BOEM funding for environmental programs is in Table 19, and a breakdown of the types of research activities that have been funded by this program over the past several fiscal years is shown in Figure 1.

Table 19: Department of the Interior (Dollars in Millions)

Mission Area/Program	*FY 2016 Enacted*	*FY 2017 Estimate*	*FY 2018 Proposed*	*FY 17-18 Dollar Change*	*FY 17-18 Percent Change*
Bureau of Ocean Energy Management					
Environmental Programs	68.0	67.9	73.8	5.9	9%
Total	**68.0**	**67.9**	**73.8**	**5.9**	**9%**

Sources: DOI FY 2017 and FY 2018 Budget in Brief documents. Budget numbers for activities in FY 2017 are FY 2017 amounts under the continuing resolution in effect when the FY 2018 budgets were transmitted.
Note: Totals may not add due to rounding.

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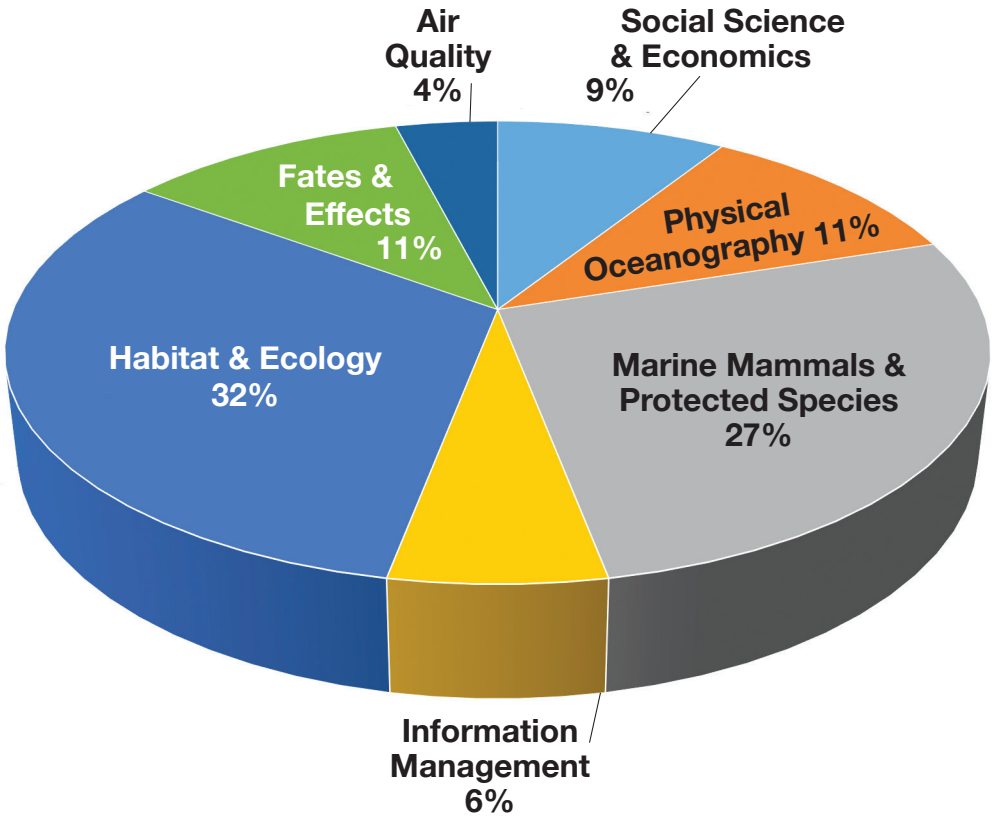
[153] DOI. 2017. Fiscal Year 2018—The Interior Budget in Brief: May 2017 [FY 2018 Budget in Brief], p. BH-19.

[154] Outer Continental Shelf Lands Act, section 20 (a) and (b); 43 U.S.C. 1346(a) and (b), and FY 2018 Budget in Brief, p. BH-20, which states that ""BOEM decisions and management of OCS oil and gas, marine minerals, and renewable energy development will continue to be informed through the environmental assessments, studies, and partnerships conducted through BOEM's Environmental Programs."

[155] Ibid., p. BH-20.

Figure 1: Environmental Studies Program Funds by Discipline (FY 2012–FY 2016, Cumulative)



Source: BOEM Budget Justification—FY 2018*, p. 109.*

Beginning in 2015, BOEM has partnered with the National Academies of Sciences, Engineering, and Medicine to support an external advisory committee on environmental science and assessment for offshore energy and mineral resources. The committee is intended to provide independent information on issues relevant to BOEM's environmental studies and assessment activities, including periodic reviews of BOEM's programs, providing peer review, conducting technical workshops, and facilitating stakeholder discussions of controversial issues.[156] BOEM also released a Strategic Framework for its Environmental Programs in May 2017, listing ten strategic scientific questions that it will use to frame and guide its research portfolio development over the next five to ten years.[157]

The budget increase slated for the environmental programs in FY 2018 is related to efforts by the department to formulate a new Five-Year OCS Oil and Gas Leasing Program for 2017–2022 to

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[156] DOI. 2017. *Budget Justifications and Performance Information: FY 2018—Bureau of Ocean Energy Management* [BOEM Budget Justification – FY 2018], p. 109.

[157] DOI. 2017. *Bureau of Ocean Energy Management—Environmental Studies Program: Strategic Framework*, available at https://www.boem.gov/Strategic-Framework-2017/ (last accessed July 2017).

replace the current one, which was approved by the prior administration in January 2017. The current leasing program excludes several offshore areas, such as sections of the Atlantic Ocean and the Beaufort and Chukchi Seas offshore Alaska. On May 1, 2017, Interior Secretary Zinke issued a new Secretarial Order directing that the development of the new Five-Year Plan give "full consideration…to leasing the OCS offshore Alaska, Mid-Atlantic, South Atlantic, and the Gulf of Mexico…."[158] To carry out this directive, BOEM will have to undertake environmental analyses in these areas, which previously were not under consideration. For this reason, the FY 2018 budget Request has, within the overall totals for environmental programs, an increase of $8.6 million targeted to the new five-year OCS Leasing Program, with offsetting reductions of $1.5 million and $1.0 million in the budget lines for environmental studies programs and IT development.[159]

According to the BOEM, in FY 2018, under the funding level requested, the reduction in effort under the Environmental Studies Program line represents a decision to "defer funding for other studies not directly supporting the planning areas under potential consideration."[160] While this represents a change in the geographic distribution of areas being studied under BOEM's Environmental Programs, it probably does not represent a meaningful diminution of BOEM's overall scientific effort in environmental research.

Bureau of Reclamation (BoR)

The BoR is both the largest supplier and manager of water in the seventeen western states and the second largest producer of hydroelectric power in the U.S.[161] Much of the bureau's $1.1 billion annual budget is focused on the operation of its facilities (including managing associated water supply systems), large ecosystems restoration projects (such as the California Bay-Delta Restoration), and settling claims of Native Americans to water resources in the western U.S. Within the budget are research and development activities that do not relate directly to the environment (such as advancing water supply treatment technologies such as desalination), as well as some R&D activities that are environmental in nature. Table 20 identifies budget trends in three of the bureau's programs that have included significant research related to the environment.

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[158] DOI. Secretarial Order 3350 ("America-First Offshore Energy Strategy"), May 1, 2017, sec. 4a.(1), available at https://www.doi.gov/sites/doi.gov/files/press-release/secretarial-order-3350-offshore-508.pdf (last accessed July 2017).

[159] DOI. FY 2018 Budget in Brief, p. BH-22.

[160] DOI. BOEM Budget Justification – FY 2018, p. 98.

[161] U.S. Department of the Interior [DOI]. 2017. Fiscal Year 2018—The Interior Budget in Brief: May 2017 [FY 2018 Budget in Brief], pp. BH-33, BH-34.

Table 20: Department of the Interior (Dollars in Millions)

Mission Area/Program	*FY 2016 Enacted*	*FY 2017 Estimate*	*FY 2018 Proposed*	*FY 17-18 Dollar Change*	*FY 17-18 Percent Change*
Bureau of Reclamation—Selected Programs for Environmental Research					
Research and Development Science and Technology	16.6	18.5	11.1	-7.5	-40%
WaterSMART Program					
Basin Studies Program	5.2	5.2	5.2	0.0	0
Bureau-wide research on quagga-zebra mussels (new crosscut in FY 2018)	—	—	7.7	—	—
Total (excluding mussels)	**21.8**	**23.2**	**16.3**	**-6.9**	**-30%**

Sources: DOI FY 2017 and FY 2018 Budget in Brief documents. Budget numbers for activities in FY 2017 are FY 2017 amounts under the continuing resolution in effect when the FY 2018 budgets were transmitted.
Note: Totals may not add due to rounding.

Science and Technology Program

The primary research and development program for BoR is its Science and Technology Program. While some of the work funded under this program has a very applied emphasis, in recent years the program has also provided more fundamental work to strengthen the scientific basis of understanding for phenomena important to the bureau's operations.

One key area in which the bureau has been actively engaged is its Climate Change and Variability Program. This program has been aimed at improving the ability to predict, and effectively adapt to, the risks and impacts of climate change and variability on western water resources. The program has supported development of technical tools and science that western water managers can use to better adapt to the hazards posed by short-term weather and climate variability (from floods to droughts) as well as those posed by long-term climate change. Program products are used in planning and assessments supported by reclamation region and area offices as well as bureau-wide programs (e.g., WaterSMART Program, Dam Safety Program).[162] In FY 2018, the overall Science and Technology Program is slated to be cut by 40 percent. Within that amount, it appears that the climate-related water resources research is being completely phased out, as the detailed budget justifications document for this activity only

[162] DOI. 2016. *Budget Justifications and Performance Information: Fiscal Year 2017—Bureau of Reclamation*, p. BW-53.

mentions the following research areas: water infrastructure, power and energy, water operations and planning, developing new water supplies, and environmental compliance issues confronting water and power delivery.[163]

Basin Studies Program

Within the bureau's WaterSMART Program, the Basin Studies Program has funded collaborative approaches to evaluating the impacts of climate change through risk assessment; developing landscape-level science; communicating information and science to other entities and agencies; and working with stakeholders to develop adaptation strategies to cope with water supply and demand imbalances.[164] These assessments, aimed at supporting an integrated strategy to respond to new weather patterns in a changing environment, appear to be funded at the same level as in previous years in the FY 2018 budget request.[165]

Quagga-Zebra Mussels

The bureau has funded research, across several of its elements, on monitoring and preventing further spread of invasive quagga and zebra mussels, for a number of years.[166] While a total funding amount for these efforts in recent fiscal years is not available, in FY 2018, the bureau is funding an $7.7 million integrated program, guided by a Quagga-Zebra Mussels Action Plan for western U.S. waters, aimed at preventing invasive mussels from infecting the Columbia River Basin, which is the last major uninfected watershed in the U.S. While the $7.7 million will include prevention, containment, and control activities that are not research, it will also include research focused on better methods and on monitoring and early detection.[167] This appears to be an increase over previous fiscal years, but because it had not been baselined in prior budgets, the amount of increase for environmental research is difficult to assess.

National Park Service

The NPS is charged with preserving lands and historic features that were designated by the nation for their cultural and historic significance, scenic and environmental worth, and educational and recreational opportunities.

Many of the NPS activities have an environmental R&D component, but the bulk of the research can be found in the National Parks Operation—Park Management—Resource Stewardship line. This line has two components, Natural Resource Stewardship and Everglades Restoration and

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[163] DOI. 2017. *Budget Justifications and Performance Information: Fiscal Year 2018—Bureau of Reclamation*, p. Bureauwide-57.

[164] DOI. FY 2017 Budget in Brief, pp. BH-37, BH-41.

[165] DOI. FY 2018 Budget in Brief, pp. BH-39, BH-42.

[166] DOI. "Invasive Mussel Detection and Monitoring Program for Reclamation Reservoirs," available at https://www.usbr.gov/mussels/history/factsheets/musseldetectionfactsheet.pdf (last accessed July 2017).

[167] DOI. FY 2018 Budget in Brief, pp. BH-35, BH-36.

Research. Within each of these components research activities are commingled with other restoration and conservation activities, so funding numbers reflecting research alone cannot be derived from the DOI budget documents. A qualitative discussion of the research activities in these areas, though, follows.

Resource Stewardship

The Resource Stewardship sub activity supports the NPS mission by protecting, preserving, and restoring natural and cultural resources and providing the knowledge and information necessary to ensure their proper management. The NPS inventories, evaluates, documents, preserves, protects, monitors, maintains, and interprets the natural and cultural resources at park units, trails and wild and scenic rivers.

Natural resource activities and programs that have an environmental component include:

- **Air Resource Management and Research** NPS maintains an extensive monitoring network for fine particles, ambient air quality (namely ozone), and deposition of mercury, sulfur, nitrate and ammonia.

- **Biological Resource Management** The NPS conducts an extensive range of activities to preserve and manage biological resources, native species and their habitats, and contribute to the overall health of the park ecosystem. Subject-matter specialists and park managers work together to address technically complex biological resource stewardship and management needs that require the application of scientific knowledge and involve legal or policy-related guidance.

- **Cooperative Ecosystem Studies Units** (CESUs) A CESU is an interdisciplinary, multi-agency collaborative partnership of federal agencies and universities organized within a broad bio-geographic area. CESUs provide usable knowledge for resource managers, responsive technical assistance to parks, and continuing education for park personnel, and serve as science advisors and subject matter experts for parks.

- **Cooperative Landscape Conservation** As discussed above, DOI's approach to climate change is through LCC and climate science centers. NPS conducts climate impact science studies, utilizes adaptation management techniques and carbon sequestration methods, and performs energy efficiency activities focused on practical, on-the-ground information and actions designed to achieve the service's mission.

- **Geologic Resources** Geological features and processes are key influences on both the health of park watersheds, landscapes, and marine resources, and the NPS's ability to sustain biological communities on the lands and waters it manages. Subject-matter specialists provide park managers with scientific information and technical support in a range of areas including disturbed land restoration; mitigation of geologic hazards (e.g., rockfalls, landslides, debris flows); geologic resource inventory and monitoring; soil resources, and coastal shorelines; and planning that integrates the use of information on park geologic features and processes in park decision making.

- **Inventory and Monitoring (I&M)** The NPS administers a service-wide effort to inventory and monitor the condition or "health" of key vital sign parameters. This science-based information helps provide park personnel with a broad-based understanding of the status and trends in the condition of park natural resources as a basis for making and assessing the results of management decisions, working with other agencies, and communicating with the public to protect park natural systems and native species.

- **Water Resources** The NPS protects and manages fresh and marine waters in parks, including aquatic wildlife and vegetation to preserve park natural resources and ecosystems. It also works to restore water quantity (levels and flows) and quality to desired conditions; implement the 2010 Executive Order setting forward the nation's new National Ocean Policy as it affects ocean, coastal, and Great Lakes parks; and to ensure that water and water rights are available to meet visitor and administrative needs. Aquatic resource professionals address park management needs, including water resources planning, identification and prioritization of protection and restoration projects, development of water-related scientific information, aquatic resource restoration projects, and participation in legal or administrative processes. The NPS works with other partners in responding to coastal climate change effects, water quality impairments, fisheries management, harmful algal blooms, marine debris, and ecosystem restoration of the ocean, coastal and Great Lakes parks. These partnerships support systematic observations of sea and lake levels, ocean acidification, ocean warming, and other impacts to assess climate change vulnerability and enable parks to prepare for and respond to coastal climate change.

Of the total $131.8 million reduction in the FY 2018 budget request for NPS Park and program operations, $13.1 million would be from Natural Resource Stewardship. This represents a 6 percent decrease in funding from FY 2017 levels, which would affect all activities under this heading, including research. At the proposed level of funding, the NPS expects that the percentage of acres managed in a natural condition that are in a desired condition could decrease 3.6 percent, the percent of acres infested with invasive plants which are controlled could decrease 0.3 percent, and the park populations of exotic invasive animal species effectively controlled could decrease 1.0 percent. A decrease in the number of acres controlled would likely result in an increase in several of the 1,500 invasive animal and plant species populations.[168]

Everglades Restoration and Research

The Everglades Restoration and Research program is critical to the restoration, preservation, and protection of federal interest lands in South Florida. The research component of this program provides technical tools and data that assist the NPS in understanding the function of the present ecosystem, in evaluation of alternative plans for restoration, and in assessment of the effects of built restoration projects on NPS resources. The research program also supports detection, containment and control techniques for exotic species, as well as studies of large-scale

[168] Ibid., p. ONPS-ResStew-4.

ecosystem events, and the potential effects of climate change on DOI resources in South Florida. In FY 2018, the research component of the Everglades Restoration and Research Program will focus applied science projects on data and syntheses needed to inform decisions regarding the design and function of the current and future restoration projects, the effects of large scale disturbance events (such as the recent seagrass die-off in Florida Bay), and the effects of climate change and invasive species on NPS resources.[169]

The Critical Ecosystems Studies Initiative (CESI) will remain one of the primary venues providing scientific information for use in restoration decision-making and guiding NPS land management responsibilities in South Florida. To date, CESI-funded applied science has contributed to the basic body of knowledge about the Everglades ecosystem:

- How it functioned naturally before large-scale drainage in the first part of the 20th century.
- How it has been altered and is currently functioning.
- What the requirements are for restoration of the ecosystem.

During the life of the program, the emphasis on funding of projects has shifted from basic research and modeling to emphasizing restoration project assessment and monitoring. Given new developments in the fields of invasive species research and climate research, funding for the basic research component of the CESI program remains essential.[170]

Of the total $131.8 million reduction in the FY 2018 budget request for NPS Park and Program Operations, $0.7 million would be from Everglades Restoration and Research. This represents a 6 percent decrease in funding from FY 2017 levels, which would affect all activity under this heading, including research. A decrease in funding would result in fewer financial resources and staff to support the restoration, preservation, and protection of federal lands in the Everglades.[171]

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[169] Ibid., p. ONPS-ResStew-29, ONPS-ResStew-30.

[170] Ibid., p. ONPS-ResStew-30, ONPS-ResStew-31.

[171] Ibid., p. ONPS-ResStew-29.

Department of State—U.S. Agency for International Development (DOS–USAID)

Table 21: DOS/USAID CE R&D-Related Funding by Program (Dollars in Millions)[172]

	FY 2016 Enacted	*FY 2017 Estimate*	*FY 2018 Proposed*	*FY 17-18 Dollar Change*	*FY 17-18 Percent Change*
Global Environment Facility (GEF)	168	168	102	-66	-39%
Clean Technology Fund (CTF)	171	170	0	-170	-100%
Strategic Climate Fund (SCF)	50	60	0	-60	-100%
Green Climate Fund (GCF)	0	0	0	0	0%
Global Climate Change Initiative (GCGI)	304	362	0	-362	-100%
Total	**693**	**760**	**102**	**-657**	**-87%**

The DOS is the lead U.S. foreign affairs agency within the executive branch and the lead institution for the conduct of American diplomacy. Through the DOS annual funding, the U.S. is the world's leading financial contributor to the UNFCCC and to the IPCC—the principal international organization for the assessment of scientific, technical, and socioeconomic information relevant to the understanding of climate change, its potential impacts, and options for adaptation and mitigation. Recent DOS contributions to these organizations provide substantial support for global climate observation and assessment activities in developing countries. DOS also works with other agencies in promoting international cooperation in a range of bilateral and multilateral climate-change initiatives and partnerships.

USAID carries out U.S. foreign policy by promoting broad-scale human progress at the same time as it expands stable, free and democratic societies; creates markets and trade partners for the U.S.; and fosters good will abroad. USAID's climate-change and development strategy calls for enabling countries to accelerate their transition to climate resilient, low emission sustainable economic development through direct programming and integration of climate-change adaptation and mitigation objectives across the agency's development portfolio. USAID leverages scientific and technical resources from across the U.S. government (for example, NASA, NOAA, USDA, USGS) as it applies its significant technical expertise to provide leadership in development and implementation of low-emissions development strategies, creating policy frameworks for

[172] Budget of the U.S. Government FY 2018; DOS 2018 budget justifications; FY 2016 and 2017 omnibus appropriations bills and reports. Totals may not add due to rounding.

market-based approaches to emission reduction and energy sector reform, promoting sustainable management of agriculture lands and forests, and mainstreaming adaptation into development activities in countries most at risk. USAID has long-standing relationships with host country governments that enable them to work together to develop shared priorities and implementation plans. Finally, USAID bilateral programs work in key political and governance areas where multilateral agencies cannot.

The DOS and USAID do not support CE R&D directly. Their roles are largely to support diplomatic and financial mechanisms to help influence international environmental and climate policies and agreements. This happens through two significant processes: (1) supporting UNFCCC efforts to provide the latest science related to environmental and climate policy issues like the IPCC, and (2) to fund CIFs to help implement international climate and environmental agreements. In 2010, President Obama created the GCCI to integrate climate change considerations into U.S. foreign assistance through a range of bilateral, multilateral, and private sector mechanisms to promote sustainable and climate-resilient societies, foster low-carbon economic growth, and reduce greenhouse gas emissions from deforestation and land degradation.

The CTF, SCF, and GCF are the most recent CIFs. All of these efforts are designed to help implement current climate agreements—like the 2015 Paris Accord signed by 195 counties—to keep global warming to below two degrees Celsius. Developed countries are largely responsible for the GHG emissions and subsequent warming of the planet since the industrial revolution. These funds are designed to help developing countries move away from fossil fuel based economies since most of these counties have not significantly contributed to current warming and will disproportionally suffer given projected warming through the end of the century. The president has promised to cease payments to the United Nations' climate change programs, and the current administration has also reported concerns about the overlap between these programs and whether the U.S. is paying an unfair share to support these international efforts. As a result, the administration has proposed to significantly reduce the GEF and eliminate CIFs and the GCCI.

Regarding whether the U.S. is paying an unfair share, the previous administration committed $3 billion to the GCF. In dollars, that is roughly twice what France, England, Germany, and Japan individually pay. Yet, it is far below all those countries on a per capita basis and the U.S. GHG emissions are higher per capita than any of these other countries.[173] The elimination or reduction of these efforts could unravel over twenty years of challenging yet productive international diplomacy relative to both climate and environmental issues. The collapse of these efforts could relegate civilization to loosing another decade addressing the issues facing future generations relative to a changing climate, and missing out on the significant economic return of moving toward a green economy. Some of the greatest economic competitors to the U.S. have moved aggressively into the green economy (e.g., mitigation and adaptation strategies and adopting

[173] http://www.greenclimate.fund/how-we-work/resource-mobilization

renewable energy sources). China in particular has been very aggressively moving toward a greener economy and will likely dominate it if the U.S. does not respond. Regardless of what one believes about climate change, this will be a significant missed economic opportunity, and one that will bring new wealth and jobs to the country that takes leadership in this area.

In Table 21, the Green Climate Fund shows no funding in FY 2016-FY 2018. Funds were requested each year, but not appropriated. The administration has proposed to eliminate the GCF, and an overall 87 percent reduction to these programs. While not shown in Table 21, the current administration has also not designated FY 2018 funds for the United Nation's World Meteorological Organization (WMO, pending an interagency strategic review of U.N. contributions. The WMO received contributions of approximately $15M from the U.S. in the FY 2016 and FY 2017 budgets.

The following is a brief description of the six areas of DOS USAID CE R&D funding:

- **Global Environment Facility** The GEF unites 183 countries in partnership with international institutions, civil society organizations, and the private sector to address global environmental issues while supporting national sustainable development initiatives. Today the GEF is the largest public funder of projects to improve the global environment. An independently operated financial organization, the GEF provides grants for projects related to biodiversity, climate change, international waters, land degradation, the ozone layer, and persistent organic pollutants. The GEF also serves as a financial mechanism for the following conventions:
  - Convention on Biological Diversity
  - United Nations Framework Convention on Climate Change
  - UN Convention to Combat Desertification
  - Stockholm Convention on Persistent Organic Pollutants
  - Minamata Convention on Mercury

  The UNFCCC funds the IPCC, which brings together scientists from around the world to periodically provide the latest science regarding climate change. Given their proposed 39 percent reduction to the GEF, it is unclear whether the current administration will continue support to these conventions and the IPCC.

- **Clean Technology Fund** The CTF empowers developing and emerging economies by providing resources to scale up low carbon technologies with significant potential for long-term GHG savings. The CTF and Strategic Climate Fund (below) are part of the larger CIFs that were designed by developed and developing countries and are implemented with the multilateral development banks (e.g., the World Bank) to bridge the financing and learning gap between now and the next international climate change agreement.

- **Strategic Climate Fund** The SCF provides financing to pilot projects to help vulnerable countries adapt their development programs to improve resilience to climate change and a program to prevent deforestation.

- **Green Climate Fund** The GCF was created to support the efforts of developing countries to respond to the challenge of climate change. GCF helps developing countries limit or reduce their GHG emissions and adapt to climate change. It seeks to promote a paradigm shift to low-emission and climate-resilient development, taking into account the needs of nations that are particularly vulnerable to climate change impacts. It was set up by the 194 countries that were part of the UNFCCC in 2010. It aims to deliver equal amounts of funding to mitigation and adaptation, while being guided by the convention's principles and provisions. When the Paris Agreement was reached in 2015, the GCF was given an important role in financing the agreement and supporting the goal of keeping climate change well below 2 degrees Celsius. In the U.S., funds were requested each year for the GCF, but no funds were appropriated. The Trump Administration has proposed to eliminate the GCF.

- **Global Climate Change Initiative** President Obama created the GCCI in 2010 to integrate climate change considerations into U.S. foreign assistance through a range of bilateral, multilateral, and private sector mechanisms to promote sustainable and climate-resilient societies, foster low-carbon economic growth, and reduce GHG emissions from deforestation and land degradation. The GCCI is implemented through programs at the Department of State, the Department of the Treasury, and USAID. The definition of the GCCI is different between the FY 2016, FY 2017, and FY 2018 budgets so it is difficult to track this across the years (e.g., the GEF, CTF, SCF, and GCF are sometimes all or partially included in the GCCI).

- **World Meteorological Organization** The United Nation's WMO received contributions of approximately $15M in the FY 2016 and FY 2017 budgets. For FY 2018, the administration has not included a funding level for the WMO pending an interagency strategic review of U.N. contributions. The WMO provides the framework for the essential international cooperation among the national meteorological and hydrological services of its 191 member countries and territories.

National Aeronautics and Space Administration (NASA)

The NASA Earth Science mission is to "develop a scientific understanding of Earth's system and its response to natural or human-induced changes, and to improve prediction of climate, weather and natural hazards."[174] Towards that end, NASA Earth Sciences is responsible for the development, deployment, and operation of satellite and airborne missions to obtain critical measurements enabling long-term global observations of the land surface, biosphere, solid Earth, atmospheres, and oceans. In addition, the division conducts and sponsors research to advance scientific understanding of Earth including how the global earth system is changing and what is causing these changes now and in the future. The four major research areas are (1) research and analysis, (2) satellite missions, (3) applied sciences and (4) enabling technology. The research and

[174] https://science.nasa.gov/earth-science

analysis program includes six interdisciplinary science focus areas which are interconnected. The focus areas are carbon cycle and ecosystems; water and energy cycle; climate variability and change; atmospheric composition; weather; and earth surface and interior. The focus of the applied science program is on the practical uses of the data. It leverages the knowledge and technology to better society, especially as they relate to decision making and services. The program supports enabling capabilities that span across the entire Earth Science Division including data processing, airborne science to new technologies. The solicitations are always open to scientists and engineers at NASA and other federal laboratories, academia, and industry and include the training of the next generation of leaders in the field as well as development of critical data management plans.

One of the most important contributions of NASA Earth Science is the stewardship of the large quantities of data that are generated daily. These data require multiple temporal and spatial scales and demand a range of data products available to the user community. Thus, Earth Science has set up requirements that must be followed for data processing, archival, and dissemination of space-based measurements obtained through these NASA Earth missions. The data generated from the NASA supported research are utilized by scientists and engineers to provide the foundation for research activities supported not only by NASA but other federal agencies (including, NSF, NOAA, EPA, NIH), other governments, industry and private foundations. *These data that are not available by other means are the crown jewels for earth science.* Indeed, without NASA's inputs, there would be an incredible gap in critical information that is important for the success of other agencies, such as NOAA, Department of Interior, NSF and others. This is one of the reasons that, as noted earlier, NASA Earth Science is the major budgetary contributor to the USGCRP.

Given the critical importance of these data generated by NASA *in-situ*, surface-, ship-, balloon- and/or space-based platforms, NASA Earth Science has an extensive process for long-term strategic planning that includes the decadal study for the satellite component conducted by the National Academy of Sciences (NAS). The most recent report is entitled *Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond*.[175] The NAS's Space Studies Board in collaboration with other Earth Science related boards (Board on Atmospheric Science and Climate, Board on Earth Science and Resources, Ocean Studies Board, Polar Research Board, Water Science and Technology Board), is in the process of releasing the 2017–2027 Decadal Survey for Earth Science and Applications from Space (ESAS 2017).[176] The goals of these types of documents is that they will be used to assist and guide science priorities and investments into the next decade.

Using these and other NASA recommendations, along with all-encompassing planning activities that include both bottom-up and top-down approaches, Earth Sciences can lay the foundation

[175] http://www.nap.edu/catalog.php?record id=11820

[176] http://sites.nationalacademies.org/DEPS/esas2017/DEPS_169443

for the next generation of space-based measurements required by multiple users to advance understanding of our Earth. It can also identify areas of investments for future technologies that will enhance our ability to understand the earth system.

This planning is critical for sustaining a coordinated approach for long-term global observations of the land surface, biosphere, solid Earth, atmosphere, and oceans. Presently, Earth Science classifies seventeen missions into three categories: foundational missions, decadal survey missions and climate continuity missions. Climate continuity missions are critically important to our nation given that they provide systematic measurements that are required to be monitored long-term. The word continuity is part of the title because it is essential that there are not breaks in collecting specific data points. The aim is for the new missions to overlap approximately six months with the older technologies, enabling calibration of the data and ensuring a continued flow of this vital information.

The president's budget for Earth Science represents a 5 percent cut of the programs' annual budget. The budget continues the support of the launch of Landsat 9 as early as FY 2021 and fully funds Ice, Cloud, and Land Elevation Satellite (ICESat-2); Gravity Recovery and Climate Experiment (GRACE-FO); Surface Water and Ocean Topography (SWOT); NASA-ISRO Synthetic Aperture Radar (NISAR). In addition, Earth Science will benefit from the targeted $70M per year investment for technology development on CubeSats/SmallSats. Indeed, the positive aspect is that this budget provides support for these Earth-observing missions in space as well as airborne missions.

However, using the justification of budget constraints and higher priorities within Science Mission Directorate (planetary science, astrophysics and heliophysics receive increases), this budget requests the termination of five Earth Science missions. Four of the five reductions target missions aimed at understanding climate change. Moreover, the budget also terminates the Carbon Monitoring System, a project that NASA began developing under congressional direction in 2010.

Plankton, Aerosol, Cloud, ocean Ecosystem Satellite

The aim of PACE is to "provide systematic observations and continuity for ongoing ocean color research, systematic observations of aerosol and clouds in the climate record, and enhanced ocean color remote sensing over a broad spectrum."[177] NASA began taking ocean color measurements, which provided information on planetary carbon sink in plants, in 1997 with the launch of the Seawifs satellite. Not only will PACE monitor the health of the ocean and its living marine resources including phytoplankton community composition, it will provide researchers with extended data records on aerosol particles and clouds, which are still considered one of the most uncertain components in the understanding of physical climate. Potential outcomes are an enhanced understanding of how marine ecosystems impact nutrients which could then lead to new comprehension about harmful algal blooms and oxygen minimum zones. PACE will also

[177] https://pace.gsfc.nasa.gov

enhance what is understood about the carbon cycling in the ocean-land-atmospheric system. PACE provides a strategic climate continuity mission in support of NASA's Plan for a Climate-Centric Architecture for Earth Observations and Applications from Space (2010).

The Orbiting Carbon Observatory-3[178]

OCO-2[179] is presently in operation and has been monitoring global carbon dioxide levels since 2014. OCO-3 is the future space instrument that would provide continuation for studying the concentration distributions of carbon dioxide. One unique feature of OCO-3 is that NASA will be able to develop and assemble the instrument using spare materials from OCO-2 and the instrument will be installed on the Japanese module of the ISS after a 2018 launch. Thus, it is a complete stand-alone payload that will operate for the duration of the ISS. OCO-3 contributes to delineating the distribution of CO_2 on Earth as it relates to growing urban populations and changing patterns of fossil fuel combustion. It is in development as part of the continuity missions.

The Climate Absolute Radiance and Refractivity Observatory Pathfinder[180]

The aim of the CLARREO mission is to detect the complete spectrum of radiation from the Sun reflected by Earth. This tier-1 mission was recommended by the National Research Council Decadal Survey (2007). It is presently set to launch in the 2020s and can be installed on the ISS. The goal is to have better radiation measurements than current space-based sensors. Moreover, the measurements can be tied to accepted international standards and be calibrated on-orbit. It will also demonstrate the ability to calibrate the sensors of other satellites that cross the CLARREO orbital path [e.g. Clouds and the Earth's Radiant Energy System (CERES) and Visible Infrared Imaging Radiometer Suite (VIIRS)]. The data provided by CLARREO would help climate scientists understand many of the uncertainties that impede current climate models. Recently, the CLARREO project held a successful concept review that reaffirmed the importance of the mission to NASA Earth Science, and demonstrated both the feasibility of the project and the development of technology enabling progression to the next phase of development and implementation. It is in development as part of the foundational mission.

Radiation Budget Instrument (RBI)[181]

The RBI is in development as part of Joint Polar Satellite System 2, a NOAA/NASA project to launch in late 2021. NOAA is the lead and NASA assists in implementation of the instruments. The scanning radiometer instrument measures reflected sunlight and emitted thermal radiation, enhancing the understanding of the effects of clouds on Earth's energy balance. It will extend the unique global climate measurements of the Earth's radiation budget provided by the CERES instruments since 1998. Per NASA, the long-term satellite data from RBI will enhance

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[178] https://www.jpl.nasa.gov/missions/orbiting-carbon-observatory-3-oco-3/ and https://science.nasa.gov/missions/oco-3

[179] https://oco.jpl.nasa.gov/

[180] https://clarreo.larc.nasa.gov/

[181] https://fpd.larc.nasa.gov/rbi.html

understanding of the links between the Earth's incoming and outgoing energy, and properties of the atmosphere that affect it. The data also will positively impact weather forecasting.

Earth Viewing Instruments Aboard the Deep Space Climate Observatory (DSCOVR) Spacecraft[182]

DSCOVR was launched in 2015 as part of a partnership between NASA, NOAA, and the U.S. Air Force. The primary objective is the monitoring of real-time solar wind, which is critical to the accuracy and lead time of space weather alerts and forecasts from NOAA. It augments data coming from NASA's Advanced Composition Explorer (ACE) which was launched in 1997.[183] Given its vantage point of 1.5 million kilometers from Earth and between the Earth and sun, DISCOVR enables unique images of the Earth and can also track changes with unmatched specificity. Images can show detailed characteristics such as ozone, vegetation, atmospheric aerosols, and cloud heights. The budget eliminates operation of the instruments enabling the images of Earth.

Carbon Monitoring System[184]

CMS is a project that NASA developed in 2010 in response to congressional direction. The goal is to develop methods for monitoring and assessing of the GHG emissions from forests and other natural carbon stocks. CMS will capitalize on NASA satellite observations and modeling capabilities to develop products that will be useful in providing accurate measurements of carbon emissions on a global level and could lead to better understanding of carbon emissions. These types of data could be used by any nation to understand its own carbon emissions and storage.

Earth Science Research and Analysis, and Computing and Management

Earth Science Research and Analysis is the core of the research program and funds the analysis and interpretation of data from NASA's satellites as well as the airborne and *in-situ* measurement, including support for essential computational models. The proposed budget reduction for Earth Science reduces the number of new research awards that can be made in FY 2018. Graduate students, postdoctoral fellows, and undergraduates are supported on these research grants. Thus, this reduction in grant support not only impacts scientific progress but also has major consequences for training of the next generation of earth scientists and engineers.

Office of Education

While the FY2018 budget request continues the Science Mission Directorate's STEM Science Activation Project and the education components integrated with Earth Science missions, the proposed elimination of the NASA Office of Education can have lasting negative impact on the future U.S. workforce in STEM fields. The Office of Education, which received $115 million in 2016, is primarily responsible for NASA's educational outreach programs. Since 1989, the

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[182] https://www.nesdis.noaa.gov/content/dscovr-deep-space-climate-observatory

[183] http://www.srl.caltech.edu/ACE/ace_mission.html

[184] https://carbon.nasa.gov/ and https://daac.ornl.gov/cgi-bin/dataset_lister.pl?p=33

National Space Grant and Fellowship Program, located in every state, the District of Columbia, and the Commonwealth of Puerto Rico, has supported education and outreach activities, fellowships, and scholarships to excite students and the public about the importance of STEM careers and their societal benefits. The Space Grant national network consists of over 850 affiliates at universities, colleges, industry, museums, science centers, and state and local agencies. In addition, the Office of Education provides funding to students to help them prepare for jobs in aerospace. It supports programs and camps with a focus on inclusion. Furthermore, it oversees the Minority University Research and Education Programs that fund grants to minority colleges and institutions, and the Experimental Program to Stimulate Competitive Research program that supports a broad range of STEM career development across our country. Elimination of the Education Office could negatively impact the diversity and size of the future workforce in aeronautics, science and engineering. While as noted above, the education activities of Science Mission Directorate were not reduced, the Office of Education also supports their work by coordinating projects for students, faculty, and institutions that broaden the base of those who compete for NASA research awards.

In summary, while NASA Science Mission fared well, the draconian cuts in Earth Science will have long-term negative impacts for science and graduate education supported not only by NASA but the other federal research agencies.

National Oceanic and Atmospheric Administration (NOAA)

Table 22: NOAA CE R&D Funding by Program (Dollars in Millions)[185]

	FY 2016 Enacted	*FY 2017 Estimate*	*FY 2018 Proposed*	*FY 17-18 Dollar Change*	*FY 17-18 Percent Change*
National Ocean Service	77	68	59	-9	-13%
National Marine Fisheries Service	77	68	56	-13	-19%
Oceanic and Atmospheric Research	395	422	350	-72	-17%
National Weather Service	22	20	13	-7	-33%
Nat'l Satellite, Data, & Info Service	26	22	29	7	34%
Mission Support		5	0	-5	-100%
Office of Marine & Aviation Ops		117	164	47	40%
Total	**596**	**721**	**672**	**-49**	**-7%**

NOAA is a science-based federal agency within the Department of Commerce with regulatory, operational, and information service responsibilities. Through its mission of science, service, and stewardship, NOAA advances the understanding of and ability to anticipate changes in the earth's environment, by improving society's ability to make scientifically informed decisions, and by conserving and managing ocean, coastal, and Great Lakes' resources.

Science at NOAA is the systematic study of the structure and behavior of the ocean, atmosphere, and related ecosystems; integration of research and analysis; observations and monitoring; and environmental modeling. Science provides the foundation and future promise of the service and stewardship elements of NOAA's mission. Service is the communication of NOAA's research, data, information, and knowledge for use by the nation's businesses, communities, and in people's daily lives. Stewardship is NOAA's direct use of its knowledge to protect people and the environment, as the agency exercises its authority to regulate and sustain marine fisheries and their ecosystems, protect endangered marine and anadromous species, protect and restore habitats and ecosystems, conserve marine sanctuaries and other protected places, respond to environmental emergencies, and aid in disaster recovery.

[185] Amounts for NOAA Environmental R&D are based on NOAA's estimates for Research and Development Investments contained within NOAA's annual Budget Estimates Submitted to the Congress. Totals may not add due to rounding.

CE R&D Within NOAA

NOAA provides research-to-application capabilities that apply new understanding to questions, develop research products and methods, and apply emerging science and technology to user needs.

These capabilities are brought to bear on the four strategic goals directing NOAA's mission:

- **Climate Adaptation and Mitigation**—An informed society anticipating and responding to climate and its impacts
- **Weather Ready Nation**—Society is prepared for and responds to weather-related events
- **Healthy Oceans**—Marine fisheries, habitats, and biodiversity are sustained within healthy and productive ecosystems
- **Resilient Coastal Communities and Economies**—Coastal and Great lakes communities are environmentally and economically sustainable.

While NOAA's four goals are complementary, achieving each presents a challenge for R&D. Addressing the needs of the individual goals requires examining the common science and technology elements that support all of the goals, such as observations, modeling, and computer technologies. NOAA also seeks to improve how its R&D is used by its stakeholders, incorporating assessments of how its science is used by society.

For FY 2018, NOAA is requesting a budget of $4.8 billion, a reduction of nearly $1 billion from FY 2017. Within this budget, NOAA has prioritized support for its core functions including: current generation of polar orbiting satellites; and at-sea monitoring infrastructure, management of commercial and recreational fisheries, and domestic seafood production via aquaculture. NOAA-owned labs and centers are emphasized at the expense of extramural programs such as Sea Grant, Prescott, and university-based cooperative research institutes. As shown in Table 22, Environmental R&D at NOAA is proposed to decline by an estimated 7.3 percent or $49.2 million NOAA-wide. If one excludes ship and aircraft acquisition costs carried in the Office of Marine and Aviation Operations budget, the reduction in support for Environmental R&D in NOAA's program offices is estimated at $96 million—a 16 percent reduction. The programs and facilities being terminated or reduced related to NOAA environmental R&D are described below under each program or activity.

National Ocean Service (NOS)

NOS delivers science-based tools and services to understand, predict, and protect America's coasts, Great Lakes, and ocean waters, and sustain healthy and resilient economies, communities, and ecosystems. The coast is home to over half the nation's population, providing food, jobs, commerce, recreation, and energy. It is also facing pressure from threats such as coastal storms, sea level rise, marine debris, habitat loss, harmful algal blooms, coastal development, and port congestion. In response, NOS provides science and services such as creating and updating nau-

tical charts and inundation maps (including the underlying geospatial framework), monitoring sea-level trends and collecting other ocean observations, responding to oil spills, managing national marine sanctuaries, protecting corals and other critical habitat, and funding state and regional management efforts.

- **Impact of the Reduction**
  - **Eliminates Coastal Zone Management Grants and Regional Coastal Resilience Grants**.
  - **Eliminates Federal support for National Estuarine Research Reserve Systems and Construction**.
  - **Eliminates National Center for Coastal Ocean Science Competitive Funding Support for Research on Ecological Threats**—FY 2018 is scheduled to be the final year of funding for thirty-five of fifty open awards. To the extent possible, NOAA will use any FY 2017 appropriations for the program to complete funding cycles for existing projects. At least thirteen projects will not receive complete funding under the baseline scenario, and will need to find alternative sources of funding to finish their research and technology transitions.
  - **Eliminates Regional Geospatial Modeling Grants**—NOAA will continue to support a range of other regional geospatial requirements through NOS's Coastal Zone Management and Services and Navigation, Observations and Positioning program activities. These activities include height modernization, Continuously Operating Reference Stations (CORS), data access and capacity building.
  - **Eliminates Support for Joint Ocean and Coastal Mapping Center**—to discontinue single-year cooperative agreements with academic institutions for joint ocean and coastal mapping centers.

National Marine Fisheries Service (NMFS)

NMFS is responsible for the stewardship of the world's largest exclusive economic zone. NMFS protects and preserves the nation's living marine resources and their habitats through scientific research, fisheries management, law enforcement, and habitat conservation. NMFS has both domestic and international responsibilities, and is a source of information for the economic benefits that can be derived from sustainable use and conservation of living marine resources.

- **Impact of the Reduction**
  - **Terminates Reef Fish Stock Assessments**—NOAA proposes a reduction of $5.0 million in grants for development and implementation of agency-independent and alternative approaches to research and stock assessments for reef fish in the Gulf of Mexico.
  - **Terminates Prescott Grants** (marine mammal stranding rescue program).
  - **Cancels Interjurisdictional Fisheries Grants**.
  - **Terminates NMFS Coastal Ecosystem Resiliency Grants** for on-the-ground habitat restoration.

- **Reduces Support for Cooperative Research Program**—NOAA proposes to reduce funding for the Cooperative Research program—the collection of fundamental fisheries information to support the development and evaluation of management options. This will lead to approximately ten fewer projects funded in FY 2018. The program will continue to execute cooperative research with industry, fishermen, and other stakeholders as available funding allows.

Office of Oceanic and Atmospheric Research (OAR)

OAR strengthens the science that is the foundation of all NOAA products and services. Whether improving warning lead times for tornadoes and hurricanes or understanding the response of ecosystems in a rapidly changing environment, OAR's research improves management of natural resources, builds understanding of the earth system, and strengthens the economy. OAR is NOAA's research hub: innovating, incubating, and integrating research along with partners inside and outside of NOAA. OAR hosts a network of research laboratories, grant programs, and cooperative institutes with academia.

- **Impact of the Reduction**

  - **Reduces Climate Research**—NOAA's budget reduces competitive research grants to cooperative institutes, universities, NOAA research laboratories, and other partners. NOAA laboratories receive a portion of their financial support through NOAA's competitively awarded grants. The FY 2018 budget request will reduce extramural grant competitions that fund research in all 50 states and support NOAA laboratories and nine Cooperative Institutes focused on climate research. This decrease will reduce competitive funding, including for the Atmospheric Chemistry, Carbon Cycle & Climate (AC4) program, the MAPP data archive, the International Research & Applications program, the Coastal & Ocean Climate Applications Program, and the Sectoral Applications Research Program.
  - **Terminates the National Sea Grant College Program**.
  - **Eliminates Arctic Research**.
  - **Terminates the Joint Technology Transfer Program**.
  - **Closes the Unmanned Aircraft Systems Program Office**.
  - **Closes the Air Resources Laboratory** (ARL)—NOAA will end ARL's applied research and observational data collection that is being used to study and project effects of air chemistry on human health and the environment. NOAA will no longer support the model used for emergency response applications and by researchers to study topics ranging from mercury deposition to anthrax bioterrorism. The budget also ends ARL's support for agencies to predict where airborne hazardous materials – like acid rain, wildfire smoke, mercury contamination, or radioactive materials – will go.
  - **Eliminates the Autonomous Underwater Vehicle Demonstration Testbed**.
  - **Ends Genomics Research**.

- **Closes Down the Infrasonic Weather Monitoring Research Program**.

National Weather Service

NWS provides weather, water, and climate forecasts and warnings for the US.., its territories, adjacent waters, and ocean areas. NWS collects environmental information and provides services for other governmental agencies, the private sector, the public, and the global community. NWS has 122 weather forecast offices, thirteen river forecast centers, and dozens of other specialty prediction centers throughout the country.

- **Impact of Reduction**
  - Terminates Surface and Marine Observations, Tsunami Warning System, and Mid-Range Weather Outlooks; and
  - Reduces support for high performance computing, Numerical Weather Prediction Modeling, National Water Model Development, Advanced Hydrologic Prediction System Expansion, Consolidate Climate Prediction Center/Weather Prediction Center Functions.

National Environmental Satellite, Data, and Information Service (NESDIS)

NESDIS observes the Earth, sun, oceans, and atmosphere. These observations are critical to the United States' contribution to a global environmental observation strategy. NESDIS develops and operates the nation's environmental satellites, composed of the Geostationary Operational Environmental Satellites for short-range warning and forecasting, and the Polar-orbiting Operational Environmental Satellites for longer term forecasting. Additionally, NESDIS operates National Data Centers that house the world's largest archive of climatic, oceanographic, and geophysical data. NESDIS provides data and information to a broad spectrum of users including weather forecasters who issue storm warnings, national and international researchers who study the environment, and the public.

- **Impact of Reduction**
  - Terminates Big Earth Data Initiative.
  - Reduces support for Polar Follow-on Satellite Development, Ground System to Process Radio Occultation Data, Data Products, Regional Climate Centers, and Space Weather Follow-on Program.

Mission Support

Mission Support manages, operates, and maintains the nation's civil fleet of research and survey ships and aircraft, as well as NOAA's Dive Program and the NOAA Commissioned Officer Corps, the nation's seventh uniformed service. NOAA's ships are specially equipped and designed to support the agency's programs, and have capabilities not found in the commercial fleet. NOAA aircraft are specially modified to carry instrument packages appropriate for NOAA's missions,

providing a wide range of research and survey capabilities, from weather research, hurricane surveillance, to snow pack surveys for flood prediction and water resource management, to coastline mapping for erosion studies, to marine mammal surveys.

- **Impact of Reduction**
  - **Terminates NOAA Office of Education including NOAA Bay-Watershed Education and Training Regional Program**.

National Science Foundation

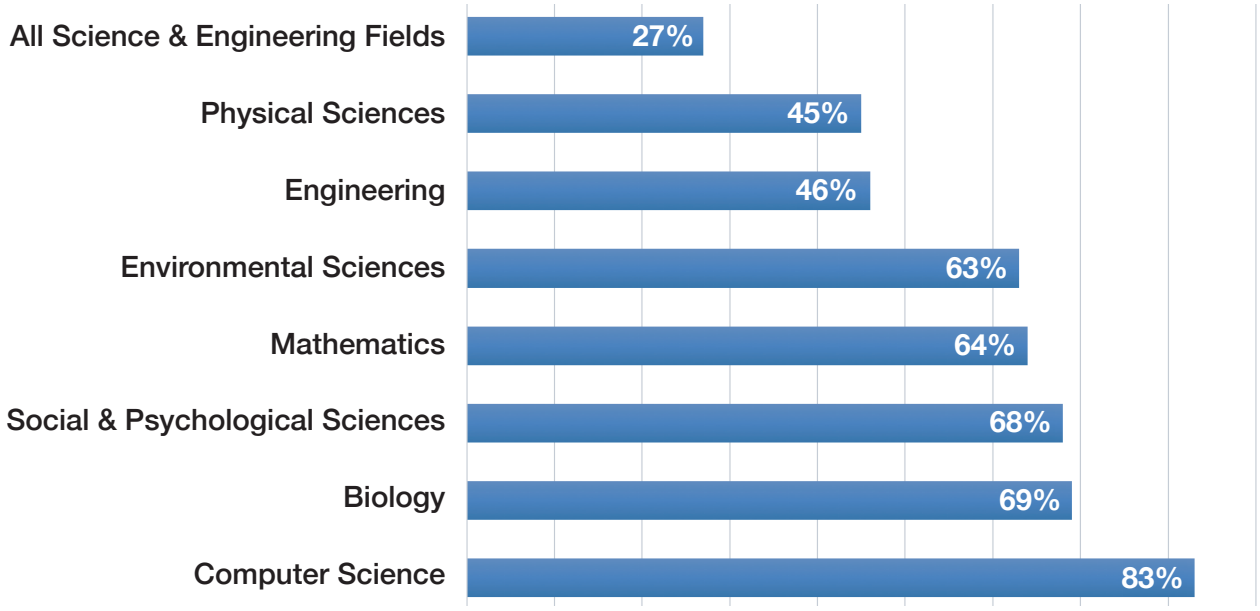
Table 23: NSF CE R&D Funding by Program (Dollars in Millions)[186]

	FY 2016 Enacted	*FY 2017 Estimate*	*FY 2018 Proposed*	*FY 17-18 Dollar Change*	*FY 17-18 Percent Change*
Biological Sciences	724	747	672	-75	-8%
Engineering[187]	184	184	168	-15	-10%
Geosciences	877	875	783	-91	-7%
Polar Programs	449	441	409	-32	-10%
Total	**2,233**	**2,248**	**2,032**	**-216**	**-10%**

[186] Source: FY 2017 Estimate is based on amounts contained in NSF's FY 2017 current (spending) plan submitted to House and Senate Appropriations Committees in June 2017. With the exception for the amounts shown in Engineering, the amounts displayed in this table are the total for each disciplinary directorate at NSF. Unless otherwise noted, these amounts come from the annual Budget Estimates NSF provides to the Congress. Note: Totals may not add due to rounding.

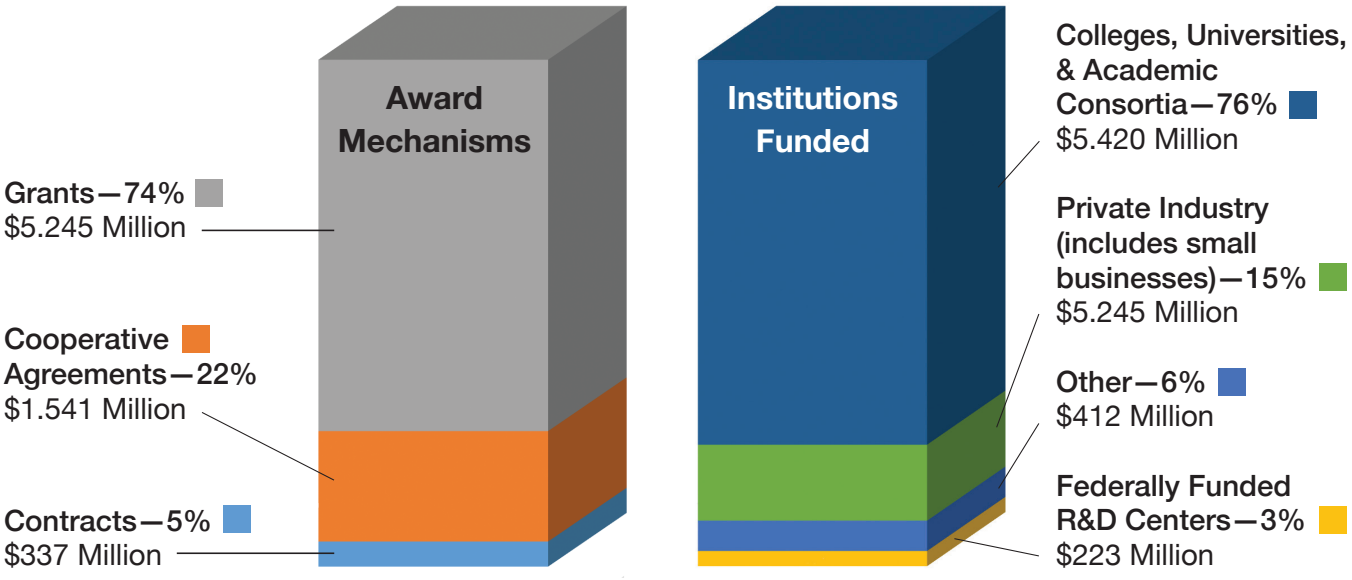
[187] This amount is the Division of Chemical, Bioengineering, and Transportation Systems Research (CBET) within the Directorate for Engineering. CBET provides a substantial amount of the support for environmental R&D in the Engineering Directorate.

Figure 2: NSF Support of Academic Basic Research in Selected Fields (As a Percentage of Total Federal Support)



Source: NSF/National Center for Science and Engineering Statistics, Survey of Federal Funds for Research and Development. Notes: Biology includes Biological Sciences and Environmental Biology, Biology and Psychological Sciences exclude NIH funding from the total amount of federal support.

Figure 3: Obligations for Research and Education Programs for FY 2016



Source: NSF FY 2017 Budget Request to Congress. https://www.nsf.gov/pubs/2016/nsf16034/nsf16034.pdf, p6. Note: NSF Research and Education Programs include R7RA, EHR, and MREFC appropriations. Other institutes funded include federal, state, and local governments; nonprofit organizations, and international organizations. Totals may not add due to rounding.

NSF's annual budget represents 27 percent of the total federal budget for basic research conducted at U.S. colleges and universities, and this share increases to approximately 60 percent when medical research supported by NIH is excluded. In many science and engineering fields NSF is the primary source of federal academic support. NSF provides an estimated 63 percent of all federal support for academic research in the environmental sciences.

In FY 2018, NSF expects to evaluate over 50,000 proposals through a competitive merit review process and make approximately 11,000 new competitive awards, which includes 8,000 new research grants. The number of new research grants decreases by roughly 11 percent from previous levels. In FY 2018, NSF support is expected to reach approximately 292,000 researchers, postdoctoral fellows, trainees, teachers, and students. In FY 2018, the funding rate will decline from 21 percent to 19 percent.

Most NSF awards are to academic institutions. As shown in Figure 3, 76 percent of support for research and education programs ($5.4 billion) was to colleges (including two-year and community colleges), universities, and academic consortia. Private industry, including small businesses, accounted for 15 percent ($1 billion), and support to federally-funded research and development centers accounted for 3 percent ($223 million). Other recipients included federal, state, and local governments; nonprofit organizations; and international organizations. A small number of awards fund research in collaboration with other countries, which adds value to the U.S. scientific enterprise and maintains U.S. leadership in the global scientific community.

Environmental R&D Within the National Science Foundation[188]

Much of NSF's support for environmental research is focused on understanding fundamental processes involved in physical, biological, and human system interactions. Examples include research in the areas of ecosystem dynamics, atmospheric chemistry, biogeochemical cycles, coastal ocean processes, population biology and physiological ecology, earth system history; and solar influences. NSF also supports research activities across all scientific and engineering disciplines to address issues related to the preservation, management, and enhancement of the environment. Areas of interest include air and water quality, biodiversity, environmental technology, natural disaster reduction, water and watersheds research, and risk assessment.

NSF addresses environmental R&D issues by funding merit-reviewed research proposals submitted largely by the academic community that seek to advance the frontiers of knowledge, provide state-of-the-art instrumentation and facilities, develop new analytical methods, enable cross-disciplinary collaborations, and develop a diverse, highly trained workforce.

Long-term, continuous, and consistent observational records are essential for testing hypotheses

[188] The definition of environmental R&D used in this section includes environmental physical, life, and social sciences; environmental engineering; critical operational environmental observations; and studies that utilize any or all of the above to address pollution problems or activities that impair the sustained functioning and productivity of the earth's environment.

quantitatively and are a cornerstone of NSF environmental R&D activities. NSF supports a variety of research observing networks and facilities (i.e. ocean observing, long-term ecological research, marine laboratories, field stations, etc.) that complement, and are dependent on the environmental monitoring systems maintained by its federal partners.

Total NSF support for CE R&D is estimated to decline in the FY 2018 budget request by an estimated $216 million or 10 percent as shown on Table 23 on page 92. This would result in approximately 800 fewer awards for environmental R&D along with a reduction in support for up to 2,500 individuals, including senior scientists, post-doctoral students, graduate, and undergraduate students supported in 2018.

Impact of Reduction

Specific program and facility impacts related to the FY 2018 budget request are detailed under the relevant sections below. However, NSF has a number of NSF-wide environmental research initiatives impacted by the FY 2018 budget request. These include: Risk and Resilience; the U.S Global Change Research Program; and Science Engineering and Education for Sustainability (SEES).

- **Risk and Resilience** investments ($31 million; a reduction of 28 percent NSF wide but GEO proposes a modest increase of $500K in its participation in this initiative) aim to improve predictability and risk assessment and increase preparedness for extreme natural and man-made events in order to reduce their impact on quality of life, society, and the economy. In FY 2018, Prediction of and Resilience against Extreme Events (PREEVENTS) and the Critical Resilient Interdependent Infrastructure Systems and Processes (CRISP) program will continue, along with other contributing activities. PREEVENTS is a focused research effort that will help to better understand and mitigate the risks posed to the U.S. by natural hazards. The CRISP program will promote research on ICI systems and processes and educate the next generation of scientists and engineers in how to best improve the resilience of U.S. infrastructures in the face of changing and increasing risks. The projects supported will make ICI services more effective, efficient, dependable, adaptable, resilient, safe, and secure.

- **U.S. Global Change Research Program** ($264 million; a reduction of about $65 million) is not just an NSF-wide program but a major interagency initiative involving a dozen other federal agencies. NSF will continue to support research that contributes to the USGCRP Goal Areas to 1) Advance science, and 2) Inform decisions. In FY 2018, NSF will continue to engage with other USGCRP agencies on priorities from intra-seasonal to centennial predictability, predictions, and projections; water cycle research; understanding the impacts of global change on the Arctic region and effects on global climate; and fundamental research on actionable science. In addition, NSF will further seek the greater integration of social science research, methodologies, and insights into understanding and supporting responses to global change, improving computing capacity, and maintaining needed observational capabilities over time.

- **Science Engineering and Education for Sustainability** SEES is terminated in FY 2018 representing a reduction of $103.6 million of targeted support for the research and education activities covered by this initiative. SEES was a coordinated effort to support research spanning a wide range of scientific domains that began in FY 2010. Multiple perspectives and areas of expertise were supported to increase the understanding of integrated systems of human society and the natural world and to lead the development of solutions to sustainability challenges. SEES is a multi-directorate NSF program that concludes in FY 2017. NSF will continue investing in SEES research via other programs and mechanisms, such as hazards-related research projects under NSF's Risk and Resilience investment area, and research through other NSF programs.

Biological Sciences (BIO)

BIO's top priority is core research across all biological science areas. U.S. academic research in the biological sciences depends on NSF funding; 69 percent of basic academic research in non-medical biology is supported by NSF. BIO considers this role essential to the promotion of vibrant and innovative fundamental biological research at U.S. universities and colleges, noting that BIO's programs support the real and theoretical bases for original research in other scientific disciplines as well as downstream applications of potential societal benefit. Broad support for biology is necessary to produce knowledge relevant to national needs in food, health, energy, and environment. Environmental R&D in BIO is provided primarily by the following divisions: Division of Integrative Organismal Systems (IOS); Division of Environmental Biology (DEB); and the Division of Biological Infrastructure (DBI).

Construction of the National Ecological Observatory Network (NEON) is expected to be complete by the spring of 2018 and BIO will assume full responsibility for operations and maintenance (O&M). NEON consists of geographically distributed field and lab infrastructure networked into an integrated research platform for regional to continental scale ecological research. Cutting-edge sensor networks, instrumentation, experimental infrastructure, natural history archive facilities, and remote sensing will be linked via the internet to computational, analytical, and modeling capabilities to create NEON's integrated infrastructure. In FY 2018, NEON O&M funding totals $65 million to be provided by the DBI. With NEON reaching full operational status in FY 2018, it now comprises nearly 10 percent of BIO's FY 2018 budget request.

Integrative Organismal Systems

IOS supports research at the level of organisms, at the meso-scale of biological organization between molecular/cellular and populations/ecosystems. IOS-supported research affords new understanding of how organisms respond and adapt to changing environmental conditions. About 62 percent of the IOS portfolio is available for new research grants. The remainder supports research and education grants made in prior years.

- **Impact of Reduction** Support for research declines by over $78 million. The majority of this reduction is related to the transfer of the Plant Genome Research Program ($67 million) from IOS to the Emerging Frontiers division within BIO.

Division of Environmental Biology

DEB supports fundamental research on Earth's biodiversity and the ecological and evolutionary processes that explain the origin and maintenance of genetic variation in nature. Models developed from biodiversity and ecological research are used to predict drivers of environmental change that impact society and enhance the nation's ability to strategically prepare for environmental threats, and field defense capabilities that are resilient and adaptive. Approximately 66 percent of the DEB portfolio is available for new research grants.

- **Impact of Reduction** DEB will prioritize basic research that focuses on science related to URoL[189] at scales of biological organization spanning local populations of organisms to regional and continental scale ecosystems. Emphasis will be on the integration of ecology and evolution, and sustaining support for development and testing of theory that transcends disciplinary boundaries to understand biological phenomena that cannot be explained by either discipline alone. Support for the Dimensions of Biodiversity Program will be sustained at $11.0 million. Research projects funded by this program provide foundational knowledge on the maintenance and functional properties of the diversity of life on Earth. Support for the Long Term Ecological Research (LTER) Program will decrease $1.40 million to a total of $20.30 million, which will impact the ability to sustain a national network of sites conducting research on the structure and function of the nation's ecosystems. The LTER sites encompass a large range of ecosystem types in the U.S., including deserts; mountains; lakes; swamps; prairies; coastal regions; tropical, temperate, and boreal forests; and arctic tundra. Research supported by this program contributes to the understanding of ecosystem services and environmental sustainability. Support for the Ecology and Evolution of Infectious Disease Program will be sustained at $6.0 million. This program, which is a partnership with the NIH and USDA, funds research to advance basic understanding and develop predictive models for disease risk, including threats to humans, wildlife, farm animals, crops, and native plants. Encouragement and support for research using NEON data, samples, and resources to address macro-scale environmental questions in the DEB core programs will continue in anticipation of the completion of NEON construction.

Division of Biological Infrastructure (DBI)

DBI supports the development of, or improvements to, research infrastructure, including cyberinfrastructure, instrumentation, improvements to biological research collections, living stock collections, field stations, and marine labs. In addition, DBI supports the development of human capital through undergraduate and postdoctoral research experiences. A priority in FY 2018 will be on developing new tools and supporting cyberinfrastructure to meet the data integration challenges of ecological forecasting associated with NEON or predictive relationships from genomic, environmental, and phenotypic characteristics of biological systems. In general,

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[189] Understanding the Rules of Life (URoL) will address major challenges in biology. These include understanding living systems across scales of size, time and place, and the complex relationships between genotype and phenotype in plants, animals, and microbes.

34 percent of the DBI portfolio is available for new research grants and 66 percent funds continuing grants made in previous years.

- **Impact of Reduction** In FY 2018, DBI will utilize the outcomes of two program evaluations conducted in FY 2017 to reduce support by nearly 30 percent (or $20 million) for biological research collections. NEON operations ($65 million) makes up nearly 40 percent of the DBI budget request of $170 million for FY 2018. Research funding decreases $9.83 million to a total of $30.68 million. Support for centers will decrease $13 million to a total of $21 million. The Centers for Analysis and Synthesis, CyVerse (formerly iPlant) and the National Institute for Mathematical and Biological Synthesis, as well as the Nanoscale Science and Engineering Centers, Centers for the Environmental Implications of Nanotechnology (CEIN)-UCLA and CEIN-Duke, will have completed their respective funding cycles in FY 2017.

Engineering: Chemical, Bioengineering, and Transportation Systems Research

The majority of environmental R&D within the NSF Engineering Directorate is provided by CBET. This division supports research to enhance U.S. national health, energy, food, water, environment, process manufacturing, and security. Through CBET, the physical, chemical, life, and social sciences are integrated in engineering research and education, resulting in advances in the fields of biotechnology, bioengineering, biomanufacturing, advanced materials, and environmental engineering. CBET programs invest in fundamental engineering research in energy, water, and biotechnology, and in research projects focusing on sustainable water and energy use.

- **Impact of Reduction** Support will be reduced to a level of $5 million for projects to advance the understanding of the complex food-energy-water system and water-energy, food-energy, and food-water subsystems. Support for Sustainable Chemistry, Engineering, and Materials will be reduced by $1.3 million as the NSF-wide SEES initiative sunsets in FY 2017. CBET will continue support for research in engineering biology to improve the ability to engineer biological systems that could help address major economic and societal challenges in energy, the environment, and sustainable manufacturing. Approximately 80 percent of the CBET portfolio is comprised of new research grants, and 20 percent supports continuing grants.

Geosciences

Geoscience supports basic research that advances the frontiers of knowledge for improving the understanding of the many processes that affect the global environment. These processes include the planetary water cycle, geologic interactions that cross the land-ocean interface, and the behavior of ice sheets. Outcomes from such research includes better prediction and understanding of natural environmental hazards such as earthquakes, tornadoes, hurricanes, tsunamis, drought, and solar storms. Support is provided for interdisciplinary research on such issues as: mitigating the impacts of hazardous events; and understanding future availability and distribution of fresh water. GEO provides about 59 percent of the federal funding for basic research at academic institutions in the atmospheric, earth, and ocean sciences.

Division of Atmospheric and Geospace Sciences (AGS)

AGS supports activities to further understanding of the dynamics of the sun, the physics, chemistry, and dynamics of the Earth's atmosphere and near-space environment, and how the sun interacts with the Earth's atmosphere. AGS provides support for basic science projects; and the acquisition, maintenance, and operation of observational and cyberinfrastructure facilities and services that enable modern day atmospheric and geospace science research activities. In addition to traditional individual investigator multiyear grants, the division also supports small-scale, limited duration exploratory research projects; collaborative or multi-investigator group projects; and the National Center for Atmospheric Research (NCAR), one of NSF's Federally Funded Research and Development Centers serving the needs of the atmospheric and geospace research community. Only about 25 percent of the AGS portfolio is available to support new research grants. The remainder supports research grants made in prior years and the research infrastructure that supports the capabilities, creativity, and innovation of the atmospheric and geospace science community.

- **Impact of Reduction**
  - Support for the AGS disciplinary and interdisciplinary research programs decreases by $7.29 million, to a total of $101.56 million, to support basic research into understanding weather and atmospheric variability and extreme atmospheric and space weather phenomena, and improving the fundamentals that lead to better predictability of extreme events. AGS will support the NSF Risk and Resilience initiative at a level of $1.50 million through GEO's PREEVENTS activity. Investments in the SEES portfolio decrease to zero, concluding the ramping down of the SEES Earth Systems Modeling (EaSM) program. Support for early-career researchers remains an AGS priority. The division will support Faculty Early Career Development (CAREER) grants at $5.05 million.
  - AGS funding for NCAR declines by $16 million to a total of $89 million. NCAR provides the university community with unique research resources including high performance computing, modelling, and observing capabilities along with important technical support. This decrease could require extensive reassessment and refocusing of NCAR capabilities based on community input.

Division of Earth Sciences (EAR)

EAR supports research in geomorphology and land use, hydrologic science, geobiology and low temperature geochemistry, sedimentary geology and paleobiology, geophysics, tectonics, petrology and geochemistry, and integrated Earth systems. In addition, EAR has an Instrumentation and Facilities Program that supports community-based, shared-use facilities and the acquisition and development of instrumentation by individual investigators; Earth Scope, a large-scale facility with an associated science program focused on studying the structure and tectonics of the North American continent; and an education program that funds a number of activities to attract and support students and young investigators to the field of Earth science. In general, 36 percent of the EAR portfolio is available for new research grants and 64 percent is

available for continuing grants and the research infrastructure needed by this community.

- **Impact of Reduction** CAREER (young investigator) funding will be supported at a level of $7 million, a decrease of $1 million. The reduction will result in approximately two fewer CAREER awards in FY 2018. Support for Risk and Resilience research will be reduced from $4 million to $1.5 million. This decrease will be offset by an increase in GEO's ICER division. EAR will decrease investment in Seismological Facilities for the Advancement of Geoscience and Earth Scope (SAGE)[190] and Geodesy Advancing Geosciences and Earth Scope (GAGE).[191] Availability of portable instruments for research and maintenance and upkeep of the facility will decrease. Funding of all other research infrastructure at $17.4 million, a decrease of $4.5 million, will require that EAR's Geoinformatics Program fund no new projects in FY 2018 and that the Instrumentation and Facilities Program make no new commitments for instrument acquisition and development in FY 2018.

Integrative and Collaborative Education and Research (ICER)

ICER supports novel, complex, or partnership projects in both research and education. These investments cut across traditional boundaries within the geosciences, encouraging interdisciplinary activities and responding directly to critical needs of the entire geoscience community. Through investment in Risk and Resilience, ICER will improve predictability and risk assessment in order to increase resilience that will reduce the impact of extreme events on lives, society, and the U.S. economy. Research at the food-energy-water (FEW) nexus will result in understanding interactions across the FEW nexus, how they are likely to affect the world, and how to proactively plan for the consequences of these interactions. About half of the ICER portfolio is available for new research grants while the remaining half supports continuing grants.

- **Impact of Reduction** In FY 2018, ICER will no longer provide support for operation and maintenance for the Ocean Observatories Initiative (OOI).

Division of Ocean Sciences (OCE)

OCE provides support of basic scientific and technological research to better understand changing ocean circulation and other physical, chemical, and biological parameters. OCE also supports research on the geology of the ocean margins and sub-seafloor to investigate the stability of methane hydrates, natural hazards associated with earthquakes and volcanic eruptions, microbial life deep below the seafloor, and other fundamental ocean processes of high societal relevance. Since ocean science requires access to the sea, in partnership with the

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[190] The Seismological Facilities for the Advancement of Geoscience and Earth Scope (SAGE) comprise a distributed, multi-user, national facility for the development, deployment, and operational support of modern digital seismic instrumentation to serve national goals in basic research and education in the earth sciences, earthquake research, global real-time earthquake monitoring, and nuclear test ban verification.

[191] Geodesy Advancing Geosciences and Earth Scope (GAGE) comprises a distributed, multi-user, national facility for the development, deployment, and operational support of modern geodetic instrumentation to serve national goals in basic research and education in the Earth sciences with a focus on studies of Earth's surface.

Office of Naval Research and academic institutions, OCE supports research vessels, deep submergence capability including submersibles and autonomous vehicles, and technologically advanced sensors and instrumentation. In general, 32 percent of the OCE portfolio is available for new research grants in basic science and technological innovation. The remaining 68 percent supports ongoing awards made in prior years, as well as the major research infrastructure of the Academic Research Fleet, the International Ocean Discovery Program, and the Ocean Observatories Initiative.

- **Impact of Reduction**
  - OCE's budget for disciplinary and interdisciplinary research will decrease by $15.96 million, to a total of $132.25 million, which reflects a strategic reapportioning to continue to support ocean science research and technology programs as per *Sea Change* (National Academy of Sciences, 2015) recommendations. In FY 2018, OCE will specifically continue to invest resources into ocean technology via OCE's own programs as well as in coordination with other federal agencies. OCE will no longer participate in the Oceans and Human Health program, which was jointly supported with the National Institute of Environmental Health Sciences.
  - OCE is decreasing support for ship operations with the academic fleet by $5 million to a level of $78 million. The majority of this reduction will fall on the RV/*Langseth*, a national facility for marine seismology. NSF will reduce its support for this national facility from $14 million annually to $10 million annually. This reduction will dramatically reduce the number of days per year available for research from six months to three or four months per year. Reducing the availability of the *Langseth* for marine seismology research will adversely impact the ability of the research community to carry out some of the science priorities in *Sea Change*, the report by the NAS. The total support for operations and maintenance of the Ocean Observatories Initiative (OOI) will be decreased by $10 million from OCE, in addition to an end to ICER support, resulting in a total OOI support for operations and management in FY 2018 of $31 million.

Office of Polar Programs (OPP)

The OPP is the primary U.S. supporter of fundamental research in the polar regions. In addition, NSF provides interagency leadership for U.S. activities in polar regions. In the Arctic, NSF helps coordinate research planning as directed by the Arctic Research Policy Act of 1984. The NSF director chairs the Interagency Arctic Research Policy Committee created for this purpose. In the Antarctic, per Presidential Memorandum 6646, NSF manages all U.S. activities as a single, integrated program, making Antarctic research possible for scientists supported by NSF and by other U.S. agencies. The latter include NASA, NOAA, USGS, the Smithsonian Institution, and the DOE. The U.S. Antarctic Program research activity supported by NSF also supports leadership by the DOS in the governance of the continent and Southern Ocean under the aegis of the Antarctic Treaty System. OPP supports investments in core research and education, and provides research support and infrastructure, such as permanent stations and temporary field camps in the Antarctic and the Arctic. OPP's FY 2018 budget request is centered around three key priorities: (1) maintaining strong disciplinary programs that provide a base for

U.S. investments in cross-disciplinary system science programs; (2) maintaining U.S. research community activities in polar system science and; (3) supporting critical facilities that enable frontier research in the Earth's polar regions.

- **Impact of Reduction**
  - In FY 2018, OPP will reduce research funding by $12.73 million, to a total of $110.58 million. This will be accomplished by making fewer awards in polar science programs and by reducing OPP's support for science coordination and workshop activities. Funding for LTER increases by $160,000, to $2.25 million, reflecting the two projects in the Antarctic and one new project in the Arctic. A continued investment of $500,000 will contribute polar research efforts to the cross-directorate Risk and Resilience emphasis area through the PREEVENTS program. OPP will phase out SEES funding as that program reaches its planned termination.
  - Arctic Research Support & Logistics (ARSL) funding provides support for Arctic researchers, including access to airplanes, helicopters, research vessels including icebreakers, and field camps in Alaska, Greenland, Canada, Arctic Scandinavia, Russia, and the Arctic Ocean. ARSL support will be reduced by $8 million, to $36 million, in concert with a reduction in Arctic science awards. OPPs funding for the GAGE and the SAGE facilities will continue at the same level as FY 2016. IceCube Neutrino Observatory support funding will decrease $2 million, to $3.5 million. The funding level in FY 2016 reflected an extension of the prior cooperative agreement while a new agreement was competitively awarded. This facility is jointly funded by the Directorate of Mathematical and Physical Sciences.
  - U.S. Antarctic Facilities and Logistics funding will be reduced $18.68 million, to $177.85 million, in concert with a reduction of Antarctic science awards. For Antarctica, a primary objective is to continue progress on a multi-year commitment toward more efficient and cost-effective science support as recommended by the U.S. Antarctic Program Blue Ribbon Panel report, *More and Better Science in Antarctica through Increased Logistical Effectiveness*. NSF issued a formal response to this report in March 2013. Emphases include safety and health improvements as well as planning for renewal of outdated facilities. In particular, investments of $1.80 million will be made to bring the Antarctic Infrastructure Modernization for Science (AIMS) project to the final design review stage and to prepare for the construction phase. The AIMS program will consolidate the footprint and core facilities at McMurdo Station toward significantly enhanced efficiency and cost-effectiveness of science support. U.S. Antarctic Logistical Support funding increases by $3.48, million to $71.0 million, to enhance support of critical Antarctic airlift and the marine based annual resupply mission.

U.S. Department of Agriculture (USDA)

Table 24: USDA CE R&D Funding by Program (Dollars in Millions)[192]

	FY 2016 Enacted	*FY 2017 Estimate*	*FY 2018 Proposed*	*FY 17-18 Dollar Change*	*FY 17-18 Percent Change*
Agricultural Research Service: Environmental Stewardship	203	202	189	-14	-7%
National Institute of Food and Agriculture					
Integrated Activities: Organic Transition	4	4	0	-4	-100%
Agricultural and Food Research Initiative (AFRI)					
AFRI Foundational Program—Bioenergy, Natural Resources, Environment (BENRE)	14	16	17	1	6%
AFRI Challenge: Climate Change	17	4	**		
AFRI Challenge: Sustainable Bioenergy	27	26	**		
AFRI Challenge: Water for Agriculture (FY16)/ Water for Food Production Systems(FY17)	21	34	**		
AFRI Sustainable Agricultural Systems			65	**	**
Formula Programs: McIntire Stennis	34	34	29	-5	-15%
Sustainable Agriculture Program	25	27	19	-8	-30%
Special Research Grants					
Global Change (UV-B-Monitoring)*	1	1	0	-1	-100%
Biomass Research and Development*	2	2	0	-2	-100%
Sun Grant (special appropriation)	2	2	0	-2	-100%
U.S. Forest Service: Forest and Rangeland Research					
Wildland Fire & Fuels R&D	21	21	18	-3	-16%
Invasive Species R&D	33	33	28	-5	-16%
Recreation R&D	4	4	3	-1	-16%
Resource Management & Use	89	89	75	-13	-16%
Water, Air & Soil R&D	34	34	28	-6	-16%
Wildlife & Fish R&D	26	26	22	-4	-16%
Inventory & Monitoring R&D	83	83	84	1	1%
Total USDA Climate and Environment R&D	**641**	**644**	**578**	**-76**	**-12%**

[192] USDA FY 2018 Budget Summary, https://www.obpa.usda.gov/budsum/budget_summary.html; USDA Fiscal Year 2018 Budget Justification, https://www.obpa.usda.gov/budsum/fy18budsum.pdf

* The authorization of these three programs have ended.
** The six former AFRI challenge areas will be combined into Food Systems in FY 2018. This includes three former challenge areas that were not considered to include CE R&D. The Integrated Water Quality was terminated in 2014. The program was replaced by Water for Agriculture (FY 2014-2016), then changed to Water for Food Production Systems (FY 17) under AFRI.

The USDA has broad responsibilities in the areas of farm services; food safety; food, nutrition, and consumer services; marketing and regulatory programs; rural development; natural resources and environment; and research, education and economics.

The USDA REE mission area is conducted through ARS (primarily intramural), NIFA (primarily extramural), ERS, and NASS. The USDA NRE mission area is conducted through the Forest Service.

Agricultural Research Service

ARS is the USDA's chief in-house scientific research agency. The agency conducts research to develop new scientific knowledge, transfer technology to the private sector to solve technical agricultural problems of broad scope and high national priority, and provide access to scientific information. This research covers a wide range of critical problems affecting American agriculture, ranging from animal and crop protection and production to human nutrition, food safety, and natural resources conservation. ARS research is organized into national programs. Less than 20 percent of the ARS budget is focused on the environment. Environmental Stewardship comes under the Natural Resources and Sustainable Agricultural Systems National Program. ARS research programs in environmental stewardship:Í

> "emphasize developing technologies and systems that support profitable production and enhance the Nation's vast renewable natural resource base. ARS is currently developing the scientific knowledge and technologies needed to meet challenges and opportunities in: water availability and watershed management, changes in climate, gaseous and particulate matter emissions, soil health and productivity, agricultural and industrial byproducts, agricultural system competitiveness and sustainability, and conservation and restoration of range lands, pasture ecosystems, and agroecosystems."[193]

National Institute of Food and Agriculture

NIFA is the USDA's major extramural research agency, spanning the biological, physical, and social sciences related to agricultural research, economic analysis, statistics, extension, and higher education. NIFA provides funding for projects conducted in partnership with the State Agricultural Experiment Stations, the State Cooperative Extension System, land-grant universities, colleges, and other research and education institutions, as well as individual researchers.

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[193] 2018 USDA budget summary, https://www.obpa.usda.gov/18arsexnotes2018.pdf

More than half ($854 million) of the FY 2017 NIFA budget of $1.5 billion goes to research and education. Less than 20 percent of the NIFA research budget is classified here as CE. An additional $475 million goes to extension. NIFA promotes sustainable agriculture through national program leadership and funding for research and extension. It offers competitive grants programs through AFRI and a professional development program, and it collaborates with other federal agencies through the USDA Sustainable Development Council. NIFA provides linkages between the federal and state components of a broad-based, national agricultural research, extension, and higher education system. NIFA provides funding for projects conducted in partnership with State agricultural experiment stations, the State Cooperative Extension System, land grant universities, colleges, and other research and education institutions, as well as individual researchers. Federal funds are distributed to enhance capacity at universities and Night Nightinstitutions by statutory formula funding and competitive grants.

NIFA administers USDA's primary competitive research grants program, AFRI, which supports investigator-initiated research with the strong potential to contribute to major breakthroughs in the food, agricultural, natural resource, and human sciences.

The environmental components of AFRI are primarily in the foundational programs of fundamental research, which include Bioenergy, Natural Resources, and Environment (BENRE) and in various areas of applied research. Through FY 2017, applied research was supported through six areas of challenge grants that included Climate Change, Sustainable Bioenergy and Water as well as three challenge areas that were not considered to be climate and environment. Starting with FY 2018 the former challenge areas will be consolidated into a single Sustainable Agricultural Systems area.

NIFA also supports a Sustainable Agriculture Program that seeks to provide more profitable farms, promote environmental stewardship, and enhance quality of life for farm families and communities.

The NIFA interagency agreement with the FWS leverages technology and innovation and involves youth in STEM outreach and exposure. Youth participants develop science process skills related to using geographic information systems and research design, analyzing and interpreting data, and reporting findings to the community, which have enabled them to become better consumers of science and citizens capable of making wise STEM policy choices.

NIFA provides support for research and extension activities at land-grant institutions through McIntire-Stennis Cooperative Forestry Grants—grants to the states on the basis of statutory formulas. Eligibility is limited to the seventy-eight cooperating institutions, most of which are land-grant institutions.

As an integrative activity, NIFA has included an Organic Transition Program that supports the development and implementation of biologically based management practices that mitigate the ecological, agronomic and economic risks associated with a transition from conventional to organic agricultural production systems.

U.S. Forest Service (USFS)

The USFS manages 154 national forests and twenty grasslands encompassing 193 million acres of land; 439 wilderness areas totaling over 36 million acres of land; twenty national recreation areas; six national scenic areas; six national monument areas; two national volcanic monument areas; and two national historic areas. These lands are managed under the principles of multiple-use and sustained yield. Multiple uses include the extraction of timber and other forest products; forage of livestock; mineral extraction; outdoor recreation; conservation of watershed, wildlife, fish and other natural resources; and other purposes.

Approximately 6 percent of the overall budget of the USFS (total USFS budget is $4.8 billion discretionary) is devoted to CE R&D, which supports the sustainable management of the nation's forests and rangelands. USFS R&D is federally mandated to provide new knowledge and technologies to foster healthy watersheds, forest products, wildlife protection, robust urban ecosystems, and other benefits. Research is conducted at more than sixty-seven laboratories nationally, organized around five regional research stations, plus the International Institute of Tropical Forestry in Puerto Rico and the Forest Products Laboratory in Madison, Wisconsin. A network of eighty experimental forests complements these R&D laboratories and serves as sites for most of the agency's long-term research.

Within its broad mission to develop knowledge and technology to enhance the economic and environmental values of all of the nation's forests, the budget supports specific research needs that arise from managing 193 million acres of system lands. Principal areas of research include forest disturbance prediction and response, watershed management and restoration, urban natural resource stewardship, and inventory and analysis. USFS R&D provides the basic and applied science that bolsters the agency's efforts to promote resilient forests and sustainable communities that can adapt to forest threats such as drought, fire, and insect and disease infestations.

Proposed FY 2018 Budget

The FY 2018 request for discretionary budget authority to fund USDA programs and operating expenses is about $21 billion, approximately $4.8 billion below FY 2017.[194]

The REE mission area supports the creation and dissemination of knowledge spanning the biological, physical, and social sciences related to agricultural and food research, economic analysis, statistics, extension, and higher education. REE enhances the U.S. position as a global leader in a highly competitive food and fiber system; promotes economic and environmentally sustainable agricultural practices; and contributes to continued agricultural prosperity, thriving rural communities, and well-informed consumers. The budget proposes $2.5 billion for agricultural research and related activities.

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[194] https://www.obpa.usda.gov/budsum/fy18budsum.pdf

Agricultural Research Service

The ARS budget proposes the termination of intramural and extramural research projects and closure of 17 laboratories, locations or worksites. The FY 2018 budget requests $189 million for environmental stewardship, a reduction of $13.7 million (7 percent) from FY 2017. The budget would include a decrease of $17.5 million from twenty-three ongoing research projects at sixteen USDA facilities. The reductions include projects related to water, soil, rangelands, forage, cropping systems, genetics, climate change, air quality and bioenergy.[195]

National Institute of Food and Agriculture

The FY 2018 budget requests approximately $1.3 billion in discretionary funding for NIFA, including nearly $350 million for AFRI, while "eliminating lower priority programs." NIFA would experience a net decrease of $48.5 million for research and education activities for a total of $769.6 million ($818.1 million and 217 staff years available in FY 2017).[196]

Specific changes in the FY 2018 budget include three small research programs whose authorizations have expired are proposed for termination:

- Global Change, UV-B Monitoring ($1.4 million available in FY 2017).
- Organic Transition Program ($4 million available in FY 2017).
- Biomass Research and Development ($2 million available in FY 2017).

Termination is proposed for the Sun Grant program ($2.5 million available in 2017) which has been funded by special appropriations. This program provides grants to six Sun Grant centers that provide competitive awards to subcenters to enhance national energy through the development, distribution, and implementation of biobased energy technologies. Activities are supported that promote diversification, and the environmental sustainability of, agricultural production in the U.S., and economic diversification in rural areas of the U.S using biobased energy and product technologies. Funds are also used to enhance the efficiency of bioenergy and biomass research and development programs through improved coordination and collaboration among USDA, DOE, and land-grant colleges and universities.

Within the AFRI Foundational Program, the BENRE Program is proposed to increase slightly from $16 million to $17 million.

> "Starting with FY18 the former challenge areas will be consolidated and NIFA proposes to invest $65.8 million in the Sustainable Agricultural Systems programs to support large integrative projects that address major outcomes of agricultural systems. This component of AFRI will build on the advances made in research, education, and extension priority outcomes through the former AFRI Challenge Areas such as water, resiliency, and

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[195] https://www.obpa.usda.gov/18arsexnotes2018.pdf

[196] https://www.obpa.usda.gov/19nifaexnotes2018.pdf

adaptation to climate variability, food safety, childhood obesity prevention, bioenergy, and food security. Sustainable Agricultural Systems will address these challenge topics comprehensively and collectively, rather than in isolation. This integration will enable NIFA's goal of advancing the convergence of agricultural sciences with engineering, nutritional and food sciences, social sciences, and other disciplines, including nanotechnology, computational sciences, and advanced manufacturing, to generate new scientific discoveries, new products, new markets, and consequently new high-skilled jobs. These systems-level projects will collectively marshal the many facets of the agricultural system, from farms to supply chain businesses to consumers, to transform the way food is produced, processed, transported and consumed, and address interrelated challenges of food security, water availability, environmental resilience, feedstock needs of the bio-economy, and nutritional security."[197]

The challenge grant areas that included climate change, sustainable bioenergy, and water totaled $64 million in FY 2017. Thus, the consolidation with the three nonclimate and environment areas would result in a substantial budget reduction.

A decrease of $5.6 million is proposed for the Sustainable Agriculture Research and Education Program ($24.6 million available in FY 2017). Base funding will be used to help farmers and ranchers adopt practices that are profitable, environmentally sound, and beneficial for communities. Grants awarded by the four regional administrative councils support projects that address crop and livestock production and marketing, stewardship of soil and other natural resources, economics, and quality of life. The program will continue to focus on high priority solutions for farmers and ranchers across all U.S. regions by maintaining the number of grants provided to farmers and ranchers to develop innovative sustainable practices.

A decrease of $5 million for McIntire-Stennis Cooperative Forestry ($33.9 million available in FY 2017) is proposed. McIntire-Stennis base funds are used to assist grantees in carrying out a program of state forestry research at schools and colleges and developing a trained pool of forest scientists capable of conducting needed forestry research, which includes: ecological restoration; catastrophe management; valuing and trading ecological services; energy conservation, biomass energy, and biobased materials development; forest fragmentation; methods for fostering healthy forests; and a globally competitive forest resources sector. The McIntire-Stennis Cooperative Forestry Research program provides formula funds to support research related to use of the nation's forest resources. Timber production, forest land management, wood utilization, and the associated development of new products and distribution systems are some of the topics of this research. Additional areas of investigation include wildlife, recreation, water, range, and environmental quality, which are essential to the long-term productivity and profitability of the integrated system of forest resources. Much of the research supported with McIntire-Stennis funding is not amenable to support from the private sector or competitive grants. McIntire-Stennis base funds are used to support the eight legislated goals and funds are distributed to States based on legislated formula.

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[197] FY 2018 NIFA Budget Explanatory Notes Page Number 19-49, https://www.obpa.usda.gov/18arsexnotes2018.pdf

USDA Forest Service

For FY 2018, $259 million is proposed for Forest and Rangeland Research, a net decrease of $31.4 million (-11%) from the FY 2017 annualized CR (including $1 million for annualization of the 2017 pay increase and $2.4 million for the 2018 pay increase) and a decrease of 192 staff years ($290.4 million and 1,746 staff years available in 2017).[198] The Forest Inventory and Analysis (FIA) program budget is proposed to increase by $2.1 million (1%) to $77 million to strengthen the collection, coordination, and assessment of field inventory data, create a robust landscape scale inventory and analysis effort in all fifty states and U.S. territories, and continue efforts to introduce FIA surveys in interior Alaska. Each other strategic program area is proposed to be reduced by 16 percent. The FY 2018 budget request proposes the Forest Service to focus on research that supports the management of National Forest System lands and the agency's wildland fire suppression efforts. This funding level allows for a five year measurement cycle in the east and a ten year measurement cycle in the west. The FY 2018 budget request also includes $6.8 million for the inventory and monitoring on the status and trends of the nation's renewable resources on all forest and rangelands, as required by the Forest and Rangeland Renewable Resources Planning Act of 1974.

The agency is also continuing efforts to support the transfer of agency R&D products to industry in order to promote the nation's economic growth through innovation, stimulating the creation of commercial and industrial markets for presently underutilized or non-merchantable forest resources resulting from restoration and fuel treatment operations.

Specific decreases across the other Strategic Program Areas (SPA)[199] include:

- A decrease of $3.4 million (-16%) for the Wildland Fire and Fuels SPA. The FY 2018 budget request proposes $17.8 million for air quality research including research on smoke and prescribed fire, managing social dynamics of fire in wildland-urban interface areas, and wildfire research technology transfer efforts. Additional fire research funding is supported by the National Fire Plan Research and Development line within the Wildland Fire Management appropriation of $17.6 million.
- A decrease of $5.3 million (-16%) for the Invasive Species SPA. The FY 2018 budget request proposes $28.3 million for research that provides information and technology needed to reduce or eliminate the spread or impact of invasive species. See the "Funding for Selected Insects, Diseases and Invasive Plants by Fiscal Year" table in the Forest Health Management Overview for proposed investment levels, by insect, disease, or pathogen.
- A decrease of $671,000 (-16%) for the Recreation SPA. The FY 2018 budget request proposes $3.6 million for research on producing science and technology that natural resource managers can use to offer quality outdoor recreation experiences for current and future generations.

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[198] https://www.fs.fed.us/sites/default/files/usfs-fy18-budget-justification.pdf

[199] https://www.fs.fed.us/sites/default/files/usfs-fy18-budget-justification.pdf, page 35.

- A decrease of $13.5 million (-16%) for the Resource Management and Use SPA. The FY 2018 budget request proposes $75.2 million for research that provides the scientific and technological base to sustainably manage and use forest resources and fiber-based products.
- A decrease of $5.3 million (-16%) for the Water, Air, and Soil SPA. The FY 2018 budget request proposes $28.5 million for research that enables the sustainable management of water, air, and soil resources by providing information on how forests can support clean air and drinking water through improved resilience.
- A decrease of $4.1 million (-16%) for the Wildlife and Fish SPA. The FY 2018 budget request proposes $21.8 million for research that provides knowledge and tools to sustain the health, diversity, and productivity of aquatic and terrestrial animals on the Nation's forests and grasslands.

Summary

The overall proposed FY 2018 budget for USDA includes a reduction of 11 percent. All three USDA research agencies—ARS, NIFA, and USFS—show substantial reductions in environmental research. These reductions include termination of existing ongoing research at ARS, terminations of small programs and reductions in larger programs at NIFA and drastic 16 percent cuts in all forest and rangeland research programs (other than inventory and monitoring, which is related to timber harvest) at USFS.

The net effects would directly hurt farmers, ranchers, and foresters who depend upon USDA science to implement sound management of natural resources. The consequences of decreased health of farmland, rangeland, and forests will hurt people and the environment through increased loss of crops to pests, disease, fire, erosion, and nutrient runoff resulting in higher prices and loss of productivity.

Appendix 2—List of Report Contributors

Dr. Jack Fellows (Study Chair) Dr. Fellows was formerly the Science and Space Branch Manager in the Executive Office of the President's Office of Management and Budget. For over thirteen years, he oversaw the federal R&D budget and was a co-creator of the U.S. Global Change Research Program.

Dr. David Blockstein Chief Scientist of the National Council on the Science and Environment, and regularly involved in analyzing the federal environmental research budgets and programs.

Dr. Tamara Dickinson Dr. Dickinson recently served as Principal Assistant Director for Environment and Energy at the Office of Science and Technology Policy. She was a Program Coordinator for Data Preservation, Informatics, and Laboratories at the USGS. She has also served in various capacities at the National Academies on the Board on Earth Sciences and Resources and the Space Studies Board. Dr. Dickinson has also held program management and science policy positions at NASA Headquarters and NSF.

Dr. Michael Holland Dr. Holland is the Executive Director of the New York University Center for Urban Science and Progress. Prior to NYU, he was Senior Advisor and Staff Director in DOE's Office of the Under Secretary for Science. Mike has also served as the program examiner in the Office of Management and Budget overseeing DOE's Office of Science and Advanced Research Projects Agency-Energy, as an Office of Science and Technology Policy senior policy advisor, and as staff for the U.S. House of Representative's Committee on Science.

Mr. Kei Koizumi Currently a Visiting Scholar in science policy at the American Association for the Advancement of Science (AAAS). Most recently the Assistant Director for Federal Research and Development at the White House Office of Science and Technology Policy (OSTP). Before joining OSTP, he served as the Director of the R&D Budget and Policy Program at the AAAS.

Dr. Kathie L. Olsen Dr. Olsen is the Founder and Managing Director of the consulting firm ScienceWorks. Before starting ScienceWorks, she was the NSF Deputy Director and Operating Officer, the Office of Science and Technology Policy Associate Director for Science, and the NASA Chief Scientist.

Dr. Robert M. Simon Dr. Simon recently retired as the Office of Science and Technology Policy Principal Advisor to the Director for Energy, Transportation, and Resources. He was a Senior Advisor in DOE's Office of Science, and from 1999–2012 was the Democratic Staff Director of the U.S. Senate Committee on Energy and Natural Resources.

Dr. Ari A. N. Patrinos Dr. Patrinos is Chief Scientist of Novim, managed biological and environ-mental research at the Department of Energy (DOE) for twenty years after a ten year research career at three DOE National Labs. He was also the President of Synthetic Genomics Inc. for five years. A Distinguished Industry Professor of Mechanical and Biomolecular Engineering at New York University (currently on leave) he served as Senior Adviser to the DOE Secretary during 2016.

Mr. Joel Widder Co-founder and Partner, Federal Science Partners LLC and former Deputy Director, Office of Legislative and Public Affairs, National Science Foundation.

Appendix 3—List of Acronyms

AAAS	American Association for the Advancement of Science
ACE	Advanced Composition Explorer
AFRI	Agriculture and Food Research Initiative
AGS	Atmospheric and Geospace Sciences
AIMS	Antarctic Infrastructure Modernization for Science
ALCC	ASCR Leadership Computing Challenge
ARL	Air Resources Laboratory
ARM	Atmospheric Radiation Measurement
ARS	Agricultural Research Service
ARSL	Arctic Research Support & Logistics
ASCR	Advanced Scientific Computing Research
BENRE	Bioenergy, Natural Resources, and Environment
BER	Biological and Environmental Research
BIO	Biological Sciences
BLM	Bureau of Land Management
BOEM	Bureau of Ocean Energy Management
BoR	Bureau of Reclamation
CASC	Climate Adaptation Science Centers
CBET	Chemical, Bioengineering, and Transportation Systems Research
CE	Climate and environment
CE R&D	Climate and environment research and development
CEIN	Centers for Environmental Implications of Nanotechnology
CERES	Clouds and the Earth's Radiant Energy System
CESI	Critical Ecosystems Studies Initiative
CESM	Community Earth System Model
CESU	Cooperative Ecosystem Studies Units
CI	Cooperative Institutes
CIF	Climate Investment Funds
CLARREO	Climate Absolute Radiance and Refractivity Observatory
CLU	Climate and Land Use
CMGP	Coastal and Marine Geology Program
CMHRP	Coastal/Marine Hazards and Resources Program
CMS	Carbon Monitoring System
COE	Centers of Excellence
CORS	Continuously Operating Reference Stations
CR	Continuing Resolution
CRISP	Critical Resilient Interdependent Infrastructure Systems and Processes
CSAC	Chemical Security Analysis Center
CSS	Climate Science Center
CRU	Cooperative Research Unit

CTF	Clean Technology Fund
DBI	Division of Biological Infrastructure
DEB	Division of Environmental Biology
DHS	Department of Homeland Security
DoD	Department of Defense
DOE	Department of Energy
DOI	Department of the Interior
DOS	Department of State
DSCOVR	Deep Space Climate Observatory
DRS	Defense Research Sciences
E3SM	Energy Exascale Earth System Model
EAR	Division of Earth Sciences
EaSM	Earth Systems Modeling
ECO	Ecosystems Mission Area
EES	Earth and Environmental Sciences
EGIS	Enterprise Geographic Information System
EH	Environmental Health
EMSL	Environmental Molecular Sciences Laboratory
EP	Environmental Protection
EPA	Environmental Protection Agency
EPIC	Earth Poly-Chromatic Imaging Camera
EQT	Environmental Quality Technology
ERS	Economics Research Service
ESP	Earth Science Program
ESTCP	Environmental Security Technical Certification Program
FEMA	Federal Emergency Management Agency
FFRDC	Federally funded research and development centers
FIA	Forest Inventory and Analysis
FEW	Food-Energy-Water
FTC	Fish Technology Centers
FWS	Fish and Wildlife Service
FY	Fiscal Year
GAGE	Geodesy Advancing Geosciences and Earth
GCAM	Global Change Assessment Model
GCCI	Global Climate Change Initiative
GCF	Green Climate Fund
GEF	Global Environment Facility
GEO	Group on Earth Observations
GEOSS	Global Earth Observation System of Systems
GHG	Greenhouse Gas
GRACE-FO	Gravity Recovery and Climate Experiment Follow-On Mission
HHS	Health & Human Services
ICE	Immigration & Customs Enforcement

ICESat-2	Ice, Cloud, and Land Elevations Satellite
ICER	Integrative and Collaborative Education and Research
ICI	Interdependent Critical Infrastructures
IOS	Integrative Organismal Systems
IPCC	Intergovernmental Panel on Climate Change
IRAP	International Research & Applications
ISS	International Space Station
LCC	Landscape Conservation Cooperatives
LCSP	Land Change Science Program
LRMA	Land Resources Mission Area
LTER	Long Term Ecological Research
MAPP	Modeling, Analysis, Predictions & Projections
MFIMP	Multilateral Fund for the Implementation of the Montreal Protocol
NAAQS	National Ambient Air Quality Standards
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NASS	National Agricultural Statistics Service
NBACC	National Biodefense Analysis and Countermeasures Center
NBAF	National Bio and Agro-Defense Facility
NCAP	National Civil Applications Program
NCAR	National Center for Atmospheric Research
NCASC	National Climate Adaptation Science Center
NCEO	National Centre for Earth Observation
NEON	National Ecological Observatory Network
NESDIS	National Environmental Satellite, Data, and Information Service
NFS	National Forest System
NGO	Nongovernmental organizations
NIEHS	National Institute of Environmental Health Sciences
NIFA	National Institute of Food and Agriculture
NIH	National Institutes of Health
NISAR	NASA-ISRO Synthetic Aperture Radar
NLI	National Land Imaging
NMFS	National Marine Fisheries Service
NMNH	National Museum of Natural History
NOAA	National Oceanic and Atmospheric Administration
NOPP	National Oceanographic Partnership Program
NOS	National Ocean Service
NPS	National Park Service
NRE	Natural Resources and Environment
NSF	National Science Foundation
NSS	National Seed Strategy for Rehabilitation and Restoration
NUSTL	National Urban Security Technology Laboratory
NWS	National Weather Service

O&M	Operations and maintenance
OAR	Oceanic and Atmospheric Research
OCE	Division of Ocean Sciences
OCO-3	Orbiting Carbon Observatory
OCS	Outer Continental Shelf
OMAO	Office of Marine and Aviation Operations
OMB	Office of Management and Budget
OOI	Ocean Observatories Initiative
OPP	Office of Polar Programs
ORD	Office of Research and Development
OSTP	Office of Science and Technology Policy
OWEAR	Ocean Warfighting Environmental Applied Research
PACE	Plankton, Aerosol, Cloud, Ocean Ecosystem
PREVEENTS	Prediction of and Resilience against Extreme Events
R&D	Research and Development
RBI	Radiation Budget Instrument
RDT&E	Research Development Test and Evaluation
REA	Rapid Ecoregional Assessments
REE	Research, Education, and Economics
SAGE	Seismological Facilities for Advancement of Geoscience and EarthScope
SARP	Sectoral Applications Research Program
S&T	Science and Technology
S&TD	Science and Technology Directorate
SCF	Strategic Climate Fund
SEES	Science Engineering and Education for Sustainability
SERC	Smithsonian Environmental Research Center
SERDP	Strategic Environmental Research & Development Program
SPA	Strategic Program Areas
STEM	Science, technology, engineering and math
STRI	Smithsonian Tropical Research Institute
SWOT	Surface Water & Ocean Topography
UNFCCC	United Nations Framework Convention on Climate Change
URoL	Understanding the Rules of Life
USACE	US Army Corp of Engineers
USAID	US Agency for International Development
USDA	US Department of Agriculture
USFS	US Forest Service
USGCRP	US Global Change Research Program
USGS	US Geological Survey
VIIRS	Visible Infrared Imaging Radiometer Suite
WMO	World Meteorological Organization
WTP	Worker Training Program

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Statement for the Record from

The National Association of Marine Laboratories
The IOOS Association
The National Estuarine Research Reserve Association
The Coastal States Organization
The Sea Grant Association
The National Marine Sanctuary Foundation
for the
Subcommittee on Commerce, Justice, Science, and Related Agencies
Committee on Appropriations
House of Representatives/United States Senate
March/April 2018

In support of FY 2019 Appropriations for the Nation's Ocean, Coastal, and Great Lakes Research, Education, Conservation, and Resource Management Enterprise

Mr. Chairman and Members of the Subcommittee, this joint statement is submitted on behalf of the non-profit organizations listed above who share **a deep and overriding concern for and frequently partner together to strengthen the health of the Nation's oceans, coasts, and Great Lakes.** We refer to ourselves as an ad hoc *Coastal Roundtable* and meet periodically to share mutual concerns, discuss and undertake joint programmatic initiatives, and exchange information and best practices.

This Subcommittee is uniquely responsible for the health of the ocean, coastal, and Great Lakes enterprise through your oversight and resource decision-making responsibilities related to NOAA, NSF, NASA, and other agencies. That enterprise is a critical part of the security of the Nation as it relates to economic, environmental, national, homeland, energy, conservation resources, and food security issues. In FY 2019 the Administration has proposed the elimination of most of the funding for this Subcommittee's extramural support for ocean, coastal, and Great Lakes research, conservation, observing, and education programs. We urge the Subcommittee to strengthen the support for ocean and coastal programs consistent with the new spending levels in the Bipartisan Budget Act of 2018.

For centuries, our oceans and coasts have sustained lives and livelihoods, divulged ancient and unforeseen treasures, stirred our dreams of remarkable new discoveries, and thrilled us to discover and observe the extraordinary marine life below the surface. But never in history have we had the immense opportunities now beckoning from the sea. On the horizon is a new ocean/coastal economy, an exciting frontier that offers great promise for making our nation safer, healthier, and more prosperous. This new economy is a knowledge-based economy, looking to the ocean and coastal enterprise not for extraction of material goods but for data, observations, and information to address societal challenges and inspire their solutions. This economy is entrepreneurial and environmentally responsible, collaborative, and competitive.

A recent report from the Center for the Blue Economy reported that the ocean economy generated a larger share of U.S. economic activity than farming, food products, oil and gas extraction, and forest products. Employment supported by this part of the economy is almost as large as the employment of all of these industries combined. The Great Lakes alone generated nearly $5 trillion in economic activity or about 30% of combined U.S. and Canadian economic output. Finally, the U.S. marine transportation system is an essential driver of the U.S. economy and its impact is felt well beyond the coast and reaches into the

heartland of the nation. America's seaports are crucial generators of economic development and well-paying jobs, both regionally and nationally, that is felt throughout all supply chains that use the ports.

The ocean and our coasts are invaluable for humanitarian, environmental, and health reasons. The oceans are a primary source of food for over one billion people, a globally significant regulator of the earth's climate, the basic source of water for the hydrologic cycle, a cleaning agent that absorbs carbon dioxide and generates oxygen, and home to thousands of flora and fauna. The ocean has been a source of new drugs to treat certain cancers. Blue-green algae, commonly found in Caribbean mangroves, are used to treat small-cell lung cancer and certain sponges produce chemical substances that can be used to treat cancer and manage pain. A wide gulf often separates science from the people who need research results to protect and support them. However, the new ocean economy puts science and predictive capabilities to work in a way that can fill critical, fast-rising needs across sectors.

All of the organizations that have lent their names to this statement stand in strong support for the ocean, coastal and Great Lakes research, conservation, observing, and education programs managed by NOAA's National Ocean Service and Office of Oceanic and Atmospheric Research. Specifically, we are referring to:

- The National Sea Grant College Program and Marine Aquaculture;
- The Ocean, Coastal, and Great Lakes Cooperative Institutes;
- The Integrated Ocean Observing System;
- The National Estuarine Research Reserve System;
- The National Marine Sanctuary System;
- Coastal Zone Management and Services;
- Coastal Management Grants;
- The Digital Coast Program;
- Coastal Resilience;
- Coastal Science and Assessment; and
- NOAA Education.

Sea Grant is a unique program within NOAA that sends 95% of its appropriated funds to coastal states through a competitive process to address issues that are identified as critical by public and private sector constituents and coastal communities throughout the United States. Sea Grant fosters cost-effective partnerships among state universities, state and local governments, NOAA, and coastal communities and businesses, leveraging nearly $3 for every $1 appropriated by Congress. In 2016, the Sea Grant program helped generate an estimated $611 million in economic impacts, created or sustained over 7,000 jobs, provided 33 state-level programs with funding that assisted 494 communities with technical assistance on sustainable development practices, worked with about 1,300 industry and private sector, local, state and regional partners, and supported the education and training of over 2,300 undergraduate and graduate students.

America's estuaries sustain coastal businesses, protect communities from flooding, keep water clean, preserve commercial fisheries, support wildlife, and provide opportunities for recreation. The National Estuarine Research Reserve System (NERRS) maintains 280 stations that track local water quality, pollution, and weather around the country. Every 15 minutes, these platforms collect data – 42 million data points each year – that track hazardous spills, shellfish industry operations, storm damage and more. Reserves engage more than 36,000 volunteers and community members. Nearly 95% of Reserves allow for recreational fishing; 85% allow for hunting. Reserve programs help sustain more than 10,000 jobs, provide training to more than 13,400 people, and assist more than 2,000 decision makers and 570 businesses. Reserve programs reach more than 3,000 educators and 81,000 K –12 students receive STEM

education in the outdoors. More than 100 universities and research institutions partner with Reserves on science and monitoring. These collaborations have supported approximately 350 graduate research fellows. Similar to Sea Grant, approximately 98% of federal NERRS funding goes to the communities in which the Reserves are located. NERRS funding also leverages State matching funds raising $6 million annually to supplement the federal funding.

Coastal observing systems are used to gather real time information and turn it into useful products that support human populations, coastal economies and a healthy, sustainable environment. They provide timely, actionable information developed from reliable and user-driven science to provide insight into present and future conditions. The need for data and information about our coasts and Great Lakes to help protect lives, economies and the environment has never been greater. Flood protection, safe and efficient marine operations, fisheries, aquaculture, water quality and safe recreation require an expanded network of observing systems and enhanced analysis that will improve predictive and forecasting capabilities for all users. The Integrated Ocean Observing System (IOOS) is a federal partnership with regional organizations that is improving our understanding of the diverse characteristics of the nation's regions. IOOS generates and delivers quality information about the nation's oceans, coasts and Great Lakes. IOOS increases economic efficiency and minimizes redundancy by leveraging non-federal investments; in fact, over fifty percent of the marine data now assembled and disseminated by NOAA's National Data Buoy Center is from non-federal sources. IOOS provides a cost-effective approach to providing the nation with reliable information to enhance maritime commerce; improve weather and flooding forecasting; supporting fisheries, ecosystems and water quality; and enhances our ability to plan for and respond to unforeseen hazards.

The National Coastal Zone Management Program (CZM Program) is a state-federal partnership supports the effective management, beneficial use, protection, and development of the coastal zone. Healthy coastal resources support business and conservation and long-term planning is essential for coastal areas to remain the economic drivers they are today. In FY 2017, states and territories matched over $56.9 million in investment in the CZM Program. The CZM program helps ensure that our nation's coastal communities are able to plan for an uncertain future and help protect lives and investments on the coast. This state-federal partnership ensures the responsible use of coastal resources by balancing the needs of economic development and conservation of natural resources while also planning for potential impacts to a state's coastal zone.

America's National Marine Sanctuary System consists of 13 national marine sanctuaries and two marine national monuments encompassing over 620,000 square miles of marine and Great Lakes waters. Sanctuaries are home to millions of species, preserve our nation's maritime heritage, and promote public access for exploration and world-class outdoor recreation and enjoyment for future generations. They generate $8 billion annually in local economies and support numerous jobs and businesses in the fishing, tourism, recreation, and scientific research sectors. Because of strong ties to the local communities, businesses, and organizations, every dollar of public investment in sanctuaries stimulates a greater return on investment for our communities by heavily leverage private funds and partner contributions. Sanctuary visitor centers, vessels, and facilities are key assets for communities; stimulate public-private partnerships on emerging technologies, cutting edge science, and hands on education; and attract millions of visitors to the coasts each year.

The Digital Coast Program was developed to meet the unique information needs of the coastal management community. It provides access not just to a growing body of coastal data, but also the tools, training, and information needed to make over 5 trillion points of LIDAR, 37 terabytes of imagery, and

800,000 square miles of land cover, collected from both federal and non-federal sources, useful for coastal managers, planners, and decision makers charged with managing the Nation's coastal resources. The products and services provided by the Digital Coast include data, information, and training for more than 4,000 coastal communities.

This nation is facing increasing challenges when it comes to protecting the economic and environmental viability of our ocean, coastal, and Great Lakes enterprise. For example, the U.S. is the leading global importer of fish and fishery products, with 91% of the seafood we eat originating abroad – half of which is from aquaculture. Driven by imports, the U.S. seafood trade deficit grew to over $14 billion in 2016. Other nations, such as China, are rapidly moving to challenge this Nation's preeminence in science and technology as detailed in the recently released *Science and Engineering Indicators – 2018* report from the National Science Board.

In science, technology, engineering, and mathematics education, the number of S&E bachelor's degrees in China more than quadrupled from 359,000 in 2000 to 1.65 million in 2014. At the same time, U.S. S&E bachelor's degrees grew from 400,000 in 2000 to 650,000 in 2015. In 2007, China surpassed the U.S. as the largest producer of doctoral degrees in the natural sciences and engineering. In the geosciences, the field from which the ocean, coastal and Great Lakes enterprise draws heavily from for its future workforce, in terms of R&D expenditures, the average annual growth rate for *the geosciences* in the US was just 0.1% from 2007 to 2016, *the lowest growth rate of the assessed fields in science and engineering*.

In the face of these disturbing trends, we urge the Subcommittee to reject the Administration's ocean and coastal proposals for FY 2019 and instead, prioritize its portfolio of ocean and coastal programs within the new spending levels in the Bipartisan Budget Act of 2018. We offer the following specific programmatic investments for FY 2019 funding that we believe would effectively strengthen our ocean and coastal enterprise:

- National Sea Grant College Program, $85 million for research, education, extension, and outreach activities, including Marine Aquaculture, STEM education, and Sea Grant fellowship programs within the NOAA Operations, Research, and Facilities (ORF) account within the Office of Oceanic and Atmospheric Research;

- National Estuarine Research Reserve System, $27 million in NOAA's Operations, Research and Facilities account within the National Ocean Service;

- National Estuarine Research Reserve System, $1.7 million for the Procurement, Acquisition and Construction account within the National Ocean Service;

- Sanctuaries and Marine Protected Areas, $57 million within the National Oceanic and Atmospheric Administration's (NOAA) Operations, Research, and Facilities (ORF) account in the National Ocean Service;

- Marine Sanctuaries Construction, $8.5 million within NOAA's Procurement, Acquisition, and Construction (PAC) account in the National Ocean Service;

- Coastal Zone Management Grants, $75 million within NOAA's Operations, Research, and Facilities (ORF) account, National Ocean Service (under Coastal Management Grants line);

- Coastal Resilience Grants, $15 million within NOAAs Operations, Research, and Facilities account, National Ocean Service (under Coastal Management Grants line);

- Regional Integrated Ocean Observing System (IOOS), $37.7 million within NOAA's Operations, Research, and Facilities account, National Ocean Service; and

- Digital Coast Program, $5 million within NOAA's Operations, Research, and Facilities account, National Ocean Service.

We appreciate the funding constraints and the many worthy competing claims the Subcommittee must confront. In this statement, we have tried to provide information that demonstrates the relationship and connection the Subcommittee's ocean, coastal, and Great Lakes portfolio has to the economic and environmental health of our coastal communities and our coastal resources. Our coasts are home to 40 percent of the nation's population. Annually our coastal counties produce more than $7.6 trillion in goods and services, employ 53.6 million people, and pay $3 trillion in wages. Coastal wetlands conservation measures prevented an estimated $625 million in property damages during Hurricane Sandy. Ocean, coastal, and Great Lakes research, education, conservation, and resource management practices funded by this Subcommittee have and will continue to protect and minimize property damage, loss of lives, loss of vital habitat, and loss of vital marine resources. These are investments in the future health and well-being of our coastal communities' economies which will result in returns of improved quality of life, environment and economic resilience many times over the federal investment.

Thank you for the opportunity to provide this unified message.

MEMORANDUM FOR 45TH PRESIDENT OF THE UNITED STATES

Date: July 2016

From: The National Association of Marine Laboratories

Re: Ocean, Coastal & Great Lakes Research and Education Fuels the Nation's ~~Ocean and Coastal~~ Economy

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The National Association of Marine Laboratories (NAML), first established in 1985 with nearly a dozen separate marine laboratories, has grown into a network of over 100 institutions operated by universities, non-profit organizations, and local, state, and federal governments that focus on the oceans, coasts and Great Lakes. According to the National Academy of Sciences' report *Sea Change: 2015-2025 Decadal Survey of Ocean Sciences (p.92)*, **marine laboratories are one of the most cost effective and highly relevant** components of the ocean, coastal, and Great Lakes research and education enterprise.

NAML labs are national assets formed by the unique merger of natural, intellectual, social, and infrastructural capital that leads to important scientific endeavors required to understand our rapidly changing natural world. They are repositories of long-term observations and datasets. These facilities are distributed throughout our nation's coastlines and provide diverse and unique settings for research, access to vital research infrastructure, and opportunities for education and outreach, while employing thousands of scientists, engineers, students, and educators. Scientists at NAML laboratories provide critical, actionable findings that inform policy and improve decision-making on important issues such as food safety, water quality, coastal resiliency, and natural resource management. Students and citizens that visit NAML labs engage in experiential learning that enhances science literacy and improves knowledge of our ocean and coastal environments.

The ocean, coastal and Great Lakes communities are significant drivers of the nation's economy – in coastal and inland communities. Ocean, coastal, and Great Lakes research and education, much of which is conducted within the network of NAML laboratories, is a vital part of the nation's research and education enterprise, and is a critical component of the economic and environmental health of the nation. The nation is faced with a widening gap between the actual level of federal funding for research and education and the required investment to sustain the U.S. as the world's leader in innovation. Therefore, NAML strongly recommends:

- **The nation increase its investment in research and education to develop the knowledge, people, and technologies that power the ocean and coastal economies, create jobs, improve health, strengthen our national security, and support the U.S. as a global leader;**
- **This effort should include ocean observations, data integration, and related cyber and physical infrastructure; monitoring, research, and response to changing environmental conditions (such as sea level rise, ocean temperature increases, and ocean acidification); and**
- **Renew the commitment to improve the quality of STEM education and re-energize efforts to attract, recruit, support, and retain women, minorities and others not currently well represented in the science and technology workforce.**

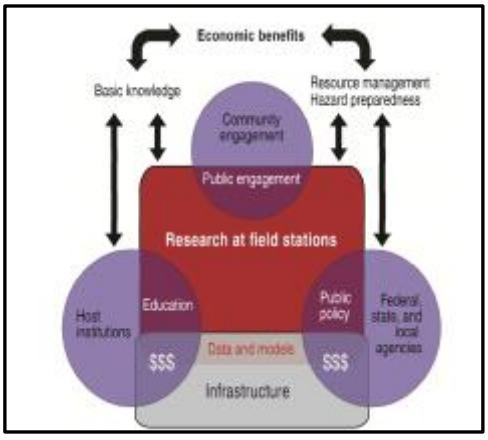
The Value of the Nation's Coastal and Ocean Economy

For centuries, the sea has sustained lives and livelihoods, divulged ancient and unforeseen treasures, and stirred our dreams of remarkable new discoveries. But never in history have we had the immense opportunities now beckoning from the sea. On the horizon is a new blue economy, an exciting oceanic frontier that offers great promise for making our nation safer, healthier, and more prosperous. The new blue economy is a knowledge-based economy, looking to the sea not for extraction of material goods but for data and information to address societal challenges and inspire their solutions. This economy is entrepreneurial and environmentally responsible, collaborative and competitive.[i]

A recent report from the Center for the Blue Economy reported that the ocean economy[ii] generated a larger share of U.S. economic activity than farming, food products, oil and gas extraction, and forest products. Employment supported by the ocean economy is almost as large as the employment of all of these industries combined. The Great Lakes alone generate nearly $5 trillion in economic activity or about 30% of combined U.S. and Canadian economic output. Finally, the U.S. marine transportation system is an essential driver of the U.S. economy and its impact is felt well beyond the coast and reaches into the heartland of the nation. America's seaports are crucial generators of economic development and well-paying jobs, both regionally and nationally, that is felt throughout all supply chains that use the ports.

The ocean and our coasts are invaluable for humanitarian, environmental, and health reasons. The oceans are a primary source of food for over one billion people, a globally significant regulator of the earth's climate, the basic source of water for the hydrologic cycle, a cleaning agent that absorbs carbon dioxide and generates oxygen, and home to thousands of flora and fauna, many with pharmaceutical value. The ocean has been a source of new drugs to treat certain cancers. Blue-green algae, commonly found in Caribbean mangroves, are used to treat small-cell lung cancer and certain sponges produce chemical substances that can be used to treat cancer and manage pain. A wide gulf often separates science from the people who need research results to protect and support them. However, the new blue economy puts science and predictive capabilities to work in a way that can fill critical, fast-rising needs across sectors.[i]

The network of the Nation's marine laboratories is cost effective, highly relevant, and the vehicle that brings science to those who depend on research results to protect lives and support livelihoods.



Source: *Enhancing the Value and Sustainability of Field Stations and Marine Laboratories in the 21st Century,* National Academy of Sciences. 2014

Examples of ocean, coastal and Great Lakes research impacting coastal economies

Oysters: The Pacific Northwest is home to the largest hatchery based oyster industry in the US. Research conducted at Oregon State University found that losses of $110 million dollars to the hatchery industries of Oregon and Washington State were due to ocean acidification, which impedes shell formation in the early stages of oyster development. Based on OSU's research findings, the hatcheries in the Pacific Northwest have adapted by "buffering" their hatchery and nursery waters, the equivalent to using "Tums" to buffer an acidic stomach. Although buffering can be done in a controlled hatchery to a limited extent, it is not practical to buffer the entire ocean. Further research is focused on finding more acid-tolerant oyster strains for providing brood stock to the hatcheries.

The National Association of Marine Laboratories (NAML) is a nonprofit organization representing the ocean, coastal and Great Lakes interests of member laboratories that employ thousands of scientists, engineers and professionals nationwide. NAML labs conduct high quality research and education in the natural and social sciences and translate that science to improve decision-making on important issues facing local, state, regional, national and international entities.

Great Lakes Restoration: **Muskegon Lake is part of the Great Lakes coastal wetlands ecosystem, which is a critical source of food and habitat for fish and wildlife within the Great Lakes. Approximately 65% of the shoreline had been hardened with seawalls and concrete or rock riprap. Additionally, broken concrete, foundry slag, sheet metal, slab wood, saw dust and other materials in shallow water areas posed hazards to recreation and degrade habitat. The Muskegon Lake Habitat Restoration Project was initiated, to restore hardened shoreline areas, create or restore emergent and open-water wetlands, and remove unnatural fill on the south shore of Muskegon Lake. Scientists at the Annis Water Resources Institute at Grand Valley State University used both biological and socioeconomic research to improve the design and impact measurement of the restoration activity. The economic impact of the restoration returned $66 million to the region for the $10 million expended.**

Lobsters -- In the Gulf of Maine, since 1980 the temperatures have been rising on average at the rate of one degree Celsius every 40 years. But in the last decade the temperatures are increasing at a rate of one degree about every four years. As the temperatures rise, so do the incidences of shell disease in lobsters. Scientists at the University of Maine, describe the latter as a "nasty looking disease" with dramatic effects on the lobster's exoskeleton. It is a bacterial infection that dissolves the shell, pitting it and rendering the lobster unpalatable for sale. In its most severe forms, the disease can cause blindness, prevent the lobster from molting - when it sheds its exoskeleton - and interfere with its hormonal system. In the latter case, an egg-bearing female lobster might suddenly cast off its skeleton, taking the eggs with it. The disease is now present in some 30 per cent of the harvestable size lobster caught in southern New England. With knowledge of the temperature link to this disease, scientists are working to devise mitigation strategies to address this issue.

Maintaining a Vibrant Ocean, Coastal, and Great Lakes Research and Education Enterprise is Important for the Economic and Environmental Health of the Nation

Research conducted by people educated and trained, in part, at the nation's network of marine laboratories has uncovered the linkage between changes in ocean temperature and its impact on the lobster industry; the role science can play to maximize the return on shoreline restoration; and the impact of ocean acidification on the oyster industry. Training and research centered in the nation's network of marine laboratories should:

- develop vital, lifesaving adaptive and mitigation strategies to enhance coastal resiliency with forthcoming environmental challenges facing the Nation;
- develop a deeper fundamental understanding of earth system science so that we can more accurately predict and respond to severe weather and climate changes on local, regional, national, and global scales;
- develop techniques and technologies that will increase the competitiveness of the U.S. aquaculture industry, and contribute to sound fishery management practices, thereby enhancing food security by increasing society's access to safe, affordable, sustainable, and healthy seafood; and
- lead to the discovery of new marine biological agents that may prove valuable in the treatment of diseases and other ailments.

To develop the knowledge and technologies needed to meet these and other challenges in the ocean, coastal, and Great Lakes environment, it will take the continued education and training of people in science, technology, engineering, and mathematics (STEM). This argues for a renewed commitment to improve the quality of STEM education provided at the pre-K levels and continuing on through the undergraduate and graduate levels of education and for a meaningful and sustained effort to attract, recruit, support, and retain women, minorities, and others not currently well represented in our scientific and technical workforce.

The U.S. Research and Education Enterprise is Essential for the Long Term Health of the Nation

NAML lab directors are concerned about the long-term health of the nation's research and education enterprise and its ability to contribute to the nation's ocean and coastal economy. Increased funding for research, development, and education is critical to the economic enterprise. However, the U.S. is failing to keep pace with our competitors' investments in R&D. For example, China's research investments are rapidly growing by an average of 8% per year, in pursuit of the goal of investment equal to 3% of GDP. By contrast, U.S. investments have not been growing at an influential pace. At this rate, China will surpass the U.S. in R&D intensity in about eight years.

Re-gaining our Nation's competitive edge will require federally funded research and education to become a higher priority than has been the case in over two decades. The Nation needs an enriched workforce of trained, science savvy, entrepreneurs. Basic research is often where the breakthroughs occur that change existing theories and revolutionize technologies. During the 18 years from 1975 to 1992, the federal investment in basic research grew at an average annual inflation-adjusted rate of over 4%, despite serious challenges including the 1973 oil embargo, the Great Inflation of 1979–1982, and the final years of the Cold War. Leaders in both parties, in the White House and Congress, were able then to agree that investments in research should be a high priority for federal support.

Additionally, scientific and technological advances allow us to better understand our world. Building our knowledge allows us to respond more appropriately to new challenges, adapt to changing conditions, and take advantage of emerging opportunities for the benefit of our Nation. Strong science, technology, and engineering capabilities and informed people and communities are the foundation for improving our understanding of the marine environment—from the coasts to the deep sea—and informing our decisions about how best to manage the activities that affect the valuable and multiple resources the marine environment provides. Sustained scientific research and innovative technologies give us the high-quality information we need to maintain or restore ocean resources, guide development and investment opportunities, safeguard lives and property from marine hazards, enhance national security, prepare for and respond to the impacts of climate change and ocean acidification, improve public health, and protect ocean resources. Advancing our scientific, technological, and engineering capabilities also increases the Nation's competitiveness and helps spur the innovation that drives our economy and improves our quality of life. Ultimately, success in improving the ways we use and manage ocean resources depends on building broad public understanding and recognition of the importance of the ocean, coasts, and Great Lakes to our daily lives and the long-term welfare of our Nation.

For the United States to continue to be a global leader in understanding and acting on the connections between our well-being and the health of the natural environment, we need to continue exploring and expanding our knowledge of the ocean, our coasts, and the Great Lakes. Management and policy decisions must be based in the context sound science provides, through the integration of natural and social science data, information, and knowledge. The next Administration must support actions that will contribute to high quality science and ensure that information based on that science is made available to guide decisions and actions. Insight gained from scientific research, advances in observations, and innovative technologies will further enable evaluation of trade-offs between alternative management scenarios, enhance our ability to balance competing demands on ecosystems, and strengthen our Nation's economic and scientific competiveness. At the same time, increasing understanding of the ocean, coasts, and Great Lakes among our people and communities will empower better-informed public stewardship of ocean resources.

NAML lab directors believe the challenges confronting this Nation and the world with respect to sea level rise and its impact on national security, domestic unrest in developing countries, expanding diseases, flooding, severe weather, and coastal community economic resiliency will all rely on the natural and social sciences, engineering, and technological developments to provide the information and people needed to deal with these challenges. Continuing changes to the ocean and coastal environment, such as ocean and coastal acidification and rising ocean temperatures, will have impacts on marine life (both plant and animal life) that we do not

fully understand, but yet will surely complicate issues related to food security, commercial fishing, and seafood production and marketing. This country must accelerate the discovery of new scientific knowledge and the education and training of its technical workforce to meet these and many other challenges facing us in the 21st century.

Investments in research and education are essential for maintaining technological innovations and advancements that will help our society and a global population survive in rapidly changing times. NAML urges stronger investment into the research and education enterprise of the United States, to reverse the trend of the last 24 years that has left the United States trailing our international competitors. Every research dollar invested returns economic prosperity many times over. If the U.S. is to meet the environmental and economic challenges facing this country, we must make the necessary investments in our research and education enterprise. Nowhere is this need greater than for our ocean, coastal and Great Lakes communities – which serve the economy of our entire nation. Failure to act now may put us in a position from which we cannot recover.

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July 2016

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[i] Spinrad, R. W. (2016), *The new blue economy: A vast oceanic frontier*, *Eos, 97,* doi:10.1029/2016EO053793. Published on 08 June 2016.

[ii] *State of the U.S. Ocean and Coastal Economies – 2016 Update,* Center for the Blue Economy, Middlebury Institute of International Studies at Monterey.

NOAA UPDATE
To The MAFAC Meeting

RDML Tim Gallaudet, PhD, USN Ret.

Assistant Secretary of Commerce for Oceans and Atmosphere and
Acting Under Secretary of Commerce for Oceans and Atmosphere

November 28, 2017

Agenda

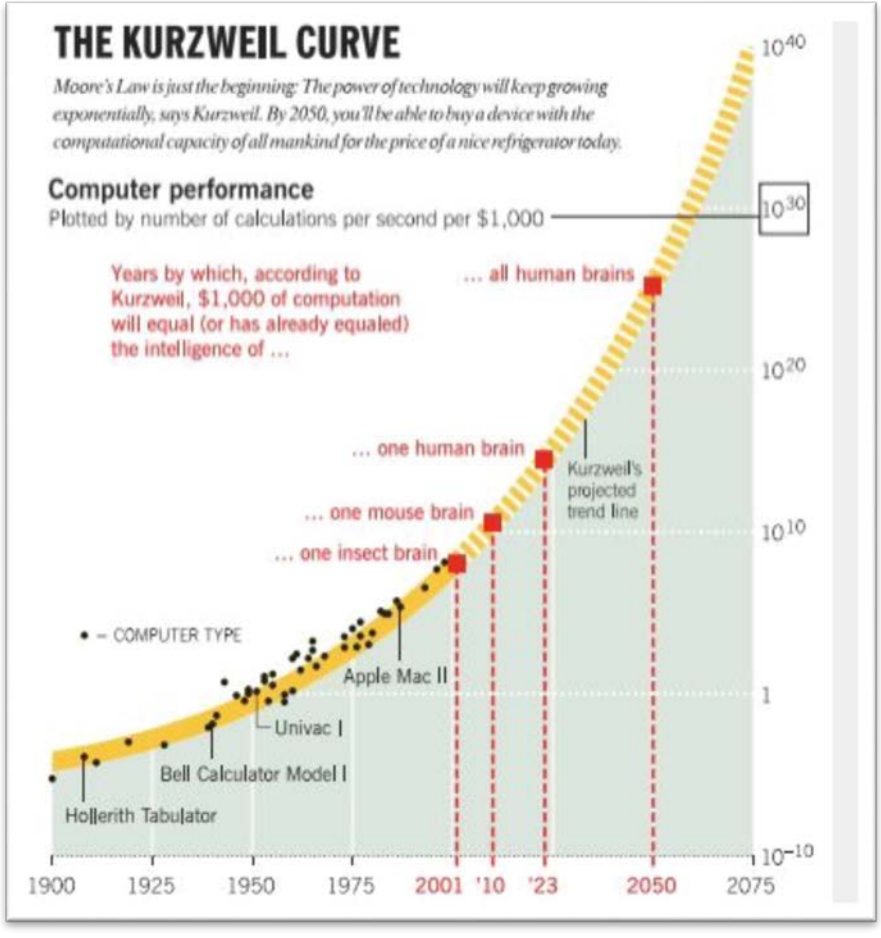
- * Personal Introduction
- * Strategic Imperatives
- * NOAA Priorities 2017-2022
- * Implications For NOAA Fisheries

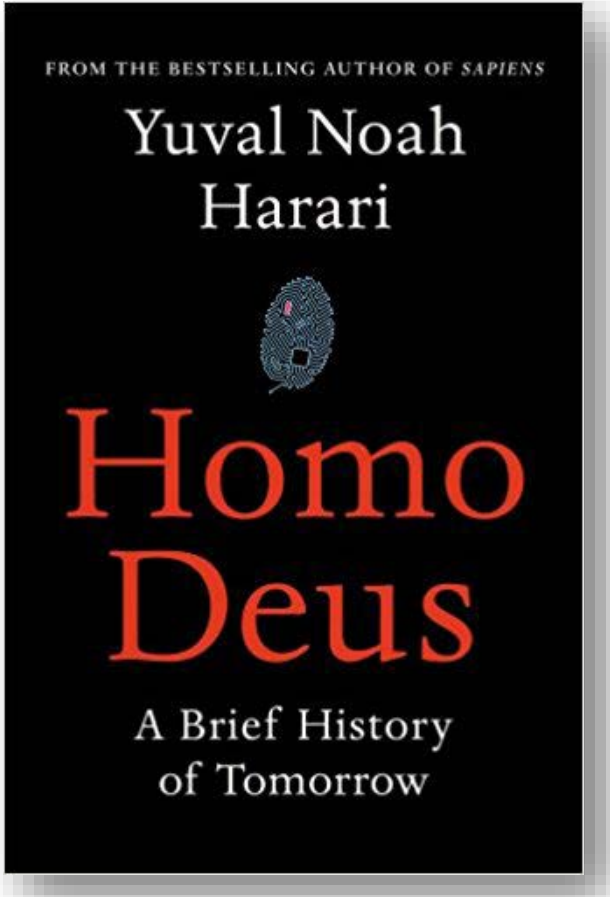
How I Got Here

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NOAA
U.S. DEPARTMENT OF COMMERCE

Strategic Imperatives

Exponential Technology Advancement



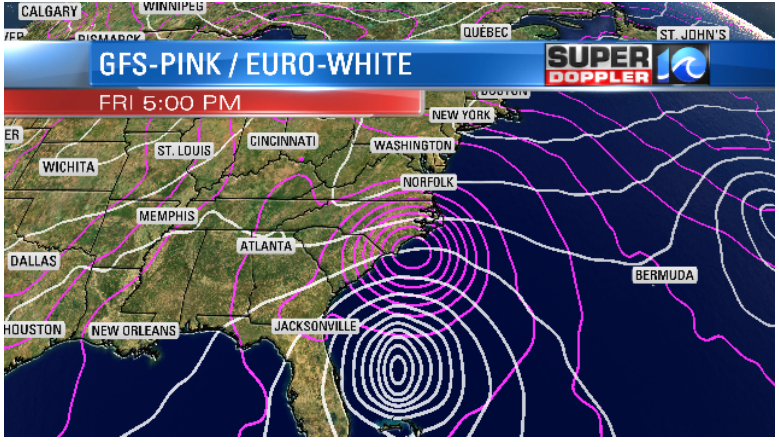


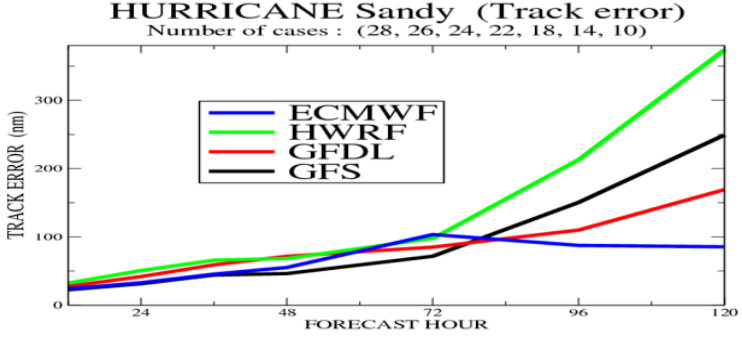
A Maritime Moore's Law

Return to Great Power Competition

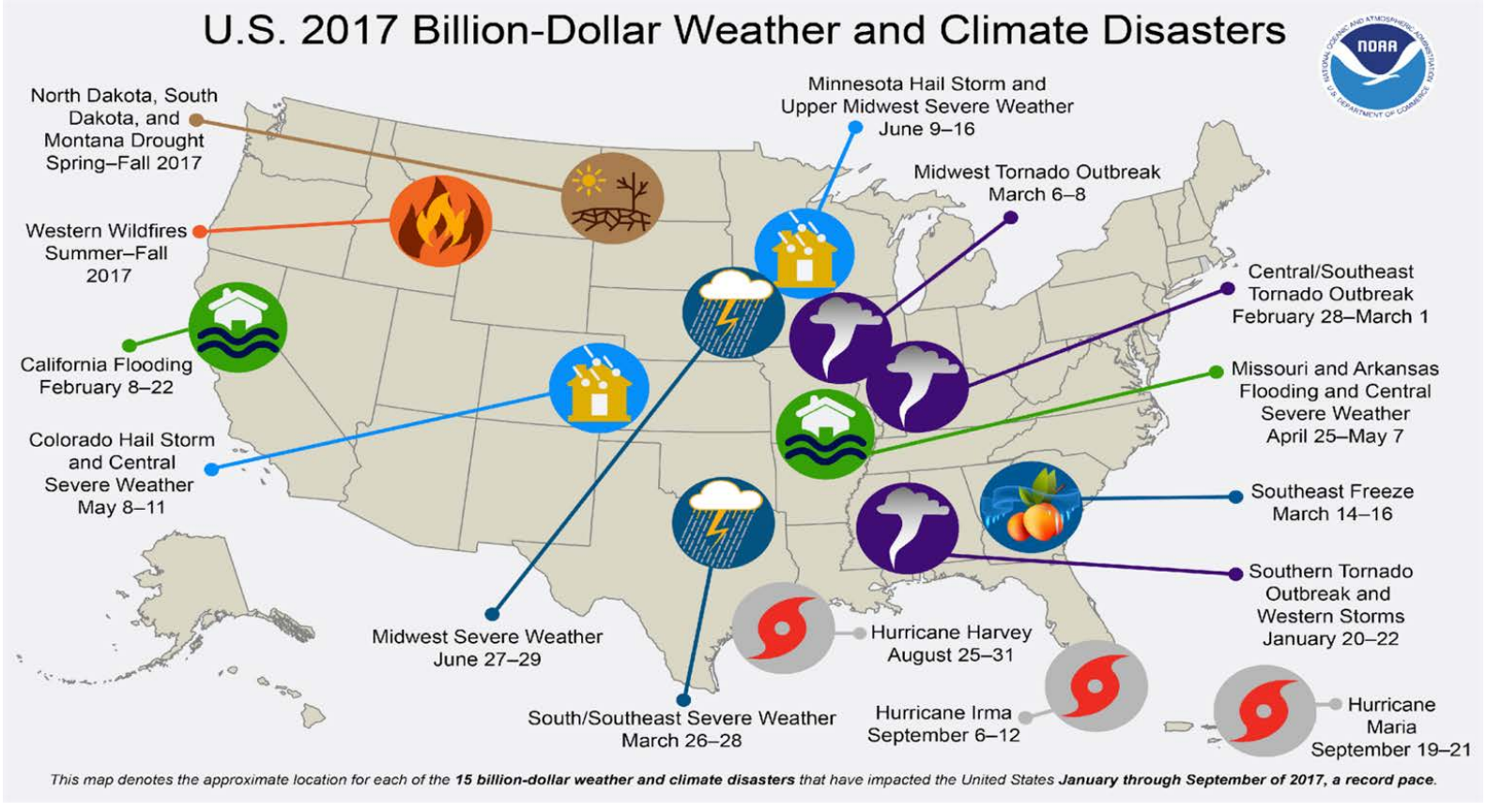
NOAA Priorities 2017-2022

#1. Lead the World in Earth System Observation & Prediction





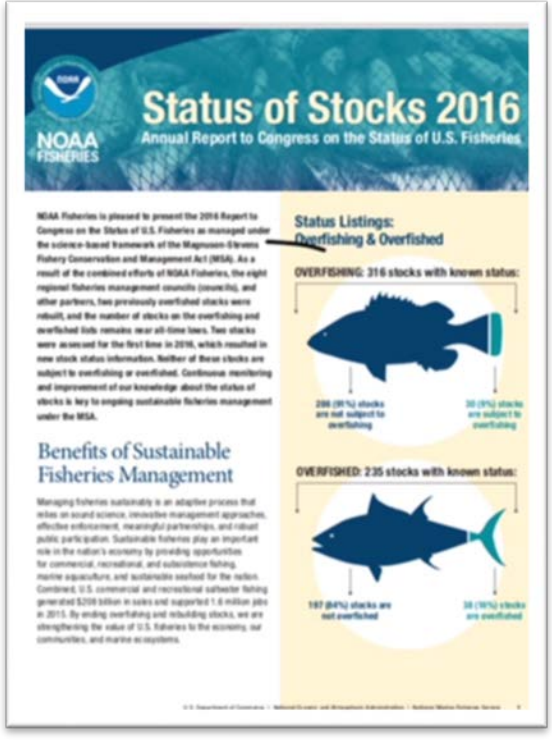
#2. Minimize Extreme Wx & Water Event Impacts



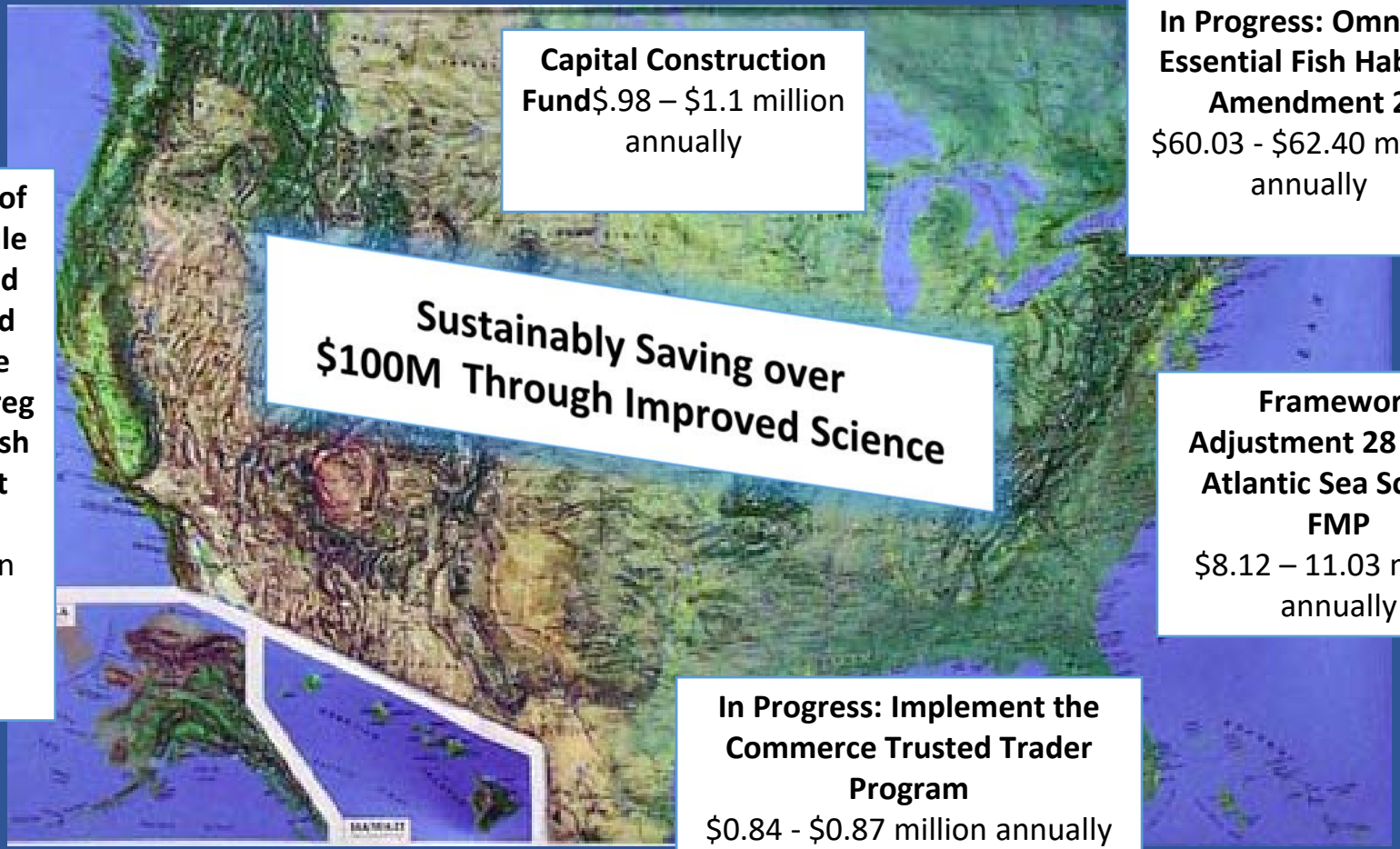
#3. Increase the Sustainable Economic Contributions of Our Fisheries and Oceans

Implications for NOAA Fisheries

We Are Succeeding



Deregulation & Increasing Flexibility



Withdrawal of Proposed Rule for Protected Species Hard Caps for the California/Oregon Large-Mesh Drift Gillnet Fishery
$0.28 million annually

Capital Construction Fund$.98 – $1.1 million annually

Sustainably Saving over $100M Through Improved Science

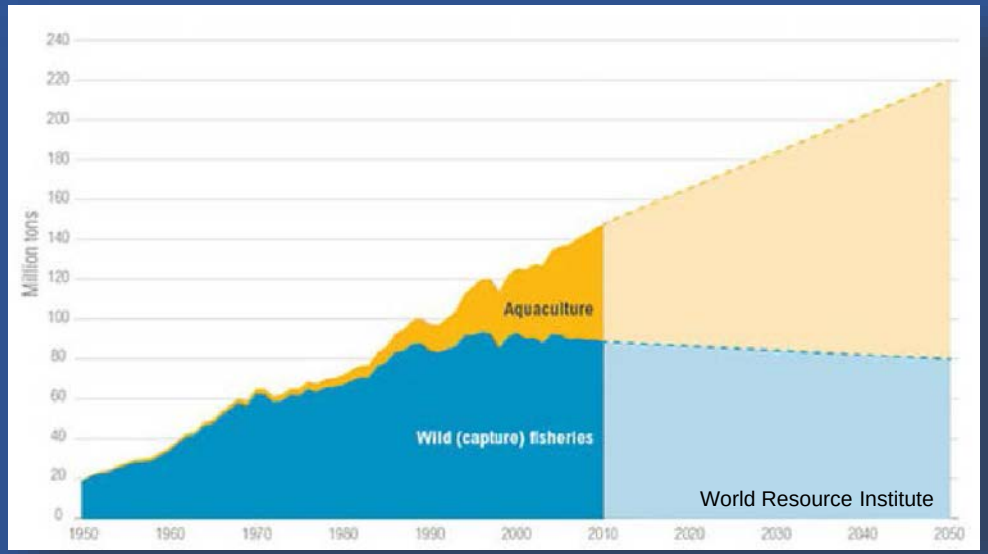
In Progress: Omnibus Essential Fish Habitat Amendment 2
$60.03 - $62.40 million annually

Framework Adjustment 28 to the Atlantic Sea Scallop FMP
$8.12 – 11.03 million annually

In Progress: Implement the Commerce Trusted Trader Program
$0.84 - $0.87 million annually

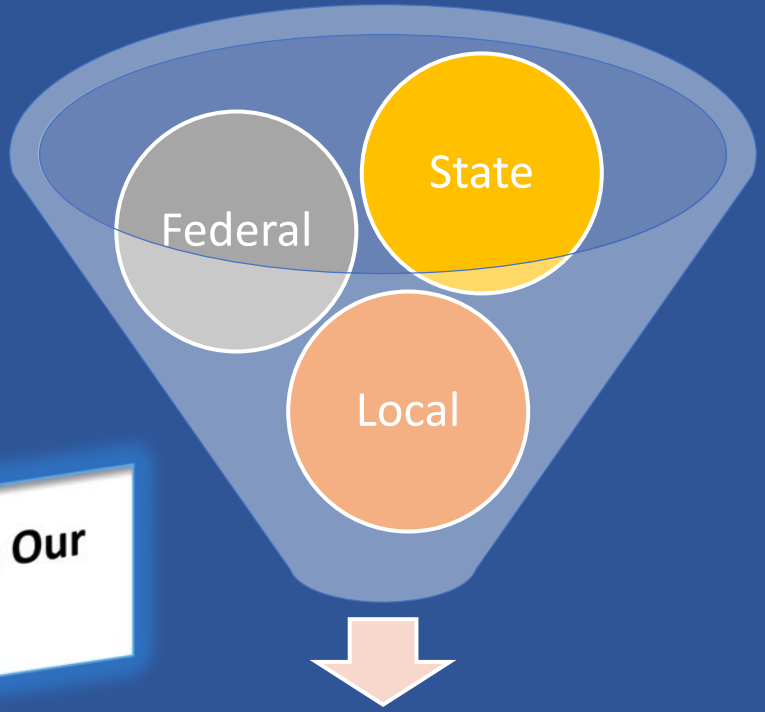
Towards A National Aquaculture Initiative

The Demand



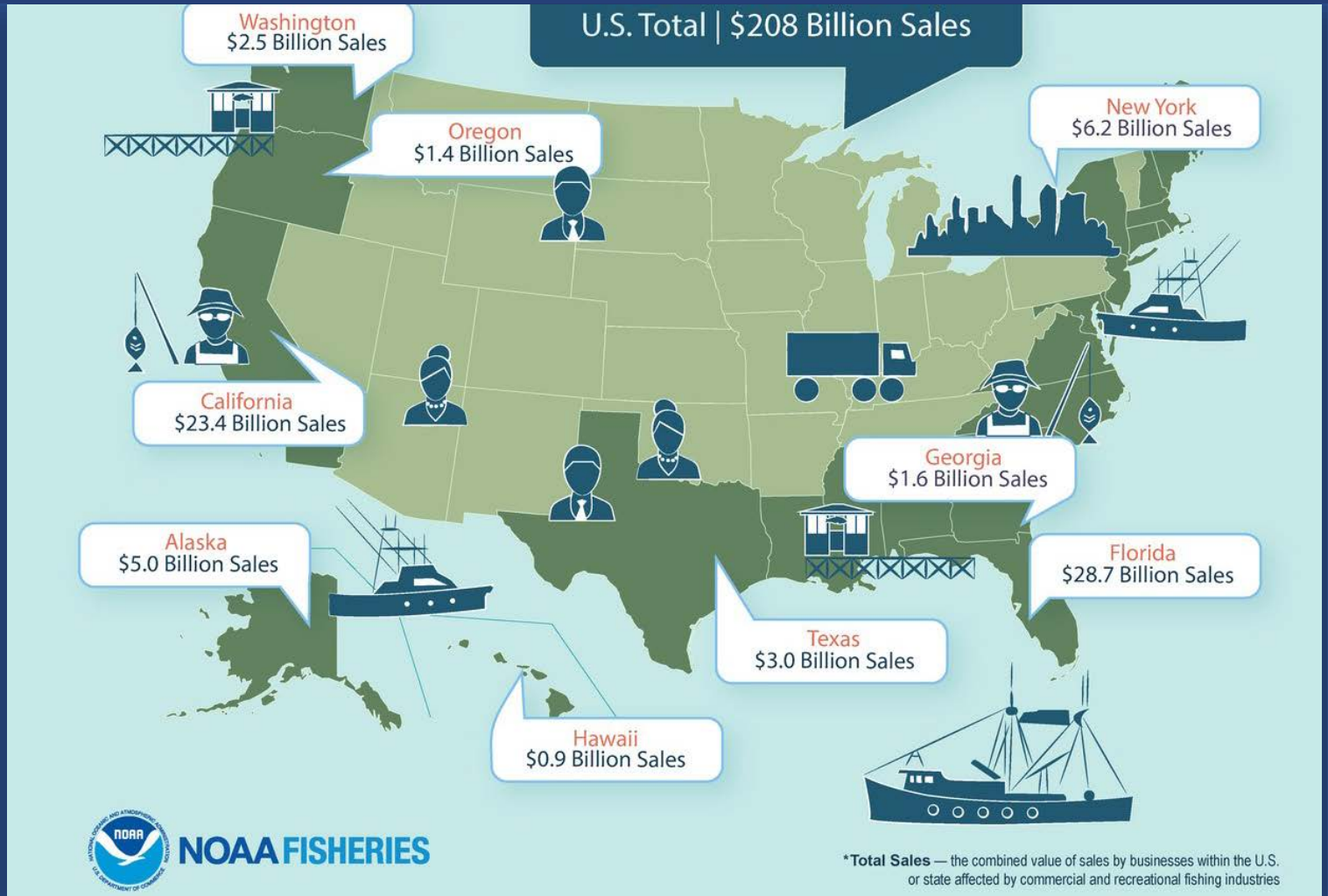
Applying Sound Science & Policy to Reduce Our Seafood Trade Deficit

Streamlined, Centralized Permitting

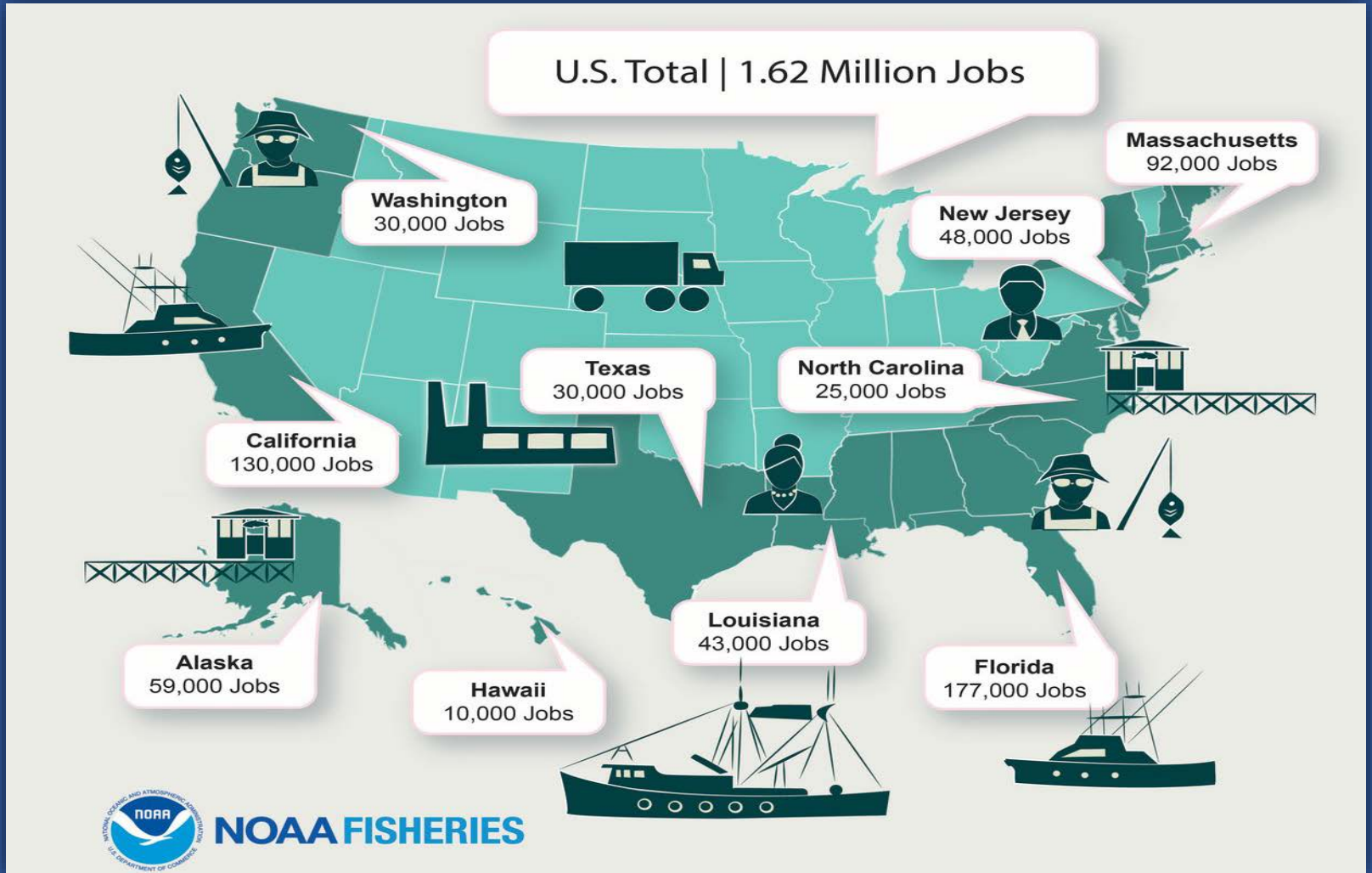


Aquaculture Permitting

The Economic Contributions of U.S. Fisheries



The Economic Contributions of U.S. Fisheries



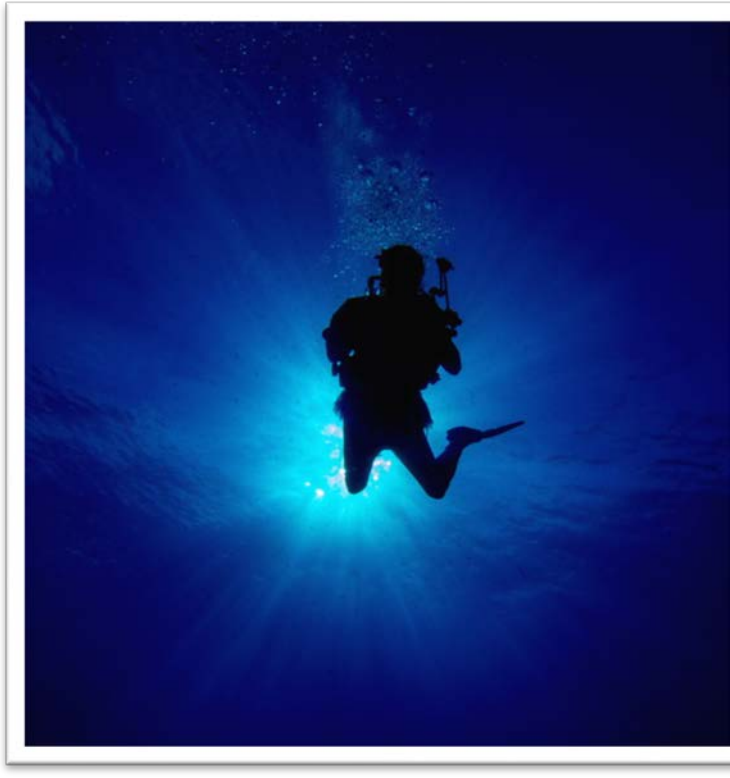
A National Marine Moonshot…

Marine Fisheries Advisory Committee

Abundant Seas: Making the Most of America's Marine Resources

December 2016

The Marine Fisheries Advisory Committee (MAFAC) is pleased to welcome the new Administration. We have prepared the following report to share our thoughts and recommendations regarding priority initiatives for marine resources with the transition team and incoming leadership of the Department of Commerce and NOAA. We are looking forward to working with you.



To Accelerate America's Blue Economy

Thank you!