2017
NOAA Science Report

National Oceanic and Atmospheric Administration
U.S. Department of Commerce

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Foreword

The National Oceanic and Atmospheric Administration (NOAA), housed within the Department of Commerce, is the nation's premier ocean, weather, and atmospheric science agency. Every day, NOAA collects nearly 20 terabytes of data, more than twice the volume of data of the printed collection of the U.S. Library of Congress. NOAA's scientists and engineers connect the dots of all this data, providing valuable products and services that touch the lives of every American. NOAA products and services affect more than one-third of America's gross domestic product and include daily weather forecasts and information valued at more than $600 billion,[1] navigational tools, disaster response, and science to enable the nation's $208 billion fisheries industry.[2]

NOAA scientists discovered new creatures and features on the seafloor, developed tools for the aquaculture industry and U.S. seafood production, and predicted the path of a tornado hours before it formed saving countless lives. In collaboration with our Cooperative Institutes, NOAA is also looking to the future, developing numerical prediction models that will revolutionize forecasts for hurricanes and other severe weather events, and working with industry to develop the next generation of weather satellites. Through partnership with the U.S. Navy, NOAA also advances national security through our products and forecasts. The result is a better, faster, more holistic, and more economical national and natural resource security capability.

NOAA is developing a unified modeling strategy for the entire agency, and always upholds the highest standards of scientific integrity. Our highly-skilled workforce covers a range of academic disciplines, and our researchers are consistently recognized, both domestically and internationally, as the top experts in their respective fields.

In short, NOAA continues to provide exemplary science to citizens, emergency managers, and decision-makers. This sustained commitment to research and development has resulted in an unmatched return on investment. No other agency does what NOAA does.

This year's NOAA Science Report contains a mere fraction of NOAA's achievements. Even a quick scan through the report shows how taxpayer investments are paying off and the benefits of NOAA's research products in terms of the economy, environment, and community preparedness. I hope you will take the time to look at the many examples of the impactful research NOAA provides our nation.

Craig N. McLean
NOAA Research Council Chair
December 2017

1 Lazo, J.K., Lawson, M., Larsen, P.H., and Waldman, D.M. (2011). United States Economic Sensitivity to Weather Variability. Bulletin of the American Meteorological Society, p.710. DOI:10.1175/2011BAMS2928.1.
2 National Marine Fisheries Service. (2017). Fisheries Economics of the United States, 2015. U.S. Department of Commerce, NOAA Technical Memorandum No. MFS-F/SPO-170, p. 6, Washington, D.C.: U.S.

Introduction

Enriching Life Through Science

Reaching from the surface of the sun to the depths of the ocean floor, the mission of the National Oceanic and Atmospheric Administration (NOAA) depends on a strong research foundation for understanding the complex systems that define our planet.

This understanding ultimately provides a range of users with the information and intelligence needed to protect lives, support livelihoods, and enhance lifestyles. From providing the daily weather forecasts that help safeguard communities, to informing fisheries management that keeps our nation fed and fishermen's jobs secured, NOAA's products and services affect more than one-third of America's gross domestic product and help protect people and property.

Why NOAA Invests in Research

NOAA's investment in research is critical to continually improving the quality, reliability, and cost-effectiveness of the products and services to end users.

These products and services are developed through a dynamic engagement between the agency and its users: stakeholders communicate their needs to NOAA, sparking new research initiatives or improvements to current services, while NOAA continues to improve research and services to meet the needs of the people who depend on them.

By integrating research conducted internally with work from our partners, including cooperative institutes (CI), universities, other government agencies, and the private sector, NOAA can transform basic conceptual research into the data, tools, and information our stakeholders rely on.

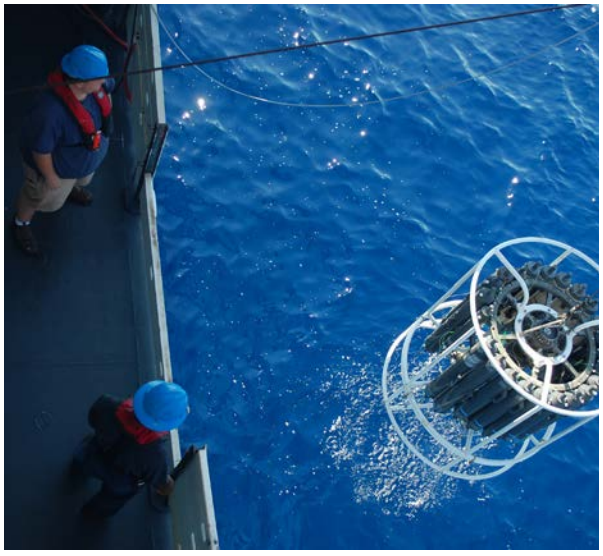
In short, we view the concept for this investment as a focusing effort in which we balance a *broad base of research investments to serve a wide diversity of end users.*

NOAA's Mission: Science, Service, and Stewardship

1. To understand and predict changes in climate, weather, oceans and coasts

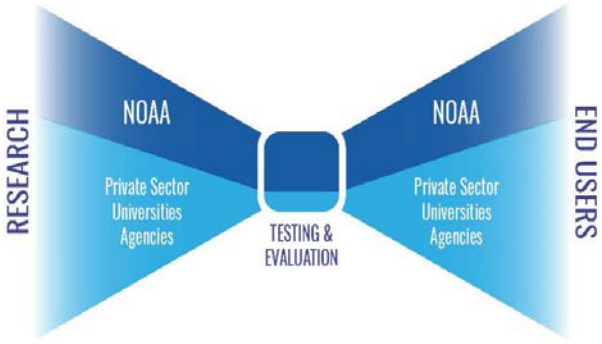
2. To share that knowledge and information with others

3. To conserve and manage coastal and marine ecosystems and resources



The Portfolio Logic Model

Like an investor administering financial holdings, NOAA manages its research and development (R&D) portfolio to ensure that we are serving the American public effectively while appropriately balancing investments across the agency's diverse mission responsibilities. The strategy for doing so is defined by NOAA's portfolio logic model: the why, what, where, and how of NOAA's R&D investment.



"Bow-tie" concept borrowed from UK Met Office .

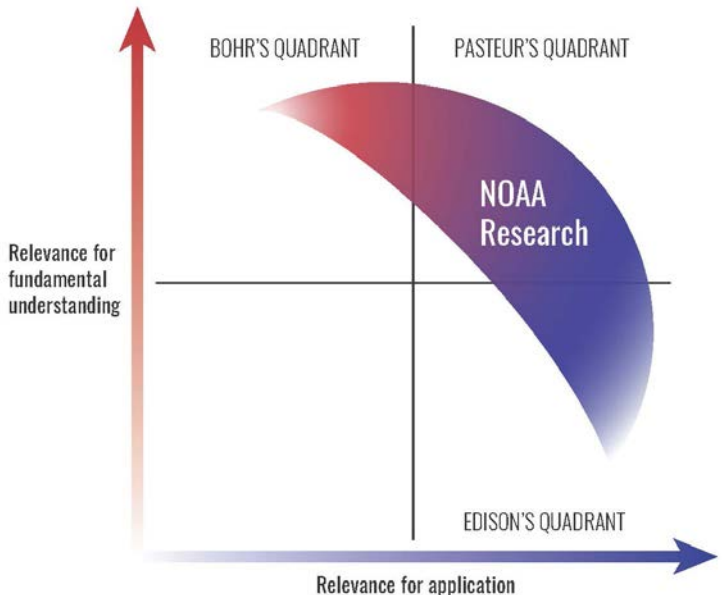
What Kind of Research NOAA Supports

NOAA's R&D addresses the needs of the user community while advancing fundamental scientific understanding. Our R&D portfolio must allow the flexibility to consider contributions to the scientific knowledge base separately from (albeit related to) enhancing applicability.

In the context of the classical treatment by Donald Stokes [Stokes, 1997], we strive to position our investment primarily in "Pasteur's Quadrant," while including critical investments aimed primarily at either advancing fundamental understanding or enhancing applications.

NOAA strategically invests in a mix of research projects across the risk-reward spectrum. We pursue a range of projects, from low-risk projects that result in incremental gains (e.g., periodic improvements to our already-existing storm prediction models) to high-risk projects with high potential gains but less certainty of success (e.g., exploratory research).

This sets NOAA on the cutting edge of R&D while still ensuring that we meet the needs and expectations of our users.



Donald Stokes proposed the above chart in his 1997 book Pasteur's Quadrant: Basic Science and Technological Innovation. this chart portrays that, while some research largely focuses on fundamental understanding (Bohr's quadrant upper left) or application (Edison's quadrant, lower right), it is possible for research to be highly relevant for both fundamental understanding and real-life applications (Pasteur's quadrant, upper right). the majority of NOAA research strives for this dual relevance as reflected in Pasteur's quadrant.

Introduction

All Six NOAA line offices provide a unique contribution to NOAA R&D

The National Marine Fisheries Service (NMFS), also known as NOAA Fisheries, is responsible for the stewardship of the nation's ocean resources and their habitat. Their main goals are to ensure productive and sustainable fisheries, safe sources of seafood, the recovery and conservation of protected resources, and healthy ecosystems—all backed by sound science and an ecosystem-based approach to management. The sound science behind these goals is largely carried out by NMFS's regional science centers and laboratories.

The National Ocean Service (NOS) works to provide science-based solutions through collaborative partnerships to address evolving economic, environmental, and social pressures on our ocean and coasts. NOS program offices address the science of ocean and coastal resources, tides, the complexity of Earth's surface, coastal resilience, nautical chart making, marine sanctuaries, responses to oil and chemical spills, and ocean observation and monitoring.

The National Environmental Satellite, Data, and Information Service (NESDIS) aims to provide timely access to global environmental data from satellites and other sources to promote, protect and enhance the Nation's economy, security, environment and quality of life. Their research activities involve operating the NOAA National Data Centers, providing data and information services including Earth system monitoring, performing official assessments of the environment, and conducting related research.

The Office of Oceanic and Atmospheric Research (OAR), also known as NOAA Research, seeks to use rigorous research to better understand the complex systems that support our planet. OAR runs several NOAA research laboratories and the National Sea Grant College Program, as well as heading offices focused in ocean exploration, climate, weather and air quality, unmanned aircraft systems (UAS), and ocean acidification.

The National Weather Service (NWS) works to provide weather, water, and climate data, as well as forecasts and warnings for the protection of life and property and enhancement of the national economy. They conduct R&D activities to collect these data and perform the necessary predictions to create a weather-ready nation.

The Office of Marine and Aviation Operations (OMAO) does not have an internal R&D agenda, but instead supports the research of other line offices through providing, managing, and operating the aircraft and marine vessels necessary to carry out this research.

Where NOAA Invests in Research

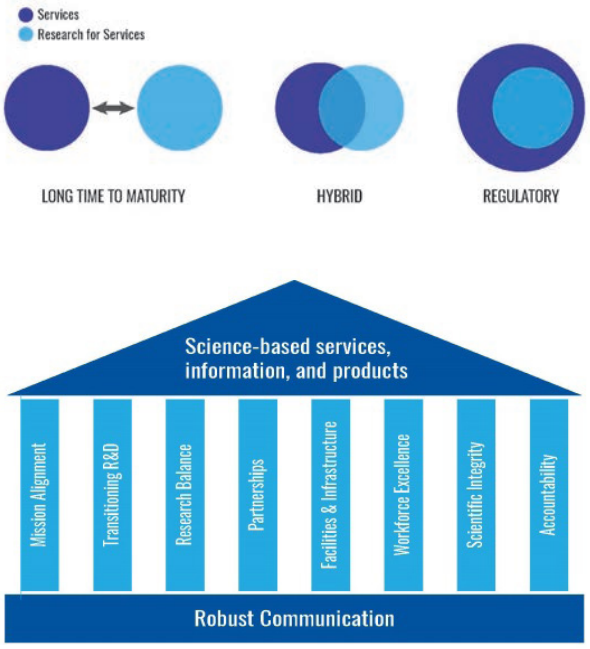
NOAA maintains both intramural and extramural research investments. There is not a singular formula nor operational concept for distributing research support inside and outside of the agency. Some programs invest the majority of their R&D funding internally, at labs and science centers with federal employees. Other programs invest the majority of their funding to external R&D partners, at universities, industry, and other research institutions. Moreover, in many cases, programs invest with a distribution of R&D funds intramurally and extramurally.

In the past, NOAA analyzed the balance of investment [Fluharty et al., 2006; MacDonald et al., 2006]. Most recently, NOAA issued Strategic Research Guidance in 2015 [NOAA, 2015], 2016 [NOAA, 2016a], and 2017 [NOAA, 2017], and NOAA Administrative Order (NAO) 216-115A [NOAA, 2016d].

This guidance indicates that the principles around which the determination should be made about where to invest research funding are based on the expected time to maturity of research (for which external investments allow flexibility and 'course-corrections' through grants and contracts), and applicability to regulatory functions (for which direct engagement between the users and researchers might be most easily accommodated through internal investments).

Conceptually, this means that a balance of considerations for mission relevance, time to maturity, and need for flexibility indicate the balance of intramural and extramural investment as shown below.

NOAA partnerships are vital to the agency's R&D efforts, allowing for collaboration with leading universities, federal agencies, private companies, NGOs, and other science innovators, as well as the mutually beneficial sharing of facilities, equipment, and staff expertise. Key mechanisms for partnerships include Cooperative Institutes (Prospectus for Cooperative Institutes in the 21st Century - CI21 [NOAA, 2016e]) and Cooperative Science Center agreements with universities; the Sea Grant network; extramural grant programs; contracts; Cooperative Research and Development Agreements with the private sector; and more.



What Principles Guide NOAA Research

NOAA strives to direct, formulate, and evaluate all agency research in light of the following eight principles through the NOAA Administrative Order (NAO) 216-115A: mission alignment, transition readiness (NAO 216-105B [NOAA, 2016c]), research balance, optimized partnerships, sustained facilities and infrastructure, workforce excellence, scientific integrity, and accountability.

These principles, grounded in communication within the agency and between our partners, work together to uphold NOAA's high-quality research, development, services, and products.

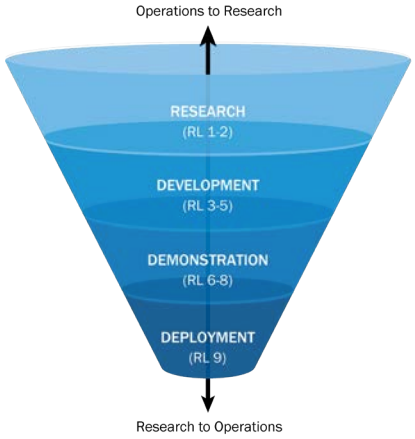
Introduction

How NOAA Research Transitions into Operations, Applications, Commercialization, and Utilization (R2X)

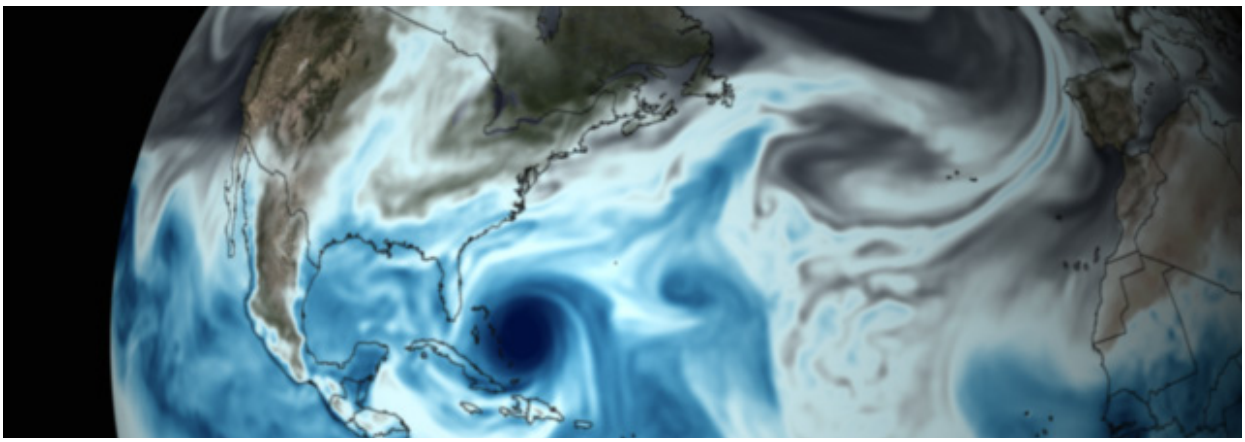
It is essential to ensure there is transition of research and development to maintain our capability of meeting mission requirements across all NOAA missions.

In the Fiscal Year (FY) 2017, Congress established the Research Transition Acceleration Program (RTAP) at NOAA in line with the President's Budget request. RTAP is designed to support the acceleration of mature short- and long-term R&D activities to the "mission-qualified" level (Readiness Level 8, RL 8) in one to three years. This pace is significantly reduced from historically longer transition times, which have taken decades in some cases.

NOAA's RTAP is improving the process and providing some of the needed resources to accelerate the transition of R&D outputs into NOAA's operations, applications, commercialization, and other uses for societal benefits, which we call R2X. The full description of NOAA's re-engineered transition process is defined in NAO 216-105B. In the end, these process and resource improvements will continue to strengthen the culture of transitioning R&D at NOAA.



Red Snapper.



Examples of Research Transition

Currently, NOAA line offices are conducting a limited range of highly successful transition activities. The activities listed below highlight just a few of the R&D projects that have been selected to move from research to operations, applications, and policy.

Establishing an Operations-to-Research Infrastructure (S4) to facilitate Research-to-Operations transitions of multiple scientific projects aimed at improving NOAA modeling systems

NOAA and academia established an infrastructure called S4 to engage the broader research community in the use of NOAA numerical modeling systems. This infrastructure was composed of a supercomputer, a user support mechanism, and a software configuration management system, models porting. These scientists are working on improving satellite data utilization in NOAA numerical modeling systems in order to facilitate their Research to Operations (R2O) transitions. Through S4, researchers from government, private sector, and academia have access to a variety of NOAA numerical models including ocean, weather, air quality and land, which allow them to perform their research in an operational-like environment and therefore greatly facilitate their R2O transition effort and mature their technical readiness level.

A multitude of NOAA systems benefited from the S4, including the Global Forecast System/ Gridpoint Statistical Interpolation (GFS/GSI) system for global weather forecasting, the Hurricane Weather Research and Forecast (HWRF) for hurricane prediction, the Hybrid Coordinate Ocean Model (HYCOM) system for ocean prediction, North American Land Data Assimilation System (NLDAS) for land assimilation, and prediction and Weather Research and Forecasting model coupled to Chemistry (WRF-Chem) system for air quality.

Transitioning Optical Technologies to Improve Surveys for Red Snapper and Other Reef Fishes

Current fish surveys conducted in the Gulf of Mexico provide measures of observations per unit effort that can be compared over space and time, enabling the generation of relative abundance indices. While relative abundance indices are considered good indicators of biomass trends, these indices do not give an accurate estimate of the overall stock size. This research 1) develops a capability for estimating true local density for red snapper and other fish species from video surveys, 2) classifies the seabed and other habitat parameters to estimate stock conditions, and 3) generates absolute abundance estimates aimed at reducing uncertainty in the stock assessment and improve NOAA Fisheries ability to monitor the status of red snapper and other reef fish.

Operationalizing these optical technologies will provide total abundance estimates of red snapper and other reef fishes, reducing scientific uncertainty, improving the stock assessment and providing for more sustainable fishery yield.

North American Multi-Model Ensemble (NMME)

A multi-model ensemble prediction system comprised of operational and research climate models developed and demonstrated via NOAA Climate Test Bed (CTB) was transitioned to the NOAA Climate Prediction Center (CPC) as an operational seasonal prediction tool. Uniquely, the product makes operational use of research climate models to form the ensemble forecast.

As part of the Weather-Ready Nation vision, such forecasts and applications stemming from NMME hold the promise of providing early warning of and mitigation to high-impact weather events.

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Example of Research Transition Continued

Operationalizing a Forecast System for Lake Erie Harmful Algal Blooms

The goal of transitioning the Lake Erie forecast system from demonstration at the NOAA National Centers for Coastal Ocean Science to operations at the NOAA Center for Operational Oceanographic Products and Services is to establish an operating capability for twice-weekly bulletin forecasts that provide information on the current size, density and location of the Harmful Algal Bloom along with a 72 hour forecast of where it will transport to.

The transition plan documents the steps necessary to achieve that objective without additional resources to base budgets and articulates the observations/data streams required to support the sustainment of operational requirements of the forecast system.

By providing sustained operational semi-weekly bulletin forecasts of potential threats to public water supplies, stakeholders are better able to make effective and timely water treatment decisions so as to avoid major impacts such as the Toledo water crisis of 2014.

Automated High-resolution Ensemble-based hazard Detection Guidance Tool

The overarching goal of this work is to transition a well-tested system for generation of ensemble post-processing hazard guidance products to operational status in the NOAA National Weather Service. A direct outcome of the project improves the ensemble hazard guidance tool for operational forecasters, thereby reducing the ensemble information overload problem and enabling a more efficient and accurate characterization of forecast uncertainty. Ultimately, the NOAA National Weather Service's weather guidances will become more useful and higher quality.

This tool will improve forecast accuracy of high-impact weather features such as rainbands, snow bands, low ceilings etc.; and will enhance forecasters' ability to communicate forecast uncertainty.

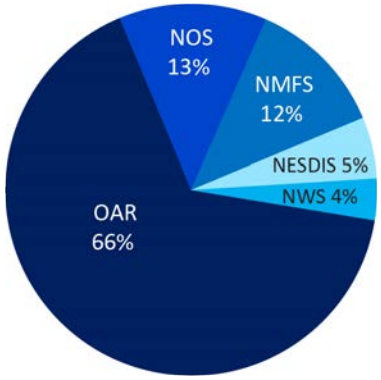
What is the Budget for NOAA Research

NOAA dedicated $585 million, or approximately 10 percent of the agency's total budget, to R&D in Fiscal Year 2017 (FY17), with R&D defined as all research and development activities outside of facilities and equipment purchases. This continues a five-year trend of increased R&D expenditures, highlighting NOAA's efforts to keep up with increased stakeholder demand for environmental intelligence and services in the face of a changing planet.

Where Does it Go

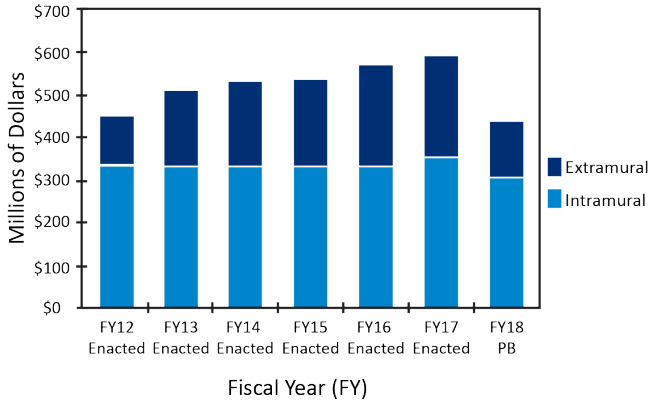
Approximately 60 percent of NOAA's FY17 R&D budget went to internal R&D efforts, including those at NOAA labs and science centers within the line offices. The remaining 40 percent was set aside for extramural research, enabling partnerships and collaborations with non-NOAA entities. Over the past five years, NOAA has been dedicating an increasing percentage of our resources to extramural research, which shows the importance NOAA places on external partnerships in fulfilling our R&D mission.

NOAA FY17 Enacted R&D Budget by Line Office



Note: OMAO has no internal R&D funding but instead supports the research of other line offices through providing, managing, and operating the aircraft and marine vessels necessary to carry out this research.

NOAA R&D Extramural vs. Intramural



Note: All graphs exclude facilities and equipment from R&D budget calculations.

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NOAA (2016b), FY2017 NOAA Budget Summary, p. 38, National Oceanic and Atmospheric Administration, Washington, D.C.

NOAA (2016c), NOAA Administrative Order 216-105B - Policy of Research and Development Transitions, National Oceanic and Atmospheric Administration, Washington, D.C.

NOAA (2016d), NOAA Administrative Order 216-115A - Research and Development in NOAA, National Oceanic and Atmospheric Administration, Washington, D.C.

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Integrated Earth System Processes & Predictions

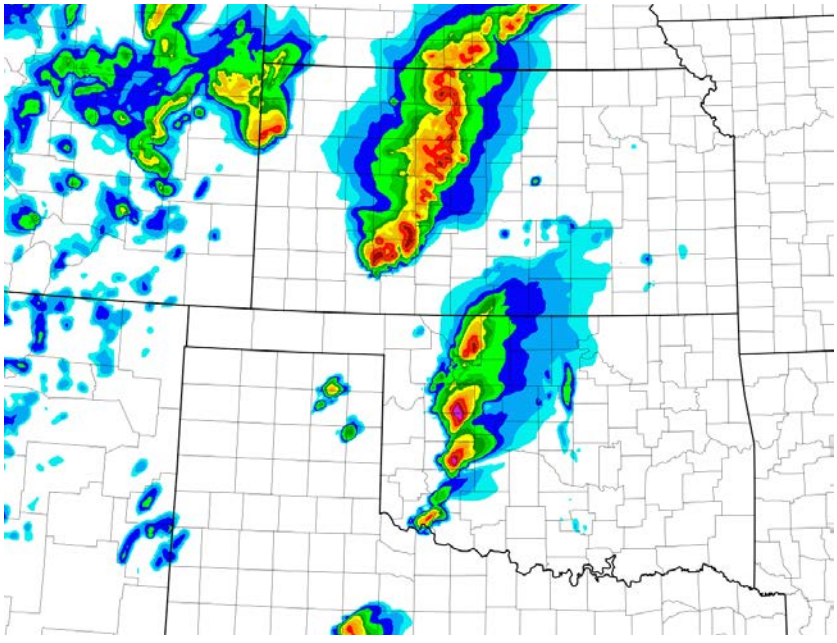
NOAA has a broad set of predictive responsibilities, reflected in its large and highly diverse modeling enterprise. Models are essential tools for enhancing scientific understanding, making predictions and projections, and ensuring informed decision-making to meet NOAA's mission needs.

For example, NOAA uses models for the following:

- informing weather, air quality, and ocean forecasting;
- providing predictions and projections of atmospheric, hydrologic, cryospheric, and oceanic dynamics and composition over a range of temporal and spatial scales;
- developing hazard mitigation such as tsunami and oil spill trajectory models, and ecological forecasting models for harmful algal blooms, hypoxia and ocean acidification;
- and supporting ecosystem-based management of marine resources including understanding and predicting associated socio-economic impacts.

Model development and improvements depend on a continued understanding of earth system processes, developed through targeted field and laboratory studies, as well as the exploitation of new types and sources of data.

While a single report outlining the scientific work and achievements of NOAA researchers throughout the past year would fill many volumes, this NOAA Science Report highlights a small but representative fraction of the critical work NOAA does every day. The research depicted in this chapter highlights some of the data, tools, products, and services that NOAA's research activities provide, giving us critical insights into the complex and diverse integrated earth systems that impact our country and our planet.



The HRRR offers significant improvements to both spatial and temporal resolution which is critical for predicting rapidly evolving severe weather. This 13-hr HRRRv3 forecast of simulated radar composite reflectivity, accurately predicting tornadic supercells in western Oklahoma on May 17, 2017.

Model Enhancements Improve Timeliness and Resolution of Weather Forecasts

On August 23, 2016, NOAA's High-Resolution Rapid Refresh (HRRR) and Rapid Refresh (RAP) models received significant updates. HRRR is an hourly-updated model developed by the NOAA Earth System Research Laboratory. It covers the lower 48 United States at three-kilometer resolution, incorporates radar data, and provides information to the National Water Model. RAP is an hourly-updated model covering all of North America at 13-kilometer resolution and provides information at a more regional scale. These upgrades extended hourly forecasts an additional three hours (from 15 to 18 hours for HRRR, from 18 to 21 hours for RAP) providing the public more time to prepare for high-impact weather events, such as thunderstorms. HRRR is the first model to produce fifteen-minute snapshots that are updated every hour with resolution sharp enough to predict individual thunderstorms. Using grid points about two miles apart, HRRR can help forecasters pinpoint neighborhood-sized threats, such as storms with the potential to produce tornadoes and heavy precipitation that can lead to flash flooding and abundant snowfall. The next upgrade in early 2018 will extend the RAP to 39 hours, the HRRR to 36 hours, and add coverage for Alaska.

Better Prediction of Harmful Algal Blooms

NOAA continues to improve the nation's ability to forecast, detect, and mitigate the impacts of harmful algal blooms (HABs). HABs occur when colonies of algae—simple plant-like organisms that live in the sea and freshwater—grow out of control while producing toxic or harmful effects on people, fish, shellfish, marine mammals, and birds. They can affect regional tourism, beach recreation, and recreational and commercial fishing. The NOAA National Centers for Coastal Ocean Science (NCCOS) and partners predict when and where HABs will occur and deliver forecasts for Lake Erie, the Gulf of Maine, and the Gulf of Mexico. In 2016, the early season projections for Lake Erie were improved by adding a Maumee River flow forecast model from the NOAA National Weather Service. NCCOS also established an initial operating capability at the NOAA Center for Operational Oceanographic Products and Services for the production of the twice-weekly Lake Erie HAB bulletin which became operational in July 2017. These forecasts support coastal resource managers, public water suppliers, and public health officials with the information they need to coordinate response efforts, including protecting drinking water and issuing health advisories.

"The FAA has long supported [NOAA's numerical modeling research and the most recent operational transition of the HRRR to NWS operations improves aviation forecasts at air terminals and aloft, reducing air traffic delays, which cost the airline [industry] billions of dollars annually."

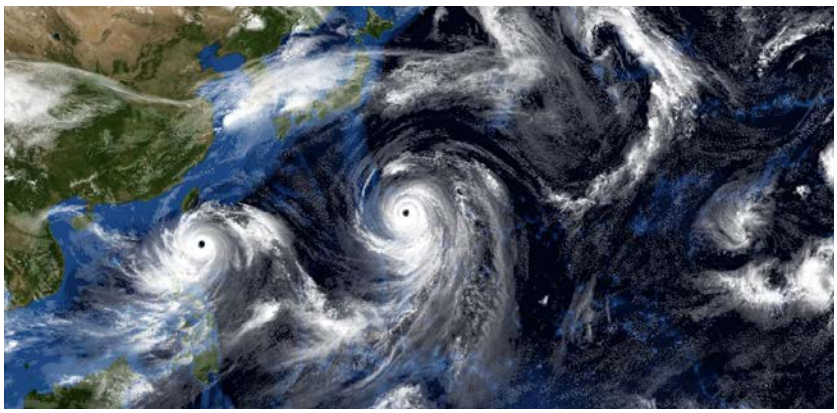
- Steve Abelman,Federal Aviation Administration

A glass of water from Lake Erie on August 3, 2014.

Integrated Earth System Processes & Predictions

Global Climate Model Revealing Changing Ocean Conditions

Historically, global climate models have lacked the resolution required to accurately represent the Gulf Stream's position in the Northwest Atlantic contributing to unrealistic regional ocean circulation data and temperature projections for this region. The NOAA Geophysical Fluid Dynamics Laboratory's (GFDL) high-resolution global climate model is now capable of accurately incorporating shifts in the Gulf Stream for this area, improving warming projections off the U.S. northeast coast. Scientists from GFDL and their colleagues examined the effect of increasing atmospheric CO2 on ocean temperature in the Northwest Atlantic using four models with varying resolutions. Their findings, based on output from four global climate models of varying ocean and atmospheric resolution, indicate that ocean temperature in the U.S. Northeast Shelf is projected to warm twice as fast as previously projected, and almost three times faster than the global average. Furthermore, the highest-resolution model shows a northerly shift of the Gulf Stream and a retreat of the fresh polar current, contributing to the increase in temperature over the region. The highest resolution GFDL model, CM2.6, matched the Northwest Atlantic circulation and water mass distribution most accurately. These findings illustrate that prior climate change projections for the region may be far too conservative.



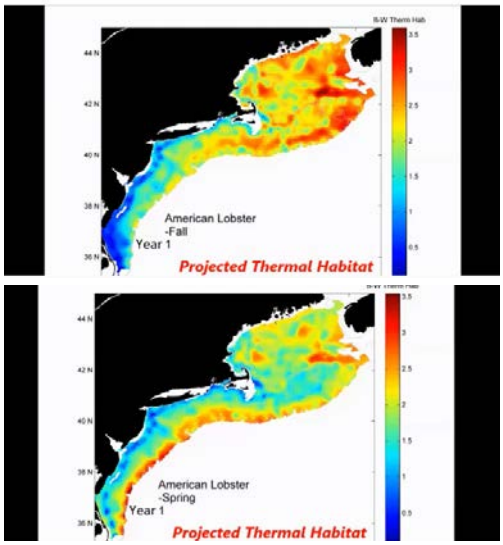
This is an experimental global 3 km forecast using initial conditions donated by the European center to depict typhoons Goni (left) and Atsani (right). Goni reached Category 4 a few days earlier, Atsani had just weakened from a category 5 storm. The time was picked to compare the model output to a famous Himawari satellite image (August 21, 2015).

A Revolutionary Global Weather Model

NOAA's newest weather prediction tool, the Next Generation Global Prediction System (NGGPS), will dramatically improve U.S. operational weather and hurricane forecasting. Powered by the more efficient and more comprehensive Finite-Volume on a Cubed Sphere (FV3) dynamic core, NGGPS provides a new level of accuracy to weather forecasts. Using FV3, weather forecast models are capable of weather prediction on scales ranging from low-resolution global climate predictions to high-resolution severe weather modeling. This summer, FV3 powered experimental hurricane forecast models at NOAA Research and the NOAA National Weather Service in parallel with operational forecast models. The experimental runs of the global FV3-powered system accurately predicted Hurricane Harvey's second landfall, and performed as well as the industry standard European forecast model. The FV3-based runs also demonstrated improved track guidance compared to the U.S. operational Global Forecasting System, particularly in terms of the three to five day lead times.

Marine Species Distribution Shifts Will Continue Under Ocean Warming

Using a high-resolution global climate model (CM2.6) and historical observations of species distributions on the Northeast U.S. Shelf, NOAA scientists have found that commercially important species will continue to shift their distribution as ocean waters warm two to three times faster than the global average through the end of this century. These findings, reported in *Progress in Oceanography,* suggest ocean temperature will continue to play a major role in where commercially important species, such as Atlantic cod, haddock, and American lobster, find suitable habitat. Sea surface temperatures in the Gulf of Maine have warmed faster than 99 percent of the global ocean over the past decade. Current projections predict temperature increases of seven to nine degrees Fahrenheit (four to five degrees Celsius) above current conditions. Many species have already shifted further north, resulting in major changes to both the composition of species occurring in different regions on the shelf as well as shifts from one management jurisdiction to another. These changes will directly affect American fishing communities, as species now landed at those ports move out of range, and new species move in. Distribution shifts in commercially valuable species may result in fishing communities changing gear types and fishing trip durations with altered fuel costs.



Projected thermal habitat distributions for American lobster in the fall (top image) and spring (bottom image) based on the based on the NOAA Geophysical Fluid Dynamics Laboratory's high-resolution global climate model (CM2.6).

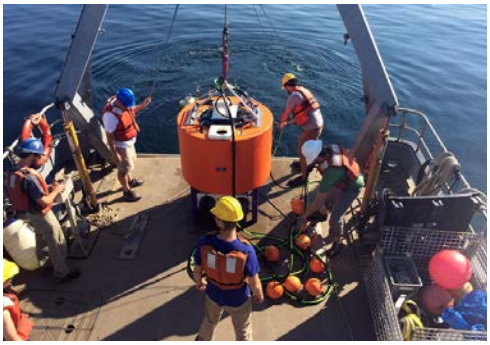
NOAA Fisheries Demonstrates First Use of Environmental DNA for Studying North Pacific Porpoise

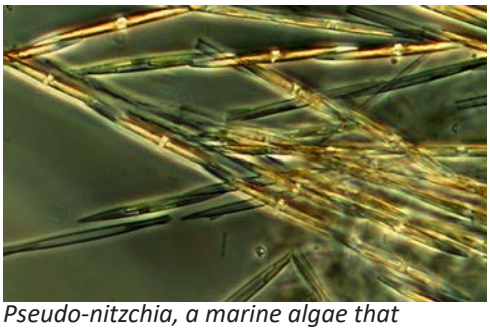
In collaboration with the NOAA Alaska Fisheries Science Center, the NOAA Northwest Fisheries Science Center developed a method using environmental DNA to generate population level sequence data for harbor porpoise. Environmental DNA allows scientists to collect DNA without sampling the animal itself by using traces of DNA the animal leaves behind in the environment. In this case, DNA was isolated from samples of seawater collected in the fluke prints of harbor porpoise during the NOAA Alaska Science Center's 2016 survey of inland waters in Southeast Alaska. This DNA was successfully amplified and sequenced using highly sensitive next generation sequencing techniques. This approach will allow us to generate genetic data for a species that previously proved near impossible to collect genetic samples from live animals, allowing for better determination of natural population units, which is vital for conservation and management. Characterizing the population structure of marine mammals is a critical step in identifying and mitigating the potential impacts of fisheries bycatch. This novel technique provides a valuable and cost-effective new method for examining the stock structure of this species and potentially other difficult to sample marine species.

Integrated Earth System Processes & Predictions

NOAA Fisheries Leads Pacific Northwest Ecological Forecasting

Harmful algal blooms can severely impact commercial and recreational shellfisheries resulting in over $100 million loss to fishery harvests in a single season. The NOAA Northwest Fisheries Science Center (NWFSC) led several efforts in 2017 to better predict harmful algal blooms in the Pacific Northwest Region. In May 2017, the NOAA NWFSC produced a regional forecasting bulletin for the toxic algae found along the Washington and Oregon coasts. The Pacific Northwest Harmful Algal Blooms Bulletin combined oceanographic information with measurements of algae abundance to predict persistent levels of toxic algal blooms in early summer and to provide a recommendation for shellfish harvest. In addition to the bulletin, the NOAA NWFSC deployed a robotic water sampler and analyzer from May to July to detect harmful algae and biotoxins to provide State, Tribal, and commercial resource managers near real-time information for decisions about shellfish operations. These accomplishments are the synthesis of two decades of research and monitoring underscoring NOAA Fisheries' commitment to a safe and productive seafood economy.





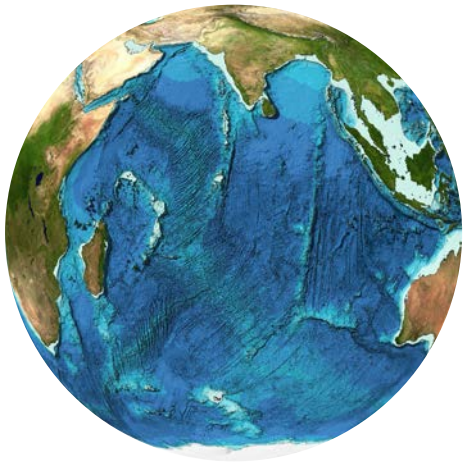
Pseudo-nitzchia, a marine algae that produces a toxin called domoic acid.

Climate Predictions for Fisheries

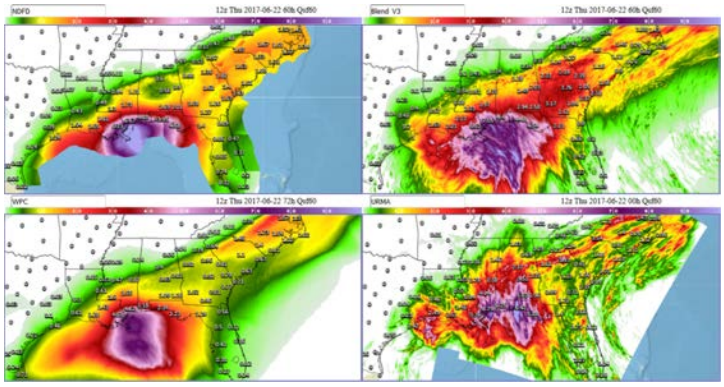
Fluctuations in sea surface temperatures (SST) influence living marine resources affecting both human health and coastal economies. NOAA's North American Multimodel Ensemble (NMME), a newly available experimental seasonal forecasting system, is helping change the way marine resource managers make decisions by providing better climate forecasts from seasons to decades. NMME improves upon current global climate forecast systems by offering superior prediction of SST anomalies. Through improved understanding of SST changes, fisheries managers are better equipped to refine catch limits for climate-sensitive species and anticipate shifts in species distributions. In the California Current System, a highly productive large marine ecosystem, SST forecasts have already shown considerable promise for producing forecasts at finer scales and for improving short-term marine resources management.

Mapping the Final Frontier: Seabed 2030

The disappearance of Malaysian Airlines flight MH370 revealed just how little we know about the ocean floor. While the ocean covers approximately 70 percent of the Earth's surface, less than ten percent of the seafloor has been mapped at high resolution. Seabed 2030 is a collaboration between the Nippon Foundation and the General Bathymetric Chart of the Oceans, an organization of scientific experts that operates under the auspices of the International Hydrographic Organization (IHO) and the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific, and Cultural Organization, to facilitate the complete mapping of the ocean floor by the year 2030. NOAA is helping make strides towards this goal by supporting bathymetric data collection, and hosting the IHO Data Centre for Digital Bathymetry, an open-access worldwide archive of bathymetric data.



NOAA/NASA



Rainfall forecast for Tropical Storm Cindy. Upper Left shows the National Digital Forecast Database (NDFD)/Official WFO forecast. Upper Right shows the National Blend of Models V3.0. Lower Left shows Weather Prediction Center (WPC) forecast. Lower Right shows observed 60 hour rainfall.

Delivering Consistent Weather Forecasts

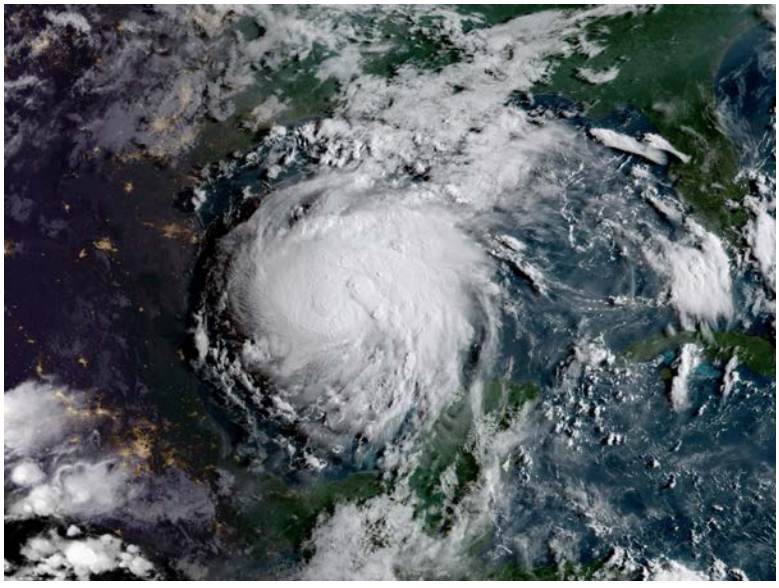
NOAA's National Blend of Models combines information from the NOAA National Weather Service (NWS) and non-NWS models and uses the best available science to provide a consistent weather forecast product across the United States. This blend of model data creates a highly accurate and consistent starting point for weather forecasts, and is an important part of NOAA's efforts to achieve a Weather-Ready Nation. In 2017, Weather Forecast Offices in the Midwest made significant strides toward the development the National Blend of Models Version 3.0 when they completed the initial phase of a six month demonstration project. This demonstration confirmed that a common starting point for weather forecasts saves time and improves consistency without sacrificing accuracy. Version 3.0, which became operational on July 27, 2017, provides significant upgrades to the National Blend of Models and helps unlock resources to perform Impact-Based Decision Support Services. This allows core partners, such as emergency managers, to make decisions when severe weather events impact the lives and livelihoods of American citizens. The next upgrade, Version 3.1, will focus on the Fire Weather, Aviation, and Marine program areas and is scheduled to become operational in July 2018.

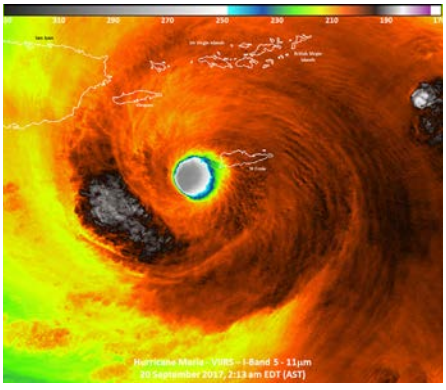
Integrated Earth System Processes & Predictions

Preparing the Nation for Hurricanes

NOAA plays a significant role in helping our nation prepare for and respond to hurricanes. Through a series of model developments and new forecast tools, NOAA continues to build a Weather-Ready Nation by improving hurricane forecasts and warnings. This summer, the NOAA National Weather Service launched a new hurricane forecast model, Hurricanes in a Multi-scale Ocean-coupled Non-hydrostatic model (HMON). HMON replaces the retiring Geophysical Fluid Dynamics Laboratory model, and works with existing operational hurricane models to better predict hurricane track and intensity. Development of HMON is an important step toward implementing the NOAA National Weather Service's long-term strategy for coupling models. The NOAA National Hurricane Center also introduced three new products during the 2017 hurricane season: new storm surge watches and warnings, new "Time of Arrival" graphics, and advisories, watches, and warnings with longer lead times. These new products provide coastal communities critical information about the timing of storm surges and storm-force winds, highlighting coastal areas where there are life-threatening risks.

Through the Hurricane Forecast Improvement Project, NOAA continues to improve the accuracy of hurricane forecasts. This summer the experimental basin scale Hurricane Weather Research and Forecasting (HWRF) model was run in parallel with operational hurricane models, and showed a ten percent improvement in track prediction for both Hurricanes Harvey and Irma on par with the European Model for days four to five.





Top left: Geocolor image of Tropical Storm Harvey in the Gulf of Mexico captured by GOES-16 the morning of August 24, 2017. Top right: GOES-16 image of Hurricane Irma approaching Anguilla on September 6, 2017. Bottom right: NOAA/NASA Suomi NPP satellite Visible Infrared Imaging Radiometer Suite image of Hurricane Maria on September 20, 2017.

NOAA Fisheries Advances Fish Assessment Model

Stock Synthesis (SS) is a statistical and demographic model developed and maintained by NOAA Fisheries scientists and used by NOAA, state, and international agencies for operational fish stock assessments. SS has over 230 registered users globally. It has supported assessments of 90 U.S. fish and shellfish stocks, and is increasingly being used in Australia, South America, Europe, and for international tuna and billfish. NOAA Fisheries scientists just released a new version of SS that has advanced capability for analysis of diverse species and assessment situations. This includes recently published statistical advances that improve how data on proportions of fish at each age are treated, and the degree to which year-to-year fluctuations in fish productivity (recruitment) are not random and can be informed by environmental data. Fish stock assessments are a key and well-recognized foundation of successful fishery management. They provide knowledge of the current status of stocks and pro-active projections of sustainable catch levels. SS supports assessments for extremely important fish stocks from Pacific cod in Alaska, to Pacific whiting on the U.S. west coast and Canada, to red snapper in the Gulf of Mexico. The new version of SS adds increased flexibility in configuration and a graphical interface such that diverse scenarios can be explored in public assessment meetings, leading to greater societal acceptance of assessment results as the scientific basis for fishery management. Going forward, this new version will facilitate improved and more comprehensive fish stock assessments and serve as a foundation for science-based fishery management around the world.

Design and Implementation of a Vaccination Program for Wild Hawaiian Monk Seals

NOAA's Hawaiian Monk Seal Research Program has made major strides toward protecting this endangered population against the threat of the potentially deadly morbillivirus thanks to the implementation of a broad scale vaccination program. This project has used cutting edge research to develop novel analytical tools and veterinary protocols, leading to several publications as well as positive media coverage. After initial successes in the Main Hawaiian Islands, the program expanded into the Northwest Hawaiian Islands field camps. Through these efforts, approximately half of the Main Hawaiian Islands seals have been vaccinated, and already about one third of seals in the Northwest Hawaiian Islands, making a substantial step toward herd immunity (full population protection).

Integrated Earth System Processes & Predictions

Improved Sub-seasonal and Seasonal Forecasts

NOAA is working to advance predictions of subseasonal to seasonal (S2S) phenomena, addressing the gap between traditional weather forecasts and seasonal outlooks. Currently, weather forecasts focus on individual storm events and extend from hours to two weeks, while seasonal outlooks, such as El Niño Southern Oscillation (ENSO) and precipitation anomalies, provide forecasts for three months and beyond. The NOAA Research Climate Program Office, the NOAA National Weather Service, and other U.S. agencies have found that an ensemble of forecasts from North American Multi-Model Ensemble System (NMME) can, on average, produce more skillful and reliable seasonal prediction for temperature, precipitation, and ENSO than other prediction tools. For the subseasonal range, NOAA, in partnership with other agencies, developed a joint initiative, known as SubX (Subseasonal Prediction Experiment), to test whether research models add forecast skill above that available from only operational models on the three to four week timescale. Skillful forecasts on these timescales are valuable to many sectors including agriculture, health, and water resources. The skill of the research models will be evaluated through SubX in real-time over the next year in addition to evaluating their performance for a retrospective forecast period from 1999 to 2015. NOAA Research's Modeling, Analysis, Predictions, and Projections program has initiated a broad research initiative organized as the S2S Prediction Task Force to improve the modeling of subseasonal predictability sources and enhance three to four week prediction skill in future NOAA modeling systems.

Study finds Monkfish to be Serial Spawners

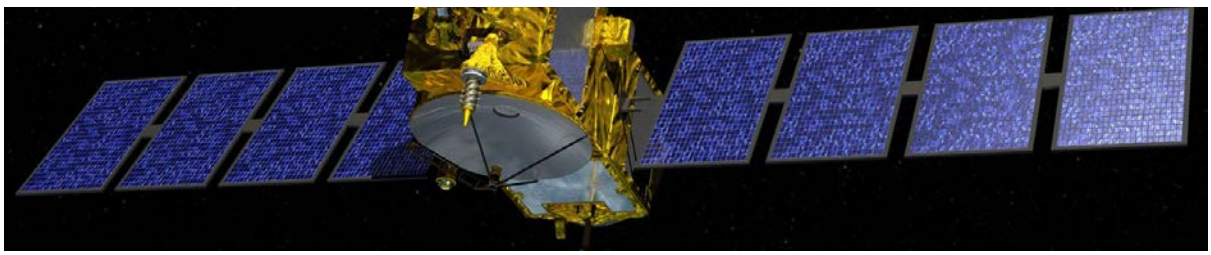
Although often caught by fishermen, monkfish (Lophius americanus) were not considered a viable commercial fishery until the 1980s. Today, monkfish is one of the most valuable finfish fisheries in the Northeast. NOAA researchers have found that individual monkfish, also called goosefish, spawn more than once during a spawning season that can last six months. The study, published online in the Journal of Fish Biology, compared findings from 1982-1985 and 2009-2012, two very different periods for monkfish. As monkfish population size declined overtime, the population was dominated by young small females with reduced spawning capacity compared to the older larger females more common in the past. Evidence that monkfish are serial spawners is encouraging news, as serial spawning is a reproduction strategy that results in more eggs, increasing the number of fish surviving to adulthood. This in turn contributes to a more resilient population and fishery.

Environmental Observations and Data

NOAA uses a wide range of sensors and platforms to conduct sustained and experimental observations of phenomena ranging from solar flares to undersea earthquakes that are essential to NOAA's environmental intelligence mission. As the only federal agency with the operational responsibility to provide weather, water, ocean, climate, and ecosystem forecasts, NOAA is charged with collecting accurate, timely, and comprehensive observations of the Earth and its surrounding space. These activities generate greater than 20 terabytes of data each day (more than twice the data of the entire printed collection of the United States Library of Congress), which, in turn, NOAA utilizes to produce useful environmental intelligence for society. These data, and the intelligence derived from these data, are critical tools that support government decisions and policies, scientific research, and the economic, environmental, and public health of the United States.

Data science efforts within NOAA span the entire data exploitation spectrum including acquisition, quality control, metadata cataloging, validation, reprocessing, storage, retrieval, dissemination, and production of useful intelligence and products for society. To support NOAA's data management efforts, advances in signal processing (e.g., compression, sampling, thinning) are needed in order to keep pace with the scale at which NOAA is generating and collecting environmental data. Furthermore, NOAA is also investigating and leveraging emerging developments in high-performance data access, storage and computing, data mining, natural language processing, and machine learning. Innovative processing techniques and R&D are being investigated to extend sensor capabilities to extract new products from measurements and find ways to increase the signal-to-noise ratio of measurements. To support improved data applications, NOAA continues to make advances in the current capabilities to couple 'traditional' datasets (e.g., physical, chemical, and biological) and fuse those data with 'non-traditional' data (e.g., social, behavioral, and economic) and 'unconventional' sources (e.g., citizen science).

Lastly, in light of exponentially increasing computational demands, NOAA seeks to connect its high-performance computing capabilities with this expanded data analytics capability as well as augment its petascale computing systems and capabilities toward the exascale. Listed within this chapter are a few representative examples of the many ways NOAA has leveraged and improved its observational assets and data to make groundbreaking discoveries and provide improved environmental intelligence for its stakeholders and the American people.

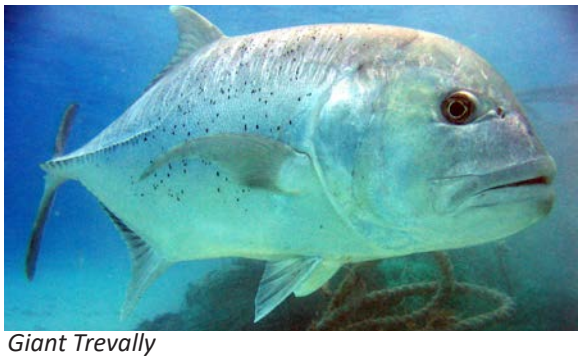


Next Generation Satellite Provides Enhanced Observational Capabilities

The Geostationary Operational Environmental Satellite-R series (GOES-R) is the nation's next generation of geostationary weather satellites. These satellites, beginning with the successful launch of GOES-16, on November 19, 2016, will provide continuous imagery of Earth's Western Hemisphere as well as critical data for weather forecasts. The GOES-R series will significantly improve the detection and observation of environmental phenomena that directly affect public safety, protection of property, and our nation's economic health and prosperity. During post launch testing GOES-16 provided imagery to forecasters and experimental flood maps to FEMA to aid in the forecast, warning, and recovery from the impacts of hurricanes Harvey, Irma, and Maria along the southeast Gulf Coast. GOES-16 will move into the GOES East position replacing GOES-13 in December 2017. GOES East provides coverage of the continental United States and provides optimal viewing of the states and cities most impacted by high impact and severe weather events including Atlantic hurricanes, thunderstorms, tornadoes, fires, lightning, major winter storms, flooding, and volcanic eruptions.

"[GOES-R] puts [the U.S.] on top of the food chain when it comes to weather satellites around the world. Nobody has anything like this."

- Al Roker, Today Show 8/25/16



Giant Trevally

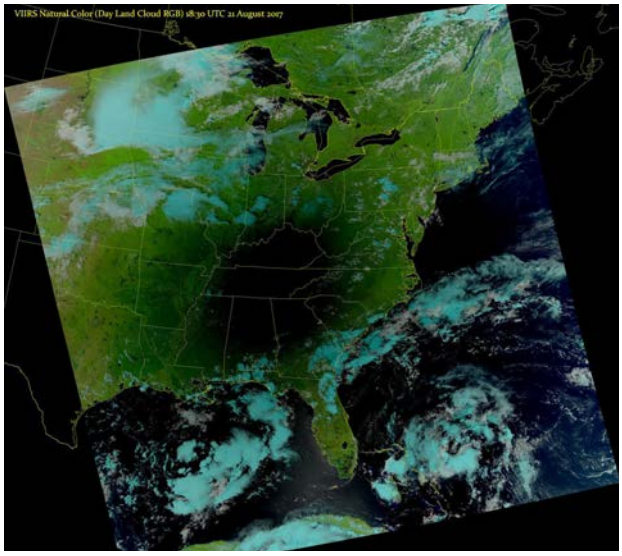
First Stock Assessments of 27 Hawaii Reef and Bottom Fish Species

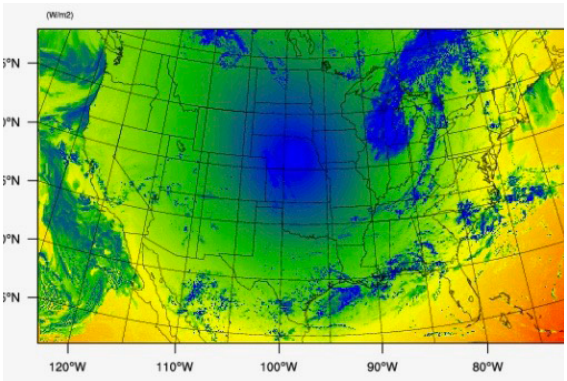
Reef fish are an economically important fishery in the Hawaiian Islands. They serve as an important source of food for local fisherman, hold significance in Hawaiian culture, and draw tourists to coral reefs. The NOAA Pacific Islands Fisheries Science Center recently pioneered an improved stock assessment approach for 27 of the most commonly exploited coral-reef species of Hawaii, including the culturally important kala or unicornfish. Previously data-poor, catch-based models that lumped whole families of species together were used to set reef fish annual catch limits. NOAA's improved approach combines observed length data, life history-based stock assessment models, and commercial and recreational catch data to calculate the current stock condition. Findings from this assessment suggest 11 out of the 27 species assessed are experiencing overfishing including the giant trevally, five species of surgeonfish, two species of goatfish, and three species of parrotfish. By comparing these findings to well-established sustainability guidelines, NOAA scientists were able to propose options for future fisheries management.

Environmental Observations and Data

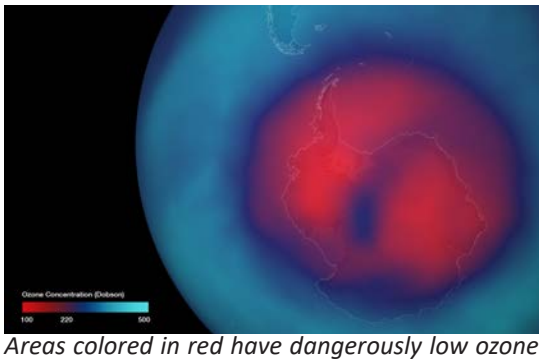
What Happens During a Solar Eclipse?

On Monday, August 21, the U.S. experienced the first total solar eclipse to move across the entire Continental U.S. in 99 years. This astronomical event provided scientists a rare opportunity to study one of the principal drivers of the Earth's weather, the sun. Leading up to the event, NOAA meteorologists and weather modelers provided eclipse-watchers with forecasts for their viewing location. Scientists at the NOAA Earth Systems Research Laboratory also used the experimental High-Resolution Rapid Refresh forecast model to determine how the solar eclipse would affect the Earth's weather, predicting a nine to twelve degree Fahrenheit (five to seven degrees Celsius) temperature drop in areas experiencing total eclipse. During the event, scientists from the NOAA National Severe Storms Laboratory deployed a truck equipped with surface instruments, launched weather balloons, and flew two unmanned aerial systems to record the atmosphere and better understand the eclipse's effects. The NOAA Air Resources Laboratory division in Oak Ridge, Tennessee also partnered with the NOAA National Centers for Environmental Information to collect data from 13 U.S. Climate Reference Network stations across the country two hours before and after the eclipse. Finally, NOAA's newest weather satellite, GOES-16, captured the eclipse with the Advanced Baseline Imager and provided a clear view of the moon's shadow as it traveled diagonally across the Continental United States.





The top left photo is a color enhanced infrared image of the moon's shadow during the solar eclipse from the NOAA/NASA Suomi NPP satellite. The top right photo charts the state capitals in the path of the total solar eclipse. The bottom right photo is a model projection from NOAA's experimental High Resolution Rapid Refresh weather model, and shows the predicted effect of the eclipse on solar radiation reaching the ground.



Areas colored in red have dangerously low ozone concentrations, below 220 Dobson units, and are associated with the "hole" that forms over the region around September and October each year.

International Ozone Treaty Reduces Greenhouse Gas Emissions

Earlier this year, the NOAA Earth System Research Laboratory celebrated the 50th anniversary of ozonesonde launches, a type of balloon-borne sensor, at the Boulder, Colorado and South Pole stations. What started out as a modest research project driven by scientific curiosity provided NOAA with some of the first insights into how ozone, a trace gas that blocks the sun's harmful ultraviolet rays, is distributed in the atmosphere. Ozonesondes have helped provide the long-term records that allow us to understand changes in the Earth System, such as diagnosing the cause of the Antarctic ozone hole. A new study by NOAA scientists shows the Montreal Protocol, the international treaty adopted to restore the Earth's protective ozone layer, not only has reduced the size of the Antarctic ozone hole, but also has a major side benefit of reducing climate-altering greenhouse gas emissions. This is because many of the ozone-depleting substances are also potent greenhouse gases. New research estimates that by 2025 the Montreal Protocol will reduce U.S. greenhouse gas emissions by the equivalent of 500 million tons of carbon per year compared with 2005 levels. This would be equivalent to about ten percent of the current U.S. emissions of carbon dioxide.

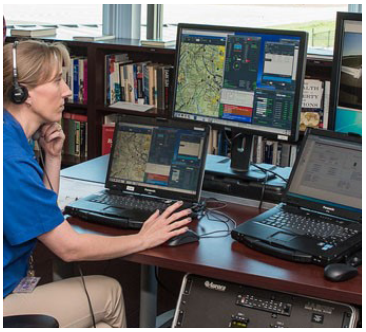
Nutrient Sensor Challenge

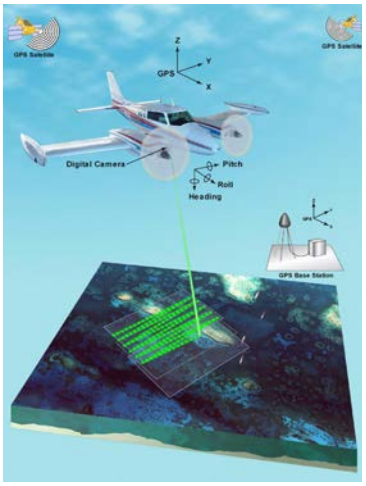
Alliance for Coastal Technologies

NOAA Supports Development of New Nutrient Sensor

The Nutrient Sensor Challenge is a market-based competition designed to spur innovation for better water nutrient management. Earlier this year, Systea, S.p.A was announced as the winner for their instrument that measures both dissolved nitrate and phosphorous nutrients in an integrated, cost-effective package. The U.S. Integrated Ocean Observing System partnered with the Alliance for Coastal Technologies to conduct the competition, which challenged companies to develop sensors to measure dissolved nitrate and/or phosphorous content with a purchase price at or below $5,000. Nutrient pollution costs the $2.2 billion annually and threatens human and economic health. Less expensive, new generation sensors would help expand research and operational monitoring opportunities, thereby improving our nation's ability to manage risks to public safety and forecast coming events. By demonstrating successful strategies for incorporating nutrient sensors into existing water monitoring efforts, the Challenge can help states and communities overcome major barriers to preventing and reducing nutrient pollution.

Environmental Observations and Data



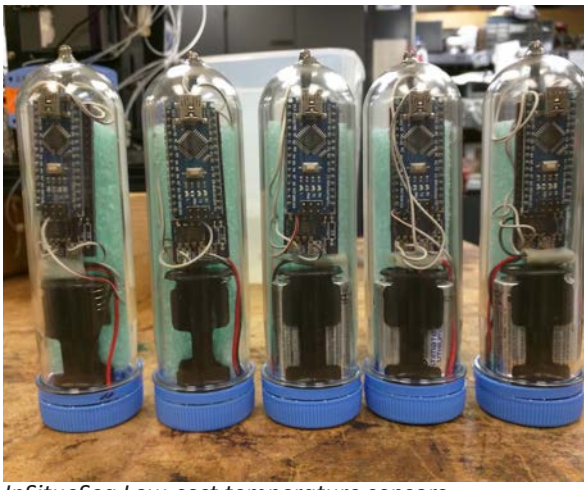


Gravity Data from Unmanned Aircraft to Improve Floodplain Management

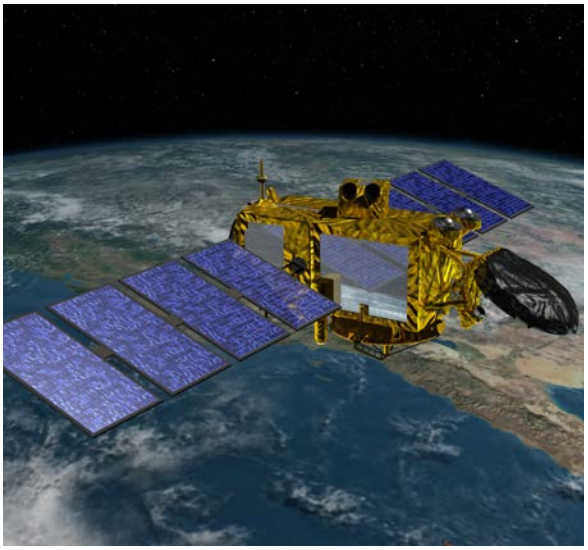
NOAA's Gravity for the Redefinition of the American Vertical Datum (GRAV-D) project is a nationwide effort to collect gravity data from airborne instruments. These measurements are used to create precise estimates of elevation (up to two cm in many places) which are used to provide more accurate models of water flow on land. Through a Small Business Innovation Research grant, NOAA conducted one of the first operational tests of a gravity-measurement device on an optionally piloted aircraft in March 2017. An unmanned plane can more easily obtain GRAV-D data in remote locations and has the potential to greatly reduce the costs and safety hazards associated with data collection in remote regions such as Alaska. Improved accuracy of gravity measurements will provide an estimated $240 million in annual savings from improved floodplain management, and an additional $282 million in savings from activities that benefit from more precise elevations, including coastal resource management, construction, agriculture, and emergency planning.

Advancement of Shoreline Mapping Techniques

The NOAA National Geodetic Survey (NGS) supports NOAA's Integrated Ocean and Coastal Mapping approach to 'map once, use many times' by planning and coordinating with multiple parties interested in using our topographic-bathymetric ('topo-bathy') LIDAR data. Topo-bathy LIDAR is a method for determining water depth and allows ships to operate safely in areas with rugged shorelines, such as Alaska, the North Atlantic Coast, and the Caribbean. For example, NGS updated NOAA Nautical Charts for Key West and the Florida Keys Outer Reef directly supporting navigational safety and U.S. Coast Guard operations. Many of these areas are in dire need of a new survey; some areas in particular have not had surveys conducted since the 1900s to 1930s. NGS has completed processing and delivering 258 square nautical miles of topo-bathy lidar data for Key West and the Keys outer reef area for application to NOAA nautical chart products. NGS's lidar sensor was capable of reaching depths up to 18 meters (60 feet) along the outer reef, and for the first time we were able to resolve some imprecisely-positioned charted dangers. NGS has the unique capability of being able to help survey nearshore areas where it is either inefficient or dangerous for NOAA hydrographic vessels to survey.



InSitueSea Low-cost temperature sensors



Development of a Low Cost Sea Temperature Sensor

In 2016, NOAA developed a low cost sea temperature sensor to be used at coral reefs around the world and provide high accuracy measurements (0.05-0.1 degrees Celsius). For approximately $10 in parts, these sensors can run more than 240 days using two AA batteries when they are deployed operationally. In comparison, similar off-the-shelf sensors run over $100 each. The lower cost will allow substantially more sensors to be deployed at coral reefs worldwide and increase our knowledge of sea temperature in critical locations. These sensors will provide micro-habitat sea temperature fluctuations at coral reef areas, offer environmental information on coral bleaching, and a comparison and verification of satellite sea surface temperature data. This is crucial to better understand and monitor the daily fluctuations at coral reefs. In early November 2016, the sensors were tested by measuring temperature every ten minutes at depths up to 33.5 meters (110 feet) for about two months, then retrieved to evaluate performance.

Increased Satellite Capability to Monitor Global Sea Levels

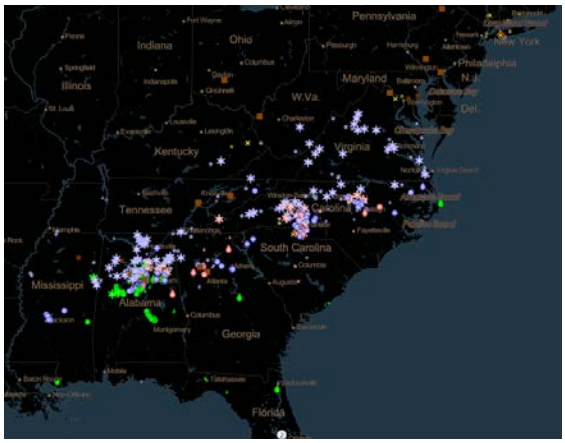
Jason-3, an international satellite mission led by NOAA, NASA, the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT), and the French space agency, Centre National D'Etudes Spatiales (CNES), is the fourth in a series of US-European satellite altimeter missions designed to measure the sea surface height variability of the global ocean. The satellite was successfully launched on January 17, 2016, from Vandenberg Air Force Base, California and, just six months later, Jason-3 was declared operational and the near real-time products created with its data were made publicly available. Initially, the satellite flew in tandem with its predecessor, Jason-2, 830 miles above Earth's surface, collecting comparable measurements of sea surface height down to the sub-centimeter level. Then, in mid-October 2016, Jason-2 was moved so that its ground track now "interleaves" with that of Jason-3. The result is a doubling of the Jason satellites' observations of the ocean. Now, with twice the coverage, the Jason mission is providing more accurate coverage of ocean conditions which improved the intensity forecasts during this year's Atlantic hurricane season.

Environmental Observations and Data

NOAA Supports Citizen Science

Citizen Science is a rapidly growing field that offers opportunities for government to partner with the public to address real-world challenges. In April 2017, a four-part television series "The Crowd & The Cloud" broadcast on PBS highlighted several NOAA citizen science projects. The first episode begins with the story of the Community Collaborative Rain, Hail, and Snow Network and its connections to the NOAA National Weather Service. Other NOAA citizen science projects, such as SkyWarn, Meteorological Phenomena Identification Near the Ground, Cyclone Center, Old Weather, Delaware Horseshoe Crab Survey, and Long-term Monitoring Program and Experiential Training for Students, were also featured in the series and on the program's website. Funded by the National Science Foundation (NSF), this program is expected to reach approximately 80 percent of U.S. television households.

Pelika Andrade/University of Hawaii Sea Grant



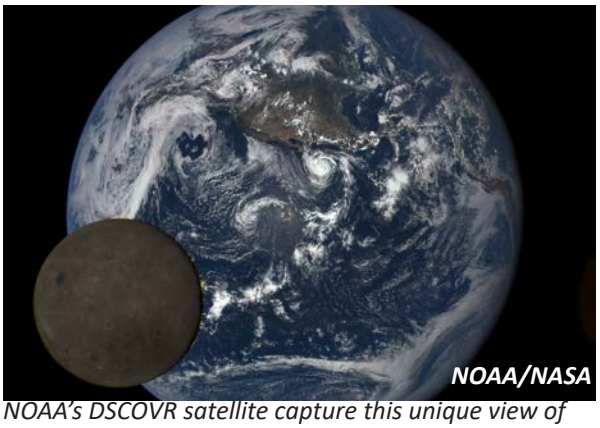
Engaging Citizen Science to Improve Weather Forecasts Worldwide

An exemplary application of citizen science, the Meteorological Phenomena Identification Near the Ground (mPING) project is a crowd-sourcing, mobile phone app that allows anyone to submit precipitation observations to the NOAA National Severe Storms Laboratory (NSSL). These observations are used to validate and improve radar-based precipitation type (e.g., rain, sleet, snow, freezing rain, etc.) methodologies developed by NSSL in support of NOAA National Weather Service (NWS) forecasters. A database has been developed for efficient and secure ingest and distribution of mPING observations via an open application program interface (API), which allows other app developers to access and distribute the data. Since January 2017, over 254,000 reports have been submitted to the database. During this same time, the database has been queried 41 million times, of which two percent were from NWS entities (38,600,000 are from a commonly-used commercial app called RadarScope that uses the open API, while the rest are from other entities). Finally, mPING improved the skill of winter precipitation type forecasts (out to eighteen hours) by a factor of four to six over older techniques, for ice pellets and freezing rain.

Future Satellite for Global Weather Forecasts

Joint Polar Satellite System-1 (JPSS-1), or NOAA-20 as it will be known once operational, is the second spacecraft within NOAA's new generation of polar-orbiting satellites that will launch in late 2017. The JPSS-1 platform will allow satellite data to be quickly incorporated into a number of models improving weather forecasts. These key observations increase the accuracy of three to seven day weather forecasts enabling emergency managers to make timely decisions that protect American lives and property, including ordering effective evacuations.

This hurricane season, the NOAA JPSS Program provided FEMA and other natural disaster response agencies with NOAA/NASA Suomi NPP satellite data during Hurricanes Harvey, Irma, and Maria. This satellite imagery was used to develop large scale flood maps and identify power outages, helping FEMA and first responders focus their efforts. The NOAA JPSS Program also helped support emergency response efforts for the Western U.S. wildfires throughout the 2017 fire season. Suomi NPP Day-Night imagery and smoke forecasts from the experimental High Resolution Rapid Refresh Smoke Model have accurately forecast the movement of smoke, allowing actions to be taken to mitigate the impact of this smoke on firefighters and nearby towns



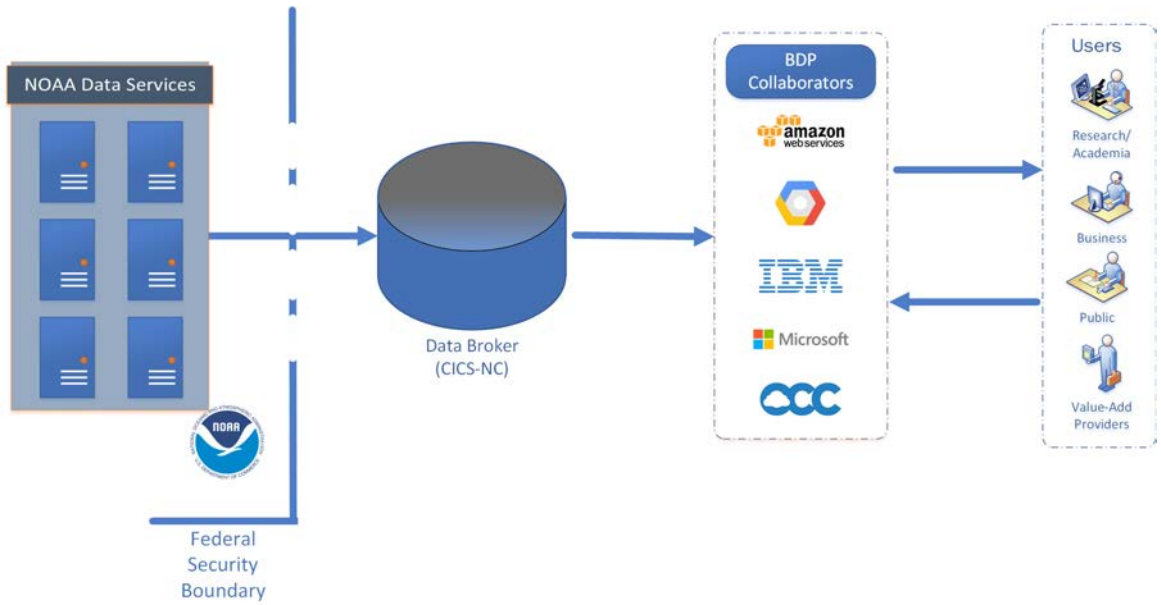
NOAA's DSCOVR satellite capture this unique view of the moon. The series of test images illuminated the "dark side" of the moon.

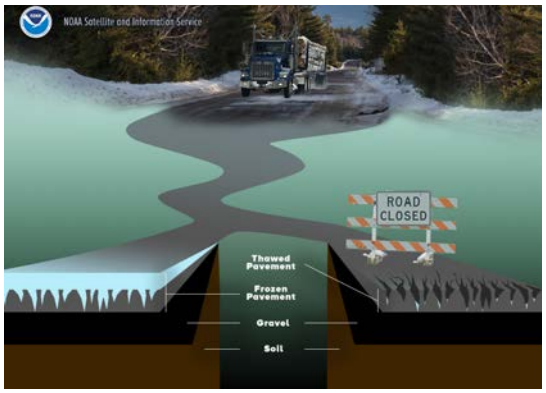
Key for Revolutionizing Space Weather Forecasts

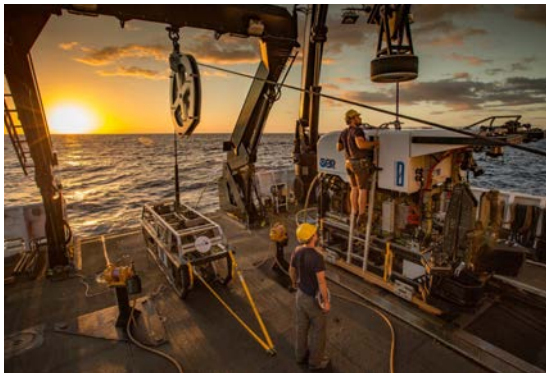
Deep Space Climate Observatory (DSCOVR) satellite became the Nation's first operational satellite to occupy Lagrange point 1, or L1 orbit--a gravity neutral point in space that allows DSCOVR to essentially hover between the sun and Earth at all times. From this position, DSCOVR acts as something of a solar storm buoy that provides Real-Time Solar Wind data to the NOAA Space Weather Prediction Center. Space weather, and the resulting geomagnetic storms, has demonstrated the potential to disrupt virtually every major public infrastructure system, including transportation systems, power grids, telecommunications and GPS. With timely and accurate alerts produced from DSCOVR data, infrastructure managers can take action to avert the greatest damage. In addition to monitoring solarwinds, DSCOVR's Earth Polychromatic Imaging Camera, a four megapixel CCD camera and telescope built by NASA, provides an image of the sunlit side of the Earth every two hours. This means it can capture the shadow of the moon crossing the planet during a solar eclipse, as it did in May of 2016 and more recently on August 21, 2017 during the much anticipated total solar eclipse.

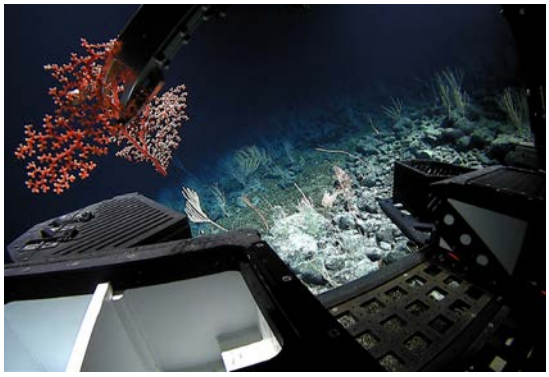
Accessibility of All NOAA Data through Partners

NOAA's Big Data Project (BDP) is investigating how the value of NOAA's data may be leveraged in Public-Private Partnerships to broaden its use and dissemination through modern cloud platforms and associated technologies. Working with Amazon Web Services (AWS), Google Cloud Platform, IBM, Microsoft Azure, and the Open Commons Consortium (OCC), NOAA experts identify and deliver NOAA datasets of interest around which partners can build business cases to justify their investments.. For example, one of the first data sets to be delivered was NOAA's Next Generation Weather Radar (NEXRAD) data. Access of the NEXRAD data by volume on AWS has increased by 130 percent over past usage patterns, while the load on NOAA access systems has decreased by 50 percent. Instead of simply placing NOAA's data files on their cloud servers, Google invested their labor to integrate NOAA's historical climate and weather data into their BigQuery tools, and observed over 800,000 accesses, with 1.2PB of data use, during the first four months of 2017. NOAA's new GOES-16 geostationary satellite data began transfer to the BDP partners in the summer of 2017, and OCC has already placed a suite of software tools alongside those data and enabled non-experts to use NOAA data for new analyses and information products. The National Water Model's 23-year historical output has begun distribution to the BDP partners platforms and will be combined with the latest forecasts on these platforms. Fisheries, genomics, climate model, ocean observing and other NOAA data are also accessible or under consideration for BDP access. The NOAA Cooperative Institute for Climate and Satellites has piloted the role of a "data broker", to ensure secure, high-quality data deliveries from NOAA to the BDP partners with minimal impacts on NOAA federal resources. NOAA and its partners are realizing the potential of this collective effort among federal government, private industry, and academia, including stimulating new business opportunities and novel applications, all at no net cost to the U.S. taxpayer.









Helping Departments of Transportation in Northeast Conserve Low Volume Roads

In many northern states, state departments of transportation (DOTs) adjust allowable weight limits of trucks transporting goods on rural, "low volume" roads depending on air temperature. DOT's use "seasonal load restrictions" in order to reduce potential damage to the structural integrity of these roads due to "freeze-thaw" conditions. The NOAA Northeast Regional Climate Center, working with the Infrastructure Climate Network at the University of New Hampshire, created a Roadway Freezing-Thawing interface that allows road managers in the northeast to better assess when load restriction should be applied or suspended. Using the latest temperature data from the NOAA National Centers of Environmental Information and borrowing an approach developed by the Minnesota DOT, real-time, color contour maps of air-freezing and thawing indices for Maine, New Hampshire, and the Northeast are generated. These maps help state DOTs balance the needs of the industry with conservation of the roads, as well as the environmental impacts associated with seasonal load restrictions.

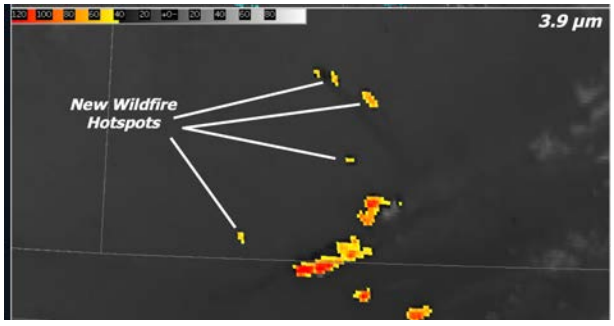
Exploring the Unknown

NOAA is the only federal agency whose mission includes exploring the unknown reaches of the ocean, providing high-value environmental information for both current and emerging management needs. Ocean exploration operations aboard NOAA Ship Okeanos Explorer were the subject of The Economist Films, *The Deep*. The 15-minute film released on March 23, 2017, features NOAA's Okeanos Explorer and remotely operated vehicle (ROV) Deep Discoverer, and examines the value of ocean exploration, the many moving parts of an archaeological dive, and the challenges of science at sea. Much of the footage is from Okeanos Explorer operations in the central and western Pacific, as part of NOAA's Campaign to Address Pacific monument Science, Technology, and Ocean NEeds. As of October 2017 the film has more than 307,000 views on YouTube. The expeditions conducted aboard the Okeanos Explorer by NOAA and affiliated academic and non-federal partners provided the scientific data and information needed to evaluate the ecological and scientific importance of areas proposed to be expanded or established as marine national monuments.

Environmental Observations and Data

Moving toward Real-time Water-level and Ocean Current Observations

In March 2017, the NOAA Center for Operational Oceanographic Products and Services transitioned their acoustic Doppler current profiler (ADCP) system from research to operations. The ADCP, which collects ocean current information used to provide real-time water velocity information and update Tidal Current Tables for mariners, can now automatically transmit data using real-time telemetry via an Iridium satellite. This system can be placed in remote locations along navigation channels, providing accurate information to help ship operators protect their cargo and the environment as they navigate these narrow channels with increasingly larger vessels. The new approach eliminates the less reliable radio communications link and the entire data-receiving shore station employed by the old system. The new systems also realizes a cost savings of about $20 thousand at installation and about $6 thousand a year on operations and maintenance savings. The first operational Iridium Aids-to-Navigation ADCP (iATON) located in Chesapeake Bay passed 180 days of continuous operation with more than 95 percent real-time data provision. Another iATON is now operational in Chesapeake Bay and three more iATONs are planned for the Miami Physical Oceanographic Real-time System, and one in Delaware Bay.



GOES-16 Data Tested in Weather Forecasts

Data from the new GOES-16 satellite will revolutionize our basic understanding of circulation systems and ability to forecast high impact events, such as the severe thunderstorms, tropical cyclones, fire events, and solar eruptions. With the new GOES-16 data, weather forecasters are able to see for the first time the formation and detailed structure of weather systems, such as wind and cloud patterns. For example, on March 6, 2017 a series of deadly wildfires spread across portions of Kansas and Oklahoma into the Texas Panhandle. The real-time imagery from the GOES-16 satellite enhanced the NOAA National Weather Service's ability to identify and communicate critical information to emergency responders and other local government decision makers on the ground. This event showed the unique value GOES-16 adds to future decision support services. NOAA forecasters have received training to use GOES-16 data and are prepared to use the data as soon as it is available for use in daily operations.

New Method for Estimating North American Right Whale Numbers

North Atlantic right whale recovery is one of NOAA Fisheries' most difficult conservation challenges. Right whales live in waters that support continuous commercial activities often resulting in serious injuries such as entanglements in fishing gear and ship strikes. Prior population estimates for this species used counts of different individuals seen in a year, combined with some assumptions about deaths among those animals not seen. In recent years this method has been confounded because these whales are not being sighted at the times and places where they have historically been found, and therefore are less likely to be seen. The improved population estimation method uses a new mathematical development to estimate North Atlantic right whale abundance. This new method is an improvement over the previous approach that estimated North Atlantic right whale abundance from a multi-decadal time series of photographs to identify individual whales from their natural marks. Results obtained using the new population estimation method are less affected by changes in whale distribution, less reliant on sighting frequency, and better account for animals that are still alive, but not frequently seen. It also allows for trends in population numbers to be seen sooner than was possible using sighting data only.

NOAA Fisheries Develops a Method for Identifying Deep-sea Coral Species from Environmental DNA Samples

Working with water samples collected in collaboration with the Ocean Exploration Trust during their 2016 West Coast Expedition, researchers at the NOAA Northwest Fisheries Science Center have developed a method to identify deep-sea coral species using environmental DNA (eDNA) samples. Coral cells isolated from the water provided enough DNA to identify individual corals in the area. Using eDNA samples can provide more definitive identification to the species level than image data alone, and can also identify species that may not be clearly observed in video or images, but are nonetheless present. Collection of water samples is much faster than collecting tissue samples, is lower impact allowing for identification of multiple species in the community, and can be performed by a wider array of vehicles. Deep-sea corals provide habitat to numerous commercially important species, such as grouper, rockfish, shrimp, and crab. This technique will increase NOAA's opportunities to sample deep sea organisms and obtain the information needed to conserve and manage these important, but hard to access ecosystems. A paper describing this work was recently published in an upcoming special issue of Deep-sea Research II.

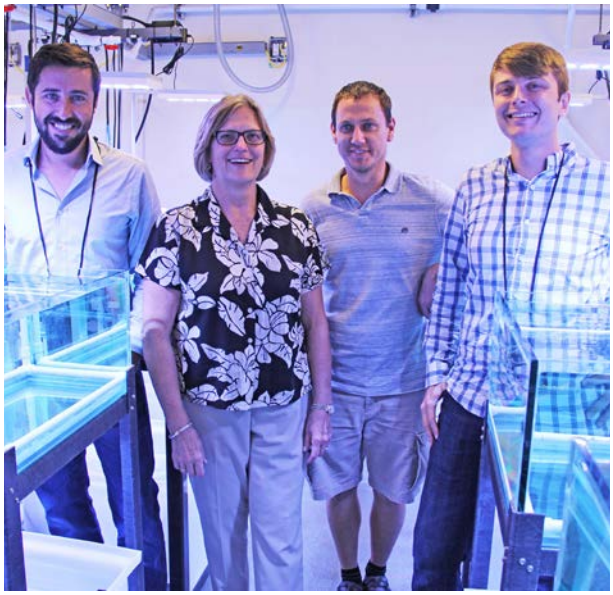
Environmental Observations and Data

Hawaiian Monk Seal Genome Sequencing and Annotation Completed

A two-year collaboration between the NOAA Pacific Islands Fisheries Science Center and Johns Hopkins University has led to a map of the Hawaiian monk seal genome. The project was completed in July 2017 with the publication of the annotated genome. This is notable on two fronts. First, it opens the door for a variety of new research projects related to the health and disease, evolutionary biology, and other aspects of the endangered species. Second, new techniques were developed and applied to sequence the genome at a fraction of the cost of other techniques.

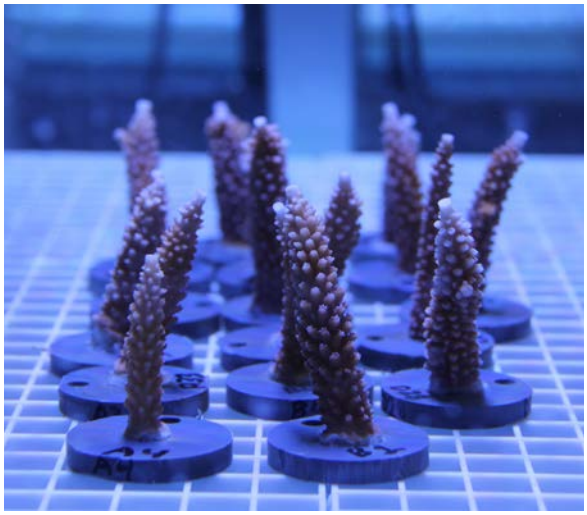
Key Findings from Coral Reef Ecosystem Surveys Published

At 370,000 square nautical miles, the Pacific Remote Islands Marine National Monument is the largest marine protected area in the United States and the second largest in the world. In collaboration with university partners, the NOAA' Pacific Islands Fisheries Science Center (PIFSC) recently published *Coral Reef Ecosystems of the Pacific Remote Islands Marine National Monument*. This publication provides an overview of key findings about spatial patterns and temporal trends of the coral reef ecosystems observed during NOAA's Pacific Reef Assessment and Monitoring Program research surveys conducted from 2000 to 2016. These surveys conducted by NOAA PIFSC's Coral Reef Ecosystem Program with financial support from NOAA's Coral Reef Conservation Program document the status, trends, and conditions of the coral reef ecosystems around each of the Pacific Remote Islands. To better understand the status of coral reefs in the region on a broader scale, PIFSC also performed a Pacific-wide comparison for oceanographic conditions, benthic community, fish community, and the microbial community. These detailed characterizations of coral reef ecosystems are important for ecosystem-based management, and for evaluating the effectiveness of conservation efforts. Additionally, this information can be paired with socio-economic surveys to identify connections between the status of coral reefs and the human uses and benefits of coral reef ecosystems.



New Experimental Coral Reef Laboratory

In partnership with the University of Miami's Rosenstiel School, NOAA's Atlantic Oceanographic and Meteorological Laboratory recently completed work on a state-of-the-art Experimental Reef Laboratory. For the first time, scientists will be able to precisely regulate CO2 levels and temperature, providing insight on how corals, such as the threatened staghorn coral, respond to two of the major threats to coral reefs: thermal stress and ocean acidification. Thermal stress from elevated sea surface temperatures cause coral bleaching, while ocean acidification obstructs coral's ability to build their skeletons. Using 16 identical aquaria, researchers can now program CO2 conditions at coral reefs in the Florida Keys or simulate future CO2 levels and ocean temperatures. This ability to mimic real world conditions as well as predicted scenarios provides NOAA with a versatile tool for observing how corals respond to an array of stress factors. In southeast Florida alone, coral reefs are estimated to generate $4.4 billion in local sales, $2 billion in local income, and 70,400 full and part-time jobs. By exploring coral resiliency mechanisms, researchers are hopeful they can discover the molecular underpinnings that will enable some corals to adapt and, ultimately, survive a marine environment in transition.



Decision Science, Risk Assessment, and Risk Communication

NOAA regularly monitors and assesses risk from environmental hazards. However, that investment has no value unless NOAA also communicates risk effectively. NOAA remains steadfast in its focus to transition research conducted within and across a variety of social science disciplines (e.g., psychology, economics, political science, sociology, and anthropology) into user friendly applications and policy, giving individuals and groups the decision aids they need. NOAA leverages newly established relationships with other federal agencies, most notably the National Science Foundation (see NOAA - National Science Foundation Memorandum of Agreement), who invest considerable resources in social, behavioral, and economic sciences research.

The summaries found within this chapter provide some representative examples of the research and development underway at NOAA in the realms of decision science, risk assessment, and risk communication.

Tools and Expertise to Help U.S. Aquaculture Industry Expand

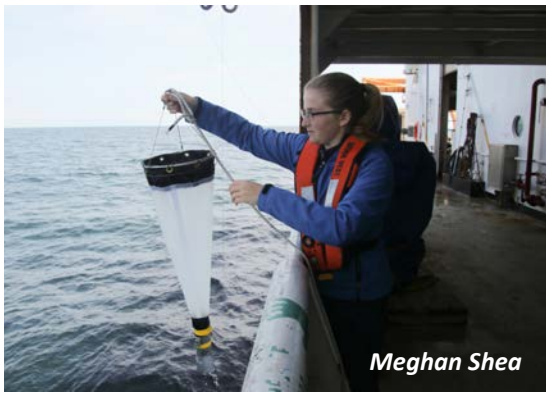
Offshore aquaculture is a promising new frontier for U.S seafood production. However, the growth of this industry has been constrained by concerns regarding negative environmental effects of improperly sited farms. In response to these concerns, the NOAA National Centers for Coastal Ocean Science and the NOAA Office of Coastal Management partnered to develop a new offshore aquaculture planning tool, CanVis Aquaculture. This seascape visualization tool contains an image library of aquaculture gear, vessels, buoys, and other infrastructure that can be used to simulate the changes that result from aquaculture development. Coastal managers and developers in Hawaii, California, and Washington are currently using this tool to visualize and plan offshore aquaculture projects. Through this effort, NOAA is supporting economic growth while balancing environmental and societal impacts of a burgeoning U.S. industry.

Offshore aquaculture pens

Assessing the Vulnerability of the California Current Ecosystem to Ocean Acidification

Assessing the vulnerability of U.S. coastal large marine ecosystems to the effects of ocean acidification (OA) is one of the primary goals of the NOAA Ocean Acidification Program (OAP). To achieve this, OAP coordinates efforts across NOAA to determine how ocean chemistry is changing in response to OA, evaluate the sensitivities of marine resources to these changes, and provide tools and information to impacted dependent human communities. In 2016, OAP advanced efforts along each of these fronts, including support for the fifth West Coast Ocean Acidification (WCOA) cruise executed by the NOAA Pacific Marine Environmental Laboratory in May to June, 2016. WCOA documented multiple ecosystem stressors (OA, temperature, and hypoxia) throughout the California Current. Data from these surveys are important to the development and validation of the NOAA Joint Institute for the Study of the Atmosphere and Ocean Seasonal Coastal Ocean Prediction of the Ecosystem (J-SCOPE). J-SCOPE provides seasonal outlooks for the Pacific Northwest waters, including forecast of corrosive conditions harmful to valuable living marine resources. Documenting and predicting changes in ocean chemistry is most useful to stakeholders and industries when there is a robust understanding of the sensitivity of the marine resources to ocean chemistry. In 2016, OAP-funded researchers at the Northwest Fisheries Science Center reported the effects of OA on the survival rate of a broad range of species in the California Current Ecosystem. This advance supports the inclusion of OA into future ecosystem forecast models that inform private and public-decision makers at the local, state, and regional level.


Meghan Shea

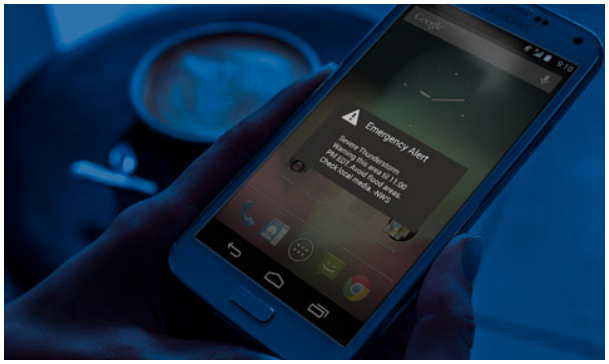

Meghan Shea

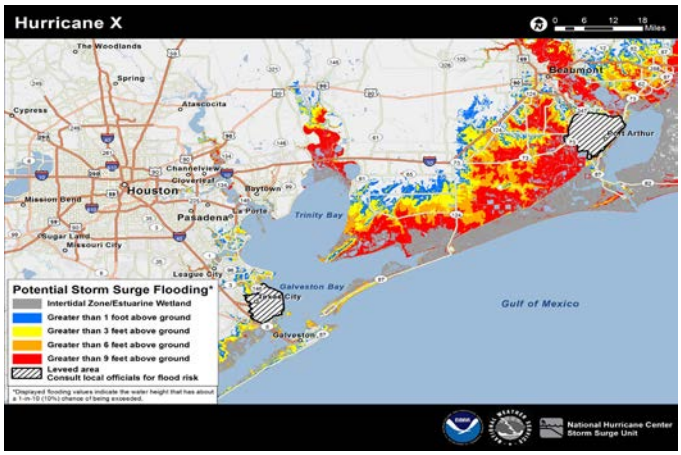

Katie Douglas

Decision Science, Risk Assessment, and Risk Communication

Forecasting a Continuum of Environmental Threats

The NOAA National Weather Service (NWS) watch and warning process has not fundamentally changed in over 50 years. However, society, technology, and science have made great advances. The Forecasting a Continuum of Environmental Threats (FACETs) paradigm modernizes the high-impact weather forecasting and communication process by adapting to evolving technology. At the core of this paradigm shift is a change in how weather forecasters communicate the public's vulnerability to extreme weather events. By using information based on probabilities, forecasters can provide the public more precise watches and warnings. This framework will enable decision-makers who require more advanced notice, such as hospitals, schools, and large venues, to set their own threat thresholds based on their specific needs. It will also enable new science advances, such as Warn-on-Forecast and Phased Array Radar, to be fully leveraged into better warnings and forecasts for society. Since hazardous weather forecasting is a physical science done by humans for humans, social and behavioral science is fully integrated into FACETs research and development. Collaborative research projects between NOAA Research, NWS, and academic partners are beginning to move us toward the FACETs paradigm. In the spring of 2017, several experiments were conducted in the NOAA Hazardous Weather Testbed bringing together NWS forecasters, researchers, and partners such as emergency managers and broadcasters to evaluate early prototypes of forecast and warning technology based on the FACETs approach.





"We have had several very successful Weather-Ready Nation events in conjunction with the NWS Peachtree City office during recent years. Each one of these events has had lasting effects on the Atlanta community -- leaving neighborhoods much better prepared to handle severe weather challenges."

- Gary A. Harris, Center for Sustainable Communities

Weather-Ready Nation Helps to Build Ready, Responsible, and Resilient Communities

The products and services produced by the NOAA National Weather Service (NWS) provide a foundation for U.S. business investments of $1.7 billion annually in value added products and services.[1] The Weather-Ready Nation (WRN) initiative focuses on helping our Nation become more resilient to increasingly extreme weather, water, and climate events through greater accuracy in forecasts and warnings, evolving services to community decision makers, and better ways to communicate risk to our core partners and the public. At the heart of WRN is Impact-Based Decision Support Services (IDSS). IDSS ensures that accurate, consistent, and high-quality forecasts are effectively communicated to end users. In short, IDSS bridges the gap between generating a forecast and delivering that forecast in a way that ensures the recipient of the forecast knows what actions to take. As a result, the NWS partners, like emergency managers, as well as the public, can make better informed and more timely decisions. NWS's evolution toward IDSS requires understanding the societal impacts of environmental threats such as tornadoes, hurricanes, and flooding. Moreover, NWS must use knowledge gained from the social sciences to better understand the relationship between forecasts or other environmental information and decision-making within the broader society. Quantifying and then communicating forecast certainty especially as it relates to key decision thresholds during extreme events is fundamental to the success of IDSS. To this end, NOAA, in consultation with social scientists, conducted research toward the development of the Potential Storm Surge Inundation Graphic (operational in 2016), the development of an experimental Storm Surge Watch/Warning product and the Onset of Tropical Storm Force Winds, which is intended to depict the potential time of arrival of sustained winds of tropical storm force.

1 U.S. Department of Commerce, Economics and Statistics Administration. (2014). Fostering Innovation, Creating Jobs, Driving Better Decisions: The Value of Government Data, p.15

NOAA and Biomedical Researchers Collaborate to Find Out if Cancer Cures are Living on Alaska's Seafloor

Ten years ago, a NOAA Alaska Fisheries Science Center scientist discovered a small green sponge, the *Latrunculia austini*. No one could have predicted the attention this unassuming sponge would receive in the years following its discovery. While plain in appearance, this golf-ball sized sponge contains unique chemical compounds that may hold the key for developing life-saving cancer treatments. Biomedical researchers at the Hollings Cancer Center in South Carolina and at the Henry Ford Cancer Institute in Detroit have demonstrated that several of this green sponges' molecules selectively target and kill pancreatic tumor cells in laboratory tests. Although many challenges still need to be addressed, this discovery holds great potential for developing new medicines. Continued public-private partnerships along these lines will enable NOAA to learn more about the ocean while potentially advancing valuable research that may have life-saving benefits.

The above photo shows the living shoreline at the NOAA Beaufort Lab in Beaufort, North Carolina.

Promoting Nature-based Shorelines to Protect the Coast

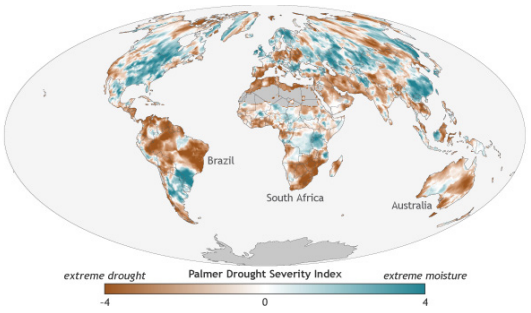
Scientists at the NOAA National Centers for Coastal Ocean Science (NCCOS) worked with other offices within NOAA to co-author NOAA's Guidance for Considering the Use of Living Shorelines in October 2015. NCCOS scientists found that living shorelines, or shorelines made up of mostly natural material, can reduce damage and erosion while simultaneously providing ecosystem services to society, including food production, carbon dioxide reduction, nutrient and sediment removal, and water quality improvement. In 2017, NCCOS social science researchers completed an economic assessment of the coastal habitat in and around the Jacques Cousteau National Estuarine Research Reserve in New Jersey. The team combined spatial wetland data, outputs from storm models, and property information to determine the maximum flood depth at the parcel level for three storm scenarios: a Hurricane Sandy event, a 50-year event, and a 25-year storm event. The team then applied mathematical depth-damage functions developed by the U.S. Army Corps of Engineers to estimate the damages from these storm events. The researchers found that living shorelines reduced property damages in each storm scenario. Following the success of this assessment, the researchers hope to replicate the approach in another location.

State of the Climate in 2016

The State of the Climate in 2016 was released with the August edition of the Bulletin of the American Meteorological Society. The report is a broad "annual physical" of the global climate system, using dozens of indicators, hundreds of data sets, and contributions from more than 450 authors from 64 nations around the world. Scientists from across NOAA contributed to the report, underscoring both the report's breadth, and the breadth of connections between climate and NOAA's mission. As an annual analysis, the report's findings inform less frequent climate assessments, such as the National Climate Assessment commissioned by the U.S. Global Change Research Program, and that of the Intergovernmental Panel on Climate Change. The State of the Climate in 2016 was shared widely upon its release, most visibly through the media, but more importantly to the operational community. For example, on the day of its release, it was shared by United Nations Office for Disaster Risk Reduction to its thousands of constituents around the world to inform their vulnerability-reduction work.

Advances in Precision Navigation

As cargo ships grow to keep pace with global demand, ports are increasingly in need of accurate, real-time information on conditions to operate effectively. NOAA's Navigation Services have partnered with port authorities and private industry across the nation to build observing infrastructure to support real-time delivery of oceanographic data. These products enhance efficiency and safety for the nation's ports. Key successes in 2017 include 1) delivery of a new Physical Oceanographic Real Time System (PORTS®) in Matagorda Bay, TX to help mariners navigate strong currents coming into seaport, 2) addition of a new air gap sensor for Charleston PORTS® and Delaware Bay PORTS to help ships measure the clearance between the water surface and major bridges, 3) creation of the Tampa Bay Marine Channel Forecast, an online tool that gives vessel operators transiting through Tampa Bay access to critical oceanographic and meteorological forecasts. Of special note, with the assistance of NOAA's navigation services, the Port of Long Beach was able to increase the draft limit, the minimum water depth a ship can safely navigate, from 20.1 meters to 20.4 meters (66 feet to 67 feet) with the ultimate goal of reaching a 21 meters (69 foot) draft. This approach has the potential to save nearly $10 million annually while effectively managing the risk of grounding.



Drought in 2016 was among the most extensive in the post-1950 record: more than half of the land area south of 20 degrees North was subject to some degree of drought in 2016. The above figure is a NOAA Climate.gov map, adapted from Figure 2.1q in State of the Climate in 2016

Decision Science, Risk Assessment, and Risk Communication

CAMEO Mobile Application Launched

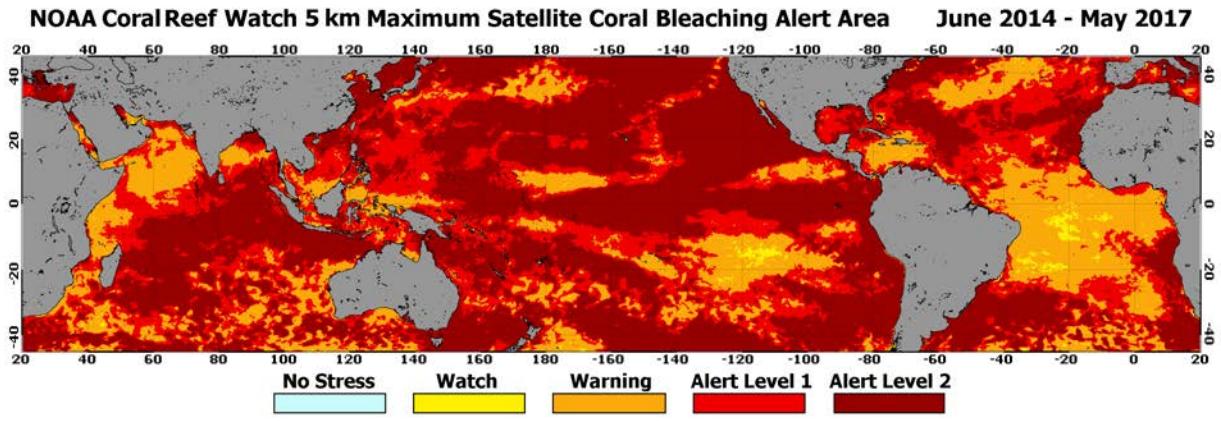
Introduced in 1986, Computer-Aided Management of Emergency Operations (CAMEO) Chemicals is the most widely used chemical response software in the world. The CAMEO website provides emergency responders and planners with information about thousands of hazardous chemicals as well as possible safety hazards if chemicals are mixed together during a hazardous materials incident. It is routinely used nationwide for chemical incidents initiated by extreme weather such as hurricanes, tornadoes, and wildfires as well as human error. In 2017, NOAA launched a mobile app version for iOS and Android. The app doesn't require an internet connection, uses responsive design to adjust to tablets and phones, and includes a tool to predict whether an explosion, toxic fumes, or other safety hazard could occur if a group of chemicals were mixed during an incident.

Severe Weather Model Predicted Tornado's Path Hours Before it Formed

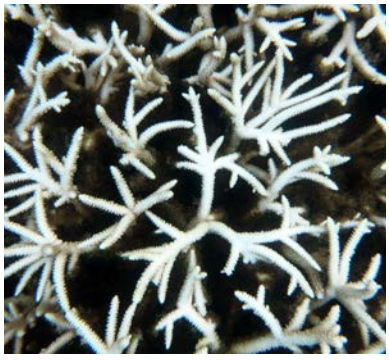
On May 16, 2017, NOAA forecasters alerted residents in parts of western Oklahoma about the potential for large hail and damaging tornadoes, particularly in the area around Elk City. Ninety minutes later, a dangerous, rain-wrapped tornado struck the small town killing one, injuring eight, and destroying about 200 homes and more than 30 businesses. Normally, meteorologists issue warnings based on radar depictions or spotter reports. This time NOAA's National Weather Service (NWS) issued an additional advisory prompted by output from an experimental Warn on Forecast (WoF) system. WoF isn't operational yet, but represents a significant step to providing more precise hazardous weather information to the public. Based on the information NOAA provided, emergency management was able to activate the outdoor warning sirens about 30 minutes ahead of the tornado. The foundation of the NOAA National Severe Storms Lab WoF prototype that predicted the path of this tornado is NOAA's experimental hourly-updating High Resolution Rapid Refresh–Ensemble regional analysis and prediction system. The High Resolution Rapid Refresh-Ensemble is a spin-off of the NOAA Earth System Research Laboratory's High Resolution Rapid Refresh severe weather forecast model now in operation at all 122 NWS forecast offices.

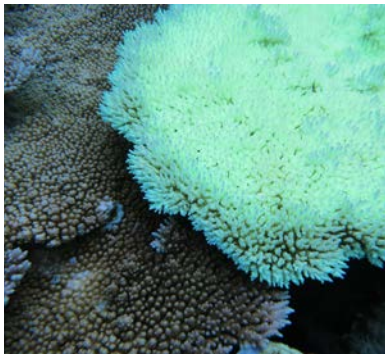
Sustained High Ocean Temperatures Trigger Massive Coral Bleaching

The Third Global Coral Bleaching Event (June 2014 to May 2017) was the longest, most widespread, and possibly the most damaging coral bleaching event on record. Coral reefs are not only one of the most biodiverse and valuable ecosystems on Earth, but they also provide significant economic and social benefits valued at approximately $9.8 trillion U.S. dollars per year. They support subsistence, recreational, and commercial fisheries, tourism, shoreline protection, and they yield compounds important for medicinal development. Globally, at least 500 million people rely on coral reefs for food, coastal protection, and their livelihoods. With support from the NOAA Coral Reef Conservation Program, Coral Reef Watch communicates information about climate change, ocean warming, and impacts (such as bleaching, associated disease, and death) on coral reefs worldwide. Partnering with collaborative agencies around the world, NOAA Coral Reef Watch also enhances understanding of links between environmental conditions and ecosystem impacts to provide coral reef and coastal ecosystem managers with improved satellite monitoring, modeled products, and understanding to guide effective coral reef management, monitoring, and protection in a changing climate.



NOAA Coral Reef Watch's satellite Coral Bleaching Alert Area product shows the maximum heat stress during the Third Global Coral Bleaching Event. Regions that experienced the high heat stress that can cause coral bleaching, from June 1, 2014 to May 31, 2017, are displayed. Alert Level 2 heat stress indicates widespread coral bleaching and significant mortality. Alert Level 1 heat stress indicates significant coral bleaching. Lower levels of stress may have caused some bleaching as well. More than 70% of coral reefs around the world experienced heat stress that can cause bleaching and/or death during the three-year long global bleaching event.





Decision Science, Risk Assessment, and Risk Communication

NOAA Fisheries Conducted the First Ecosystem Status Review Workshop

NOAA Fisheries hosted a workshop to review existing Ecosystem Status Reports (ESRs), and develop plans for future improvement. ESRs are a critical step towards implementing Ecosystem Based Fishery Management. This approach recognizes that fishery stocks exist in the context of a broader ecosystem, and that the full array of interactions within the ecosystem, including human interactions, should be considered when developing management strategies. ESRs provide crucial scientific information about the ecosystems so that they can be maintained in a healthy, productive, and resilient condition. The workshop identified priorities for addressing current, and future ecosystem science and management objectives, and improving ESRs.

Reducing Waste and Increasing Profits for the Texas Pacific White Shrimp Mariculture Industry

Reducing aquaculture's environmental impact is a widely accepted goal of seafood producers, retailers, and consumers. Addressing this concern requires a shift from traditional flow-through systems to recirculating aquaculture systems (RAS), but RAS adoption is slow because it is currently less expensive to discharge wastewater than to treat it. NOAA's Texas Sea Grant funded a research project to develop and pilot new technology to culture Pacific white shrimp. With little or even no water exchange, RAS reduces or eliminates the amount of nutrients released to the environment, escape of non-native culture species, and the spread of pathogens to the environment. When managed properly, the technique can increase production to four crops per tank per year, yielding nine kg or more per cubic meter and reducing the costs of Pacific white shrimp mariculture from $5 per pound to only $2 per pound. Researchers completed a manual on the design and operation of the system. The manual, which is scheduled to be released through the World Aquaculture Society in 2017, includes economic analyses of production trials and is designed to help shrimp producers working in indoor no-water-exchange systems for the production of marketable shrimp. Overall, through projects and programs like this, NOAA's Sea Grant has had an economic impact more than eight times greater than federal investment.[1]

1 NOAA Sea Grant. (2017, May). A smart investment in our coastal economy. [PDF].

New Regional Sea Level Scenarios Help Communities Prepare for Risks

NOAA released a new technical report for the Sea Level Rise and Coastal Flood Hazard Scenarios and Tools Interagency Task Force, which was convened by the U.S. Global Change Research Program and National Ocean Council in 2015. Researchers from NOAA, Rutgers University, the Environmental Protection Agency, South Florida Water Management District, Columbia University, and U.S. Geological Survey co-authored the report. These new scenarios integrate updated global sea level rise scenarios with regional factors, such as changes in land elevations and ocean circulation, that influence sea level regionally. The researchers scaled these scenarios down to a one-degree gridded resolution, or roughly 70 miles. Regional trends will help communities track a range of scenarios that they may fall under for each of the time-frames, and assess their risk of experiencing impacts under the scenario. This allows a coastal manager in Miami and one in Mobile, Alabama, using the same scenario to prepare for different outcomes.

Water Prediction

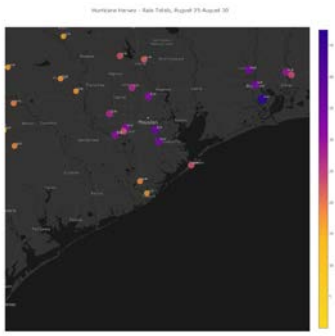
Leveraging capabilities and expertise from across NOAA to better understand and predict all aspects of the water cycle remains a critical national priority. NOAA is uniquely positioned to provide the tools, data, and information needed to strengthen the nation's water security, reduce vulnerability to climate variability and change, and catalyze more effective management and use of our nation's valuable water resources. In short, NOAA's water research focuses on predictability of water quantity and water quality.

The research examples depicted in this chapter represent a portion of the research happening at NOAA concerning water and the critical role the agency has in enhancing water-related products and decision-support services across the country.

Storm Surge Planning and Preparedness

S.C. DHEC/MyCoast

Roughly 123 million Americans and $10.64 trillion in property and infrastructure along the U.S. Gulf Coast are vulnerable to storm surges. Researchers at NOAA's Southern Climate Impacts Planning Program (SCIPP) have been working with decision makers in communities and businesses along the Gulf Coast to help protect people and valued assets from storm-induced flooding which, evidence shows, is being compounded by the slow creep of sea level rise. To date, SCIPP has supported 50 projects to protect critical infrastructure valued at $15 billion, including the Houston Ship Channel Project and the Galveston Ike Dike Project. SCIPP's secret weapon is SURGEDAT—a unique, painstakingly developed database of all Gulf Coast storm surges dating back to 1880. SURGEDAT incorporates 67 sources of authoritative federal science data and over 3,000 sources of historical information to help researchers analyze and understand where and how storm surges have impacted the Gulf Coast, and how communities and businesses can prepare for the next one.



In the midst of 2017's active hurricane season, SCIPP provided live coverage of storm surge data at more than 50 locations along the track of Hurricanes Harvey, Irma, and Maria. Additionally, the team used SURGEDAT to display precipitation totals based on citizen science data in the immediate aftermath of each storm. Researchers are using the data collected through SURGEDAT to verify the ADCIRC storm surge model by assessing how much agreement exists between measured and modeled storm surge.

Tracking Precipitation to Provide Flash Flooding Forecasts at the Neighborhood Level

The Flooded Locations and Simulated Hydrographs (FLASH) project advances the state of flash flood prediction through newly developed Multi-Radar/Multi-Sensor rainfall estimation tools and hydrologic models. FLASH begins with rainfall rates measured by radar and uses a sophisticated modeling system to track what every raindrop is doing on the ground: whether it infiltrates into the soil or flows across impervious roads, parking lots, and waterways. The system models where water will go and when and where it will become a flood, with updates as frequent as every two minutes - a key attribute for cities that can flood quickly. In 2016, research indicated that the FLASH system doubles accuracy of the current operational system and improves the spatial resolution by 500 percent, which can indicate specific locations of flash flood impacts downstream, saving lives and mitigating damage to property. These new high-resolution tools will provide reliable flash flood forecasts at the neighborhood level as well as provide up to six hours of forecast lead time, affording critical time for community response. FLASH improves NOAA National Weather Service forecasters' abilities to identify rare, severe flash floods from minor ones, enabling them to communicate this information to local emergency managers and the public. The FLASH forecasts are particularly useful over small, fast-reacting headwater basins and in urban catchments, complementing the new National Water Model for flash flood modeling and prediction.

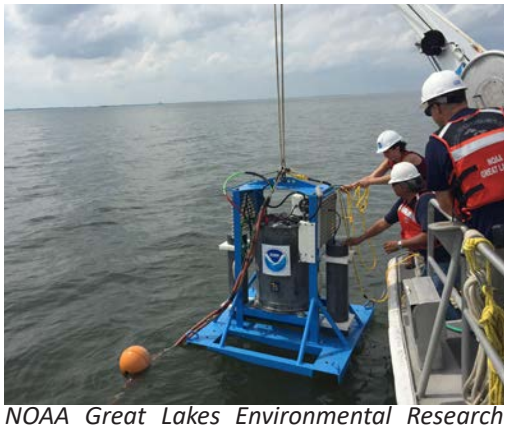
Biologists Watch Steelhead Trout Return after Historic Dam Removal

NOAA was one of many partners that contributed to the recent removal of the San Clemente Dam on the Carmel River in California. This project, the largest dam removal in California to date, reconnected over 40 kilometers (25 miles) of habitat for South Central California coast steelhead, a distinct population segment of fish listed as threatened under the Endangered Species Act in 2006. Historically, the steelhead fishery attracted anglers from throughout the state, providing important outdoor recreational opportunities and contributing to the regional recreational economy. Removing the dam has made it easier for steelhead to swim upstream to their spawning habitat. Strong winter rains in 2017 and associated surges in streamflow, accelerated habitat restoration by resulting in the increased availability of large wood and a greater range of sediment types; thus, increasing the structural diversity of the habitat available for steelhead. So far, NOAA scientists monitoring the changes in the ecosystem have seen more juvenile fish in the river, a very promising sign for potential improvement in the steelhead population.

Water Prediction

Better Toxin Detection for Harmful Algal Blooms

Toxins produced by harmful algal blooms (HABs) accumulate in marine resources and are a major cause of human seafood poisoning, which impacts subsistence harvests, economic development, and international trade. Paralytic shellfish poisoning (PSP) poses a serious health threat in Alaska, and often leads to harvesting restrictions and closures that result in economic losses for shellfish growers and subsistence harvesters. Despite the bulk of shellfish toxicity research, there is still confusion about the algal species that cause PSP in Alaska. NCCOS conducted sampling from southeast Alaska to Kodiak Island to identify which PSP-causing algae are most commonly found in the region, then developed new assays for these algae. The assays will help Alaska's monitoring programs better identify when there is a high risk of PSP, along with the environmental conditions that lead to PSP-causing algal blooms.



NOAA Great Lakes Environmental Research Laboratory vessel operator, Kent Baker, NOAA Cooperative Institute for Great Lakes Research research technician Emily Davenport, and Roman Marin of Monterey Bay Aquarium Research Institute deploying the environmental sample processor, ESPniagara, in western Lake Erie on July 11, 2017.

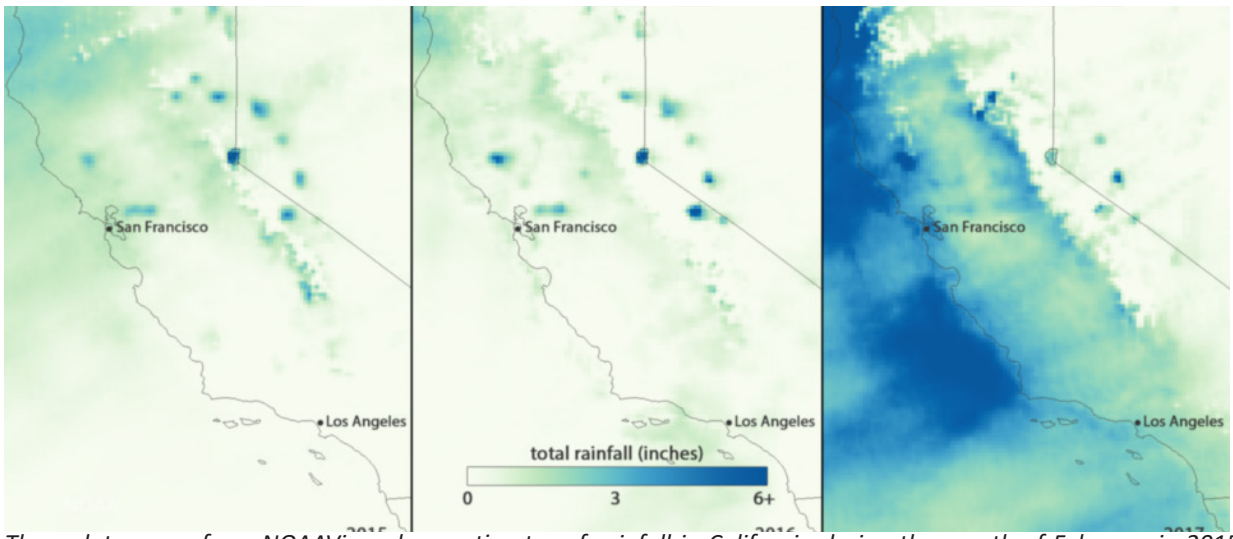
In-situ Water Collection Instrument Sequences Samples in Real-time

The world's first-ever freshwater Environmental Sample Processor (ESP) is tracking the levels of dangerous toxins produced by cyanobacteria that bloom each summer in the western basin of Lake Erie. The ESPniagara, aptly named for its use in a Great Lakes system, is a "lab in a can" designed in collaboration with the NOAA National Centers for Coastal Ocean Science, the NOAA Cooperative Institute for Great Lakes Research, and Monterey Bay Aquarium Research Institute. The ESPniagara autonomously collects water samples to monitor for microcystin, the dominant algal toxin in western Lake Erie. The goal is to provide drinking water managers with data on harmful-algal toxicity in near real-time, before the water reaches municipal water intakes. This toxicity data produced by the ESPniagara, coupled with NOAA's twice-weekly Lake Erie Harmful Algal Bloom (HAB) Bulletin and the Experimental HAB Tracker nowcast and five-day forecast provide water managers with more precise bloom location, projected direction, intensity, and toxicity.

California Sees Record Breaking Precipitation in Winter 2017

After years of drought, in February 2017 California received nearly a season's worth of rain in a single month. These record breaking amounts of rain and snow resulted in a near catastrophe at California's second largest reservoir, Oroville Dam, when damage to dam's emergency spillways threatened both lives and property. The NOAA National Weather Service (NWS) worked in collaboration with federal, state, and local partners to provide essential support throughout the crisis. NOAA not only provided daily forecast updates to the California Governor's Office of Emergency Services and the Federal Emergency Management Agency (FEMA), but also ensured rapid communications with first responders. Throughout the event, NOAA's GOES-West Satellite provided Rapid Scan Operations allowing forecasters to examine evolving storm systems in greater detail. Once the threat to public safety was addressed, the NOAA Fisheries West Coast Region worked side-by-side with state partners to evacuate six million hatchery fish from murky waters. This coordinated response helped protect the public's investment in the Feather River Fish hatchery, which is one of the most important fish hatcheries in CA, and includes steelhead and chinook salmon. Finally, snow-level radar developed by the NOAA Earth System Research Laboratory is part of a state-of-the-art observing network that helps scientists and decision makers better understand the causes and impacts of winter storms, which helps facilitate integrated water management.

Dan Kolke/California Department of Water Resources

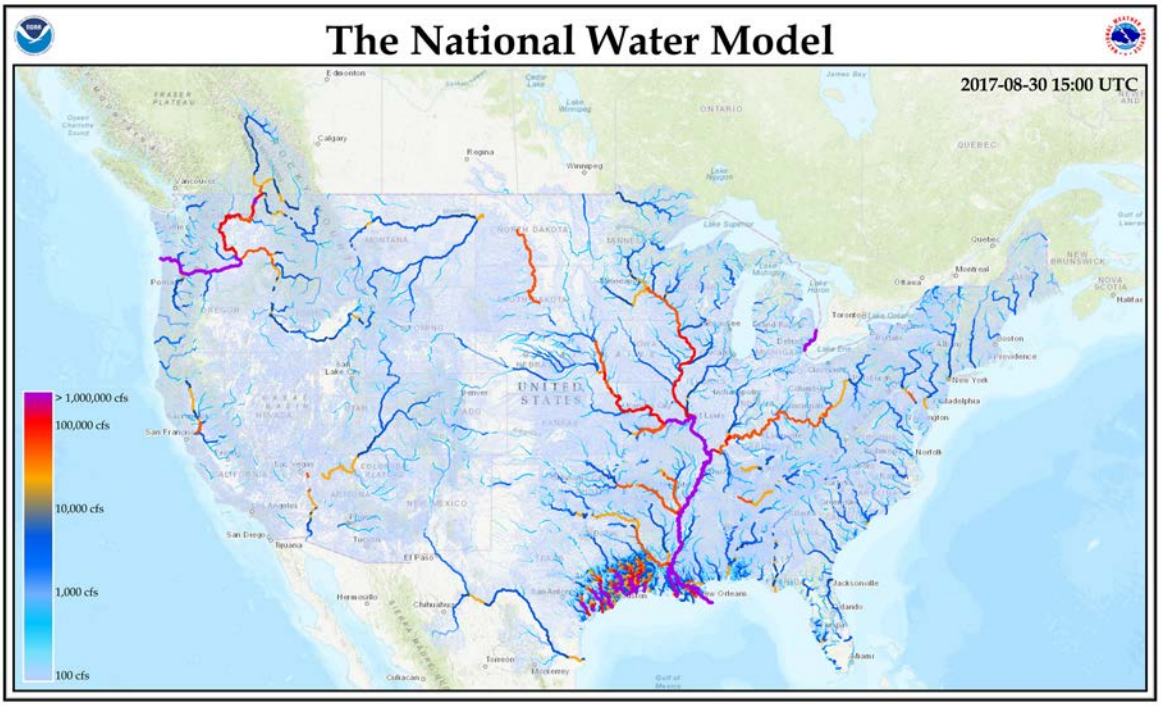


These data maps from NOAAView show estimates of rainfall in California during the month of February in 2015 (left), 2016 (center), and 2017 (right). As is evident from the deeper shade of blue in the image on the right, the state recieved far more rainfall this year than in the previous two years.

Water Prediction

National Water Model

On August 16, 2016, NOAA's efforts to build a Weather-Ready Nation took a major step forward with the NOAA National Weather Service's launch of a new, highly sophisticated National Water Model (NWM). The NWM is a continental-scale water resources model based on the Weather Research and Forecasting Hydrology modeling architecture developed by the National Center for Atmospheric Research. Unprecedented in its reach, the NWM uses data from over 8,000 U.S. Geological Survey (USGS) stream gauges to produce flow simulations for 2.7 million stream reaches, extending water resource information to the homes and businesses of over 100 million Americans who live in coastal communities. For the first time, communities will receive hourly, weekly, and monthly water forecasts based on output from the NWM. This information will help businesses, community leaders, first responders, emergency managers, and state and local governments make more informed decisions to protect lives and livelihoods. This model represents NOAA's first foray into high performance computing for water prediction. Using this model, NOAA National Weather Service forecasters now have access to data for 700 times more locations than previously available. The first update to the NWM was deployed on May 8, 2017 and included improvements to how atmospheric predictions are used, calibration of hydrologic parameters, land surface model upgrades, corrections to the model's national river network, upgrades to output formats, and increases in cycling frequency and forecast length.



The above image shows results from the NWM analysis run on August 30, 2017 during Hurricane Harvey. Note the very high streamflows in southeastern Texas after Harvey generated rainfall amount from 20 to 61 inches of rain over the region.

" I have great respect for the scientific quality of NOAA. It's my understanding that there are four Nobel Prize winners at NOAA, and that is certainly a measure of their expertise."

Nomination of Wilbur L. Ross, Jr., to be Secretary of the Department of Commerce: Hearings before the Committee on Commerce, Science, and Transportation, Senate, 115th Cong. 41 (2017) (Testimony of Wilbur L. Ross, Jr.).

Arctic

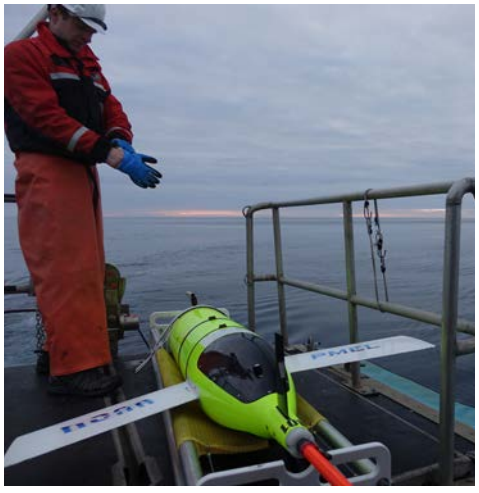
NOAA provides Arctic information and a set of indicators that describe the present state of the Arctic ecosystem and climate. Climate change is making the Arctic a greener, warmer, and increasingly accessible place for economic opportunity. However, climate impacts such as sea ice loss and rising ocean acidification are straining coastal community resilience and sound resource stewardship. In addition, advancing U.S. security interests in the Arctic requires improved maritime domain awareness, for which NOAA's weather and sea ice forecasts are critically important.

In order to understand, mitigate, and adapt to the impacts that anthropogenic and climatic stressors are having on the Arctic, NOAA is engaging in innovative research to fill critical gaps in the understanding of the Arctic environment. As a leader of Arctic research, NOAA is working to develop more accurate and timely predictions of changing sea-ice cover with the help of sustained observational efforts as well as the development of improved sea-ice models. In Arctic coastal zones, NOAA is undertaking research and monitoring of water levels, erosion, and changes in coastal bathymetry to strengthen resiliency efforts in coastal communities and improve coastal navigation services. NOAA's research to advance scientific understanding of key Arctic species and how climate-related changes and biophysical interactions impact those species, other marine resources, and the communities that rely on them is critical. This research will assist in the development of responsible High Arctic fisheries management plans.

This chapter provides a representative sampling of the research that NOAA scientists are conducting to best understand how the Arctic region and its living resources are being impacted and influenced by global weather, ocean, and climate patterns.

Innovative Technology for Arctic Exploration

The Innovative Technology for Arctic Exploration (ITAE) testbed program develops science-driven technologies to enhance NOAA's current ocean observing (i.e., ship-based surveys and long-term mooring observations) in the ice-driven Arctic. In 2017, ITAE tested a suite of developments including sailing drones, profiling floats, and shallow-water gliders. The Saildrone, an unmanned surface vehicle, is being tested from the Arctic to the tropics to better understand how changes in the ocean are affecting weather, climate, fisheries and marine mammals. In 2017, NOAA researchers and Saildrone, Inc. developed the Saildrone as a joint reconnaissance tool for fisheries and oceanographic surveys. This data can have direct impact on increasing survey efficiency, enhanced accuracy and coverage of stock assessments, improved weather forecasts and climate modeling, and spatial coverage of ocean acidification surveys in remote Arctic regions. The Air Launched Autonomous Micro Observer, or ALAMO floats, in collaboration with the Arctic Heat Open Science Experiment, were launched from a NOAA aircraft in summer 2017 to help fill gaps of oceanographic conditions during ice covered months in the Arctic. Developed in 2017, the Oculus coastal glider surveyed a region that is typically studied with both long-term moorings and ship-based water column profiles, enhancing the spatial resolution and data quality. These developments are being used to assess critical ecosystem-level baselines in a rapidly changing Arctic, and will enable NOAA and its partners and stakeholders to strengthen foundational science and improve stewardship of ocean resources in this remote and complex area.



Climate Prediction Center Experimental Seasonal Sea Ice Prediction

The Arctic region has some of the most extreme and challenging environmental conditions on Earth. Safely traveling, fishing, transporting goods, and managing resources in the Arctic critically depends on accurate weather, marine, and sea ice forecasts. Accurate prediction of sea ice is essential for stakeholders in the Arctic region. To improve sea ice predictions, the NOAA Climate Prediction Center (CPC) developed an Experimental Forecast System that resulted in a dramatic skill improvement for sea ice forecasts. Experimental predictions from March to October for 2015 to 2017 were produced, and the comparison with available observations showed that the CPC Experimental Forecast System produced significantly more accurate seasonal sea ice forecasts than the operational Climate Forecast System. Predictions from the CPC Experimental Forecast System have become a routine contribution to the NOAA NWS Alaska Region's Sea Ice Outlook. This project was carried out in close collaboration with the University of Washington Polar Science Center.

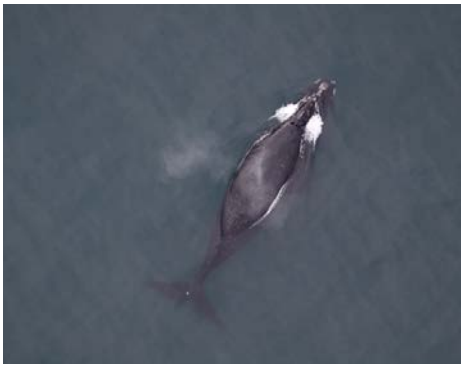
Arctic

Autonomous and Piloted Aircraft Support Search and Rescue

The NOAA Unmanned Aircraft Systems (UAS) Program Office, working together with representatives of AeroVironment Inc., conducted a Search and Rescue Exercise, called Arctic Shield, in the waters north of Alaska in order to test the utility of integrating unmanned aircraft into a simulated response incident. Working from the deck of the U.S. Coast Guard Cutter HEALY, the research team launched a small unmanned aircraft, the AeroVironment Puma, to search for a simulated missing person stranded in icy waters. Following the launch, the Puma used both its electro-optical and infrared cameras to locate the simulated victim floating in a survival raft on the water approximately one nautical mile away from the ship. The Puma was able to relay the coordinates to the test control center on board the HEALY, which then directed a Coast Guard H-60 and Era Helicopter to the scene. Both helicopters deployed rescue swimmers to simulate recovery and then returned safely to shore. The exercise concluded with a successful net capture of the Puma UAS and a recovery of the survival raft by the HEALY. Much of this mission was conducted under the auspices of a Cooperative Research and Development Agreement (CRADA) between NOAA and AeroVironment,. The results from this and other tests will be analyzed by both NOAA and AeroVironment to improve NOAA's operational capabilities and AeroVironment's products for real-life mission-based scenarios.

Scientists Capture Images and Other Needed Biological Data on Rare Whales

On a recent research survey, scientists at the Alaska Fisheries Science Center were able to locate not one, but two extremely rare North Pacific right whales as part of the Pacific Ocean Whale and Ecosystem Research program, a collaborative effort spearheaded by the International Whaling Commission. NOAA researchers managed to obtain photo-ID quality photos of both whales, as well as a biopsy sample from one of the two animals. The information obtained from this survey will improve our understanding of the population dynamics of this critically endangered species, and help guide conservation and management efforts in the future.



Scientists Track Antarctic Penguins Using Chemical Signatures

Scientists at the NOAA Southwest Fisheries Science Center have developed a new method for tracking wildlife migration; using chemical signatures found in animal tissues. By collecting and analyzing tail feathers of Chinstrap and Adélie penguins researchers were able to associate chemical patterns in the tail feathers with specific penguin wintering areas. This allows researchers to deduce where penguins have been and enables tracking the animal's movements in a less expensive and less invasive way than standard geolocation tags. These methods could potentially be applied to a wide variety of marine animals, improving migration studies overall.

Bibliometrics

This chapter represents a rigorous assessment of NOAA's scholarly research output between 2011 and 2016. Through analysis of publications authored during that time period, NOAA's core research areas were identified and used to establish a robust scholarly performance metric to demonstrate NOAA's productivity and impact within these research areas. As a benchmarking exercise, these metrics were then compared with those of other federal agencies conducting research in these disciplines.

The research areas listed below represent the bulk of NOAA's scholarly output between 2011 and 2016, with nearly 81% of all NOAA articles identified falling within one or more of these seven disciplines, all of which are strongly aligned with the agency's mission objectives.

1) Meteorology and Atmospheric Sciences
2) Marine and Freshwater Biology
3) Oceanography
4) Environmental Sciences
5) Fisheries
6) Ecology
7) Geosciences (Multidisciplinary)

Based on this clear demarcation of productivity, we defined these seven research areas as NOAA's core research areas. For each research area, we then compared NOAA's productivity and impact metrics with those of the four other federal agencies that were most productive in that research area. These comparisons demonstrate that NOAA is at the leading edge in both productivity and impact in all seven core research areas.

D.J. Kast/University of Southern California

Methods

Scholarly data and metrics for this report were obtained using InCitesTM (Clarivate Analytics), a web-based platform that allows for the assessment of the research productivity and relative impact of research organizations based on peer-reviewed articles indexed in Web of Science.

For the purposes of this report, a "NOAA article" is defined as a peer-reviewed publication indexed in the Web of Science (WoS) Core Collection and identified by WoS indexers as having one or more authors who list their affiliation as National Oceanic and Atmospheric Administration. This report analyzes articles that fit this criteria and were published between 2011 and 2016 and indexed in the InCites dataset as of August 19, 2017.

Articles that only acknowledge the receipt of financial, logistical or other support from NOAA or any NOAA office or program are not included in this report. Also not included in this analysis are book chapters, conference papers, technical reports, and other items including some journal articles which are not indexed by WoS. As such, the publication counts presented in this report can be assumed to be undercounts of the actual number of publication produced by NOAA. However, the reported counts can be considered a representative sample of NOAA's research output between 2011 and 2016.

This report focuses on NOAA's seven core research areas, determined by using the WoS research schema, comprised of 252 research areas assigned to articles based on the journals in which they are published. Within each research area, productivity and impact was assessed based on the total number of published articles and the following citation metrics: i) Hirsch-Index or H-Index; ii) percent of documents which have received citations; iii) percent of documents in the top 10% of articles cited.

For benchmarking purposes, productivity and impact data were collected for the four most productive federal agencies aside for NOAA, within each core research area. The articles this data is based are identified using the same methodology used for identifying NOAA articles.

Additional productivity and citation metrics have been included which illustrate NOAA's research output as a whole and provide context for the rest of the analysis. These metrics include total number of NOAA-authored peer-reviewed publications, total citations received, average citations received per article, and international collaborations and were obtained using InCites and WoS. The international collaborations map was created using the Science of Science Tool (Sci2) using the country or territory associated with author affiliations for coauthors of NOAA-articles for which that data was available.

References

NAS (2012). Best Practices in Assessment of Research and Development Organizations, The National Academies Press.

D. Hicks, P. Wouters, L. Waltman, S. de Rijke, I. Rafols. (2015). The Leiden Manifesto for Research Metrics, Nature (520) 429-431.

Bibliometrics

NOAA Peer-reviewed Articles 2011-2016

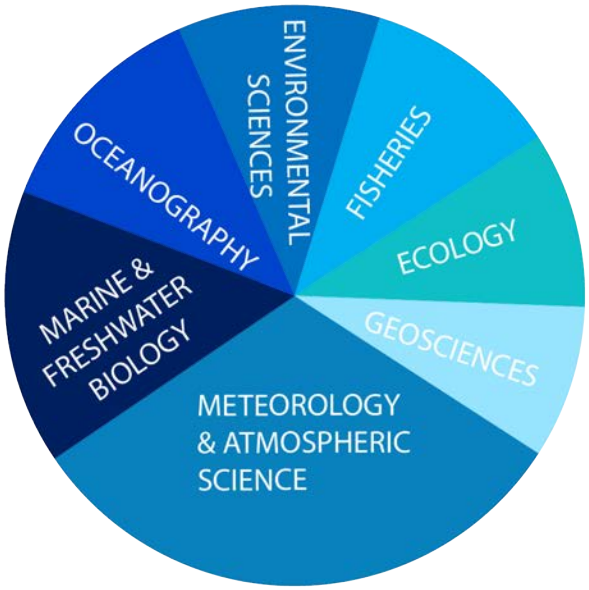
11,475 Total Publications

114 H-Index

165,451 Sum of Times Cited

90.83% % of Articles Cited

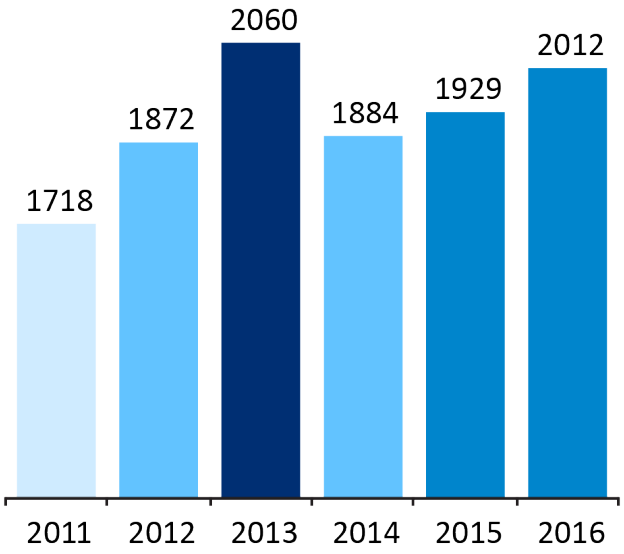
Top Research Areas



80% of NOAA articles fall under these seven research areas.

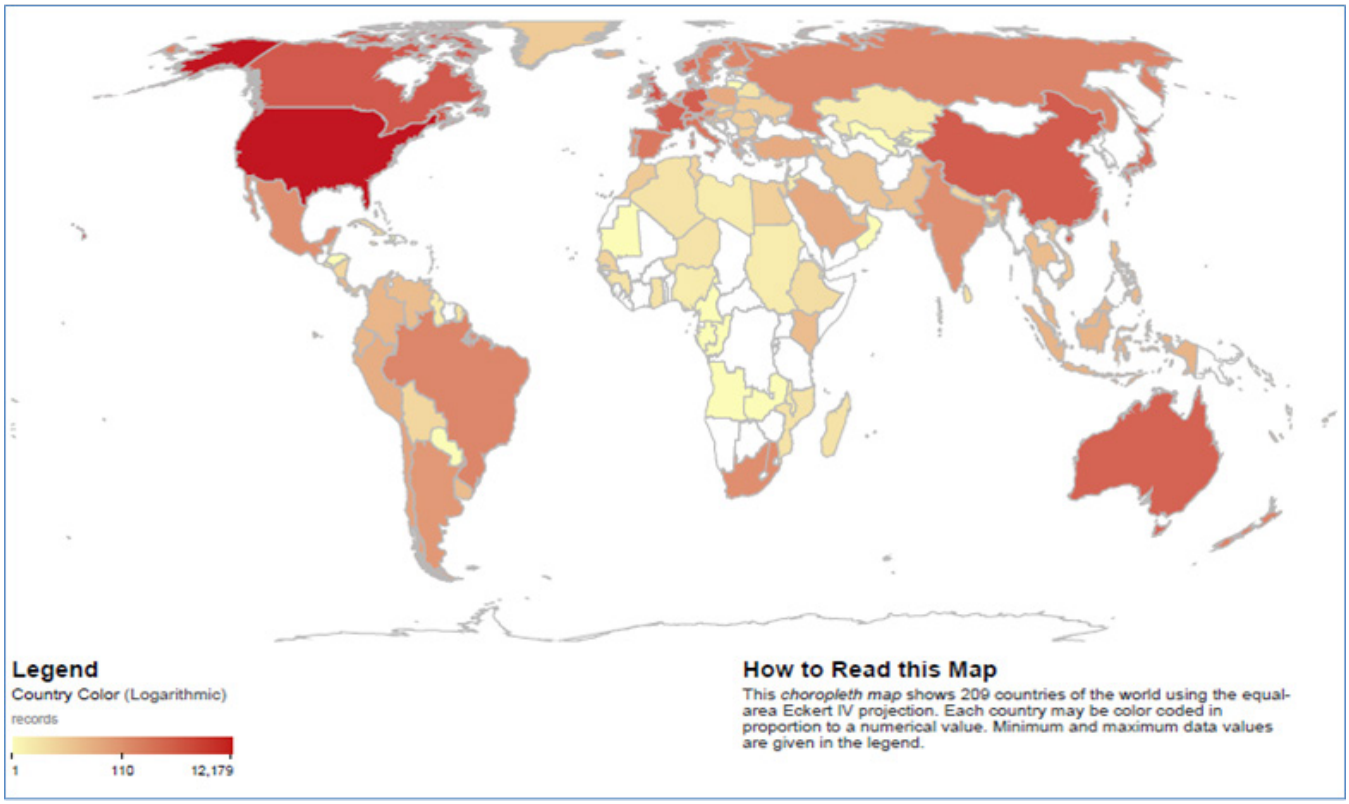
WoS Subject Area	# of Articles
Meteorology & Atmospheric Science	3608
Marine & Freshwater Biology	1758
Oceanography	1456
Environmental Sciences	1294
Fisheries	1276
Ecology	1124
Geosciences	979

Articles Per Year



Year	# of Articles
2011	1718
2012	1872
2013	2060
2014	1884
2015	1929
2016	2012

International Collaborations

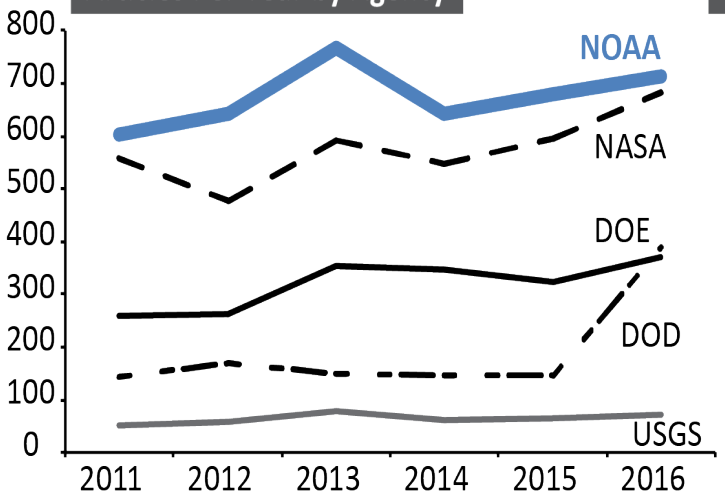


Bibliometrics

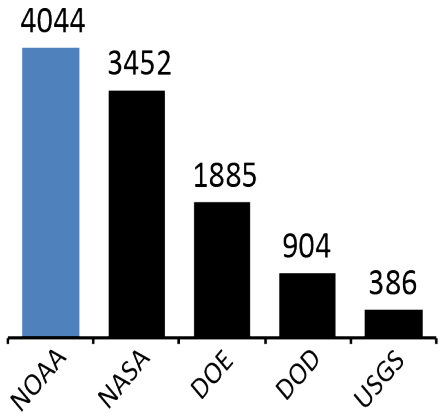
Productivity **Meteorology and Atmospheric Sciences**

Between 2011 and 2016, NOAA published an average of 674 per year in the field of meteorology and atmospheric sciences, resulting in a total of 4044 articles.

Articles Per Year by Agency



Total Number of Articles by Agency



Top Journals

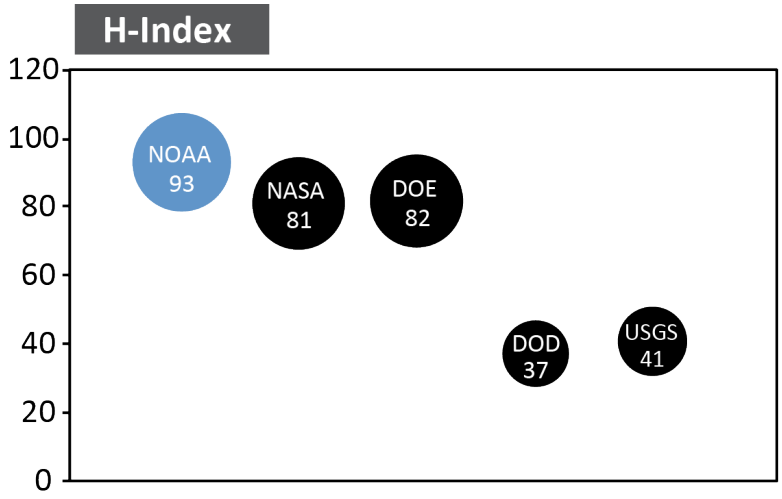
- Journal of Climate
- Journal of Geophysical Research-Atmospheres
- Atmospheric Chemistry and Physics
- Bulletin of the American Meteorological Society
- Monthly Weather Review

Highly Cited Papers

- Taylor, et al. 2012. An Overview of the CMIP5 and the experiment design. BAMS.
- Meinshausen, et al. 2011. The RCP greenhouse gas concentrations and their extensions from 1765 to 2300. Climatic Change.
- Gent, et al. 2011. The Community Climate System Model Version 4. J Climate

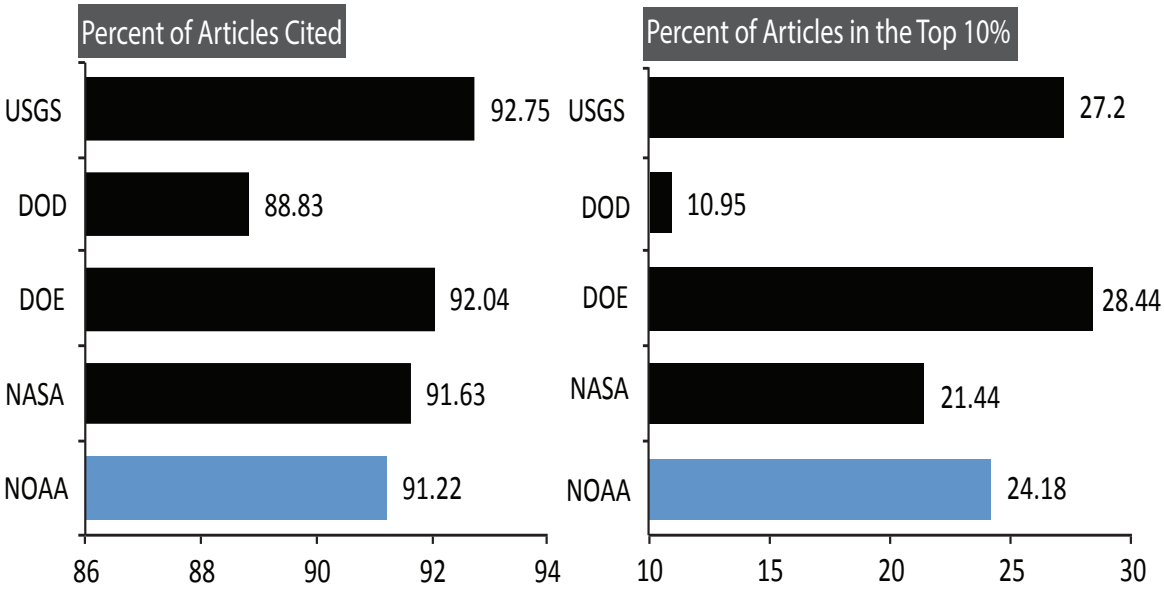
Impact Meteorology and Atmospheric Sciences

Within the field of meteorology and atmospheric sciences, NOAA has an H-index of 93 – meaning that 93 of these articles have been cited in the peer-reviewed literature at least 93 times.



In total, 91% of the 4044 articles have been cited within the peer-reviewed literature.

24% of the 4044 articles fall within the top 10% of the most cited articles in meteorology and atmospheric sciences.

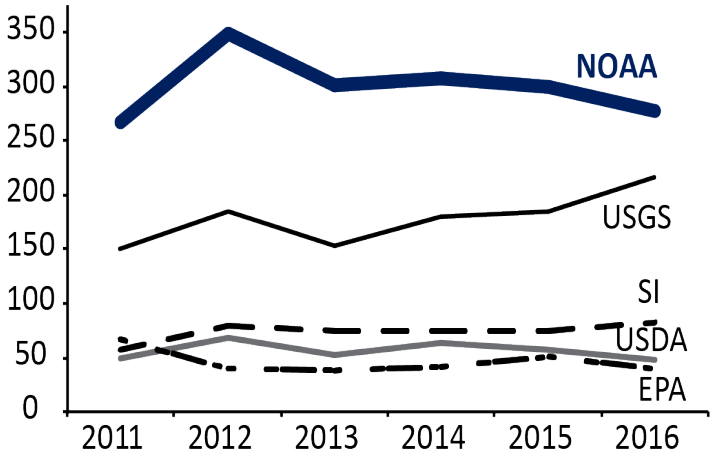


Bibliometrics

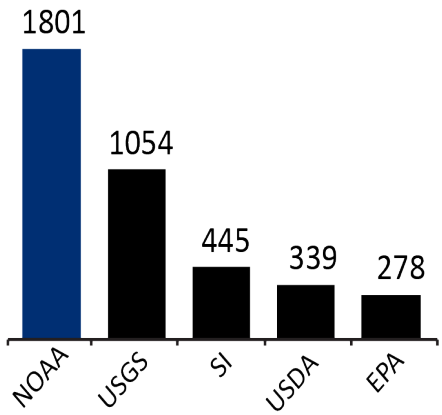
Productivity **Marine and Freshwater Biology**

Between 2011 and 2016, NOAA published an average of 300 per year in the field of marine and freshwater biology, resulting in a total of 1801 articles.

Articles Per Year by Agency



Total Number of Articles by Agency



Top Journals

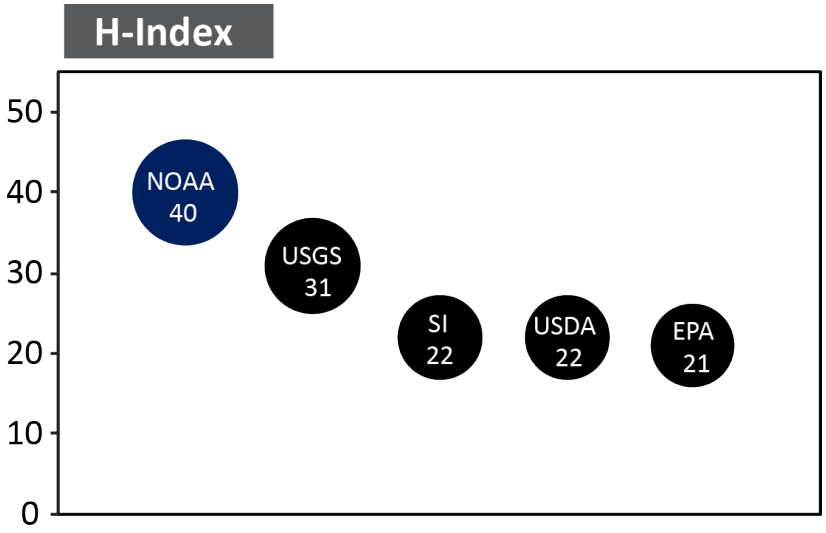
- Marine Ecology Progress Series
- ICES Journal of Marine Science
- Canadian Journal of Fisheries and Aquatic Sciences
- Marine Pollution Bulletin
- PLOS One

Highly Cited Papers

- Brown-Peterson et al. 2011. A Standardized Terminology for Describing Reproductive Development in Fishes. Marine and Coastal Fisheries.
- Sugihara et al. 2012. Detecting Causality in Complex Ecosystems. Science.
- Hunt et al. 2011. Climate impacts on eastern Bering Sea foodwebs: a synthesis of new data and an assessment of the Oscillating Control Hypothesis. IJMS.

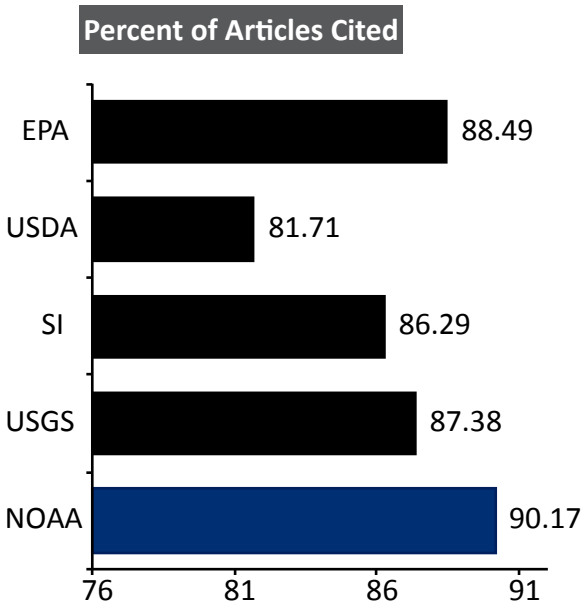
Impact **Marine and Freshwater Biology**

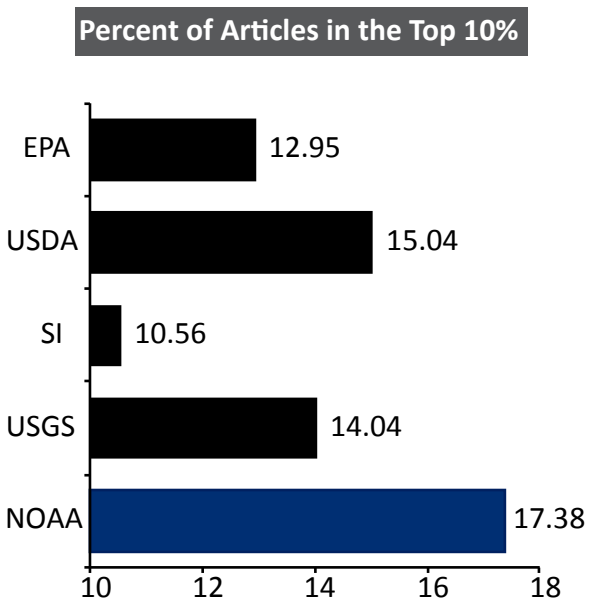
Within the field of marine and freshwater biology, NOAA has an H-index of 40 – meaning that 40 of these articles have been cited in the peer-reviewed literature at least 40 times.



In total, 90% of the 1801 articles have been cited within the peer-reviewed literature.

17% of the 1801 articles fall within the top 10% of the most cited articles in marine and freshwater biology.



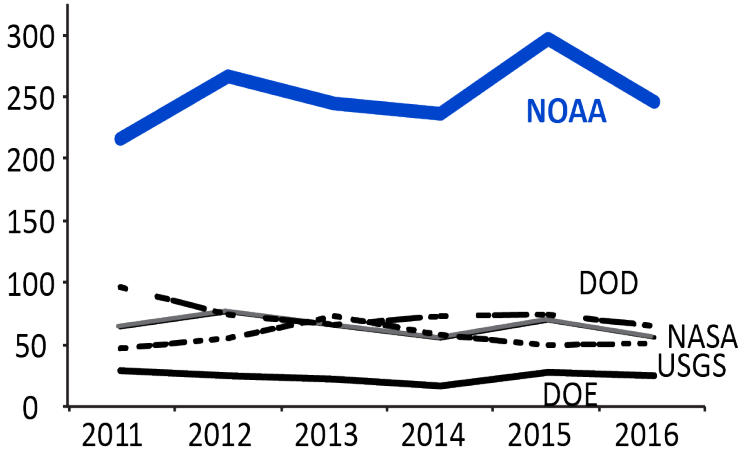


Bibliometrics

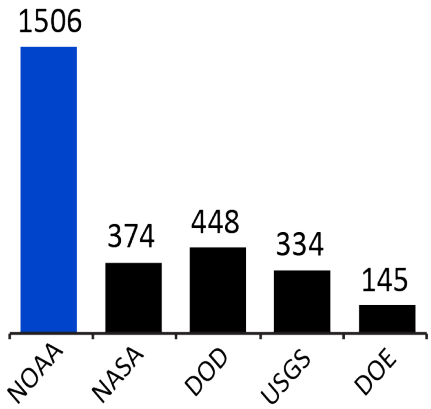
Productivity **Oceanography**

Between 2011 and 2016, NOAA published an average of 251 per year in the field of oceanography, resulting in a total of 1506 articles.

Articles Per Year by Agency



Total Number of Articles by Agency



Top Journals

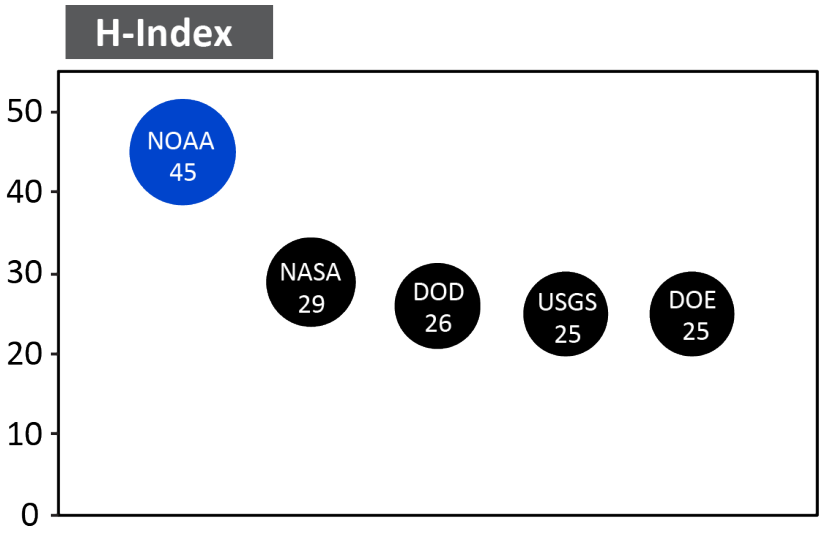
- Marine Ecology Progress Series
- Journal of Geophysical Research-Oceans
- ICES Journal of Marine Science
- Deep-Sea Research Part II-Oceanography
- Oceanography

Highly Cited Papers

- Smith, et al. 2011. Impacts of Fishing Low-Trophic Level Species on Marine Ecosystems. Science.
- Hunt, et al. 2011. Climate impacts on eastern Bering Sea foodwebs: a synthesis of new data and an assessment of the Oscillating Control Hypothesis. IJMS.
- Barton, et al. 2012. The Pacific oyster, Crassostrea gigas, shows negative correlation to naturally elevated carbon dioxide levels: Implications for near-term ocean acidification effects. Liminol Oceanogr.

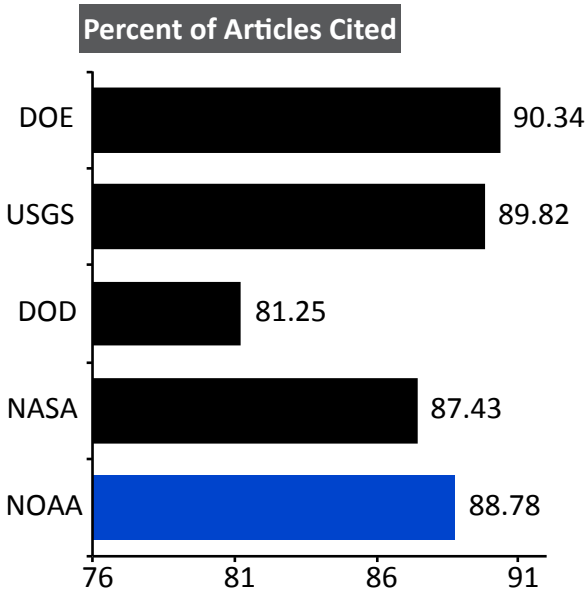
Impact **Oceanography**

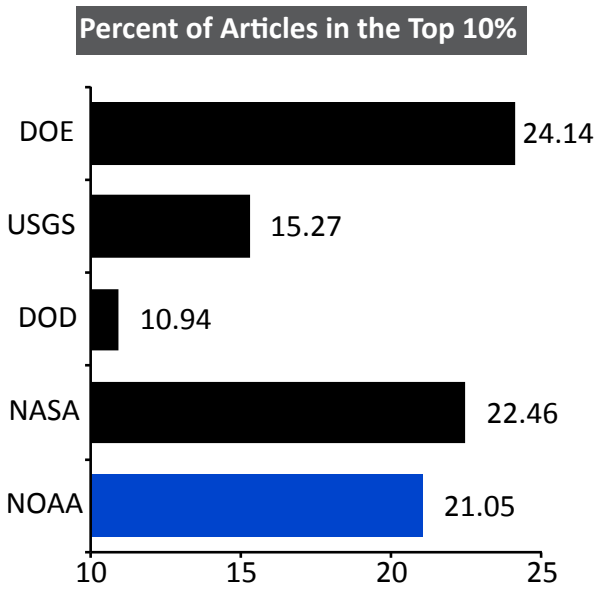
Within the field of oceanography, NOAA has an H-index of 45 – meaning that 45 of these articles have been cited in the peer-reviewed literature at least 45 times.



In total, 89% of the 1506 articles have been cited within the peer-reviewed literature.

21% of the 1506 articles fall within the top 10% of the most cited articles in oceanography.



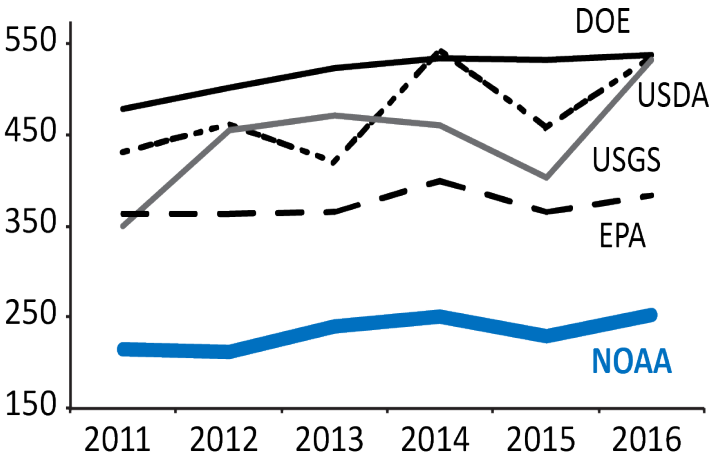


Bibliometrics

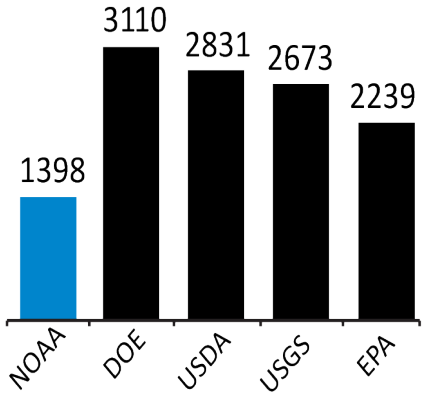
Productivity **Environmental Sciences**

Between 2011 and 2016, NOAA published an average of 233 per year in the field of environmental sciences, resulting in a total of 1398 articles.

Articles Per Year by Agency



Total Number of Articles by Agency



Top Journals

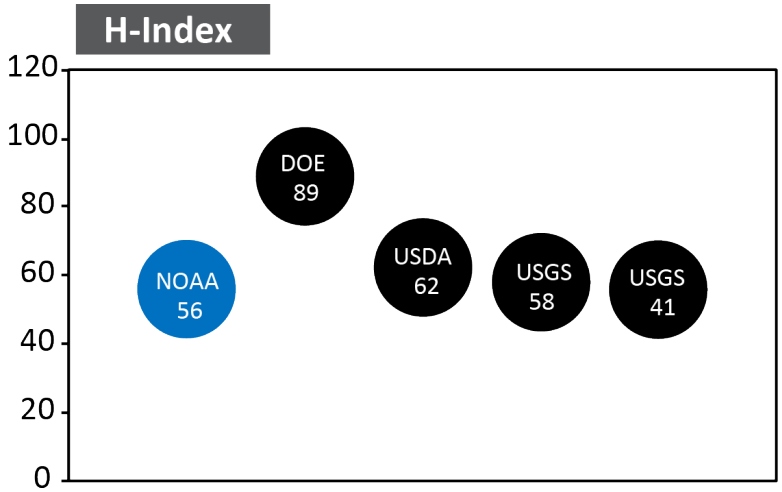
- Nature Climate Change
- Atmospheric Environment
- Environmental Science & Technology
- Climate Change
- Remote Sensing of Environment

Highly Cited Papers

- Meinshausen, et al. 2011. The RCP greenhouse gas concentrations and their extensions from 1765 to 2300. Clim. Change.
- England, et al. 2014. Recent intensification of wind-driven circulation in the Pacific and the ongoing warming hiatus. Nat. Clim. Change.
- Aufdenkampe, et al. 2011. Riverine coupling of biogeochemical cycles between land, oceans, and atmosphere. Front Ecol Environ.

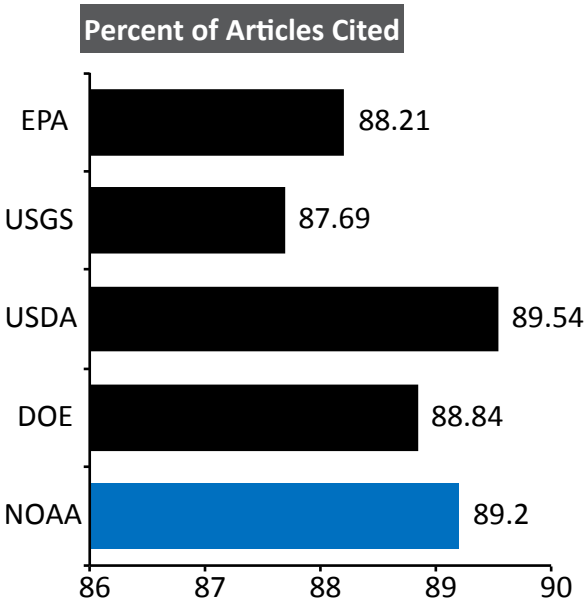
Impact **Environmental Sciences**

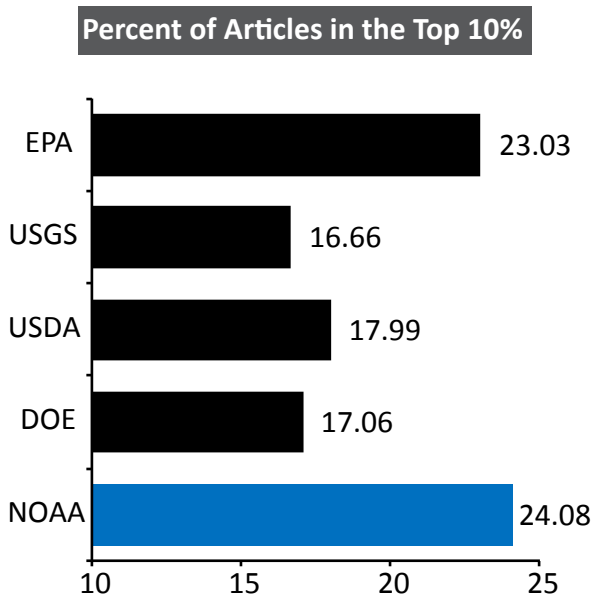
Within the field of environmental sciences, NOAA has an H-index of 56 – meaning that 56 of these articles have been cited in the peer-reviewed literature at least 56 times.



In total, 89% of the 1398 articles have been cited within the peer-reviewed literature.

23% of the 1398 articles fall within the top 10% of the most cited articles in environmental sciences.



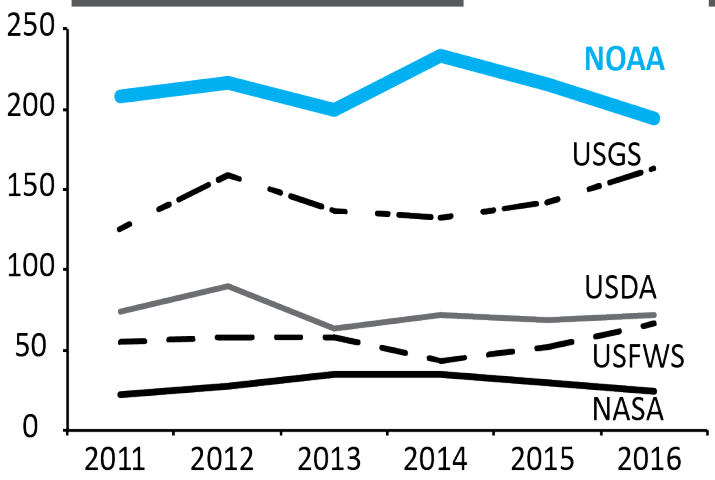


Bibliometrics

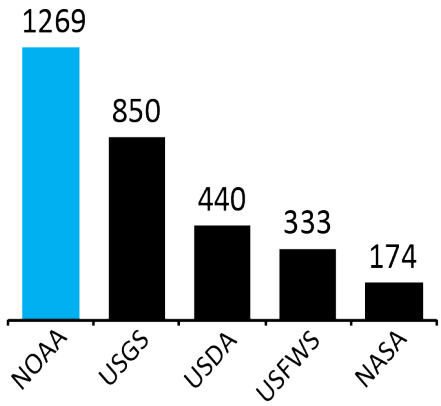
Productivity **Fisheries**

Between 2011 and 2016, NOAA published an average of 212 per year in the field of fisheries, resulting in a total of 1269 articles.

Articles Per Year by Agency



Total Number of Articles by Agency



Top Journals

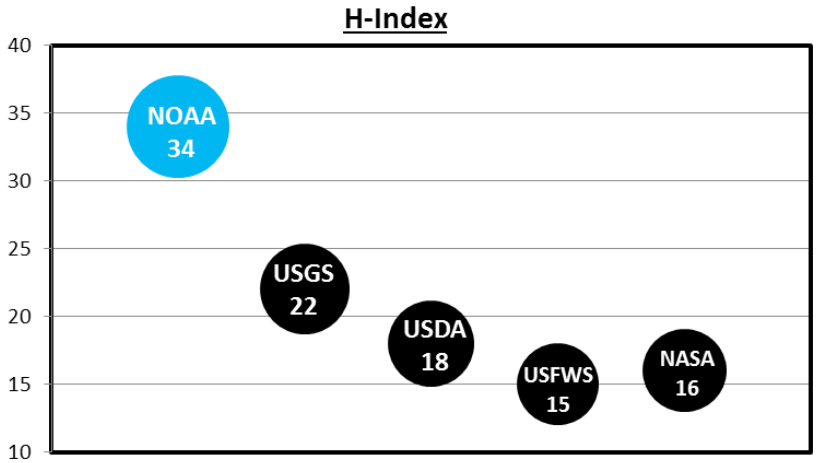
- ICES Journal of Marine Science
- Canadian Journal of Fisheries and Aquatic Sciences
- Fisheries Research
- Transactions of the American Fisheries Society
- Fishery Bulletin

Highly Cited Papers

- Brown-Peterson, et al. 2011. A Standardized Terminology for Describing Reproductive Development in Fishes. Mar. Coast. Fish.
- Fulton, et al. 2011. Lessons in modeling and management of marine ecosystems: the Atlantis experience. Fish Fish.
- Methot, et al. 2013. Stock synthesis: A biological and statistical framework for fish stock assessment and fishery management. Fish Res.

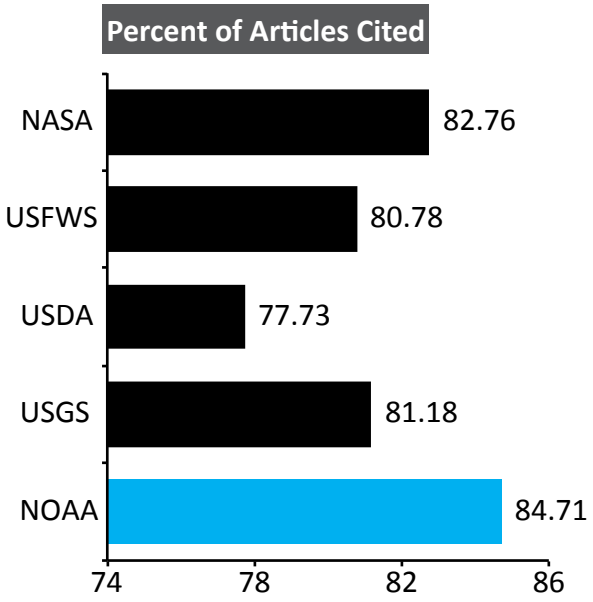
Impact **Fisheries**

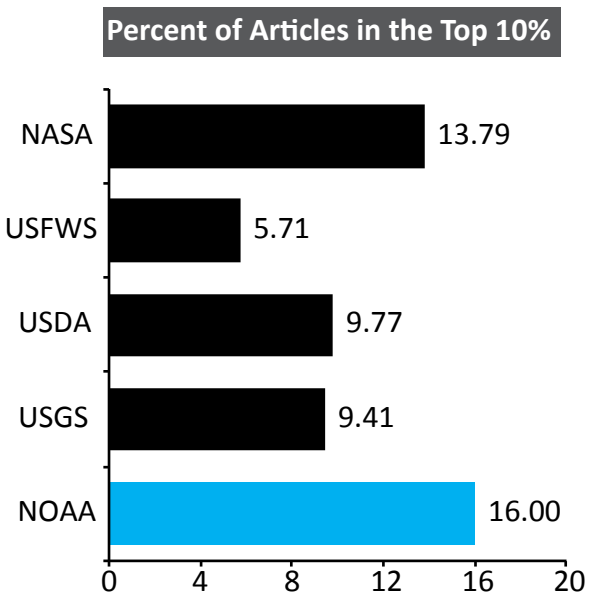
Within the field of fisheries, NOAA has an H-index of 34 – meaning that 34 of these articles have been cited in the peer-reviewed literature at least 34 times.



In total, 85% of the 1269 articles have been cited within the peer-reviewed literature.

16% of the 1269 articles fall within the top 10% of the most cited articles in fisheries.

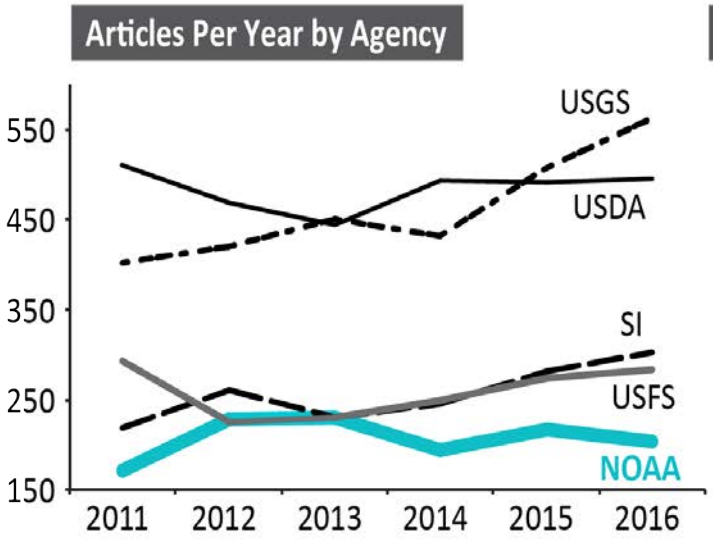


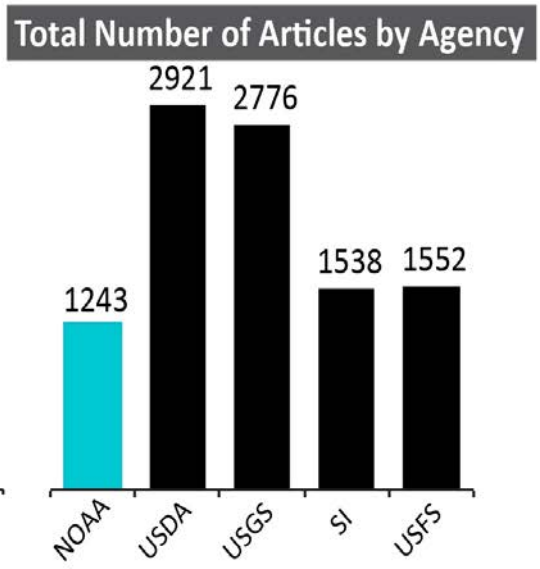


Bibliometrics

Productivity **Ecology**

Between 2011 and 2016, NOAA published an average of 207 per year in the field of ecology, resulting in a total of 1243 articles.





Top Journals

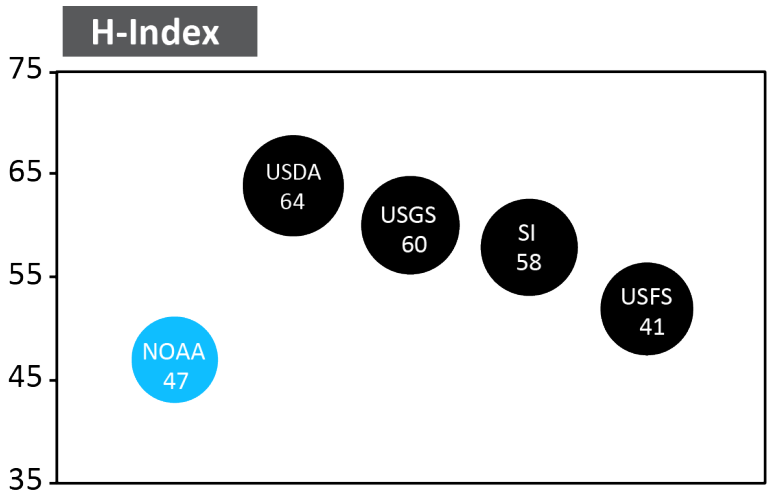
- Marine Ecology Progress Series
- Biogeosciences
- PLOS One
- Proceedings of the Royal Society B- Biological Sciences
- Frontiers in Ecology and the Environment

Highly Cited Papers

- Block, et al. 2011. Tracking apex marine predator movements in a dynamic ocean. Nature.
- Burrows, et al. 2011. The Pace of Shifting Climate in Marine and Terrestrial Ecosystems. Science.
- Aufdenkampe, et al. 2011. Riverine coupling of biogeochemical cycles between land, oceans, and atmosphere. Front Ecol Environ.

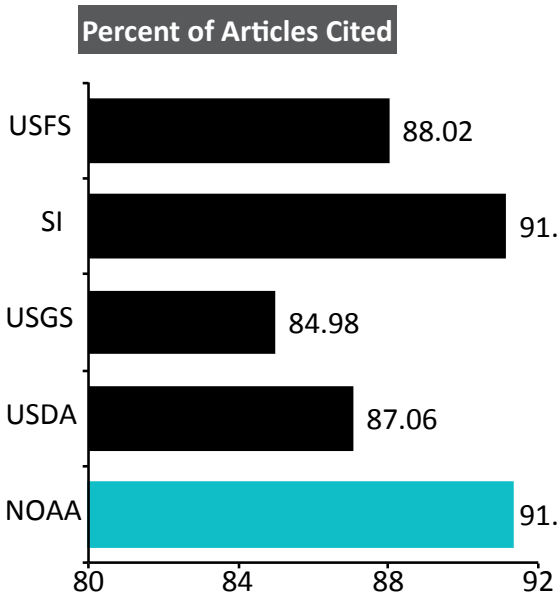
Impact Ecology

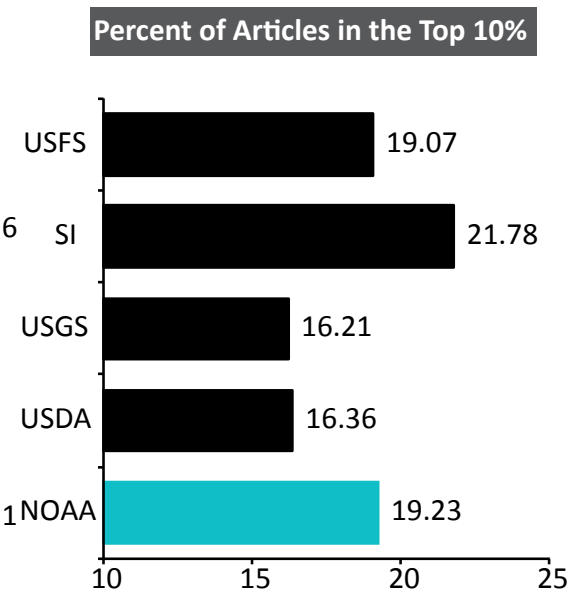
Within the field of ecology, NOAA has an H-index of 47 – meaning that 47 of these articles have been cited in the peer-reviewed literature at least 47 times.



In total, 91% of the 1243 articles have been cited within the peer-reviewed literature.

19% of the 1243 articles fall within the top 10% of the most cited articles in ecology.



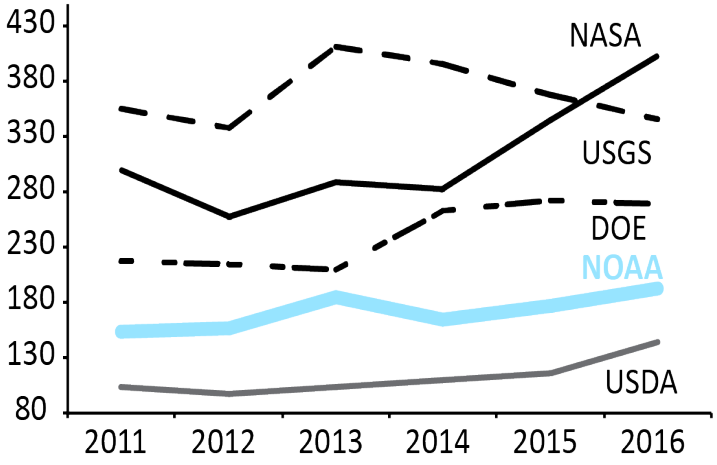


Bibliometrics

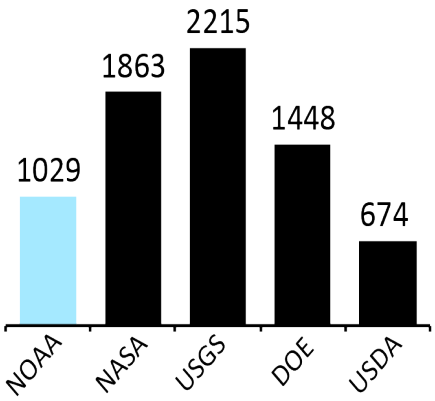
Productivity Geo-Sciences

Between 2011 and 2016, NOAA published an average of 172 per year in the field of geo-sciences, resulting in a total of 1029 articles.

Articles Per Year by Agency



Total Number of Articles by Agency



Top Journals

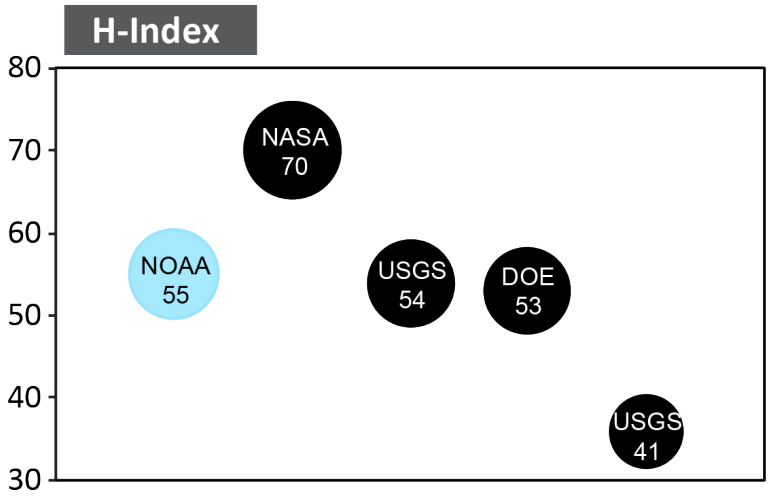
- Geophysical Research Letters
- Biogeosciences
- Nature Geoscience
- Geoscientific Model Development
- Global Biogeochemical Cycles

Highly Cited Papers

- Seton, et al. 2012. Global continental and ocean basin reconstructions since 200 Ma. Earth Science Reviews.
- Levitus, et al. 2012. World ocean heat content and thermosteric sea level change (0-2000 m), 1955-2010. Geophysical Research Letters
- Bopp, et al. 2013. Multiple stressors of ocean ecosystems in the 21st century: projections with CMIP5 models. Biogeosciences.

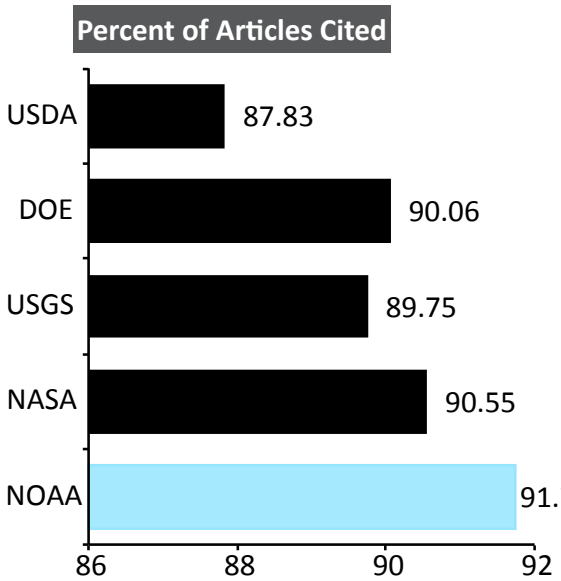
Impact Geo-Sciences

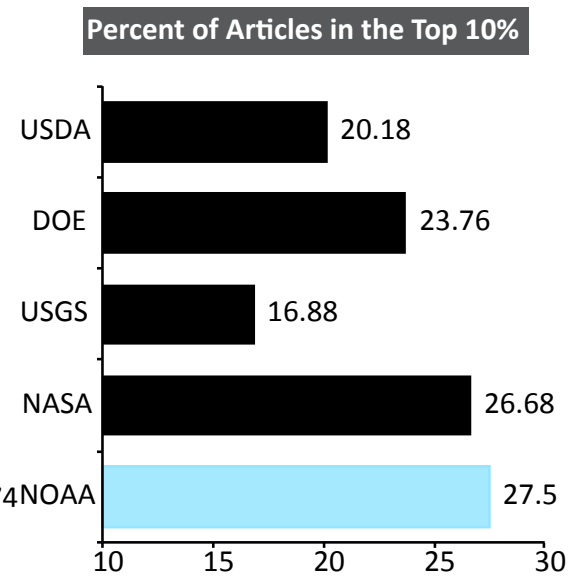
Within the field of geo-sciences, NOAA has an H-index of 55 – meaning that 55 of these articles have been cited in the peer-reviewed literature at least 55 times.



In total, 92% of the 1029 articles have been cited within the peer-reviewed literature.

28% of the 1029 articles fall within the top 10% of the most cited articles in geo-sciences.





NOAA's Scientific Workforce

A creative and vibrant scientific workforce is at the core of NOAA's R&D and mission services enterprise. Each day, NOAA works to improve lives and support livelihoods through the support of a highly skilled, passionate, and diverse workforce, which includes federal employees, contractors, grantees, as well as dedicated volunteers. Today with over 11,300 federal employees and thousands of NOAA team members, NOAA represents leading experts from a diversity of academic disciplines, from researchers studying space weather impacts on electricity here on Earth's surface, to mechanical engineers working on deep sea ocean exploration, to social scientists who investigate how to best communicate storm warnings to the public to prevent casualties.

Scientific Awards and Achievements

Our incredible employees are recognized time and time again through appointments to leadership positions in professional societies, external awards, invitations to speak at prestigious events, and more. Collectively, these employees drive high-quality labs and programs to achieve meaningful work, establishing NOAA as a leader amongst federal agencies in the majority of its main R&D focus areas.

One notable way that outstanding achievements are recognized is through a variety of awards. Within this chapter, you will find the NOAA employee and team member winners for and in support of Scientific or Engineering Achievements. The winners of these awards demonstrate the far-reaching impact that R&D at NOAA can have on the nation.

In addition to scientific achievement, many folks within NOAA receive additional awards for leadership, professional excellence, heroism, and more. While we are unable to list all of the NOAA staff who have been honored this year, you can find the additional award winners within the linked websites (e.g. Department of Commerce Gold and Silver Medals and NOAA Administrator's Award).

Department of Commerce and National Oceanic and Atmospheric Administration Awards

(199 awards presented to 484 individuals and 32 offices)

Award	Recipient(s)	Award Organization
2016 Cline Award	Matthew Sardi, Jeffrey Lewitsky, and Andy Latto	NWS
2016 Cline Award	Michael Ryan	NWS
2016 Cline Award	Derek Giardino, Amanda Schroeder, Roger Erickson, Felix Navejar, Jonathan Brazzell, Lance Escude, Kent Kuyper, Stephen Carboni, Donovan Landreneau, Joseph Rua, Michael Marcotte, Montra Lockwood, Andrew Tingler, Donald Jones, Timothy Humphrey, and Todd Mogged	NWS
2016 Cline Award	Jamie Rhome	NWS
2016 Cline Award	Kennard Kasper and Christopher Rothwell	NWS
2016 Cline Award	Christopher J. Morris, Robert Simpson, Barry Bowers, Melissa Beat, Nicholas Fenner, Lance Goehring, Cynthia B. Elsenheimer, Heather Lorenzen, and Tabatha Seymore	NWS
2016 Cline Award	Daniel Brown and John Cangialosia	NWS
2016 Cline Award	Jennifer Daniel	NWS
2016 Cline Award	Anthony Mignone and John Cannon	NWS
2016 Cline Award	Patricia Douglass	NWS
2016 Cline Award	Krizia Negron Hernandez	NWS
2016 Fisheries Bulletin Best Paper Award	David E. Richardson	NMFS
2016 OAR Outstanding Scientific Paper	John Miller	OAR
2016 OAR Outstanding Scientific Paper	Joseph Resing	OAR
2016 OAR Outstanding Scientific Paper	Jeremy Mathis, Richard Feely, and Jessica Cross	OAR
2016 OAR Outstanding Scientific Paper	Georg Grell	OAR
2016 OAR Outstanding Scientific Paper	Steven Brown, James M. Roberts, Robert Banta, Jessica B. Gillman, Andrew O. Langford, David D. Parrish, Colm Sweeney, Michael K. Trainer, Robert J. Zamora, William P. Dubé, Abigail Koss, Brian M. Lerner, Rui Li, Stuart A. McKeen, Christoph J. Senff, Chelsea R. Thompson, Patrick R. Veres, Rebecca A. Washenfelder, Carsten Warneke, Bin Yuan, and Ravan Ahmadov	OAR

NOAA's Scientific Workforce

Award	Recipient(s)	Award Organization
2017 Department of Commerce Bronze Medal	Dawn "Dee Dee" Anders, Steve Ansari, Steve DelGreco, Ed Kearns, Katy Matthews, Brian Nelson, Ryan Nelson, and Doug Ross	Department of Commerce
2017 Department of Commerce Bronze Medal	Freeman B. Blackwell, Johnny R. Clark, Albert J. McMath, Van D. Crawford, Thomas E. Reynolds, William F. Nock, Mark O. Hall, Gregg Frostrom, Vernon E. McIntosh, and Nathan B. Clark	Department of Commerce
2017 Department of Commerce Bronze Medal	Andre Hammond, Amy Bennett, James Schreiber, Brian Little, Chadd St. Pierre, Russell Dyson, Bruce Plott, Paul Haggerty, Donna McNamara, and Linda Stathoplos	Department of Commerce
2017 Department of Commerce Bronze Medal	GOES-R Ground Segment Project Schedule Management Team	Department of Commerce
2017 Department of Commerce Bronze Medal	Jerod W. Cook	Department of Commerce
2017 Department of Commerce Bronze Medal	Robert Simons	Department of Commerce
2017 Department of Commerce Bronze Medal	Jessica Beck-Stimpert, Susan Bunsick, Michael Rubino, Andrew Strelcheck, Denise Johnson, Stephen Holiman, Shepherd Grimes, Mara Levy, Lauren Lugo, and Heather Blough	Department of Commerce
2017 Department of Commerce Bronze Medal	Christopher D. Wilson, Alejandro De Robertis, and Scott R. Furnish	Department of Commerce
2017 Department of Commerce Bronze Medal	Garwin Yip, Brycen Swart, Evan Sawyer, Brian Ellrott, Amanda Cranford, Eric Danner, Christina Durham, Rachel Johnson, and Maria Rea	Department of Commerce
2017 Department of Commerce Bronze Medal	Jonathan A. Hare, Roger B. Griffis, Larry Alade, Antonie S. Chute, Kiersten L. Curti, Tobey H. Curtis, Daniel Kircheis, John F. Kocik, Sean M. Lucey, Camilla T. McCandless, Lisa M. Milke, David E. Richardson, Eric Robillard, Harvey J. Walsh, and Michael A. Alexander	Department of Commerce
2017 Department of Commerce Bronze Medal	Richard Merrick, Bonnie Ponwith, Russ Beard , Mary Erickson , Frank Parker, Rebecca Allee, Gary Matlock, Lois Schiffer, Chauncey Kelly , and Stephen Smith	Department of Commerce

Award	Recipient(s)	Award Organization
2017 Department of Commerce Bronze Medal	Alaska Regional Office, Alaska Fisheries Science Center, and Office of the General Counsel, Alaska Section	Department of Commerce
2017 Department of Commerce Bronze Medal	Highly Migratory Species Management Division, Southeast Regional Office Information Technology Branch, Southeast Regional Office Limited Access Privilege Programs/ Data Management Branch, and General Counsel for Fisheries and Protected Resources Section	Department of Commerce
2017 Department of Commerce Bronze Medal	Jason Woolard and Jon Sellars	Department of Commerce
2017 Department of Commerce Bronze Medal	Daniel Baumgardt	Department of Commerce
2017 Department of Commerce Bronze Medal	Christa G. von Hillebrandt-Andrade	Department of Commerce
2017 Department of Commerce Bronze Medal	Brian Barjenbruch, Jacob Beitlich, Evan M. Bookbinder, John T. Ferree, Michael J. Hudson, Harold “Jim” Keeney, Jr., Phillip Kurimski, Greg Mann, and Richard Wagenmaker	Department of Commerce
2017 Department of Commerce Bronze Medal	Derek R. Deroche and Brian P. Walawender	Department of Commerce
2017 Department of Commerce Bronze Medal	Ronla Henry, Bryan Ruby, Joshua Watson, William Gery, Tony Freeman, Ulysses Davis, Eugene Petrescu, Eric Lau, Shannon White, and Steve Schotz	Department of Commerce
2017 Department of Commerce Bronze Medal	Yuejian Zhu, Dingchen Hou, Shrinivas Moorthi, and Steven Earle	Department of Commerce
2017 Department of Commerce Bronze Medal	Ocean Prediction Center	Department of Commerce
2017 Department of Commerce Bronze Medal	West Gulf River Forecast Center	Department of Commerce
2017 Department of Commerce Bronze Medal	Weather Forecast Office Amarillo, TX	Department of Commerce
2017 Department of Commerce Bronze Medal	Weather Forecast Office Spokane, WA	Department of Commerce

NOAA's Scientific Workforce

Award	Recipient(s)	Award Organization
2017 Department of Commerce Bronze Medal	Weather Forecast Office Taunton, MA	Department of Commerce
2017 Department of Commerce Bronze Medal	Southeast River Forecast Center, Weather Prediction Center, Weather Forecast Office Wilmington, NC, Weather Forecast Office Charleston, SC, and Weather Forecast Office Columbia, SC	Department of Commerce
2017 Department of Commerce Bronze Medal	Weather Forecast Office Albuquerque, NM, Weather Forecast Office Lubbock, TX, and Weather Forecast Office Midland/Odessa, TX	Department of Commerce
2017 Department of Commerce Bronze Medal	Weather Forecast Office Fairbanks, AK, Weather Forecast Office Anchorage, AK, and Alaska Regional Operations Center	Department of Commerce
2017 Department of Commerce Bronze Medal	Weather Forecast Office New York, NY, Center Weather Service Unit, New York, Weather Forecast Office Mt. Holly, NJ, Weather Forecast Office State College, PA, Weather Forecast Office Pittsburgh, PA, Weather Forecast Office Charleston, WV, Weather Forecast Office Baltimore/Washington, Center Weather Service Unit Leesburg , Weather Forecast Office Blacksburg, VA, Weather Forecast Office Wakefield, VA, Weather Forecast Office Paducah, KY, Weather Forecast Office Louisville, KY, Weather Forecast Office Jackson, KY, Weather Prediction Center, Ocean Prediction Center, and National Aviation Meteorologists Warrenton, VA	Department of Commerce
2017 Department of Commerce Bronze Medal	Eric J. Anderson, Greg A. Lang, John G.W. Kelley, and Aijun Zhang	Department of Commerce
2017 Department of Commerce Bronze Medal	Simone Alin, Catherine Cosca, Richard Feely, Dwight Gledhill, Elizabeth Jewett, Jeremy Mathis, Christopher Sabine, Krisa Arzayus, Russell Brainard , Zdenka Willis	Department of Commerce
2017 Department of Commerce Bronze Medal	Physical Sciences Division, Aircraft Operations Center, and NOAA Ship Ronald H. Brown	Department of Commerce
2017 Department of Commerce Bronze Medal	ENS Max Andersen, ENS Marybeth Head, Alex Ligon, LT Joseph Carrier, LT Matthew Forrest, CAPT Shepard Smith , Kirk Andreopoulos, Michael Peperato, LT Damian Manda, and LT Eric Younkin	Department of Commerce

Award	Recipient(s)	Award Organization
2017 Department of Commerce Gold Medal	James Ott	Department of Commerce
2017 Department of Commerce Gold Medal	Marta Nammack, Shannon Bettridge, Philip Clapham, Nance Young, Angela Somma, Paul Wade, Ruth Ann Lowry, and Brianna Dema	Department of Commerce
2017 Department of Commerce Gold Medal	Brian Cosgrove, Edward Clark, Donna Page, Thomas Graziano, Cham Pham, Mary Mullusky, Simon Hsiao, Steven Earle, Rebecca Cosgrove, and Scott Lindsey	Department of Commerce
2017 Department of Commerce Gold Medal	Mickey Fitzmaurice, Jesse Reich, Chris O'Connors , and Joy Hargraves	Department of Commerce
2017 Department of Commerce Gold Medal	Geostationary Operational Environmental Satellite – R Series Program	Department of Commerce
2017 Department of Commerce Gold Medal	Mark Paese, Mary Ann Kutney, Charles Wooldridge, Mara J. Browne, and Katherine Sharpless	Department of Commerce
2017 Department of Commerce Gold Medal	Jamie Rhome, Jesse Feyen, Douglas Marcy, and Jennifer Sprague	Department of Commerce
2017 Department of Commerce Platinum Medal	James Ott	Department of Commerce
2017 Department of Commerce Silver Medal	Atuatasi-Lelei Peau, Lisa Symons, Dana Wilkes, Dave Lott, Catherine Berg, Ruth Yender, Clifford Edwards, Duane Smith, and Murray Bauer	Department of Commerce
2017 Department of Commerce Silver Medal	Pacific Marine Environmental Laboratory Acoustics Program and Pacific Marine Environmental Laboratory Engineering Development Division	Department of Commerce
2017 Distinguished Career Awards	Glenn Rutledge	NOAA
2017 Distinguished Career Awards	Richard Merrick	NOAA
2017 Distinguished Career Awards	Galen Tromble	NOAA
2017 Distinguished Career Awards	Barbara A. Schroeder	NOAA

NOAA's Scientific Workforce

Award	Recipient(s)	Award Organization
2017 Distinguished Career Awards	James A. Bohnsack	NOAA
2017 Distinguished Career Awards	Ann Matarese Kiernan	NOAA
2017 Distinguished Career Awards	Kathy Salter	NOAA
2017 Distinguished Career Awards	Reed Bohne	NOAA
2017 Distinguished Career Awards	Norman Meade	NOAA
2017 Distinguished Career Awards	Robert Hartman	NOAA
2017 Distinguished Career Awards	Frederick Toepfer	NOAA
2017 Distinguished Career Awards	Richard Wagenmaker	NOAA
2017 Distinguished Career Awards	Ronald J. Stouffer	NOAA
2017 Distinguished Career Awards	Stephen R. Piotrowicz	NOAA
2017 Distinguished Career Awards	Dian Seidel	NOAA
2017 Distinguished Career Awards	Robert C. Hansen	NOAA

Award	Recipient(s)	Award Organization
2017 Dr. Daniel L Albritton Outstanding Science Communicator Award	Sarah Kapnick	OAR
2017 Dr. Daniel L Albritton Outstanding Science Communicator Award	James Overland	OAR
2017 EEO/ Diversity Individual Award	Melinda Marquis	OAR
2017 EEO/ Diversity Laboratory of the year	ESRL	OAR
2017 NESDIS Outstanding Science & Data Management Employees of the Year	Boyin Huang, Viva Banzon, Tim Boyer, Gennady Chepurin, Jay Lawrimore, Matthew Menne, Thomas Smith, Russell Vose, and Huai-Min Zhang	NESDIS
2017 NOAA Administrator's Award	Gregory Mandt	NOAA
2017 NOAA Administrator's Award	Xiangqian Wu and Timothy Schmit	NOAA
2017 NOAA Administrator's Award	Debra Lambert, Erin Schnettler, Galen Tromble, Stephanie Hunt, Seema Balwani, Katherine Renshaw, Scott Breen, Caroline Park, Patrick Lynch, Richard Methot Jr., and Jason Cope	NOAA
2017 NOAA Administrator's Award	John Lamkin, Trika Gerard , Elizabeth Johns, Ryan Smith, and Aras Zygas	NOAA
2017 NOAA Administrator's Award	Martha Nizinski, David Packer, David Stevenson, Brian Kinlan, Jeremy Potter, and Thomas Hourigan	NOAA
2017 NOAA Administrator's Award	Patrick Rutten, Robert Cifelli , Robert Stabler Webb, Mark Strudley, Alan Haynes, Joshua Fuller, Natalie Cosentino-Manning, and David Boughton	NOAA

NOAA's Scientific Workforce

Award	Recipient(s)	Award Organization
2017 NOAA Administrator's Award	Christopher Yates, Robert Coey, Daniel Wilson, Frederick R. Rogers, Eric Shott, Joseph Dillon, Shelby Mendez, and Kathryn Kempton	NOAA
2017 NOAA Administrator's Award	Suzanne B. Bricker and Julie M. Rose	NOAA
2017 NOAA Administrator's Award	Jay Field and Lisa Rosman	NOAA
2017 NOAA Administrator's Award	Randall Kosaki , Kelly Gleason Keogh, and Jason Leonard	NOAA
2017 NOAA Administrator's Award	Adam Mathis	NOAA
2017 NOAA Administrator's Award	Rebecca Cosgrove, Michelle Mainelli, Douglas Fenderson, and Kyle Nevins	NOAA
2017 NOAA Administrator's Award	Ryan Kittell, and Jeffrey Lorens, and William Schneider	NOAA
2017 NOAA Administrator's Award	Brad McCune and Randy Rieman	NOAA
2017 NOAA Administrator's Award	Timothy Schneider, Ivanka Stajner, Vijay Tallapragada, Frederick Toepfer, and Jeffrey Whitaker	NOAA
2017 NOAA Administrator's Award	Robert Hallberg and Stephen Griffies	NOAA
2017 NOAA Administrator's Award	Doug Kennedy and Sherman Fredrickson	NOAA
2017 NOAA Administrator's Award	Nancy Beller Simms	NOAA

Award	Recipient(s)	Award Organization
2017 NOAA Administrator's Award	Guinevere Lewis	NOAA
2017 NOAA Administrator's Award	David A. Score	NOAA
2017 NOAA Administrator's Award	Jeremy Andrucyk, Marlene Kaplan, Lonnie Gonsalves, Michelle Crockett, Natalie Huff, Richard Hill, Nicole Mason, Eli Salahuddin, and DaNa Carlis	NOAA
2017 NOAA Team Members of the Month	Patti Jones, Lindsay Averill, Lans Rothfusz, Mark Wakeam, Erin McNamara, Emre Saricicek, Frank J. Forbell, Sarah Latshaw, Adena G. Fritz, Michelle Clingan, Jamese Sims, Susan Merle, Amy Merten, Kara Stevens , Erin Strange, Jim Durkee, David Dowell, Dale Morris, Kiana Campbell, Thomas Breard, Geoff Carrion, and Randy Cho	NOAA
2017 NOAA Technology Transfer Award	Ronald B. Johnson	NOAA
2017 NOAA Technology Transfer Award	Quay Dortch, Marc Suddleson, Rick Stumpf, Jenifer Rhodes, and Dwight Trueblood	NOAA
2017 NOAA Technology Transfer Award	Dave Eckberg	NOAA
2017 NOAA Technology Transfer Award	Richard J. Okulski, Roman Berdes, John Cannon, and Anthony Mignone	NOAA
2017 NOAA Technology Transfer Award	Melinda Marquis , Curtis Alexander, Stan Benjamin, John M. Brown, James Wilczak, Robret Banta, and Allison McComiskey	NOAA
2017 NOAA Technology Transfer Award	Ariel F. Stein, Barbara J.B. Stunder, Mark D. Cohen, and Roland R. Draxler	NOAA
2017 NOS Employee of the Year	William Sweet	NOS
2017 NOS Employee of the Year	Stephanie Kemerer	NOS

NOAA's Scientific Workforce

Award	Recipient(s)	Award Organization
2017 NOS Employee of the Year (Group Award)	Robert Loesch, Ashley Miller, Laura Rear McLaughlin, Robert Bassett, Brian Johnson, Jennifer McRae, Grace Gray, Brett Gregory, Artara Johnson, Nathan Holcomb, Kevin Harrison, Christopher McGrath, Christopher DiVeglio, Laurita Alomassor, and Kelly Kriner	NOS
2017 NOS Employee of the Year (Group Award)	Robert Heitsenrether, Winston Hensley, Armin Pruessner, Paul Fanelli, and Eddie Roggenstien	NOS
2017 OAR Employee of the Year Award	Noah Lawrence-Salvas	OAR
2017 OAR Employee of the Year Award	Yvette Jefferson	OAR
2017 OAR Employee of the Year Award	LaToya Richardson	OAR
2017 OAR Employee of the Year Award	Gary A. Wick	OAR
2017 OAR Employee of the Year Award	Jasmin John	OAR
2017 OAR Employee of the Year Award	Senita M. Hill	OAR
2017 Peer Recognition Rafting Award	James Noel, Joseph Heim, David Vallee, Alison MacNeil, Ronald Horwood, and Neal Strauss	NOS
2017 Silver Sherman Award	 Anne-Marie Runfola	NOAA
2017 Silver Sherman Award	 Laura Engleby	NOAA
2017 Silver Sherman Award	 Howard Friedman	NOAA

Award	Recipient(s)	Award Organization
2017 Silver Sherman Award	Laurice Churchill	NOAA
2017 Silver Sherman Award	Shawna Karlson	NOAA
2017 Silver Sherman Award	Troy Wilds	NOAA
2017 Silver Sherman Award	Rita Williams	NOAA
2017 Silver Sherman Award	Bobbi Simmons	NOAA
2017 Silver Sherman Award	William Payne	NOAA
2017 Silver Sherman Award	Jennifer Hinden	NOAA
2017 Silver Sherman Award	Pamela Sellman	NOAA
2017 Silver Sherman Award	Clark King	NOAA
2017 Silver Sherman Award	Karen Laskowski	NOAA
2017 Silver Sherman Award	Jeff Van Buskirk	NOAA
2017 Silver Sherman Award	Kimberly Hurst	NOAA
2017 Silver Sherman Award	CAPT Nancy Hann	NOAA
2017 Silver Sherman Award	Wendy Marshall	NOAA
2017 Silver Sherman Award	Jennifer Ise	NOAA
2017 Silver Sherman Award	Joan Langhans	NOAA
2017 Silver Sherman Award	Robert C. Hansen	NOAA
2017 Silver Sherman Award	Tonya Coleman	NOAA
2017 Silver Sherman Award	Michelle Chawlk-Howard	NOAA
2017 Silver Sherman Award	Tim Osborn	NOAA
2017 Silver Sherman Award	Benjamin Dunford	NOAA

NOAA's Scientific Workforce

Award	Recipient(s)	Award Organization
2017 Silver Sherman Award	Shirley Kick	NOAA
2017 Silver Sherman Award	Althea Lee	NOAA
2017 Silver Sherman Award	Lee Benaka	NOAA
2017 Silver Sherman Award	Todd Harding	NOAA
2017 Silver Sherman Award	Ben Sherman	NOAA
2017 Silver Sherman Award	Michelle DeLaFuente	NOAA
2017 Silver Sherman Award	Amanda McCarty	NOAA
2017 Silver Sherman Award	Laurie Mukai	NOAA
2017 Silver Sherman Award	Margaret Eggleston	NOAA
2017 Silver Sherman Award	Tammy Adams	NOAA
2017 Silver Sherman Award	Leila Afzal	NOAA
2017 Silver Sherman Award	Apryl Corey	NOAA
2017 Silver Sherman Award	Carol Breger	NOAA
2017 Silver Sherman Award	Vanessa Rini-López	NOAA
2017 Silver Sherman Award	Donna Franklin	NOAA
2017 Silver Sherman Award	Margot Bohan	NOAA
2017 Silver Sherman Award	Trivita Horton	NOAA
2017 Silver Sherman Award	Raul J. Alvarez II	NOAA

Award	Recipient(s)	Award Organization
2017 Silver Sherman Award	Linda Lawhorn Brown	NOAA
2017 Silver Sherman Award	Katherine Renshaw	NOAA
2017 Silver Sherman Award	Charles A. McLeod	NOAA
2017 Silver Sherman Award	Chauncey Kelly	NOAA
2017 Silver Sherman Award	Tracey Thompson	NOAA
2017 Silver Sherman Award	Sylvia Scott	NOAA
2017 Silver Sherman Award	Andrea Bleistein	NOAA
2017 Silver Sherman Award	Dana Whiteley	NOAA
2017 Silver Sherman Award	Bruce Cowden	NOAA
2017 Silver Sherman Award	Nancy Beller-Simms	NOAA
2017 Silver Sherman Award	Linda Stathoplos	NOAA
2017 Silver Sherman Award	Ron Guilmette	NOAA
2017 Silver Sherman Award	Cheryl Oliver	NOAA
2017 Silver Sherman Award	John Gorman	NOAA
2017 Silver Sherman Award	Douglas Hilderbrand	NOAA
2017 Silver Sherman Award	Michelle Barbieri	NOAA
2017 Silver Sherman Award	Todd Lericos	NOAA
2017 Silver Sherman Award	Rachel Krasna	NOAA
2017 Silver Sherman Award	Terrell "B" Ballard	NOAA
2017 Silver Sherman Award	Ed Farley	NOAA
2017 Silver Sherman Award	Ann Akagi	NOAA

NOAA's Scientific Workforce

Award	Recipient(s)	Award Organization
2017 Silver Sherman Award	CAPT Mike Hopkins	NOAA
2017 Silver Sherman Award	Daniel Cobb	NOAA
2017 Silver Sherman Award	Mike Benavidez	NOAA
2017 Silver Sherman Award	Kathy Middleton	NOAA
2017 Silver Sherman Award	Robert Lane	NOAA
2017 Silver Sherman Award	Jennifer Walsh	NOAA
2017 Silver Sherman Award	Kate Clark	NOAA
2017 Silver Sherman Award	Cynthia Burley	NOAA
2017 Silver Sherman Award	Carol Kavanagh	NOAA
2017 Silver Sherman Award	Lonnie Gonsalves	NOAA
2017 Silver Sherman Award	Nancy Krystkiewicz	NOAA
2017 Silver Sherman Award	Kathleen Bailey	NOAA
Certificate of Appreciation at Tropical Cyclone Operations and Research Forum	Morris Bender and Timothy Marchok	NWS/OAR
New U.S. Patents for Technologies	Daniel M. Murphy	USPO
NOS Contractor Recognition Award	Todd Recicar	NOS
NOS Contractor Recognition Award	Giuseppe Masetti	NOS

External Scientific Awards

(74 awards presented to 107 individuals and 3 offices)

Award	Recipient(s)	Award Organization
AGU Fellow	Stephen Griffies	American Geophysical Union
AGU Fellow	Georgory E. Tucker	American Geophysical Union
AGU Fellow	Walter H.F. Smith	American Geophysical Union
AMS Fellow	Alexander Ryzhkov	American Meteorological Society
AMS Fellow	Jin Huang	American Meteorological Society
AMS Fellow	Shian-Jian Lin	American Meteorological Society
AMS Fellow	Michael A. Alexander	American Meteorological Society
AMS Fellow	Georg A. Grell	American Meteorological Society
AMS Fellow	Gregory C. Johnson	American Meteorological Society
AMS Fellow	Roger S. Pulwarty	American Meteorological Society
AMS Fellow	Elizabeth C. Weatherhead	American Meteorological Society
AMS Fellow	Jeffrey S. Whitaker	American Meteorological Society
AMS Fellow	Samuel P. Williamson	American Meteorological Society
AMS Fellow	Fuzhong Weng	American Meteorological Society
Annual Achievement Award	Joseph Olson, Eric James, and Kathy Lantz	Utility Variable-Generation Integration Group
Atmospheric Sciences Ascent Award	Larry W. Horowitz	American Geophysical Union
Aviation Meteorology Award	Judy E. Ghirardelli	National Weather Association
BBVA Foundation Frontiers of Knowledge Award for Climate Change	Syukuro Manabe	BBVA Foundation
Bernhard Haurwitz Memorial Lecturer	George Kiladis	American Meteorological Society

NOAA's Scientific Workforce

Award	Recipient(s)	Award Organization
California Academy of Sciences Fellow	Carlos Garza	California Academy of Sciences
Charles Franklin Brooks Award	David R. Smith	American Meteorological Society
Charles L Mitchell Award	Daniel Keeton	American Meteorological Society
CIRA Research and Service Initiative Award	Melissa Petty	Cooperative Institute for Research in the Atmosphere
CIRES Bronze Medal	Physical Sciences Division Staff	Cooperative Institute for Research in Environmental Sciences
CIRES Employee of the Year Award	Dave Costa, Leslie Hartten, Darren Jackson, Paul Johnston, Don Murray, and Dan Wolfe	Cooperative Institute for Research in Environmental Sciences
CIRES Gold Medal for Scientific/ Engineering Achievement	Gilbert Compo, Prashant Sardeshmukh, and Chesley McColl	Cooperative Institute for Research in Environmental Sciences
Colorado Governor's Awards for High-Impact Research	Valery Zavorotny	CO-LABS
Colorado Governor's Awards for High-Impact Research	Daniel T. Lindsey	CO-Labs
Denny Medal	Joaquin Trinanes and Gustavo Goni	Institute of Marine Engineering, Science, and Technology
Distinguished Service Award	Lee Benaka	American Fisheries Society
Dr. T. Theodore Fujita Research Achievement Award	Richard Thompson	National Weather Association
Editor's Award Winners	Brian Etherton	American Meteorological Society
Editor's Award Winners	Heather Archambault	American Meteorological Society

Award	Recipient(s)	Award Organization
Editor's Award Winners	Pierre-Emmanuel Kirstetter	American Meteorological Society
Editor's Award Winners	Shuguang Wang	American Meteorological Society
Editor's Award Winners	James LaDue	American Meteorological Society
Editor's Most Recently Chosen Notable Papers	Daniel Murphy, Hagen Telg, Scott Stalin, and Tim Bates	Aerosol Science and Technology
Employee of the Year Award (Scientific Category)	Sang-Ki Lee	South Florida Federal Executive Board
Errington Lifetime Conservation Award	Barbara Taylor	Iowa State University
Excellence in Partnering Award	James Hendee, Elizabeth Johns, Christopher Kelble, and Christopher Sinigalliano	National Oceanographic Partnership Program
Excellence in Science & Technology	V. Ramaswamy	University at Albany Alumni Association
Francis W. Reichelderfer Award	Christopher C. Balch	American Meteorological Society
Henry Stommel Research Award	Gregory C. Johnson	American Meteorological Society
Highly Cited Researcher	Andrew Wittenberg	Clarivate Analytics
Highly Cited Researcher	Isaac Held	Clarivate Analytics
Highly Cited Researcher	Larry W. Horowitz	Clarivate Analytics
Highly Cited Researcher	Paul Ginoux	Clarivate Analytics
Highly Cited Researcher	Thomas Delworth	Clarivate Analytics
International Sea Turtle Society President's Award	Vincent Saba	International Sea Turtle Society
Jeremy Grantham Lecture on Climate Change	V. Ramaswamy	Divecha Centre for Climate Change
Joanne Simpson Mentorship Award	Kenneth F. Carey	American Meteorological Society
Kenneth C. Spengler Award	Elizabeth C. Weatherhead	American Meteorological Society

NOAA's Scientific Workforce

Award	Recipient(s)	Award Organization
Larry R. Johnson Special Award	National Weather Service Operations Proving Ground	National Weather Association
Lifetime Achievement Award	R. Michael Hardesty	International Coordination-group for Laser Atmospheric Studies (ICLAS)
NASA Group Achievement Award	Ru-Shan Gao, Shang Liu, Troy Thornberry, Steve Ciciora, Andrew Rollins, Laurel Watts, James Elkins, Geoff Dutton, Brad Hall, Eric Hintsa, Fred Moore, David Nance, Dale Hurst, Emrys Hall, Allen Jordan, Stephanie Evan, Karen Rosenlof, Cathy Rasco, Debra Dailey-Fisher, Annie Davis, Richard McLaughlin, and Eric Ray	NASA
Notable Papers chosen by the Editorial Advisory Board	Daniel Murphy	Aerosol Science and Technology
Notable Technology Development Award	Scott Abbott, Tom Ayers, Daniel Gottas, Jesse Leach, Clark King, and Allen White	Federal Laboratory Consortium Mid-Continent Region
Operational Achievement Award Group	National Weather Service Forecast Office Las Vegas, NV	National Weather Association
Outstanding Performance Award for Science and Engineering	Derek Hageman	Cooperative Institute for Research in the Environmental Sciences
Outstanding Performance Award for Service	Sandy Starkweather	Cooperative Institute for Research in Environmental Sciences
Outstanding Reviewer Award	Aaron Levine	American Geophysical Union
Outstanding Reviewer Award	Lori Bruhwiler	American Geophysical Union
Outstanding Reviewer Award	Michael McPhaden	American Geophysical Union

Award	Recipient(s)	Award Organization
Outstanding Reviewer Award	Robert Rogers	American Geophysical Union
Outstanding Reviewer Award	Wayne Angevine	American Geophysical Union
Outstanding Reviewer Award	Rik Wanninkhof	Institute Of Physics
Presidential Early Career Award for Scientists and Engineers (PECASE)	Mandy Karnauskas	White House Office of Science and Technology Policy
Presidential Early Career Award for Scientists and Engineers (PECASE)	Corey Potvin	White House Office of Science and Technology Policy
Presidential Early Career Awards for Scientists and Engineers (PECASE)	Anne Perring	White House Office of Science and Technology Policy
Rober D. Cess Distinguished Lecture	Isaac Held	Stony Brook University
Special Achievement Award	Trisha Palmer	National Weather Association
Special Achievement in GIS Award (SAG)	Fernando Salas and Nathan Swain	ESRI
Sverdrup Gold Medal Award	Michael A. Alexander	American Meteorological Society
Young Alumnus Award	Adam Clark	Iowa State College

NOAA's Scientific Workforce

Scientific Integrity

NOAA and its sister agencies have put Scientific Integrity at the forefront, addressing two aspects of the issue: 1) raising the stature of our research scientists in the Federal government; and 2) addressing scientific misconduct.

For the former, NOAA has developed procedures and policies to ensure that employees are encouraged to serve in an official capacity as an officer or board member of a non-profit organization. These prestigious positions give our scientists the opportunities to help frame and direct research agendas and priorities within the relevant technical communities. As a result, NOAA now has over 40 scientists serving in these capacities, and many of those serving have done so at the highest levels. The impact this will have on our ability to recruit and retain top scientific talent into the federal government is quite powerful.

This list reflects only those NOAA personnel who were actually serving in FY 2017.

NOAA Scientist	Job Title	Professional Society	Position
Deborah Lee	Director, Great Lakes Environmental Research Laboratory	American Academy of Water Resources	President-elect, President, Past President
Fiona Horsfall	Chief, NWS Climate Services Division	American Association of State Climatologists	ex-Officio Executive Board
Tamara Houston	Regional Climate Services Program Manager	American Association of State Climatologists	ex-Officio Executive Board
Shivonne Nesbit	Fish Biologist/ESA Permit Specialist	American Fisheries Society	Officer of the Executive Committee
Linda Rhodes	Supervisory Research Microbiologist	American Fisheries Society Fish Health Section	Secretary-Treasurer
Patrick Lynch	National Stock Assessment Program Lead	American Fisheries Society-Marine Fisheries Section	Secretary-Treasurer
Richard McBride	Supervisory Research Fish Biologist	American Fisheries Society-Marine Fisheries Section	Northeastern Division Representative to Board

NOAA Scientist	Job Title	Professional Society	Position
Richard Methot, Jr.	Senior Scientist for Stock Assessments; Chair of the Council of NOAA Fellows	American Fisheries Society-Marine Fisheries Section	President-elect, President, Past President
Allen Shimada	Fishery Management Biologist, Office of Science and Technology (OST)	American Institute of Fishery Research Biologists (AIFRB)	Treasurer and Chair of the Investment Committee
Andrea Bleistein	Physical Scientist	American Meteorological Society	Councilor
Tanja Fransen	Meteorologist in Charge	American Meteorological Society	Councilor on the Executive Board
Gail Hartfield	Lead Meteorologist	American Meteorological Society	Councilor
John Cortinas	Director, Office of Weather and Air Quality	American Meteorological Society	Councilor
George Leshkevich	Physical Scientist, Great Lakes Environmental Research Lab	American Society for Photogrammetry and Remote Sensing Eastern Great Lakes Region	Secretary/ Treasurer
Carrie Haisley	Meteorologist in Charge	Anchorage Chapter of the American Meteorological Society	Acting President
Carrie Haisley	Meteorologist in Charge	Anchorage Chapter of the American Meteorological Society	Treasurer
Christine Lipsky	Research Fishery Biologist	Aqua Kids TV	President and Science Advisory, Board of Directors
Christine Lipsky	Research Fishery Biologist	Atlantic International Chapter of the American Fisheries Society	Secretary/ Treasurer
Jayme Layber	Hydrologist	California Geographic Information Association	Board Member
Michael Carver	Resource Protection Specialist	California Whale Rescue	Member, Board of Directors
Marie DeLorenzo	Research Ecologist	Carolina's Society of Environmental Toxicology and Chemistry	Member, Board of Directors
Peter Key	Research Biologist	Carolina's Society of Environmental Toxicology and Chemistry	Member, Board of Directors

NOAA's Scientific Workforce

NOAA Scientist	Job Title	Professional Society	Position
Alisa Young	Physical Scientist	Colorado Association of Black Professional Scientists and Engineers	Board Member
Dan Kowal	Chief, Standards & Evaluation Branch	Colorado State Science Fair	Treasurer
James Manning	Research Oceanographer	Educational Passages	Member, Board of Directors
Derek Parks	Technology Transfer Program Manager	Federal Laboratory Consortium	Member, Board of Directors
Michelle Crockett	National Program Manager EEO and Diversity	Federally Employed Women	Immediate Past President
Chris Yates	Fish and Wildlife Administrator	Honda Marine Science Foundation	Member, Board of Directors
Christa von Hillebrandt-Andrade	Manager, Caribbean Tsunami Warning Program	International Association with Physical Science of the Oceans	Member of the Executive Committee
Richard Litaker	Supervisory Ecologist	International Society for the Study of Harmful Algae	Vice President
Bart Merrick	Education Coordinator, NOAA Chesapeake Bay Office (NCBO)	Maryland Association for Environmental and Outdoor Education (MAEOE)	Member, Board of Directors
Lisa Milke	Research Fishery Biologist	National Shellfisheries Association	Secretary
Jared Guyer	Lead Forecaster, Storm Prediction Center	National Weather Association	Councilor
John Gagan	Science and Operations Officer	National Weather Association	Council Member
Gail Hartfield	Senior Forecaster at Weather Forecast Office Raleigh, NC	National Weather Association	President
Todd Lericos	Meteorologist in Charge	National Weather Association	Councilor
Jennifer McNatt	Emergency Response Meteorologist	National Weather Association	Councilor

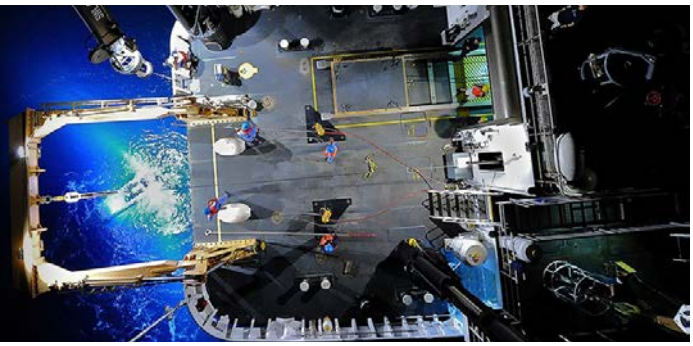
NOAA Scientist	Job Title	Professional Society	Position
Trisha Palmer	Senior Forecaster, Weather Forecast Office Greenville-Spartanburg, SC	National Weather Association	Councilor
Pat Spoden	Science and Operations Officer, Weather Forecast Office Paducah, KY	National Weather Association	Councilor
Michael Vescio	Meteorologist in Charge	National Weather Association	Secretary
Frank Brody	Meteorologist in Charge	National Weather Association	Councilor: Commissioner of Committees
Randy Graham	Meteorologist in Charge, Weather Forecast Office Salt Lake City, UT	National Weather Association	Secretary
Stephania K. Bolden	Supervisory Fisheries Biologist	North American Sturgeon and Paddlefish Society	Member at Large of the Governing Board
Robert Schwemmer	Regional Maritime Heritage Coordinator, ONMS	Santa Barbara Maritime Museum (SBMM)	Member, Board of Directors
Kathy Moore	Biologist	Society for Wildlife Forensic Science	Director of Professional Development
Eugene Olmi	Program Analyst	Southeastern Estuarine Research Society	Past President
Steve Runnels	Warning Coordination Meteorologist	Southwest Missouri Emergency Support organization	Secretary
Jeffrey Kelley	General Forecaster/ Meteorologist	The High Plains Chapter of the American Meteorological Society/National Weather Association	Treasurer

NOAA's Scientific Workforce

Laboratory and Program Science Reviews

Peer review and evaluation is critical in maintaining NOAA's world-class research enterprise. Each line office takes a different approach to implementing the reviews of their laboratories and programs, consistent with the principles and guidance expressed in NAO 216-115B. The NAO on Research and Development in NOAA requires an evaluation of NOAA's R&D activities by performing regular, independent peer review assessments at least every five years. These reviews assess R&D activities for quality of the science, as well as how well the activities meet NOAA's mission needs and/or requirements (i.e. relevance and performance). Each line office takes a different approach to implementing the required reviews, consistent with the mandates of the NAO.

Office of Oceanic and Atmospheric Research Science Program and Laboratory Reviews



In 2017, NOAA Research conducted program reviews of the Unmanned Aircraft Systems (UAS) Program.

External reviewers assessed the quality of the laboratories' research and development, and they reviewed the approaches that are in place to ensure that high quality work will be performed in the future. Furthermore, they assessed progress toward meeting NOAA Research's goal to conduct preeminent research. Reviewers assessed the degree to which the research and development is relevant to NOAA's mission and of value to the Nation. Finally, reviewers assessed the overall effectiveness with which the laboratories' plan and conduct their research and development, given the resources provided, to meet NOAA Strategic Plan objectives and the needs of the Nation

Museum Science Industry Chicago

Laboratory/Office	Last Review Date
Atlantic Oceanographic and Meteorological Laboratory (AOML)	2014
Air Resources Laboratory (ARL)	2016
Earth System Research Laboratory (ESRL)	2015
Geophysical Fluid Dynamics Laboratory (GFDL)	2014
Great Lakes Environmental Research Laboratory (GLERL)	2016
National Severe Storms Laboratory (NSSL)	2015
Pacific Marine Environmental Laboratory (PMEL)	2014
Unmanned Aircraft Systems Program (UAS)	2017

National Weather Service Science Program and Laboratory Reviews

The NOAA National Weather Service (NWS) focuses on transitioning science advancements from research partners, such as NOAA Research labs and the external research community, into the NWS by advancing their technical readiness levels and implementing them into operations based on prioritized operations and service requirements.

NWS developmental and transition organizations include the Environmental Modeling Center, Meteorological Development Laboratory, and National Water Center. In addition, the NWS field structure includes Science and Operations Officers (122) at Weather Forecast Offices, Development and Operations Hydrologists (13) at River Forecast Centers and seven (7) science support branches located within the National Centers for Environmental Prediction (NCEP) that provide science support and transition capabilities.

NWS has regular processes to provide systematic science and management oversight and independent review for NWS developmental and transition organizations that ensure NWS development and transition priorities are consistent with operations service delivery requirements. These processes include annual planning processes for operations and budget execution, quarterly program reviews conducted by NWS senior leadership, and annual reviews of NWS operational modeling and centralized product/service suites by stakeholders, partners, and users. NWS also has a standing community advisory group of independent scientific experts under the auspice of University Corporation for Atmospheric Research (UCAR) to conduct annual reviews that ensure NWS models, tools, products and services are based on sound science.

Independent reviews, e.g., the UCAR group, provide findings and recommendations to NWS programs, and these are addressed by relevant leadership in a formal response that includes a time-line of action items. NWS development and transition organization's' response and action results are reported to the review group at the subsequent annual review meetings.

NOAA's Scientific Workforce

National Marine Fisheries Service Science Program Reviews

Sound science is critical for making the right decisions when it comes to managing our nation's fisheries and protected species. To maintain our world-class science, NOAA Fisheries continually strives to advance the science that informs fisheries and protected resources management. In January 2013, as part of ongoing improvement efforts, NOAA Fisheries began a systematic peer review process at all six of our regional science centers and our headquarters Office of Science and Technology. Experts from within and outside the agency carefully examine our fisheries science programs on a 5-year cycle to evaluate the quality, relevance, and performance of science and research conducted in NOAA Fisheries Science Centers and associated laboratories to strategically position the agency in planning future science and research.

Independent reviewers provide recommendations to each Science Center program and these are addressed by relevant leadership in a formal response that includes a time-line of action items. At the end of each year, a national response to the full suite of review reports is developed that includes action items best addressed at the national level.

The schedule of annual reviews covers the core science program areas that directly support the NOAA Fisheries mission. Over a five-year period, NOAA Fisheries will review programs that support:

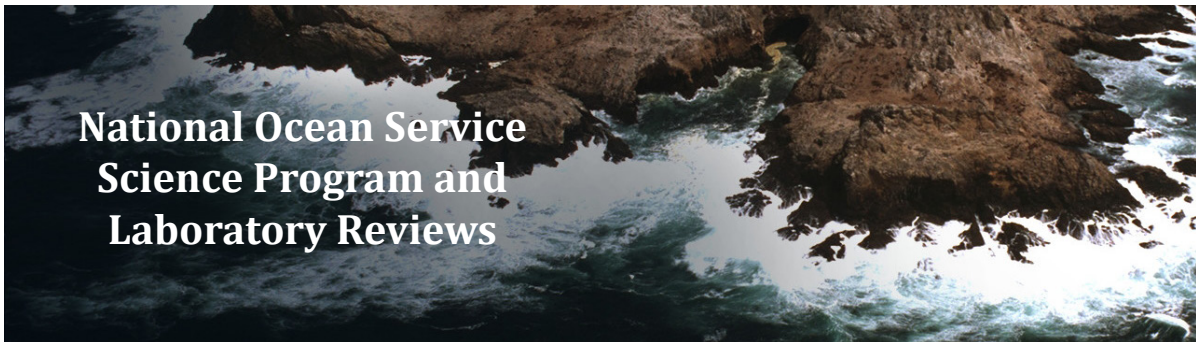
- FY 2013 – Data used for fishery stock assessments
- FY 2014 – Fishery stock assessment process
- FY 2015 – Protected species science
- FY 2016 – Ecosystem, climate, and habitat science
- FY 2017 – Economics and social science

In FY 2017, NOAA Fisheries completed a 5 year review cycle covering all major science programs at the Regional Science Centers and the Office of Science and Technology. During FY 2018, NOAA Fisheries will conduct a strategic analysis all program review results (34 individual reviews).

NOAA Fisheries Regional Science Centers, Associated Laboratories, and Offices that conduct science programs covered by NOAA Fisheries Science Program Reviews

NMFS Regional Science Center /Office	Associated Laboratories
Alaska Fisheries Science Center Seattle, WA	Auke Bay, AK
Northeast Fisheries Science center Woods Hole, MA	Milford, CT Narragansett, RI Orono, ME Sandy Hook, NJ
Northwest Fisheries Science Center Seattle WA	Manchester, WA Mukilteo, WA Newport, OR Pasco, WA Point Adams, OR
Pacific Islands Fisheries Science Center Honolulu, PI	
Southeast Fisheries Science Center Miami, FL	Beaufort, NC Galveston, TX Lafayette, LA Panama City, FL Pascagoula, MS Stennis, MS
Southwest Fisheries Science Center La Jolla, CA	Santa Cruz, CA Monterey, CA
Office of Science and Technology, Headquarters, Silver Spring, MD	Washington, DC

NOAA's Scientific Workforce



Science from the NOAA National Ocean service delivers ecosystem science solutions to help sustain coastal communities and economies. Ultimately this research:

- underpins NOAA's ability to predict and prepare for natural events and their impacts;
- enables faster and more accurate and efficient coastal mapping and monitoring;
- develops a multidisciplinary approach to understanding and conserving coral reef ecosystems; and
- helps assess risk.

National Center for Coastal Ocean Science (NCCOS)

Historically, NCCOS conducted periodic reviews of each of its Centers. These Centers were least reviewed between 2005 and 2012. An NOS-wide assessment between 2010 and 2012 provided extensive feedback and recommendations for coastal science , which initiated a realignment of NCCOS' science portfolio.

From 2014-2016 the office established a portfolio management system to oversee four key science priorities. Beginning in FY17, NCCOS will cycle through annual reviews on each of these priority areas:

- Stressor Impacts and Mitigation: HABs and Hypoxia Research Review beginning Q2 FY18

National Estuarine Research Reserve System

The National Estuarine Research Reserve System (NERRS) is a network of 29 coastal sites designated to protect and study estuarine systems. National estuarine research reserves are living laboratories, ideal sites for research and long-term monitoring.

Science Collaborative

The NERRS Science Collaborative, a competitive grant program, is the mechanism by which most of the NOAA-funded research undertaken at the nation's research reserves is accomplished. An external review of the effectiveness of collaborative science projects is currently underway. The University of Michigan, as the administrator of the NERRS Science Collaborative, is contracting with a third party to conduct the review. Results are expected in September 2018.

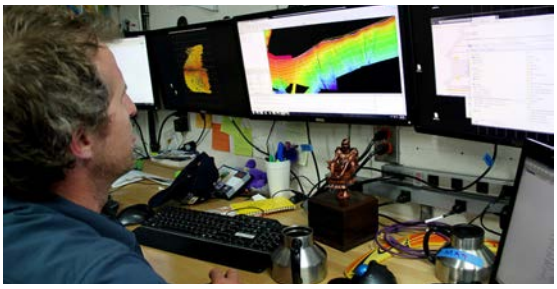
System-Wide Monitoring Program (SWMP)

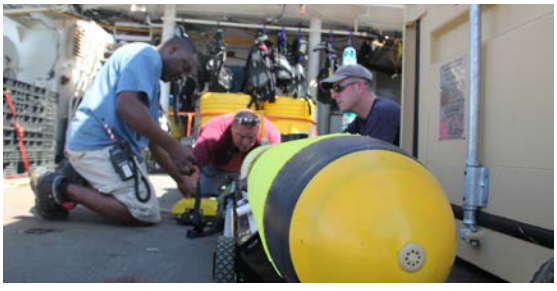
The monitoring program, known as the System-Wide Monitoring Program, provides long-term data on water quality, weather, biological communities, habitat, and land-use and land-cover characteristics. The use of standardized instrumentation and protocols for data collection at each reserve establishes the NERRS as a coordinated network of coastal observing sites for detecting and understanding environmental change. A comprehensive review of the SWMP was conducted in 2007 by an external review panel.

Coral Reef Conservation Program Science Evaluation

The NOAA Coral Reef Conservation Program (CRCP) contributed funds to the National Academies of Science for the purpose of a National Research Council (NRC) review of interventions that might be implemented to improve resilience of corals into the future. Evaluation of uncertainties, benefits, and risks of various coral intervention techniques in an ecosystem context could direct future research needs and inform policy, legal, and ethical issues. The NRC's ad hoc committee will review and evaluate novel ecological and genetic interventions that have potential to enhance recovery and sustainability of corals under near-future scenarios of rapidly deteriorating environmental conditions that are warmer, less favorable for calcification, have impaired water quality, and pose continuing disease threats. The final report will review emerging science, assess risks and benefits of intervention strategies in an ecosystem context, recommend additional research, and identify appropriate interventions for the next 5 to 20 years in the Atlantic/Caribbean coral reef ecosystems.

NOS Office	Lab/Program	Last Review Date
National Estuarine Research Reserve System (NERRS)	System-Wide Monitoring Program	2007
	Science Collaborative Program	Expected completion in September 2018
Coral Reef Conservation Program (CRCP)	NRC Coral Intervention Study	2017
Office of Coast Survey	Annual Peer review of the Joint Hydrographic Center	2017





NOAA's Scientific Workforce

National Environmental Satellite, Data, and Information Service Science Program and Laboratory Reviews

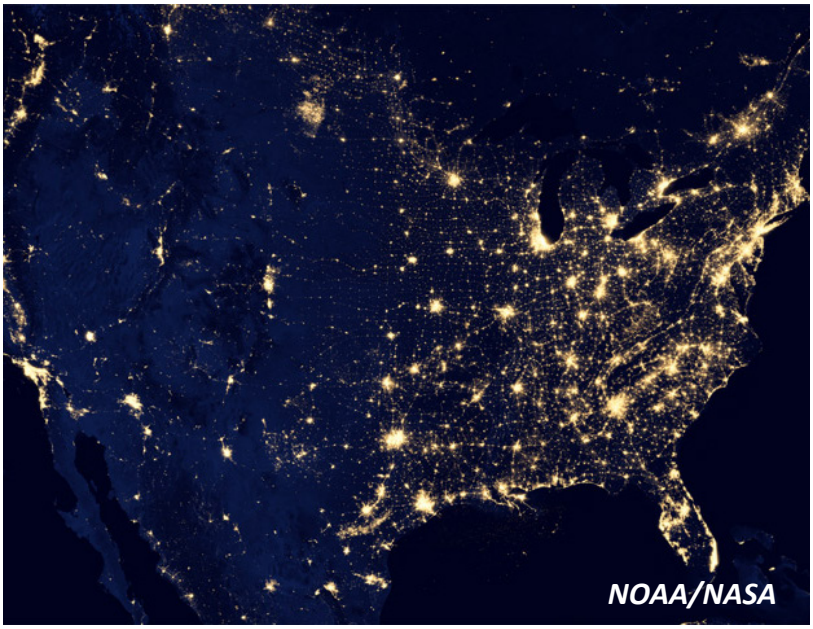
NESDIS' Center for Satellite Applications and Readiness (STAR) translates NOAA's investment in the acquisition and management of the nation's operational environmental satellites into information value for NOAA users. For NOAA satellites, STAR fulfills the critical role of developing data product algorithms which translate low level data into useful information, calibrating the satellite sensors to make the data accurate, and validating the data products to assure they meet the intended purpose. After transition to operations, STAR performs long-term maintenance of calibration and data product quality, and provides anomaly resolution. For Partner Satellites, STAR assures the data streams are quality assured, tailored to NOAA user needs and fit for purpose. To support users, STAR conducts training, user readiness and risk reduction activities. To prepare for the future and meet strategic stakeholder objectives, STAR conducts scientific-research which advances Satellite Remote Sensing methods to aid formulation of next generation sensors and data products and advance their maturity for future stakeholder use.

NESDIS Centers for Environmental Information (NCEI) provide data stewardship and archival storage for environmental information produced across NOAA's missions and observing systems, and for selected partner environmental information; produces retrospective data products that combine relevant sources of observations and environmental data into information products across all time scales and NOAA environmental domains relevant to a broad range of users both inside and outside the agency; and provides access to archived data sets and information products. NCEI conducts scientific research to advance stewardship, understanding of environmental phenomenon, methods for information products, and applications. Environmental Domains include meteorology, oceanography, cryosphere, climatology, space weather, and geophysics. An independent team of distinguished scientific administrators conducted an External Review of STAR research and development on March 19-21, 2010. It was STAR's first External Review since 2000.

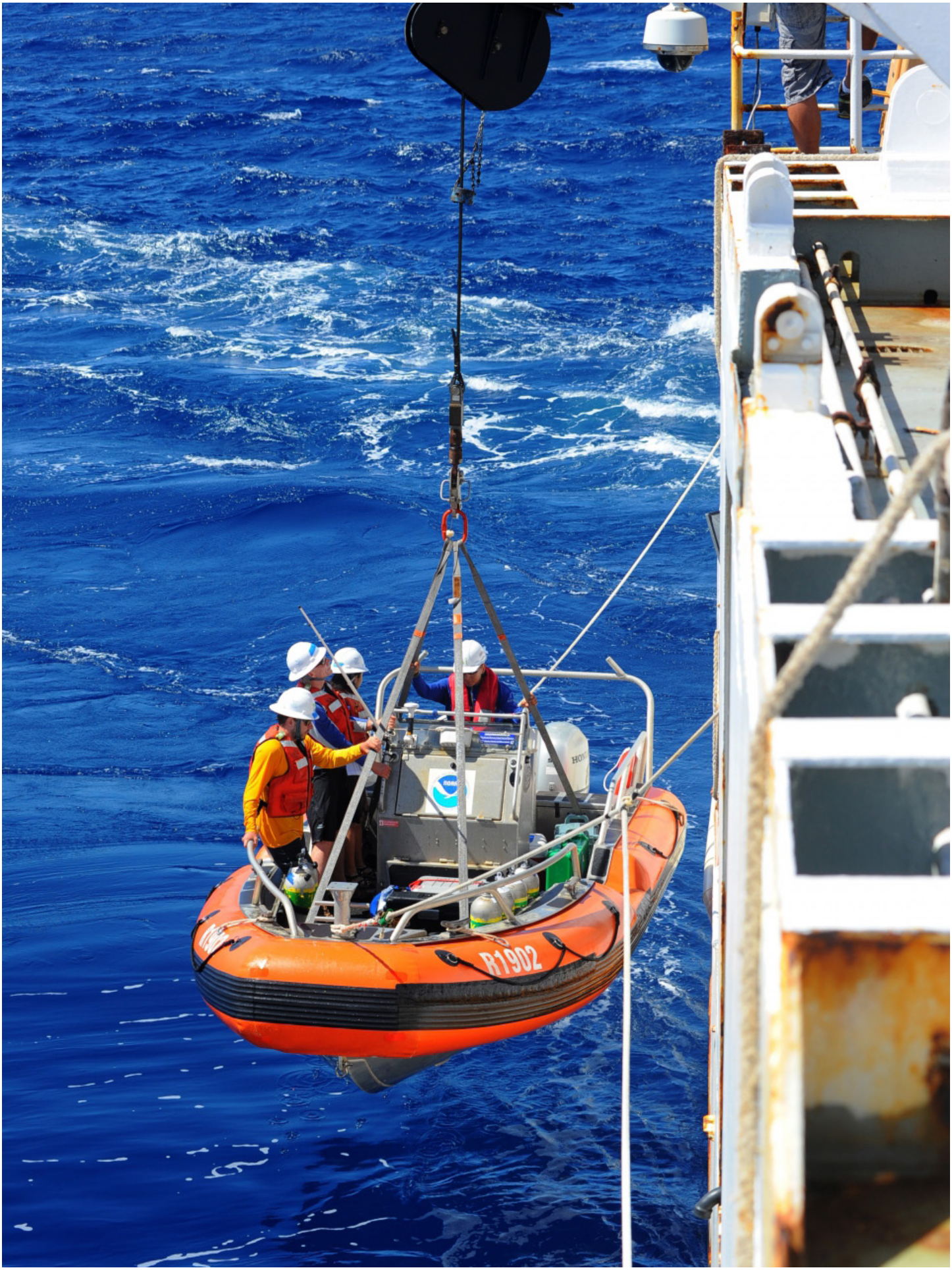
Although such reviews had typically been conducted every five years, STAR's 2005 review was delayed while NOAA directed improvements to the oversight of NOAA science based on a) the quality of research, b) the relevance to NOAA's mission, and c) the performance of the research organization.

The new guidelines went into effect in 2009. STAR was the first organizations to be reviewed under those guidelines. Neither NCEI or its predecessor organizations – National Climatic Data Center, National Oceanographic Data Center, or National Geophysical Data Center have been reviewed under the policy.

Laboratory/Office	Last Review Date
Center for Satellite Applications and Research	2010


NOAA/NASA


Lockheed Martin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Concluding Thoughts

Scientific research and development are the foundation for the myriad of services NOAA provides the American people. In 2017, NOAA scientists developed innovative technologies, deployed cutting-edge scientific techniques, and transformed predictive model capabilities. NOAA research aided emergency response efforts across the country from the Western United States wildfires to the Eastern United States Hurricanes. Additionally, our research enhanced the efficiency and safety of our nation's ports, improved fisheries management plans to ensure productive fisheries for years to come, developed methods to improve aquaculture production, and made advances in weather forecasting.

In addition to serving all Americans, NOAA is committed to producing quality science. A rigorous assessment of NOAA's scholarly research demonstrated that NOAA has the highest productivity among federal agencies in the fields of meteorology and atmospheric science, marine and freshwater biology, oceanography, and fisheries. This outstanding productivity and impact of NOAA's research reflects our continued commitment to Science, Service, and Stewardship.

The many scientific achievements highlighted in this report are made possible by our talented workforce. Between 2016 and 2017, our scientists received over 580 individual and 30 team Department, NOAA, and external accolades. Our continued success depends on maintaining a vibrant and diverse workforce.

Thank you for looking at this year's NOAA Science Report representing a selection of NOAA's work on behalf of the American people. I am proud of all that NOAA has accomplished, and look forward to NOAA's future accomplishments in the coming years.

Craig N. McLean
NOAA Research Council Chair
December 2017

Glossary

ADCP	Acoustic Doppler Current Profiler
API	Application Program Interface
AWS	Amazon Web Services
BDP	Big Data Partnership
CAMEO	Computer-Aided Management of Emergency Operations
CI	Cooperative Institute
CNES	Centre National D'Etudes Spatiales
CO-OPS	Center for Operational Oceanographic Products and Services
CPC	Climate Predication Center
CRADA	Cooperative Research and Development Agreement
CRCP	Coral Reef Conservation Program
CTB	Climate Test Bed
DOC	Department of Commerce
DOT	Department of Transportation
DSCVR	Deep Space Climate Observatory Satellite
eDNA	Environmental DNA
ENSO	El Niño Southern Oscillation
ESP	Environmental Sample Processor
ESR	Ecosystem Status Report
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FAA	Federal Aviation Administration
FACETS	Forecasting A Continuum of Environmental Threats
FEMA	Federal Emergency Management Agency
FLASH	Flooded Locations and Simulated Hydrographs
FV3	Finite-Volume on a Cube Sphere
FY	Fiscal Year
GFDL	Geophysical Fluid Dynamics Lab
GFS	Global Forecast System
GOES-R	Geostationary Operational Environmental Satellite R-Series
GPS	Global Positioning System
GRAV-D	Gravity for the Redefinition of the American Vertical Datum
GSI	Gridpoint Statistical Interpolation
HAB	Harmful Algal Bloom
HMON	Hurricanes in a Multi-scale Ocean-coupled Non-hydrostatic model
HRRR	High-Resolution Rapid Refresh
HWRF	Hurricane Weather Research and Forecast
HYCOM	Hybrid Coordinate Ocean Model
iATON	Iridium Aids-to-Navigation ADCP
IDSS	Impact-Based Decision Support Services
IHO	International Hydrographic Organization
ITAE	Innovative Technology for Arctic Exploration

JPSS	Joint Polar Satellite System
J-SCOPE	JISAO Seasonal Coastal Ocean Prediction of the Ecosystem
mPing	Meteorological Phenomena Identification Near the Ground
NAO	NOAA Administrative Order
NASA	National Aeronautics and Space Administration
NCCOS	National Centers for Coastal Ocean Science
NCEI	National Centers for Environmental Information
NERRS	National Estuarine Research Reserve
NESDIS	National Environmental Satellite, Data, and Information Service
NEXRAD	Next Generation Weather Radar
NGS	National Geodetic Survey
NLDAS	North American Land Data Assimilation System
NMFS	National Marine Fisheries Service
NMME	North American Multi-Model Ensemble
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NPP	National Polar-orbiting Partnership
NSF	National Science Foundation
NSSL	National Severe Storms Laboratory
NWFSC	Northwest Fisheries Science Center
NWM	National Water Model
NWS	National Weather Service
OA	Ocean Acidification Program
OAP	Ocean Acidification Program
OAR	Office of Oceanic and Atmospheric Research
OCC	Open Commons Consortium
OMAO	Office of Marine and Aviation Operations
PIFSC	Pacific Islands Fisheries Science Center
PORTS	Physical Oceanographic Real Time System
R&D	Research and Development
R2O	Research to Operations
R2X	Research to Operations, Applications, Commercialization, and Utilization
RAP	Rapid Refresh
RAS	Recirculating Aquaculture Systems
RL	Readiness Level
RTAP	Research Transition Acceleration Program
S4	Supercomputer for Satellite Simulations and Data Assimilation Studies
SCIPP	Southern Climate Impacts Planning Program
SS	Stock Synthesis
SST	Sea Surface Temperature
SWMP	System-Wide Monitoring Program
UAS	Unmanned Aircraft System
USGS	United States Geological Survey
VIIRS	Visible Infrared Imaging Radiometer
WCOA	West Coast Ocean Acidification
WoF	Warn on Forecast
WoS	Web of Science
WRN	Weather-Ready Nation

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GOES satellite observing Earth

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