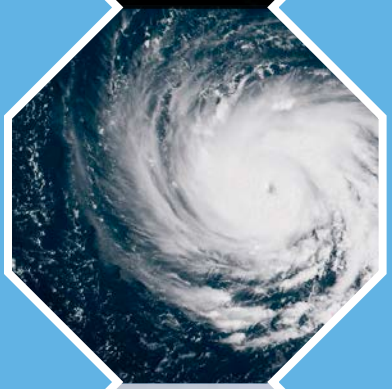

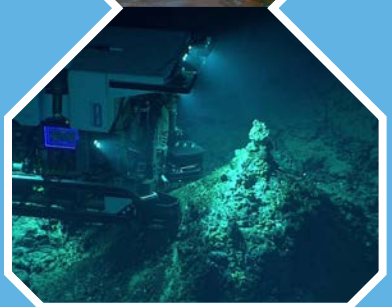

2018

NOAA Science Report

National Oceanic and Atmospheric Administration

U.S. Department of Commerce

NOAA Technical Memorandum NOAA Research Council-001

2018 NOAA Science Report

Harry Cikanek, Ned Cyr, Ming Ji, Gary Matlock, Steve Thur

NOAA
Silver Spring, Maryland

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UNITED STATES
DEPARTMENT OF
COMMERCE

Wilbur Ross
Secretary

NATIONAL OCEANIC
AND ATMOSPHERIC
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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. NOAA's research extends from the depths of the ocean to the surface of the sun with NOAA scientists working around the clock and across the globe to serve NOAA's mission. In 2018 alone, NOAA observed never-before-seen solar storms on the surface of the sun and launched new satellites into space. Together with our Cooperative Institutes, NOAA unveiled new weather models that better predict hurricane intensity, supported public safety by forecasting where volcanic ash would travel when a volcano erupted in Hawai'i, and produced tools that provide early warnings for drought.

NOAA scientists responded to harmful algal blooms producing forecasts to warn the public what beaches red tides will affect. Tools were released to aid in opening up new areas to aquaculture and enable safe navigation into the nation's busiest ports. New species and habitats were discovered at the bottom of the ocean. Through all of this work, NOAA science supports a robust U.S. economy and enhances national security.

All of these achievements are made possible by NOAA's highly-skilled workforce who uphold the highest standards of scientific integrity. NOAA's scientists are consistently recognized, both domestically and internationally, as the top experts in their fields.

This year's NOAA Science Report highlights only a fraction of NOAA's scientific achievements. As you read through the report, I hope you will gain a better understanding of the importance NOAA research has on the economy, environment, and communities across the nation.

Craig N. McLean
NOAA Research Council Chair
December 2018

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, 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

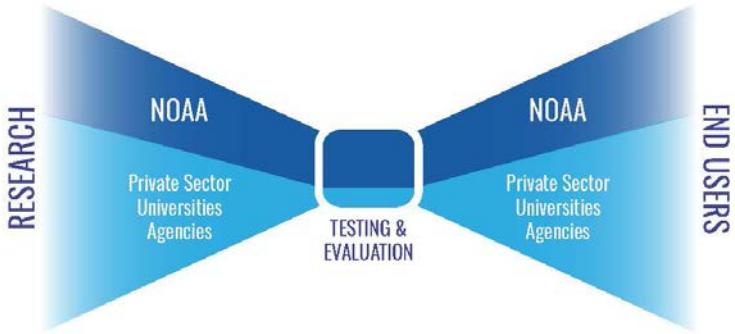
1. To understand and predict changes in climate, weather, oceans and coasts.

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.

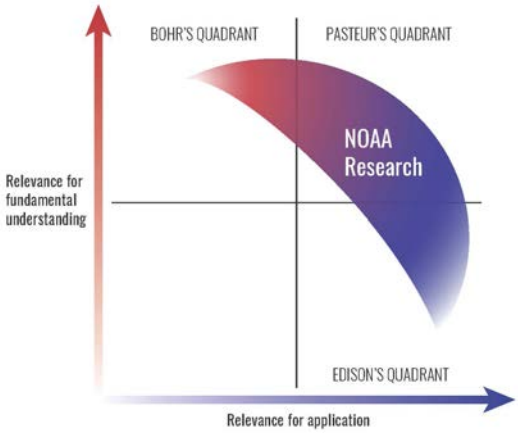
What Kind of Research NOAA Supports

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).

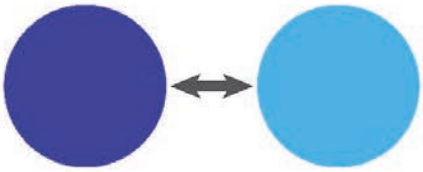
This sets NOAA on the cutting edge of R&D while still ensuring that we meet the needs and expectations of our users.



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's research strives for this dual relevance as reflected in Pasteur's quadrant.*

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.



LONG TIME TO MATURITY

HYBRID

REGULATORY

Services
Research for Services

In the past, NOAA analyzed the balance of investment [Fluharty et al., 2006; MacDonald et al., 2006]. Most recently, NOAA issued 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 to the left.

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 Institute (Prospectus for Cooperative Institutes in the 21st Century -CI21[NOAA, 2016e]) and Cooperative Science Center agreements with universities; the Sea Grant Program; the National Oceanographic Partnership Program (NOPP), extramural grant programs; contracts; Cooperative Research and Development Agreements with the private sector; and more.

NOAA is dedicated to building the U.S. economy and supporting U.S. businesses through its Small Business Innovation Research (SBIR) and Technology Transfer Programs.

NOAA Contributes to a Strong and Resilient U.S. Economy

NOAA is dedicated to building the U.S. economy and supporting U.S. businesses through its Small Business Innovation Research (SBIR), Cooperative Research and Development Agreements (CRADAs), and Technology Transfer Programs.

Small Business Innovation Research (SBIR) is a highly competitive program that encourages domestic small businesses to engage with federal government in developing products and services that have potential for commercialization while being relevant to the agency mission. In fiscal year 2018, NOAA invested roughly $10 million in innovative research and development (R&D) projects to the small business community through the SBIR program. As per the SBIR legislation, all technologies developed and data produced in the NOAA SBIR program belong to the small businesses. This ensures that there's a clear path for commercialization, one of the main goals of the SBIR program. NOAA benefits from these innovative technologies through innovation and scientific advancement. More importantly, SBIR serves as an economic stimulus not only to these small businesses, but, if successfully commercialized, to the public and local communities through potential jobs created in their respective industries.

Examples of funded projects include Tridentis, LLC for the design of an autonomous, green powered, mobile coastal monitor and Creare, LLC for the manual and automated marine weather observations using smartphones.

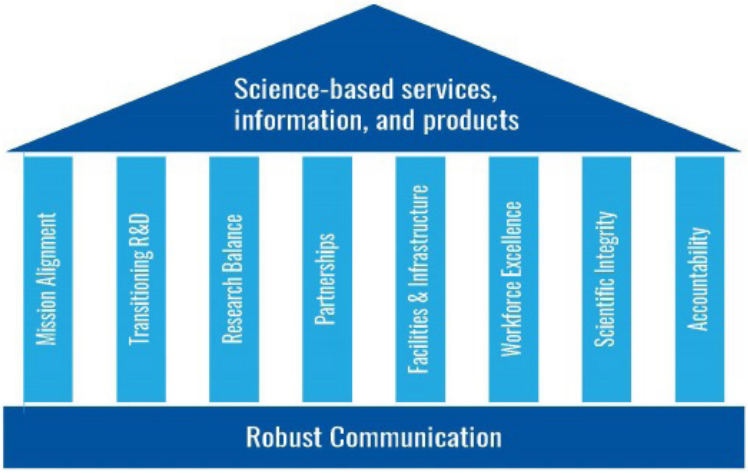
NOAA currently has 47 Cooperative Research and Development Agreements, or CRADAs, with private industry covering the full range of our research and development applications. A total of nine new agreements were signed in 2018, with another 16 agreements in various stages of development. In 2018, NOAA initiated its first Facilities Use CRADA as an innovative way to allow companies to conduct research and development at NOAA facilities for work that is supportive of the Laboratory mission. In the case of the 2018 CRADA, NOAA is providing laboratory space to a U.S. company for work in support of our aquaculture mission. NOAA has also extended its five CRADAs with the major U.S. Cloud Services Providers in support of the NOAA Big Data Project. NOAA's vast wealth of data represents a substantial untapped economic opportunity. The NOAA Big Data Project (BDP) was created to explore the potential benefits of storing copies of these data in the Cloud to allow computing directly without requiring further costly distribution. Such an approach could help form new lines of business and economic growth while making NOAA's data more easily accessible to the American public.

NOAA has a portfolio of 19 technologies that are currently under patent protection and either have been licensed or are available for licensing to industry. For example, NOAA offered up its patented NOy Cavity Ringdown technology to industry through the Small Business Innovation Research (SBIR) program in an innovative approach to commercialization. A small, Boulder-based company, High Precision Devices (HPD) won the contract to commercialize the device and received a follow-up award to generate a commercial prototype. The technology, which was developed at NOAA Research, will ideally provide a solid revenue stream both domestically and overseas for HPD. In addition to the patent portfolio, NOAA actively promotes 27 royalty-free technologies that are available to industry.

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.



NOAA's Two Priority Objectives

NOAA is supporting the Department of Commerce's Strategic Plan through two priority objectives [NOAA 2018]:

1. Minimize the impacts of extreme weather and water events by implementing the Weather Research and Forecasting Innovation Act, with the underlying goal to regain world leadership in weather modeling.

2. Accelerating the American Blue Economy, with specific focus on reducing the nation's seafood trade deficit through expanded marine aquaculture.

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.

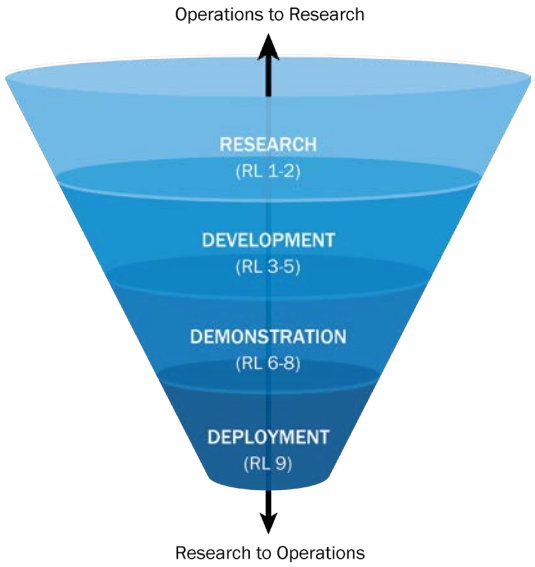
The National Environmental Satellite, Data, and Information Service (NESDIS) aims to provide timely access to global environmental data from satellites and other sources to promote, protect and enhance the Nation's economy, security, environment and quality of life. Their research activities involve environmental satellite remote sensing, 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.

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) 2018, a total of $23 million was awarded to OAR 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 funding is split between two programs: the Joint Technology Transfer Initiative (JTTI) and Ocean-Joint Technology Transfer Initiative (O-JTTI).

Created by the Weather Research and Forecasting Innovation Act of 2017 (P.L. 115-25), the JTTI ensures continuous development and transition of the latest scientific and technological advances into operations of the NOAA NWS. O-JTTI was modeled after JTTI, but with focus on transitions to operations and applications supporting a blue economy. Combined, the two programs will improve the process and provide 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.

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.

Short-term Inundation Forecasting for Tsunamis

Using tsunami measurements from the Deep-ocean Assessment and Reporting of Tsunami (DART) system, NOAA Research and NOAA NWS developed Short-term Inundation Forecasting for Tsunamis (SIFT) to forecast tsunami wave arrival times, amplitudes, and flooding. Development started with funding through the National Tsunami Hazard Mitigation Program and was then accelerated under the Emergency Supplemental Appropriations Act of 2005 in response to the December 26, 2004 Indian Ocean tsunami. SIFT has been implemented as the operational forecast system at both of NOAA's Tsunami Warning Centers (TWCs). The system provides real-time assessment of tsunami potential by interpreting DART measurements and converting the data into quantitative tsunami forecast for vulnerable communities along the U.S. coastline. SIFT helps TWC's personnel determine tsunami potential and predict coastal impact based on real-time tsunami measurements, eliminating guess-work in tsunami warning operations.

Dynamical Core for the Next Generation Global Prediction System

In order to improve forecasts of severe weather to protect lives and property, NOAA chose Finite-Volume Cubed-Sphere Dynamical Core (FV3) as the new engine to run the Next Generation Global Prediction System project (NGGPS). NGGPS will upgrade the current operational Global Forecast System (GFS) to run as a unified, fully-coupled system in NOAA's Environmental Modeling System infrastructure. It is currently being implemented into GFS by the NOAA National Centers for Environmental Prediction with a planned date of 2019 to be fully operational for global forecasts, improving forecast accuracy and providing long lead time. For example, FV3 shows considerable improvements in forecasting the most extreme winds and rainfall in a hurricane as well as more reliably predicts rapid intensification of hurricanes. NOAA continues to develop new modeling technology, including experimental global cloud-resolving models, models for statistical prediction on scales of weeks to decades, and new and improved model algorithms to lay the foundations for future forecast improvements.

Juvenile Spotted Seatrout Performance Measure for Everglades Restoration

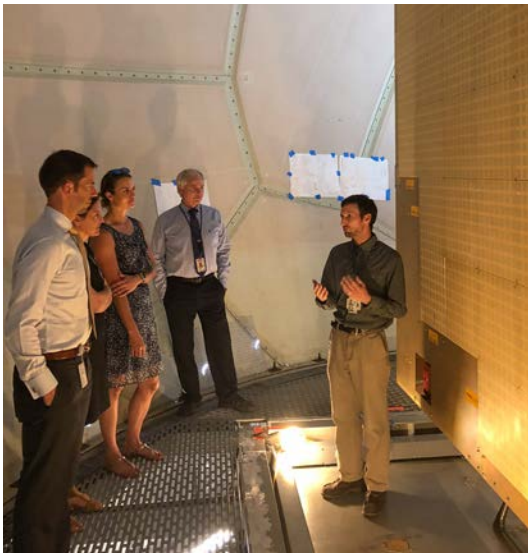
The saltwater recreational fishery adjacent to the Florida Everglades generates approximately $880 million and more than 6,000 jobs per year. This area includes Florida Bay, which not only supports a substantial recreational fishing industry within its waters, but also serves as a nursery ground for many of the adjacent commercial and recreational fishery species, such as spotted seatrout and coral reef fishes. The commercial and recreational fishery species within Florida Bay will be affected by Everglades restoration as it aims to restore Florida Bay to a more natural state. Scientists from NOAA Research and NOAA Fisheries developed, and delivered to the U.S. Army Corps of Engineers-South Florida Water Management District, a performance measure that quantitatively describes how juvenile sportfish in Florida Bay respond to water quality and habitat. The resulting juvenile spotted seatrout Habitat Sustainability Index (HSI) model can be applied to evaluate the impact and benefits to sportfish of proposed restoration projects that make incremental advancements towards Everglades restoration. Thus, it will ensure that Everglade Restoration provides benefits to human society by increasing the sustainability and health of fishery populations in Florida Bay.

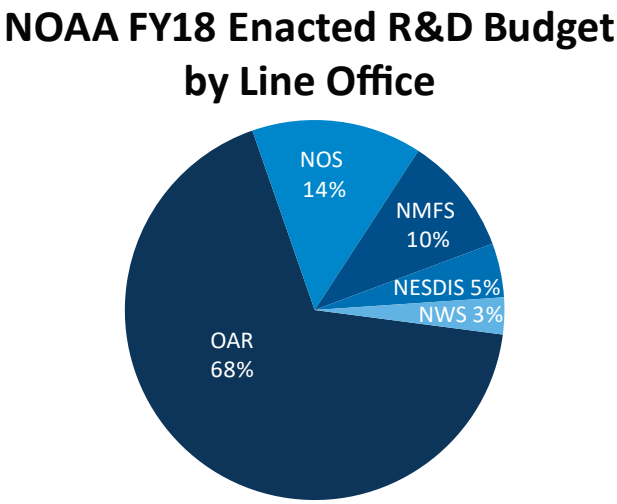
Meteorological Assimilation Data Ingest System

The Meteorological Assimilation Data Ingest System (MADIS) is a global database and delivery system developed by NOAA Research in 2001 and transitioned into NOAA NWS operations in 2015. MADIS serves the greater meteorological community by supporting the collection, integration, quality control, and distribution of NOAA and non-NOAA observations. MADIS continues to grow and improve through version releases each year. For 2018 the major improvements were to: the National Mesonet Program (an observational weather network), Hydrometeorological Automated Data System, and the Federal Highway Administration's (USDOT) Clarus Road Weather Information System. The World Meteorological Organization has also designated MADIS as the delivery system for sharing Global Aircraft Meteorological DAta Relay (AMDAR) data among all meteorological services worldwide. These datasets improve forecast accuracy by providing higher density and higher quality atmospheric observations from public and non-public sources.

What is NOAA's Research and Development Budget

NOAA dedicated $673 million, or approximately 10 percent of the agency's total budget, to R&D in Fiscal Year 2018 (FY18, 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.





Note: OMAO tracks management and operation of aircraft and vessels in support of Line Office R&D as Equipment and therefore is not displayed here.

2018 Hurricane Supplemental R&D Activities

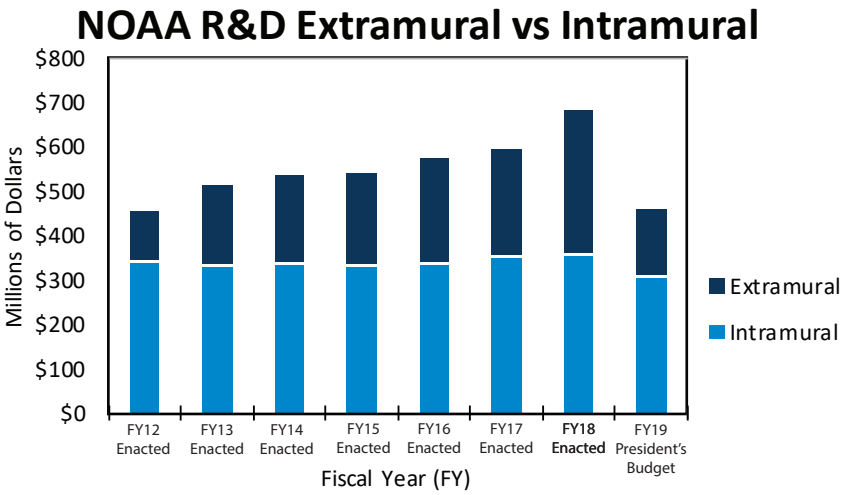
Research and development activities from the Hurricane Supplemental, formally known as the *Supplemental Appropriations for Disaster Relief* of the Bipartisan Budget Act of 2018 are planned to accelerate the implementation of NOAA's existing improvement plans by one to three years in four relevant focus areas:

1) weather forecasting,
2) hurricane intensity forecasting,
3) flood forecasting and mitigation and,
4) data assimilation from ocean and satellite observing platforms.

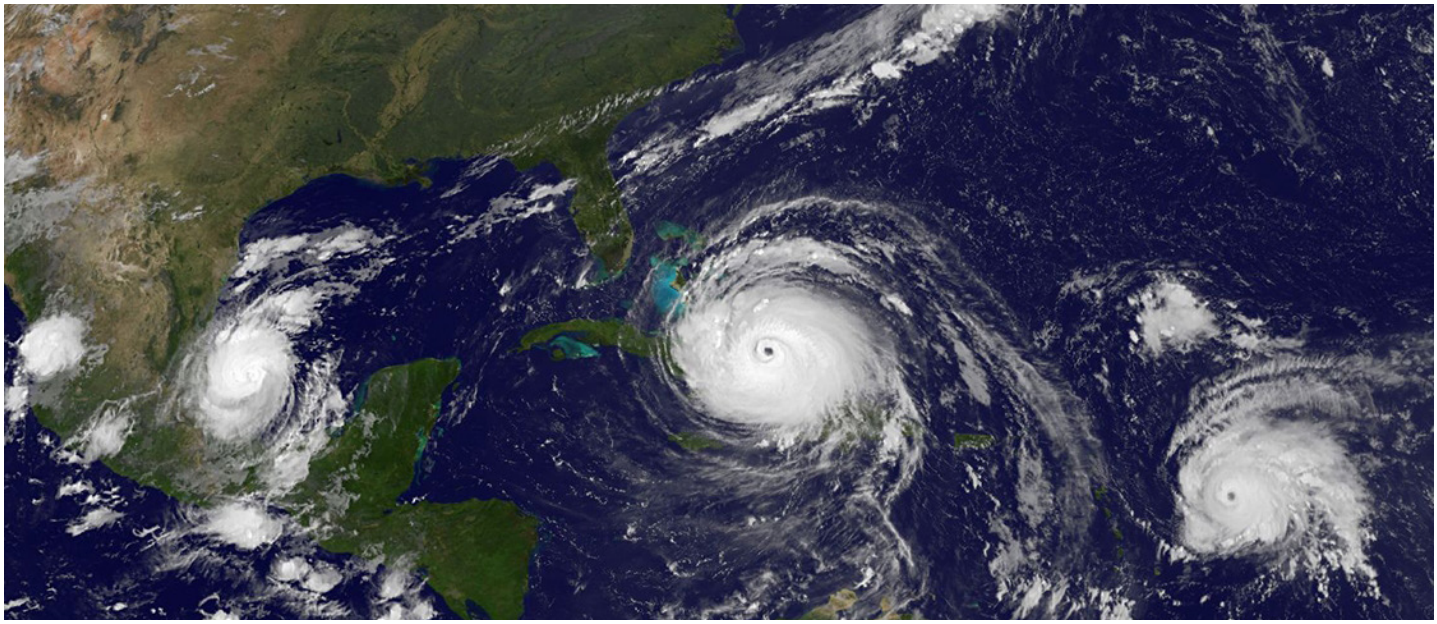
Supplemental Appropriations for Disaster Relief is referenced in the Public Law, page 3 (Division B, Subdivision 1).

Where Does it Go

Approximately 53 percent of NOAA's FY18 R&D budget went to internal R&D efforts, including those at NOAA labs and science centers within the line offices. The remaining 47 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.



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



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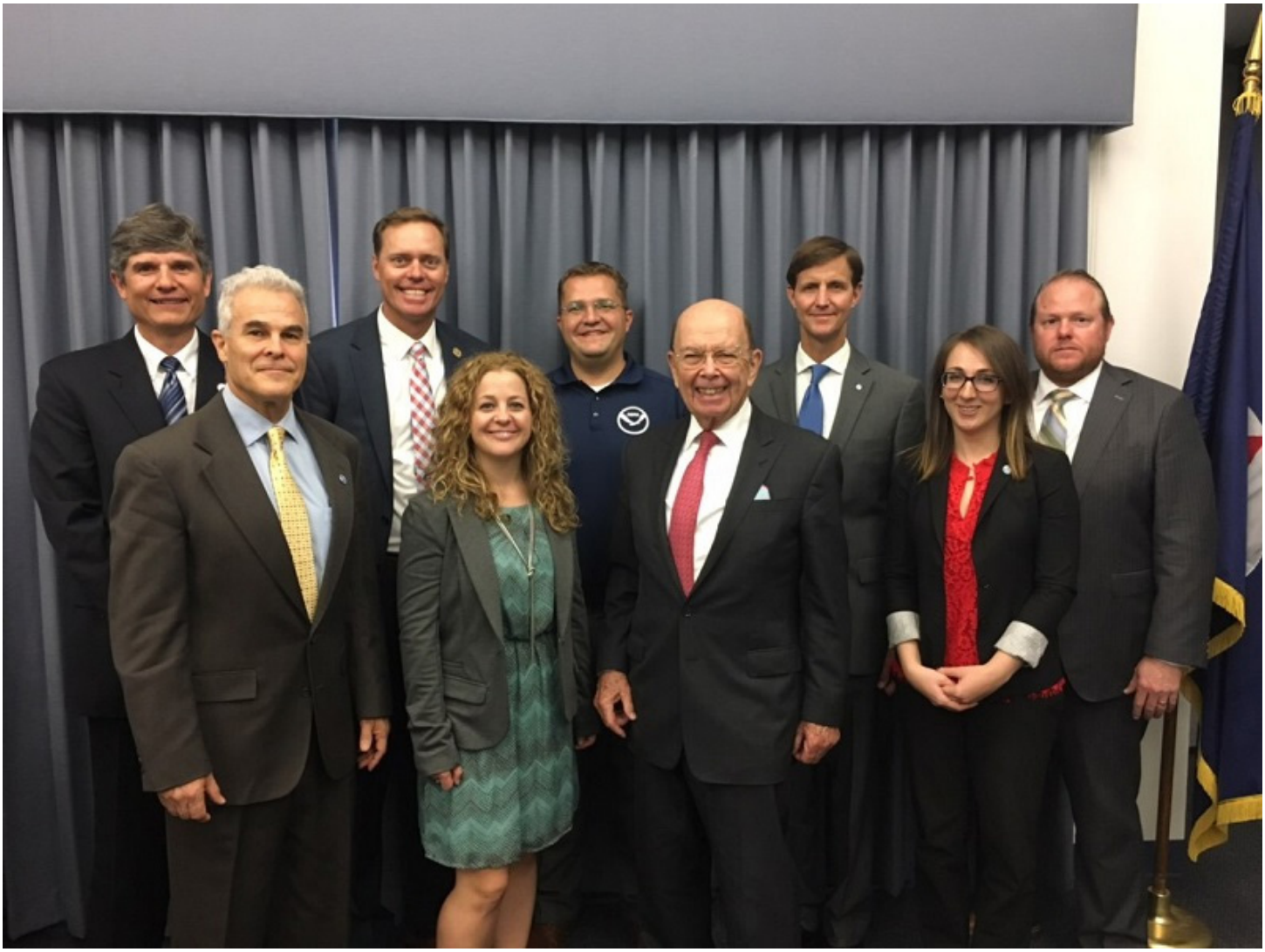


U.S. Department of Commerce (DOC) Secretary Wilbur Ross visited the Office for Coastal Management in Charleston, South Carolina in late October 2018. Acting Administrator RDML Tim Gallaudet led the meeting which included discussions about aquaculture, ports, marine debris, and NOAA NOS tools developed to help coastal leaders make science-based decisions.

Left to right: Nicholas Schmidt (NOAA Office of Coastal Management), NOAA Office of Coastal Management Director Dr. Jeff Payne, Dr. James Morris (NOAA National Centers for Coastal Ocean Science), Sarah Latshaw (NOAA Office of Response and Restoration), Kyle Ward (NOAA Office of the Coast Survey), DOC Secretary Wilbur Ross, Acting NOAA Administrator RDML (ret.) Dr. Tim Gallaudet, Dr. Erica Towle (NOAA NOS Policy Coordination Officer), Michael Platt (DOC Assistant Secretary for Legislative and Intergovernmental Affairs).

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.

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.

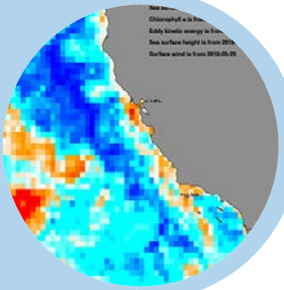
This NOAA Science Report highlights a small but representative fraction of the critical work NOAA does every day. The research depicted in this chapter highlights some of the data, tools, products, and services that NOAA's research activities provide, giving us critical insights into the complex and diverse integrated earth systems that impact our country and our planet.

Accelerate the Blue Economy

Tested a new nature-based shoreline protection technique to protect coastal communities from hazards.

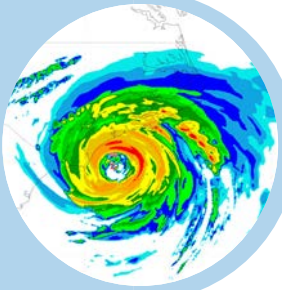
Expanded aquaculture production through seaweed farming and improved river water quality.

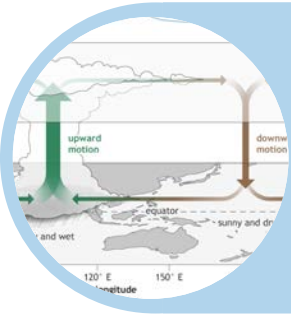
Strengthened economic and environmental sustainability of fisheries through use of a dynamic management strategy.



Prepare for Extreme Weather

Increased skill in forecasting hurricane intensity through the development of two new models.



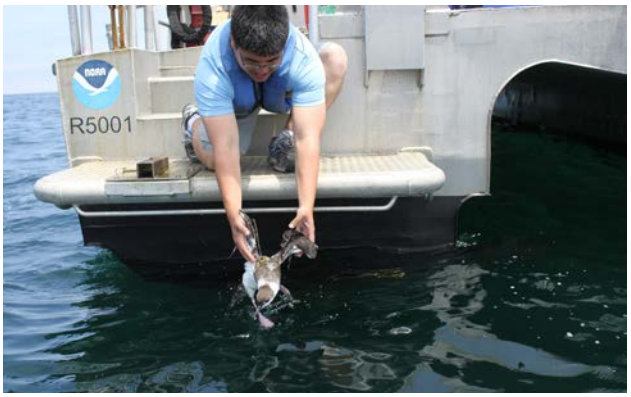


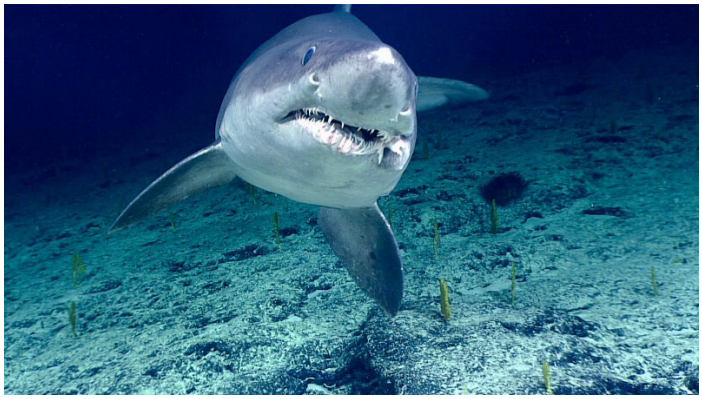
Improved accuracy and lead time on subseasonal forecasts due to deeper understanding of the link between atmospheric conditions in tropics and weather events in U.S.

Estimated the transport and dispersion of harmful sulfur dioxide and volcanic ash during Kilauea volcanic eruption.

Selected Accomplishments

- New Techniques and Tools to Expand Aquaculture
- Scientists and Industry Professionals Join Forces to Develop Best Practices for Finfish Aquaculture: The 2nd International *Seriola* Workshop
- Stock Assessment for the Main Hawaiian Islands Deep 7 Bottomfish Complex Completed
- Hawaiian Islands Cetacean Ecological Assessment Surveys 2017 Completed
- Hawaiian Monk Seal Recovery Plan: Completion of the 2017 Report on Population Status and Recovery Interventions
- New Fisheries Stock Assessment Tool Started in the Pacific Goes Global
- West Coast and Alaska Trawl Fisheries Seabird Cable Strike Mitigation Workshop
- First of its Kind Joint Survey Along the OR and WA Coast, Studying the Distribution and Stock Structure of Juvenile Salmon in Late Winter
- Grunts and Knocks: Ship Noise Complicates Fish Mating
- HYSPLIT Tracks SO_2 and Particulate Matter During Kilauea Eruption
- A Revolutionary Global Weather Model
- Experimental Model Improves Hurricane Intensity Forecasts
- Forecasting a Rare Winter Storm in Southeast U.S.
- Closing the Gap Between Weather and Climate Predictions
- COASTAL Act Coupled Wave-Surge Model
- Messaging Consistent NWS Weather Forecasts: The National Blend of Models
- Slowing Ocean Motion: AMOC Enters Uncharted Territory
- Ocean Model Collaboration with the U.S. Navy
- EcoCast: A Dynamic Ocean Management Tool to Reduce Bycatch and Support
- Whales Voices Change With Age, Just Like Ours
- Environmental and Geographic Relationships among Salmon Forage Assemblages along the Continental Shelf of the California Current
- Great Lakes Ecosystem Classification System
- National Estuarine Research Reserves (NERRS) Provide Science Platform for Coastal Resilience





New Techniques and Tools to Expand Aquaculture

NOAA is developing new techniques and tests to expand aquaculture production. Researchers with NOAA Fisheries have been helping aquaculturists, notably, GreenWave Organization's Thimble Island Ocean Farm, develop culturing strategies to grow a new crop: sugar kelp. Sugar kelp is being developed for a variety of uses, from food to potential biofuels as well to diversify the portfolio for shellfish growers and others in the seafood sector. Aquatic plant farming, primarily seaweed, also represents a significant sector of global aquaculture production (30.1 million metric tons, valued at $11.6 billion). Seaweed farming is just now being established in the U.S. and shows promise to become an important contributor to future U.S. marine aquaculture production. Researchers are helping this company and its academic partner, the University of Connecticut, develop techniques for growing the kelp across its entire life cycle — from spore culture to maturity — and harvesting strategies.

A researcher at NOAA's Milford Laboratory develops culture strategies for sugar kelp.

Developing new crops is not the only way to expand aquaculture. When the sewage treatment plant on Connecticut's Mystic River was upgraded in 2015, few residents imagined local shellfish farmers might benefit, let alone oyster and clam growers across the country. Now this is a possibility, depending on the results of a novel water quality-testing project led by New Hampshire Sea Grant in partnership with Connecticut Sea Grant which could open nearly 800 acres now off limits for commercial shellfishing. While river water quality improved following the treatment plant upgrades, researchers have to demonstrate that levels of harmful bacteria and viruses in the water meet public health safety standards before currently-closed areas can be opened to harvest. Sea Grant's work in the Mystic River supports Connecticut's shellfish industry, which generates more than $30 million in farm-gate sales annually and provides more than 300 jobs statewide. Test results thus far show favorable results, and this method could ultimately be adopted by shellfish managers working under National Shellfish Sanitation Program regulations.

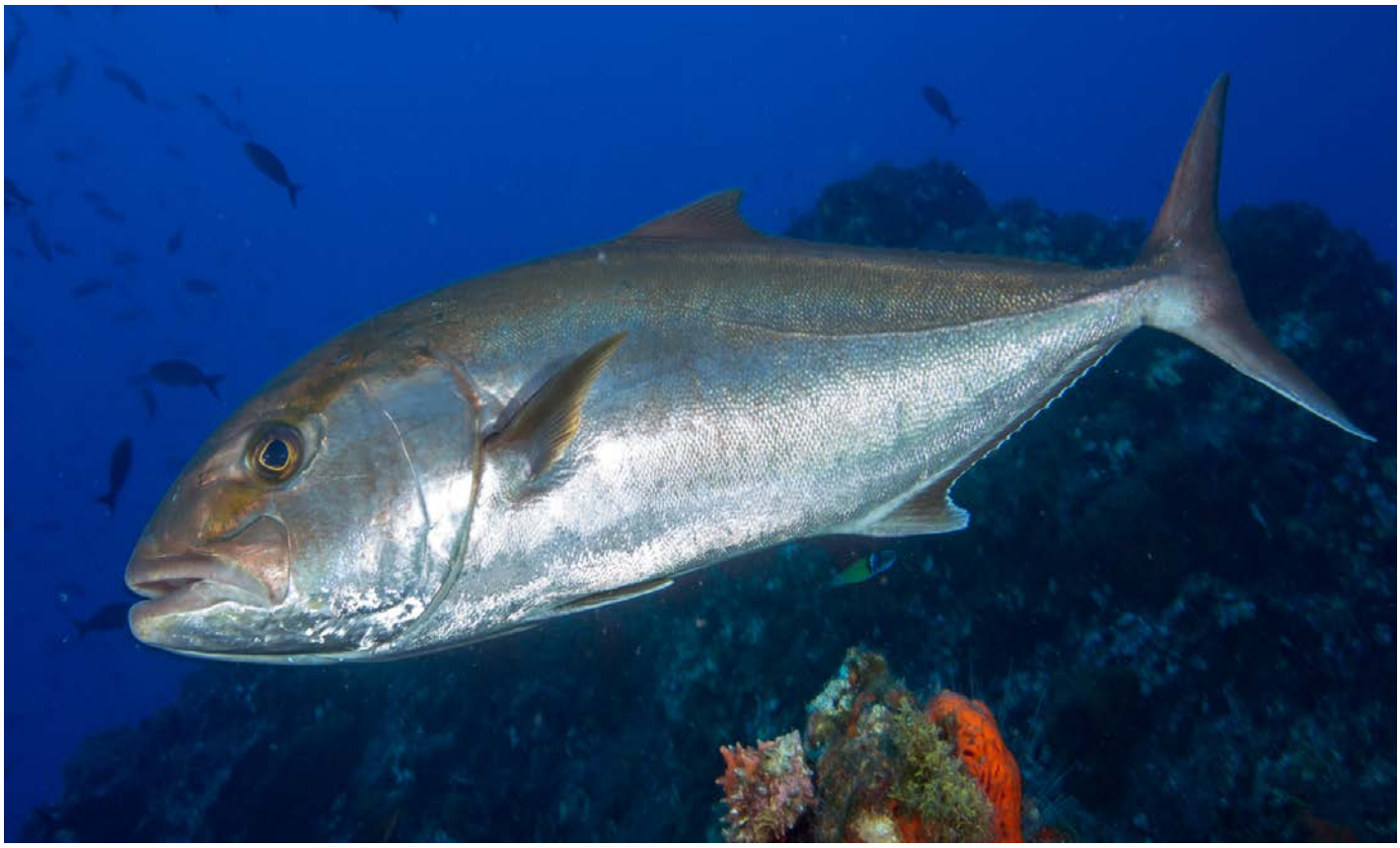
New Hampshire and Connecticut Sea Grant test water quality to open new areas for commercial shellfishing

> *"For shellfish farmers, the implications are huge, because it could increase the size of our growing areas," Steve Plant, Connecticut Cultured Oysters.*

Scientists and Industry Professionals Join Forces to Develop Best Practices for Finfish Aquaculture:

The 2nd International Seriola Workshop

Aquaculture has been identified as a priority area for NOAA Fisheries. Fish in the genus *Seriola* are highly desirable fishes that enter the food supply through recreational and commercial fishing and now through aquaculture. They can be found on seafood restaurant menus, commonly sold under the names of yellowtail and amberjack. They are also a mainstay of sushi restaurants where the same species have Japanese names such as Hiramasa, Hamachi, or Kampachi. *Seriola* species are important aquaculture species in Japan, Mexico, Chile, Australia, and in the E.U. In the U.S., *Seriola* are commercially cultured in Hawai'i, and large-scale offshore fish farming of these species is anticipated in southern California and in the Gulf of Mexico. To advance the culture of these species, NOAA scientists and collaborators have sequenced the Seriola genome and have used genomic and physiological approaches to improve aquaculture procedures. California Sea Grant and NOAA Fisheries hosted the 2nd *Seriola* Workshop that brought together the research and culture community to discuss research progress, identify routes of collaboration, and coordinate synergistic projects for breeding, rearing, and feeding of yellowtail, amberjacks and related *Seriola* species in culture. This workshop formed several new domestic and international collaborations that will be better able to address these research priorities and more rapidly benefit commercial *Seriola* culture in the U.S. and globally.



The Greater Amberjack (Seriola dumerili) *is a commercially and recreationally valuable fish. NOAA's Southwest Fisheries Science Center and California Sea Grant hosted the 2nd Seriola Workshop to develop best practices for finfish aquaculture.*

Stock Assessment for the Main Hawai'ian Islands Deep 7 Bottomfish Complex Completed

In November 2017, the recent benchmark assessment for the Main Hawai'ian Islands (MHI) Deep 7 bottomfish complex, seven species that are a focus of fishery management, underwent stock assessment review. The new benchmark assessment includes a number of improvements over prior assessments. This was the first inclusion of information from the bottomfish fishery-independent survey to incorporate underwater camera technology and a partnership with local commercial fishers. For the first time, workshops were convened with the fishers to better understand the historical catch and effort time series. The assessment improved upon the previous methods by combining commercial landings data that had been used in previous stock assessments with video surveys of sensitive areas for fishing years 1949 - 2015. The new MHI Deep 7 Bottomfish stock assessment was delivered to the Western Pacific Fishery Management Council for consideration by the Council's Science and Statistical Committee. The assessment's findings were positive and contribute to better management of the fishery; the stock was not found to be overfished, nor was overfishing present.

The NOAA Pacific Islands Fisheries Science Center developed a new stock assessment for the Main Hawai'ian Islands Deep 7 bottomfish complex.

Hawai'ian Islands Cetacean Ecological Assessment Surveys 2017 Completed

The Hawaiian Islands Cetacean Ecological Assessment Surveys (HICEAS) assess marine mammal abundance to better manage and preserve these populations as required under the Marine Mammal Protection Act (MMPA). The survey took place from July 6 to December 1, 2017 aboard NOAA Research Vessels *Oscar Elton Sette* and *Reuben Lasker* spanning 179 days-at-sea across both ships. The survey collected whale and seabird species abundance and habitat information for the recently expanded Papahānaumokuākea Marine National Monument. Additionally, it provided new abundance estimates for false killer whales in support of the False Killer Whale Take-Reduction Plan (TRP), as well as for all cetacean species as required under the MMPA. The survey also collected updated abundance and distribution data for large whale, sea turtle, and seabird species listed under the Endangered Species Act. This data was used to update whale and seabird assessments and evaluate whether bycatch rates in U.S. fisheries are sustainable under the MMPA and Magnuson-Stevens Fishery Reauthorization Act.

This spinner dolphin was spotted during the Hawaiian Island Cetacean Ecological Assessment Surveys conducted by NOAA's Pacific Island Fisheries Science Center.

Hawai'ian Monk Seal Recovery Plan: Completion of the 2017 Report on Population Status and Recovery Interventions

The Population Summary for Hawai'ian Monk Seals in 2017 builds on long term datasets with the addition of innovative analyses that estimate reproductive rates and give a status update showing some positive signs for Hawai'ian monk seal recovery, an endangered species. The range-wide population estimate for 2017 was 1345, which is slightly lower, but within the range of variation of the abundance estimated in 2016. The overall population trend is increasing, showing a 2 percent annual growth rate since 2013 (when range-wide estimates were initiated). This positive trend was largely due to multiple years of improved juvenile survival in the Northwest Hawaiian Islands (NWHI), an important turn-around from previous trends at many NWHI sites. Populations in the main Hawaiian Islands (MHI) have been stable in recent years, with a slight increase in the number of individuals identified and number of pups born in the main islands in 2017. New methodology incorporating citizen science data helped to estimate reproductive rates in the MHI population, which showed higher fertility than anywhere else in the species' range. While the current numbers are encouraging, great effort is still required to recover the monk seal population. The Population Summary also details the efforts of NOAA scientists to mitigate survival threats through life-saving interventions (such as disentangling animals from debris, removing fish hooks, translocating, and rehabilitating animals); 71 interventions were conducted during NWHI field camps, and 22 interventions were conducted in the MHI. These actions and other program activities, such as removing entangling debris from beaches, continue to contribute significantly to recovery at both the individual seal and population level.

The Population Summary for Hawai'ian Monk Seals from the NOAA Pacific Islands Fishery Science Center shows positive signs for Hawaiian monk seal recovery.

New Fisheries Stock Assessment Tool Started in the Pacific Goes Global

NOAA Fisheries released a new, widely available, open-source modelling software for stock assessment: "Just Another Bayesian Biomass Assessment" (JABBA) can be applied to improve fisheries management worldwide. Stock assessments provide information that serves as the basis for domestic and international fishery regulation. JABBA has already been applied in stock assessments of sharks, tuna, and billfishes around the world. JABBA presents a unifying, flexible framework for biomass dynamic modelling, runs quickly, and generates reproducible stock status estimates and diagnostic tools. As a case study, JABBA is applied to the 2017 assessment input data for South Atlantic swordfish (*Xiphias gladius*). We envision that JABBA will become a widely used, open-source stock assessment tool, readily improved and modified by the global scientific community. JABBA is expected to allow better stocks assessments for highly migratory species which improves the ability to manage those species.

NOAA' s Pacific Islands Fisheries Science Center releases a new tool for stock assessment, "Just Another Bayesian Biomass Assessment."

West Coast and Alaska Trawl Fisheries Seabird Cable Strike Mitigation Workshop

NOAA's Northwest Fisheries Science Center, together with Oregon and Washington Sea Grant, developed strategies to minimize seabird cable strikes.

Seabirds can strike trawl cables during fishing operations resulting in injury or death of the seabirds. Seabird strike incidents can also have negative economic impacts on the fishing industry. Seabird mortality could lead to the loss of fishing opportunities due to the incidental take of an endangered seabird species, a ban on data cables, that increase fishing efficiency, or litigation from environmental groups. In order to protect seabirds in U.S. West Coast and Alaskan waters from potentially harmful interactions with commercial fishing operations, NOAA Fisheries partnered with the U.S. Fish and Wildlife Service, Pacific States Marine Fisheries Commission, Oregon Sea Grant, Washington Sea Grant, and stakeholders from the fishing industry to hold a workshop that resulted in the development of five strategies with potential to improve seabird protection. A few of the proposed methods include: a device to decrease the height of the wire; deterrents or sprinklers to spray water on the trawl lines and discourage birds from flying near them; and the use of cable fairings or ribbons to provide additional visual cues about the presence of the wire. The results of the workshop were already put in practice as some commercial vessels began voluntarily testing these strategies in the spring of 2018. A NOAA Technical Memorandum that describes the fives strategies has been released to help the fishing industry and scientists in the U.S. and around the world develop effective seabird cable-strike mitigation strategies.

First of its Kind Joint Survey Along the OR and WA Coast, Studying the Distribution and Stock Structure of Juvenile Salmon in Late Winter

In a first survey of its kind, NOAA Fisheries surveyed the Oregon and Washington coasts for juvenile salmon in late winter. The winter period is of considerable interest because mortality on juvenile salmon is believed to be high in winter due to low prey abundance, and physical conditions in winter influence the composition and abundance of the prey available in spring. This study allowed for an examination of distribution and stock structure of salmon during this critical, less studied time period. The advanced technologies afforded by the Fisheries Survey Vessel *Shimada* enabled an additional study that examined the habitat structure of the ecosystem including physics, krill, forage fishes, salmon, and marine predators during winter. This collaborative effort sets the stage for future research efforts on the West Coast of the U.S. Proposed research directions include studies that enable the examination of ecosystem-level processes such as predator-prey dynamics across space and time and their relationships to oceanographic conditions.

A Marine Autonomous Recording Unit (MARU) used by scientists at NOAA's Northeast Fisheries Science Center to record sound on the ocean floor.

NOAA's Northwest Fisheries Science Center and Southwest Fisheries Science Center survey the Oregon and Washington coasts for juvenile salmon.

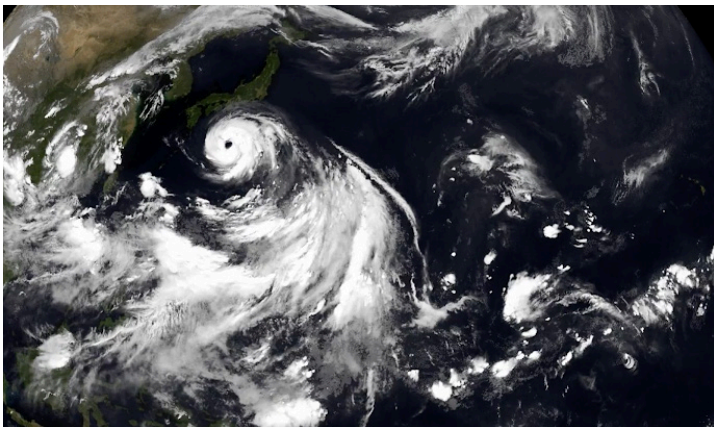
Grunts and Knocks: Ship Noise Complicates Fish Mating

NOAA scientists studying sounds made by Atlantic cod and haddock at spawning sites in the Gulf of Maine found that vessel traffic noise reduces the distance over which these animals can communicate with each other. As a result, daily behavior, feeding, mating, and socializing during critical biological periods for these commercially and ecologically important fish may be altered.

Ambient sounds include animal vocalization, physical sounds such as wind and water movement or geological activity, and human-produced sound from ships and marine construction. Many marine animals use ambient sound to navigate, to choose where to settle, or to modify their daily behaviors including breeding, feeding, and socializing. Lower-level, chronic exposure to increased ambient sound from human activities, such as vessel traffic, is one of the most widespread, yet poorly understood, factors that could be changing fish behavior. If a fish cannot hear as well as it needs to, then sound signals from other fish can be lost, compromised, or misinterpreted in ways that can cause a change in behavior. Since Atlantic cod, for example, vocalize to attract mates and listen for predators, not hearing those signals could potentially reduce reproductive success and survival.

HYSPLIT Tracks SO_2 and Particulate Matter During Kilauea Eruption

During the Kilauea eruption, NOAA Research's Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model provided estimates of the transport and dispersion of harmful sulfur dioxide (SO_2) and volcanic ash in the air. This vital information allowed emergency responders to make evacuation and other safety decisions by estimating when plumes of toxic gas would drift over population centers and where volcanic ash in the atmosphere would present a hazard for aircrafts. NOAA Research scientists are currently investigating new means to more accurately estimate concentrations of chemicals released during volcanic eruptions by combining SO_2 measurements taken downwind from the volcano with forecasts from the HYSPLIT model, incorporating the derived data and re-running HYSPLIT to provide forecast SO_2 concentration. The aim is to develop an automated system that assimilates actual measurements with calculated concentrations and transition it to NOAA NWS for operational use in support of forecasting. This volcanic ash research could result in decreased fuel consumption and reduced delays in flight arrival times for the airline industry thanks to guidance from more precise dispersion forecasts. The economic impact of SO_2 is measurable in terms of population health, lost productivity, and lost wages. In addition to tracking SO_2, NOAA is a contributor to the Interagency Vog Dashboard, a resource designed to forecast and track vog, the volcanic equivalent of smog created when sulfur dioxide from the volcano reacts with carbon dioxide, water vapor, and sunlight.



A simulated satellite image from a global experimental 3-km simulation in fvGFS produced by NOAA's Geophysical Fluid Dynamics Laboratory.

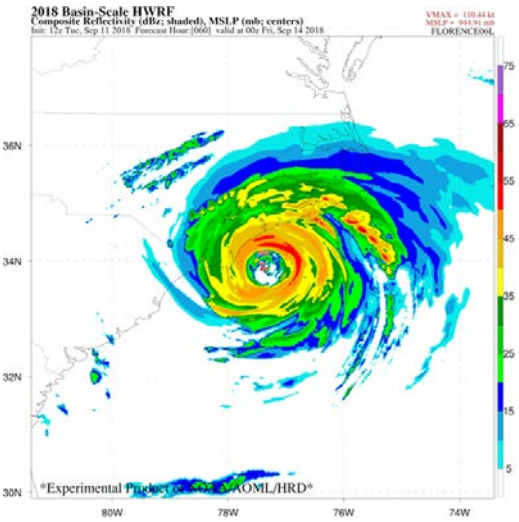
NOAA's Air Resources Laboratory tracked ash plumes and sulfur dioxide from the Kilauea volcanic eruption. Photo credit: USGS

A Revolutionary Global Weather Model

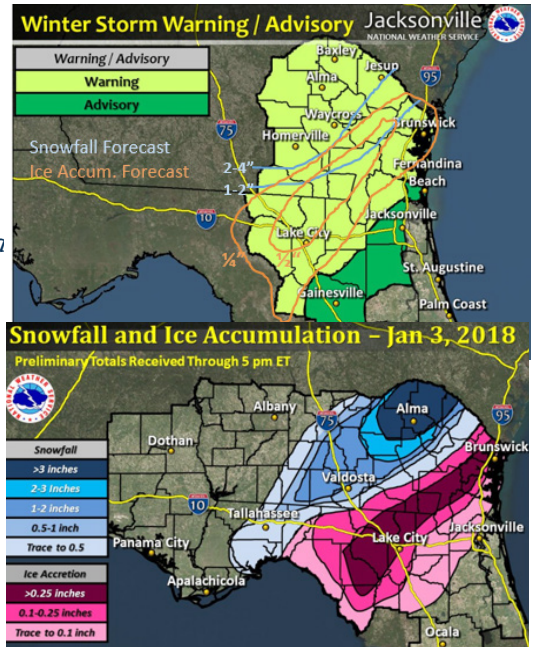
NOAA's newest weather prediction tool, the Next Generation Global Prediction System (NGGPS), will dramatically improve U.S. operational weather and hurricane forecasting. Powered by the efficient and more comprehensive Finite-Volume on a Cubed Sphere (FV3) dynamic core, NGGPS provides a new level of accuracy to weather forecasts. NOAA continues to develop FV3-based global prediction models. During the 2017 hurricane season, the NOAA fvGFS, the FV3-powered prototype for the NGGPS, showed significantly better forecasts of hurricane intensity than current operational models, such as the current Global Forecast System (GFS) or the European Centre for Medium Range Weather Forecasts (ECMWF) model. High-resolution versions of fvGFS, using global-to-regional modeling methods developed at NOAA that allow the model to 'zoom-in' on a region of the world, show even better prediction of Atlantic hurricane strength, nearly matching the accuracy of the best operational models used for hurricane forecasting. A second high-resolution version, zoomed-in over the contiguous U.S., shows promise as the basis of a unified system for both storm-scale and global modeling.

Experimental Model Improves Hurricane Intensity Forecasts

Through the Hurricane Forecast Improvement Project (HFIP), NOAA continues to improve the accuracy of hurricane forecasts with applied research using advanced computer models. For the 2018 hurricane season, operational and real-time experimental models at NOAA have performed exceedingly well as demonstrated by results for Hurricanes Lane, Florence, and Michael. For Hurricane Lane, the experimental Finite-Volume on a Cubed Sphere Global Forecast System (fvGFS) was one of the best performers for track forecast guidance. The Hurricane Weather Research and Forecasting (HWRF) model predicted the rapid intensification of Hurricane Michael at least 60 hours in advance. The experimental basin scale HWRF-B model was run in parallel with operational hurricane models during the 2018 Atlantic hurricane season. In addition to the use of aircraft data for initialization, the experimental system was coupled with an advanced ocean model and tracked each hurricane at a very fine resolution (~1.5 km). HWRF-B outperformed the operational model HWRF, especially during peak hurricane season when Hurricanes Florence, Helene, and Isaac were all active at the same time. HWRF-B outperformed the operational HWRF by at least 20-30 percent in predicting intensity of these three hurricanes at longer forecast lead times. Further, HWRF-B improves upon HWRF in its ability to track multiple storms at the same time which enables the prediction of realistic storm-storm interactions and, thus, maximum intensity and storm structure. This ability to track multiple storms will be used in the next generation Hurricane Analysis and Forecast System (HAFS), under development and transitioned to the FV3 unified forecasting system (FV3-UFS), improving our ability to better forecast hurricane intensity.



Left: The experimental basin-scale HWRF system from NOAA's Atlantic Oceanographic and Meteorological Laboratory and Environmental Modeling Center forecasted realistic radar reflectivity and storm structure days in advance of Hurricane Florence's approach to North Carolina.



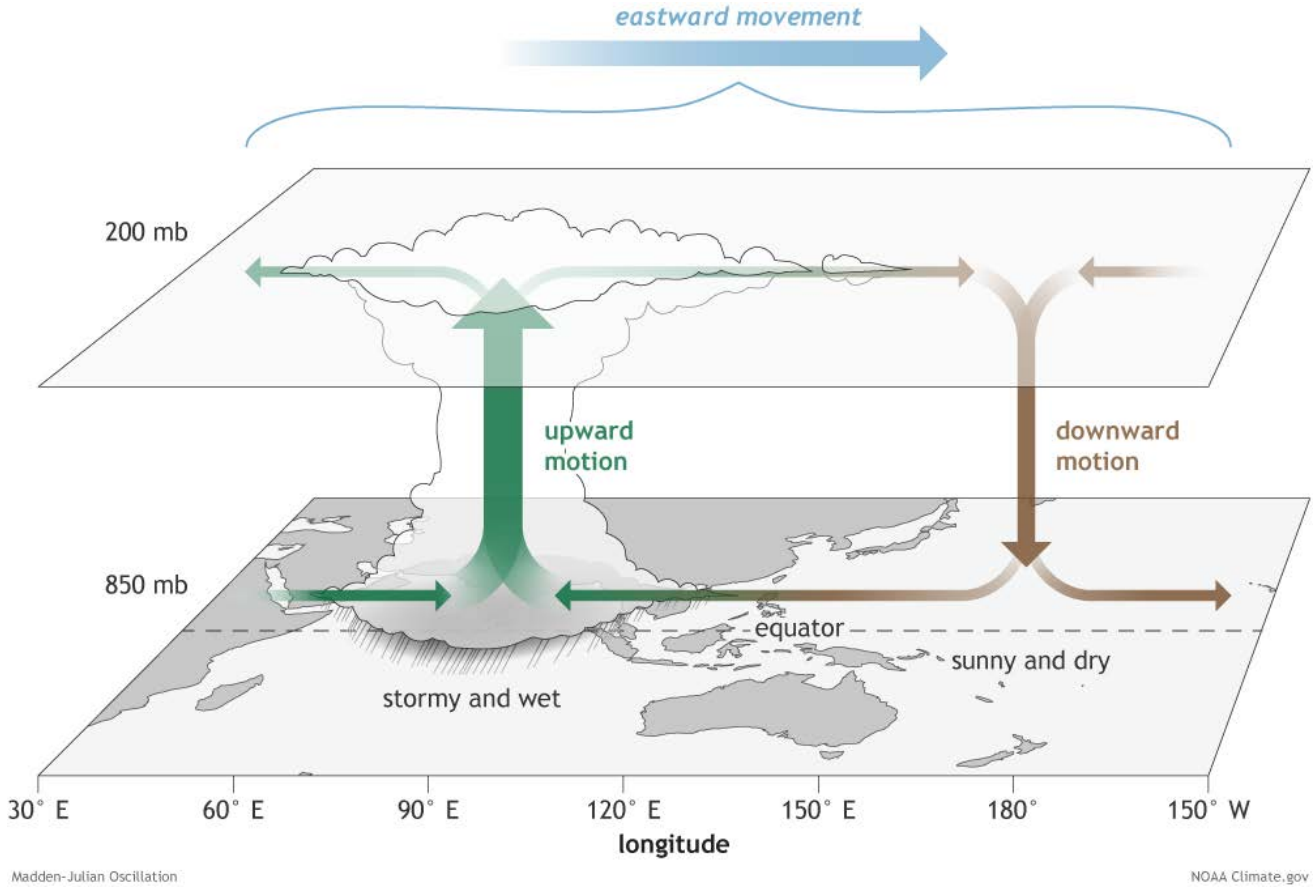
Right: The warnings and advisories issued (top) matched the areas where snow fell (bottom).

Forecasting a Rare Winter Storm in Southeast U.S.

In January 2018 a significant winter storm struck northern Florida and south Georgia, a rare event that only occurs once every 25-50 years. With schools scheduled to return from winter break, city and county managers in the region required an accurate forecast to determine whether or not to close schools, and local government offices. High resolution model guidance accurately predicted that the storm would develop just west of Tallahassee, leading to potentially significant impacts on local roadways. The North American Model (NAM) was used at longer lead times and the High Resolution Rapid Refresh (HRRR) model was used during the last 12-24 hours. Consistent guidance helped forecasters confidently provide decision support services to area emergency managers and helped decision-makers make timely decisions on school and government closures, fulfilling NOAA's mission to protect life and property.

Closing the Gap Between Weather and Climate Predictions

Historically, there has been a gap in predictive skill between two weeks and three months into the future--the subseasonal-to-seasonal (S2S) period that spans the continuum from weather to climate timeframes. Predictions on timescales between weather and climate can help energy companies determine how much power to produce to meet demands for upcoming months, assist water resource managers controlling reservoir levels ahead of upcoming water use, and help farmers understand which crops to plant the following season and whether to buy crop insurance. Through cutting-edge research and development, NOAA is gradually improving the accuracy and lead time of S2S forecasts. Predictions in this time period are a major challenge due to the inherent unpredictability of the atmosphere beyond two weeks. Now, NOAA-funded scientists have developed new insights about long-distance relationships between particular atmospheric conditions in the tropics and weather events in the U.S., which helps fill the gap in forecasters' ability to make more accurate predictions during S2S timescales. This new research, part of NOAA Research's S2S Prediction Task Force, builds on ongoing activities within NOAA labs and operational centers. Specifically, scientists at Colorado State University (CSU) found that the Madden-Julian Oscillation (MJO), a series of eastward-moving tropical rainfall patterns, can influence weather in the U.S. in predictable ways within 20-25 days. This work has the potential to enhance previous research, which resulted in the development and operational transition of a tool that uses the MJO and El Niño-Southern Oscillation to provide essential guidance for NOAA's week three to four outlooks. Through these and other achievements, NOAA is steadily closing the S2S gap and improving communities' abilities to plan for and respond to extreme events.

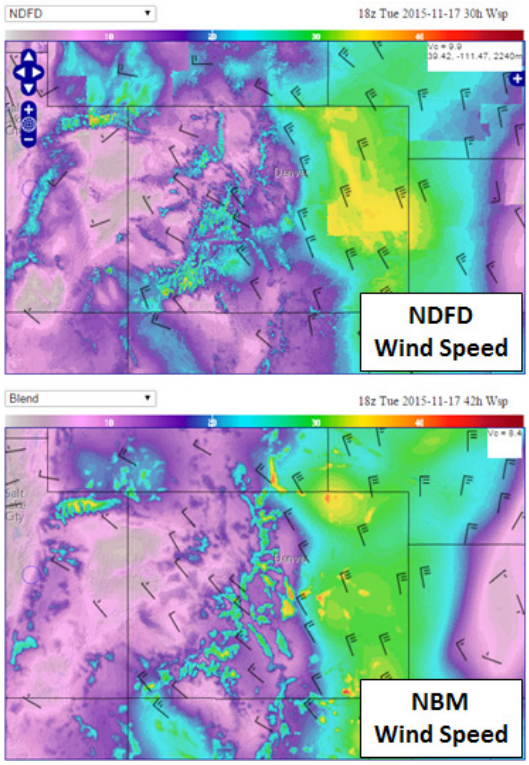


A depiction of Madden-Julian Oscillations which NOAA's Climate Program Office and scientists at Colorado State University have found can influence weather in the U.S. in predictable ways within 20-25 days.

Improvements on WAVEWATCH from NOAA's National Center for Environmental Prediction better estimate total wave-surge induced inundation.

COASTAL Act Coupled Wave-Surge Model

A significant portion of flooding due to hurricanes comes from wind-generated waves and the underlying storm surge, which pushes water up on shore and damages homes, buildings, and other structures. The Consumer Option for an Alternative System to Allocate Losses (COASTAL) Act requires an accurate modeling of flooding due to hurricanes, at the spatial resolution of an individual house. Highly-sophisticated numerical models that separately simulate surge and wave processes have been developed and validated in NOAA over the last decade to obtain accurate estimates of total wave–surge induced inundation. Furthermore, NOAA is working with the U.S. Army Corps of Engineers (USACE) to improve the WAVEWATCH III model to include storm surge, tides, and wave activity. These improvements will help the model achieve the 90 percent accuracy requirement of the COASTAL Act.



Comparison of a National Digital Forecast Database (NDFD) graphical product (top) and the National Blend of Models (NBM) product (bottom) for wind from NOAA's Office of Science and Technology Integration.

Messaging Consistent NWS Weather Forecasts: The National Blend of Models

NOAA's National Blend of Models (NBM) combines information from NOAA NWS and non- NOAA NWS models and uses the best available science to provide a consistent weather forecast product across the U.S. 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. NBM Version 3.1, which was implemented on October 3, 2018, will continue to fill existing product gaps with the blend of model data. A few highlights associated with this release include: (1) improving quantitative precipitation forecasts, especially in the mountainous West, (2) the addition and improvement in aviation guidance routinely used in daily airport operation planning and the creation of Terminal Aerodrome forecasts (TAFs), (3) a suite of fire weather guidance that will assist NOAA NWS forecasters in relaying critical information to emergency managers to improve Impact-Based Decision Support Services, and (4) the release of an NBM text product that provides NBM guidance at stations for various temporal horizons.

Slowing Ocean Motion: AMOC Enters Uncharted Territory

Researchers from the U.S. and Europe reconstructed changes in a large-scale system of ocean currents that circulates warm, salty water from the South Atlantic and tropics via the Gulf Stream to the colder North Atlantic. They concluded that the system, called the Atlantic Meridional Overturning Circulation (AMOC), has slowed down or weakened by about 15 percent since the 1950s. One result is that ocean temperatures in the Northeast U.S. Shelf region are expected to continue warming faster than the global ocean, which will continue to affect fisheries and living marine resources in this commercially important region.

The rapid ocean warming observed along the Northeast U.S. Shelf may be associated with the Gulf Stream shifting northwards and closer to shore, a consequence of the AMOC slowdown. In the CM2.6 global climate model, NOAA's high resolution climate model, enhanced warming of ocean bottom temperatures in the Northeast U.S. Shelf and in the Gulf of Maine is a result of both a poleward retreat of the cold Labrador Current and a northward shift of the warmer Gulf Stream. These changes in ocean currents and temperatures have impacts on fish, other species, and their prey.

Continued warming is likely to further weaken the AMOC in the long term through changes to the hydrological cycle, sea-ice loss, and accelerated melting of the Greenland Ice Sheet, all of which are causing North Atlantic waters to become fresher and less dense. As a result, ocean temperatures along the Northeast U.S. Shelf are expected to continue warming and further impacts on fisheries in the region are expected.

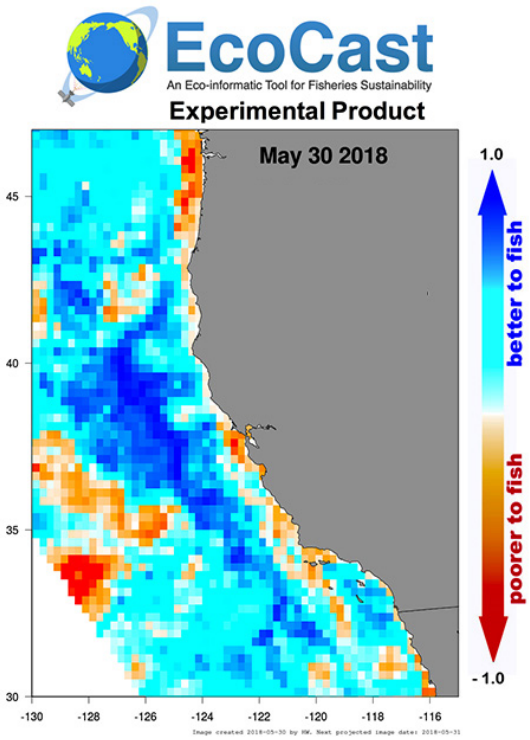
Research from NOAA's Northeast Fisheries Science Center finds warming ocean temperatures in the Northeast U.S. shelf region due to the weakening of the Atlantic Meridional Overturning Circulation (AMOC), which could impact temperature sensitive species such as lobsters.

NOAA's Geophysical Fluid Dynamics Laboratory's Modular Ocean Model (MOM6) is being considered by the U.S. Navy as a workhorse ocean model.

Ocean Model Collaboration with the U.S. Navy

The nation's security and economic well-being rely upon accurate global analysis and prediction capabilities of the physical environment over time scales of a few days to a few decades. Due to recent trends in the climate mean and variability, the use of historical data to predict average conditions and extreme events affecting commerce, defense, infrastructure and water, energy, and other resources is less reliable for making informed decisions. However, ocean models have proven capable of significantly enhancing these prediction capabilities. The U.S. Navy's global ocean model is running operationally and producing valuable guidance. NOAA Research is addressing the Navy's interests in having direct comparison with important existing capabilities in their own ocean model, and assessing the potential to use the latest generation of the Modular Ocean Model (MOM6) as the workhorse ocean model. Updates to MOM6 made in 2018 are of comparable (or superior) quality by all measures to the Navy's operational global forecasts. This is a significant milestone in the evaluation of MOM6 as a candidate for filling the Navy's future global ocean forecasting needs and a substantial expansion of collaboration between NOAA and the Navy.

EcoCast: A Dynamic Ocean Management Tool to Reduce Bycatch and Support



EcoCast is a dynamic ocean management tool that aims to minimize fisheries bycatch and maximize fisheries target catch in real-time from NOAA's Southwest Fisheries Science Center.

New computer-generated daily maps will help fishermen locate the most productive fishing spots in near real-time while warning them where they face the greatest risk of entangling sea turtles, marine mammals, and other protected species. Scientists developed the maps, the products of a system called EcoCast, to help reduce accidental catches of protected species in fishing nets. Traditional ocean management strategies tend to be static with boundaries that are fixed in space and time. To capture broad-scale oceanic processes and protect highly migratory species, for example, these regions become larger than necessary with opportunity costs for commercial fisheries.

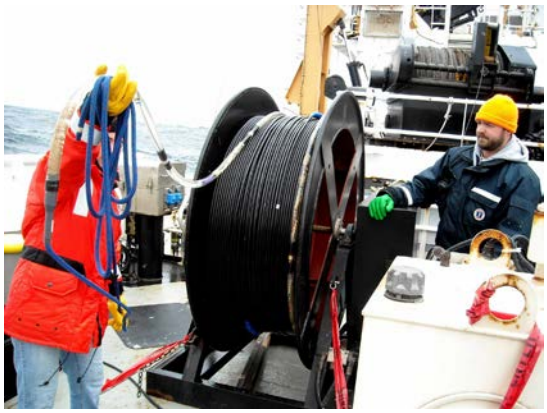
EcoCast uses a dynamic management strategy, which better aligns scales of management to the scales of variability of the features and resources being managed. By incorporating real-time satellite, buoy, modeled and observed data, EcoCast provides management recommendations that reflect current marine state. EcoCast will help fishermen, managers, scientists, and others understand in near real time where fishing vessels have the highest probability of catching targeted species and where there is risk of catching protected species. In doing so, EcoCast aims to improve the economic and environmental sustainability of fisheries and reduce bycatch of protected species.

Currently, NOAA Fisheries closes a large area off the West Coast to the swordfish fishery seasonally to protect leatherback turtles, which travel widely and can be caught incidentally in the nets. With EcoCast, fisheries managers could outline small "dynamic closures" that shift according to the likely locations of the species they are trying to protect. Since they concentrate protection where it is needed most, dynamic closures for leatherback sea turtles could be two to ten times smaller than the current static closures while still safeguarding the species that need protection.

EcoCast is available now and is being developed by a consortium of scientists, managers, and members of the fishing industry. The EcoCast team is made up of scientists from several universities (San Diego State University, University of California Santa Cruz, University of Maryland, Old Dominion University, Stanford University) and NOAA Fisheries, working in direct collaboration with resource managers, fishing industry, and other stakeholders. Fishermen have participated throughout the development of EcoCast, which boosts its usefulness to the fishing fleet.

Whales Voices Change With Age, Just Like Ours

Much like those of human infants and other mammals, calls made by whales younger than one year were shorter and less structured than adult sounds. As the animals mature, their calls became clearer, with better defined structure and longer call durations. The calls continue to develop as the animal ages, decades after it has physically matured. The frequency and duration of these calls may be able to tell us about a whale's body weight, size, physical condition, and stamina, all key factors in reproductive success for this endangered animal. An improved understanding of how calls change with age and individual can help direct conservation strategies by identifying when North Atlantic right whales are present and tracking the health of individuals.



Researchers with the NOAA's Northeast Fisheries Science Center use the hydrophone, an underwater microphone (top), to listen for sounds made by right whales (bottom).

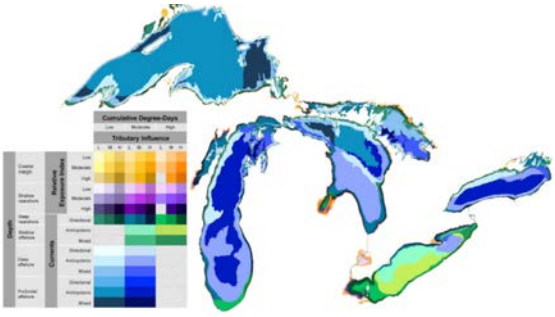
Environmental and Geographic Relationships among Salmon Forage Assemblages along the Continental Shelf of the California Current

Pacific salmon (*Oncorhynchus spp.*) survival into adulthood supports a $420 million fishery in the U.S. and is determined by the critical period when juveniles first enter the ocean. When fewer salmon prey species are available, juvenile salmon grow more slowly, which increases their chances of being preyed upon. Additionally, predators, when faced with insufficient other prey, will eat more juvenile salmon, causing a significant amount of mortality on the salmon population. Therefore, identifying variables affecting the distribution of prey facilitates ecosystem-based management of salmon (specifically, Chinook, *Oncorhynchus tshawytscha*) in the California Current. NOAA Fisheries consolidated data from two surveys that measured suitable prey species, forage fish, for salmon on the coastal California Current shelf. The work, thus far, has demonstrated that Cape Blanco in southern Oregon represents a biogeographic break in community structure of forage fishes and that winter upwelling is a determining factor of the availability of forage fish on the shelf. This work is essential to understanding the proximate driver of salmon recruitment north and south of the Cape Blanco.

NOAA's Northwest Fisheries Science Center is studying how prey availability influences the survival to adulthood of economically important salmon species.

Great Lakes Ecosystem Classification System

The Great Lakes are the largest freshwater ecosystem in the world, with nearly 84 percent of North America's surface fresh water and 22 percent of the world's surface fresh water. More than 35 million people rely on the Great Lakes for drinking water, jobs and their way of life. The region's economy generates $6 trillion. The Great Lakes' unique geology, bathymetry, and climate create complex patterns of temperature, mechanical energy, water quality, and biological assemblages within and around the lakes. A collaboration of state, federal, university and non-governmental organization scientists developed an ecological classification system to help organize and simplify this complexity to advance monitoring, assessment, management, and research of the Great Lakes. Researchers organized the Great Lakes into 77 Aquatic Ecological Units (AEUs) using depth, temperature, motion from waves and currents, and influence from nearby tributaries. The habitat classification simplifies a large (~100,000 km^2), complex ecosystem. Researchers can use the AEUs to describe and explain existing ecological patterns. Resource managers can use the AEUs to facilitate inventory surveys, evaluate habitat status and trends, and track the effects of human disturbance across different types of ecological units. The classification now informs policy development of environmental principles of the Great Lakes and will aid managers to prioritize critical fish habitat for protection and restoration.



NOAA's Great Lakes Environmental Research Laboratory has developed a classification system for the Great Lakes.

A monitoring protocol is tested at the Hudson River National Estuarine Research Reserve (photo credit: Hudson River NERR).

National Estuarine Research Reserves (NERRS) Provide Science Platform for Coastal Resilience

NOAA partners with coastal states to maintain 29 sites designated to protect estuarine systems. Collectively, these sites form the National Estuarine Research Reserve System (NERRS) which provides real-life labs for coastal monitoring, conservation, and research. Recent studies in the NERRS have made key contributions to our understanding of how to protect coastal communities from coastal hazards. Research in New Hampshire's Great Bay reserve demonstrated the value of NERRS to serve as a natural buffer against storm surge, sea level rise, and runoff. Findings from this work, available online, are supporting land use decisions and policy. Researchers working at the Guana Tolomato Matanzas reserve in Florida are field testing and optimizing a new nature-based shoreline protection technique that is already showing benefits. Scientists and engineers installed a series of "gabion-break" structures that run parallel to the shore to dissipate waves using a combination of wooden breaks and shell filled cages. The research shows that this unique hybrid design is fostering oyster settlement and reef development and allowing sediment accretion and the expansion of marsh grasses in a section of Florida's Intercoastal Waterway with heavy boat traffic. Over the past ten years, the NERRS Science Collaborative has supported the Hudson River Sustainable Shorelines Project, which engages a regional research team to quantify the ecological functions and physical stresses on the full range of Hudson River shorelines. The team recently developed, tested, and trained land managers to use rapid assessment protocols allowing state regulators to rapidly determine the environmental success of restored shoreline projects. Ongoing collaboration with a variety of partners has enabled this research to better inform state funding and permitting programs and has inspired a number of new sustainable shoreline projects along the Hudson River.

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.

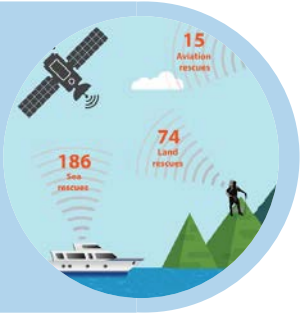
Data science efforts within NOAA span the entire data exploitation spectrum including acquisition, quality control, metadata cataloging, validation, reprocessing, storage, retrieval, dissemination, and production of useful intelligence and products for society. To support NOAA's data management efforts, 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.

Accelerate the Blue Economy

Mapped more than 635,000 square kilometers of seafloor in and around the Pacific Remote Islands.

Developed new method to identify incidents of illegal fishing using satellite and GPS technology.



Prepare for Extreme Weather

Broadened outlook for coastal high tide flooding to more than 100 coastal locations and updated it based on new national flooding thresholds.

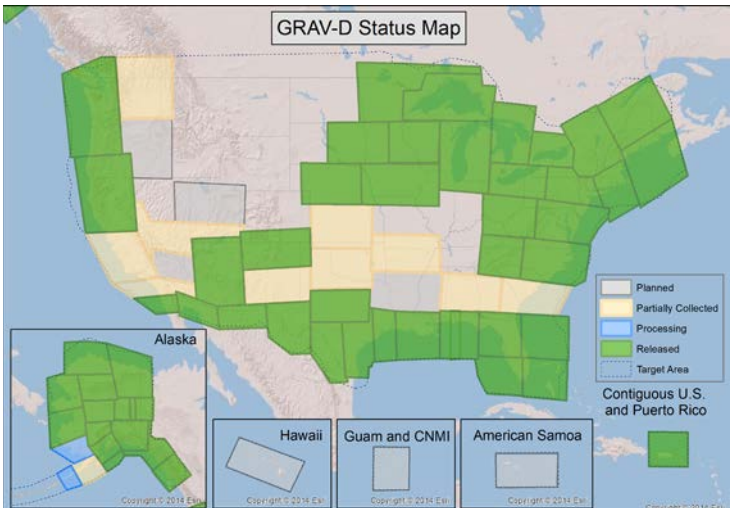
Launched two new satellites to improve weather, severe weather, hurricane, flooding, fire weather, and air quality forecasts.

Selected Accomplishments

- Update to GRAV-D/NSRS Modernization: Use of Innovative Technology to Expand Coverage and Complete the 2022 Gravity-Based Vertical Datum
- New Buoy in Chesapeake Bay to Identify Areas Most Vulnerable to Ocean Acidification
- Machine Vision to Collect Timely Fisheries Data
- NOAA Uses Unmanned Systems to Enhance Navigation
- Saildrone Makes Key Observations in Tropics for Long-Term Weather Forecasts
- Deep-Sea Benthic Surveys Inform Fishery Management Council Decisions in the Pacific and Gulf of Mexico
- NOAA Concludes the Campaign to Address Pacific monument Science, Technology, and Ocean NEeds (CAPSTONE)
- Development of High Tide Flooding Thresholds and Application to Flooding Outlooks
- Citizen Scientists
- New 'Atlas' Reveals Patterns of Earth's Microbial Diversity
- Developing the First Survey of Untrawlable Fish Habitats in Alaska
- We Heard You Were in the Area: Listening for Right Whales
- Shining a Light on Illegal Fishing
- Photo Survey Provides Rare Look at Basking Shark Behavior
- Using Underwater Video to Examine the Functional Role of Shellfish Aquaculture and Natural Nearshore Habitats in Puget Sound, Washington
- Puget Sound Habitat Status and Trend Monitoring
- Understanding the Value of Our Environmental Data
- New Experimental Coral Reef Laboratory
- Not Just Blowing Smoke: Spotting and Monitoring Fires from Space
- Tracking Lightning From Space: The GOES Satellites' Geostationary Lightning Mapper
- Next Generation Satellites Enhance Observational Capabilities
- When Solar Storms Attack: Space Weather and our Infrastructure
- New Polar-Orbiting Satellite for Global Weather Forecasts and Emergency Responders
- Another Climate Milestone on Mauna Loa
- Emissions of Ozone-Destroying Chemical are Increasing Again
- Annual Greenhouse Gas Index Measures Earth's Thermostat Setting
- Weather and Climate Data for Tribes
- Emissions from Personal Care Products Comparable to Tailpipe Emissions

Update to GRAV-D/NSRS Modernization: Use of Innovative Technology to Expand Coverage and Complete the 2022 Gravity-Based Vertical Datum

An accurate and consistent national positioning system supports infrastructure for all modes of modern transportation – land, air and sea. NOAA's modernization of the National Spatial Reference System (NSRS), the authoritative framework for all positioning activities in the U.S., enables users to quickly determine locations and heights to within one to two inches with GPS. The precise positioning provided by the NSRS will support construction, marine and fresh water navigation, flood risk determination, emergency management, property delineation, and new economic opportunities, such as smart vehicles and autonomous navigation. NSRS's modernization is made possible by NOAA's Gravity for the Redefinition of the American Vertical Datum (GRAV-D) project, a nationwide effort to collect gravity data from airborne instruments to modernize the vertical reference frame for the U.S. In 2018, the GRAV-D project reached 70 percent completion for the Nation and 98 percent completion over mainland Alaska.



NOAA's National Geodetic Survey is modernizing the authoritative framework for all positioning activities in the U.S. with Gravity for the Redefinition of the American Vertical Datum (GRAV-D).

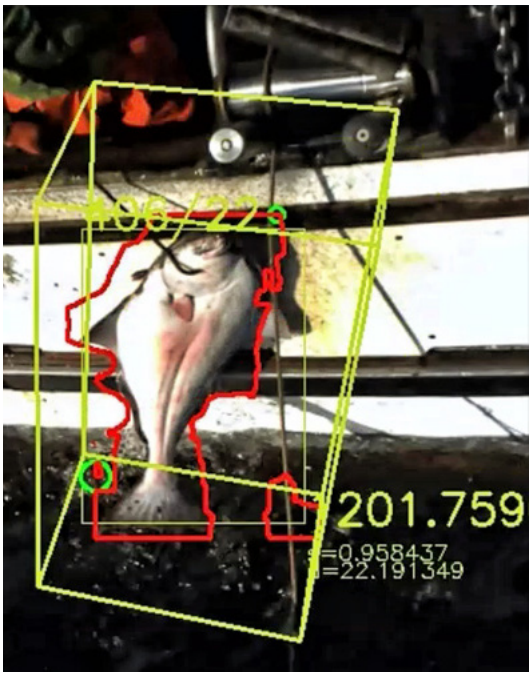
NOAA's Ocean Acidification Program, Pacific Marine Environmental Laboratory, and Integrated Ocean Observing System are monitoring water conditions in Chesapeake Bay.

New Buoy in Chesapeake Bay to Identify Areas Most Vulnerable to Ocean Acidification

Establishing sustained ocean acidification monitoring sites in estuarine environments has been identified as a high priority by the scientific community (e.g., Strategic Plan for Federal Research and Monitoring of Ocean Acidification), and now, the first long-term estuarine ocean acidification mooring is operating in the Chesapeake Bay. The current NOAA ocean acidification mooring network consists of 21 moorings in coral, coastal, and open-ocean environments of U.S. waters and select sites across the globe. The Chesapeake Bay is the largest U.S. estuary and provides a variety of resources that support recreational and commercial economies in multiple states. There is sizable natural variation in coastal water chemistry in large estuaries like the Chesapeake Bay, making it difficult to identify the human-driven components of ocean acidification and ecosystem responses that follow. A buoy at the interface of Bay and ocean will advance our understanding of ocean acidification and help differentiate human impacts from natural chemical variations. The information from this long term monitoring will inform management options and adaptation strategies, allowing the Bay to continue to support communities and industries, including fishing and recreation.

Machine Vision to Collect Timely Fisheries Data

NOAA Fisheries scientists, academia, and commercial fishermen are working together to develop innovative monitoring tools to identify and measure fish from digital images. Fisheries scientists and managers are increasingly turning to electronic monitoring to augment observer data by deploying camera systems to record catches on fishing boats and remotely monitor compliance in federal fisheries, assess fish populations, and inform management. These systems produce vast amounts of video data that are reviewed manually back on land, which delays the availability of data that could be used for fishery management. Machine vision technology would automate image analysis at sea, providing data needed to make management decisions in a quicker and more efficient manner than electronic monitoring systems which require manual data processing. The Electronic Monitoring (EM) Innovation Project started in 2013 is working in collaboration with numerous international, federal and state agencies, as well as the Information Processing Laboratory at the University of Washington, who is leading the development of machine vision to automate length measurement and species identification. Working with the fishing industry, the team has overcome one of the biggest hurdles to the project: developing equipment that can survive Alaskan weather and seas.



A view of a catch from NOAA's Alaska Fisheries Science Center machine vision tool.

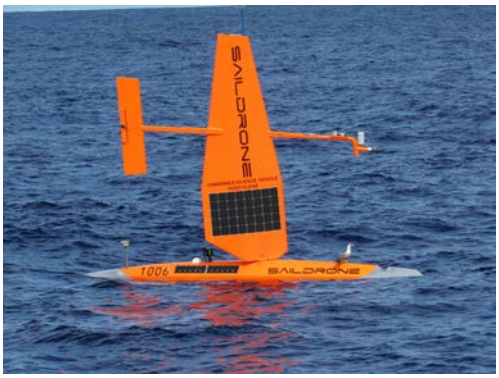
NOAA Uses Unmanned Systems to Enhance Navigation

Recreational boaters, fisherman, and cruising vessels are aware of the hazards in shallow waters, such as the area of the Chesapeake Bay along the Eastern Shore of Maryland. To safely travel in these waters, they rely on a system of beacons and buoys, known as aids to navigation (ATON). The U.S. Coast Guard (USCG) Aids to Navigation Team (ANT) recently requested the assistance of NOAA NOS to identify areas where ATON needed repairs, relocation, or removal. Crews from NOAA and the USCG operated an Echoboat autonomous surface vehicle to survey the Chesapeake's shallow waters. Once the survey data is processed and delivered to the USCG ANT, they can make informed decisions about maintaining ATON. Through NOAA's autonomous survey capabilities, USCG may also find old ATON anchors and recycle them back into service, which would result in a potential cost savings.

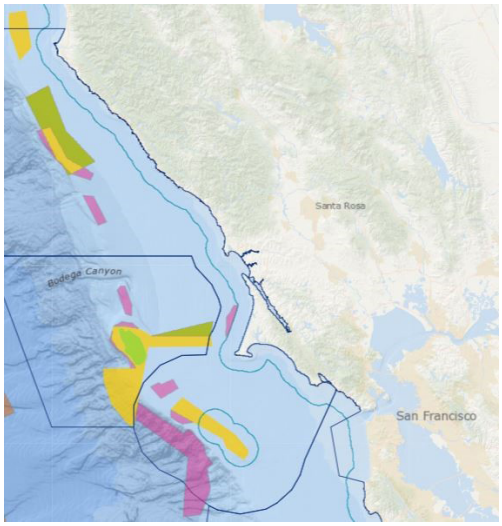
NOAA's Office of the Coast Survey loads an Echoboat onto a U.S. Coast Guard vessel (bottom) to survey the Pocomoke River channel (top).

Saildrone Makes Key Observations in Tropics for Long-Term Weather Forecasts

The saildrone is an autonomous sailing drone currently being explored as a tool to provide high quality oceanic and atmospheric observations. On September 1, 2017, two saildrones departed Alameda, California, on a six-month, 7400+ nautical km mission to the equator and back in an effort to improve the Tropical Pacific Observing System (TPOS). The two saildrones returned to Saildrone headquarters eight months later, after fighting strong westerly currents and light winds which caused some navigational difficulties. Preliminary results indicate that the saildrone's sensors provide high quality measurements and revealed interesting results about ocean features that may not be revealed from satellite or moored buoys. On October 3, 2018, four saildrones departed from Hawai'i on their second mission to the equator to capture oceanic and atmospheric data, such as temperature, winds, currents, and ocean carbon dioxide concentrations during a developing El Niño. This year, two of the four saildrones have been outfitted with larger, more efficient sails, making them faster and more capable in low wind-strong current environments. A third mission is planned for February 2019. The TPOS missions will test whether the saildrone can provide measurements at the quality that matches research ships and proven mooring technology. If this is the case, saildrones could become a powerful and cost-effective tool for providing key observations for long-term weather forecasts.



NOAA's Pacific Marine Environmental Laboratory is using Saildrone to make oceanic and atmospheric observations in the tropical Pacific.



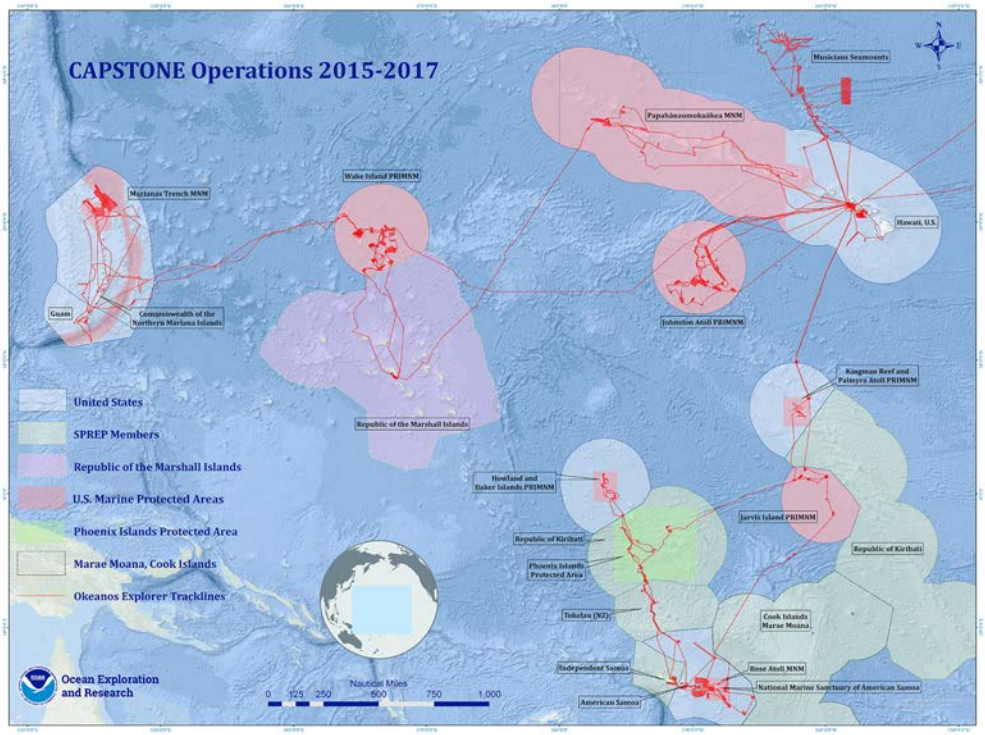
A map of new spatial management decisions off the coast of California based on NOAA's National Centers for Coastal Ocean Science deep sea benthic surveys.

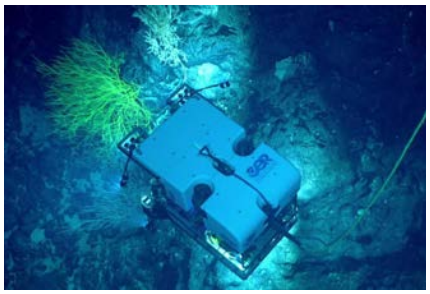
Deep-Sea Benthic Surveys Inform Fishery Management Council Decisions in the Pacific and Gulf of Mexico

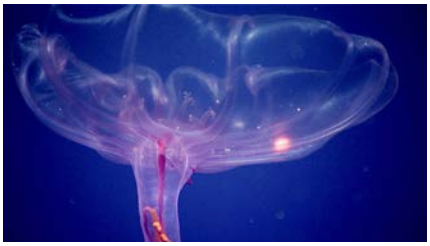
NOAA NOS data and analyses from deep sea benthic surveys directly influenced two major Fishery Management Council (FMC) decisions. In May 2018, the Pacific FMC proposed new fisheries openings off of northern California to be accompanied by new fisheries closures in rocky areas along southern California to protect deep sea corals, important spawning grounds for commercially valuable species including grouper, snapper, sea bass, and rockfish. The closures included 460 km^2 within the Greater Farallones National Marine Sanctuary. In June, the Gulf of Mexico FMC designated 21 sites totaling 1250 km^2 as Habitat Areas of Particular Concern, to safeguard some of the region's coral hot spots and restrict damaging fishing gear in most of those areas. Both decisions were based on survey data and other collaborative research with full support of the fishing communities. NOAA's Draft Environmental Impact Statement indicates the economic impact of these proposals will be a positive net benefit to fisheries landings and value. The large closure areas had small negative economic impacts (due to their extreme depth and distance offshore), while the smaller openings had larger positive economic impacts, up to three times the landings and value of the closure areas.

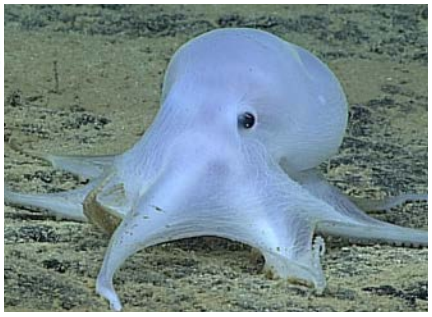
NOAA Concludes the Ocean Exploration Campaign to Address Pacific monument Science, Technology, and Ocean NEeds (CAPSTONE)

From July 2015 - September 2017, NOAA and partners conducted the Campaign to Address Pacific monument Science, Technology, and Ocean NEeds (CAPSTONE) using NOAA Ship *Okeanos Explorer.* CAPSTONE was a major multi-year foundational science effort focused on deepwaters of central and western Pacific U.S. marine protected areas (MPAs). The initiative provided timely, actionable information to support decision making, and also served as an opportunity for the nation to highlight the importance of these remote and largely unexplored areas. Throughout CAPSTONE, NOAA conducted 24 expeditions, 187 remotely operated vehicle dives, and mapped more than 635,000 km^2 of seafloor, an area close to the size of Texas, in and around the Pacific Remote Islands, Papahānaumokuākea, Marianas Trench, and Rose Atoll Marine National Monuments, the Hawaiian Islands Humpback Whale and American Samoa National Marine Sanctuaries, and the high seas. The campaign contributed a wealth of publicly available data, including high-resolution maps for large portions of the Pacific Ocean, first documentations of several underwater cultural heritage sites, the discovery of potential new species, range expansions of numerous known species, and important insights into geological, oceanographic, and biological processes. These data and information improve our understanding of how underwater geological features are formed across the central and western Pacific and help to identify biogeographic patterns and natural and cultural resources. CAPSTONE results also allow decision-makers to better address emerging regional priorities such as deep-sea mineral locations, sustainable fisheries, and potential U.S. Extended Continental Shelf designations. More than 260 scientists, students, and managers participated in CAPSTONE expeditions via telepresence technology, and live video feeds from these expeditions received more than 16.5 million views.





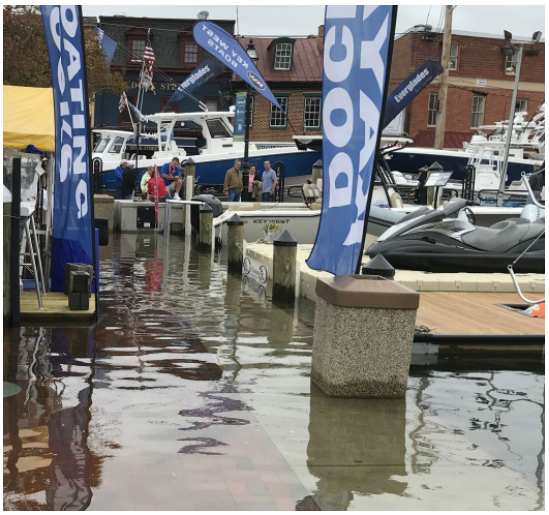




The Campaign to Address Pacific monument Science, Technology, and Ocean NEeds (CAPSTONE) operating areas from 2015 - 2017 (top left). Using a Remotely Operated Vehicle Deep Discoverer (top right) NOAA's Office of Ocean Exploration and Research observed a deep-sea swimming sea cucumber (middle right) and a ghostlike octopod (bottom right).

Development of High Tide Flooding Thresholds and Application to Flooding Outlooks

Coastal flooding damages infrastructure and causes additional hazards when it creeps into busy city centers and streets. In 2018, NOAA released the State of High Tide Flooding and 2018 Outlook to assess coastal high tide flooding based on new national flooding thresholds. This new approach expands the outlook to more than 100 coastal locations and highlights the impact of high tide flooding. This technical report allows NOAA to communicate these new thresholds and the frequency of visible flooding to decision-makers to inform mitigation measures.



NOAA's Center for Operational Oceanographic Products and Services technical report highlights the impact of high tide flooding.

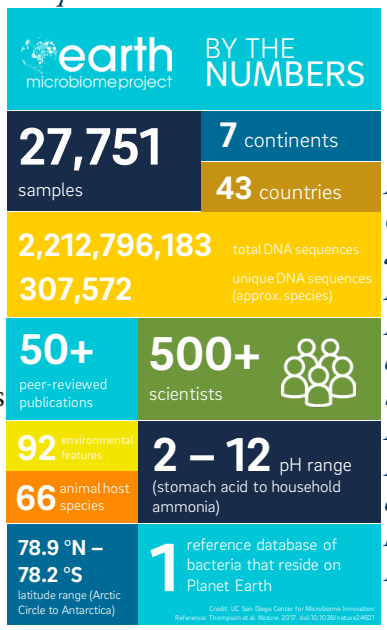
Citizen Scientists

Citizen science addresses societal needs, supports hands-on learning, and enhances research and monitoring. At NOAA, citizen scientists connect to NOAA's mission through more than 40 projects. For example, Steller Watch engages online volunteers that have classified 340,000 images to help track movement and survival of Steller sea lions in Alaska's remote eastern Aleutian Islands. In another project, data on the seafloor's depth and shape, is crowdsourced from recreation boats to tankers, and made publicly available by NOAA. Through these projects and many others, NOAA makes citizen science a vital part of observing, predicting and protecting our environment.

Each year, volunteers with Hawaiian Islands Humpback Whale National Marine Sanctuary participate in the Sanctuary Ocean Count to keep track of visiting humpback whales.

New 'Atlas' Reveals Patterns of Earth's Microbial Diversity

Microbes found in animals and throughout the oceans and soils support ecosystem services, including food production. Understanding how environmental conditions affect this critical component of the Earth system can help anticipate how communities will adapt as conditions change. The Earth Microbiome Project, led in part by NOAA scientists, recently published the first reference database, or atlas, of microbes covering the planet. This new database catalogs the microbiomes of Earth, which can help launch innovations in aquaculture, agriculture, energy, medicine, and the built environment (including space vehicles). This catalogue can facilitate exchange of knowledge and encourage scientific collaborations to advance understanding of microbial diversity in a global context.

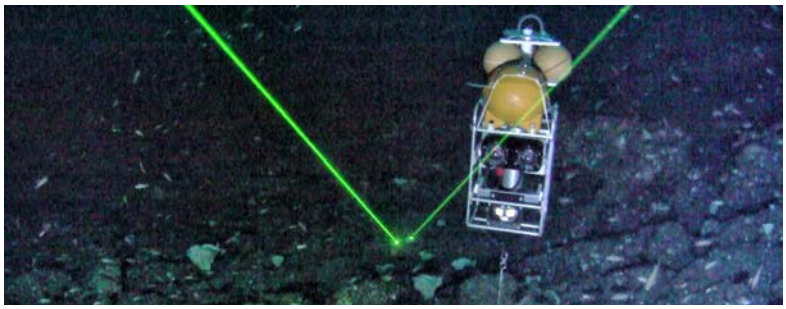


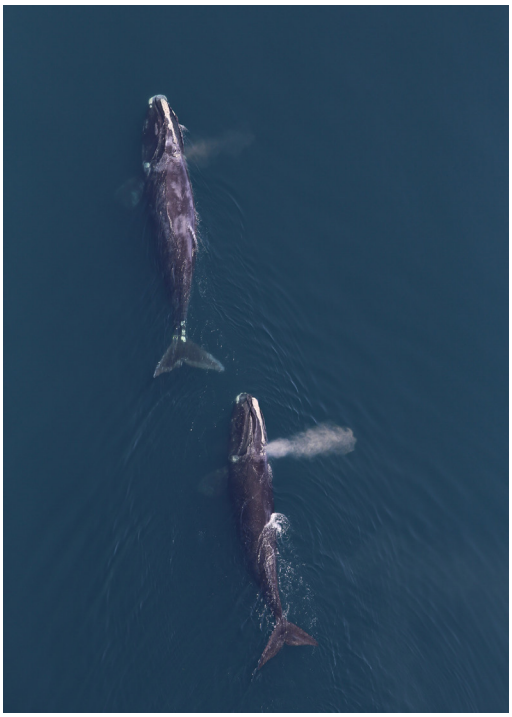
NOAA's Atlantic Oceanographic and Meteorological Laboratory contributed to the Earth Microbiome Project, which catalogs the microbiomes of Earth.

NOAA's Alaska Fisheries Science Center designed a camera (bottom right) to survey untrawlable habitat in the Gulf of Alaska (top).

Developing the First Survey of Untrawlable Fish Habitats in Alaska

Bottom-trawl and midwater acoustic surveys have been the main source of fishery-independent data for assessing fish stocks in Alaska. However, a bottom trawl cannot sample the steep, rocky areas - untrawlable areas - that species such as Atka mackerel and rockfishes prefer. Acoustic instruments can be used in these areas, but are limited in detecting fish on or near the seafloor and cannot discern between fish species or sizes. Untrawlable areas make up to 17 percent of federally managed areas where bottom-trawl surveys are regularly conducted in the Gulf of Alaska and 54 percent in the Aleutian Islands. In order to survey untrawlable areas, NOAA Fisheries is designing the first large-scale image-based fish survey in Alaska, and one of the first untrawlable habitat surveys nationwide. These image-based surveys use automated image analysis to identify and determine the length of the fish in the captured images, identifying a fish in one fifth of the time it would take a trained biologist. These fish stock assessments are necessary for setting catch limits in these areas; an improved understanding of the fish populations will improve the management of these species.

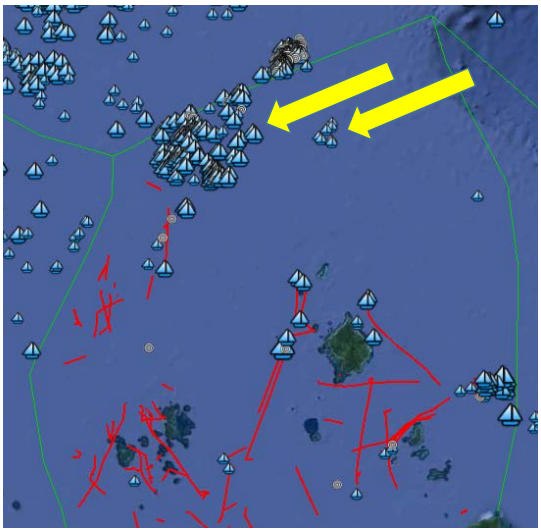




NOAA's Northeast Fisheries Science Center uses passive acoustic monitoring to confirm North Atlantic right whale locations.

We Heard You Were in the Area: Listening for Right Whales

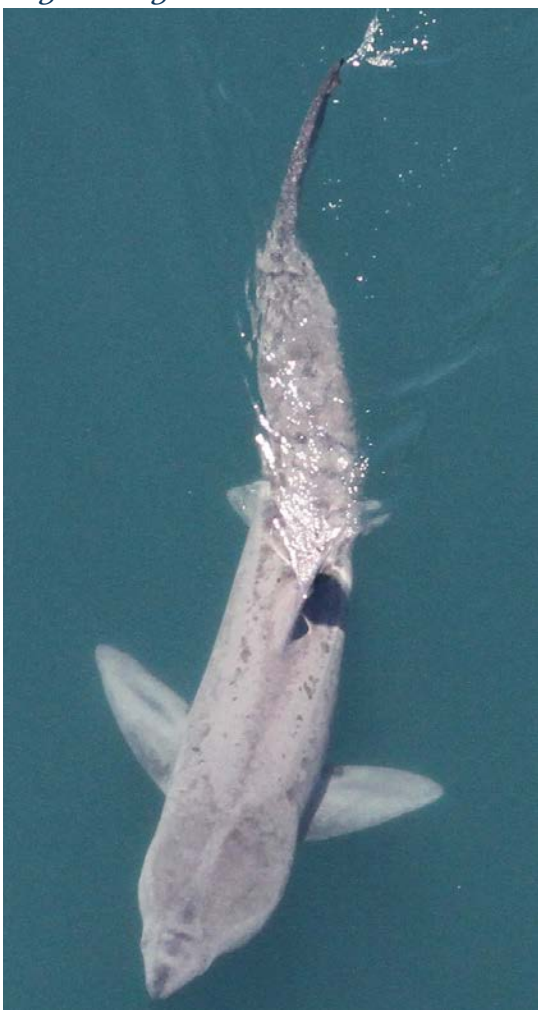
A new study confirms what marine mammal researchers have suspected for a while: North Atlantic right whales use nearly the entire eastern seaboard during the winter, and they move around much more than was previously thought. How long they spend in some areas of their range has also changed in recent years. This study combined 10 years of data collected by 19 different organizations throughout the western North Atlantic and is one of the first comprehensive, long-term passive acoustic studies to investigate an entire habitat range for a marine mammal at this time and space scale. It not only helps clarify habitat use by these endangered animals to inform the management of these areas, but also demonstrates the power and cost-effectiveness of passive acoustic monitoring.



NOAA's National Center for Environmental Information detects boats with the Visible Infrared Imaging Radiometer Suite (VIIRS) instrument on the Joint Polar Satellite System (JPSS) satellites without a vessel monitoring system (VMS), representing potential illegal fishing.

Shining a Light on Illegal Fishing

Illegal, unreported, and unregulated (IUU) fishing is a global problem that threatens ocean ecosystems and sustainable fisheries. IUU fishing poses not only an environmental threat to fish stocks and their ecosystems, but also a threat to food security and socio-economic stability in many parts of the world, with developing countries most at risk. NOAA's new Boat Detection products detect vessels by light, including fishing vessels using lights to attract fish, with the day/night band of the Visible Infrared Imaging Radiometer Suite (VIIRS) instrument on the Joint Polar Satellite System (JPSS) satellites. Scientists cross-matched VIIRS boat detections with ship tracks coming from GPS beacons such as Vessel Monitoring System (VMS) or Automatic Identification System (AIS) devices. This capability can be used to identify vessels detected by VIIRS, but lacking AIS or VMS, and represent potential illegal fishing in certain fishing grounds.



NOAA's Northeast Fisheries Science Center documented basking shark aggregation events from photographs taken for North Atlantic right whale surveys. (Photo credit Greg Skomal).

Photo Survey Provides Rare Look at Basking Shark Behavior

Observations of basking shark aggregations are relatively rare. Examining 40 years of aerial photographs taken during routine surveys for North Atlantic right whales, researchers documented ten large basking shark aggregation events. Groups ranging from as few as 30 to nearly 1,400 individual animals were observed in waters from Nova Scotia to Long Island. Comparing these images to other data collected at the time by satellites and ships allowed researchers to understand more about basking shark behavior. The study also demonstrates the value of long-term data collection— surveys intended to answer one question hold a wealth of other valuable information - you might learn something you were not even looking for.

Using Underwater Video to Examine the Functional Role of Shellfish Aquaculture and Natural Nearshore Habitats in Puget Sound, Washington

Estuaries are highly productive and complex ecosystems filled with diverse nearshore habitats that include salt marshes, mudflats, eelgrass and kelp meadows, and shellfish beds. Many fish and invertebrates, including threatened and endangered species such as Pacific Northwest salmon, depend extensively on estuaries for feeding, rearing, and as refuge from predators. Shellfish aquaculture beds provide vital economic and societal benefits, but also have the potential to contribute to the functional role of ecosystems. Shellfish aquaculture provides a distinct type of habitat in estuaries, from the organisms themselves to the structures used to anchor the shellfish (e.g., on-bottom oyster bags, off-bottom longlines). This shellfish aquaculture habitat may provide both refuge and food for higher trophic levels. Yet, our understanding of how these functions compare to those provided by other nearshore habitats, such as eelgrass and mudflats, remains limited.

With an eye toward streamlining data collection from the marine environment, NOAA Fisheries, Washington Sea Grant, The Nature Conservancy, and shellfish growers throughout the Puget Sound region are collaborating to understand the ecological function of shellfish-growing areas relative to other habitats. To do so, they are using underwater video cameras to document fish and larger invertebrates, such as Pacific salmon and Dungeness crabs, in both shellfish aquaculture and adjacent eelgrass and mudflat habitats. This research will help identify how and where shellfish aquaculture has a positive, neutral, or negative influence on habitat availability, and thereby increase understanding of this understudied type of habitat in the intertidal zone.

NOAA's Northwest Fisheries Science Center, Washington Sea Grant, The Nature Conservancy, and shellfish growers have teamed up to install underwater video cameras (below) to understand the influence of shellfish aquaculture on habitat availability (right).

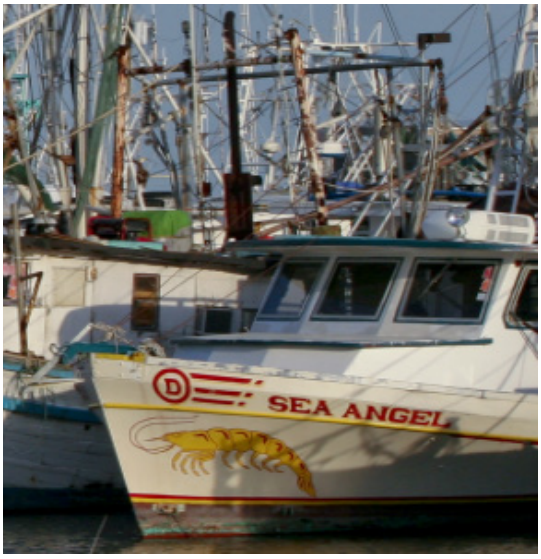
Puget Sound Habitat Status and Trend Monitoring

Salmon and steelhead are important commercial and recreational species in the Pacific Northwest, and are an integral part of the culture of Native American tribes in the region. NOAA Fisheries is required to evaluate progress toward recovery of salmon and steelhead listed under the Endangered Species Act, including assessing the status of habitat supporting those species. However, there were no consistent freshwater and nearshore habitat data across the Pacific Northwest with which to assess habitat status or trends. NOAA Fisheries developed a program to collect data on status and trends of salmon habitats in large rivers, floodplains, deltas, and the nearshore of Puget Sound and subsequently expanded the monitoring to the Oregon Coast. This program provides data to determine whether habitat conditions are improving, static, or declining, which is necessary for determining whether any listed salmon or steelhead can be removed from the Endangered Species List. The research team found the habitat metrics to be good predictors of Chinook salmon productivity among Puget Sound rivers and a rigorous sampling approach demonstrated previously undocumented differences in habitat conditions in forested, agricultural, and developed areas. By providing data required to support and potentially delist these species, this research will support commerce and culture in the Pacific Northwest.

The Northwest Fisheries Science Center developed a program to collect data on salmon habitats.

Understanding the Value of Our Environmental Data

NOAA data supports a wide range of multi-billion dollar economic sectors in the U.S. and the global economy. Express couriers, rail systems, retailers, and third-party weather forecasts rely on this free and publicly available information to determine routes, scheduling, seasonal merchandising, and weather risks. Ocean and coastal data give the fishing industry tools to determine prime fishing locations through private forecasters who build fishing reports using archived data. Numerous resources, such as the Climate Disk, and datasets, including the Global Historical Climatology Network–Daily (GHCN-D), provide a foundation for these decisions. NOAA recently completed three reports that examined the use and benefit of the data delivered to fisheries, private sector weather providers, and transport and logistics industry. For example, the $1.5 trillion Logistics and Transport Industry relies heavily on ground station climate data to plan air cargo schedules, determine refrigeration needs, and support delivery to the consumer.

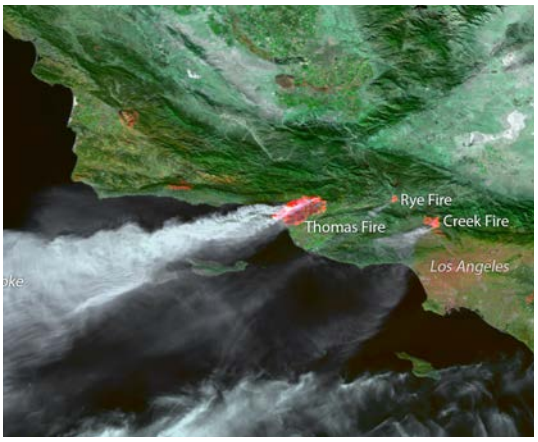


NOAA's National Centers for Environmental Information provides data that supports a wide range of sectors, including the fishing industry pictured above.

Scientists with NOAA's Atlantic Meteorological and Oceanographic Laboratory and the Cooperative Institute for Marine and Atmospheric Studies use the Experimental Reef Laboratory to study how corals react to current and future temperature and water chemistry conditions.

New Experimental Coral Reef Laboratory

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. Widespread coral mortality in recent years has led to a decline in coral cover and erosion of reef framework structures. NOAA Research's Experimental Reef Laboratory (ERL) at the Cooperative Institute for Marine and Atmospheric Studies (CIMAS) is a unique experimental facility that allows unprecedented control of seawater temperature and chemistry. By simulating future and present day conditions, scientists have been able to measure how coral reef organisms respond at the molecular level. Over the past year, individual and collaborative studies have been run in this facility covering important topics ranging from identifying mechanisms of coral heat stress resistance to quantifying the responses of endangered staghorn corals in dynamic ocean acidification conditions. Additionally, scientists have evaluated methods for treating coral disease, measured acidification-related acceleration of reef habitat erosion, and quantified how elevated concentrations of carbon dioxide can change the genes expressed in species that dissolve reef framework structures. Results from these studies will enable scientists to understand at the molecular level how some corals may be able to adapt to and survive in projected future ocean conditions.



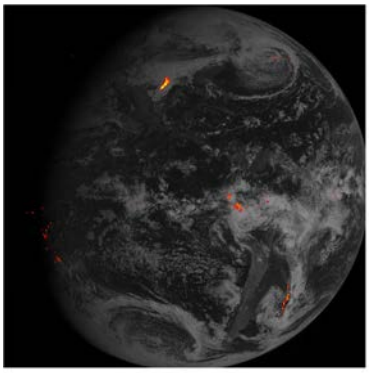
NOAA's Center for Satellite Applications and Research uses satellites to monitor wildfires, including the fires in the image above in southern California.

Not Just Blowing Smoke: Spotting and Monitoring Fires from Space

Fires, whether naturally occurring or man-made, have substantial impacts on both the landscape and air quality. NOAA satellites can detect and monitor fires and provide data on their characteristics. The imagers on the Suomi National Polar-orbiting Partnership and NOAA-20 satellites, called the Visible Infrared Imaging Radiometer Suite (VIIRS), observe every location of the globe at least twice a day and can spot blazes and plumes of smoke at a higher precision than any similar heritage sensors. The Advanced Baseline Imager (ABI) on the new generation geostationary GOES-R series provides fire observations at an unprecedented frequency of at least 15 minutes, which helps with timely detection and monitoring of fires for their entire duration. The updated satellite-based fire information improves air quality forecasts by providing better information of fire locations as well as characteristics of fires, which help determine their intensity, and the expected rise of smoke into the atmosphere. This information helps improve the accuracy of air quality forecasts.

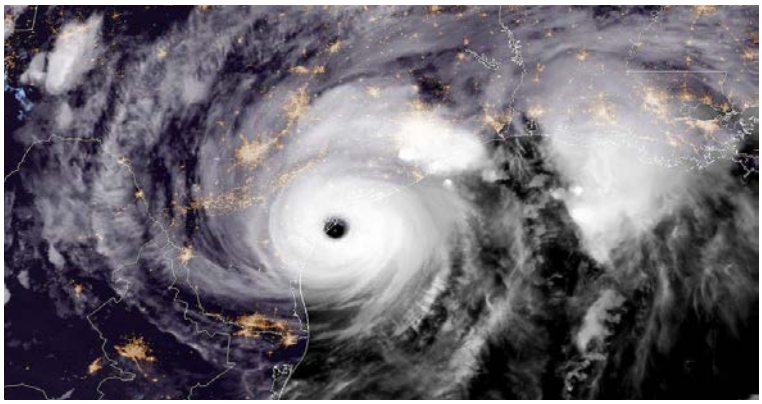
Tracking Lightning From Space: The GOES Satellites' Geostationary Lightning Mapper

The Geostationary Lightning Mapper (GLM) currently onboard NOAA GOES East satellite is the first lightning detector in a geostationary orbit and is transmitting data never before available. The GLM continuously looks for lightning flashes in the Western Hemisphere and records data every 20 seconds that can help forecasters anticipate when a storm is forming, intensifying, and becoming more dangerous, as well as identify where the risk of lightning strikes to the ground is greatest. This information is important to predict public safety hazards, and in dry areas such as the western U.S., to help identify areas prone to wildfires sparked by lightning. When combined with radar and other satellite data, GLM data will help forecasters anticipate severe weather and issue flood and flash flood warnings sooner. Scientists continue to determine the best way for integrating these data into the NOAA NWS forecast and warning process. These data will also be used to produce a database to track changes in lightning activity over an extended period of time. This long-term monitoring is important due to lightning's role in maintaining the electrical balance between Earth and its atmosphere and the potential changes in extreme weather and severe storms under a changing climate.



Left: Lightning data captured from GOES-16 on February 14, 2017 over the course of an hour.

Right: GOES-16 image of Hurricane Harvey approaching the Texas Coast.



"[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

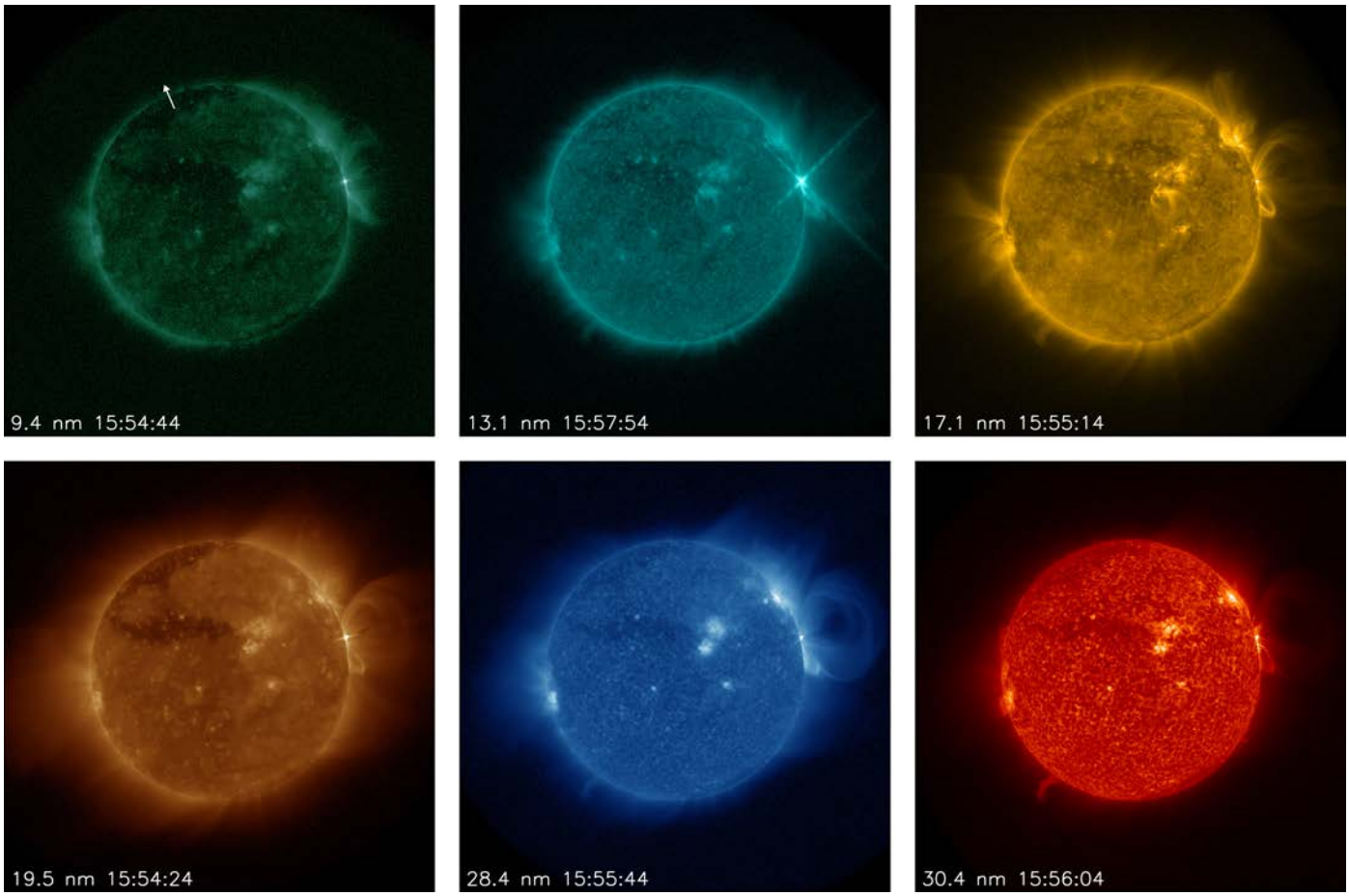
Next Generation Satellites Enhance Observational Capabilities

The Geostationary Operational Environmental Satellite R-Series (GOES-R) is the nation's next generation of geostationary weather satellites. Beginning with the successful launch of the first GOES-R (GOES-16) satellite in November 2016, and made operational in December 2017 followed by the launch of GOES-S (GOES-17) in March 2018, these satellites provide continuous imagery and atmospheric measurements of Earth's Western Hemisphere. These measurements include total lightning data and space weather monitoring to provide critical atmospheric, hydrologic, oceanic, climatic, solar, and space data. The GOES-R Series has significantly improved the detection and observation of environmental phenomena that directly affect public safety and our nation's economic health and prosperity. For example, during post-launch testing, GOES-16 provided imagery to forecasters and experimental flood maps to the Federal Emergency Management Agency (FEMA) to aid in the forecast, warning, and recovery from the impacts of Hurricane Harvey. As Hurricane Harvey remained parked along the Texas coast, where it caused torrential downpours and flooding, NOAA NWS personnel used GOES-16 data to provide impact-based decision support to emergency managers. When the storm made landfall, forecasters in Corpus Christi, Texas tracked the location of the eyewall to alert emergency managers when they would have a window of opportunity to evacuate dozens of people to safety before the back end of the hurricane struck.

On March 1, 2018, at 5:02 PM eastern time, NOAA's GOES-S satellite blasted off into space and soon took its place as GOES-17, the newest satellite in NOAA's most advanced geostationary series. The Atlas V rocket that launched the satellite propelled it into orbit 22,000 miles (35,400 km) above Earth.

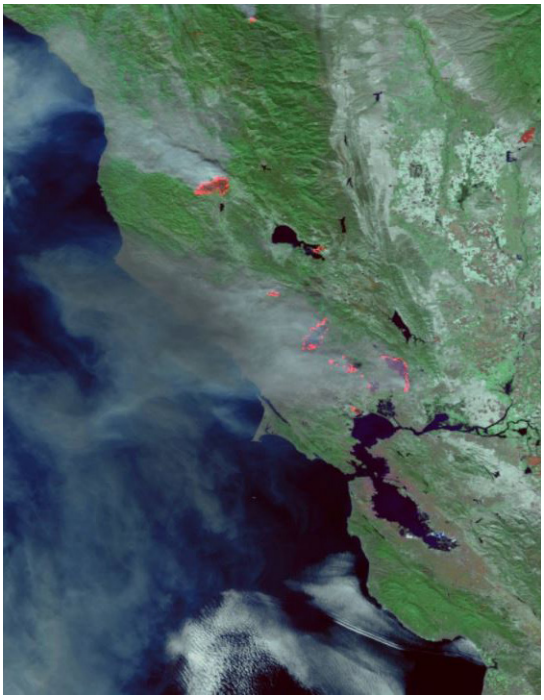
When Solar Storms Attack: Space Weather and our Infrastructure

Solar flares and eruptions, along with high-speed solar wind streams, are the primary drivers of space weather affecting the Earth. These events can cause geomagnetic storms which can disrupt power utilities and communications and navigation systems and can also cause radiation damage to orbiting satellites and the International Space Station. When the sun flared dramatically in September 2017, causing geomagnetic storms and radio blackouts on Earth, GOES-16's Solar Ultraviolet Imager (SUVI) captured the events in dramatic detail. SUVI is the best method NOAA has to observe phenomena on the sun that can directly affect Earth. SUVI has a larger field of view than previous solar imagers, allowing it to see solar phenomena at greater heights above the surface of the sun. The instrument also has six wavelength channels, or passbands, that capture simultaneous images of the sun's outer atmosphere. On September 10, 2017, a solar flare released as much energy in a few minutes as all of humanity has ever produced. SUVI's observations of that event revealed a number of unique features: it captured the onset of the solar eruption, followed by a powerful extreme-ultraviolet wave that disrupted much of the corona and was visible to heights approaching twice the sun's radius. Observations from SUVI can inform forecasters at the Space Weather Prediction Center about the properties of geomagnetic storms, and thus their impacts, before they reach Earth, providing early warning of possible impacts to Earth's space environment and potentially disruptive events on the ground.



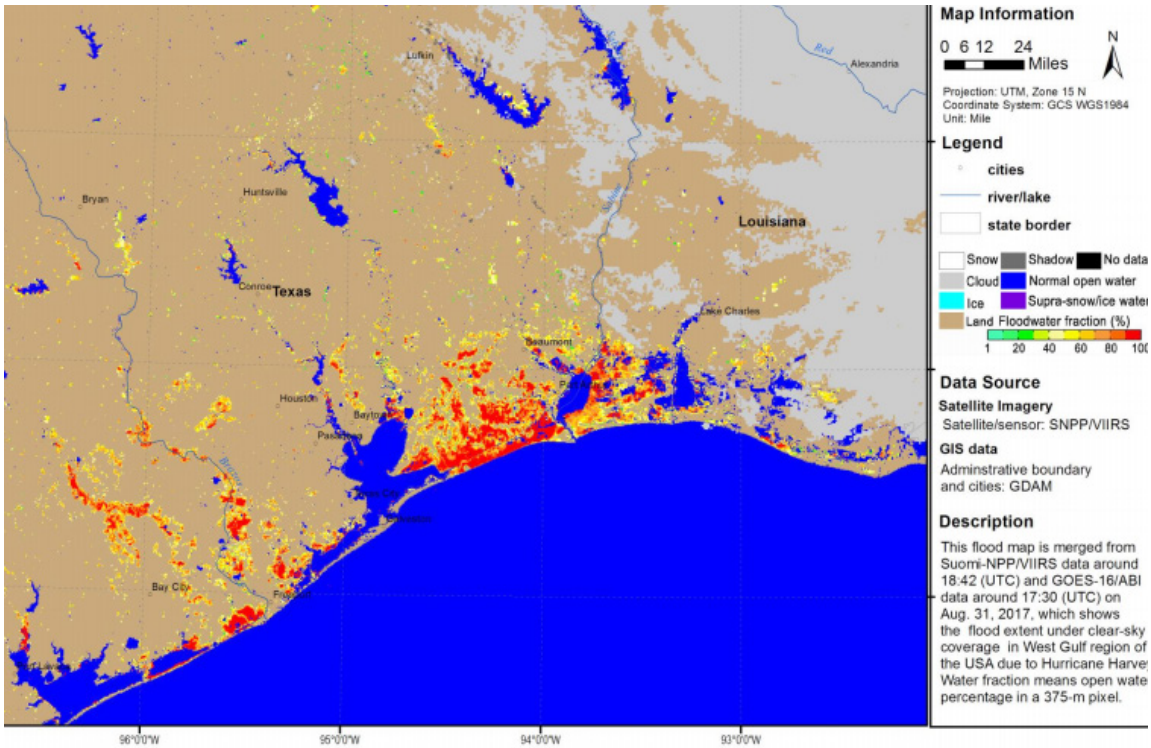
Images of the sun's corona through GOES-16's Solar Ultraviolet Imager (SUVI) on September 10, 2017.

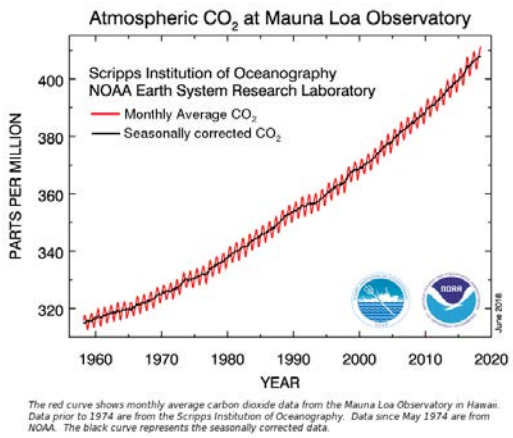
New Polar-Orbiting Satellite for Global Weather Forecasts and Emergency Responders



NOAA's Joint Polar Satellite System Program uses satellite imagery to respond to western U.S. wildfires in 2017 (above) and to develop large-scale flood maps and identify power outages after Hurricane Harvey (below).

Launched in November 2017, NOAA-20 is NOAA's newest polar-orbiting satellite under the Joint Polar Satellite System-1 (JPSS-1) series. When NOAA-20 became operational in May 2018, it began providing global data to the NOAA NWS to develop timely and accurate U.S. weather forecasts. These key satellite 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. During the active 2017 Atlantic hurricane season, the NOAA JPSS Program provided the Federal Emergency Management Agency (FEMA) and other natural disaster response agencies with data from the NOAA/NASA Suomi National Polar-Orbiting Partnership satellite (Suomi NPP) 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 (HRRR) have accurately forecast the movement of smoke, allowing actions to be taken to mitigate the impact of this smoke on firefighters and nearby towns.





Scientists at NOAA's Earth System Research Laboratory Global Monitoring Division measured monthly average CO_2 above 410 ppm for April, May, and June of 2018.

Another Climate Milestone on Mauna Loa

This year monthly average carbon dioxide (CO_2) was above 410 ppm at NOAA's Mauna Loa Observatory in Hawai'i for April, May, and June. These levels have not been observed in the remote atmosphere for several million years. The observatory catches clean air from an altitude of four km above the middle of the Pacific Ocean, yet the human impact on Earth's atmosphere is clearly visible. Every year CO_2 climbs higher as the burning of coal, oil, and natural gas continues. In this way human activities are committing the Earth to more and more climate change, as well as increasing acidification of the global oceans, for a very long time. The added CO_2 does not disappear by natural processes from the atmosphere and ocean system for thousands of years.

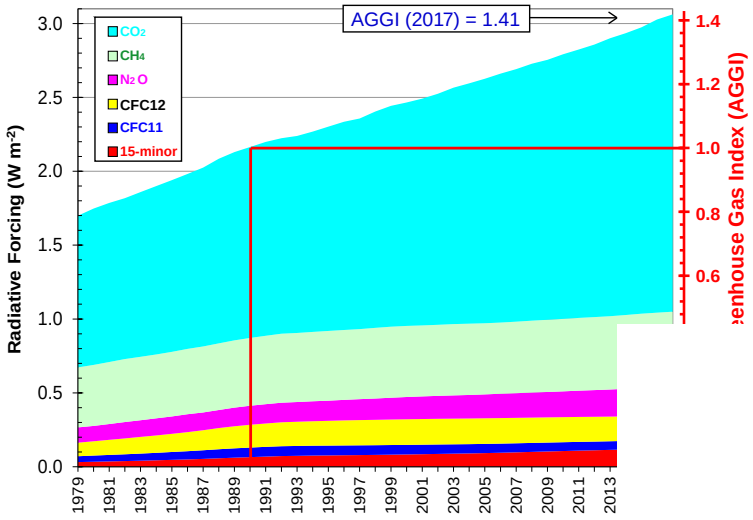
NOAA Earth System Research Laboratory Global Monitoring Division's S. Montzka presents results related to the unexpected increase in CFC-11 emissions to the 40th meeting of the Open Ended Working Group of the Parties to the Montreal Protocol on July 11 2018. This work was a collaboration between NOAA's Earth System Research Laboratory Chemical Sciences Division and Global Monitoring Division, and the NOAA Climate Program Office.

Emissions of Ozone-Destroying Chemical are Increasing Again

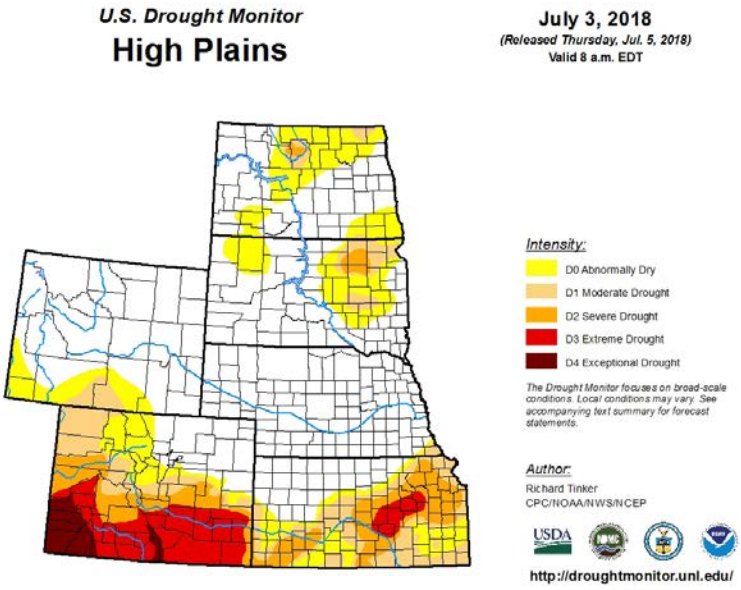
Stratospheric ozone is essential to all life on Earth, shielding the planet from dangerous ultraviolet (UV) radiation that is capable of disrupting agriculture and ecosystems and causing cancer in humans. In response to the internationally agreed upon Montreal Protocol on Substances that Deplete the Ozone Layer (1987), Congress, in the Clean Air Act of 1990, stated that NOAA shall monitor stratospheric ozone and the compounds that deplete it, and report to Congress every three years. NOAA continues to meet this requirement through its observations, analyses, and engagement at the science-policy interface. In 2018, through careful analysis of their long-term observations, NOAA scientists detected a multi-year increase of emissions of a major ozone-depleting gas (chlorofluorocarbon-11, or CFC-11) that arises in part from eastern Asia and represents a significant challenge to the historically successful Montreal Protocol. If these emissions persist without mitigation, they would have a substantial and adverse impact on ozone recovery. Within weeks of its publication, Parties to the Montreal Protocol and the (international) Ozone Secretariat have taken up the issue to identify and mitigate the problem as soon as possible.

Annual Greenhouse Gas Index Measures Earth's Thermostat Setting

The Annual Greenhouse Gas Index (AGGI) is a simple index representing warming supplied by long-lived trace gases in the atmosphere, and how their influence is changing in response to human activity. The 2018 update of the index shows this warming influence continues to increase. In 2017, it reached a value of 1.41, meaning the warming influence has increased 41 percent above the warming supplied by those gases in 1990. The index provides a direct measure of the effectiveness of policies related to controlling global greenhouse gas concentrations and, ultimately, climate. The product is used in the Environmental Protection Agency's Annual Report on the Environment, as a National Physical Indicator of Climate Change in support of the National Climate Assessments, and in the update of the World Meteorological Organization Annual Greenhouse Gas Bulletin - which is distributed worldwide in five languages and updated on climate.gov.



Left: Scientists at NOAA's Earth System Research Laboratory Global Monitoring Division calculated the 2018 Annual Greenhouse Gas Index (AGGI) reached a value of 1.41, meaning the warming influence has increased 41 percent above the warming supplied by those gases in 1990.



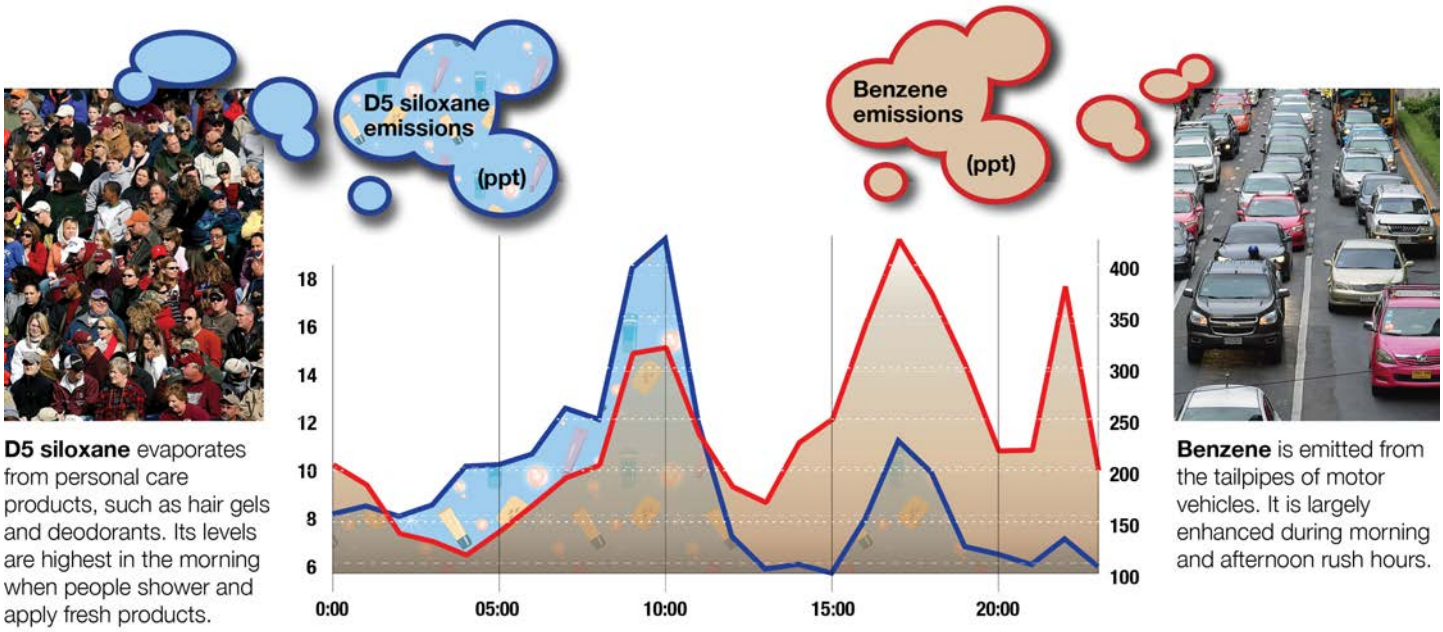
Right: NOAA's National Centers for Environmental Information and the High Plain Regional Climate Center support Native American tribes with weather and climate data, including the U.S. drought monitor.

Weather and Climate Data for Tribes

NOAA and the High Plains Regional Climate Center are supporting eight Native American tribes in the Missouri River basin as they build capacity in water resources management through tools such as NOAA's Drought Monitor and precipitation and flooding data. By exchanging knowledge with the tribes to produce the first-ever regional climate summary, the tribes will be better equipped to integrate climate knowledge and data into decision making. In March 2018, four tribes in northeastern Kansas and southeastern Nebraska released their first regional climate summary, which includes temperature and precipitation, river and stream data, soil moisture, and other environmental health indicators. The long-term goals of this work are: to build the tribes' capacity for water management, increase understanding of vulnerabilities to extreme events, and plan response-and-resilience efforts.

Emissions from Personal Care Products Comparable to Tailpipe Emissions

Surprising new NOAA-led research has revealed that consumer products are becoming one of the leading sources of secondary air pollution in urban areas. The findings open the door to a new area of air quality research and provide important information for environmental and public health agencies to consider. The research, based on data from field campaigns in Los Angeles, California and Boulder, Colorado, shows that as emissions from the transportation sector have declined, petroleum-derived ingredients in paints, pesticides, and even perfumes have become more significant as contributors to ground-level ozone and fine particulates. Emissions from these household mainstays are now comparable to those of the transportation sector, even though we consume 15 times more petroleum in fuel than in consumer products.



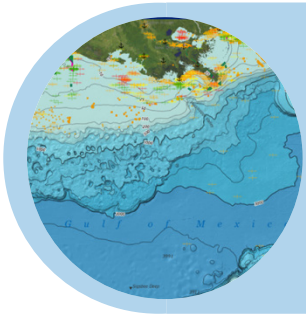
Scientists from NOAA's Earth System Research Laboratory, Cooperative Institute for Research in Environmental Sciences (CIRES), and other collaborators have found consumer products are becoming one of the leading sources of secondary air pollution in urban areas. Image credit: Kathy Bogan, CIRES

Decision Risk Assessment & 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.

Accelerate the Blue Economy



Released web-based tool for exploration, permitting, and siting of offshore aquaculture in the Gulf of Mexico.

Introduced a new program for nation-wide expansion of precision navigation services to high traffic U.S. ports.

Prepare for Extreme Weather

Explored how weather forecasters communicate the public's vulnerability to extreme weather events with a goal of providing the public more precise watches and warnings.

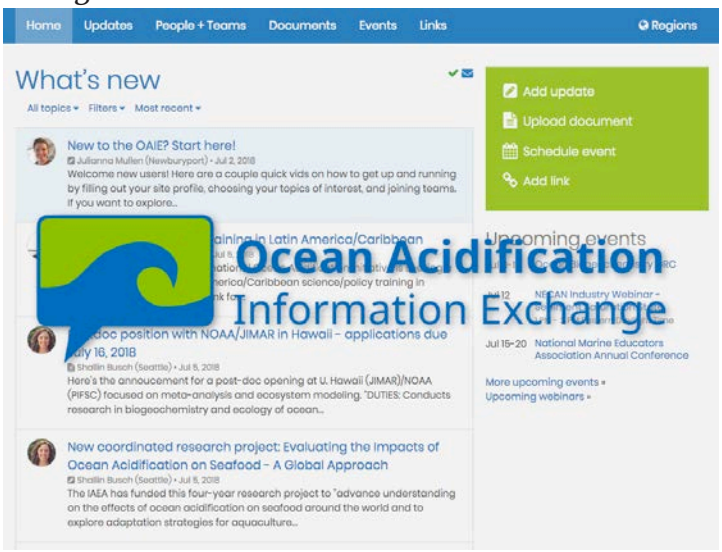
Deployed over 200 Incident Meteorologists on the scene of wildfires.

Selected Accomplishments

- Launch of Ocean Acidification Information Exchange
- New Publication Evaluates Coral Reef Ecosystem Management Scenarios
- Gulf Aquamapper: NOAA Develops Tools for Aquaculture
- Forecasting a Continuum of Environmental Threats Siting in the Gulf of Mexico
- Social Science Adds Needed Piece to the Weather Puzzle
- Fire Weather Decision Support and Incident Meteorologist Deployment
- Fishing Families Project
- Meaningful Stakeholder Engagement in Fishery Management is Not Just a Dream
- State of the Climate 2017
- SARSAT: A Beacon for Help
- Installation of NOAA's Physical Oceanographic Real Time Data (PORTS®) at Port of Miami Advances Maritime Commerce
- NOAA Advances Precision Navigation Services to Enhance U.S. Commerce
- Climate Science Special Report Serves as Foundation to Assess Climate-Related Risks

Launch of Ocean Acidification Information Exchange

The Ocean Acidification Information Exchange is a new online portal launched by the Interagency Working Group on Ocean Acidification and the Northeast Regional Association of Coastal Ocean Observing Systems (NERACOOS), with funding from NOAA and the Bureau of Ocean Energy Management (BOEM), in response to the Federal Ocean Acidification Research and Monitoring Act of 2009. The Ocean Acidification Information Exchange is different from most websites: instead of providing one-way transfers of information to website readers, the Information Exchange encourages interaction among its users. The website's more-than 650 members address ocean and coastal acidification through collaboration and information sharing, building a well-informed community that is the foundation for successful adaptation to this environmental challenge. For example, a post about a new observing system in Tampa Bay, Florida kick-started a collaboration between a chemist and biologist on laboratory experiments on Florida stone crab, one of the state's most important commercial fisheries. Anyone working on ocean or coastal acidification is welcome to join the site, including scientists, citizen scientists, aquaculturists, fishing industry, technology developers, educators, non-governmental organization employees, resource managers, policy makers, concerned citizens, and data managers.



NOAA's Ocean Acidification Program has supported the launch of the Ocean Acidification Information Exchange online portal.

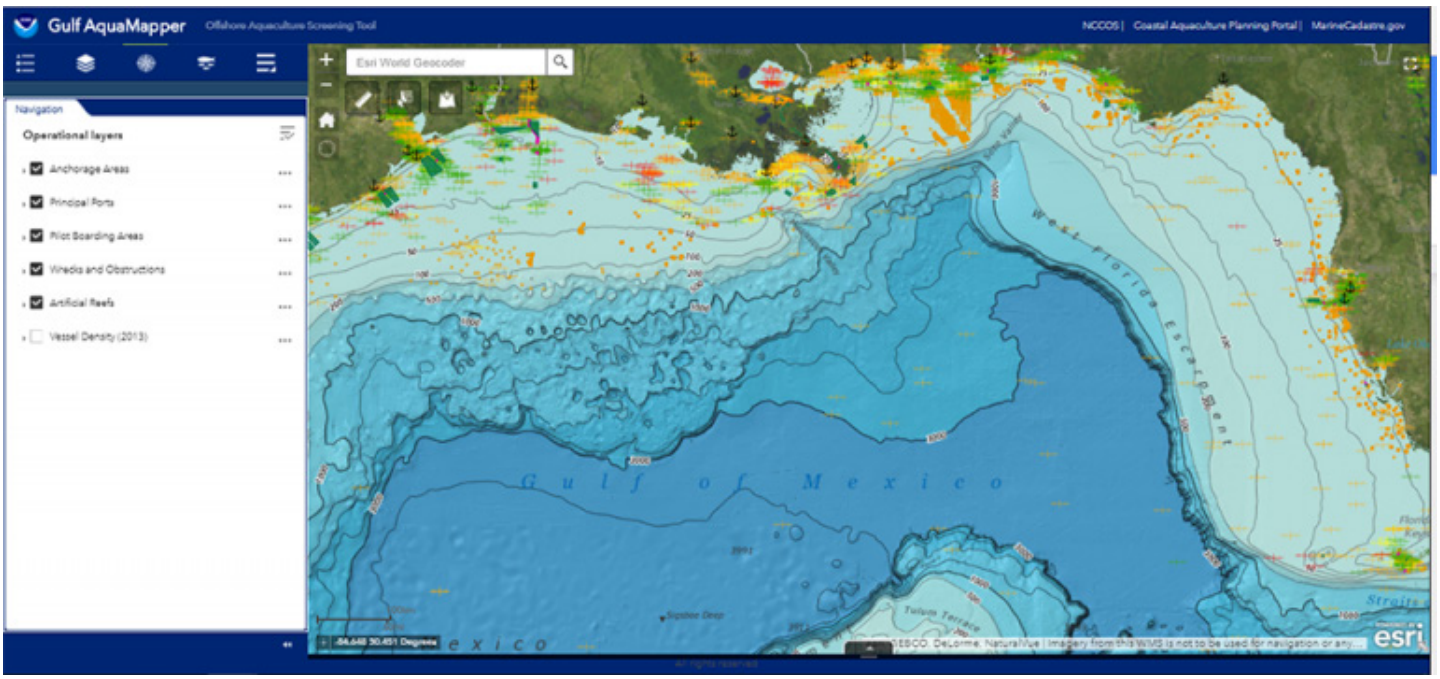
NOAA's Pacific Islands Fisheries Science Center examines how different management strategies together with climate change would impact coral reef ecosystems .in Hawai'i.

New Publication Evaluates Coral Reef Ecosystem Management Scenarios

NOAA Fisheries applies ecosystem models to assess how management strategies or climate change would impact ecosystems. Globally, coral reefs have been exposed to various pressures including land-based pollution, fishing, and climate-induced coral mortality. These pressures have led to a 35 percent decline in coral cover and a 50 percent decline in coral reef fish populations in the Puako region of West Hawaii. The state of Hawai'i Division of Aquatic Resources wanted to know trade-offs in alternative management scenarios. These scenarios included no change in current management, reduced fishing, reduced land-based pollution, fishing of herbivores, line-fishing only, and marine protected areas. All options showed some improvement in ecosystem structure and resilience except the no change scenario. Allowing only line fishing generated the most balanced trade-off between stakeholders, with positive gains in both ecosystem resilience and dive tourism, while only moderately decreasing fishery value within the area. As a result of this study, the line-fishing scenario is currently taken into consideration for future management.

Gulf AquaMapper: NOAA Develops Tools for Aquaculture Siting in the Gulf of Mexico

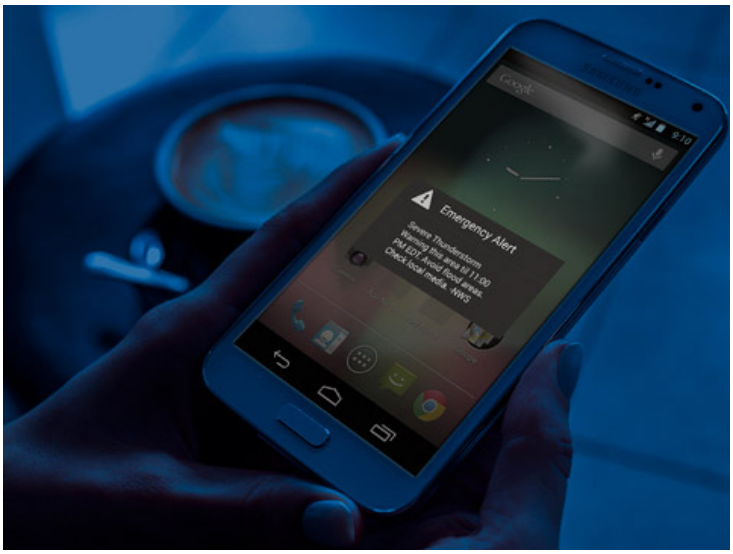
NOAA developed the Gulf AquaMapper, a web-based tool for exploration, permitting, and siting of offshore aquaculture in the Gulf of Mexico. The Gulf AquaMapper is a geodatabase featuring aquaculture-relevant GIS data for biological, navigational, military, social, economic, physical, and chemical parameters. The mapper marks the first spatial planning tool designed specifically for aquaculture in the Gulf of Mexico and integrates more than 50 types of data. With this tool, NOAA seeks to streamline the permitting process by reducing logistical and economic inefficiencies for coastal managers and aquaculture investors. This is one of more than 30 tools in NOAA's Coastal Aquaculture Planning Portal with specific applications for planning and siting of aquaculture operations and industries. The product provides a user-friendly interface that serves as a single resource for private industry and coastal managers focused on identifying suitable areas for aquaculture development. Multiple data layers, such as shipping lanes, military operating area boundaries, and marine reserves, can be viewed simultaneously for a more comprehensive assessment of competing uses. Maps can be printed and shared to inform a more detailed site assessment to verify environmental conditions and establish site-specific designs.



The interface of Gulf AquaMapper shown above was created by NOAA's National Centers for Coastal Ocean Science as a web-based tool for exploration, permitting, and siting of offshore aquaculture in the Gulf of Mexico.

Forecasting a Continuum of Environmental Threats

The NOAA NWS watch and warning process for severe weather has not fundamentally changed in more than 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, NOAA NWS, and academic partners are beginning to move us toward the FACETs paradigm. Several experiments conducted in the NOAA Hazardous Weather Testbed in the last two years brought together NOAA 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. Results from these experiments are being shared with NOAA NWS to facilitate plans to transition FACETs concepts toward operational use.



Several NOAA offices including the National Severe Storms Laboratory, Office of Weather and Air Quality, Earth System Research Laboratory Global Systems Division, Atlantic Oceanographic and Meteorological Laboratory, and the National Centers for Environmental Prediction are developing ways to provide the public more precise watches and warnings for severe weather.

Social Science Adds Needed Piece to the Weather Puzzle

Providing the public with information about possible dangers doesn't stop the threats from having an impact, and it alone doesn't motivate people to take action. A recent National Academy of Science report driven by NOAA concludes that a better understanding of how individuals (including forecasters), households, and communities respond to weather forecasts, watches, and warnings will help agencies realize the greatest return on investment from improvements in weather information. As such, NOAA Research is prioritizing their social science research efforts around two themes. The first focuses on the forecaster operational decision environment, such as NOAA Research's efforts to understand the cognitive demands on the human forecaster and create more user-friendly tools to incorporate new technologies into forecasts. The second theme focuses on understanding how people receive, interpret, perceive, and respond to new forecast information. NOAA is currently funding dozens of researchers in disciplines such as communication, psychology, and economics across NOAA's Cooperative Institutes and laboratories. For example, one project will examine how the ability to extend tornado warning lead time to one hour affects vulnerable populations and businesses. Another project, Verification of the Origins of Rotation in Tornadoes Experiment-Southeast (VORTEX-SE), looks at the vulnerability of the southeastern U.S., an area of high tornado prevalence and high vulnerability to tornadoes. Investments in the social sciences enable NOAA to save lives and increase the value of improved weather forecasts by understanding the needs of the American public.

NOAA's Office of Weather and Air Quality and National Severe Storms Laboratory are working to better understand how individuals respond to weather forecasts.

Incident Meteorologists (IMET) from NOAA's Analyze, Forecast, and Support Office work on the scene of wildfires.

Fire Weather Decision Support and Incident Meteorologist Deployment

The NOAA NWS Fire Weather Program provides critical forecasts for the safety, protection and operational intelligence of the fire-fighting community. Services range from daily, routine forecasts defined for land management protection zones to site-specific spot forecasts. The site-specific spot forecasts provide fire officials and emergency managers with tailored, location-specific forecasts using weather parameters defined and requested directly by incident management. When it comes to in-the-field decision support, the NOAA NWS Incident Meteorologist (IMET) program is ready to go at a moment's notice when fire outbreaks occur. With an average of 140 IMET dispatches per year, IMET staff are sent directly to fire incidents with specialized equipment designed to support all levels of incident management with operational forecasts. These IMETs spend 10 to 14 days camping at the actual site of the fires, issuing forecasts and warnings tailored to the incident itself. In 2017, IMETs were immediately on site during the devastating California Santa Ana fires in northern and southern parts of the state. In total, 2017 saw 200 IMET dispatches nationally, with a NOAA NWS response time, from request to the arrival of the IMET, of less than 24 hours. This immediate and timely response defends the lives of all responding fire fighters and enables the effective defense of public lives and personal assets in the path of nearly every significant wildfire.

Fishing Families Project

NOAA Fisheries hosted a series of workshops throughout 2018 as part of a social science research study to look at the impacts of fisheries management and socioeconomic conditions in Alaska's fisheries and fishing communities. Specifically, these workshops gather information about what happens to fishing family dynamics when fishing rules change. They also are exploring how fishing families and the roles of women in Alaska's fisheries may evolve with marketing innovations, strategic intergenerational networks and regulatory frameworks. Broader social and economic changes can affect whether and how families participate in fisheries or engage in other types of employment, affecting families' choices about the continuation of family fishing businesses. Two workshops were held in 2017. For 2018, three workshops were held in Sitka, Anchorage, and Kodiak, AK with two more planned in Petersburg and Cordova, AK. The results from this effort will provide a history of how generations of families have adapted to the implementation of management programs including limited entry and catch share programs, and how they now address decreasing abundance of certain key fish stocks. This information provides fisheries managers with a better understanding of the impacts of proposed regulatory changes on fisheries participants and their families.

NOAA's Alaska Fisheries Science Center is working with Alaskan Natives to understand how regulatory changes affect fishing families.

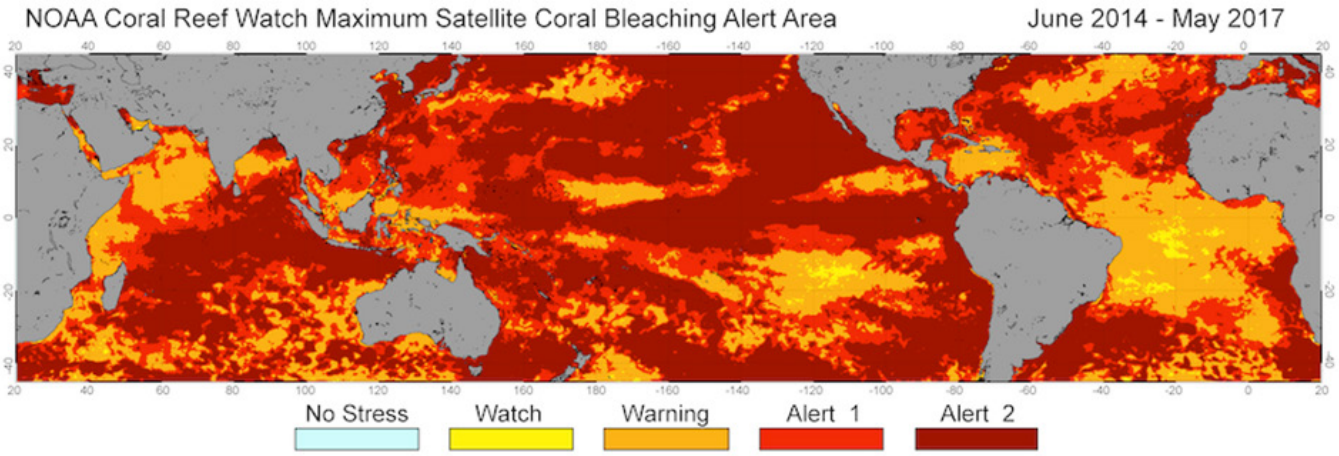
Meaningful Stakeholder Engagement in Fishery Management is Not Just a Dream

The New England Fishery Management Council is using a stakeholder driven process to develop management objectives and options in the Atlantic herring fishery, an important bait species for the multi-million dollar lobster industry. During 2016 and 2017, NOAA Fisheries scientists worked with New England Fishery Management Council staff to include stakeholders more directly in the fishery management process by increasing their involvement and ability to provide input about their concerns on the proposed rules. This new stakeholder driven approach now enables both ecosystem and economic factors along with the more traditional fishery stock performance, to be incorporated into the management objectives.

NOAA's Northeast Fisheries Science Center works with the New England Fisheries Management Council to involve stakeholders more directly in the fishery management process.

State of the Climate 2017

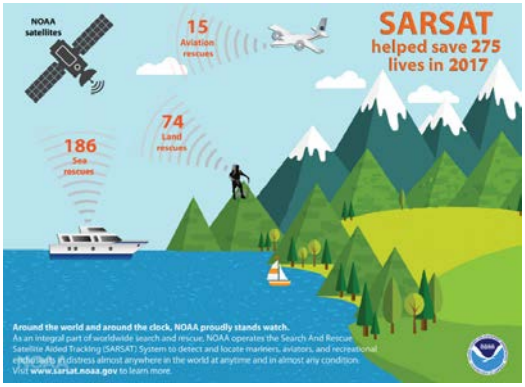
The State of the Climate in 2017 report was released with the August edition of the Bulletin of the American Meteorological Society. The report is an annual assessment for dozens of key climate variables in the oceans, atmosphere, land, and cryosphere; it also includes regional climate summaries around the world, notable weather events, and emerging impacts. In total, the report includes the results of hundreds of peer-reviewed datasets, with contributions from more than 500 authors from 65 nations. The report informs the climate science community, decision makers, and the public about the ongoing evolution of the climate system and related extreme events. Scientists from across NOAA contributed to the report, underscoring both the report's extent 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. It brings together scientists from many fields, fostering collaborations across disciplines and continents. The State of the Climate in 2017 was shared widely upon its release, most visibly through the media, but more importantly to the operational community.



A multi-year coral reef bleaching event is one of the findings highlighted in the 2017 State of the Climate Report.

SARSAT: A Beacon for Help

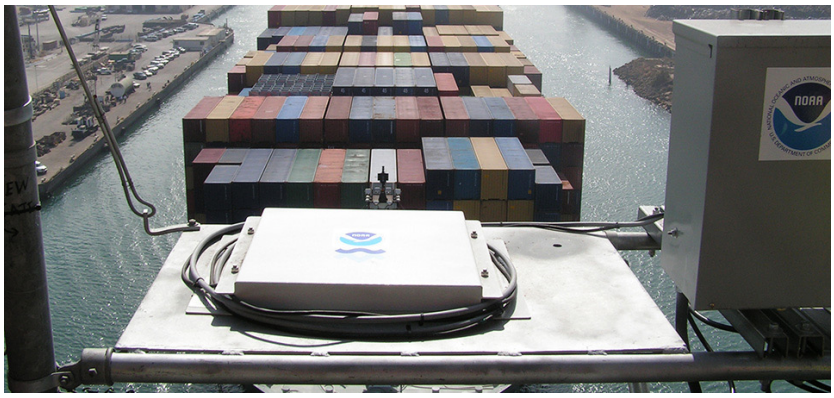
Thanks to NOAA satellites, 275 people were rescued within the U.S. and its surrounding waters in 2017. NOAA satellites are part of the international Search and Rescue Satellite Aided Tracking System (SARSAT). This system uses a sprawling network of spacecraft to detect and locate distress signals quickly from emergency beacons aboard aircraft, boats, and from handheld personal locator beacons (PLBs). Federal law requires that all emergency position indicating radio beacons (EPIRBs), personal locator beacons (PLBs), and emergency locator transmitters (ELTs) be registered in the NOAA SARSAT Beacon Registration Database. Up-to-date beacon owner information allows for the most efficient use of search and rescue resources upon beacon activation and can decrease rescue response time during distress situations.



NOAA satellites helped rescue 275 people in the U.S. and its surrounding waters in 2017.

Installation of NOAA's Physical Oceanographic Real Time Data (PORTS®) at PortMiami Advances Maritime Commerce

PortMiami partnered with NOAA NOS to install PORTS®, a new Physical Oceanographic Real Time System in spring 2018 to ensure big ships can safely navigate the port. PortMiami is among America's busiest ports and recognized across the globe as the Cruise Capital of the World and the Global Gateway. PortMiami contributes more than $41.4 billion annually to Miami-Dade County and the state of Florida and generates 324,000 direct, indirect, and induced jobs. The new system, consisting of three new current meter sensors in PortMiami's channel, will provide critical real-time information to big ship operators for the safe transit into PortMiami by avoiding collisions and groundings.



PORTS®, which stands for Physical Oceanographic Real-Time System, produced by NOAA's Center for Operational Oceanographic Products and Services is a network of physical oceanographic and meteorological sensors that provide mariners with up-to-date information about what's going on in the environment.

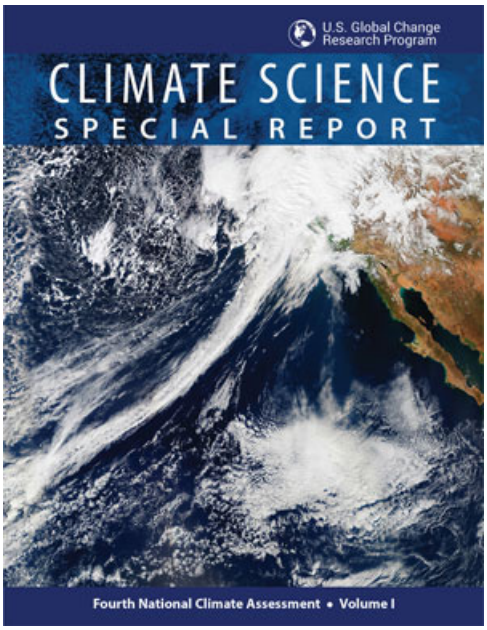
Precision Navigation from NOAA's Office of the Coast Survey provides mariners with the information they need to safely and efficiently transport maritime commerce.

NOAA Advances Precision Navigation Services to Enhance U.S. Commerce

Comparable to the way car technology supports drivers, NOAA has launched a new program to develop the next generation of marine navigation tools that provide mariners with the information they need to safely and efficiently transport maritime commerce. This next generation of products is referred to as Precision Navigation. Precision Navigation seamlessly integrates high-resolution bathymetry with real-time and forecast data—such as water levels, currents, salinity, temperature, and precipitation—to produce a stronger decision support tool to equip mariners for critical go/no-go decisions. This program involves various types and sources of data, requires the coordinated efforts of several NOAA offices, and was first implemented in the Port of Long Beach, CA. In 2018, NOAA established a team dedicated to assist with expanding the program to ports nationwide. Future plans will expand and implement Precision Navigation into the Port of New York/New Jersey which supports more than $184 billion in commerce, as well as the Lower Mississippi River Port Complexes. Researchers are currently conducting a socio-economic study to examine the return on investment of the Precision Navigation program.

Climate Science Special Report Serves as Foundation to Assess Climate-Related Risks

The Climate Science Special Report is an authoritative assessment of the science of climate change, with a focus on the U.S. It represents the first of two volumes of the Fourth National Climate Assessment, mandated by the Global Change Research Act of 1990. The assessment covers observations and future projections of temperature, precipitation, sea-level rise, large-scale climate variability, extreme storms, Arctic change, and ocean acidification. The assessment includes long-term perspectives to inform mitigation and potential climatic surprises. Stabilizing global mean temperature to less than 3.6°F (2°C) above pre-industrial levels requires substantial reductions in net global CO_2 emissions in coming decades and zero net emissions later in the century. Potential surprises include compound extreme events such as simultaneous heat and drought or flood and wildfire. The report was developed under the auspices of the interagency U.S. Global Change Research Program and NOAA took a lead role in both the technical development and administration of the report.



NOAA played a lead role in both the technical development and administration of the Climate Science Special Report.

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.

Accelerate the Blue Economy

Provided weekly warnings for harmful algal blooms along Florida's coasts.

Prepare for Extreme Weather

Doubled the accuracy of current operational flash flood prediction systems and improved the spatial resolution by 500 percent.

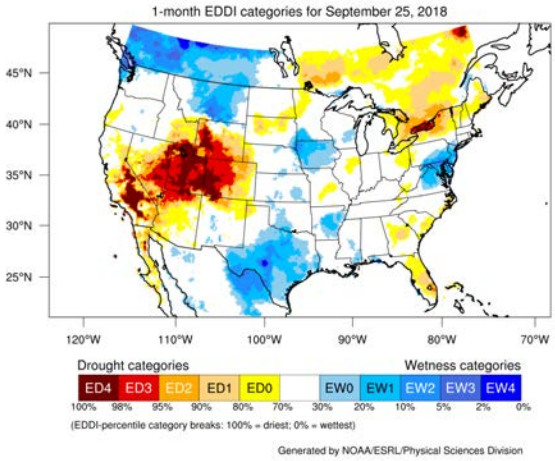
Selected Accomplishments

- Improving Flooding Forecasts in Urban Areas
- Drought Index Aids in Identifying Areas of Potential Food Insecurity
- Tracking Precipitation to Provide Flash Flooding Forecasts at the Neighborhood Level
- NOAA Plays a Leading Role in Forecasting and Response to 2018 Florida Red Tide

Improving Flooding Forecasts in Urban Areas

When big storms hit California, current technology does not provide forecasters with the detailed information needed to inform reservoir operations, flood protection, combined sewer-stormwater systems, and emergency preparedness. The Advanced Quantitative Precipitation Information (AQPI) system is a collaborative federal, state, and local partnership funded by the state of California. AQPI is deploying experimental radars for estimating precipitation (two out of five are currently in place), collecting streamflow and soil moisture observations for estimating runoff, and producing experimental forecasts of extreme precipitation and coastal inundation in the urban regions surrounding San Francisco Bay. As part of AQPI, NOAA is able to evaluate several models including the High Resolution Rapid Refresh (HRRR) forecast model performance in complex terrain, National Water Model sensitivity to experimental radar precipitation estimates, and applications of a coastal coupled version of the National Water Model. The system will aid water managers in mitigating flood, water supply, and water quality risks across the nine-county region surrounding San Francisco Bay. AQPI is anticipated to achieve a significant benefit to cost ratio through a combination of avoided flood damage costs from early warnings; forecast-informed operations to maximize reservoir capture for water supply and fisheries flows; minimization of water quality impacts from combined sewer overflows; and enhancement of public safety for various transportation modes (pedestrian, highways, marine, and airports). These benefits are anticipated to become increasingly important as costs associated with extreme weather events continue to escalate.

Left: NOAA scientists from the Earth System Research Laboratory Physical Sciences Division and Global Systems Divisions have identified areas in the San Francisco Bay area prone to shallow flooding (red).



Right: NOAA's Earth System Research Laboratory Physical Sciences Division, Climate Program Office, and partners are improving the Evaporative Demand Drought Index.

Drought Index Aids in Identifying Areas of Potential Food Insecurity

NOAA Research and partners are improving multiple components of the Evaporative Demand Drought Index (EDDI). EDDI provides an estimate of the atmosphere's ability to take up water vapor and contributes to a more complete understanding of the feedback between the land and atmosphere leading up to and during drought conditions. EDDI has proven to be a useful tool for drought early warning and monitoring. The various drought products on the EDDI website and the Western Water Assessment Regional Integrated Sciences and Assessments (RISA) dashboard are available for use by a wide range of stakeholders, including water, fire, forest and range managers, as well as agricultural producers. An important new application of EDDI is in monitoring fire-weather risk. In collaboration with the Famine Early Warning Systems Network (FEWS NET), NOAA Research is adapting EDDI products to provide vital information as a drought index for early warning of potential food insecurity and a number of other agricultural applications. EDDI is transitioning to operations as a Joint Technology Transfer Initiative (JTTI) partnership project with the NOAA NWS.

Tracking Precipitation to Provide Flash Flooding Forecasts at the Neighborhood Level

Flash flooding kills more people in the U.S. than tornadoes and hurricanes and is second only to extreme heat fatalities. To better protect people in the U.S., NOAA Research has developed a system called the Flooded Locations and Simulated Hydrographs (FLASH) project to advance the state of flash flood prediction through newly developed Multi-Radar/Multi-Sensor rainfall estimation and extreme precipitation analysis tools and hydrologic forecast 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 flash flood prediction system and improves the spatial resolution by 500 percent. These new high-resolution tools will provide reliable flash flood forecasts at the neighborhood level as well as provide up to 12 hours of forecast lead time, affording critical time for community response, saving lives and mitigating damage to property. FLASH improves NOAA NWS forecasters' ability 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 flood modeling and prediction.

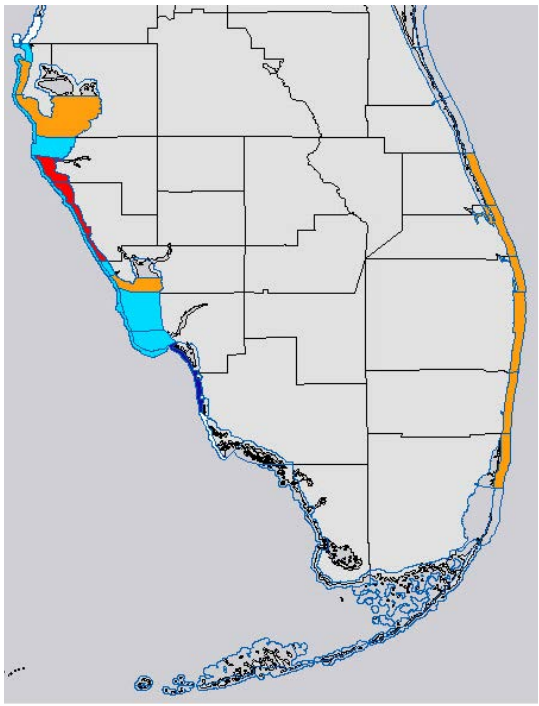
The Flooded Locations and Simulated Hydrographs (FLASH) tool from NOAA's National Severe Storms Laboratory, Office of Weather and Air Quality, and National Centers for Environmental Prediction tracks what every raindrop is doing on the ground to provide reliable flash flood forecasts at a neighborhood level.

NOAA Plays a Leading Role in Forecasting and Response to 2018 Florida Red Tide

NOAA has played a major role in the response and mitigation of harmful algal blooms (HABs) in Florida through the delivery of the Gulf of Mexico HAB Forecast Bulletin and by providing critical support of research and response activities. For decades, coastal communities on Florida's Gulf Coast have dealt with the impacts of red tide, a HAB caused by the algal species *Karenia brevis*. Under favorable ocean conditions, these microscopic organisms bloom in the Gulf of Mexico and spread along the Florida coasts. The toxins produced by this species can poison fish, marine mammals, turtles, and other aquatic wildlife. They also can result in severe respiratory impacts for beachgoers through ocean spray and other means. Florida has experienced higher-than-average bloom severity in 2018, resulting in major impacts to the tourism and leisure industries along its coasts.

Dead fish on a Florida beach due to red tide. NOAA's National Centers for Coastal and Ocean Science and Atlantic Oceanographic and Meteorological Laboratory are supporting research on response and mitigation efforts.

The NOAA HAB Forecast Bulletin provides state and local officials and the public with weekly warnings at county levels that show bloom extent and trajectory, as well as projections of areas where public health is likely to be impacted. In October 2018, NOAA began initial testing on an improved version of the forecast that will lead to warnings that can be delivered for individual beaches on a daily basis. If successful, this will mark a significant advancement in NOAA's ability to provide actionable information at a scale that is highly valuable to the public. In addition to the forecast, NOAA provides financial support for assisting with the mobilization of research and analytical services by local officials during blooms. Awards in 2018 have provided for a team from the Florida Fish and Wildlife Research Institute and Mote Marine Lab to join an expanded NOAA-led sampling cruise to map the extent of red tide in southwest Florida and for research on potential treatments for birds and other animals sickened by toxins from the bloom. In addition, NOAA provided over $800 thousand in grant awards to Florida to support additional research on HABs to further assist with response and mitigation efforts. NOAA Florida-related HAB efforts alone demonstrate the value of the agency's applied research portfolio and resulting delivery of science products and services that meet the needs of coastal communities.



NOAA's harmful algal bloom (HAB) Forecast Bulletin from the Center for Operational Oceanographic Products and Services provides the public weekly warning at county levels.

NATIONAL WEATHER
RADAR TESTBED
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Polar Science

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 resilience 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.

Accelerate the Blue Economy

Detected the effects of small-scale ocean conditions on ecosystems in the Arctic due to implementation of new coastal gliders.

Prepare for Extreme Weather

Increased understanding of the effects of Arctic sea ice loss on mid-latitude weather.

Selected Accomplishments

- Oculus Coastal Glider in the Arctic Identifies Important Ecosystem Transition Area
- Potential for Arctic Regions and Mid-Latitude Weather Linkages
- Arctic Heat Open Science Experiment Provides Real-time Ocean Data to Global Weather and Sea Ice Modelers
- Leading the Charge in Coordinating Environmental Monitoring of Alaska Arctic Harmful Algal Blooms

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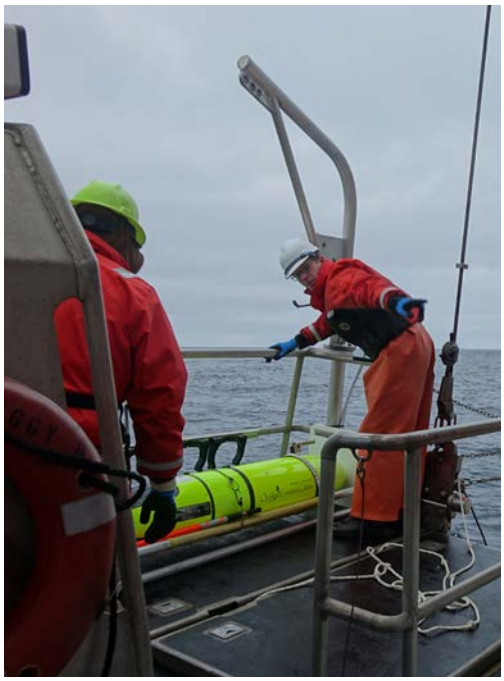
NOAA

Oculus Coastal Glider in the Arctic Identifies Important Ecosystem Transition Area

The Oculus Coastal Glider is a new glider specifically engineered to work in the difficult conditions of the Arctic. It can rapidly change its depth for more efficient and adaptive surveys in shallow shelf environments. Measurements collected during the successful 2017 summer mission in the Bering Sea revealed new detailed information for an important transition area that divides the ecosystems of the northern and southern Bering Sea shelf. Observations by the Oculus Glider suggests the existence of numerous eddies that can influence food availability for commercially important species. Incorporating this higher resolution sampling, not previously available through shipboard and moored buoy observations, into the Bering Sea Observing Network will improve the understanding of the effects of small-scale ocean conditions on the ecosystem. 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. Increased understanding of the effects of the environment on distribution and survival of commercially important fish species is critical for sustainably managing the fisheries.



Scientists from NOAA's Pacific Marine Environmental Laboratory prepare to launch Oculus Coastal Glider.

Potential for Arctic Regions and Mid-Latitude Weather Linkages

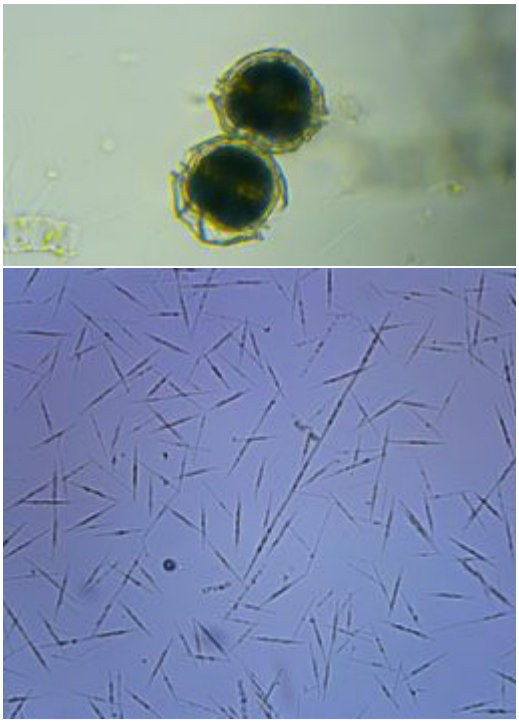
Arctic weather has impacts reaching beyond just the Arctic, potentially impacting tens of millions of people. Scientists have been studying the influence of Arctic weather on mid-latitude weather in an effort to provide longer term forecasts. However, the meteorological processes involved are complex and assessments continue to be controversial. NOAA Research and NOAA NWS have made progress toward clarifying the situation in the last year. Recent case studies have shown the Arctic is not the primary cause for the evolution of midlatitude weather, but warmer Arctic temperatures can prolong cold spells in the midlatitudes by reinforcing a wavy jet stream. Wavier jet stream patterns allow cold air from the Arctic to easily flow into the Midwest and eastern United States.

Scientists from NOAA's Pacific Marine Environmental Laboratory are studying whether a warming arctic may cause severe winter weather in midlatitudes.

An Air-Launched Autonomous Micro-Observer (ALAMO) float is deployed from NOAA's Twin Otter allowing NOAA's Pacific Marine Environmental Laboratory and Climate Program Office to study sea ice.

Arctic Heat Open Science Experiment Provides Real-time Ocean Data to Global Weather and Sea Ice Modelers

A scarcity of in situ observations in the Arctic currently hinder the capability of models to predict changes in sea ice. However, autonomous technologies such as those used by the Arctic Heat Project are helping to close this gap. Air-Launched Autonomous Micro-Observer (ALAMO) ocean profiling floats that have been modified for Arctic deployments have the ability to measure ocean heat from the ocean surface to seafloor over a period of months to years. More than 1,000 Arctic Ocean profiles have been collected by the Arctic Heat project and transmitted in real-time via the Global Telecommunications System (GTS) since 2016. Real-time open data streams contribute to improved short term forecasts (one to ten days), which are of critical importance to support safe marine transportation as well as longer-term seasonal predictions which are important to define the operation and shipping season.



NOAA's Climate Program Office, Integrated Ocean Observing System, and Sea Grant are working in the Arctic on harmful algal blooms, such as those caused by Alexandrium *and P*seudo-nitzschia *pictured above.*

Leading the Charge in Coordinating Environmental Monitoring of Alaska Arctic Harmful Algal Blooms

Warming ocean conditions in the Pacific Arctic have given rise to unprecedented harmful algal blooms (HABs) in recent years. HABs are defined by the negative impacts they have on marine animals and resources, such as producing toxins or causing fish kills. The U.S. Bering Strait Region consists of approximately 10,000 people in 16 remote coastal communities that are particularly susceptible due to dependence on marine wildlife subsistence harvested for nutritional, cultural, and economic means. The lack of preparedness to collect physical samples during previous events has resulted in a significant sampling gap and represents a missed opportunity to trace important environmental changes that have a direct impact on western Alaska communities. In partnership with the Interagency Arctic Research Policy Committee, NOAA, Alaska Ocean Observing System Harmful Algal Bloom Network, and Alaska Sea Grant are leading an Environmental Intelligence campaign to coordinate research and monitoring efforts and to communicate timely results to communities in response to food safety and security concerns.

Bibliometrics

This chapter represents a rigorous assessment of NOAA's scholarly research output between 2011 and 2017. 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 2017, with nearly 82 percent 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) Geo-sciences (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.

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 2017 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 2017.

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 percent 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.

The analysis in this report is distinct from that presented in the *Bibliometric Analysis of NOAA Articles: FY2012-FY2016* as the time period covered and dataset analyzed differ significantly. The analysis in that report is based on a curated bibliography of NOAA articles published between fiscal years 2012 and 2016 as identified by the staff of the NOAA Central Library. Any discrepancies in publication counts or indicators is due to this difference in methodology.

References

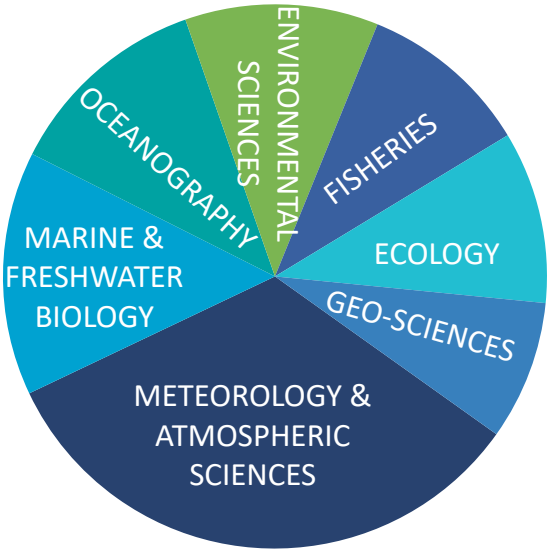
NAS (2012). Best Practices in Assessment of Research and Development Organizations, The National Academies Press.

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

NOAA Peer-Reviewed Articles 2011-2017

13,621	138	234,166	92%
Total Articles	H-Index	Times Cited	% of Articles Cited

Top Research Areas

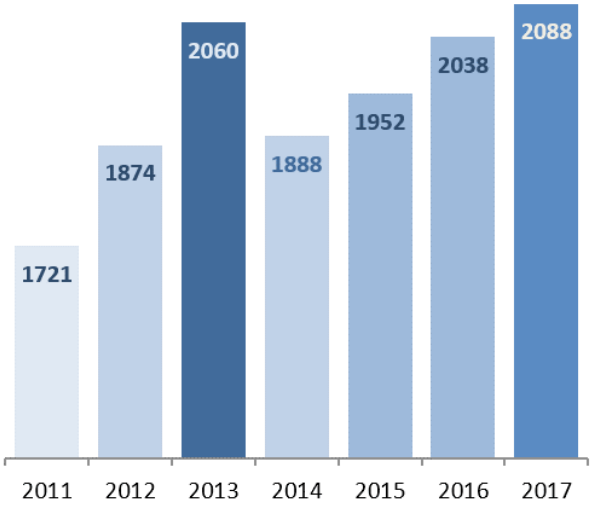


WoS Subject Area	# of Articles
Meteorology & Atmospheric Sciences	4815
Oceanography and Marine Sciences	8533
Marine & Freshwater Biology	*2110*
Oceanography	*1777*
Environmental Sciences	*1673*
Fisheries	*1491*
Ecology	*1482*
Geo-sciences	1205

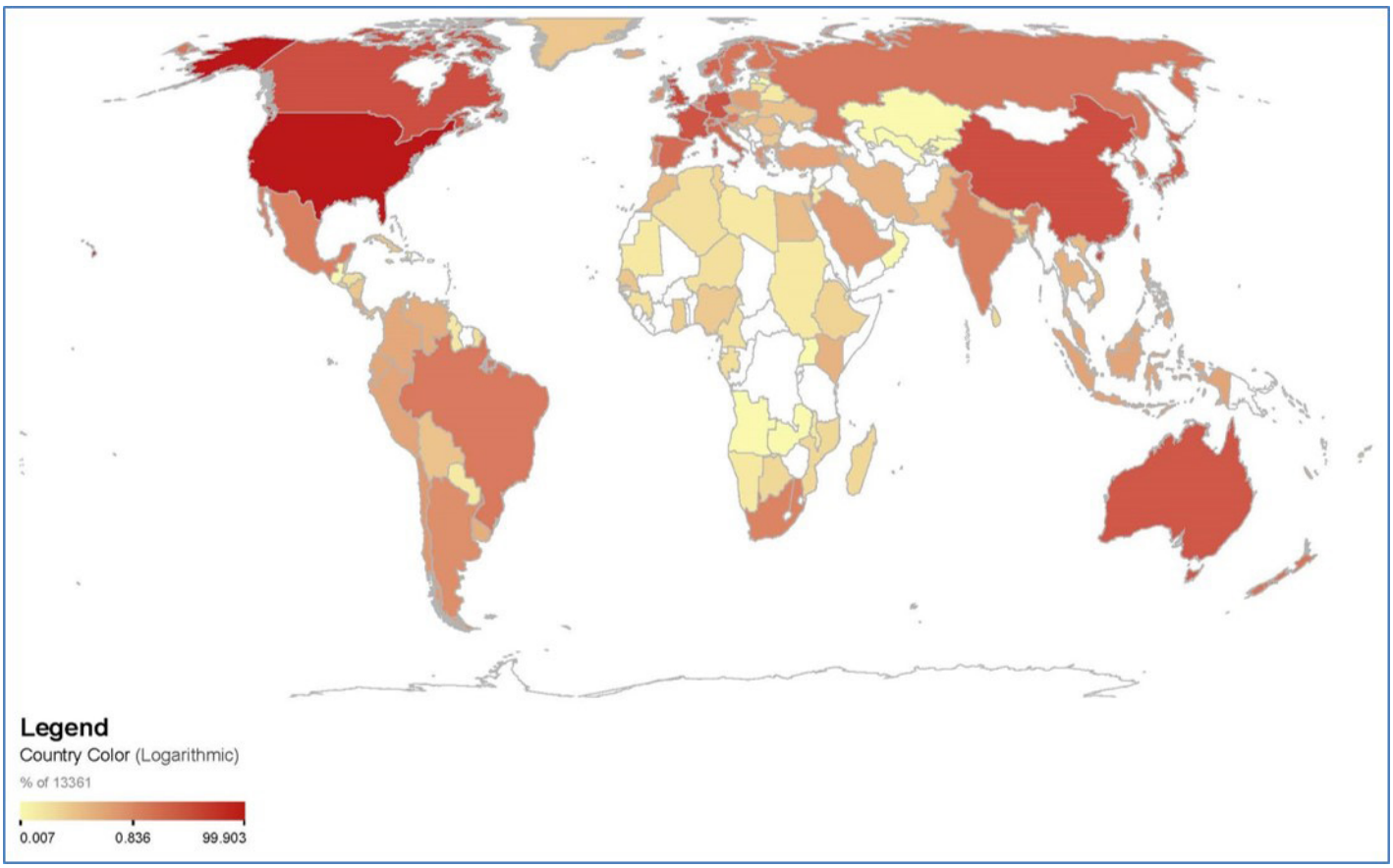
Note some articles fall into more than one WoS subject area.

Articles Per Year

Year	# of Articles
2011	1721
2012	1874
2013	2060
2014	1888
2015	1952
2016	2038
2017	2088



International Collaborations

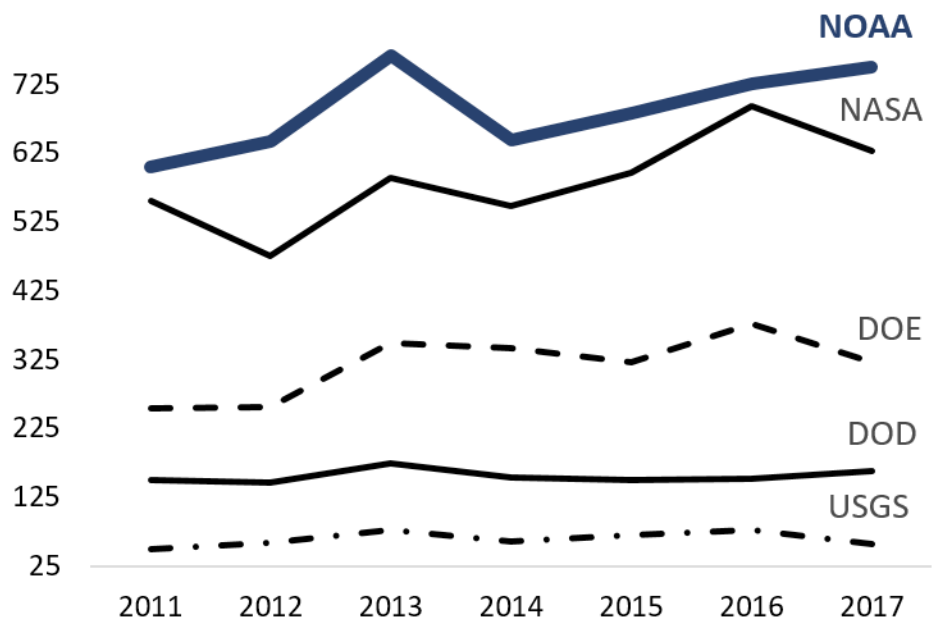


How to Read this Map
This choropleth map *shows the world map using the equal-area Eckert IV projection. Each country may be color coded in proportion to a numerical value which represents co-athorship on NOAA publications.. Minimum and maximum data values are given in the legend.*

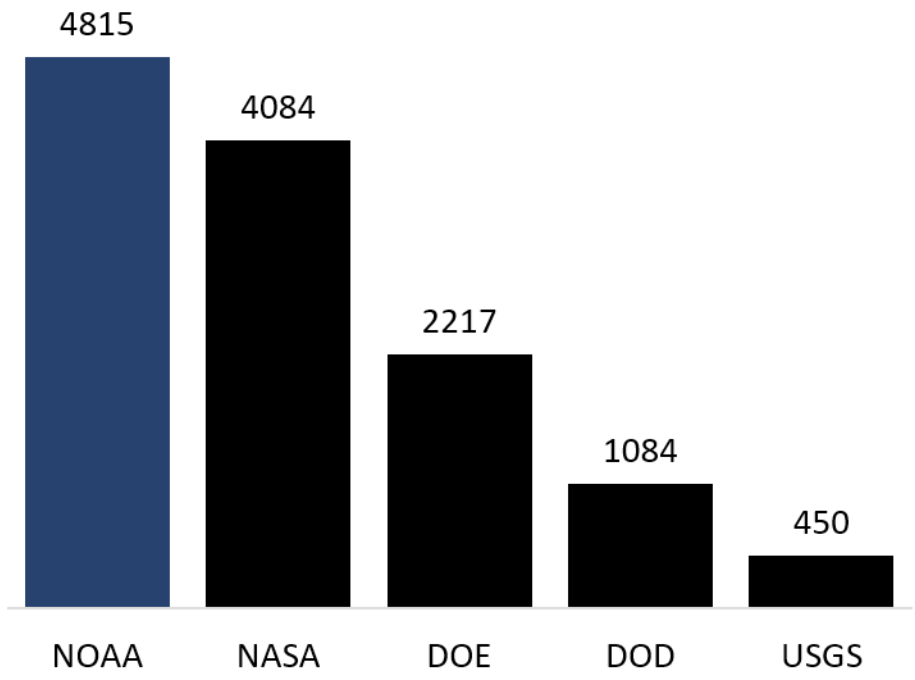
Productivity

Between 2011 and 2017, NOAA published an average of 687 articles per year in the field of meteorology and atmospheric sciences, resulting in a total of 4815 articles.

Articles Per Year by Agency



Total Number of Articles by Agency



Top Journals where NOAA Publishes

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

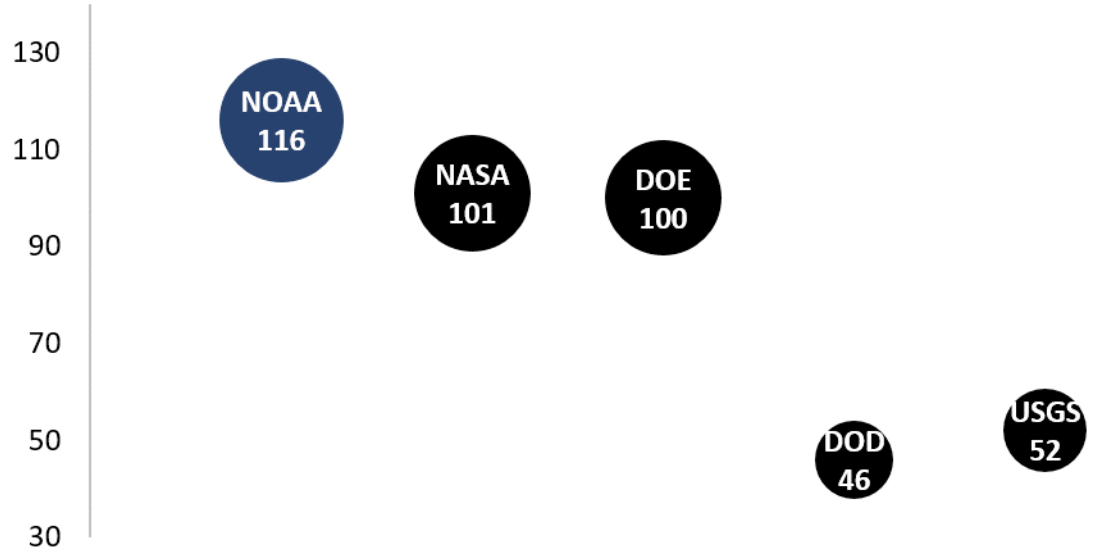
Highly Cited Papers

- Taylor, et al. 2012. An Overview of the MIP5 and the experiment design. *BAMS.*
- Rienecker, et al. 2011. MERRA: NASA's Modern-Era Retrospective Analysis for Research and Applications. *J Climate.*
- Meinshausen, et al. 2011. The RCP greenhouse gas concentrations and their extensions from 1765 to 2300. *Climatic Change.*

Impact

Within the field of meteorology and atmospheric sciences, NOAA has an H-index of 116 - meaning that 116 of these articles have been cited in the peer-reviewed literature at least 116 times.

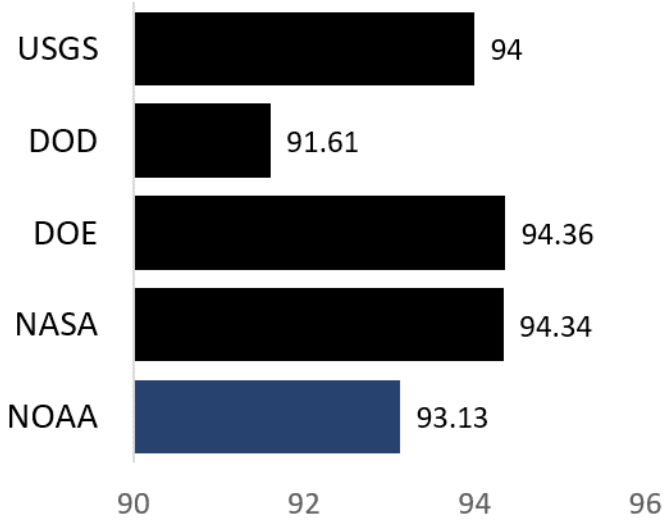
H-Index



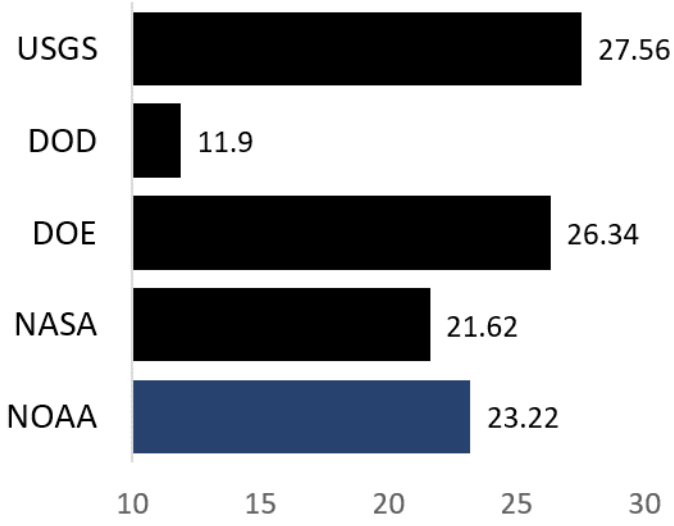
In total, 93 percent of the 4815 articles have been cited within the peer-reviewed literature.

23% of the 4815 articles fall within the top 10 percent of the most cited articles in meteorology and atmospheric sciences.

Percentage of Articles Cited



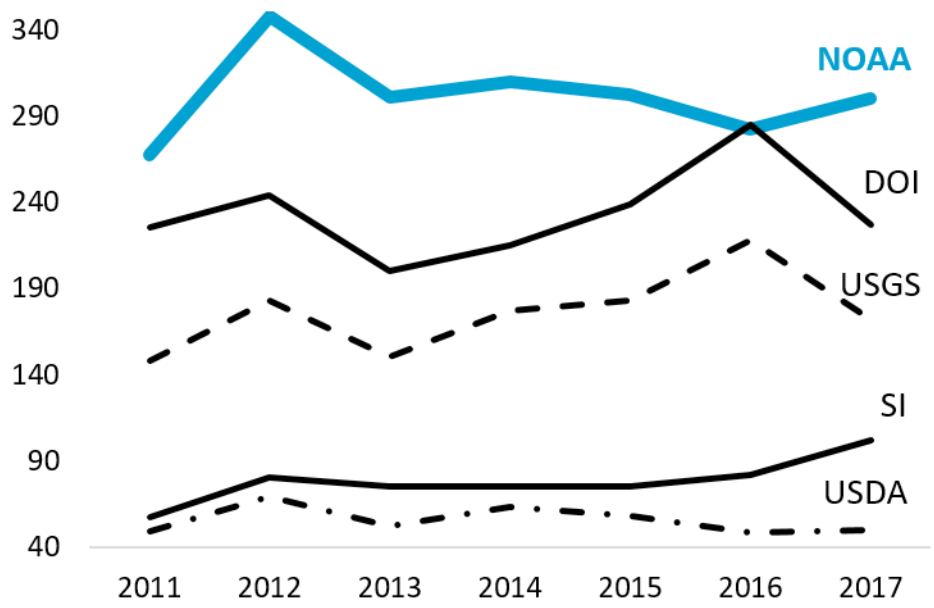
Percentage of Articles in Top 10%



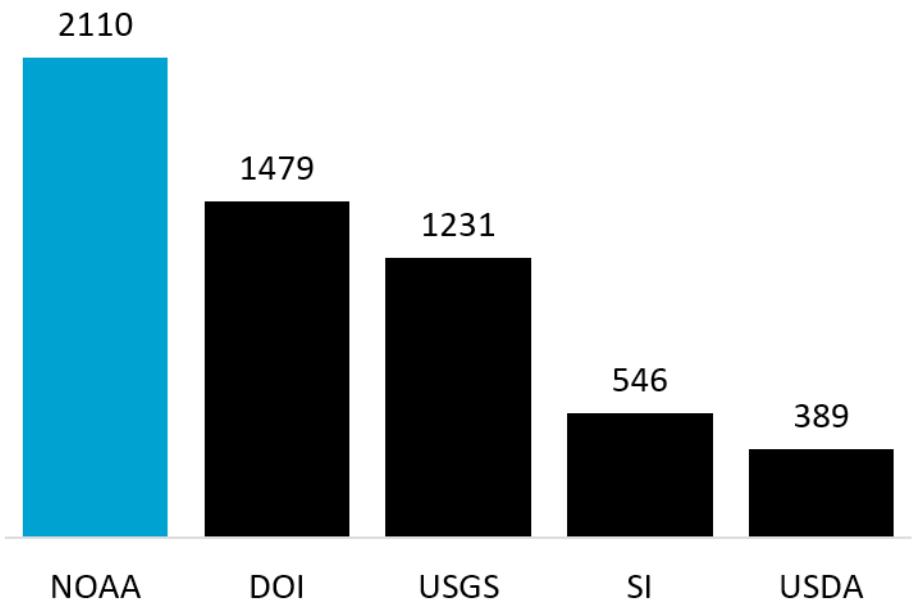
Productivity

Between 2011 and 2017, NOAA published an average of 301 articles per year in the field of marine and freshwater biology, resulting in a total of 2100 articles.

Articles Per Year by Agency



Total Number of Articles by Agency



Top Journals where NOAA Publishes

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

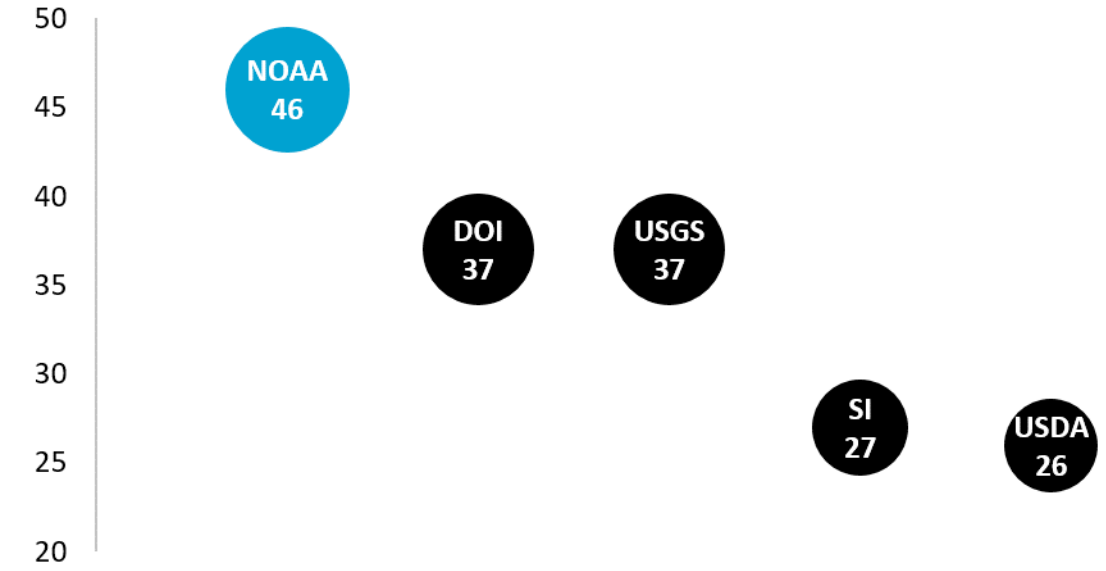
Highly Cited Papers

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

Impact

Within the field of marine and freshwater biology, NOAA has an H-index of 46 - meaning that 46 of these articles have been cited in the peer-reviewed literature at least 46 times.

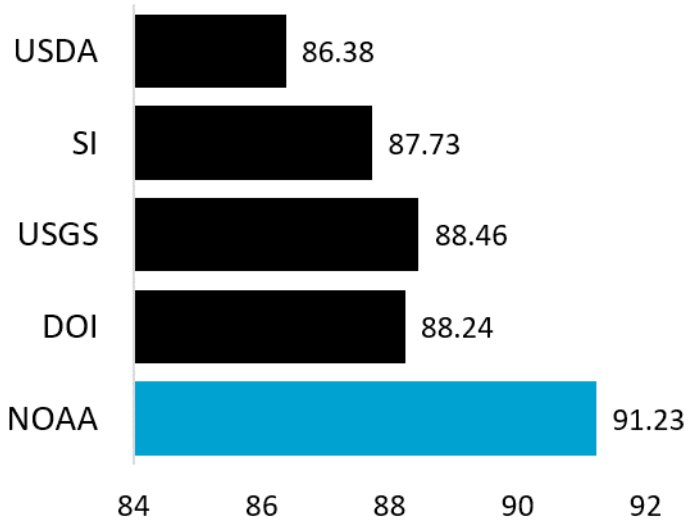
H-Index



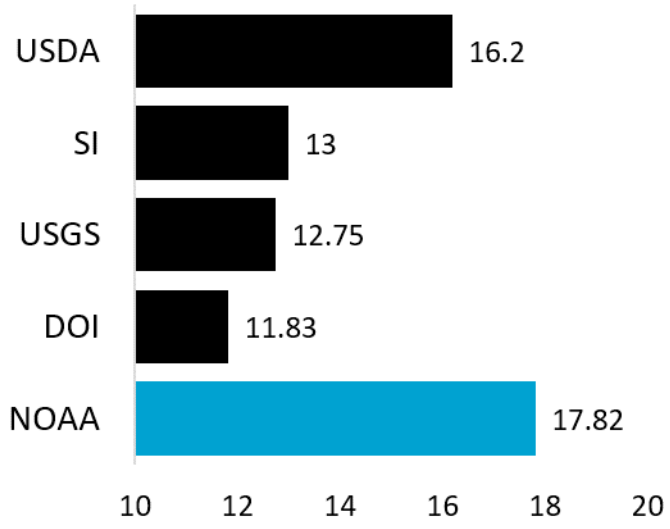
In total, 91 percent of the 2110 articles have been cited within the peer-reviewed literature.

18% of the 2110 articles fall within the top 10 percent of the most cited articles in marine and freshwater biology.

Percentage of Articles Cited



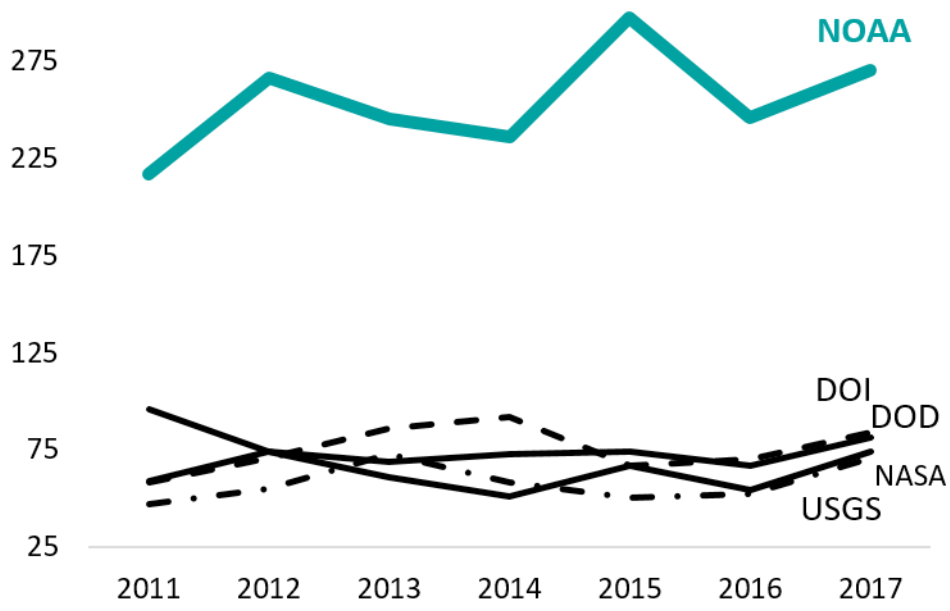
Percentage of Articles in Top 10%



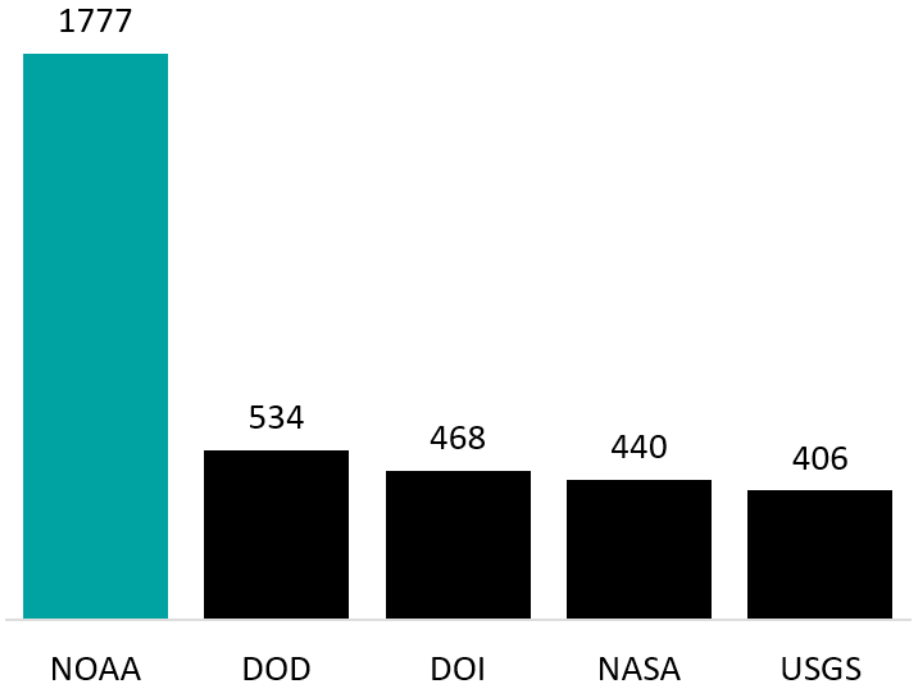
Productivity

Between 2011 and 2017, NOAA published an average of 253 articles per year in the field of oceanography, resulting in a total of 1777 articles.

Articles Per Year by Agency



Total Number of Articles by Agency



Top Journals where NOAA Publishes

- Marine Ecology Progress Series
- Journal of Geophysical Research - Oceans
- ICES Journal of Marine Science
- Deep-Sea Research Part II - Topical Studies in Oceanography
- Ocean Modelling

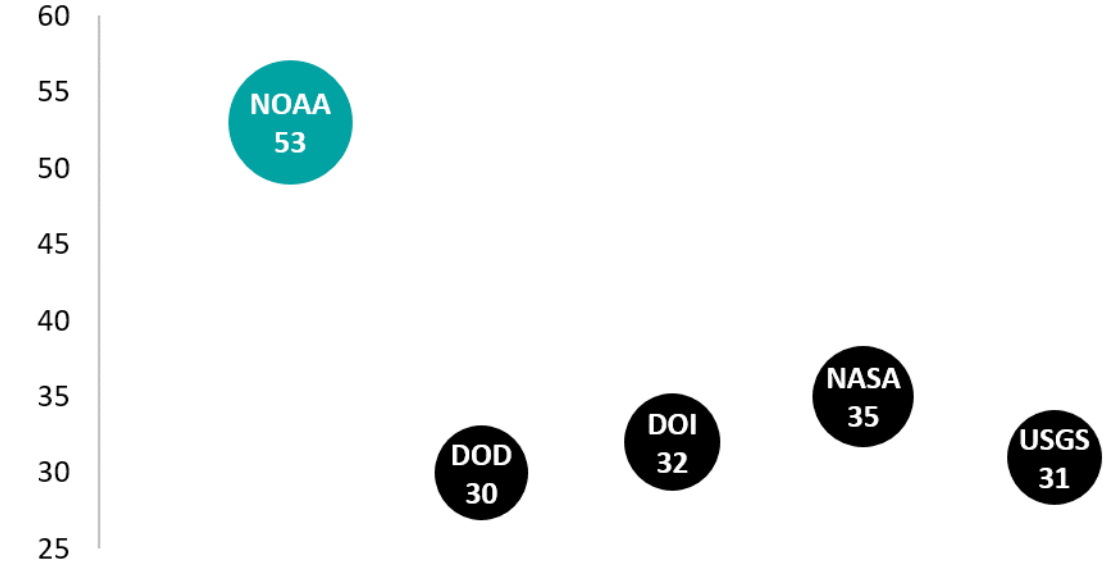
Highly Cited Papers

- Smith, et al. 2011. Impacts of Fishing Low-Trophic Level Species on Marine Ecosystems. *Science.*
- 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. *Limnology & Oceanography.*
- Hunt, et al. 2011. Climate impacts on eastern Bering Sea foodwebs: a synthesis of new data and an assessment of the Oscillating Control Hypothesis. *ICES Journal of Marine Science.*

Impact

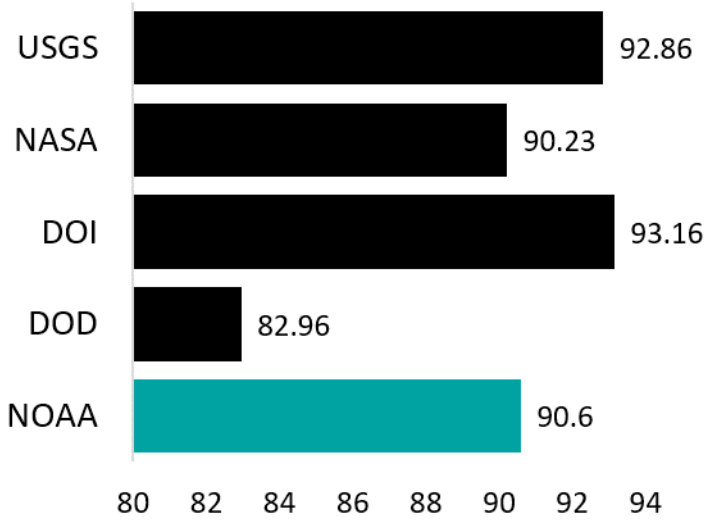
Within the field of oceanography, NOAA has an H-index of 53 - meaning that 53 of these articles have been cited in the peer-reviewed literature at least 53 times.

H-Index

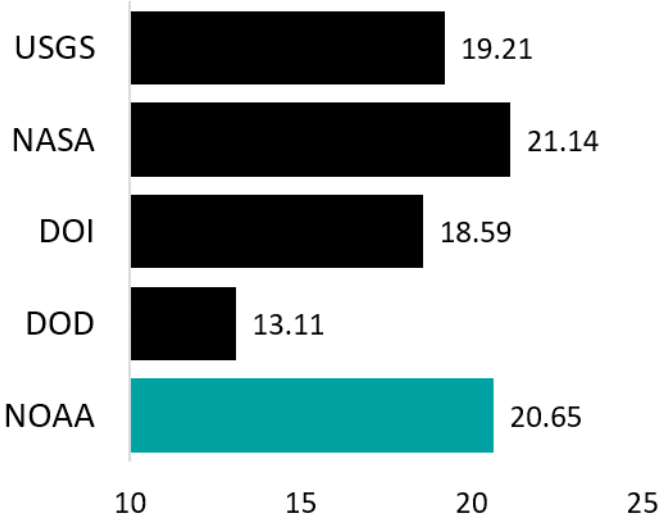


In total, 91 percent of the 1777 articles have been cited within the peer-reviewed literature.
21% of the 1777 articles fall within the top 10 percent of the most cited articles in oceanography.

Percentage of Articles Cited



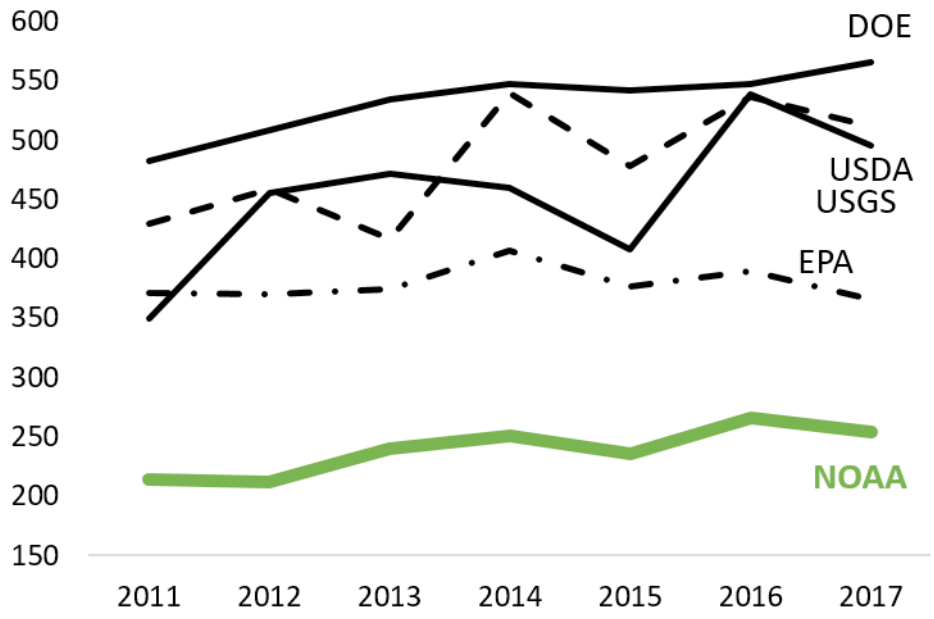
Percentage of Articles in Top 10%



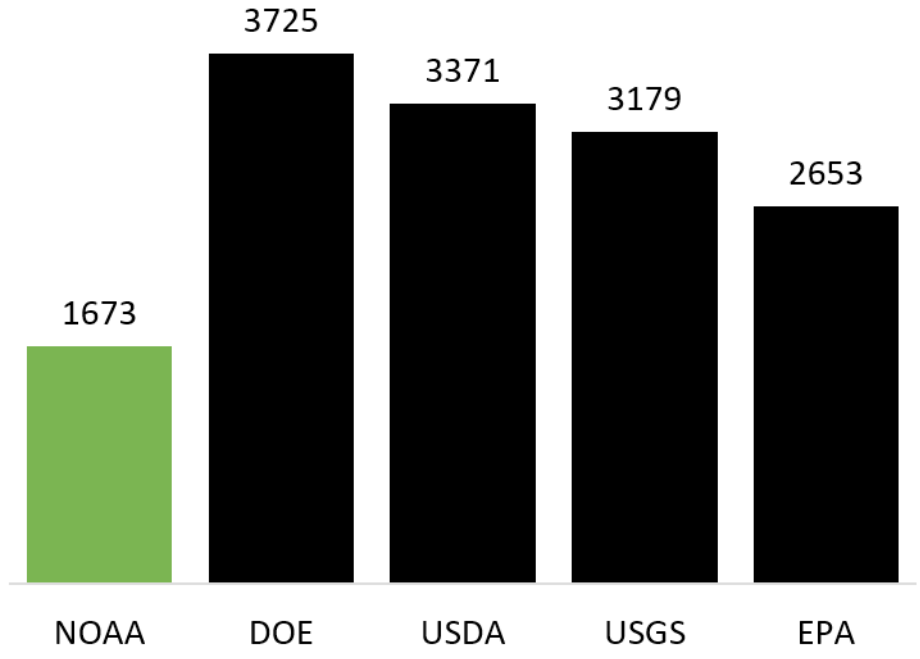
Productivity

Between 2011 and 2017, NOAA published an average of 239 articles per year in the field of environmental sciences, resulting in a total of 1673 articles.

Articles Per Year by Agency



Total Number of Articles by Agency



Top Journals where NOAA Publishes

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

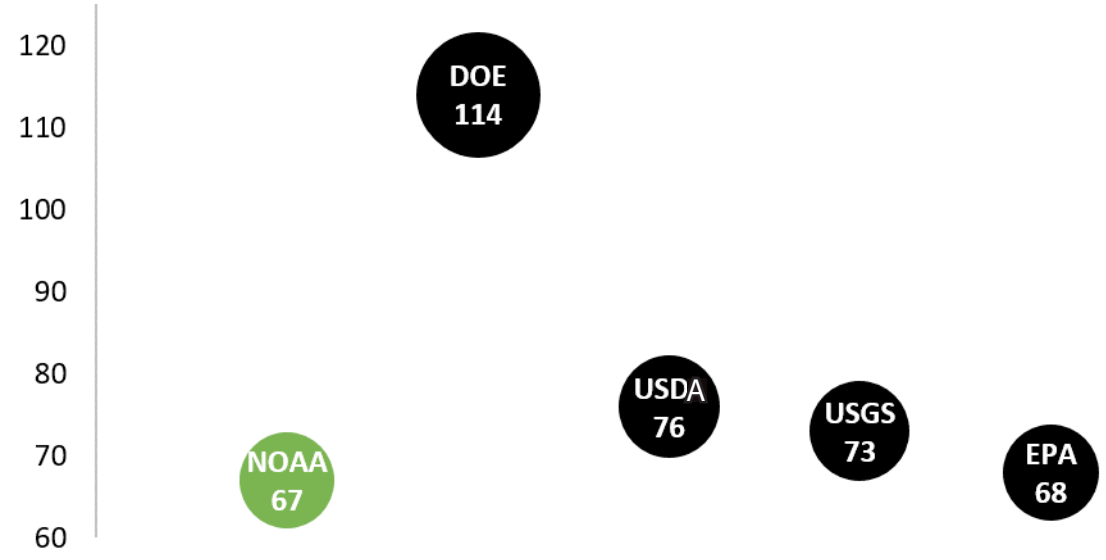
Highly Cited Papers

- Meinshausen, et al. 2011. The RCP greenhouse gas concentrations and their extensions from 1765 to 2300. *Climatic Change.*
- England, et al. 2014. Recent intensification of wind-driven circulation in the Pacific and the ongoing warming hiatus. *Nature Climate Change.*
- Aufdenkampe, et al. 2011. Riverine coupling of biogeochemical cycles between land, oceans, and atmosphere. *Frontiers in Ecology & the Environment.*

Impact

Within the field of environmental sciences, NOAA has an H-index of 67 - meaning that 67 of these articles have been cited in the peer-reviewed literature at least 67 times.

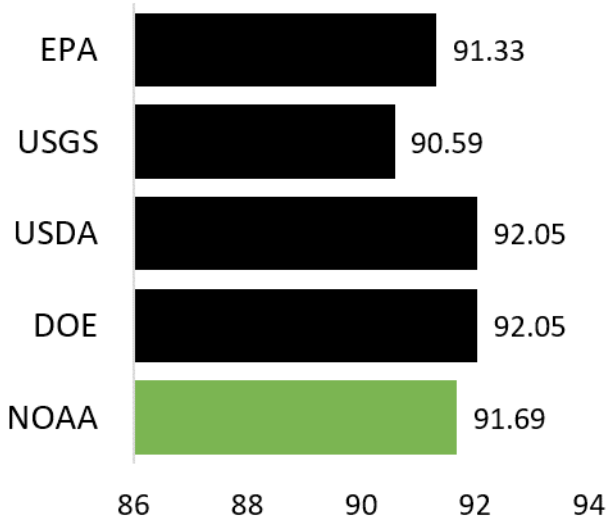
H-Index



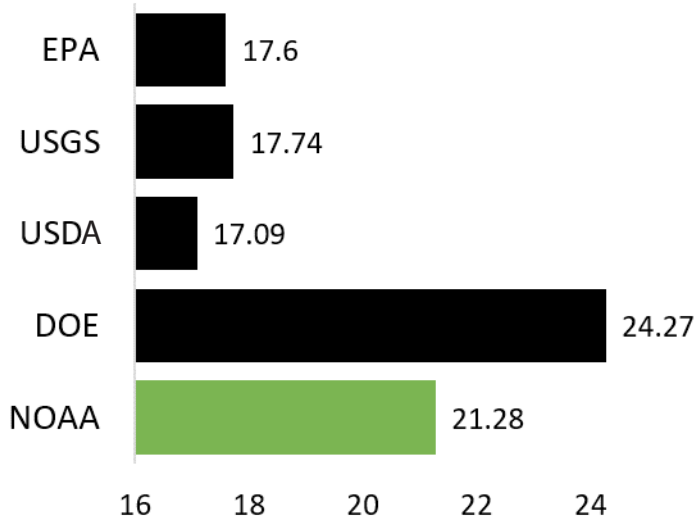
In total, 92 percent of the 1673 articles have been cited within the peer-reviewed literature.

21% of the 1673 articles fall within the top 10 percent of the most cited articles in environmental sciences.

Percentage of Articles Cited



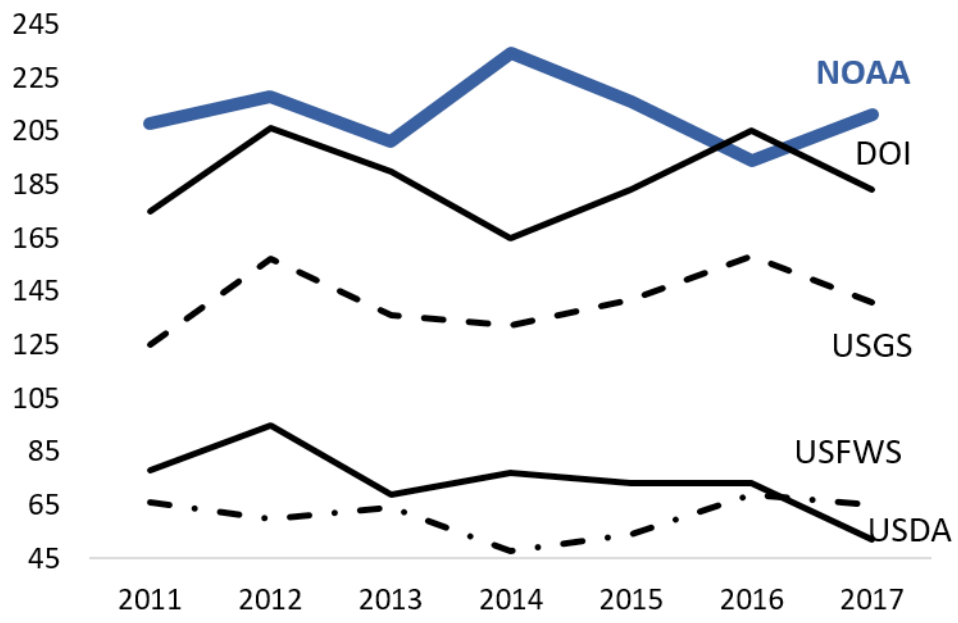
Percentage of Articles in Top 10%



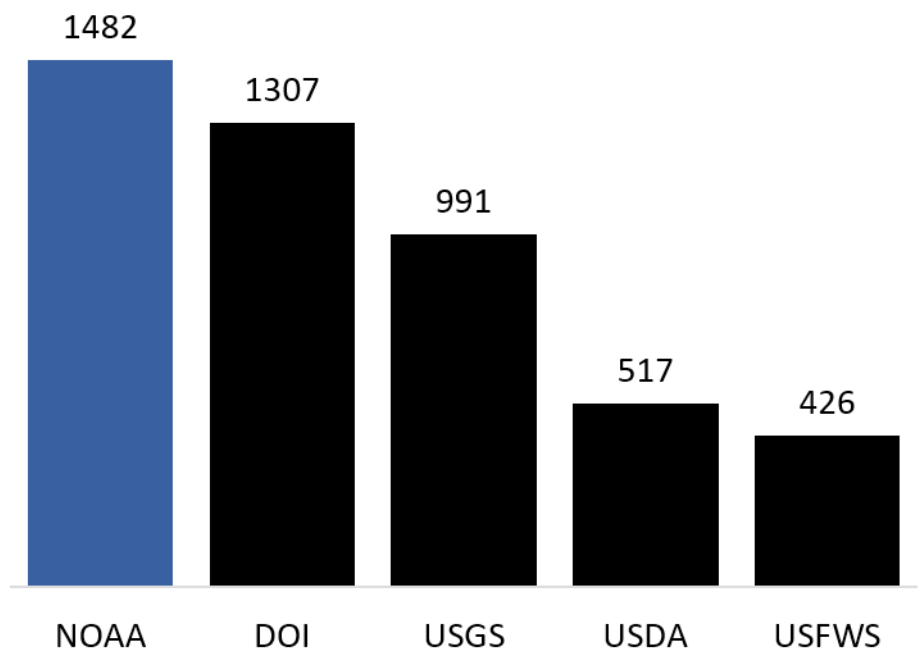
Productivity

Between 2011 and 2017, NOAA published an average of 211 articles per year in the field of fisheries, resulting in a total of 1482 articles.

Articles Per Year by Agency



Total Number of Articles by Agency



Top Journals where NOAA Publishes

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

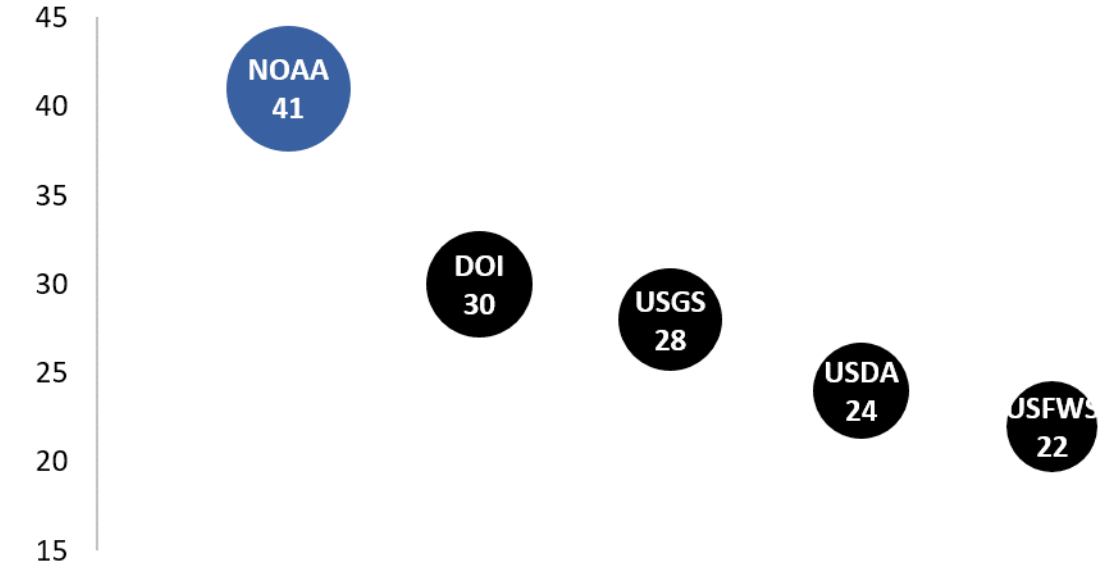
Highly Cited Papers

- 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

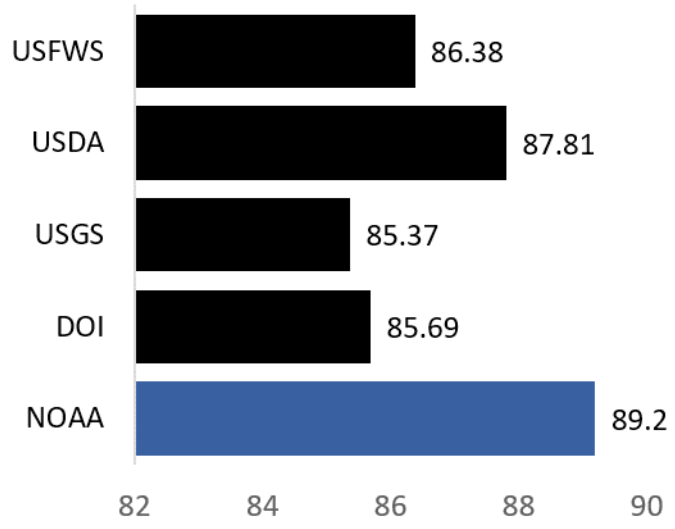
Within the field of fisheries, NOAA has an H-index of 41 - meaning that 41 of these articles have been cited in the peer-reviewed literature at least 41 times.

H-Index

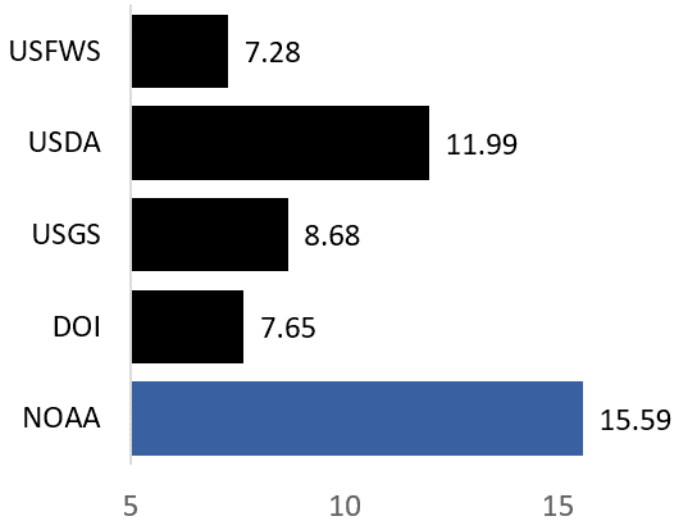


In total, 89 percent of the 1482 articles have been cited within the peer-reviewed literature.
16% of the 1482 articles fall within the top 10 percent of the most cited articles in fisheries.

Percentage of Articles Cited



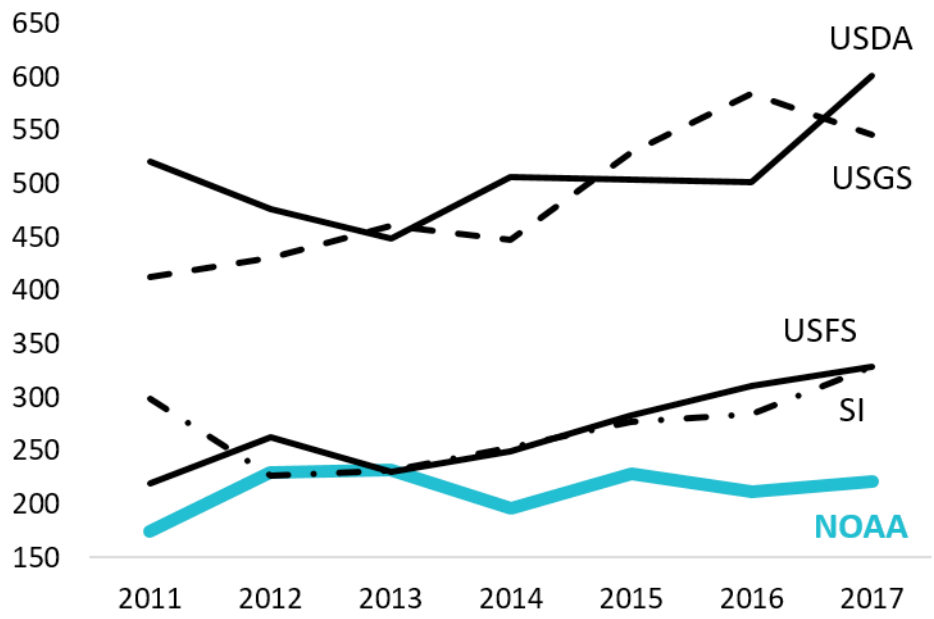
Percentage of Articles in Top 10%



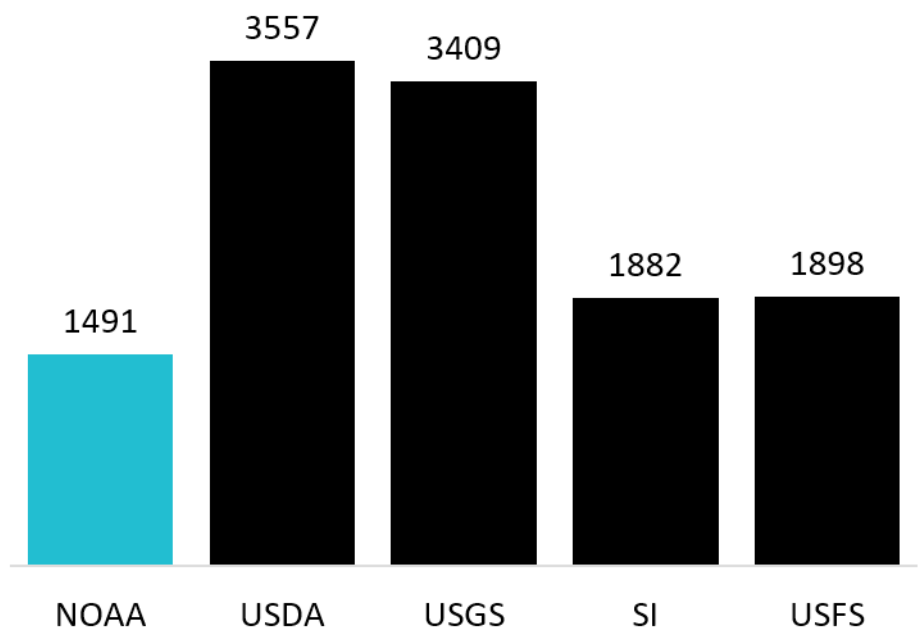
Productivity

Between 2011 and 2017, NOAA published an average of 213 articles per year in the field of ecology, resulting in a total of 1491 articles.

Articles Per Year by Agency



Total Number of Articles by Agency



Top Journals where NOAA Publishes

- Marine Ecology Progress Series
- Biogeosciences
- PLOS One
- Proceedings of the Royal Society B - Biological Sciences
- Global Change Biology

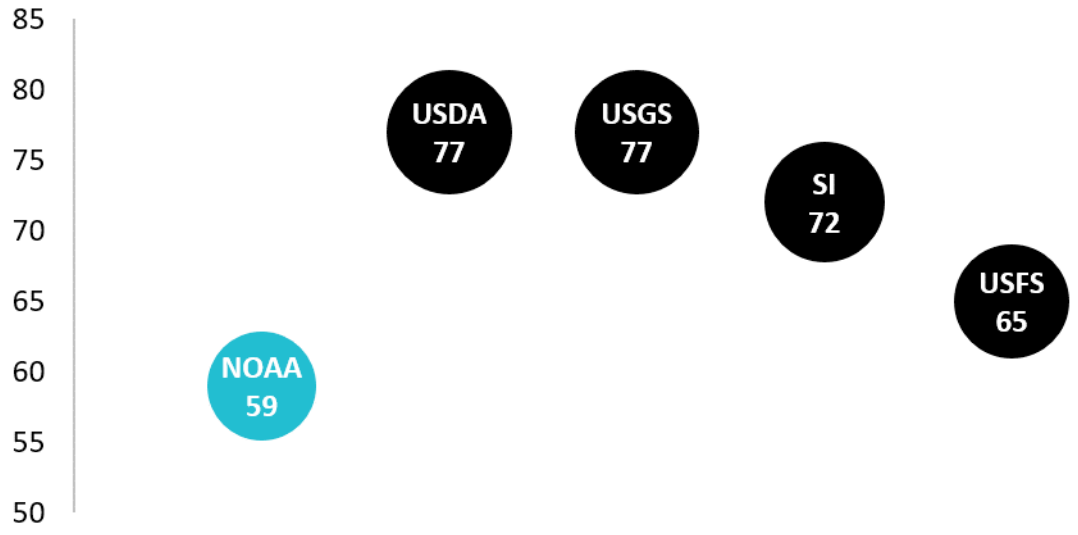
Highly Cited Papers

- 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

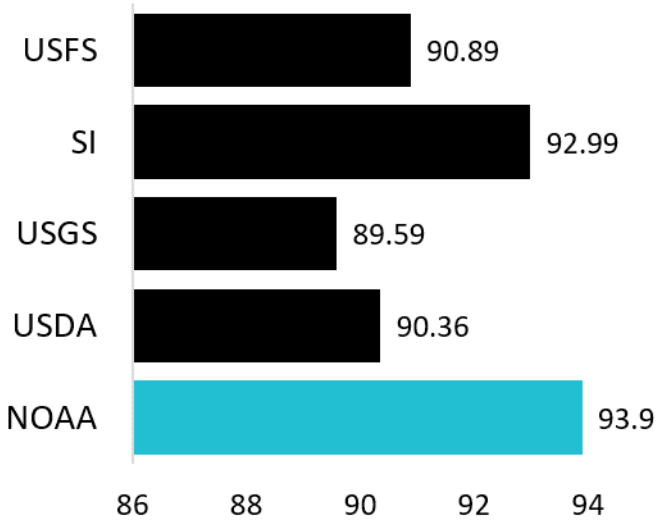
Within the field of ecology, NOAA has an H-index of 59 - meaning that 59 of these articles have been cited in the peer-reviewed literature at least 59 times.

H-Index

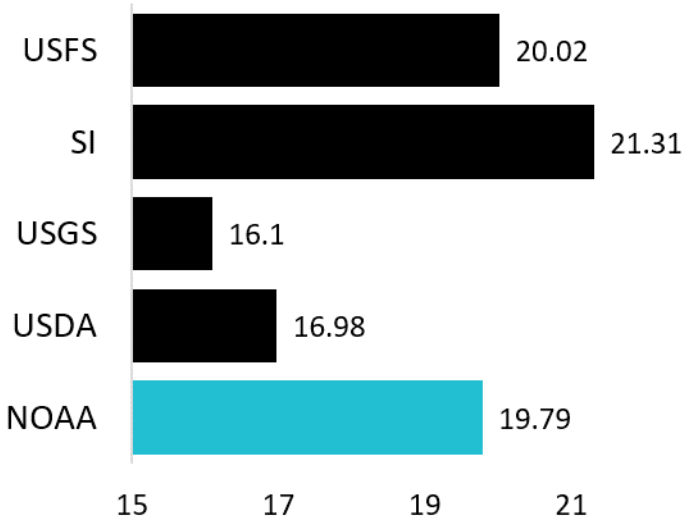


In total, 94 percent of the 1491 articles have been cited within the peer-reviewed literature.
20% of the 1491 articles fall within the top 10 percent of the most cited articles in ecology.

Percentage of Articles Cited



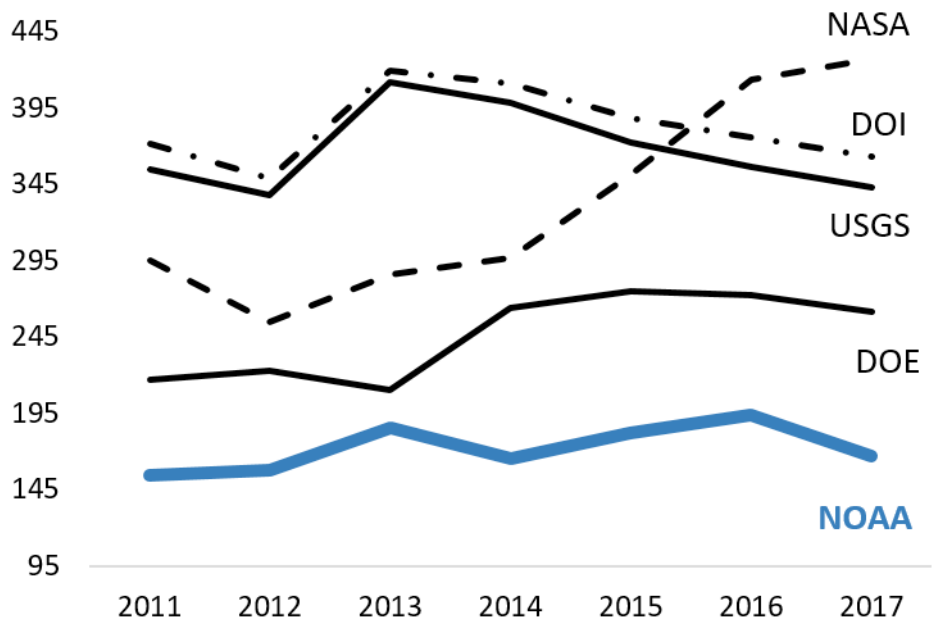
Percentage of Articles in Top 10%



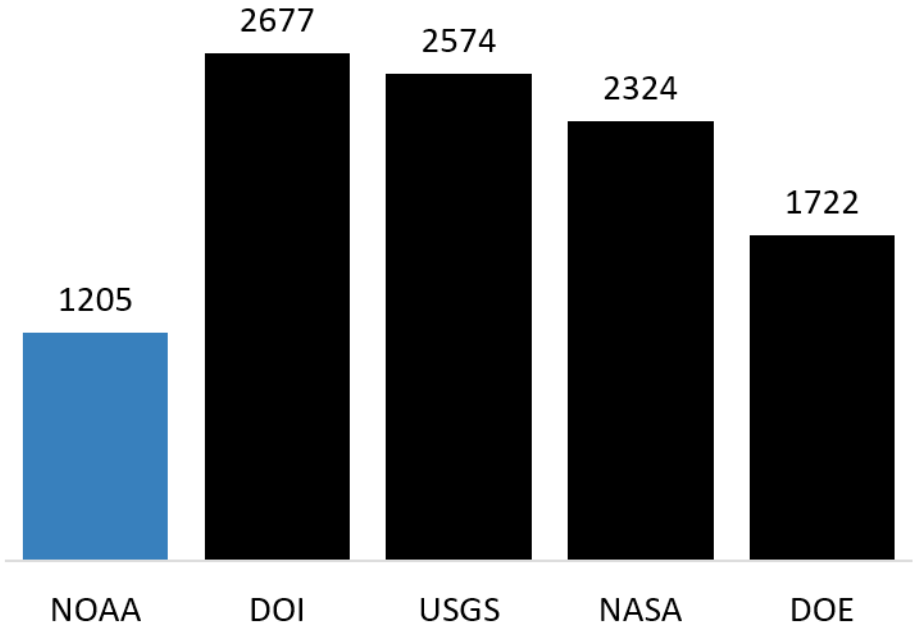
Productivity

Between 2011 and 2017, NOAA published an average of 172 articles per year in the field of geo-sciences, resulting in a total of 1205 articles.

Articles Per Year by Agency



Total Number of Articles by Agency



Top Journals where NOAA Publishes

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

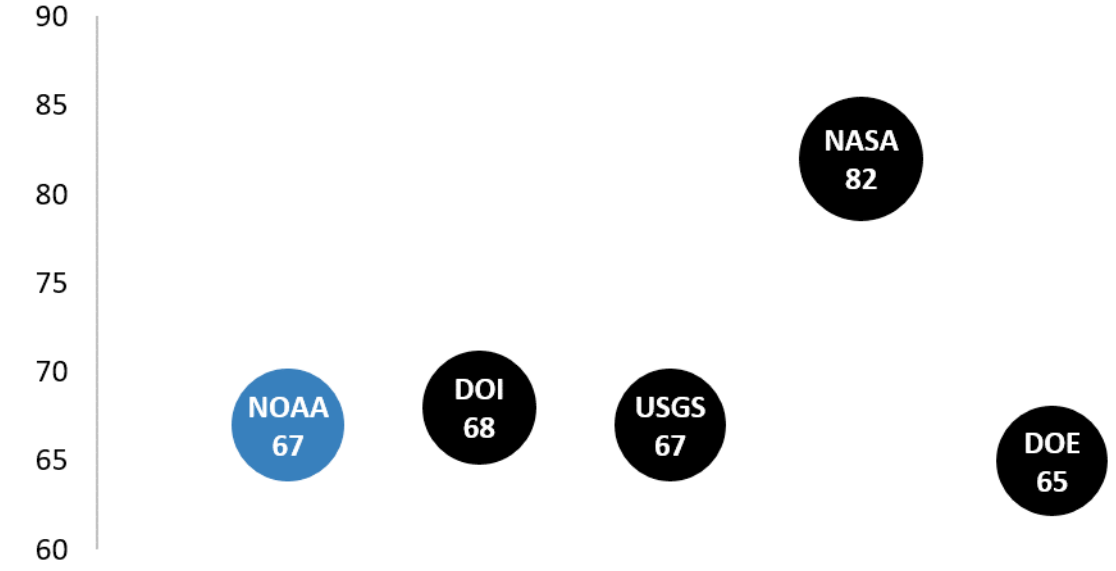
Highly Cited Papers

- 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

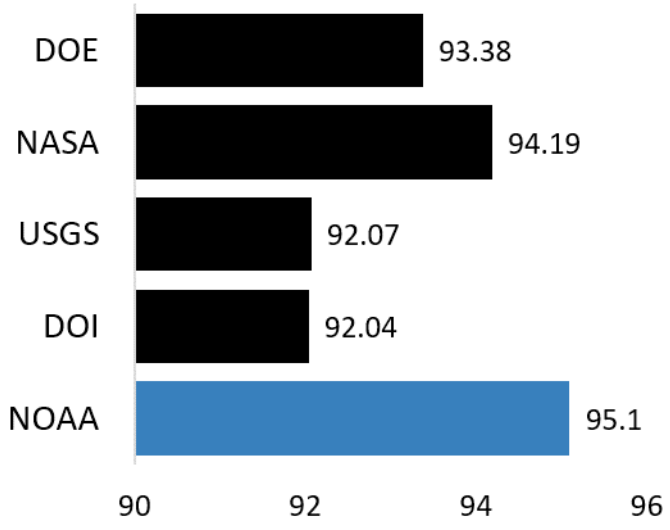
Within the field of geo-sciences, NOAA has an H-index of 67 - meaning that 67 of these articles have been cited in the peer-reviewed literature at least 67 times.

H-Index

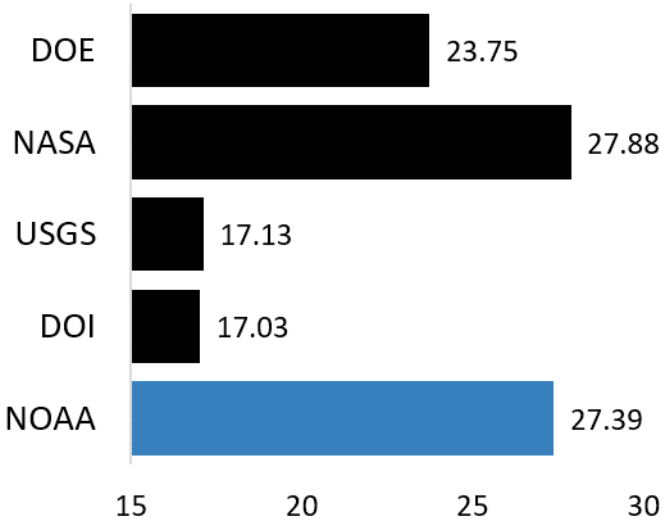


In total, 95 percent of the 1205 articles have been cited within the peer-reviewed literature.
27% of the 1205 articles fall within the top 10 percent of the most cited articles in geo-sciences.

Percentage of Articles Cited



Percentage of Articles in Top 10%



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 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 do list some of the NOAA scientific support staff who have been honored this year, you can find additional award winners within the linked website (e.g. Department of Commerce Gold and Silver Medals and NOAA Administrator's Award).

Department of Commerce and National Oceanic and Atmospheric Administration Awards

Award	Recipient(s)	Award Organization
2018 Department of Commerce Bronze Medal	Christopher Wheeler	Department of Commerce
2018 Department of Commerce Bronze Medal	Freud Park, John Relph, Andrew Allegra, Jefferson Ogata	Department of Commerce
2018 Department of Commerce Bronze Medal	Joseph Sienkiewicz, Eric Leuliette, John Loving, David R. Donahue, H. James Silva, Sheekela Baker-Yeboah, Walid Bannoura, Kimberly I. McCarty, Kirk J. Liang, and Linda Stathoplos	Department of Commerce
2018 Department of Commerce Bronze Medal	Wayne Perryman	Department of Commerce
2018 Department of Commerce Bronze Medal	Travis Ford, Andrew Kitts, David Packer, Katherine Richardson, David Stevenson, Aja Szumylo, and Peter Christopher	Department of Commerce
2018 Department of Commerce Bronze Medal	Jeromy Jording, James Dixon, Emily Reynolds, Craig Busack, Richard Turner, Allyson Purcell, Morgan Robinson, Chris Fontecchio, Charlene Hurst, and Teresa Mongillo	Department of Commerce
2018 Department of Commerce Bronze Medal	Joe Kiernan, Brian Spence, Erick Sturm, Libby Gilbert, and Carlos Garza	Department of Commerce
2018 Department of Commerce Bronze Medal	George Watters, Mi Ae Kim, and Elizabeth McLanahan	Department of Commerce
2018 Department of Commerce Bronze Medal	National Marine Fisheries Service Deepwater Horizon Team, National Ocean Service Deepwater Horizon Team, and NOAA Office of the General Counsel Deepwater Horizon Team	Department of Commerce
2018 Department of Commerce Bronze Medal	National Marine Fisheries Service IUU Fishing and Seafood Fraud Action Plan Team and Office of the General Counsel IUU Fishing and Seafood Fraud Action Plan Team	Department of Commerce
2018 Department of Commerce Bronze Medal	Amy Holman	Department of Commerce
2018 Department of Commerce Bronze Medal	Cheryl Woodley	Department of Commerce

Award	Recipient(s)	Award Organization
2018 Department of Commerce Bronze Medal	Christopher Barker, William Lehr, Amoreena MacFadyen, Caitlin O'Connor, Jeff Lankford, Debra Simecek-Beatty, David Wesley, George Graettinger, and Robb Wright	Department of Commerce
2018 Department of Commerce Bronze Medal	Chris Mobley, Julie Bursek, Chris Caldow, Laura Francis, Shauna Bingham, Peter Etnoyer, Laura Kracker, Tim Battista, Elizabeth Mackie, Nikolai Pawlenko, and Catalina Martinez	Department of Commerce
2018 Department of Commerce Bronze Medal	CAPT Richard Brennan, Julia Powell, Jeff Ferguson, Grant Froelich, Megan Bartlett, Annemieke Raymond, Micah Wengren, Jenifer Rhoades, Peter Stone, Mark Jackson, and William Forwood	Department of Commerce
2018 Department of Commerce Bronze Medal	CDR Ryan Kidder, CDR Christian Sloan, LCDR David Gothan, LCDR Matthew Nardi, LTJG Daniel Helmricks, Michael Aslaksen, Jr., Jason Woolard, Jon Sellars, Stephen White, and Andrew Halbach	Department of Commerce
2018 Department of Commerce Bronze Medal	Christina Horvat, Steven Smith, Keith Peabody, Jimmy Roper, Chris Hunt, Ron Pattison, Patrick Quigley, and Bobby Harp	Department of Commerce
2018 Department of Commerce Bronze Medal	Kim Runk and Matthew Foster	Department of Commerce
2018 Department of Commerce Bronze Medal	National Centers for Environmental Prediction Central Operations, National Weather Service Office of Dissemination, and National Centers for Environmental Prediction Space Weather Prediction Center	Department of Commerce
2018 Department of Commerce Bronze Medal	Weather Forecast Office Morristown, TN	Department of Commerce
2018 Department of Commerce Bronze Medal	Weather Forecast Office Salt Lake City, UT	Department of Commerce
2018 Department of Commerce Bronze Medal	Weather Forecast Office San Francisco Bay Area/ Monterey, CA	Department of Commerce
2018 Department of Commerce Bronze Medal	Weather Forecast Office Lake Charles, LA and Weather Forecast Office Shreveport, LA	Department of Commerce

Award	Recipient(s)	Award Organization
2018 Department of Commerce Bronze Medal	Weather Forecast Office Medford, OR, Weather Forecast Office Eureka, CA, and Weather Forecast Office Portland, OR	Department of Commerce
2018 Department of Commerce Bronze Medal	Weather Forecast Office Syracuse, IN and Weather Forecast Office Indianapolis, IN	Department of Commerce
2018 Department of Commerce Bronze Medal	Weather Forecast Office Vicksburg, MS, Lower Mississippi River Forecast Center, Arkansas-Red Basin River Forecast Center, Ohio River Forecast Center, North Central River Forecast Center, Missouri Basin River Forecast Center, Weather Forecast Office Jackson, MS, Weather Forecast Office Memphis, TN, Weather Forecast Office Lake Charles, LA, Weather Forecast Office New Orleans, LA, Weather Forecast Office St Louis, MO, and Weather Forecast Office Paducah, KY	Department of Commerce
2018 Department of Commerce Bronze Medal	Weather Forecast Office Wilmington, NC, Weather Forecast Office Charleston, SC, Weather Forecast Office Morehead City, NC, Weather Forecast Office Raleigh, NC, Weather Forecast Office Columbia, SC, Weather Forecast Office Wakefield, VA, Southeast River Forecast Center, National Hurricane Center, and Weather Prediction Center	Department of Commerce
2018 Department of Commerce Bronze Medal	NOAA Aircraft Operations Center Hurricane Matthew Research and Response Team, NOAA Marine Operations Center – Atlantic Hurricane Matthew Response Team, and NOAA Ship Ferdinand R. Hassler Hurricane Matthew Response Team	Department of Commerce
2018 Department of Commerce Bronze Medal	Steven S. Brown	Department of Commerce
2018 Department of Commerce Bronze Medal	Office of Oceanic Exploration and Research, NOAA Ship Okeanos Explorer, Office of National Marine Sanctuaries, and Maritime Heritage Program	Department of Commerce
2018 Department of Commerce Bronze Medal	Pacific Marine Environmental Laboratory 2016 Saildrone Team and Alaska Fisheries Science Center 2016 Saildrone Team	Department of Commerce
2018 Department of Commerce Bronze Medal	Elizabeth McLanahan	Department of Commerce

Scientific Awards and Achievements

Award	Recipient(s)	Award Organization
2018 Department of Commerce Gold Medal	Frank Giaretto	Department of Commerce
2018 Department of Commerce Gold Medal	Lisa M. DiPinto	Department of Commerce
2018 Department of Commerce Gold Medal	Franklin Schwing, Jennifer Doerr, Jennifer Leo, Kristopher Benson, Robert Colton, and Emma Hickerson	Department of Commerce
2018 Department of Commerce Gold Medal	Kyle Ward, Michael Annis, John Doroba, Michael Bloom, Jonathan French, Eli Smith, and Joshua Bergeron	Department of Commerce
2018 Department of Commerce Gold Medal	George Doucette, Timothy Davis, and Stephanie Moore	Department of Commerce
2018 Department of Commerce Gold Medal	Office of National Marine Sanctuaries, Office of Ocean Exploration and Research, and Pacific Islands Fisheries Science Center	Department of Commerce
2018 Department of Commerce Gold Medal	California-Nevada River Forecast Center, Weather Forecast Office Hanford, CA, and Weather Forecast Office Sacramento, CA	Department of Commerce
2018 Department of Commerce Gold Medal	Office of Response and Restoration	Department of Commerce
2018 Department of Commerce Gold Medal	National Environmental Satellite, Data, and Information Service	Department of Commerce
2018 Department of Commerce Gold Medal	NOAA Ship Thomas Jefferson	Department of Commerce
2018 Department of Commerce Gold Medal	National Oceanic and Atmospheric Administration	Department of Commerce
2018 Department of Commerce Gold Medal	Southern Region, National Weather Service	Department of Commerce
2018 Department of Commerce Silver Medal	Lisa M. Manning, Margaret (Maggie) H. Miller, and Chelsey N. Young	Department of Commerce
2018 Distinguished Career Awards	Jeffrey Brown	Department of Commerce
2018 Distinguished Career Awards	Harold C. Mears	Department of Commerce
2018 Distinguished Career Awards	Susan Snyder	Department of Commerce
2018 Distinguished Career Awards	Donna Darm	Department of Commerce
2018 Distinguished Career Awards	Robert M. Thompson	Department of Commerce

Award	Recipient(s)	Award Organization
2018 Distinguished Career Awards	James B. Burkholder	Department of Commerce
2018 Distinguished Career Awards	Steven J. Goodman	Department of Commerce
2018 Distinguished Career Awards	Maureen Kenny	Department of Commerce
2018 Distinguished Career Awards	Steven Wilson	Department of Commerce
2018 Distinguished Career Awards	Paul M. Whitmore	Department of Commerce
2018 Distinguished Career Awards	Allen Zahrai	Department of Commerce
2018 Distinguished Career Awards	Mary Baker	Department of Commerce
2018 Distinguished Career Awards	Morris Bender	Department of Commerce
2018 Distinguished Career Awards	Richard H. Grumm	Department of Commerce
2018 Distinguished Career Awards	Lyndal L. Johnson	Department of Commerce
2018 Distinguished Career Awards	Kingtse C. Mo	Department of Commerce
2018 Distinguished Career Awards	Jeffrey J. Polovina	Department of Commerce
2018 Distinguished Career Awards	Huug Van den Dool	Department of Commerce
2018 Silver Sherman Award	Thomas Williams	NOAA
2018 Silver Sherman Award	John Jensenius	NOAA
2018 Silver Sherman Award	Jocelyn Burston	NOAA
2018 Silver Sherman Award	Peter Hood	NOAA
2018 Silver Sherman Award	Matthew Butler	NOAA
2018 Silver Sherman Award	Cheryl Marlin	NOAA
2018 Silver Sherman Award	Beth Norton	NOAA

Scientific Awards and Achievements

Award	Recipient(s)	Award Organization
2018 Silver Sherman Award	Brittany Marsden	NOAA
2018 Silver Sherman Award	Shannon Rankin	NOAA
2018 Silver Sherman Award	Claudia Nierenberg	NOAA
2018 Silver Sherman Award	Jarad Makaiau	NOAA
2018 Silver Sherman Award	Teresa Murphy	NOAA
2018 Silver Sherman Award	Kate Naughten	NOAA
2018 Silver Sherman Award	Chris Harvey	NOAA
2018 Silver Sherman Award	Lara Hinderstein	NOAA
2018 Silver Sherman Award	Chris Hornbrook	NOAA
2018 Silver Sherman Award	Joe Mangin	NOAA
2018 Silver Sherman Award	Terri Lynne Ford	NOAA
2018 Silver Sherman Award	Yo-Kung John Tsui	NOAA
2018 Silver Sherman Award	Joel Perlroth	NOAA
2018 Silver Sherman Award	Carla Kirby	NOAA
2018 NOAA Administrator's Award	Margaret Miller and Chelsey Young	NOAA
2018 NOAA Administrator's Award	Michael R. O'Farrell	NOAA
2018 NOAA Administrator's Award	Mridula Srinivasan	NOAA
2018 NOAA Administrator's Award	Celeste Leroux, Melissa Beaudry, Quinn Downs, Steven Ross, Dale Jones, Christopher Rogers, and Thomas Gleason	NOAA
2018 NOAA Administrator's Award	Stephen Copps and Daniel Tonnes	NOAA

Award	Recipient(s)	Award Organization
2018 NOAA Administrator's Award	Moira Kelly, David Stevenson, Geret DePiper, Chad Demarest, and James "Mitch" MacDonald	NOAA
2018 NOAA Administrator's Award	Ruth Kelty	NOAA
2018 NOAA Administrator's Award	Shachak Pe'eri	NOAA
2018 NOAA Administrator's Award	Aaron R. Anderson, Joseph W. DelliCarpini, Chad M. Entremont, David G. Hotz, Stephen J. Keighton, Patrick T. Marsh, Jason S. Schaumann, Mike W. Sutton, Jerry R. Wiedenfeld, and Thomas J. Turnage	NOAA
2018 NOAA Administrator's Award	Matthew Kuzemchak, Nancy Briscoe, Ann Byar, Joe Duran, Adrain Kendrick, Rich Cruikshank, and David Quivey	NOAA
2018 NOAA Administrator's Award	Steve Schotz, Sanford Garrard, James Calkins, John Olsen, Bert Viloria, Joseph Fiore, Ron DeWaters, and Brian Campbell	NOAA
2018 NOAA Administrator's Award	James M. Williams, Cheryl Stephenson, Mike Miller, Olen Boydstun, Jessica Schultz, Terrell Ballard, and Jeff Turner	NOAA
2018 NOAA Administrator's Award	Robyn Heffernan, Richard Hozak, Eric Holweg, Virgil Middendorf, and Heath Hockenberry	NOAA
2018 NOAA Administrator's Award	Steve Piotrowicz, Greg Johnson, Molly Baringer, and Claudia Schmid	NOAA
2018 NOAA Administrator's Award	Shian-Jiann Lin, Rusty Benson, Lucas Harris, Zhi Liang, Tim Marchok, Whit Anderson, and Venkatachala Ramaswamy	NOAA
2018 NOAA Administrator's Award	Christian Meinig, Scott Stalin, Dirk Tagawa, and Nicholas Delich	NOAA
2018 NOAA Administrator's Award	Conrad L. Ziegler, John F. Gamache, William J. Greene, Charles F. Lynch, and Bobby G. Peek	NOAA
2018 NOAA Administrator's Award	Tanya Dobrzynski, Aria Remondi, Christopher Botnick, Janelle Smith, Summer Morlock, Vicki Schwantes, Marcus Points, Jocelyn Burston, and Meg Oates	NOAA
2018 NOAA Administrator's Award	Ana Valentín, Daniel Meléndez, Claudina Castro, Hernan Garcia, Martin Yapur, and Amneris Caba	NOAA
2018 NOAA Administrator's Award	Jennifer Hammond	NOAA
2018 NOAA Administrator's Award	Tracy Levstik	NOAA

Scientific Awards and Achievements

Award	Recipient(s)	Award Organization
2018 Technology Transfer Award	Kirk Liang	NOAA
2018 Technology Transfer Award	Vera Trainer, Nicolaus Adams, Brian Bill, and Brendan Sylvander	NOAA
New U.S. Patents for Technology	Steven S. Brown	USPO
New U.S. Patents for Technology	Daniel M. Murphy	USPO
Recognition of 50 Plus Years of Federal Service	Michael Chalfant	NOAA
Recognition of 50 Plus Years of Federal Service	Sheila Stiles	NOAA
Recognition of 50 Plus Years of Federal Service	Margo Elliott	NOAA
Recognition of 50 Plus Years of Federal Service	Clyde L. MacKenzie, Jr	NOAA
Recognition of 50 Plus Years of Federal Service	Kenneth Sherman	NOAA
Recognition of 50 Plus Years of Federal Service	Roy Anderson	NOAA
Recognition of 50 Plus Years of Federal Service	William McReynolds, Jr	NOAA
Recognition of 50 Plus Years of Federal Service	Joseph A. Petteway	NOAA
Recognition of 50 Plus Years of Federal Service	Ernest Charles Brown	NOAA
Recognition of 50 Plus Years of Federal Service	Robert Kohler	NOAA
Recognition of 50 Plus Years of Federal Service	Michael Kraus	NOAA
Recognition of 50 Plus Years of Federal Service	Greg A. Bast	NOAA
Recognition of 50 Plus Years of Federal Service	James D. McFadden	NOAA
Recognition of 50 Plus Years of Federal Service	Peggy Henson	NOAA
Recognition of 50 Plus Years of Federal Service	Helen Marie Marks	NOAA
Recognition of 50 Plus Years of Federal Service	Rosa Asberry	NOAA

Award	Recipient(s)	Award Organization
Recognition of 50 Plus Years of Federal Service	Tillman Peck	NOAA
Hollings Scholar Co-hosts/mentors	Kevin Gallo and Phil Schumacher (NWS)	NOAA
NOAA Mentoring Award	Tom Smith	NOAA
Isaac Cline Award	Matthew Sardi, Jeffrey Lewitsky and Andy Latto (National Centers for Environmental Prediction)	NWS
Isaac Cline Award	Krizia Negron Hernandez	NWS
Isaac Cline Award	Michael Ryan	NWS
Isaac Cline Award	Derek Giardino, Dr. 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
Isaac Cline Award	Jamie Rhome	NWS
Isaac Cline Award	Kennard Kasper and Christopher Rothwell	NWS
Isaac Cline Award	Christopher J. Morris, Robert Simpson, Barry Bowers, Melissa Beat, Nicholas Fenner, Lance Goehring, Cynthia B. Elsenheimer, Heather Lorenzen and Tabatha Seymore	NWS
Isaac Cline Award	Daniel Brown and John Cangialosia	NWS
Isaac Cline Award	Jennifer Daniel	NWS
Isaac Cline Award	Anthony Mignone and John Cannon	NWS
Isaac Cline Award	Patricia Douglass	NWS
NESDIS IT and Engineering Employees of the Year for 2017 (team award)	Dan Lindsey	NESDIS
Outstanding Scientific Paper	Luke Thompson (primary author)	OAR
Outstanding Scientific Paper	Ming Zhao (primary author)	OAR
Outstanding Scientific Paper	Ariel Stein (primary author)	OAR

Scientific Awards and Achievements

External Scientific Awards

Award	Recipient(s)	Award Organization
Charles L. Mitchell Award	Daniel Keeton	American Meteorological Society
NASA Outstanding Leadership Medal	Dennis Chesters	National Aeronautics and Space Administration
Selected as an AMS Fellow	Mitch Goldberg	American Meteorological Society
2018 CALCON Technical Meeting Recognition Award	Bruce Guenther	Characterization and Radiometric Calibration for Remote Sensing
2018 Robert H. Gibbs, Jr. Memorial Award for excellence in systematic ichthyology	Thomas Munroe	American Society of Ichthyologists and Herpetologists
Climate Adaptation Leadership Awards for Natural Resources	Marine Mammal Climate Vulnerability Team:Chris Orphanides, Debi Palka, Diane Borggaard, Mike Asaro, Dave Gouveia, Jenny Litz, Melissa Soldevilla, Laura Engleby, Dori Dick, Roger Griffis, Matt Lettrich	National Fish, Wildlife and Plants Climate Adaptation Strategy
MBNMS Volunteers of the Year	Scott Benson and Karin Forney	Monterey Bay National Marine Sanctuary (MBNMS)
Distinguished Professional Achievement Award	Rachel Johnson	California-Nevada Chapter of the American Fisheries Society (AFS)
AIFRB Outstanding Group Achievement Award	Paul Crone as a PI for Center for the Advancement of Population Assessment Methodology (CAPAM)	The American Institute of Fishery Research Biologists (AIFRB)
2018 AMS Weather Analysis and Forecasting Committee Early Career Award	Curtis Alexander	American Meteorological Society
FLC Far West Region award for Outstanding Partnership	Wind Forecast Improvement Project - 2 Team	Federal Laboratory Consortium Far West Region
First Prize for an Outstanding Scientific Publication	Dominikus Heinzeller	Society of Friends and Sponsors of the Institute of Meteorology and Climate Research

Award	Recipient(s)	Award Organization
2018 Sverdrup Gold Medal Award	Michael Alexander	American Meteorological Society
AMS Fellow	Michael Alexander	American Meteorological Society
2018 Bernhard Haurwitz Memorial Lecturer	George Kiladis	American Meteorological Society
AMS Fellow	Jeffrey Whitaker	American Meteorological Society
AMS Fellow	Roger Pulwarty	American Meteorological Society
American Indian Science and Engineering Society (AISES)Sequovah Fellowship Award	Roger Pulwarty	American Indian Science and Engineering Society (AISES)
Union Fellow	Walter H. F. Smith	American Geophysical Union
Finalist for the Samuel J. Heyman Service to America Medals	Tim Schmit	Partnership for Public Service
CO-LABS Governor's Award for High-Impact Research	Steven Miller, Dan Lindsey, Curtis Seaman	CO-LABS
NOAA David Johnson Award	Scott Rudlosky	National Space Club and Foundation
NASA Group Achievement Award to the GOES-R Team	Don Hillger, Dan Lindsey (and many others)	National Aeronautics and Space Administration
AMS Conference on Hurricanes and Tropical Meteorology: Most questions asked	John Knaff	American Meteorological Society
James R. Holton Award	Angel Adames-Corralia	American Geophysical Union
2018 Ascent Award	Yi Ming	American Geophysical Union
2018 AGU Fellow	Tom Delworth	American Geophysical Union
Bannan I. Miller Award	Kieran Bhatia	American Meterological Society
Revelle Medal	Isaac Held	American Geophysical Union

Scientific Awards and Achievements

Award	Recipient(s)	Award Organization
Highly Cited Researchers for 2018	Thomas Delworth, John Dunne, Paul Ginoux, Steve Griffies, Issac Held, Larry Horowitz, Vaishali Naik, Gabriel Vecchi, and Andrew Wittenbreg	American Geophysical Union
Banner I. Miller Award	Jason Dunion	American Meteorological Society
Laureate Award for Dual Defense Use	Joe Cione, Altug Aksoy, Brittany Dahl, Kelly Ryan, and Jun Zhang	Aviation Week
Award for Early-Career Professional Achievement	Gina Eosco	American Meteorological Society

National Oceanic and
Atmospheric Administration

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 their 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 2018.

NOAA Scientist	Job Title	Professional Society	Position
Kate Achilles	Deputy Director, Fisheries Ecology Division, SWFSC	National Marine Educators Association	Member, Board of Directors
Andrea Bleistein	Physical Scientist	American Meteorological Society	Councilor
Stephania K. Bolden	Supervisory Fisheries Biologist	North American Sturgeon and Paddlefish Society	Member at Large of the Governing Board
Michael Carver	Resource Protection Specialist	California Whale Rescue	Member, Board of Directors
Mark Chandler	Fisheries Biologist, Assessment and Monitoring Div., Office of Science & Technology	American Institute of Fishery Research Biologists (AIFRB)	Member, Board of Directors
John Cortinas	Director, Office of Weather and Air Quality	American Meteorological Society	Councilor
Michelle Crockett	National Program Manager EEO and Diversity	Federally Employed Women	Immediate Past President
Marie DeLorenzo	Research Ecologist	Carolina's Society of Environmental Toxicology and Chemistry	Member Board of Directors
Tanja Fransen	Meteorologist in Charge	American Meteorological Society	Councilor
Jared Guyer	Lead Forecaster, Storm Prediction Center	National Weather Association	Councilor
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

NOAA Scientist	Job Title	Professional Society	Position
Gail Hartfield	Lead Meteorologist	National Weather Association	President
Gail Hartfield	Lead Meteorologist	American Meteorological Society	Councilor
Fiona Horsfall	Chief, NWS Climate Services Division	American Association of State Climatologists	ex-Officio Executive Board
Tamara Houston	Regional Climate Services Program Manager	America Association of State Climatologists	ex-Officio Executive Board
Jeffrey Kelley	General Forecaster/ Meteorologist	The High Plains Chapter of the American Meteorological Society/ National Weather Association	Treasurer
Dan Kowal	Chief, Standards & Evaluation Branch	Colorado State Science Fair	Treasurer
Jayme Layber	Hydrologist	California Geographic Information Association	Board Member
Deborah Lee	Director, Great Lakes Environmental Research Laboratory	American Academy of Water Resources Engineers	President-elect, President, Past President
Christine Lipsky	Research Fishery Biologist	Atlantic International Chapter of the American Fisheries Society	Secretary/Treasurer
Christine Lipsky	Research Fishery Biologist	Aqua Kids TV	President and Science Advisory, Board of Directors
Richard Litaker	Supervisory Ecologist	International Society for the Study of Harmful Algae	Board Member
Patrick Lynch	National Stock Assessment Program Lead	American Fisheries Society- Marine Fisheries Section	Secretary-Treasurer
James Manning	Research Oceanographer	Educational Passages	Member, Board of Directors
Richard McBride	Supervisory Research Fish Biologist	American Fisheries Society- Marine Fisheries Section	Northeastern Division Representative to Board
Jennifer McNatt	Emergency Response Meteorologist	National Weather Association	Councilor

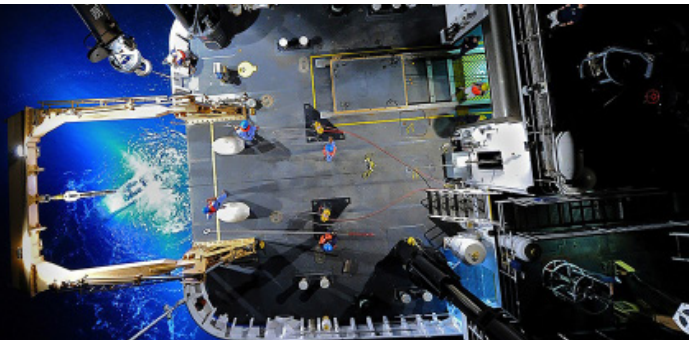
NOAA Scientist	Job Title	Professional Society	Position
Roy Mendelssohn	Supervisory Operations Research Analyst, Environmental Research Div.	International Biometric Society (IBS), Western North American Region	Regional Committee Member
Bart Merrick	Education Coordinator, NOAA Chesapeake Bay Office (NCBO)	Maryland Association for Environmental and Outdoor Education (MAEOE)	Member, Board of Directors
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
Lisa Milke	Research Fishery Biologist	National Shellfisheries Association	Secretary
M. Katherine Moore	Biologist	Society for Wildlife Forensic Science	Director of Professional Development
Shivonne Nesbit	Fish Biologist/ESA Permit Specialist	American Fisheries Society	Officer of the Executive Committee of the Oregon Chapter
Eugene Olmi	Program Analyst	Southeastern Estuarine Research Society	Past President
Trisha Palmer	Senior Forecaster, Weather Forecast Office Greenville-Spartanburg, SC	National Weather Association	Councilor
Linda Rhodes	Supervisory Research Microbiologist	American Fisheries Society's Fish Health Section	Secretary-Treasurer
Paul Schlatter	Science and Operations Officer, Boulder CO	National Weather Association	President elect, President, past President
Robert Schwemmer	Regional Maritime Heritage Coordinator, ONMS	Santa Barbara Maritime Museum (SBMM)	Member, Board of Directors
Pat Spoden	Science and Operations Officer, Weather Forecast Office Paducah, KY	National Weather Association	Commissioner of Committees
Marc Suddleson	Program Manager National Centers for Coastal Ocean Science (NCCOS)	Federal Laboratory Consortium	Member-at-Large on the Executive Board
Christa von Hillebrandt-Andrade	Manager, Caribbean Tsunami Warning Program	International Association with Physical Science of the Oceans	Member of the Executive Committee

NOAA Scientist	Job Title	Professional Society	Position
Chris Yates	Fish and Wildlife Administrator	Honda Marine Science Foundation	Member, Board of Directors
Alisa Young	Physical Scientists	Colorado Association of Black Professional Scientists and Engineers	Board Member

Laboratory and Program Science Reviews

Peer review and evaluation is critical in maintaining NOAA's world-class research enterprise. NAO 216-115B regulates Research and Development in NOAA and 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 reviews of their laboratories and programs, consistent with the principles and guidance expressed in NAO 216-115B.

Office of Oceanic and Atmospheric Research Science Program and Laboratory Reviews



In 2018, NOAA Research conducted a review of the Global Monitoring Division at the Earth System Research Laboratory (ESRL - GMD).

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 OAR'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.

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
Earth System Research Laboratory Global Monitoring Division (ESRL - GMD)	2018

National Weather Service Science Program and Laboratory Reviews

National Weather Service focuses on transitioning science advancements from research partners, such as OAR labs and the external research community, into the NWS by advancing their readiness levels and implementing them into operations based on prioritized 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 R2O priorities are consistent with operations service delivery requirements. These 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 requires transition plans for all funded R2O projects (per NOAA NAO 216-105B), to assure linkages to operations are identified at the start of each project. NWS also has a standing community advisory group of independent scientific experts under the auspices of the 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 timeline 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.

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 examined our fisheries science programs on a five-year cycle to evaluate the quality, relevance, and performance of science and research conducted in NMFS Science Centers and associated laboratories to strategically position the agency in planning future science and research.

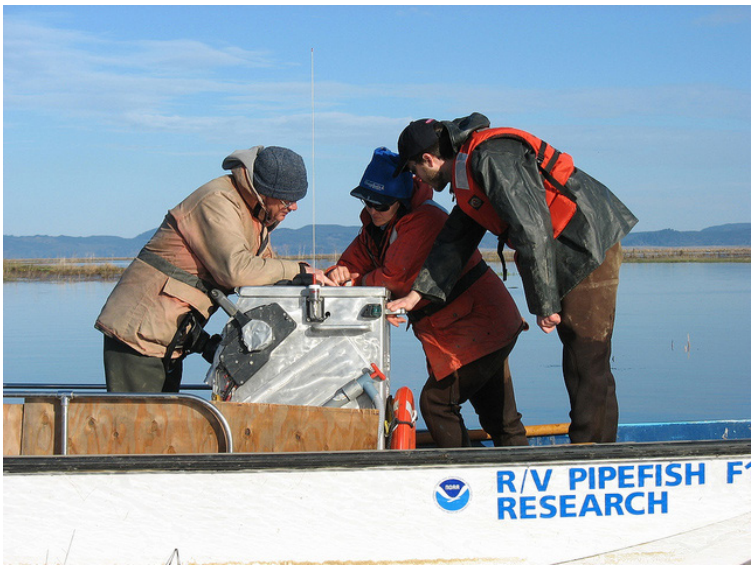
Independent reviewers provided recommendations to each Science Center program and these were addressed by relevant leadership in a formal response that included a timeline of action items. At the end of each year, a national response to the full suite of review reports was developed that included action items best addressed at the national level.

The schedule of annual reviews covered the core science program areas that directly support the NMFS mission. Over a five-year period, NMFS reviewed 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 human dimensions

In FY 2018, NMFS completed a five-year review cycle covering all major science programs at the Regional Science Centers and the Office of Science and Technology. During FY2019, NMFS will complete a strategic analysis of all program review results (34 individual reviews) initiated in FY2018. The end goal is to document lessons learned and best practices, develop approaches for better integrating science and management within regions and across mission areas, improve coordination with internal and external science and management partners, and provide strategic direction for future science program reviews.

NMFS Regional Science Centers, Associated Laboratories, and Offices that conducted science programs covered by NMFS 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	



Science from the 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 last 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 started cycling through annual reviews on each of these priority areas:

- Stressor Impacts and Mitigation: HABs and Hypoxia Research Review beginning February 2018

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 was completed in 2018. The University of Michigan, as the administrator of the NERRS Science Collaborative, contracted with a third party to conduct the review. Results are compiled in the NERRS Science Collaborative Interim Evaluation Report.

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

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 5-20 years in the Atlantic/Caribbean coral reef ecosystems.

NOS Office	Lab/Program	Last Review Date
National Center for Coastal Ocean Science (NCCOS)	Harmful Algal Bloom and Hypoxia Portfolio	2018
National Estuarine Research Reserve System (NERRS)	System-Wide Monitoring Program	2007
	Science Collaborative Program	2018
Coral Reef Conservation Program (CRCP)	NRC Coral Intervention Study	2017
Office of Coast Survey	Annual Peer Review of the Joint Hydrographic Center	2017

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

NESDIS' Center for Satellite Applications and Research (STAR) translates NOAA's investment in the acquisition and management of the nation's operational environmental satellites into information value for its users. For NOAA satellites, STAR fulfills the critical role of calibrating the satellite sensors to accurately convert their measurements to data, developing algorithms that transform the satellite data into usable products, and validating the satellite-derived products to ensure that they meet their 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 ensures the quality of their data streams. To support users, STAR conducts training, user readiness and risk reduction activities. To prepare for the future and meet strategic stakeholder objectives, STAR conducts applied research that advances Satellite Remote Sensing methods to aid in the formulation of next generation sensors and data products and advance their maturity for future stakeholder use.

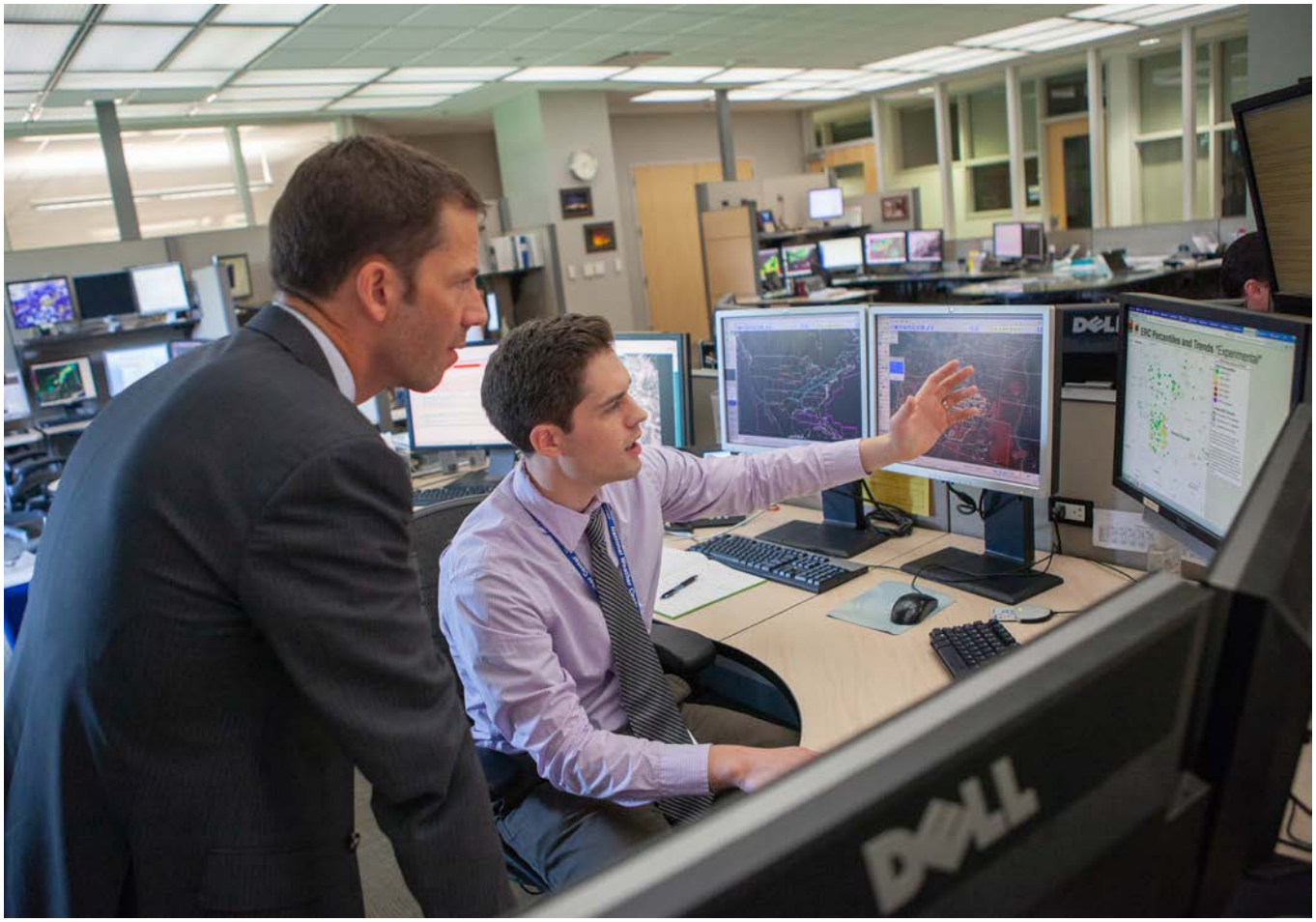
NESDIS National Centers for Environmental Information (NCEI) provide data stewardship and archival storage for environmental information produced across NOAA's missions and observing systems, and for selected partner environmental information; produces retrospective data products that combine relevant 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 organization 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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Concluding Thoughts

Through research and development, NOAA is constantly improving upon the service and products the agency provides the American people every day. In 2018, NOAA scientists developed innovative technologies, deployed cutting-edge scientific techniques, and transformed predictive model capabilities. New models can now better predict flash floods at a neighborhood level, and accurately forecast a rare Florida snowstorm. New technologies enabled stock assessments in previously unreachable areas to inform fisheries management plans to ensure productive fisheries for years to come.

In order to serve the American public, 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 Sciences, Oceanography, Marine and Freshwater Biology, and Fisheries. This outstanding productivity and impact of NOAA's research reflects our continued commitment to Science, Service, and Stewardship.

NOAA's quality science comes from its world class scientists. The many scientific achievements highlighted in this report are made possible by our talented workforce Between 2017 and 2018, the agency had over 260 individual awardees and team 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 this year, and look forward to NOAA's accomplishments in the coming years.

Craig N. McLean
NOAA Research Council Chair
December 2018

Glossary

ABI	Advanced Baseline Imager
AQPI	Advanced Quantitative Precipitation Information
ATON	Aids to Navigation
ANT	Aids to Navigation Team
ALAMO	Air-Launched Autonomous Micro-Observer
AGGI	Annual Greenhouse Gas Index
AEU	Aquatic Ecological Units
AMOC	Atlantic Meridional Overturning Circulation
AIS	Automatic Identified System
BOEM	Bureau of Ocean Energy Management
CAPSTONE	Campaign to Address Pacific monument Science, Technology, and Ocean Needs
CO_2	Carbon dioxide
CRADA	Cooperative Research and Development Agreement
CIMAS	Cooperative Institute for Marine and Atmospheric Studies
DOC	Department of Commerce
EM	Electronic Monitoring
ELT	Emergency Locator Transmitters
EPIRB	Emergency Position Indicating Radio Beacons
ECMWF	European Center for Medium Range Weather Forecasts
EDDI	Evaporative Demand Drought Index
ERL	Experimental Reef Laboratory
FEWS NET	Famine Early Warning Systems Network
FEMA	Federal Emergency Management Agency
FV3	Finite-Volume on a Cubed Sphere
FY	Fiscal Year
FSV	Fisheries Survey Vessel
FMC	Fishery Management Council
FLASH	Flooded Locations and Simulated Hydrographs
FACETs	Forecasting a Continuum of Environmental Threats
GOES	Geostationary Operational Environmental Satellite
GLM	Geostationary Lightning Mapper
GFS	Global Forecast System
GHCN-D	Global Historical Climatology Network-Daily
GTS	Global Telecommunications System
GRAV-D	Gravity for the Redefinition of the American Vertical Datum
HAB	Harmful Algal Bloom
HRRR	High Resolution Rapid Refresh
HAFS	Hurricane Analysis and Forecast System
HWRF	Hurricane Weather Research and Forecasting

HYSPLIT	Hybrid Single-Particle Lagrangian Integrated Trajectory
IUU	Illegal, Unrepresented, and Unregulated
IMET	Incident Meteorologist
JPSS	Joint Polar Satellite System
JTTI	Joint Technology Transfer Initiative
JABBA	Just Another Bayesian Biomass Assessment
MJO	Madden-Julian Oscillation
MHI	Main Hawai'ian Islands
MARU	Marine Autonomous Recording Unit
MMPA	Marine Mammal Protection Act
MOM6	Modular Ocean Model 6
NASA	National Aeronautics and Space Administration
NBM	National Blend of Models
NESDIS	National Environmental Satellite, Data, and Information Service
NERRS	National Estuarine Research Reserve System
NMFS	National Marine Fisheries Service
NOS	National Ocean Service
NOAA	National Oceanic and Atmospheric Administration
NOPP	National Oceanographic Partnership Program
NPP	National Polar-Orbiting Partnership
NSRS	National Spatial Reference System
NWS	National Weather Service
NGGPS	Next Generation Global Prediction System
NAO	NOAA Administrative Order
NAM	North American Model
NERACOOS	Northeast Regional Association of Coastal Ocean Observing Systems
NWHI	Northwest Hawai'ian Islands
O-JTTI	Ocean Joint Technology Transfer Imitative
OAR	Oceanic and Atmospheric Research
OMAO	Office of Marine and Aviation Operations
PLB	Personal Locator Beacons
PORTS	Physical Oceanographic Real Time System
RL	Readiness Level
RISA	Regional Integrated Sciences and Assessments
R2X	Research to Operations, Applications, Commercialization, and Utilization
SARSAT	Search and Rescue Satellite Aided Tracking System
SBIR	Small Business Innovative Research
SUVI	Solar Ultraviolet Imager
TRP	Take-Reduction Plan

Glossary

TAF	Terminal Aerodrome Forecasts
COASTAL	The Consumer Option for Alternative System to Allocate Losses
TPOS	Tropical Pacific Observing System
USCG	U.S. Coast Guard
USGS	U.S. Geological Survey
UV	Ultraviolet
UFS	Unified Forecast System
VORTEX-SE	Verification of the Origins of Rotation in Tornadoes Experiment-Southeast
VMS	Vessel Monitoring System
VIIRS	Visible Infrared Imaging Radiometer Suite
WoS	Web of Science

Secretary Ross with NOAA staff at the April 2018 Space Symposium in Colorado Springs, Colorado.

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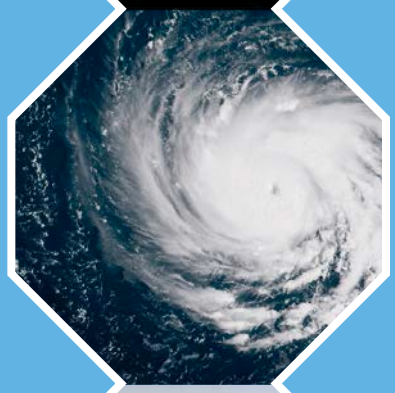
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