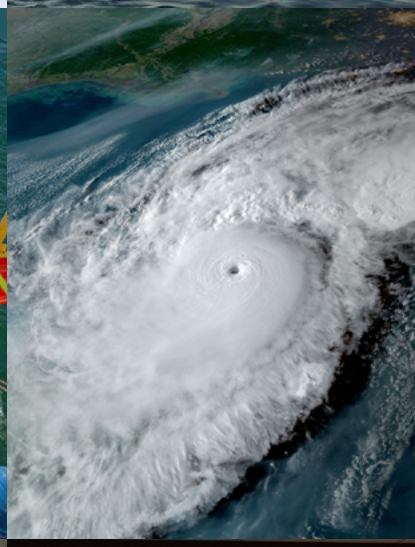
# NOAA Annual Transition Report

## Fiscal Year 2024



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

# Fiscal Year 2024 NOAA Annual Transition Report

NOAA Technical Memorandum NOAA Science Council-009

Alexander Bukvich[1], Katie Geddes[1], Bryan Cole[1], and Fiona Horsfall[1,2]

[1] Office of Research, Transition, and Application, Oceanic and Atmospheric Research (OAR)
[2] Chair, Line Office Transition Managers Committee (LOTMC)

## Layout

Megan Deehan, Office of Science Support, OAR

## Cover Photos

**(Left column top to bottom)**

An urban street blanketed with many inches of snow, following a January 2016 Mid-Atlantic blizzard. Credit: Joe Flood, NOAA/NWS Collection under license CC BY 2.0

NMFS Northeast Fisheries Science Center researchers and partners deploy a long-range autonomous underwater vehicle, also known as “Stella,” during a scallop survey. Credit: Dvora Hart

A tornado passes through central Minnesota, lifting momentarily near a rural farmstead. Taken in August, 2014 and included in the NOAA Weather in Focus Photo Contest 2015. Credit: Amanda Hill, NOAA/NWS Collection under license CC BY 2.0

**(Right column top to bottom)**

The Cleveland Water Intake Crib sits several miles offshore of the Cleveland skyline in Lake Erie. Credit: Ed Verhamme, LimnoTech

Image of Hurricane Milton from NOAA’s GOES-16 satellite on Oct. 8, 2024. Credit: NOAA/NESDIS

A high wind event in a simulation evaluating two wildland fire decision support tools in NOAA’s new Fire Weather Testbed. Credit: Lauren Lipuma, Cooperative Institute for Research In Environmental Sciences

The DriX departs on its mission to collect ocean data while the ship that deployed it continues to work alongside. Credit: NOAA/UxS Operations Center

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
Oceanic and Atmospheric Research
Office of Research, Transition, and Application
Silver Spring, Maryland
August 2025

https://doi.org/10.25923/w7xq-4a88

# Fiscal Year 2024 NOAA Annual Transition Report

NOAA Technical Memorandum NOAA Science Council-009

## Contributors


**Oceanic and Atmospheric Research (OAR)**

Ghassan Alaka, AOML
Lisa Bengtsson, PSL
Elizabeth Berg, AOML (Knauss Marine Policy Fellow)
Ligia Bernardet, GSL
Patrick Burke, NSSL
Ken Fenton, GSL
Sundararaman Gopalakrishnan, AOML
Lucas Harris, GFDL
Annette Hollingshead, AOML
Matthew Mahalik, GSL
Aaron Pratt, WPO
Andrea Ray, PSL
Isha Renta, WPO
Mark Rowe, GLERL
Zach Tolby, GSL
Castle Williamsberg, WPO

**National Marine Fisheries Service (NMFS)**

Peter Chase, NEFSC
M. Conor McManus, NEFSC
Jay Peterson, OST and NMFS LOTM

**National Ocean Service (NOS)**

Michael Card, OCS
Lonnie Gonsalves, NCCOS and NOS LOTM
Alexandria Hounshell, NCCOS
Yizhen Li, NCCOS
Felix Martinez, NCCOS
David Scheurer, NCCOS
Kari St.Laurent, NCCOS
Richard Stumpf, NCCOS

**National Weather Service (NWS)**

Patrick Ayd, Bismark WFO
Eric Guillot, AFSO
Kirstin Harnos, WPC
Israel Jirak, SPC
Nicole Kurkowski, OSTI and NWS LOTM
Michael Muccilli, AFSO
Aaron Poyer, OSTI
Wendy Sellers, OSTI
John Stoppkotte, Denver WFO
Vijay Tallapragada, EMC

**Office of Marine and Aviation Operations (OMAO)**

Joshua Bergeron, UxSOC
Ashley Hann, UxSOC
Lisa Nakamura, UxSOC and OMAO LOTM
Natalia Uribe-Castañeda, UxSOC (Knauss Marine Policy Fellow)

**National Environmental Satellite, Data, and Information Service (NESDIS)**

Michael Pavolonis, STAR
Walter Wolf, OCS and NESDIS LOTM

**Cooperative Institute for Research in Environmental Sciences (CIRES)**

Dana Tobin, University of Colorado, Boulder
Samuel Trahan, University of Colorado, Boulder

**Cooperative Institute for Severe and High-Impact Weather Research and Operations (CIWRO)**

Montgomery Flora, University of Oklahoma


## LOTMC Transition Report Working Group Members


Abigail Arnold, WPO, OAR
Eric Bayler, STAR, NESDIS (Retired)
Karin Bucht, OSS, OAR
Paul DiGiacomo, STAR, NESDIS
Josie Galloway, NCCOS, NOS
Lonnie Gonsalves, NCCOS and LOTM, NOS
Annette Hollingshead, AOML, OAR
Nicole Kurkowski, OSTI and LOTM, NWS
Meka Laster, OSS, OAR (Retired)
Hanna Odahara, AOML, OAR (Knauss Marine Policy Fellow)
Jay Peterson, OST and LOTM, NMFS
Wendy Sellers, OSTI, NWS
Peter Stone, CO-OPS, NOS

# Contents

# Introduction

Transitioning research and development (R&D) to operations (R2O), commercialization (R2C), applications (R2A), and other uses, all of which are collectively known as R2X, is a cornerstone of the National Oceanic and Atmospheric Administration's (NOAA's) ability to fulfill its mission of understanding and predicting changes in climate, weather, oceans, and coasts, and sharing that knowledge with others to inform decisions and safeguard lives and property. By accelerating the transition of scientific discoveries and technological innovations into use, NOAA ensures that cutting-edge research directly benefits the public through improved forecasts, more efficient and cost-effective coastal surveys, and improved fisheries stock assessments, among other applications. This seamless and iterative pipeline from research to operational use enhances the accuracy, timeliness, and relevance of NOAA's services across sectors. As underscored by the NOAA Administrative Order (NAO) Policy on R&D Transitions (NAO 216-105B), strengthening the R2X process is essential for maximizing the impact of federal research investments and maintaining U.S. leadership in earth system science.

This report is focused on research projects that *transitioned* or met their *intended end-use* during Fiscal Year (FY) 2024. This includes projects that have gone from Readiness Level (RL) 8 to 9, or others that have been marked as completed or transitioned, even at lower RLs. This report highlights a selection of impactful, transitioned projects, focusing on their relevance, service impact, and improvements. Finally, this report provides an overview of transition project data including the total number of transition projects, end user information, and transition type.

# The Case for Tracking Research Transitions

In April 2020, the NOAA Science Council directed the NOAA Line Office Transition Managers Committee (LOTMC) to provide quarterly updates on research projects that had transitioned to their intended use. The LOTMC is a standing committee of the Science Council focused on improving the effectiveness of NOAA's transitions of research into use, on which the outcomes of NOAA's Strategic Goals critically depend. The committee is made up of Line Office Transition Managers (LOTMs) from each of the NOAA line offices.

In FY23 Q2, the LOTMC recommended changing the cadence of reporting on transitions from quarterly to annually, with an emphasis on efficient data collection and showcasing the impact of research transitions through illustrative examples of successful projects. Quarterly reports were paused after FY23 Q1, and an annual reporting procedure was developed. In February 2025, the NOAA Science Council approved the new annual reporting procedure, which has been implemented for this FY24 Annual Transition Report.

# Fiscal Year 2024 Results (October 1, 2023–September 30, 2024)

There were 231 transitions identified in the FY24 Annual Transition Report Spreadsheet. Summary charts of these projects by NOAA line office, transition type, and end user/adopter type are displayed below.

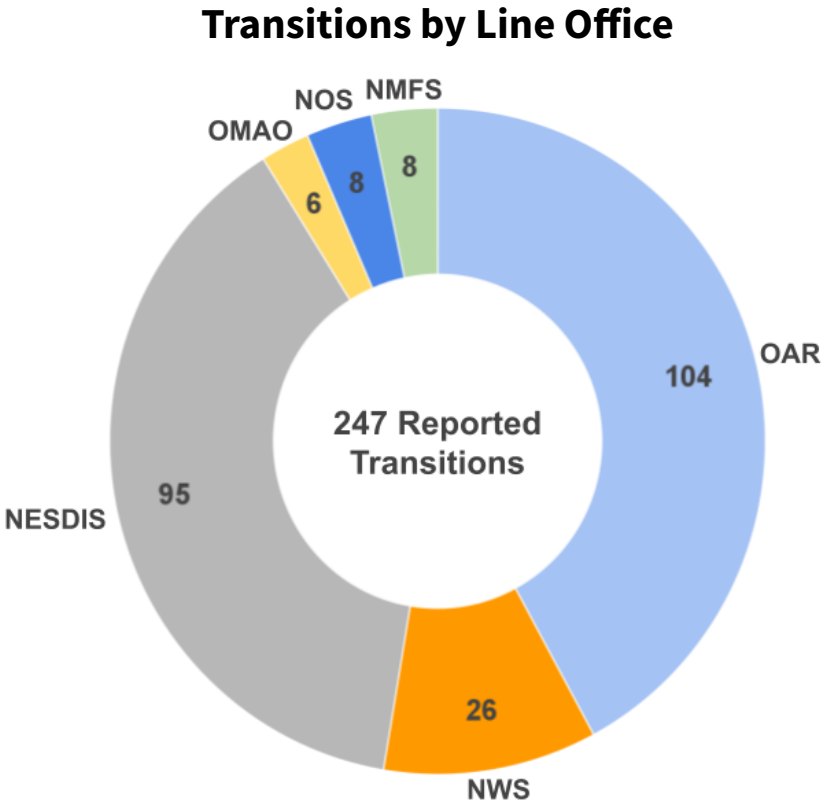



**Figure 1:** Total number of FY24 transitions as reported to the LOTMC by each line office.

- **247 transitions were reported in FY24.**
- 231* unique transitions were identified across all six line offices.

* The total of "Transitions by Line Office" is greater than the number of unique projects because some projects were reported multiple times–14 projects were reported by two line offices, and one project was reported by three line offices. It is common for multiple line offices to collaborate on R&D; therefore, multiple line offices can report on the same project (e.g., NOAA Research Pacific Marine Environmental Laboratory (PMEL) collaborated with the OMAO Uncrewed Systems Operations Center (UxSOC) on the transition of the Oculus glider into operations for NOAA ecosystem research, and both reported on that project).

## Type of Transition

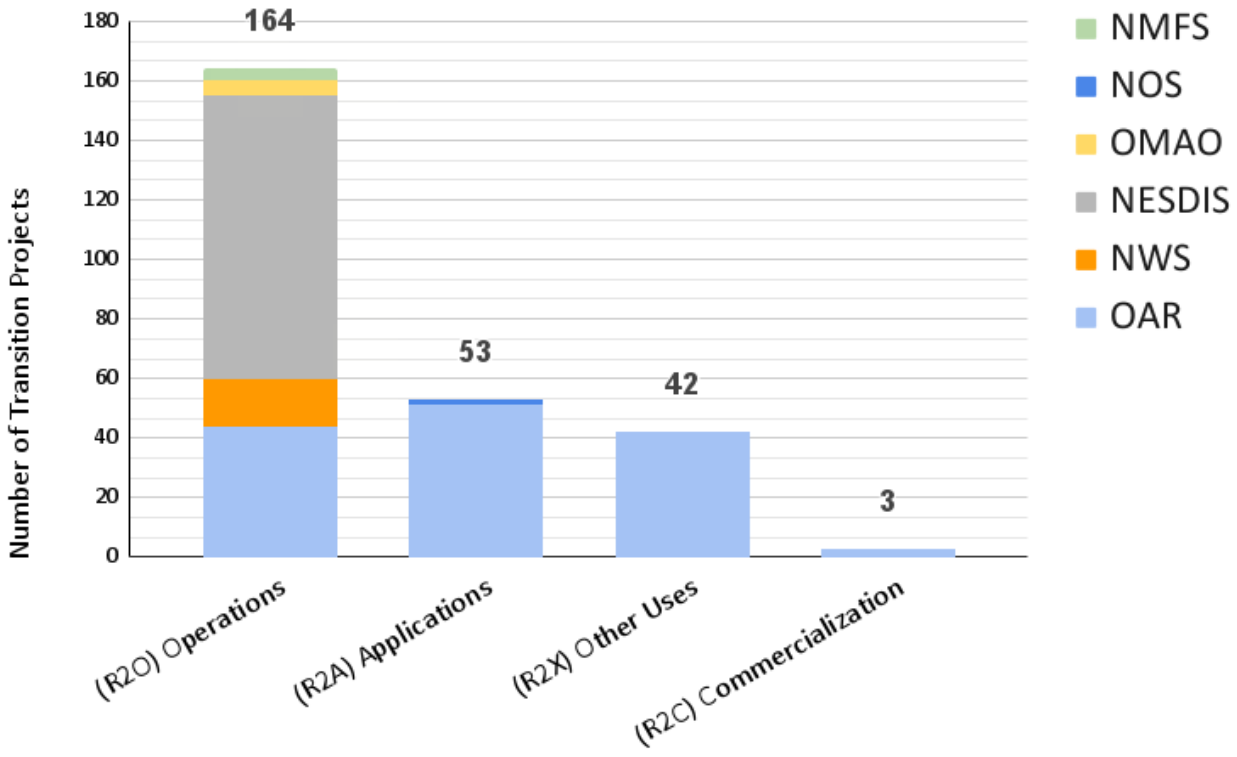



**Figure 2:** Number of transitions during FY24, as reported by type (R2O, R2A, R2C, R2X) to the LOTMC.

- 262[†] total transitions are displayed above by transition type:
  - 164 Research to Operations (R2O) projects from all six line offices
    - Operations - NOAA R&D that provides sustained and reliable mission activities to deliver products & services
  - 53 Research to Applications (R2A) from two line offices (OAR & NOS)
    - Applications - The use of a NOAA R&D output as a system, process, product, service, knowledge transfer, or tool
  - 42 Research to Other Uses (R2X) from two line offices (OAR & NWS)
    - Other Uses - Government policies, regulations, synthesis of research, public education and outreach, or other intended use
  - 3 Research to Commercialization (R2C) from one line office (OAR)
    - Commercialization - The process of introducing a NOAA product or technology into the commercial market

[†] The total of "transition types" is higher than the total number of transitioned projects (231), as some projects reported being transitioned to two or three uses. For example, 20 projects transitioned to both applications (R2A) and other uses (R2X), and 14 projects transitioned to both operations (R2O) and other uses (R2X). Additionally, some projects did not report on the final "transition type."

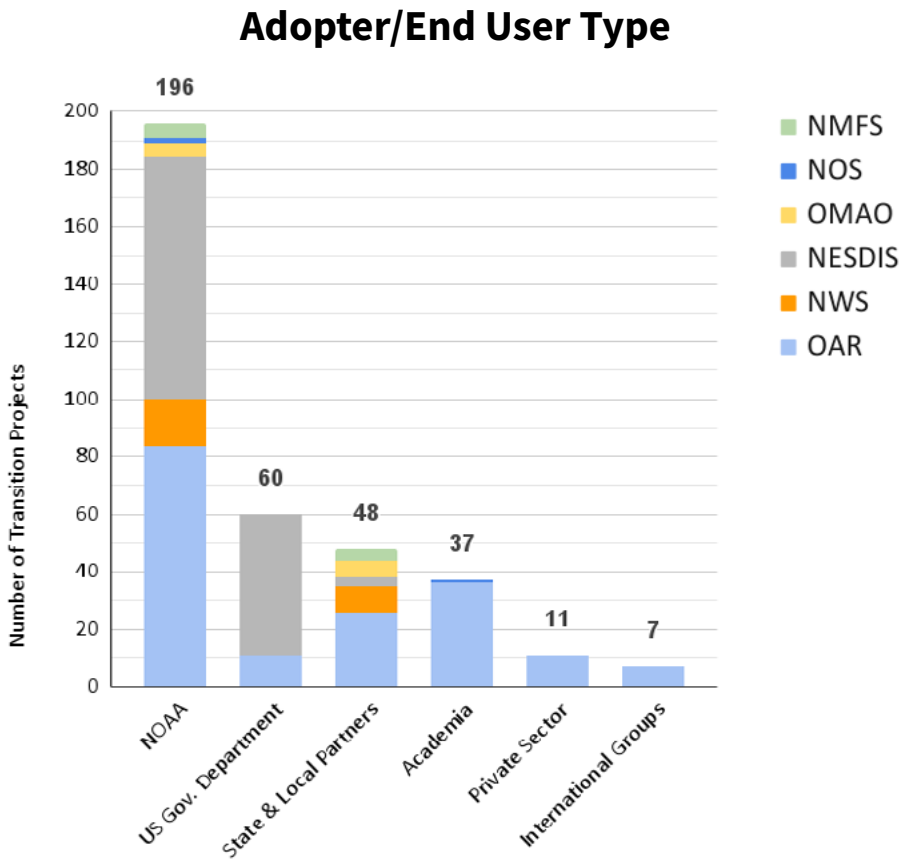



**Figure 3:** Number of transitions during FY24, sorted by end user or adopter category as reported by each line office to the LOTMC.

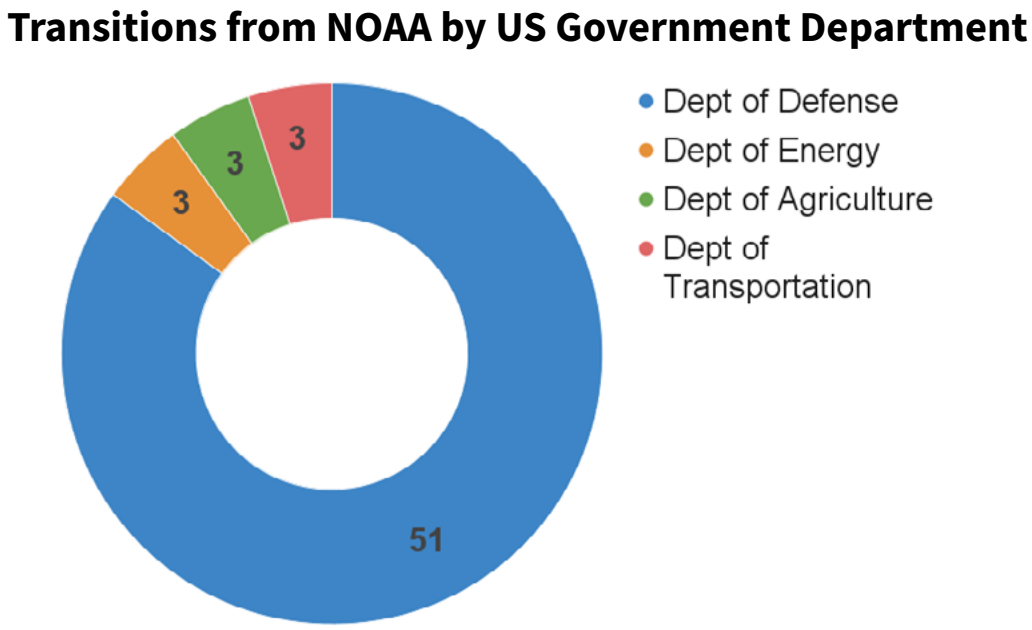



**Figure 4:** A breakdown of the US Government Departments that were reported to the LOTMC as end users or adopters, under the "US Government Department" category.

- 359‡ total transitions are displayed above by adopter/end user:

‡ The total number of "adopters/end users" is higher than the total number of transitioned projects (231), as at least 110 projects transitioned to multiple adopters/end users (e.g., 46 projects reported that end users include both the Department of Defense and NOAA).

- 196 transitions were adopted by internal NOAA end users
  - *Transitions to NOAA adopters/end users are also used by and benefit the general public, private sector users, and many others outside of NOAA. Examples of these transitions include, but are not limited to:*
    - Operational forecast products, satellite maintenance updates, fisheries stock assessments, numerical model software and code updates, new model releases, public website updates and launches, observational tools and methodology, annual reports, transfers of knowledge, upgraded radar products, and uncrewed systems developments.
  - Transitions with NOAA end users range from large operational products to incremental code updates. Ultimately, all transitions serve to advance NOAA's mission in service to society.
- 60 transitions were adopted by other US Government departments & agencies
- 48 transitions were adopted by state and local partners
- 37 transitions were adopted by academic partners
- 11 transitions were adopted by the private sector
- 7 transitions were adopted by international organizations, including, but not limited to:
  - Bahamas Aviation, Climate and Severe Weather Network (BACSWN)
  - European Meteorological Network (EUMETNET)
  - Taiwan Central Weather Administration
  - European Centre for Medium-Range Weather Forecasts (ECMWF)

# Transforming Research into Impact: Success Stories from Across NOAA

To fulfill its mission of understanding and predicting changes in the environment and communicating that knowledge to protect lives and property, NOAA continually invests in the transition of cutting-edge research into operational tools and technologies. In FY24, NOAA made significant strides across a wide array of domains—weather forecasting, marine resource management, coastal and inland hazards, and environmental monitoring—through the successful transition of high-impact research projects into real-world use. This report highlights seven such advancements, each demonstrating how scientific innovation, cross-disciplinary collaboration, and stakeholder engagement are accelerating NOAA's ability to deliver trusted, actionable information. From artificial intelligence-powered wildfire detection to next-generation hurricane forecasting models, autonomous ocean vehicles, and probabilistic winter storm tools, these efforts exemplify how NOAA's research-to-operations pipeline transforms emerging science into operational capabilities that support public safety, environmental stewardship, and economic resilience.

## Fire Weather Testbed


An end-of-day round table discussion following a 2024 evaluation exercise in the Fire Weather Testbed. Participants composed of state fire managers and NWS meteorologists, product developers, subject matter experts, and Testbed evaluators. Credit: NOAA/GSL

Early and rapid detection of fires, along with efficient communication between forecasters and emergency managers, can increase response rates and limit the potential spread of devastating wildfires. In June 2024, the Fire Weather Testbed (FWT) at NOAA's Global Systems Laboratory (GSL) became operational when it performed a comprehensive evaluation of the NOAA Next Generation Fire System (NGFS). Satellite-derived fire detection tools, such as the NGFS, have increased the ability to rapidly detect fires remotely, and the convergence of these capabilities with artificial intelligence, cross-discipline communication techniques, and the new FWT has transitioned a promising new system into operational demonstration.

Developed by NESDIS and the University of Wisconsin's Cooperative Institute for Meteorological Satellite Studies (CIMSS), the NGFS employs artificial intelligence to autonomously analyze satellite imagery from geostationary satellites, enabling the rapid identification of wildfires as small as one acre. This swift detection capability is crucial, particularly in remote or sparsely populated areas where early human detection is unlikely. The NGFS alerts forecasters and land managers through a comprehensive dashboard that includes satellite imagery, fire weather outlooks, and other critical data layers. In 2023, NWS forecast offices across the Southern Plains demonstrated the NGFS prototype's initial operational value by assessing NGFS alerts in real time to enhance wildfire monitoring and decision support. The NGFS significantly reduces response times, facilitating quicker containment efforts and potentially saving lives and property.

The FWT played a pivotal role in evaluating the NGFS by simulating real-world wildfire scenarios with participation from numerous partners, including NWS forecasters, state wildfire managers, land and resource managers, researchers, and social scientists. These simulations allowed for

direct assessment, evaluation, and recommendations for improvement to the NGFS's performance and its integration with the Integrated Warning Team paradigm, which enhances communication between meteorologists and land managers to issue timely fire warnings. Feedback from these exercises was overwhelmingly positive, highlighting the NGFS's potential to transform wildfire management by providing accurate, real-time information that supports rapid decision-making and coordinated response efforts. This also represents a significant milestone in the FWT itself. The evaluation of NGFS was the first comprehensive, end-to-end, in-person evaluation of a research-grade wildfire detection and response system. In the future, the FWT will continue to be available for testing and evaluating new fire weather tools, products, techniques, and systems to accelerate their readiness for operational use.

> **"Utilization of NGFS is serving to support increased situation awareness across both interagency and inter-disciplinary partners. This is proving to expedite response times in several cases while also providing real-time observation that guides resource mobilization, public communication and monitoring of fire movement and severity especially when the fire environment merits timely and accurate Fire Warnings.**
>
> - Drew Daily, Deputy Fire Management Chief, Oklahoma Department of Agriculture, Food and Forestry

The NGFS is available to NWS forecasters in an experimental setting and demonstrated its potential value in a recent outbreak of fires in Oklahoma in April 2025. The GOES satellite provided initial detection of 19 separate wildfires, facilitating early emergency response. Based on modeling what could have happened with slower response times, it is estimated that the NGFS saved more than $850 million worth of structures and property, an amount in this single outbreak more than 250 times the cost of developing the system, which was less than $3 million. NGFS, which has now been adopted for use by NOAA and is anticipated to be made operational in 2026, will undergo more evaluation and improvement before its full operational implementation.

The transition of NGFS to operational demonstration, coincident with the transition of the FWT into full use at GSL, represented a significant leap forward in automated wildfire early detection and response systems. In addition, the evaluation and iteration process established by the FWT can serve as a model for future evaluations that can further accelerate experimental tools into operations.

## Hurricane Analysis and Forecast System Version 2

Hurricanes are among the deadliest and most destructive natural disasters in the United States. According to NOAA scientists, there is a 60% chance that the 2025 hurricane season will be "above normal," meaning the United States could observe up to 19 named storms, including 3 to 5 major hurricanes (hurricanes that reach category 3 or above). Given the increased risk of loss of life and property, accurate hurricane forecasts are more important than ever.

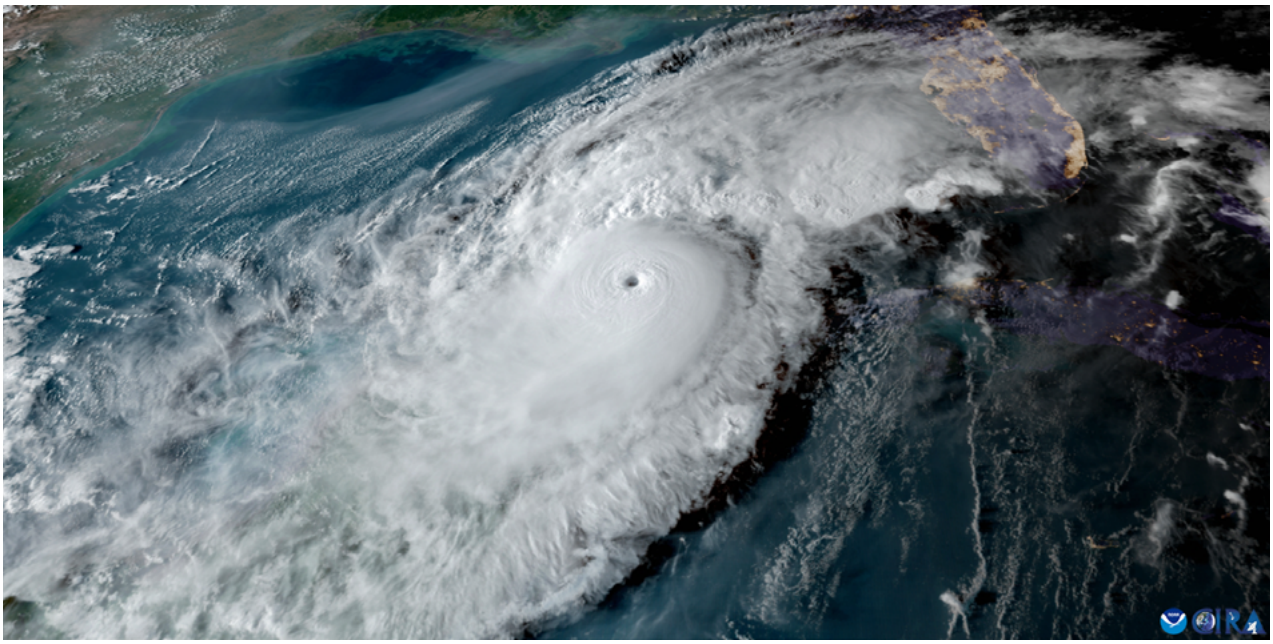


Image of Hurricane Milton from NOAA's GOES-16 satellite on Oct. 8, 2024. Credit: NOAA/NESDIS

During the 2024 hurricane season, scientists from across NOAA Oceanic and Atmospheric Research (OAR) and NWS, as well as the Cooperative Institute for Marine and Atmospheric Studies (CIMAS), collaborated to upgrade NOAA's newest hurricane forecast model, the Hurricane Analysis and Forecast System (HAFS), which resulted in 5-10% improvement in track and intensity forecast compared to the 2023 hurricane season, and roughly 50% improvement in wind and rapid intensification predictions compared to 2012. These improvements will contribute to protection of lives and property during the 2025 hurricane season and beyond.

> **NOAA and the National Weather Service are using the most advanced weather models and cutting-edge hurricane tracking systems to provide Americans with real-time storm forecasts and warnings. With these models and forecasting tools, we have never been more prepared for hurricane season.**
>
> - Howard Lutnick, Secretary of Commerce

HAFS is a Numerical Weather Prediction (NWP) model and Data Assimilation (DA) system within the NOAA Unified Forecast System (UFS) that allows forecasters to better understand and predict a hurricane's intensity and path, and enables these predictions at an earlier stage of the storm's formation–up to seven days in advance. After five years of development, demonstration, and testing, the National Hurricane Center (NHC) used the HAFS in an operational forecast for the first time in June 2023. OAR continued to update HAFS over the next year, promptly releasing an upgrade called HAFS Version 2 (HAFSv2) which became operational in July 2024, leading to these significant forecast improvements.

OAR and NWS continuously improve and update HAFS throughout each hurricane season, setting a new paradigm for research to operations that is continuous and iterative. Scientists often run 5-8 beta versions of the model throughout the season to test how various upgrades perform, with new upgrades becoming operational at NHC every year. Spearheaded by the Environmental Modeling Center (EMC), in preparation for HAFSv2 becoming operational in FY24, the NOAA Hurricane Improvement Project (HFIP) developed the Hurricane Ensembles in Real-time on the Cloud (HERC) project. HFIP partnered with Amazon Web Services (AWS) to run an ensemble (multiple versions) of NOAA's state-of-the-art HAFS model in real-time on the cloud. This ensemble, consisting of 21 versions of the model, provided valuable information to NOAA forecasters and also paved the way for future cloud computing projects at NOAA.

Four laboratories under the umbrella of OAR—the Atlantic Oceanographic and Meteorological Laboratory (AOML), the Geophysical Fluid Dynamics Laboratory (GFDL), the Physical Sciences Laboratory (PSL), and GSL—each played important and complementary roles in developing HAFSv2. AOML led much of the research and development behind HAFS through its Hurricane Research Division and strong leadership role in HFIP. AOML supports real-time testing, model upgrades, and operational transitions in close coordination with the NWS EMC. It also runs multiple experimental HAFS versions each season and developed the AOML Hurricane Model Viewer, which helps researchers and forecasters evaluate model performance during active storms. GFDL contributed the FV3 dynamical core—the engine of the model—and the MOM6 ocean model, enabling HAFS to realistically simulate storm behavior, including how hurricanes stir up cold water from the deep ocean. The MOM6 ocean model, FV3 dynamical core, and the UFS Weather Model include many components from the broader academic research community.

> **"As we witnessed last year with significant inland flooding from hurricanes Helene and Debby, the impacts of hurricanes can reach far beyond coastal communities. NOAA is critical for the delivery of early and accurate forecasts and warnings, and provides the scientific expertise needed to save lives and property.**
>
> - Laura Grimm, Chief of Staff, Performing the Duties of Under Secretary of Commerce for Oceans and Atmosphere and NOAA Administrator

GFDL also provides widely used tools like the Vortex Tracker and documents how HAFS has improved forecast accuracy. PSL enhanced the model's ability to simulate cumulus convection—small-scale rising air that forms clouds and storms—by implementing a new technique called prognostic closure, which makes the model more responsive to real-world moisture patterns. This improved the accuracy of hurricane track and intensity forecasts. Lastly, GSL conducted extensive model testing and evaluation through the Developmental Testbed Center. GSL compared different physics configurations, including those used in other operational models like Rapid Refresh (RAP) and High Resolution Rapid Refresh (HRRR), to help fine-tune HAFSv2's physical parameterizations. Together, these labs made HAFSv2 a more powerful, accurate, and operationally ready system for forecasting hurricanes.

HAFSv2 improved hurricane model accuracy and guidance for NHC forecasters, leading to more informed community preparedness strategies, including the minimization of property damage and loss of life. The earlier warning times provided by HAFSv2 provided increased accuracy at earlier stages of the storm, providing longer lead times for hurricane warnings, and more time for communities to prepare.

Building on ongoing research and development efforts across OAR and EMC, further improvements in hurricane forecast skill are anticipated, with significant advancements targeted for implementation in 2025 and 2026. This important model update also addressed key objectives outlined in the 2017 Weather Research and Forecasting Innovation Act and HFIP Strategic Plan to improve hurricane forecasting.

## DriX Uncrewed Surface Vehicle for Hydrographic Survey Efficiency

The DriX departs on its mission to collect ocean data while the ship that deployed it continues to work alongside. Credit: NOAA/UxS Operations Center

The U.S. Exclusive Economic Zone (EEZ), among the largest in the world, spans approximately 4.2 million square miles of ocean and supports a maritime economy valued at over $373 billion annually, encompassing fisheries, energy, shipping, and recreation. Realizing the full value of this area requires accurate nautical charts. However, its size creates significant difficulty in surveying the U.S. EEZ for production of up-to-date charts.

In 2023, NOAA transitioned the DriX uncrewed surface vehicle (USV) into operational use for hydrographic surveys, marking a significant advancement in seafloor mapping technology. In 2024 and again in 2025, the DriX has been integrated into NOAA's hydrographic survey missions and is being actively deployed alongside NOAA Ship *Thomas Jefferson* to perform hydrographic surveys on the Atlantic Coast. Equipped with high-resolution sonar, the DriX can operate with supervised autonomy for up to 48 hours, collecting detailed seafloor data essential for updating nautical charts and enhancing maritime navigation safety. During the 2024 Approaches to Savannah surveys, the DriX's ability to cover approximately 230 nautical miles per deployment nearly doubled the

survey capacity compared to traditional crewed small boats. In doing so, the DriX can serve as a force multiplier to NOAA's crewed hydrographic surveys – a safer and more efficient means of hydrographic data collection.

Further expanding its capabilities, NOAA initiated the 2024 Dual DriX Project, deploying two DriX USVs simultaneously in the Gulf of Maine. This month-long mission, operated remotely from the University of New Hampshire, tested the feasibility of remote, shore-based control of multiple uncrewed vehicles for seafloor mapping. The dual operation aimed to increase survey efficiency, reduce operational costs, and minimize environmental impact, all while improving the quality and quantity of hydrographic data collected. In this operating model, the DriX are able to take the place of a crewed ship in performing hydrographic surveys.

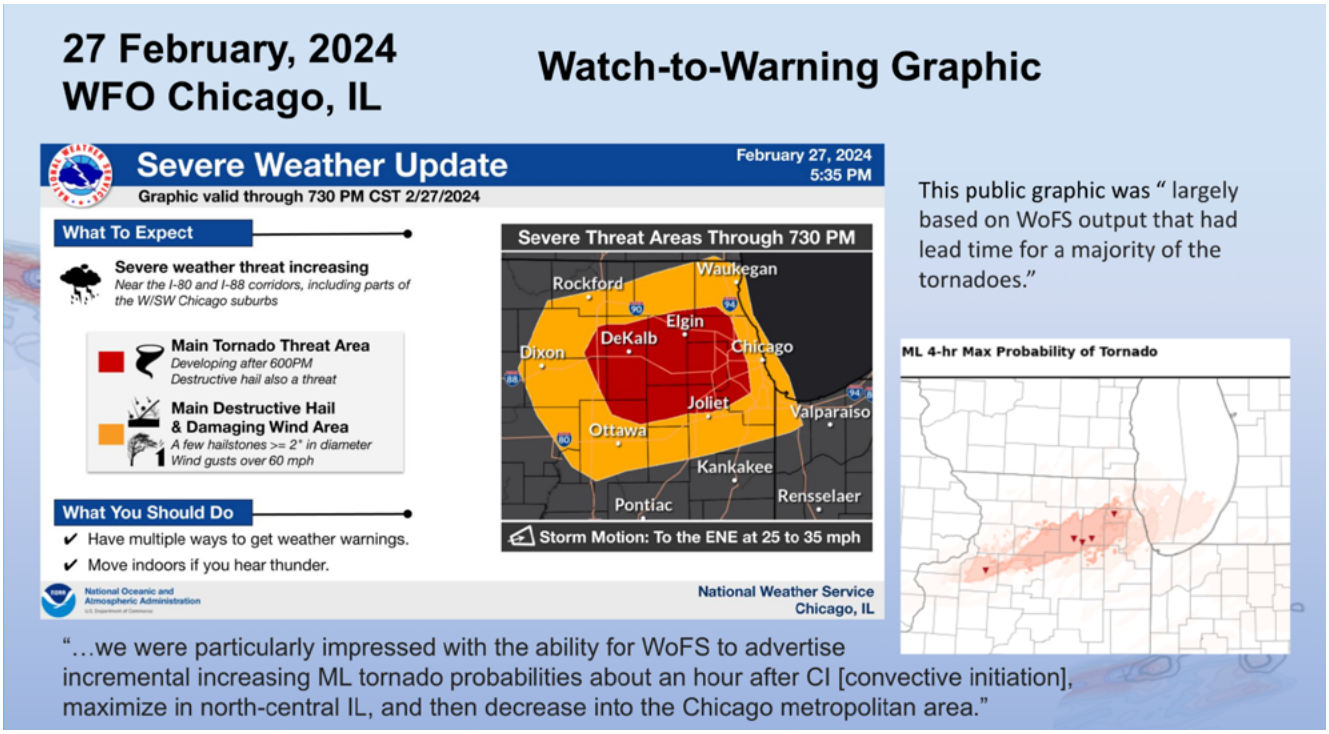
These advancements align with NOAA's mission to enhance maritime safety and support economic activities by ensuring accurate and up-to-date nautical charts. Lessons learned from these efforts will inform NOAA's integration of USVs into the Agency's Class B ships currently under construction.

## Warn-on-Forecast System Machine Learning Severe Weather Probability

In 2024, the United States experienced 17 billion-dollar weather disasters tied to severe thunderstorms, resulting in nearly $47 billion in damages. When these high-impact storms threaten lives and property, every minute counts. Improving warning lead time is critical to saving lives, reducing property loss, and safeguarding the economy. To address this need, researchers at NOAA's National Severe Storms Laboratory (NSSL) and the Cooperative Institute for Severe and High-Impact Weather Research and Operations (CIWRO) developed and demonstrated a groundbreaking new forecasting tool: the Warn-on-Forecast System Machine Learning Severe Weather Probability Suite (WoFS ML Severe).

WoFS ML Severe is built on the foundation of the Warn-on-Forecast System (WoFS)—an experimental, rapidly updating, storm-scale model that provides probabilistic forecasts of thunderstorms and their hazards. The new ML-based suite goes a step further by using machine learning to analyze WoFS output and generate skillful forecasts of individual hazards like large hail, damaging winds, and tornadoes. These forecasts are visualized through intuitive graphics that display hazard probabilities at lead times up to four hours, helping forecasters make faster, more confident decisions. Key products include a "Significant Severe" tool that identifies the risk of especially dangerous conditions such as EF-2+ tornadoes, 75 mph winds, or hail greater than two inches in diameter. The hail product even includes predictions of size, giving forecasters more precise insight into what communities might face.

Developed at NSSL and CIWRO, with support from OAR, including the Weather Program Office (WPO) and the Joint Technology Transfer Initiative (JTTI), the WoFS ML Severe suite was transitioned to a demonstrated operational capability in 2024. It has already proven its value: during a February 2024 outbreak, the NWS Weather Forecast Office (WFO) Chicago used the product suite to issue timely, high-confidence public messaging ahead of the storms.




A severe weather update issued on social media by NWS WFO Chicago ahead of a tornado outbreak in February 2024, which was supported by guidance from the WoFS ML Severe graphical output showing 4-hour maximum probability of a tornado in the region. Credit: NOAA/NSSL

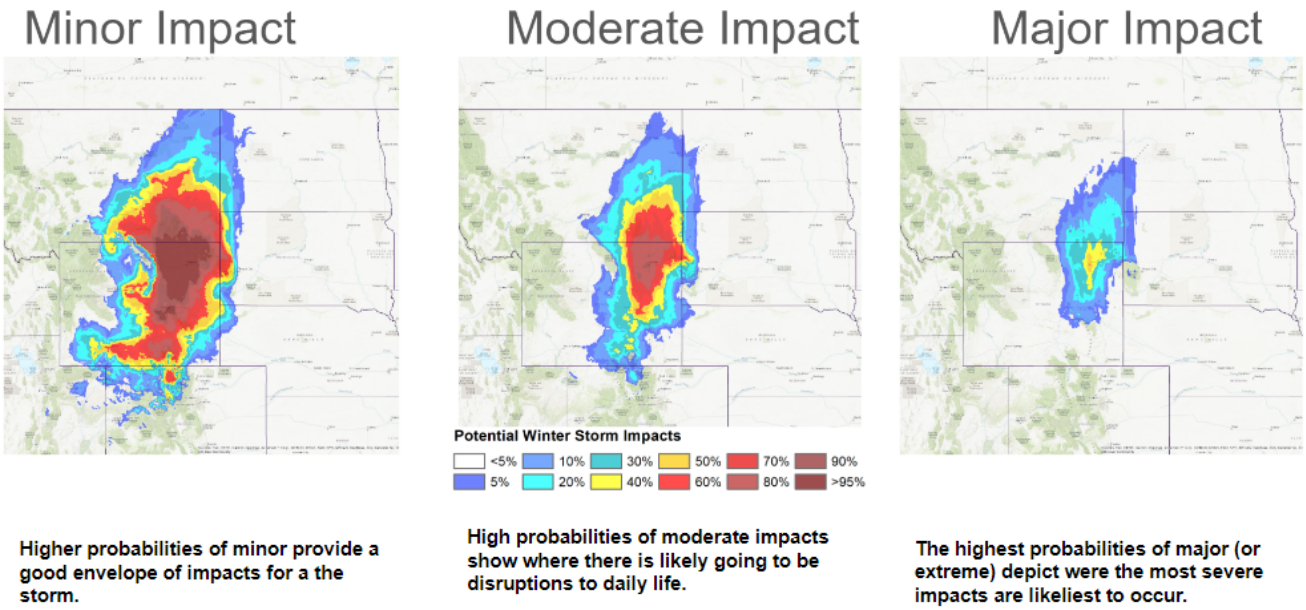
What sets this project apart is not just the technical innovation, but also the thoughtful integration of forecaster feedback and social science. Early efforts to explain how the machine learning models work helped build user trust in the tool, while refinements to how risk areas are displayed improved clarity for both forecasters and the public. These lessons will guide future efforts to integrate advanced research into real-time forecasting.

The WoFS ML Severe suite is a baseline component of WoFS, meaning it will transition to NWS operations along with the modeling system. A landmark achievement for NOAA, this component transforms complex machine learning outputs into practical tools that empower NWS forecasters to issue earlier and more accurate warnings for high-impact weather events. As already demonstrated by NWS Chicago, the WoFS ML Severe suite will pave a clear path for forecasters' preparedness when issuing short-term (0-6 hr) actionable guidance for severe weather, thereby reducing thunderstorm-related fatalities and mitigating impacts on property and the economy.

## Probabilistic Winter Storm Severity Index

Every year, winter storms pose significant threats across the United States; in 2024, winter weather disasters caused $3.6 billion in damages, with two billion-dollar events driving the majority of losses. The Winter Storm Severity Index (WSSI) provides NWS partners and the general public with a forecast designed to succinctly communicate the severity and spatial distribution of potential winter weather impacts. To complement the WSSI, in December 2023 the *Probabilistic* Winter Storm Severity Index (WSSI-P) became operational, transforming how the National Weather Service communicates winter storm risks. While the WSSI is a deterministic 3-day outlook of expected winter storm impacts, the WSSI-P provides a longer 7-day ensemble-based outlook that addresses variability in a winter storm forecast. Probabilistic forecasts, including those from the

WSSI-P, help partners and the public understand uncertainty in a forecast. For example, when snow or ice forecasts may vary, a forecast displaying probabilistic outlooks for most-likely and worst case scenarios will help decision makers make more informed decisions when winter storms are possible.




Examples of the WSSI-P graphical output of minor, moderate, and major impacts from a winter storm projected in Wyoming, Montana, and the Dakotas. Credit: NOAA/NWS Analyze, Forecast, and Support Office

The WSSI-P was developed by the NWS Weather Prediction Center (WPC) using requirements from the field/partners/public gathered by the NWS Analyze, Forecast and Support Office (AFSO), and is now operational and available to the public at www.weather.gov/wssi-p. WSSI-P forecasts are created by using the Probabilistic Winter Precipitation Forecast (PWPF) gridded information from the WPC for snow and ice and combining it with non-meteorological or static information datasets (e.g., land-use, urban areas, foliage). The output is a graphical depiction of the likelihood of potential societal impacts due to expected winter hazards using the following categories: “Minor,” “Moderate,” “Major,” and “Extreme.” It can be used in conjunction with the deterministic WSSI to get expected, low end, and high end scenarios.

> **“This is among the first NWS probabilistic impact prediction products – powering the NWS towards our probabilistic IDSS vision.**
>
> - Dr. David Novak, Director, Weather Prediction Center

As one of the first NWS probabilistic impact products, the WSSI-P experienced a relatively seamless transition into operations. For example, a key challenge of probabilistic forecast tools is the need for forecasters to understand effective interpretation and communication of outlooks to best support partners and the public. To address this challenge, initial risk-communication work from the original WSSI was leveraged and applied to the probabilistic version, ultimately streamlining transition for the WSSI-P. Further, a training module was developed by the NWS Office of the Chief

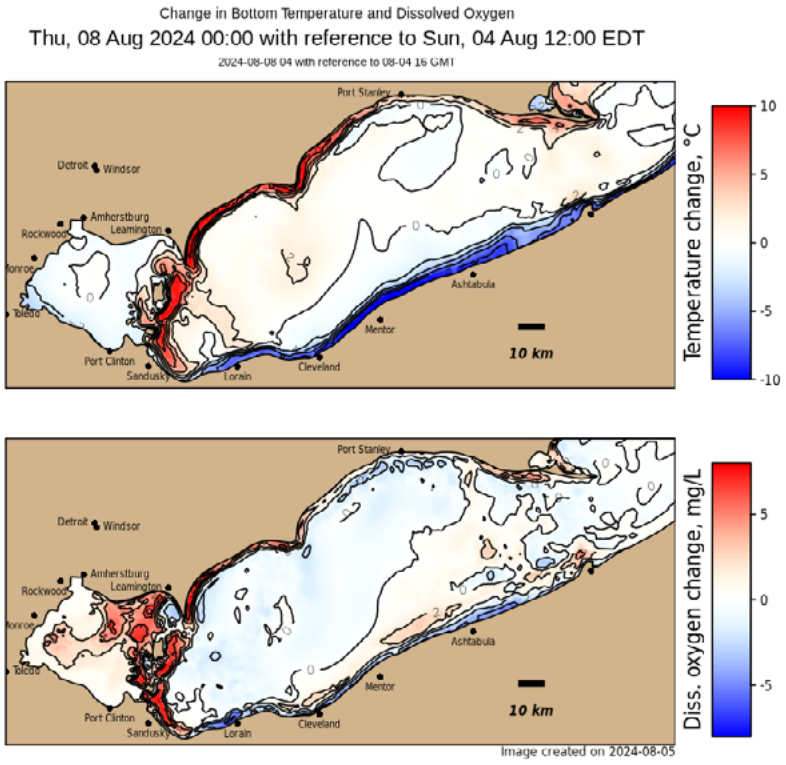
Learning Officer (OCLO) and added into the Winter Warning Operations training course for NWS forecasters.

The NWS will continue to provide yearly science updates to maintain the WSSI-P, ultimately supplying another tool for emergency managers, public officials, and other stakeholders to in planning responses, allocating resources, and reducing risks effectively, which will in turn help protect life and property and enhance the national economy.

## Lake Erie Hypoxia Forecast

Lake Erie, the shallowest and warmest of the Great Lakes, is particularly vulnerable to hypoxia—conditions of dangerously low dissolved oxygen levels in bottom waters. These low-oxygen zones, which typically develop in late summer, can disrupt municipal drinking water depended upon by over 2 million people across the U.S. and cause large-scale fish kills which disrupt fishing and tourism.

To better prepare for and respond to these threats, NOAA's Great Lakes Environmental Research Laboratory (GLERL) and Cooperative Institute for Great Lakes Research (CIGLR) developed the Lake Erie Hypoxia Forecast, a cutting-edge tool that uses a hydrodynamic model and real-time weather forecast data to predict the location and movement of low oxygen bottom water up to five days in advance. In 2024, the Hypoxia Forecast transitioned into operations in the National Centers for Coastal Ocean Science (NCCOS). This is the first time NOAA developed a hypoxia product which transitioned into operational use for societal benefit, and this transition will pave the way for future experimental products to become operational.




The Lake Erie Hypoxia Forecast model, displaying change in bottom temperature and dissolved oxygen, initialized on August 5th, 2024 and projecting changes through August 8th, 2024. This forecast preceded some of the highest manganese levels ever seen at the Cleveland Water intake facility on August 14th, 2024. Credit: NOAA/NCCOS

When hypoxic water upwells near the coast, it affects drinking water treatment processes and threatens aquatic organisms that depend on well-oxygenated habitats. The forecast provides early warnings that allow plant operators to adjust their treatment protocols, reducing risks to human health and ensuring more reliable water delivery. On August 14, 2024, Cleveland Water saw perhaps the highest manganese levels ever seen at their water intake facility. Hypoxia causes an increase in manganese in Lake Erie, which can harm human health if consumed. Cleveland Water plant operators were able to adjust their water treatment practices to remove excess manganese thanks to this Hypoxia Forecast.

> **“We saw elevated manganese beginning in the wee hours of Friday morning. Operators were ready and successfully adjusted treatment. Definitely a successful forecast.**
>
> - Maggie Rodgers, Manager of Plant Operations, Cleveland Water

Hypoxic water in Lake Erie also causes harm to fish populations, making fishing and fisheries research more difficult. Commercial fishers use the Hypoxia Forecast to decide where to place their trap nets in Lake Erie. Without this product, fishers risk placing their trap net in a hypoxic area, meaning fish would die in the net and therefore become unfit for human consumption. The Ohio Division of Wildlife uses the Hypoxia Forecast to conduct more efficient fisheries research. The Hypoxia Forecast can be used to confirm whether a fish kill was caused by a hypoxic event, or if another cause should be identified and investigated. Additionally, it is essential for the Ohio Division of Wildlife to conduct fisheries stock assessments–to gauge fish population sizes–when Lake Erie is stratified, as well as after Lake Erie is stratified, in order to paint an accurate picture of the fish populations.

> **“We are at the point in the season that we are consulting the model on a sub-daily basis. We have completed our ‘stratified’ bottom trawl survey for the season, and are using the model as an indication of when lake turnover has occurred. We will begin our ‘post-stratified’ survey once turnover is complete. If we delay, the weather becomes more difficult for sampling. Also, fish continue to grow, so biological metrics become less comparable with the historic time series.**
>
> - Ann Marie Gorman, Fairport Fish Research Station, Ohio

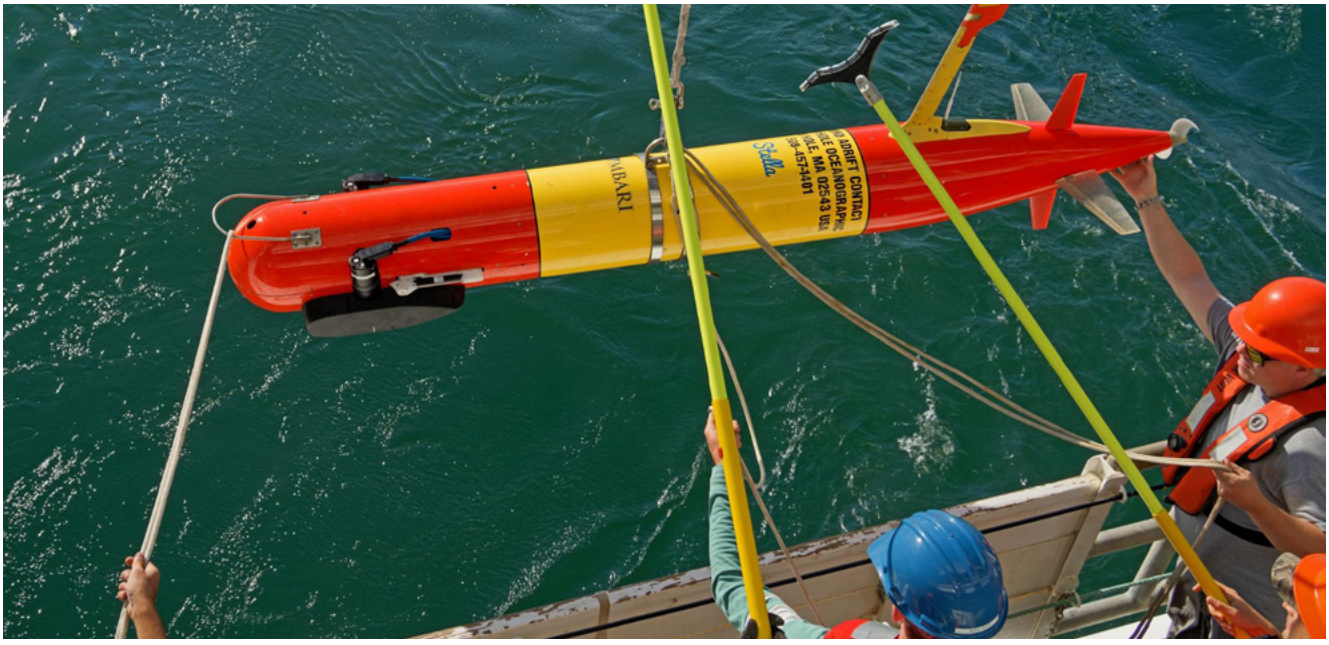
Many complex steps were involved in the transition of the Hypoxia Forecast to operations: securing funding to understand the problem and develop forecast components; establishing stakeholder relationships to rigorously assess product benefits; developing the business case and transition

plan to secure leadership support to support long-term operations; running parallel forecasts during the transition to ensure system integrity; and developing an operational concept for future improvements based on stakeholder input. The operational Hypoxia Forecast is updated daily during hypoxia season and designed to support water utility managers, public health officials, and fisheries stakeholders.

The hypoxia forecast builds on years of collaborative research by GLERL, CIGLR, and other academic institutions. From 2016–2021, researchers conducted field campaigns to collect data on temperature, oxygen levels, and circulation patterns in Lake Erie. This information has been used to develop and validate numerical models that simulate how hypoxia forms and shifts within the lake. At the conclusion of the research project, an additional two-year transition project was conducted to fund the transition of the experimental forecast at GLERL into an operational forecast at NCCOS. This ensured a seamless continuity of service to public water systems and fisheries managers while transitioning from an experimental research setting to sustained operations at NCCOS.

Given the myriad impacts caused by hypoxic waters in Lake Erie, the operational Hypoxia Forecast will provide sustained, timely, and spatially precise information that will remain critical to communities that depend on this resource.

## Long-Range Autonomous Underwater Vehicle for Scallop Surveys




NMFS Northeast Fisheries Science Center researchers and partners deploy a long-range autonomous underwater vehicle, also known as “Stella,” during a scallop survey. Credit: Dvora Hart

The Atlantic sea scallop fishery reported $467 million in landings in 2022, placing it as one of the nation’s most valuable single-species fisheries. Surveying the scallop population is critical for sustainably managing the fishery, but it is labor intensive and challenging based on their patchy and wide distribution. Additionally, offshore marine development within the Northeast U.S. Continental Shelf poses significant challenges for operating NOAA Fisheries surveys, including those for sea scallops, and requires developing additional methods to maintain data collection within these areas for stock assessments that inform fisheries management.

In 2024, NOAA Fisheries enhanced its long-standing Atlantic sea scallop survey by integrating a Tethys-class long-range autonomous underwater vehicle (LRAUV), also known as "Stella", into its survey research efforts. Developed collaboratively by the Northeast Fisheries Science Center (NEFSC) and the Woods Hole Oceanographic Institution, a stereo-imaging camera payload was developed and integrated with the LRAUV to replicate the towed HabCam system which has been in use for decades. Unlike HabCam, LRAUVs operate untethered and autonomously. Equipping these autonomous underwater vehicles with the camera payload allows them to navigate and collect high-resolution seafloor imagery without vessel support. This capability is particularly valuable in areas where traditional survey methods are challenging, such as regions where large vessels cannot easily operate. By deploying LRAUVs, NOAA aims to maintain comprehensive data collection in these evolving marine environments, ensuring the continuity and accuracy of stock assessments for the sea scallop fishery.

> **"The development of LRAUV has taken several years and a number of partners. The intent all along has been to develop a vehicle that can conduct our scallop survey autonomously. It is exciting to see the technology meeting this clear need and to think about how this technology can be used to further improve our science in support of the sea scallop fishery.**
>
> - Dr. Jon Hare, Director, Northeast Fisheries Science Center

The LRAUV-camera development and transition process took several years. During this time, the initial technology of the LRAUV was developed and demonstrated and then paired with the stereo imaging system. To ensure that the data from the LRAUV, HabCam, and other surveying methods are intercomparable, NEFSC plans to run the LRAUV as part of their survey efforts to continue gathering data for stock assessment purposes and better compare autonomous versus ship-based sea scallop estimates.

The development, transition, and ultimate integration of the LRAUV into the survey program addresses several challenges faced by NOAA. Their autonomous operation reduces reliance on large vessels, potentially reducing costs and increasing efficiency while mitigating risks associated with vessel availability, adverse weather conditions, and access to certain areas. Accurate stock assessments are essential for understanding the Atlantic sea scallop population and supporting its fishery. Future work will continue to expand the use of LRAUVs, especially as a survey mitigation tool for other NOAA Fisheries surveys, and comparing abundance estimates across different survey methodologies. The enhanced survey capabilities provided by an LRAUV contribute to NOAA's mission of conserving and managing marine resources effectively, ensuring the long-term viability of this important fishery.

# Conclusion

This FY24 Annual Transition Report underscores the critical role of R&D transitions in enabling NOAA to deliver on its mission of understanding and predicting changes in climate, weather, oceans, and coasts, and sharing that knowledge with others to inform decisions and safeguard lives and property. The seven stories highlighted herein, accompanied by more than 200 additional transitions across NOAA, demonstrate how cutting-edge research, when effectively moved to operations, applications, commercialization, and other uses, translates into tangible benefits for the nation, the public, and the economy.

Moving forward, the LOTMC is committed to refining the annual reporting process in the wake of the NOAA Research & Development Database (NRDD) sunset to ensure continued efficient and accurate tracking of transitioned projects across line offices. This refinement will be integral to preparing for the FY25 Annual Transition Report, which will further showcase NOAA's ongoing commitment to maximizing the impact of its scientific investments.

# Appendix A: Acronyms

| | |
|---|---|
| **AFSO** | Analyze, Forecast and Support Office |
| **AOML** | Atlantic Oceanographic and Meteorological Laboratory |
| **BACSWN** | Bahamas Aviation, Climate and Severe Weather Network |
| **CIGLR** | Cooperative Institute for Great Lakes Research |
| **CIMAS** | Cooperative Institute for Marine and Atmospheric Studies |
| **CIMMS** | Cooperative Institute for Meteorological Satellite Studies |
| **CIRES** | Cooperative Institute for Research in Environmental Sciences |
| **CIWRO** | Cooperative Institute for Severe and High-Impact Weather Research and Operations |
| **CO-OPS** | Center for Operational Oceanographic Products and Services |
| **DA** | Data Assimilation |
| **ECMWF** | European Centre for Medium-Range Weather Forecasts |
| **EEZ** | Exclusive Economic Zone |
| **EMC** | Environmental Modeling Center |
| **EUMETNET** | European Meteorological Network |
| **FV3** | Finite-Volume Cubed-Sphere |
| **FY** | Fiscal Year |
| **FWT** | Fire Weather Testbed |
| **GFDL** | Geophysical Fluid Dynamics Laboratory |
| **GLERL** | Great Lakes Environmental Laboratory |
| **GOES** | Geostationary Operational Environmental Satellite |
| **GSL** | Global Systems Laboratory |
| **HAFS** | Hurricane Analysis and Forecast System |
| **HAFSv2** | Hurricane Analysis and Forecast System Version 2 |
| **HERC** | Hurricane Ensembles in Real-time on the Cloud |
| **HFIP** | Hurricane Forecast Improvement Program |
| **HRRR** | High Resolution Rapid Refresh |
| **JTTI** | Joint Technology Transfer Initiative |

| | |
|---|---|
| **LOTM** | Line Office Transition Manager |
| **LOTMC** | Line Office Transition Managers Committee |
| **LRAUV** | Long-Range Autonomous Underwater Vehicle |
| **MOM6** | Modular Ocean Model Version 6 |
| **NAO** | NOAA Administrative Order |
| **NCCOS** | National Centers for Coastal Ocean Science |
| **NEFSC** | Northeast Fisheries Science Center |
| **NESDIS** | National Environmental Satellite, Data, and Information Service |
| **NGFS** | Next Generation Fire System |
| **NHC** | National Hurricane Center |
| **NMFS** | National Marine Fisheries Service |
| **NOAA** | National Oceanic and Atmospheric Administration |
| **NOS** | National Ocean Service |
| **NRDD** | NOAA Research & Development Database |
| **NSSL** | National Severe Storms Laboratory |
| **NWP** | Numerical Weather Prediction |
| **NWS** | National Weather Service |
| **OAR** | Oceanic and Atmospheric Research |
| **OCS** | Office of Coast Survey |
| **OCLO** | Office of the Chief Learning Officer |
| **OMAO** | Office of Marine and Aviation Operations |
| **ORTA** | Office of Research, Transition, and Application |
| **OSS** | Office of Science Support |
| **OST** | Office of Science and Technology |
| **OSTI** | Office of Science and Technology Integration |
| **PMEL** | Pacific Marine Environmental Laboratory |
| **PSL** | Physical Sciences Laboratory |
| **PWPF** | Probabilistic Winter Precipitation Forecast |
| **R&D** | Research and Development |

| | |
|---|---|
| **R2A** | R&D to Applications |
| **R2C** | R&D to Commercialization |
| **R2O** | R&D to Operations |
| **R2X** | R&D to Other Uses |
| **RAP** | Rapid Refresh |
| **RDEC** | Research and Development Enterprise Committee |
| **RL** | Readiness Level |
| **SPC** | Storm Prediction Center |
| **STAR** | Center for Satellite Applications and Research |
| **TRWG** | Transition Report Working Group |
| **UFS** | United Forecast System |
| **USV** | Uncrewed Surface Vehicle |
| **UxS** | Uncrewed Systems |
| **UxSOC** | Uncrewed Systems Operations Center |
| **WFO** | Weather Forecast Office |
| **WoFS** | Warn-on-Forecast System |
| **WoFS ML Severe** | Warn-on-Forecast System Machine Learning Severe Weather Probability Suite |
| **WPC** | Weather Prediction Center |
| **WPO** | Weather Program Office |
| **WSSI** | Winter Storm Severity Index |
| **WSSI-P** | Probabilistic Winter Storm Severity Index |

# Appendix B: Methods

*Source: LOTMC Transition Report Working Group (TRWG)*

In 2024, the LOTMC changed the methodology used to generate the LOTMC Transition Report in response to feedback from the NOAA Science Council as well as internal suggestions. Major changes included: 1) streamlined data collection on transitions; 2) a focus on transition success stories, also known as transition narratives; and 3) a reduction in the number of data visualizations. These changes simplified the report development process and highlighted the impact of research transitions on NOAA's mission and society. The FY24 Annual Transition Report served as a pilot, being the first implementation of the new methodology and annual cadence.

Report development followed five steps defined by the LOTMC TRWG: **1) prepare, 2) collect, 3) analyze, 4) review, and 5) report**.

**Prepare**: Initial preparations and data collection utilized the NRDD as a centralized location to report and obtain transition information across all NOAA line offices. At the end of FY24 (October 1, 2024), the LOTMC communicated to all LOTMs the purpose of the Annual Transition Report, the information to be collected, and encouraged all line offices to participate in the upcoming NRDD Project Actuals Data Call. Starting in November, the LOTMC worked with the NOAA Research and Development Enterprise Committee (RDEC) to coordinate the sharing of the FY24 NRDD Project Actuals Data Call, ensuring the most efficient data collection across all line offices, which concluded March 31, 2025.

The Office of Research, Transition, and Application (ORTA) began the annual reporting process by creating a Google folder and spreadsheet to collect FY24 transition project information. With the FY24 Project Actuals Data Call complete, ORTA then queried the NRDD to collect all available project information within the relevant timeframe.

ORTA's NRDD query intended to pull the following data:

- The first query searches the NRDD for projects that moved from RL8 ->RL9 in FY24.
    - Step 1: *RL Progress*
    - Step 2: *Desired Fields*
        - *NRDD Project ID*
        - *Project Title*
        - *Project Description*
        - *Pl Email*
        - *NOAA Point of Contact (POC) Email*
        - *LO*
        - *Office*
        - *Division*
        - *RL8 Active Date*

        - *RL9 Active Date*
    - Step 3: RL9_ActiveDate is greater than 9/30/2023 AND RL9_ActiveDate is less than 10/1/2024
- The second query searched the NRDD for any projects marked as “Transitioned”
    - Step 1: Transitions
    - Step 2: Select All Fields
        - *NRDD Project ID*
        - *Project Title*
        - *Project Descriptions*
        - *Current RL*
        - *Planned Project Start*
        - *Planned Project End*
        - *PI Email*
        - *NOAA POC Email*
        - *LO*
        - *Office*
        - *Division*
        - *Transition Plan (y/n)*
        - *No Transition Reason*
        - *Expected Transition Date*
        - *Actual Transition Date*
        - *R2A*
        - *R2C*
        - *R2O*
        - *R2X*
        - *External Adopter Name*
        - *External Adopter Type*
        - *External Adopter State*
        - *External Adopter Scale*
        - *NOAA Adopter*
    - Step 3: *ActualTransitionDate* is greater than 9/30/2023 AND *ActualTransitionDate* is less than 10/1/2024

ORTA then shared this spreadsheet, populated with NRDD query data, with the LOTMC Executive Secretariat (Exec Sec) team for distribution to the LOTMs.

**Collect**: Following the initial NRDD query (~April 15), the LOTMC Exec Sec distributed the tasking email to LOTMs with instructions to review and update project information with the NRDD. LOTMs

were tasked to: 1) review the spreadsheet to confirm accuracy of NRDD project data, and 2) conduct a survey of impactful transitions across their respective Line Office. If there were missing or inaccurate transition projects in the spreadsheet, LOTMs or project POCs were instructed to enter updated information into the NRDD for tracking. LOTMs ensured that projects included in this report have met their intended end use, either at RL 9 or another completion stage. The LOTMC Exec Sec collected LOTM input in the spreadsheet, and shared it with ORTA for the next step (~May 15).

Before the NRDD sunset,[§] the Exec Sec queried for all data up until the sunset date including necessary FY24 data, as well as Q1 & Q2 of FY25. This report includes the data collected for FY24 only. In lieu of the capability to update project information via NRDD, LOTMs were instead directed to conduct corrections and additions of project information directly in the distributed spreadsheet.

Additionally, the LOTMC Exec Sec team tasked the LOTMs to nominate projects to highlight in the Annual Transition Report. LOTMs then voted on the final list of projects to include in the report through a Google Form.

**Analyze**: ORTA then utilized the collected data to analyze project information and project highlights, composing data visualizations/figures, statistics, and narratives of key project highlights, with approximately one month to analyze the project information. The first part of the analysis produced a narrative highlighting seven projects that have transitioned or had been put into use (at the discretion of the LOTMs).

**Review**: ORTA pulled the project highlights and the figures into this report. The draft report was sent to the LOTMC Exec Sec to share with the LOTMC for review.

**Report**: Once approved, the LOTMC Chair and Exec Sec created a slideshow with the report figures and highlights to be presented to the NOAA Science Council. The report is to be posted to the Science Council website and the NOAA Institutional Repository.

§ On April 8, 2025, the NOAA Science Council accepted a recommendation to sunset the NRDD. User access was suspended and the site was archived/parked/stored.