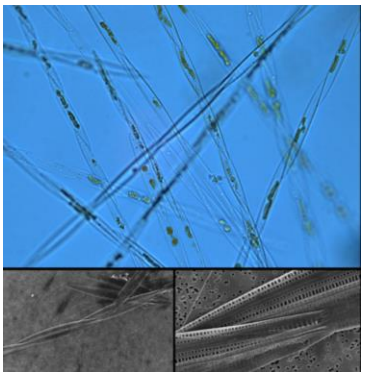
NCCOS Annual Science Review:
Harmful Algal Blooms and Hypoxia Program

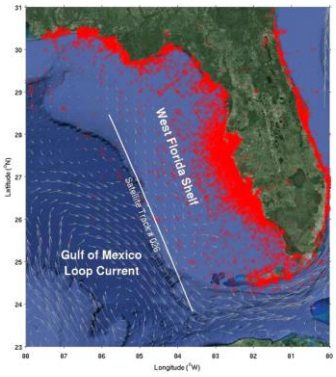
Silver Spring, Maryland
28 - 30 November, 2023

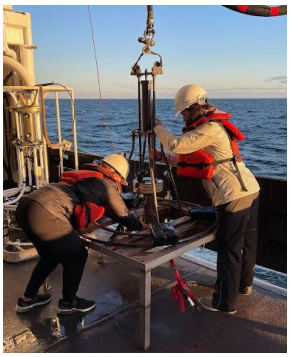
Review Website: [NCCOS HABs and Hypoxia Program Review]

Briefing Book and Meeting Materials







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NCCOS Harmful Algal Bloom (HAB) and Hypoxia Portfolio Review Agenda

Location: National Oceanic and Atmospheric Administration
1305 East-West Highway, SSMC3 - Room 4527
Silver Spring, MD

Virtual link to full day (same link for Tues, Wed, and Thrs):
NCCOS HAB & Hypoxia Program Annual Science Review
Video call link: https://meet.google.com/rri-gfip-xej
Or dial: (US) +1 503-994-4090 PIN: 765 516 502#
More phone numbers: https://tel.meet/rri-gfip-xej?pin=6081516669415

DAY 1 (Tuesday, 28 November 2023)

8:30 - 8:35 Introductions and Icebreaker - *Sean Corson, NCCOS Director*

8:35 - 8:45 Setting agenda and process for the day - *Lonnie Gonsalves and Dave Kidwell*

8:45 - 9:00 High level recap of introductory information and videos - *Lonnie Gonsalves and Dave Kidwell*

9:00 - 9:30 Graffiti board activity

9:30 - 9:45 BREAK

9:45 - 10:15 Overview of Feedback from 2018 HAB and Hypoxia Program Review - *Dave Kidwell, CRP Director; John Ramsdell, HAB-M&R Branch Chief*

10:15 - 11:15 Causes and Impacts of HABs and Hypoxia Presentation **-** *Maggie Broadwater, Program Manager, CRP*

11:15 - 11:30 Panel reflection time

11:30 - 1:00 LUNCH

1:00 - 2:45 HAB Observing and Monitoring Presentation - *Greg Doucette, Researcher Oceanographer, HAB-M&R Branch; Marc Suddleson, Program Manager, CRP; Shelly Tomlinson, Oceanographer, HAB-F Branch*

2:45 - 3:00 BREAK

3:00 - 4:45 HAB and Hypoxia Forecasts Presentation - *Alex Hounshell, Research Oceanographer, HAB-F Branch; David Scheurer, Oceanographer, CRP; Rick Stumpf, Oceanographer, HAB-F Branch; Quay Dortch, Senior HAB Scientist, CRP*

4:45 - 5:00 Executive session - *Facilitated by Review Chair, Pat Brown*

6:00 Dinner with panel at Mandalay in Silver Spring
(930 Bonifant St, Silver Spring, MD 20910)

DAY 2 (Wednesday, 29 November 2023)

8:30 - 8:35 Introductory remarks and welcome - *Lonnie Gonsalves*

8:35 - 8:40 Refresh/recap of the previous day to get the group going - *Peg Brady*

8:40 - 10:15 HAB Toxin Detection Presentation - *Tod Leighfield, Chemist, HAB-M&R Branch; Sarah Pease, Physical Scientist, Program Manager, CRP*

10:15 - 10:30 BREAK

10:30 - 12:00 HAB Control Presentation - *Kaytee Pokrzywinski, Research Marine Biologist, HAB-F Branch; Peter Moeller, Research Chemist, HAB-M&R Branch; Felix Martinez, Program Manager, GLERL, CRP*

12:00 - 1:30 LUNCH

1:30 - 3:15 R2X Stakeholder Panelist Discussion (closed session)

3:15 - 3:30 BREAK / transition between sessions

3:30 - 4:30 Public Communication and Societal Acceptance Stakeholder Panelist Discussion (closed session)

4:30 - 5:00 Executive session - *Facilitated by Review Chair, Pat Brown*

5:30 Panel Reception at Silver Branch Brewing
(8401 Colesville Rd #150, Silver Spring, MD 20910)

7:00 Dinner on own

DAY 3 (Thursday, 30 November 2023)

8:30 - 8:45 Welcome and orientate group for initial reporting – *Margo Schulze-Haugen, NCCOS Deputy Director*

8:45 - 9:00 Overview of report format, submission process, and how to follow up with Stakeholders - *Pat Brown, Review Chair*

9:00 - 10:30	Reviewer panel discussion and initial recommendations - *Pat Brown*
10:30 - 11:00	Reviewer panel verbal presentations to NCCOS leadership - *Individual Review Panel Members*
11:00 - 11:45	Presentation of summary of reviewers' comments to NCCOS leadership - *Pat Brown*
11:45 - 12:00	Thanks and final remarks - *Sean Corson, NCCOS Director*
12:00	END

Review Information

Review Panel

Members of the Review Panel include technical experts in different fields, program directors, and users of information. We have tried to balance the composition of the Review Panel, considering affiliation (Federal and non-Federal), scientific expertise (analysis of satellite imagery, ecological modeling, algal toxin detection methods and monitoring, nutrient management and mitigation, etc.), and users of information (i.e., public health officials, coastal resource managers, etc.).

The Review Panel consists of the following:

Review Panel Chair: ***Patricia Brown***: NWS DEIA Program Lead, NOAA NWS

Panelists:

Dan Ayers: Biologist, Coastal Shellfish Lead, Washington Department of Fish & Wildlife (ret.)

Zdenka Willis: Immediate Past-President, Marine Technology Society and CEO, Veraison Consulting LLC.

Christopher Winslow: Director of Ohio Sea Grant and Ohio State's Stone Laboratory

Kate Hubbard: FWC's Center for Red Tide Research, FWC-FWRI's HAB monitoring and Research Program

Dennis McGillicuddy: Senior Scientist and Department Chair Applied Ocean Physics & Engineering at Woods Hole Oceanographic Institution

Jonathan Deeds: Research Biologist, US FDA Center for Food Safety and Applied Nutrition

Stakeholder Panels

Members of the Stakeholder Panels include technical experts in different fields, program directors, and users of information. We have tried to balance the composition of the Stakeholder Panel, considering affiliation (Federal and non-Federal), scientific expertise (analysis of satellite imagery, ecological modeling, algal toxin detection methods and monitoring, nutrient management and mitigation, etc.), and users of information considering each of the research to transition categories and service delivery. The R2X Stakeholder Panel provides an opportunity for reviewers to ground truth information shared on previous days, to gain additional insights from stakeholders (users group and partners), and discuss efforts to meet stakeholder needs (i.e., coordinating with folks on the ground and making sure NOAA made/makes informed science decisions based on what is relevant and useful to the stakeholder.

The Public Communication and Societal Acceptance Stakeholder Panel provides an opportunity for reviewers to discuss with stakeholders about how NCCOS and the HAB/hypoxia program is incorporating social science principles into R2X, communicating work through outreach, and transitioning into public acceptance.

Steering Committee

The following individuals are members of the Steering Committee for this review. As with the Review Panel, they represent a variety of areas of expertise and affiliations within NCCOS. The committee includes:

David Kidwell, Director, Competitive Research Program, NCCOS

Lonnie Gonsalves, Ph.D, Chief, Stressor Detection and Impacts Division, NCCOS

Andrew Leight, Ph.D., Acting Chief, Harmful Algal Bloom Forecasting Branch

Marc Suddleson, Acting Chief, Harmful Algal Bloom Forecasting Branch

John Ramsdell, Chief, HAB Monitoring and Reference Branch, NCCOS

Shelby Butz, Ph.D., Review Coordinator, NCCOS Science Portfolio Manager, NCCOS

Alexandria Hounshell, Ph.D., Research Oceanographer, HAB Forecasting, NCCOS

David Scheurer, Oceanographer, Competitive Research Program, NCCOS

Kaytee Pokrzywinski, Ph.D., Research Marine Biologist

Purpose of Review

NOAA requires external peer-reviews of its research and development programs on a periodic basis. Such reviews can play a key role in program planning, management and oversight by providing feedback on both program design and execution. NCCOS is further interested in evaluation of its information products and their delivery to users, and engagement with stakeholders.

Specifically, the review is intended to do the following:

1. Assess NCCOS' role as a federal entity to improve scientific understanding of HABs and hypoxia, resulting in:
    a. More robust and effective environmental modeling and forecasts leading to operational forecasting and delivering early warning information to decision makers;
    b. New environmental sensors, observation platforms, monitoring protocols, and validated detection methods;

    c. Effective methods of prevention, control, and mitigation that can minimize HABs and their impacts;
    d. Event response that leverages the capabilities of other federal reference laboratories, monitoring programs and user laboratories to meet the needs of diverse management communities.
2. Evaluate NCCOS' role in delivering practicable research products, data and information, and engaging stakeholders.
3. Appraise NCCOS management and procedures for funding pre-eminent research that is coordinated across intramural and extramural programs, producing actionable results that engages stakeholders, and transitioning its research and development (R&D) to widely utilized applications.
4. Offer observations and make recommendations to better position NCCOS for implementing its HAB and hypoxia portfolio.

Scope of Review

NCCOS science includes the full spectrum of research transitions, including transitions to operations (R2O), application (R2A), commercialization (R2C), knowledge transfer, and other uses. In addition, NCCOS seeks to meet many of the service delivery standards set forth by NOAA (ref.). Science activities supporting HAB, HAB toxin, and Hypoxia-related R&D falling under the 2023 review will include 1) monitoring and detection technology, 2) improvements of modeling and predictive capabilities, 3) forecasting, and 4) control and other hazard mitigation technologies.

The review will cover all aspects of HAB and hypoxia related research, assessment, monitoring, and other activities conducted by NCCOS, both in-house and through extramural support, over the past five years. In particular, the review will focus on knowledge enhancement, forecasting, sensor development and monitoring protocols, response actions, and alleviation of HAB and hypoxia in U.S. coastal waters, including the Great Lakes. It will also consider the underlying assumptions, statutes, and organizational drivers that led to the current HAB and hypoxia portfolio and identify any changes to better position NCCOS for the future. Additional focus will be put on Research to transition pathways and service delivery.

Program Evaluation Criteria

Following enactment of the Government Performance and Results Act (GPRA) in 1993, the National Academies' Committee on Science, Engineering, and Public Policy produced a report on the unique purpose of federal research programs and inherent challenges in their evaluation. The committee concluded that federal research programs could be evaluated using three criteria: quality, relevance, and leadership, and noted that such evaluations should consider factors beyond peer review of research publications by scholars in the field (National Academy of Sciences, 2001).

In its 2008 Guide to the Program Assessment Rating Tool (PART) and citing the National Academies report, the US Office of Management and Budget (OMB) identified relevance, performance, and quality as criteria that can be used to assess the effectiveness of federal

research and development (R&D) programs. This approach was further endorsed in a 2008 National Research Council (NRC) report, which stated that research program efficiency must be evaluated in the context of relevance, effectiveness, and quality. NOAA, through an Administrative Order (NAO 216-115A, dated October 3, 2016, and its previous editions), has adopted Quality, Relevance and Performance as core evaluation criteria. The NAO also calls for a periodic evaluation of research, development and transition activities as well as outreach efforts and stakeholder engagement. Criteria are outlined and defined in NOAA Administrative Order 216-115B Handbook and the NOS Program Evaluation Framework.

Reviewer's Responsibility

NCCOS will present data and information relevant to its HAB and hypoxia portfolio during the course of the review, primarily as lecture presentations and in the briefing book. Each member of the Review Panel will use that information and any ensuing discussion to come up with independent observations, evaluation, and recommendations on different aspects of the portfolio (reviewers are encouraged to use the attached format). We have formulated the following questions to guide your review and to conform to the three core evaluation criteria, previously described in the "Program Evaluation Criteria" section above.

Quality

1. How well are NCCOS scientists, both intramural and extramural, and program managers recognized as leaders in their scientific disciplines for the quality of their contributions (e.g., authors of peer-reviewed publications; congressional briefings; invited lectures; awards and recognition; and national and international leadership positions in the scientific community)?
2. How effective are NCCOS intramural and extramural studies in developing (a) new and validated analytical methods and technologies in wide use, and (b) advanced tools to understand and mitigate HAB and hypoxia events (e.g., forecast models, sensors, and prevention-control mitigation (PCM) technologies?
3. How does NCCOS assure and does it have procedures for funding preeminent research and impactful science?

Relevance

1. How well has the portfolio supported noteworthy achievements in improving scientific understanding of causes of HAB that have led to improvements in HAB management and response?
2. How effective are the hypoxia modeling and related studies in informing Federal guidance on nutrient management strategies in upland states?
3. Is there evidence of the application of the NCCOS-produced scientific knowledge for improving preparedness and response to HAB and hypoxia events by local, state, tribal, and regional governments and for preventing or minimizing HAB and hypoxia occurrence?
4. How effective has NCCOS been in transitioning research to applications, i.e., operations, commercialization, and management use, and how such transitions may be improved.

Performance

1. How effective is the NCCOS HAB and hypoxia portfolio in meeting the requirements of HABHRCA (e.g., documenting improved scientific knowledge and communicating information on HAB and hypoxia impacts, delivering an assessment plan for the Great Lakes HAB and hypoxia, and promoting and coordinating a national research strategy on HAB and hypoxia).
2. How well does NCCOS execute its research and related studies in an efficient and effective manner given the resources?
3. How effectively does NCCOS utilize collaboration and partnerships to achieve desired outcomes, and how well are stakeholders engaged in transitioning research to applications?
4. How effective are NCCOS roles in leading workshops, symposia and training that result in outputs that drive management outcomes?

Given the scope of planned presentations as well as anticipated use of the panel's recommendations, the "Relevance" criterion is the most important one. Prior to the review, the reviewers may suggest additional criteria, and at the review, each reviewer will be free to ask additional questions as appropriate.

Anticipated Review Products

Each member of the review panel will use her / his scientific expertise and professional judgment to provide independent observations, evaluation, and recommendations on different aspects of the NCCOS HAB and hypoxia portfolio, including product value and utilization. Each member of the Review Panel will also prepare notes on his/her observations, comments and recommendations that, at a minimum, address the three core evaluation criteria: Quality, Relevance, and Performance. For convenience, a tabular format is provided for recording comments on different aspects of the review (Appendix A).

Panel members will present their preliminary finds to NCCOS and NOS leadership (Day 3 of the review). Individual written reports, following the attached format, will be due within 60 days after the review. ***No consensus report is required***. The Review Panel chair may summarize findings from the review (e.g., salient points, recurring themes, or notable exceptions) in the Review Panel's presentation to NCCOS and NOS leadership (Day 3 of the review) and in a written report (due within 60 days after the review).

NOAA procedures allow for "evaluation ratings" with a bipolar construct for program components, e.g., Exceeds Highest Expectations, Exceeds Expectations, etc. However, we are not requiring the panel members to do that. Also, note that answering the question merely by "yes" or "no" will not be sufficient in conveying your observations, assessment and recommendations and should be avoided.

Review Report

Individual reviewer reports will be compiled in a document for use by NCCOS directors and program managers. The document will be used for planning of future science and related activities and improving the performance of current and near-term projects. Individual review

reports will not be made public, and will only be used by NCCOS as background for the final report. Internal distribution of the individual reports will be limited.

NCCOS Overview

Overview

NCCOS sits within NOAA's National Ocean Service. The NOS provides data, tools, and services that support coastal economies and their contribution to the nation. The mission of NOS is to provide science-based solutions through collaborative partnerships to address evolving economic, environmental, and social pressures on our ocean and coasts. The National Centers for Coastal Ocean Science (NCCOS) is the research, monitoring and assessment organization within NOS. NCCOS delivers ecosystem science solutions: a) for the stewardship of ocean and coastal resources; and b) to support thriving coastal communities and economies.

NCCOS was formed in 1999 as the focal point for NOAA's coastal ocean science efforts to meet its coastal stewardship and resource management responsibilities. The office conducts nationwide, multidisciplinary research that integrates a broad spectrum of physical, biological, chemical, and social sciences to inform and guide resource and community managers, while seeking a balance among resource use, economic development, restoration, conservation, and human health. NCCOS works closely with coastal managers and other stakeholders to determine research needs and ensure we are delivering valuable, relevant, timely, and actionable products and tools to inform decisions. Stakeholders are often engaged in project planning and execution and provide guidance throughout the research process. NCCOS science is guided by NOAA's legislative mandates, executive orders, and NOS priorities, as well as stakeholder engagement. By providing science products and tools, NCCOS helps communities plan for, adapt to, and reduce risks from the multiple challenges facing coastal communities.

Facilities

NCCOS leadership, scientists, program managers, and staff work in several facilities across the country. They are described below.

NCCOS Headquarters Silver Spring

Silver Spring is the location of NCCOS headquarters, the Competitive Research Program, as well as scientific expertise in biogeography, habitat mapping, HAB forecasting and monitoring and bioeffects of chemical contaminants.

NOAA Beaufort Laboratory

NCCOS staff in Beaufort conduct research on harmful algal blooms, habitat mapping, aquaculture siting and impacts, ecology of marshes and coral reefs, and coastal resilience and restoration. Facility infrastructure includes seawater/culture facilities, analytical laboratories, scientific diving and small boats programs, and NCCOS business management functions.

Cooperative Oxford Laboratory (COL)

COL is a partnership between NOAA, the Maryland Department of Natural Resources and the USCG Station Oxford. COL partners combine science, response, and management capabilities to meet respective missions and collaborate to address science and management challenges.

The lab is a branch of NCCOS' Marine Spatial Ecology Division. COL scientific capabilities are diverse and include expertise in research to enhance preparedness and recovery in the face of coastal change, and research of novel methods to improve restoration and resilience practices.

Kasitsna Bay Laboratory
The Kasitsna Bay Laboratory has been the Alaska field station for both NCCOS and the National Marine Fisheries Service since the late 1950s. NCCOS partners with the University of Alaska Fairbanks on lab operations and research. The Kasitsna Bay Laboratory is a part of NCCOS's Marine Spatial Ecology Division and conducts research on coastal impacts of climate change, ocean acidification, harmful algal blooms, and oil spills and hosts Federal, state, tribal, and university researchers.

Hollings Marine Laboratory (HML)
HML is a NOAA-owned facility operated by NCCOS as a fully collaborative enterprise, governed by the five partner organizations through a Joint Project Agreement. HML partners consist of NOAA, the National Institute of Standards and Technology, the South Carolina Department of Natural Resources, the College of Charleston, and the Medical University of South Carolina. Scientists from all partner institutions work side-by-side in the laboratory, taking advantage of each other's special expertise.

NCCOS Priorities and Strategic Plan
NCCOS Strategic Science Priorities for 2017-2021 which partially encompasses the review period, are outlined in the FY 2017-2021 Strategic Plan: Advancing Coastal Science and listed below.

1. Marine Spatial Ecology
2. **Stressor Impacts and Mitigation**
3. Coastal Change: Vulnerability, Mitigation, and Restoration
4. Social Sciences

Note this program review focuses on science that falls within the Stressors Impacts and Mitigation priority, specially under the sub-priority area of Harmful Algal Bloom (HAB) Detection and Forecasting.

Sections of the 2017-2021 Advancing Coastal Science relating to the HABs and Hypoxia Program can be found in Appendix C.

In 2021, NCCOS released its FY 2022-2026 Strategic Plan: Science Service Coastal Communities, which encompasses the later half of this review period and outlines the following six science and organizational priorities:

1. Advancing Ecosystem Science for Conservation and Sustainable Use
2. **Developing and Implementing Advanced Observation Technologies and Ecological Forecasts**
3. Facilitating Resilience and Adaptation to Inundation and Climate Impacts

4. **Detecting, Monitoring, and Mitigating Impacts of Chemical and Biological Stressors**
5. Advancing Social, Economic, and Behavioral Approaches to Coastal Stewardship
6. Investing in our People and Achieving Organizational Excellence

We also mention FY 2022-2026 Strategic Plan to provide reviewers context for the direction NCCOS is heading. The HAB and Hypoxia Program is primarily captured under the fourth priority, highlighted above, with substantial contributing work from the second priority, also highlighted.

Sections of the FY 2020-2026 Strategic Plan relating to the HABs and Hypoxia Program can be found in Appendix D.

Strategic Approach

HAB Observing Research and Development

- Research and development of improved detection technologies and validation of data;
- Marine and freshwater satellite remote-sensing;
- Phytoplankton Monitoring Network monitors marine and estuarine HAB species at over 250 coastal sites.

HAB Observing Operations

- NHABON Implementation Plan with IOOS

HAB Forecasting Research and Development

- Applied research needed to inform ecological forecasts;
- Advancing satellite methods for detecting HABs;
- Developing and delivering regional forecasts.

HAB Forecasting Operations

- Plan in development with IOOS

PCM Research and Development

- Control advances promising technologies for preventing, controlling, or mitigating HABs;
- HAB Event Response provides enhanced monitoring and response to events;
- Prevention through understanding the causes and impacts of HAB events.

HAB and Hypoxia Priorities

HABHRCA

Before 1992, the Federal government did not expend much direct effort on HABs. Some funding was spent on a case-by-case basis if a new HAB occurred, but there was neither a pro-active orientation, nor a significant ongoing program dedicated to the HAB problem. Overall, Federal funding levels were very low relative to the scope, complexity, and importance of HABs. As concerns about the problem increased in the 1990's, the Federal government began to devote greater attention to HABs. In 1992, NOAA sponsored a workshop with the HAB research community to develop a National Plan. The workshop yielded a national research agenda and the creation of a Marine Biotoxins Program in NOAA.

In 1994, the Administration established an Ad Hoc Interagency Task Force on Marine Biotoxins and Harmful Algae to begin coordinating efforts on and identifying measures to address the problem. Later that year, NOAA created a National Office for Marine Biotoxins and Harmful Algal Blooms at the Woods Hole Oceanographic Institution.

In 1996, the Administration created a program called Ecology and Oceanography of Harmful Algal Blooms (ECOHAB). This inter-agency program is dedicated to conducting the basic research necessary to understand HABs, why they occur, and how to combat them. Various agencies contribute funds to the program

A 1997 scientific panel recommended the creation of a program complementary to ECOHAB that would focus on research related to the prevention, management, mitigation, and control of HABs rather than basic research. In fact, little overall has been done at the Federal level to prevent and control HABs relative to the scope and seriousness of the problem.

Recognizing the ongoing nature of HABs and hypoxia, and how they continue to affect the entire U.S., Congress has reauthorized HABHRCA twice, mostly recently in 2014 (HABHRCA 2014, P.L. 113-124). The legislation requires the creation of an Interagency Working Group on HABHRCA (IWG-HABHRCA). This body is tasked with coordinating and convening Federal agencies and their stakeholders to discuss HAB and hypoxia events in the United States, and to develop action plans and assessments of these situations. NOAA co-chairs the IWG-HABHRCA with EPA. Other member agencies include:

- FDA
- USDA NIFA, NRCS
- CDC
- USACE
- NASA
- NPS
- USGS
- BOEM
- U.S. Navy
- NIEHS
- NSF
- U.S. Department of State
- U.S. FWS

The 2014 HABHRCA reauthorization is unique for several reasons. It calls for Federal agencies to consult with stakeholders when developing action strategies, in order to develop recommendations that directly address needs and concerns related to mitigating and preventing HABs and hypoxia. It expands the focus of HABHRCA to include a specific emphasis on HABs and hypoxia in the Great Lakes and in fresh waters around the country, and recognizes the need for further coordinated action across the Federal sector to address these issues. Additionally, the legislation calls for Federal agencies to provide integrated assessments identifying the causes, consequences, and approaches to reducing HABs and hypoxia nationally, with particular emphasis on the Great Lakes. It calls for operational forecasting, observations, and modeling tools required to support forecasting, all of which are of particular relevance for the region.

HABHRCA 2004 directed NOAA to:

- Maintain and enhance the existing competitive programs at the National Oceanic and Atmospheric Administration relating to harmful algal blooms and hypoxia.
- Carry out marine and Great Lakes harmful algal bloom and hypoxia events response activities.
- Develop and enhance, including with respect to infrastructure as necessary, critical observations, monitoring, modeling, data management, information dissemination, and operational forecasts relevant to harmful algal blooms and hypoxia events.
- Enhance communication and coordination among Federal agencies carrying out marine and freshwater harmful algal bloom and hypoxia activities and research.
- To the greatest extent practicable, leverage existing resources and expertise available from local research universities and institutions.
- Increase the availability to appropriate public and private entities of:
    - Analytical facilities and technologies
    - Operational forecasts; and
    - Reference and research materials.

In addition, HABHRCA authorized funding for intramural research to the HAB forecasting and Monitoring and Reference Branches and extramural research for competitive research programs on HABs and hypoxia:

- Ecology and Oceanography of Harmful Algal Blooms (ECOHAB)
- Monitoring and Event Response for Harmful Algal Blooms (MERHAB)
- Prevention, Control, and Mitigation of Harmful Algal Blooms (PCMHAB)
- Gulf of Mexico Ecosystems & Hypoxia Assessment (NGOMEX)
- Coastal Hypoxia Research (CHRP)

See Appendix B: Branch and Program Logistics for more details on each branch.

Annual Appropriation Guidance

HABHRCA 1998 and 2004 authorized funding for intramural research and for competitive research programs on HABs and hypoxia.

- Ecology and Oceanography of Harmful Algal Blooms (ECOHAB)
- Monitoring and Event Response for Harmful Algal Blooms (MERHAB)
- Prevention, Control, and Mitigation of Harmful Algal Blooms (PCMHAB)
- Gulf of Mexico Ecosystems & Hypoxia Assessment (NGOMEX)
- Coastal Hypoxia Research (CHRP)

Logistics and Budget

	Total NCCOS appropriation	**NCCOS on HABs/ hypoxia**	**Total CRP appropriation**	**CRP on HABs/ hypoxia**
	Million $			
FY 19	$41.60	$5.55	$18.00	$12.46
FY 20	$44.00	$5.02	$19.00	$12.16
FY 21	$47.00	$5.82	$21.00	$13.16
FY 22	$50.00	$8.23	$21.50	$13.82
FY 23	$55.50	$8.90	$22.50	$14.01

Table 1: Total appropriated funds to NCCOS and the CRP and the amount spent on the HABs and hypoxia program.
NOTE: Total CRP appropriation and CRP funds on HAB and hypoxia are discretionary science funds and do not include reimbursable or transfer funds. These numbers do not include salary/labor.

	Transferable funds	**Reimbursable funds**	**NCCOS Labor**	**CRP Labor**
FY 19	$408,144	$677,046	$3,790,965	$767,725
FY 20	$358,274	$677,575	$3,789,331	$1,056,146
FY 21	$566,18	$468,622	$4,395,748	$975,146
FY 22	$714,340	$470,550	$5,759,355	$1,056,146
FY 23	$710,947	$734,674	$6,601,835	$1,109,387

Table 2: Transferable and Reimbursable funds within NCCOS and labor for both NCCOS and the CRP.
NOTE: Transferable funds originate and are transferred within NOAA. Reimbursable funds originate outside of and are received by NOAA. All CRP labor comes from the total NCCOS appropriation.

NOAA Research to Transition and Readiness Levels

Readiness Levels

A systematic project metric/measurement system that supports assessments of the maturity of R&D projects from research to operation, application, commercial product or service, or other use and allows the consistent comparison of maturity between different types of R&D projects. (Note: NOAA RL's are similar to Technology Readiness Levels (RLs) developed by NASA (Mankins, 1995) and embody the same concept for quantifying the maturity of research). A project achieves a readiness level once it has accomplished all elements described within a readiness level. A program may include projects at different RLs depending on the goals of each project. Inventions may be generated at any RL. The nine readiness levels are as follows:

RL 1: Basic research, experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view. Basic research can be oriented or directed towards some broad fields of general interest, with the explicit goal of a range of future applications (OECD, 2015).

RL 2: Applied research, original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific, practical aim or objective. Applied research is undertaken either to determine possible uses for the findings of basic research, or to determine new methods or ways of achieving specific and predetermined objectives (OECD, 2015).

RL 3: Proof-of-concept for system, process, product, service, or tool; this can be considered an early phase of experimental development; feasibility studies may be included.

RL 4: Successful evaluation of system, subsystem, process, product, service, or tool in a laboratory or other experimental environment; this can be considered an intermediate phase of development.

RL 5: Successful evaluation of system, subsystem process, product, service, or tool in a relevant environment through testing and prototyping; this can be considered the final stage of development before demonstration begins.

RL 6: Demonstration of a prototype system, subsystem, process, product, service, or tool in relevant or test environment (potential demonstrated).

RL 7: Prototype system, process, product, service or tool demonstrated in an operational or other relevant environment (functionality demonstrated in near-real world environment; subsystem components fully integrated into system).

RL 8: Finalized system, process, product, service or tool tested, and shown to operate or function as expected within user's environment; user training and documentation completed; operator or user approval given.

RL 9: System, process, product, service, or tool deployed and used routinely. At this time, projects are considered to be a collective set of activities necessary to transfer R&D output to a capability ready for an operation, application, commercial product, or service, or other use.

Transitions

Transitions encompass the transfer of an R&D output to a capability ready for an operation, application, commercial product or service, or other use. Transitions may require transition plans: A document that represents an agreement between clearly identified researchers and potential recipients, organizations, or other users of the product resulting from the transition of an R&D output. Transition Plans are essential for describing and facilitating the transition of R&D to potential end use, and represent an agreement between researchers, operators and/or users that describes a feasible transition pathway and potential Concept of Operations (CONOPS).

To meet mission needs, NOAA will optimize the timely and efficient use of R&D, including but not limited to that conducted by and funded by NOAA. To fulfill this goal, NOAA shall maintain:

a) A mission-oriented enterprise capable of quickly identifying and applying demonstrated R&D outputs to provide new and improved products, services, or more efficient operations while continuing to maintain reliable, cost-effective services for users;
b) An R&D enterprise that routinely provides proven R&D outputs to serve NOAA's mission while adapting its portfolio to address new research frontiers; and,
c) Project management, planning, and oversight processes that include routine identification of new opportunities/needs for research, development of Transition Plans, status reporting, and test and evaluation procedures.

Transition Plans

Transition Plans should be developed as early as possible to reflect the relationship between R&D and NOAA’s mission and the commitment by the entities involved to the potential transition of R&D. Transition Plans are recommended for projects that seek to progress beyond RL 4. The determination of whether a transition project shall have a written transition plan is at the discretion of the AA(s), or their designees, from the affected LO(s). In making this determination, factors that may be considered include but are not limited to the following:

a) The risks associated with, and the sensitivity of, the transition;
b) The organizations involved in the transition, and their history of implementing transition activities together;
c) The duration of the transition activities;
d) The cost of transition activities;
e) Potential societal impact; and

f) The complexity of the transition, including whether the project is novel or a routine update to existing operations or applications.

Transition Plans shall incorporate the following:

a) A description of the activities necessary to transfer an R&D output;
b) Clearly defined goals for the new/revised product or service, milestones, schedule, and transition success/acceptance criteria;
c) To the best estimate, the amount and source of funds needed to cover the costs associated with the transition, as well as the cost of future operations as necessary, including relevant requirements for equipment, upgrades, staff training, and maintenance of redundant application capabilities during the transition period;
d) A clear designation of potential researcher(s), operational entity(ies) and/or end user(s), and a description of when they will engage and as often as necessary to ensure all parties are fully invested in the R&D transition process;
e) A mechanism for providing clear communication among all participants concerning the transition, including routine engagement of the management chain in the affected LO(s) and partner organizations; and
f) A mechanism for updating the plan as necessary to reflect changes in the plan warranted by results of the transition process or unforeseen events (e.g., updated budgets).

From:http://www.corporateservices.noaa.gov/ames/administrative_orders/chapter_216/216-105B.html

Service Delivery at NOAA

Service delivery lies at the heart of NOAA's mission and is critical in all that it does. Users look to NOAA for a range of data, information, tools and services, but sometimes find them difficult to efficiently and effectively access and understand. Some users seek additional support to apply NOAA's data, information, and tools to their situation. They want answers, guidance, training, and a helping hand. Through continuous customer engagements, NOAA personnel glean important information about how data, products and tools are, or are not, serving specific localities or sectors. NOAA has been transforming from a scientific and technologically constrained set of products and services, to valuing user needs as a critical input for developing useful, actionable information. Timely and specific user needs are essential inputs for advancing and deploying new technologies, models, tools, and resources.

Effective implementation of service delivery requires relationships between information producers and consumers built on mutual trust and respect. Key to developing and maintaining these relationships is sustained engagement and collaboration that will facilitate the integration of services into actionable information. NOAA's existing network of line offices and affiliated partners is a critical asset to support improved service delivery. Many of these entities already have the desired level of trust and frequent engagement with their community members. This new model for service delivery offers a guiding concept to transform interaction among these

groups. It documents best practices for service-oriented approaches, processes, and tools to improve how NOAA's products and services are developed and delivered to society.

For more information see *A Model of Service Delivery for the NOAA Water Initiative*. This document is also included as Appendix E.

Review Sessions and Presentations

Overview of Feedback from 2018 HAB and Hypoxia Program Review

Session Summary

NCCOS held its first science program review in 2018 that covered the entirety of the HAB and hypoxia portfolio. The resulting panel report provided 20 consolidated recommendations, 15 of which were deemed actionable by NCCOS. These actions included recommendations to update HAB community science priorities, enhance the inclusion of social science efforts, and suggestions for improvements to our observations and control activities. This session will provide a review of the 2018 panel recommendations and actions NCCOS has taken in response.

Session Presenters

- David Kidwell*, CRP Director*
- John Ramsdell, *HAB-M&R Branch Chief*

Causes and Impacts of HABs and Hypoxia

Session Summary

NCCOS research to understand the causes and impacts of HABs and hypoxia (HABH) iteratively informs detection, observing & monitoring, prediction & forecasting, and control, with the overarching goal of advancing solutions. HABH research on causes and impacts results in applications that are co-created with partners engaged at all steps of the research process. Case studies in California, Florida, and Alaska will be presented in this session to illustrate the integral role partnerships play in research to understand when and why HABH events occur, and to ensure that NCCOS science applications are meeting the needs of coastal communities impacted by HABH events. In California, a holistic approach to modeling HABs, ocean acidification and hypoxia (OAH) directly informs management needs. NCCOS research on Florida red tide events and co-occurring hypoxia have bolstered federal-state-academic partnerships to advance HABH prediction. A multi-agency effort in Alaska is informing decisions related to subsistence food safety and security to mitigate the impacts of HABs on Alaska coastal communities. NCCOS coordinates these multidisciplinary efforts across NOAA and other federal agencies, engaging local, state, Tribal, regional, and international partners to drive global-scale HABH solutions.

Session Presenters

- Maggie Broadwater, *Physical Scientist, Ecology & Oceanography of Harmful Algal Blooms (ECOHAB) Program Manager, Hollings Marine Laboratory, CRP*

HAB Observing and Monitoring Presentation

Session Summary

NCCOS aims to provide sustained, stakeholder-driven observations and accessibility of actionable, region-specific data products/services essential for managing and mitigating HAB impacts. Stakeholder engagements have called for sustained access to data products and services based on timely, regional HAB observations from uncrewed in-situ systems, field-

portable devices, and targeted satellite imagery. Such actionable information is needed to support management decisions, to understand how HAB trends are responding to climate change and other drivers, and to evaluate HAB mitigation and control strategies. This session will describe several case studies focused on the transition of HAB observing and monitoring technologies and the delivery of region-specific data products and services for assessing, managing, and mitigating the risk of toxin and biomass impacts on local communities/ economies. Examples of three case studies include: 1) months-long 2nd generation ESP offshore deployments routinely provide near real-time domoic acid data from off the WA coast via NANOOS Real-Time HABs and the PNW HAB Bulletin to inform harvesting decisions by state and tribal shellfish managers; 2) customized satellite ocean color products from various EUMETSAT data streams, coupled with novel techniques to assess HABs in lower Chesapeake Bay, freshwater lakes, and other coastal systems, are being used to protect regional fisheries, aquaculture, drinking water, and human health; and, 3) the WHOI HABhub employs data integration, visualization, and product sharing to deliver regional HAB situational awareness that serves diverse stakeholders; its open-source design supports integration with other regional efforts, helping to define a National Harmful Algal Bloom Observing Network data infrastructure. In summary, this session will illustrate NCCOS' successful, stakeholder-driven R&D transitions and delivery of actionable, region-specific data products and services needed to inform decisions by resource managers for mitigating HAB impacts.

Session Presenters

- Greg Doucette, *Research Oceanographer, Hollings Marine Lab, HAB Monitoring and Reference Branch*
- Marc Suddleson, *NCCOS Program Office and Headquarters, Monitoring and Event Response for Harmful Algal Blooms (MERHAB) Program Manager, HAB Event Response Co-Manager, CRP*
- Shelly Tomlinson, *NCCOS Program Office and Headquarters, Oceanographer, HAB Forecasting Branch*

HAB and Hypoxia Forecasts: Regional Forecasts within a National Framework
Session Summary

In this session we showcase 4 regional case studies (Gulf of Mexico, Lake Erie, Gulf of Maine, and Pacific Northwest) which exemplify the diversity of approaches NCCOS has taken toward developing stakeholder driven HAB and hypoxia forecasting systems around the US coastlines and Great Lakes. Forecasting systems are developed within a national framework but require a regionally specific approach due to unique stakeholder needs, the state of scientific knowledge, modeling capabilities, and specific health and ecosystem impacts due to different HAB species and toxins. Similar approaches and methods however can be used across regions to develop and operate these regional systems in an effort to create a national HAB and hypoxia forecasting approach. Common elements for success include: co-development with stakeholders throughout the development and service delivery process; utilization of extensive regional partnerships for optimal development and support of system dependencies; and utilization of transition plans to manage the long-development timelines and extensive service delivery needs associated with these forecast systems. Importantly, forecast systems can be

externally developed and operated, through extensive NCCOS support; internally developed and operated within NCCOS; or a combination of both, depending on regional considerations and funding sources needed to sustain long-term operations. Across systems, our metrics for success include the ability for coastal managers within these regions to move from reactive to proactive management to reduce the impacts of HABs and hypoxia.

Session Presenters

- Alex Hounshell, *Research Oceanographer, Beaufort Laboratory, HAB Forecasting Branch*
- David Scheurer, *Oceanographer, NCCOS Program Office and Headquarters, CRP*
- Rick Stumpf, *Oceanographer*, *NCCOS Program Office and Headquarters, HAB Forecasting Branch*
- Quay Dortch, *Senior HAB Scientist, NCCOS Program Office and Headquarters, CRP*

HABs Toxin Detection

Session Summary

NCCOS plays a crucial role in the development of HAB toxin detection tools that can provide a direct measure of HAB poisoning risk. The goal of this effort is to eliminate HAB poisonings through accurate identification and quantification of HAB toxins. Standardized and validated toxin detection methods enhance user-focused HAB toxin detection capabilities. Furthermore, NCCOS trains stakeholders to implement standardized HAB toxin detection capabilities at the point of need. NCCOS employs an adaptable approach in the development and improvement of toxin detection tools. This process begins with research, proceeds through validation and approval, and, as necessary, can loop back to the research phase following evaluation. Equipped with resources and expertise, we collaborate with commercial, academic, governmental, and tribal partners, uniquely positioning NCCOS to advance the development of toxin detection tools. Our approach to the development of toxin detection technologies follows the R2X model, including research to commercialization, operations and application. By harnessing new technologies, adapting to changing priorities, and addressing community needs, NCCOS remains at the forefront of efficiently applying innovations that empower coastal managers and communities with decision-informing tools that are vital for issuing consumer warnings and for minimizing HAB toxin risks.

Session Presenters

- Tod Leighfield, *Chemist, Hollings Marine Lab, HAB Monitoring and Reference Branch*
- Sarah Pease, *Physical Scientist/Program Manager, HAB Event Response Coordinator, NCCOS Program Office and Headquarters, CRP*

HAB and Hypoxia Control

Session Summary

Although the control of algal growth in small freshwater ecosystems is commonplace, the ability to successfully control algal blooms at larger scales has proven to be difficult. In this session, we will discuss how NCCOS is using a 4-stage approach to tackle this problem through the development and implementation of HAB control technologies. Using internal expertise along

with external academic and industry partners, we develop ideas and take them through a proof of concept stage to assess their effect on HAB species. Promising ideas move through a research and development stage to assess their effectiveness. In this stage we test their ability to reduce or eliminate algal cells and their toxins without harming the environment. If successful, ideas are then moved into a demonstration and validation stage to demonstrate their feasibility and scalability. This stage is where we can demonstrate that a new technology can be deployed successfully at reasonable costs over the appropriate scales to control a particular HAB situation. Those technologies that have shown to be both feasible and scalable then move into the fourth and final stage which is their transfer into application. Although NCCOS does not directly engage in the operational use of HAB control technologies, at this stage we can provide guidance and support to fulfill the appropriate regulatory and permitting requirements. During the presentation, we will highlight four ongoing NCCOS projects that illustrate our efforts at one or more of these four stages.

Session Presenters

- Kaytee Pokrzywinski*, Research Marine Biologist, Beaufort Laboratory, HAB Forecasting Branch*
- Peter Moeller*, Research Chemist, Hollings Marine Laboratory, HAB Monitoring and Reference Branch*
- Felix Martinez*, Physical Scientist, Prevention, Control and Mitigation of Harmful Algal Blooms (PCMHAB) Program Manager, Great Lakes Environmental Research Laboratory, CRP*

Appendices

APPENDIX A: Tabular Report Template for Reviewers

Each member of the review panel will use her / his scientific expertise and professional judgment to provide independent observations, evaluation, and recommendations on different aspects of the NCCOS HAB and hypoxia portfolio, including product value and utilization. Each member of the Review Panel will also prepare notes on his/her observations, comments and recommendations that, at a minimum, address the three core evaluation criteria: Quality, Relevance, and Performance. For convenience, a tabular format is provided for recording comments on different aspects of the review.

A link to the Tabular Report Template for Reviewers can be found at this link.

APPENDIX B: Branch and Program Logistics

HAB Forecasting Branch

Overview:
The HAB Forecasting Branch (HAB-F) delivers monitoring and forecast products in near-real time as mandated by the Harmful Algal Bloom and Hypoxia Research and Control Act of 1998 (2004, 2014, 2019) (HABHRCA), which states that NOAA is mandated to advance the scientific understanding and ability to detect, monitor, assess and predict HABs. The Act specifically calls out the need to: 1) Identify research, development, and demonstration activities needed to minimize the occurrence of HABs; 2) Improve capabilities to detect, predict, monitor, control, mitigate, respond to, and remediate HABs; and 3) Identify ways to reduce the duration and intensity of HABs.

All HAB-F major activities involve collaborations with partners and engagement with stakeholders. Importantly, delivery products are designed to meet a range of stakeholder needs and can be targeted to specific stakeholder groups. For example, content delivered on the NCCOS/HAB-F webpage is generally designed for a broad audience, with most products geared towards a general audience, with additional products and explanations designed for or in response to a more technical audience (i.e., state and local managers; researchers). In addition, service delivery is assessed via both passive and active means, including webpage analytics and GovDelivery bulletin metrics (passive) as well as via stakeholder feedback via informal discussions, email, and user groups (active). Success is often measured in the level of engagement via web pages or bulletins, media interest, and high engagement from stakeholders and end-users.

HAB-F maintains and delivers several forecast products operationally, as defined by the NOAA policy on transitioning research to operations (NAO 216-105B). Currently these operational forecasts include western Lake Erie, the Gulf of Mexico, and the Gulf of Maine. Other forecast products are in developmental and or testing stages, including Lake Okeechobee, southeast Alaska, and the lower Chesapeake Bay. Along with operational forecasts, the branch also performs remote sensing of HABs, research on the ecological impacts of HAB and the factors leading to HABs, and research on emerging HAB control methods.

Each forecast incorporates the following key components:

- Stakeholder engagement and participation in observations is a critical component of the process in order for NOAA to develop and maintain products that address users needs.
- Scientific engagement with the community involved with the research on the blooms of concern, 3) Maintenance and growth of observations networks, including ever improving satellite surveillance, and utilization and improvement of robust computing platforms.
- Cross-NOAA coordination and engagement with regional decision makers and partners (IOOS, Regional Associations [RAs], non-governmental organizations [NGOs] and academic institutions) who drive product development and implementation, and

- Continued laboratory and field research essential to providing the information improving the forecast products to meet user requirements with the latest scientific advances.

The HAB-F Branch contains nationally and internationally recognized experts in the biology and ecology of HABs, as well as the programming, modeling, and technical expertise needed to complete the HAB-Fs mission and develop and maintain HAB research and operational products. These personnel and associated facilities and equipment are located at both the NOAA NCCOS Silver Spring and Beaufort locations, with additional contract staff at the Charleston Lab as well as located remotely. Facilities in Silver Spring consist of office space and computer systems with staff and contractors focused on HAB monitoring via satellite remote sensing and HAB modeling and forecasting efforts.

HAB-F has grown considerably in recent years, from 14 members in FY17 to a planned 24 members in FY23. This growth is in part due to increased congressional interest in HABs and the products, research, and forecasts developed by HAB-F. The additional staff give HAB-F the ability to meet programmatic needs while investing in the science community and expanding our research and operational products. HAB-F uses a combination of full time employees (FTEs), contractors, and affiliates (i.e., NERTO interns, ORISE fellows, etc.) to accomplish our mission and provide the oversight, technical expertise, and communication abilities to meet its short-term and long-term operational and research goals.

Forecasts:
HAB-F maintains several research, operations, and service delivery activities to support the branch's mission to provide regional HAB research and products to a variety of stakeholders. Each of these aspects of HAB-F are vital to maintaining the branch's ability to meet its mission and continue to provide reliable, adaptable, and dependable HAB monitoring and forecasting.

Current HAB-F operational products include HAB forecasts for Lake Erie, Gulf of Mexico, and Gulf of Maine, in addition to the operational HAB Monitoring system. Below, we discuss each operational product including the resources, partners, and data needed to run each forecast in addition to the various annual assessments, research market assessments, end-user assessments, and current research needs.

Lake Erie – Microcystis

The Lake Erie operational forecast provides information on the location, intensity, and severity of the annually occurring, summer *Micocystis* bloom in the western basin of Lake Erie. The forecast system includes a seasonal forecast used to predict the maximum bloom severity for the upcoming bloom season, and a daily forecast produced during the bloom season (~July-October) which provides information on the current bloom location and intensity as well as the upcoming 5-day forecast. The Lake Erie forecast was first developed by NCCOS using model output from GLERL as an experimental product in 2008, before being transitioned to CO-OPs for operational use in 2017. The model was then updated and returned to NCCOS in 2021. Stakeholders for the Lake Erie forecast include: federal and state agencies (Ohio EPA, US EPA,

Canada), water treatment plants, state resource and health departments, as well as beachgoers, fishers, tourists, restaurant/shop owners, and the general public.

Gulf of Mexico - Karenia brevis (red tide)

The Gulf of Mexico Harmful Algal Bloom Forecast provides products for the Florida and Texas coasts including: current location and intensity of *K. brevis* blooms based on satellite imagery and collected cell counts, as well as 36 hour respiratory irritation forecasts produced for individual beaches based on wind forecasts and cell count concentrations. For Florida, additional forecasts include the Intensification Forecast which provides daily predictions of bloom initiation or intensification on the west coast of Florida based on upwelling conditions and cell count concentrations during the early bloom season (~August-October). Respiratory irritation forecasts are updated every 3 hours on the forecast website while bloom location information is updated daily with new satellite imagery. In addition, weekly bulletins are sent to stakeholders and end-users via GovDelivery weekly during the bloom season. During periods of "HIGH" respiratory irritation risk, additional daily HAB alert warnings are sent to respective NWS Weather Forecasting Offices for additional dissemination via social media (i.e., Twitter, Facebook). The Gulf of Mexico forecast was developed over 10 years ago as an experimental product before being transferred to CO-OPs as an operational system. In 2021, the Gulf of Mexico forecast was transferred back to NCCOS as an updated, operational product. Stakeholders include: state research agencies (FWCC, Red Tide in Texas), academic and non-profits (Mote, ATM, UTRGV), county officials (Pinellas, Lee, Collier), state resource and health departments, as well as beachgoers, tourists, restaurant/shop owners, and the general public.

The respiratory irritation forecast relies on *K. brevis* cell count data collected from the HABScope community scientist network (Gulf of Mexico Coastal Ocean Observing Network, GCOOS) as well as from state and local partners including Florida Fish and Wildlife Research Institute, Pinellas County, and the Sanibel-Captiva Conservation Fund. Wind and weather forecasts used in the respiratory irritation forecast come from the National Weather Service (NWS). Respiratory irritation reports used for forecast validation are sourced from Pinellas County and Mote Marine Laboratories Beach Conditions Reporting System.

The intensification forecast uses cell count data described above, as well as wind data from NWS and is produced daily during the early bloom period (~August-October). In addition, satellite imagery is obtained from Copernicus Sentinel-3 and is processed by HAB-F daily as part of the HAB monitoring operational system. Additional products may be developed and/or incorporated into the Gulf of Mexico forecasts, including: incorporating satellite imagery as an estimate for respiratory irritation and incorporating a coastal circulation model for bloom initiation/intensification.

Gulf of Maine - Alexandrium catenella

The Gulf of Maine *Alexandrium catenella* Predictive Models provide a seasonal forecast (March) of upcoming bloom severity as well as a weekly nowcast/forecast (March-July) for the location

and intensity of the current *A. catenella* bloom in the Gulf of Maine. The forecast includes a map of *A. catenella* cysts measured during the previous fall/winter, a hydrodynamic model, and growth model to predict *A. catenella* concentrations throughout the Gulf of Maine and at specific locations along the coast. In addition, a PDF is generated weekly which includes near-real-time cell count data from external partners and forecasts of onshore transport and toxicity risk for the next 2-days. The Gulf of Maine forecast was originally developed by WHOI in 2008 before being transferred to NCCOS in 2016. The Gulf of Maine is currently in the demonstration phase and will move to operations in FY24/FY25. Stakeholders include: New England states (NH, MA, and ME), water resource authorities (MA), and NOAA NMFS. The forecast uses a map of *A. catenella* cyst distribution from the previous fall/winter obtained from an annual NCCOS/HAB-F cruise coupled with wind, cloud, humidity and heat flux data from NOAA NCEP; surface heat flux from NOAA/NASA; daily river discharge from USGS; climatological nutrient data from the University of Maine; and winds from NERACOOS buoys. During the bloom, cell counts and toxicity are sourced from Maine Department of Marine Resources, New Hampshire Department of Environmental Services, and Massachusetts Water Resources Authority.

HAB Monitoring System

The NCCOS/HAB-F HAB Monitoring System provides processed satellite imagery used to monitor HABs in key locations around the U.S. including: Green Bay, WI; Saginaw Bay, MI; Western Lake Erie; Albemarle Sound, NC; Lake Pontchartrain, LA; Lake Okeechobee, FL; and Southwest Florida. In addition, the website includes links to imagery provided by NOAA CoastWatch for Chesapeake Bay; Lake Anna, VA; Smith Mountain Lake, VA; and Lake Gaston NC/VA. Imagery is produced daily when satellite imagery is available and includes true color imagery and selected algorithms used for HAB monitoring. The HAB monitoring system also routinely processes imagery for all U.S. coastlines and Great Lakes, which is used for internal use and dissemination. Imagery is obtained from Ocean Land Color Imager (OLCI) on the Sentinel-3 satellite (EUMETSAT) and the Multispectral Instrument (MSI) on the Sentinel-2 satellite (ESA; CoastWatch products) and is processed automatically by NCCOS/HAB-F developed processing algorithms.

HAB-F Supporting Research:
In addition to these operational products, current research conducted by HAB-F is directly leading to the development of new operational HAB monitoring and forecasting capabilities in economically important and/or remote locations throughout the U.S. Importantly, these research activities and the development operational products are being co-developed with stakeholders to ensure developed products meet stakeholder needs and are delivered in a manner that allows stakeholders to use the information to make informed decisions. The Branch has also

HAB Monitoring and Reference Branch

Overview:

The Harmful Algal Bloom Monitoring and Reference (HAB-M&R) Branch is an intramural research program that conducts, in government laboratories, distinct, high-impact research that cannot be readily funded or accomplished in traditional academia. HAB-M&R began as the Marine Biotoxin Program in response to two 1987 events.

1. Mass Mortality of Bottlenose Dolphins. A press conference/news release claiming to have arrived at a definitive conclusion on the cause of the mass die-off of dolphins was due to a red tide. A Congressional Hearing found that NOAA lacked the capability to confirm the presence of toxins in marine mammals.
2. National Academy of Science Report on Seafood Safety that found that natural toxins represent the greatest non-bacterial risk to seafood consumers. The report recommended that the federal government should establish or support centers of research in toxins to enlarge the understanding, provide possible remedies and develop particular tests.

In response to the Mass Mortality of Bottlenose Dolphins, chemical methods with mass spectrometry detection were developed for confirmation of toxins in marine mammals. Beginning at a time when marine toxins were not a known cause for any Unusual Mortality Events (UMEs) it was later established that more than 50% of UMEs were confirmed positive for marine toxins. The HAB Analytical Response Team over 10 years investigated over 250 suspected HAB events and established a large database on marine toxins. In response to the National Academy of Science Report, "major emphasis should be placed on the development of rapid assays for each of the natural toxins", the program developed Toxin Detection Methods for all Classes of Algal Toxins in US Coastal Waters. Using high throughput design approaches for biological and biochemical assays, the program was able to establish rapid assays for all classes of algal toxins in US coastal waters.

To redirect efforts based on NCCOS priorities and focus on service delivery, the Genomics Program on HAB growth and toxin production and the Toxicology Program on animal models for HAB disease and toxicokinetics were eliminated. The Program on HAB Prevention and Control, Analytical Response Team to Reference Methods and Materials, Technology Transfer Program to User Laboratory Network, Phytoplankton Monitoring Network, and Diversified Sensor Program were created.

Research Portfolio:

Sensor development and deployment

A major and continuing focus of HAB science aims to identify and characterize the primary environmental (physico-chemical and biological) drivers of HAB toxicity in marine and freshwater systems. Researchers are striving to understand to what extent are variations in HAB toxicity a function of changes in the bloom population's genetic make-up versus environmental forcings. A more recent area of emphasis seeks to describe the effects of various climate change impacts on HAB growth and toxicity in different regions throughout the US. In

addition to forecasts of bloom biomass and trajectories, there is a need to accurately predict changes in bloom toxicity. Another critical requirement is development and implementation of a clear strategy for ingesting and assimilating real-time observations of toxin levels into models that will underpin toxicity forecasts.

The HAB-M&R Branch undertakes the strategic development and deployment of HAB toxin sensors across a range of uncrewed and hand-held platforms (in certain cases, co-deployed with 'omics-focused sampling/analysis capabilities). Through collaboration with IOOS Regional Associations, HAB-M&R uses an effective pathway to better understand the needs of stakeholders and end-users in relation to development of sensor technologies. This strategy for identifying specific customer needs serves to guide decisions on which existing or emerging technologies should be pursued from an R&D perspective and will have a high probability of yielding beneficial 'fit-for-purpose' solutions.

Testing technologies and laboratories

Testing technologies for HAB toxins generally need to be more user focused and validated/approved through an established authority (e.g. FDA). There are a number of tools for testing available, but most suffer from the lack of validation/approval or are over-complicated hindering widespread use. This work is inherently suited for government science since it is not truly discovery based science, nor is it widely suitable for funding either through typically soft funding mechanisms or through commercial markets. While numerous tools for toxin detection may be suitable for general scientific investigations (e.g. measuring toxins exposure in wildlife), wider adoption by State government and community organizations is hindered by limited validation and ease of use. Lack of simple and validated tools makes it difficult for communities to be informed on the risks posed by algal toxins, the greatest risk posed by HABs.

The NOAA Analytical Response Team was established to provide a formal framework through which coastal managers may request immediate coordinated assistance during harmful algal blooms and related health incidents. This team acts as one of the primary responders to HABs and associated mortality events, providing rapid and accurate identification of harmful algae and their associated toxins. This identification and analytical capability provides support for management agencies that can then make timely and informed decisions impacting stakeholders involved in coastal wildlife, human health, and commerce.

Analytical and reference methods

Historically, the discovery of new HAB toxins, as well as their monitoring for management, was based on *in vivo* methods such as animal bioassays. Today, new toxins and metabolites are discovered mainly through the use of advanced instrumentation such as liquid chromatography coupled to mass spectroscopy (LC/MS). In many cases, species that accumulate HAB toxins are known to metabolize these compounds to conjugated, reduced, or oxidized forms that either retain toxicity towards animals and humans or may be metabolized back into toxic forms during the processes of uptake, digestion, or elimination. Finally, over the past decade we have gained

a greater realization of the significant threats posed by freshwater HABs such as cyanobacteria and the cyanotoxins they produce and these toxins are increasingly appearing in the estuarine environments.

With the exception for the guidelines established under the National Shellfish Sanitation Program, which only focuses on HAB toxins that accumulate in commercial seafood there is a general lack of standardization for methods as well as sampling and sample preparation procedures to assure comparability of analytical data during responses to many HAB events. Historically, toxin chemists have focused on the parent molecules themselves. However, numerous derivatives (congeners) of these parent compounds, produced either by toxigenic HAB species or transformation of toxins in food webs, play important roles in the overall toxicity of the event. Additional methods of analysis that include both the parent toxins and transformed toxins (metabolites) are needed. There is a need for methods to accurately assess the presence and concentration of new HAB toxins and congeners for which analytical standards are not yet available. LC/MS is a universal tool for toxin identification and quantitation. However, sample preparation for LC/MS analysis is a critical step for toxin detection and toxin standard availability also limits the accurate toxin quantitation by LC/MS. Our NCCOS expertise in LC/MS analysis can support fundamental research associated with mechanisms of HAB toxin production and regulation by accurate toxin identification and quantification to advance our understanding of HABs and their toxin production.

Citizen science and high-resolution microscopy

The National Phytoplankton Monitoring Network (PMN) recognizes the connection between humans and coastal ecosystems, and provides volunteer citizen scientists with meaningful opportunities for hands-on science engagement. The acceptance of citizen science observations has traditionally been a limitation to most programs. Since the inception of PMN, the validity of citizen science observations has been achieved with a rigorous QA/QC using high resolution microscopy. The program has enhanced the nation’s ability to respond to and manage the growing threat posed by HABs by collecting important data for species composition and distribution and by creating working relationships between volunteers and professional researchers. PMN has also supported Alaska tribes in building a monitoring network for algal toxins in their subsistence, traditional, and recreational shellfish harvests. Recently, PMN has developed tools to enhance the diversity of participation of the network. NCCOS expertise has opportunities to advance HAB technologies and bring these services to a diversity of communities. PMN volunteers can also assist and serve as a test bed for other technologies developed by NCCOS and other agencies.

Projects and new areas are chosen by listening to both citizen scientists and user groups' needs and impediments. PMN has used mechanisms such as Interagency Agreements, grants and the NCCOS PAF process to develop tools, examine different lesson plans, and techniques for incorporation into the National Phytoplankton Monitoring Network. This is achieved by direct interaction with volunteers and by attending national and regional end-user meetings and workshops. Input to the monitoring network is achieved by interaction with both citizen scientists

and end-users by workshops and scientific meetings. These interactions and listening sessions are used to evolve the network. For example, the Interagency Agreement with EPA developed methods and techniques for monitoring cyanoHABs. The EPA IAA was a test bed for volunteers to examine different lesson plans and techniques for incorporation of these methods into the National PMN. A similar model will be followed for the NCCOS funded PAFs Latino PMN and Sensory Impairment project. Tools developed will be incorporated into the National PMN network once finished.

Prevention and control

HABs occur for many different reasons; however, when a bloom reaches an impactful state, the overriding concern from the public is to make it go away. The importance of controlling HABs is paramount to the NCCOS legislative mandate: The Harmful Algal Bloom and Hypoxia Research and Control Act. HABHRCA affirms Control as the intended outcome of Research. Control is the central part of the Prevention, Control & Mitigation triad, central because Prevention is not often feasible nor economically acceptable, and Mitigation is often too little and too late. As charged by the HABHRCA research strategy and action plan, the HAB-M&R Branch focuses on strategies that directly kill HAB cells or destroy their toxins, physically remove cells and toxins from the water column, and/or limit cell growth and proliferation. NCCOS research has utilized ozone impregnated nano bubbles beyond controlling HABs because of the ability to reduce or eliminate nitrogen and phosphorus from the water column, and is midway through a PAF project identifying the fate of nitrogen and phosphorus.

Of increasing concern is addressing HAB control at increasing scale and scope. Nano bubble generating instrumentation (NBOT) now exists in numerous sizes and configurations. Flow rates, oxygen and ozone generation can be scaled appropriately to the problem at hand. Larger instrumentation can be utilized on projects of bigger scope. Smaller needs such as ponds, small lakes and canals have been treated with much smaller equipment, and parameters adjusted to suit the problem being addressed. This is where CRADA agreements with the commercial side allow us to work on the science side of the problem. Multiple companies come to the CRADA with their increasingly more efficient and higher capacity instruments, which we then evaluate. We continually evaluate instruments well before they come to market and move to competing companies as they improve the technology to meet projects of larger scale.

Competitive Research Program (CRP)

Overview:
The CRP supports a suite of research programs that provide the critical information and predictive capabilities required to manage the nation's coastal resources in an ecosystem context. CRP identifies national and regional research priority issues on behalf of NCCOS and NOS, and addresses these issues via a stressor-based or regional-ecosystem approach. The issues addressed typically require multidisciplinary research teams and a significant long- term commitment of resources because of their complexity and the effort required to reach a new level of understanding sufficient to drive future coastal management decisions.

To ensure that research results and tools are used by stakeholders to achieve societal benefits. Efforts focus on leading national and regional coordination, planning, and implementation efforts to ensure that research findings, publications, and tools are used to inform coastal ecosystem management and that they result in management outcomes. This also includes engaging potential users of research products and outcomes, to ensure the delivery and transition to management applications.

CRP research priorities are based on Congressional direction, administration priorities, NOAA mandates and strategic plans, and constituent needs. Research projects are selected through competitive, merit- based processes that identify the most qualified teams of scientists in the nation, drawing from academia; governmental agencies; and other research, management, and conservation organizations. As previously mentioned, the following programs that are relevant to the review are executed by the CRP:

- Ecology and Oceanography of Harmful Algal Blooms (ECOHAB) Program
- Monitoring and Event Response for Harmful Algal Blooms (MERHAB) Program
- Prevention, Control, and Mitigation of Harmful Algal Blooms (PCMHAB) Program
- Social, Cultural and Economic Assessment of Harmful Algal Blooms (SEAHAB)
- HAB Event Response (ER) Program
- Coastal Hypoxia Research Program (CHRP)

CRP Program Research Portfolios

ECOHAB
ECOHAB is a national, peer-reviewed, competitive research funding program that seeks to achieve a holistic, quantitative understanding of nuisance and toxin-producing HABs to inform the development of predictive models, forecasts, mitigation tools, and prevention strategies.

The ECOHAB program funds research to understand the causes and impacts of harmful algal blooms (HABs) and their toxins, which is fundamental for detecting, predicting, controlling, mitigating, and responding to HAB events. ECOHAB was authorized by HABHRCA in 1998 (*guided by ECOHAB Report*) and reauthorized in 2004, 2014, and 2017.

Program goals include:

- Quantitative understanding of HABs and, where applicable, their toxins in relation to the surrounding environment with the intent of developing new information and tools, predictive models and forecasts, and prevention strategies to aid managers in coastal environments.
- Understanding leading to models of trophic transfer of toxins, knowledge of biosynthesis and metabolism of toxins, and assessments of impacts of toxins on higher trophic levels.

MERHAB

The Monitoring and Event Response for Harmful Algal Blooms (MERHAB) Research Program builds capacity along our coasts for enhanced HAB monitoring and response. This helps NOAA and state partners identify when beaches, shellfisheries, and marine animals are at risk from harmful algae, and to make informed decisions that protect public health and safeguard our coastal economies. MERHAB was authorized in 1998 by HABHRCA and reauthorized in 2004, 2014, and 2017.

As a result of the MERHAB Program, managers are better armed to mitigate HAB problems in their communities. We help states, tribes, and other monitoring agencies keep pace with the growing national HAB problem by providing them access to proven detection technologies, helping to validate these technologies, and assess benefits of incorporating existing methods. MERHAB also supports ongoing efforts to develop predictive models and operational HAB forecasts. MERHAB is authorized as a national competitive research program within NOAA under HABHRCA.

The principal objective of MERHAB is to build the capacities of local, state, and tribal governments, and the private sector, for less costly, and more precise and comprehensive monitoring of HAB cells and toxins, and for responding to HAB events. Improved monitoring and event response capability will be achieved through applications that meet management needs including:

- Adopting faster, less expensive, and more reliable detection methods for HAB cells and toxins in routine monitoring programs;
- Adopting instrumentation for low-cost, long-term observations of conditions that influence HAB dynamics;
- Improving monitoring strategies and forecast models to enhance early warning capability, foster improved response to HAB events, and demonstrate operational capabilities;
- Enhancing response capabilities to ensure trained and equipped personnel are able to mobilize quickly, conduct appropriate sampling and testing, and communicate effectively during HAB events.

PCMHAB

The PCMHAB program funds research to move promising technologies for preventing, controlling, or mitigating HABs and their impacts through development, to demonstration, and,

finally application, culminating in widespread use in the field by end-users. The program also funds socioeconomic research to assess impacts of HAB events on coastal economies and societies, and the costs and benefits of mitigation strategies to aid managers in devising cost-effective management strategies. PCMHAB was authorized as a national competitive research program within NOAA under HABHRCA in 1998 and reauthorized in 2004 and 2014. Benefits to the public include healthier fisheries and ecosystems, fewer impacts of blooms on humans and the environment, reductions in nuisance or harmful algae and decreased costs for states, tribes, and local governments in monitoring and managing HABs and their impacts.

Program goals include:

- Foster the development, demonstration, and transition of existing and promising prevention, control, and mitigations technologies and strategies to end-users.
- Assess the societal impacts of HAB events at local scales, and the costs and benefits of mitigation strategies.

SEAHAB

The SEAHAB Program funds research for the social, cultural, and economic assessments of HABs. The CRP has announced a fiscal year 2024 notice of funding opportunity (NOFO) that seeks to support research and to provide more accurate assessments of the social, cultural and economic impacts of harmful algal bloom (HAB) events at local, state, regional and national scales. This research will better inform the selection of management strategies and methods most appropriate to a specific HAB event and ongoing HAB issues.

The increase in frequency, extent, and variety of HABs has increased society's concerns about the safety of our seafood and drinking water, the health of endangered species, fish and wildlife, the sustainability of beach and lakeside communities, losses to fisheries and aquaculture, increased strain on shrinking state, local, cultural and tribal resources, and long-term aquatic ecosystem changes. Economic costs associated with HAB impacts on public health, fisheries, recreation, and tourism, as well as the use of scarce funds for monitoring and management can be significant for local communities.

HAB Event Response

The HAB Event Response Program provides immediate support to help state, tribal, and local officials manage events and advance the understanding of HABs as they occur. Three types of HAB events are prioritized: events with significant management or resource impacts, events associated with marine animal mortalities, and unusual or unique HAB events. Depending on need, the program may support or provide access to toxin analysis, data collection, training, technical assistance, and ship-based sampling. Modest funding is available to help defray the costs of immediate mobilization of response efforts.

The HAB Event Response Program works with the NCCOS Analytical Response Team, HAB Monitoring System, and Phytoplankton Monitoring Network, as well as other NOAA offices (e.g., NMFS Marine Mammal Stranding) to connect those requesting support with the applicable expertise and services to respond to ongoing HAB events.

CHRP

The Coastal Hypoxia Research Program is an NCCOS competitive research program focused on advancing the understanding and management capabilities to assess, predict, and reduce hypoxic events and their environmental impacts on our nation's oceans, estuaries, coasts, and Great Lakes ecosystems. CHRP was authorized in 1998 by HABHRCA and reauthorized in 2004, 2014, and 2017.

Program goals include:

- Improve the ability of resource managers to effectively prevent or reduce the ecological and economic impacts of hypoxia on marine and Great Lakes ecosystems.
- Prevention or reduction of hypoxia requires a fundamental understanding of the causes and consequences of hypoxia and tools to evaluate the effectiveness of management strategies.

APPENDIX C: HABHRCA Reports

Each authorization of HABHRCA has required the IWG-HABHRCA to produce a number of reports. These are listed below by the amendment that required them, and, if completed, are linked:

HABHRCA 2014 - Required

- HAB and Hypoxia Comprehensive Research Plan and Action Strategy
- Report on Implementation of the HAB and Hypoxia Action Strategy
- Great Lakes Hypoxia and HAB Integrated Assessment (Incorporated into the Research Plan and Action Strategy)
- Great Lakes HAB and Hypoxia Plan
- Progress Report on Northern Gulf of Mexico Hypoxia
    - Mississippi River/Gulf of Mexico Watershed Nutrient Task Force 2015 Report to Congress

HABHRCA 2004 - Required

- National Assessment of Efforts to Predict and Respond to Harmful Algal Blooms in U.S. Waters, 2007
- Scientific Assessment of Marine Harmful Algal Blooms, 2008
- Scientific Assessment of Freshwater Harmful Algal Blooms, 2008 Based on Proceedings of the Interagency, International Symposium on Cyanobacterial Harmful Algal Blooms (ISOC-HAB): State of the Science and Research Needs, also available as Cyanobacteria Harmful Algal Blooms: State of the Science and Research Needs
- Harmful Algal Bloom Management and Response: Assessment and Plan, 2008 Based on Research, Development, Demonstration, and Technology Transfer National Workshop Report: A Plan for Reducing HABs and HAB Impacts
- Scientific Assessment of Hypoxia in US Coastal Waters, 2010

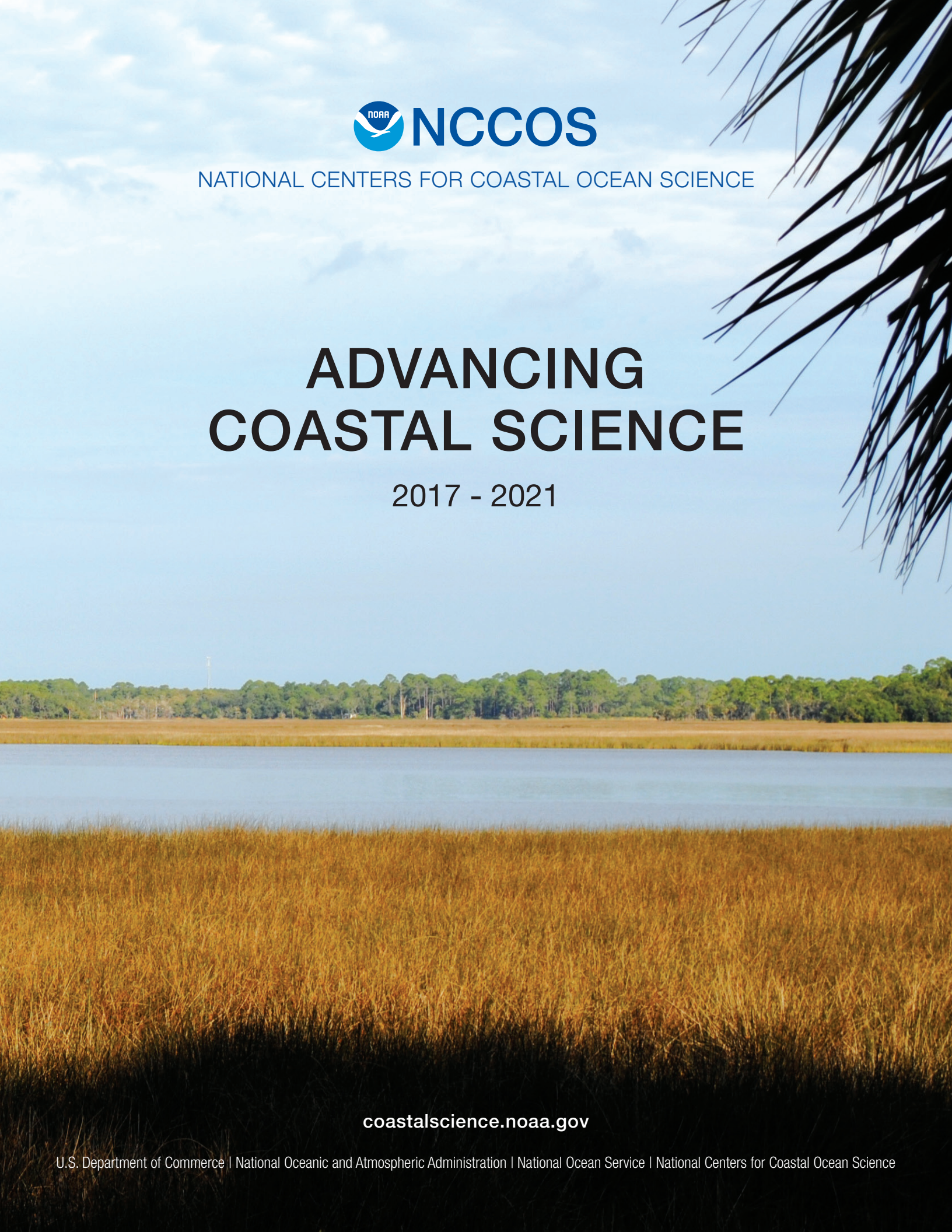
HABHRCA 1998 - Submitted to Congress

- National Assessment of Harmful Algal Blooms in U.S. Waters, 2000
- An Integrated Assessment of Hypoxia in the Northern Gulf of Mexico, 2000
- Action Plan for Reducing, Mitigating, and Controlling Hypoxia in the Northern Gulf of Mexico, 2001
- An Assessment of Coastal Hypoxia and Eutrophication in U.S. Waters, 2003

APPENDIX D: NCCOS Strategic Plans

The full PDF document for the FY 2017-2021 Strategic Plan: Advancing Coastal Science can be found at this link. For reviewers' convenience we have also included the full document below.

The full PDF document for the FY 2022-2026 Strategic Plan: Science Service Coastal Communities can be found at this link. For reviewers' convenience we have also included the full document below.



NCCOS

NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE

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Steven Thur, Acting Director
Image credit: NCCOS

LETTER FROM THE ACTING DIRECTOR

The United States has been endowed with a tremendous asset: our ocean and coastal resources. The facts are incontrovertible. Coastal counties contribute over $6.6 trillion to our Nation's gross domestic product, which is nearly 50% of national output.[1] Approximately 40% of U.S. citizens live in these counties, attracted by both the natural beauty of the coasts and plentiful employment opportunities.[1] It is here that Americans live, work, recreate, and seek to reconnect with nature.

With such a concentration of human activity, there exists the potential for conflict between various uses of these resources. In addition, the coastal environment is a dynamic place; sea levels change, natural resources shift, patterns of human use vary, and industries wax and wane. Officials at the local, state, tribal, and federal level, along with those in the corporate and non-profit sectors, must use the best available information to make decisions that affect livelihoods, property values, human health, preparedness for disasters, management of our natural resources, and protection of special places for future generations.

Our role is to conduct the research and provide the information necessary to address these complex coastal challenges. The mission of the National Centers for Coastal Ocean Science (NCCOS) is to deliver ecosystem science solutions for stewardship of the Nation's ocean and coastal resources to sustain thriving coastal communities and economies. *Advancing Coastal Science* outlines how we shall accomplish that mission. It is the product of three years of engagement with stakeholders, which enabled us to refine our understanding of the most critical issues and how our scientific expertise could aid decision-makers.

Image credit: NCCOS

Advancing Coastal Science includes a section on what makes NCCOS unique - its federal employees, contractors, and other staff who work side-by-side to improve our collective understanding and provide science solutions. They are creative, dedicated, and focused on our role in serving the public interest through science. They are why I know we will be successful in accomplishing all that *Advancing Coastal Science* outlines.

Steven Thur, Ph.D
Acting Director
National Centers for Coastal Ocean Science

VISION

Science serving coastal communities

MISSION

The National Centers for Coastal Ocean Science delivers ecosystem science solutions
~ for stewardship of the Nation's ocean and coastal resources
~ in direct support of NOS priorities, offices, and customers
~ to sustain thriving coastal communities and economies

Image credit: NCCOS

Advancing Coastal Science lays out four priorities developed as a result of a lengthy stakeholder engagement process. These priorities will be our driving force over the next five years, and will guide NCCOS's science and competitive research investments. NCCOS will continue to use the National Ocean Service Coastal Science Board to understand and prioritize coastal management science needs around the nation. NCCOS will continue to serve Gulf of Mexico communities through management of the NOAA RESTORE Act Science Program.

STRATEGIC SCIENCE PRIORITIES

Marine Spatial Ecology (MSE)

Coastal communities need to balance the inherent trade-offs between resource use and conservation. Managers need comprehensive information to evaluate the benefits and consequences of actions on both the ecosystem and the community. Marine Spatial Ecology (MSE) integrates a broad spectrum of physical, biological, and social sciences, to inform coastal and marine decision making. Communities, state and federal stewards, and industries such as aquaculture, offshore energy, and tourism use MSE to make decisions so that the economy can thrive and residents and visitors can enjoy our Nation's natural heritage, now and for generations to come.

NCCOS has long been a leader in the MSE community, providing a three-decade foundation of reliable and objective ecological and socioeconomic information. NCCOS scientists will continue to provide integrated biogeographic, ecological and social assessments – alongside mapping and monitoring products and services – to provide an end-to-end MSE enterprise in support of customers in the coastal and ocean management community. These unique capabilities are used by federal, state, and local decision makers to ensure that special places are valued, protected, and preserved, and to assist in growing the economies that are dependent on our Nation's maritime resources.

Consistent with NOAA's role as a public information agency, NCCOS includes stakeholder involvement as a standard in developing MSE products for decision makers. NCCOS focuses its MSE activities primarily where there is a clearly articulated management objective and user-defined application. NCCOS has identified four distinct MSE sub-priorities.

Ecological and Biogeographic Assessments

Stewardship of our Nation's coastal and marine resources is one of the primary purposes of the National Ocean Service, and NCCOS's nationally-recognized ecological and biogeographic assessments are critical to achieving that mission. Biogeographic assessments examine spatial and temporal distributions of organisms, habitats, and the historical and biological factors that produced them. Ecological assessments are more broad-based activities and range from defining the characteristics and status of ecosystem components that provide baseline conditions to detecting change in those conditions over time.

The Departments of Defense, Energy, the Interior, and state coastal zone programs and other federal, state, local, academic, not-for profit, and industry customers use our ecological and biogeographic assessments to meet their missions. Our customers use these assessments in various ways, such as to design and define the efficacy of marine protected areas which protect cultural or natural resources; preserve future recreational and commercial fisheries through identification of habitats used by fish; quantify and map social values and ecosystem services; and to implement sound national energy policy.

Habitat Mapping

Coastal resource managers and many coastal and offshore industries like energy and shipping need high-quality and reliable map products to make smart management and business decisions. Understanding coastal, pelagic, and benthic habitats can allow industry, regulators and special interest groups to come together to make more comprehensive planning decisions regarding, for example, the siting of offshore energy facilities or navigation routes for ships that are safer for whales, and beneficial to coastal tourism.

Federal agencies need NCCOS's habitat mapping products for management of living marine resources, monitoring and assessing conditions from the shore to the seabed over the short and long-term, and assessing the effectiveness of federal or state management actions. NCCOS's efforts to map coastal, pelagic, and benthic habitats also supports technology development, as we work with private industry and academia push the boundaries of time-sensitive, efficient and integrated data collection and visualization.

Divers around the open-ocean aquaculture cage at the Cape Eleuthera Institute.
Image credit: Kelly Martin, Cape Eleuthera Island Institute

Regional Ecosystem Science

Oceans, rivers, coastal features, and the species that inhabit them do not limit themselves to the political boundaries of cities, states or their elected officials or career resource managers. Management of these resources therefore benefits from scientific study at a regional scale.

Managers use NCCOS data, tools, and predictive models to evaluate alternative management strategies with emphasis on regional scale ecosystem processes that support ecosystem-based management. The public and/or key stakeholder groups must also be engaged in understanding and accepting the regional ecosystem science that underlies the management options and decisions if they are to give the support needed for difficult and fiscally challenging management decisions. Regional governance bodies value the broader ecosystem science approach NCCOS provides, as their management issues remain complex, crossing scientific disciplines as well as geopolitical borders.

Coastal Aquaculture Siting and Sustainability

Over 90% of seafood consumed in the United States is imported, resulting in a $12 billion trade deficit, food insecurity, and missed economic opportunities.[2] For many coastal communities, aquaculture promises economic development, revitalization of working waterfronts, and a more resilient coastal landscape. With an immense exclusive economic zone, U.S. coastal resources are vast and capable of providing environmentally sustainable seafood to meet growing U.S. and global demand.

Coastal managers, planners, and the aquaculture industry need NCCOS's innovative science. Predictive models, datasets, maps, tools, and targeted research are defining and informing sustainable aquaculture development along every coastline of the Nation. NOAA, the aquaculture industry, and coastal communities are working together to maintain healthy resilient coastal ecosystems to cultivate a sustainable aquaculture economy.

Visible "red tide" along the coast of La Jolla, San Diego County
Image credit: Kai Schumann

Stressor Impacts and Mitigation (SIM)

Stressors are factors that alter the biological performance or state of an ecosystem. Primary stressors include harmful algal blooms, chemical contaminants, nutrients, and pathogens that impact coastal habitats, resources, and communities. These stressors have been reported in every state and are increasingly affecting coastal, Great Lakes, and inland communities and economies. Chemical contaminants, hypoxic conditions, and the toxins produced by harmful algal blooms, for example, threaten human and animal health, and can cripple local and regional economies by contaminating drinking water for humans and livestock, closing fisheries, repelling tourists, and lowering property values.

Coastal, Great Lakes and inland communities rely on NCCOS for ecological forecasting, stressor detection, and an understanding of stressor impacts on coastal resources to assist in managing the security of their water supply, safety of local fishing and shellfishing industries, the health of their people, and the strength of their coastal and lakefront tourism. Federal agencies such as the Departments of the Interior, Agriculture, and Energy, and NOAA use NCCOS's scientific findings, models, tools, and technologies to inform response actions and injury assessments, and in coastal management applications. NCCOS conducts its SIM research in two sub-priority areas.

Harmful Algal Bloom (HAB) Detection and Forecasting

Managers of fisheries, beaches, and water treatment facilities need information on HAB detection and forecasting to plan for and deal with the adverse environmental, economic, and health effects associated with HABs. These managers also need to know about a bloom's toxicity: is it a mere discoloration of the water, or is it dangerous to drink or touch? In 1998, Congress recognized the severity of these threats and authorized the Harmful Algal Bloom and Hypoxia Research and Control Act. Subsequent reauthorizations expanded the mandate for NCCOS to advance the scientific understanding and ability to detect, monitor, assess, and predict HAB and hypoxia events.

NCCOS empowers communities to take action on HAB issues by developing detection tools and forecasts. We are researching what makes blooms toxic (not all blooms are toxic), and developing hand-held and autonomous tools to detect toxins, as well as analytical methods and reference materials to assure measurements are accurate. Short-term forecasts pinpoint where blooms are, how big they are, and where they are headed. Longer-term, seasonal forecasts predict the severity of HABs for the bloom season in a particular region. Citizen monitoring networks inform managers of the onset of toxic bloom events. These new detection technologies and forecasts are not only making drinking water safer and helping us understand which blooms will become toxic, they are opening the door to new commercial fisheries by providing accurate onsite testing for toxins in commercial shellfish.

Biological Effects of Contaminants and Nutrients

Contaminants and nutrients pollute the marine and coastal environment, causing acute or long-term impacts to ecosystems, humans and animals – from shellfish to pets. Federal agencies with regulatory, management, or response missions have science needs that frequently overlap with those of community, fisheries, and public works managers. NCCOS provides the science to help managers understand the biological effects of contaminants and nutrients and evolve actions over time, or respond quickly to avert a crisis.

NCCOS conducts national or long-term research to understand the effects of contaminants, nutrients, and hypoxia. Measuring contaminants in mussels and oysters, or the breadth of the Gulf of Mexico's dead zone, where agricultural runoff from the middle of the country leads to summertime conditions that cannot support bottom-dwelling marine life. These measurements and predictions allow better decisions affecting health and seafood safety by local, regional, and upstream managers.

NCCOS is also concerned with more specialized or localized research questions where there is a unique need by Federal, tribal, state, and local officials, often in partnership with an industry or non-profit organization. For example, scientific understanding of the impacts of oil dispersants in a laboratory setting can help coastal and fisheries managers, and the oil and chemical industries make long-term and rapid response decisions. NCCOS provides the science to help managers understand the biological effects of contaminants and nutrients and evolve their actions over time, or respond quickly to avert a crisis.

Coastal Change: Vulnerability, Mitigation, and Restoration

Coastal storms, flooding, and rising seas pose a persistent threat to coastal communities; in 2016, the United States experienced 15 weather and climate disasters with losses exceeding $1 billion.[3] Businesses can suffer loss of production, or the inability to reopen. People can lose their lives, homes, businesses and/or property and the social fabric that knits the community can be torn asunder. Resilience is the ability of a community to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events.

Changes in climate and an increase in extreme events can alter coastal ecosystems and the services those ecosystems provide to support our coastal communities and economy. NCCOS's research efforts seek to understand the ecosystem services that improve a community's resistance to the impacts of weather and changing climate conditions. NCCOS provides timely and actionable scientific assessments, information, and tools which coastal communities use to make risk management decisions. The Coastal Change portfolio is comprised of four distinct sub-priorities.

Vulnerability and Risk Assessment

Coastal decision makers need to understand the risks and vulnerabilities facing their communities and ecosystems in order to help them become resilient. Coastal decision makers can include city, county, and state elected officials, coastal and emergency managers and planners, leaders of industry or neighborhood associations. NCCOS develops models and tools that integrate biological, hydrologic, physical, socioeconomic, and other factors to evaluate coastal resilience. NCCOS provides assessments of a community or ecosystem's characteristics to provide a better understanding of how extreme events will impact its residents' or natural systems' ability to be resilient. These characteristics, which are subject to the impact and response of the community or ecosystem to events and disturbances, can help determine the vulnerability of the collective community, beyond its geographic, economic, or infrastructural vulnerabilities.

Together with other NOAA partners, NCCOS conveys useful risk and vulnerability assessment information to guide mitigative and adaptive planning under multiple management scenarios. Communities improve their capacity to plan, recover and adapt.

Natural and Nature-based Features

How important is a natural coastline in protecting communities from the impact of storms and floods? A study conducted by The Nature Conservancy says coastal wetlands prevented more than $625 million in property damages during Hurricane Sandy and reduced property damages throughout the Northeast by 10% on average.[4]

Recently, the use of natural and nature-based features (NNBF) has gained traction as a means to mitigate the potential impacts of extreme events, sea level rise, and inundation of coastal communities. Natural and nature-based features refers to a spectrum of features that employ a combination of natural and human engineered structures to create a shoreline. The effective use of these natural and nature-based approaches requires data to provide guidance on how, where, and when to best employ NNBF solutions. NCCOS provides the research and science components and partners with NOAA's Office for Coastal Management to help coastal communities use NNBF as an effective and aesthetically-pleasing strategy to enhance their resilience.

Climate Impacts on Ecosystems

Because the coastal zone is dominated by dynamic and complex interactions among biological and physical processes, we cannot yet accurately predict when or what threats will emerge, or how they will affect the 124 million people who live in U.S. coastal counties. Approximately 39% of Americans living in coastal counties fall into an elevated coastal hazard risk category. These include children, the elderly, households where English isn't the primary language, and those in poverty.[5]

Image credit: CH Knox / Thinkstockphotos.com

NCCOS is helping communities mitigate and adapt to climate change by conducting research on detecting and assessing change in coastal ecosystems. By observing the ecological responses of coastal habitats and species to climate change, NCCOS can help communities understand ecosystem relationships and develop indicators to evaluate progress towards long-term community resilience.

Restoration

Coastal ecosystems are vulnerable to habitat loss from impacts such as boat groundings and declining water quality. Habitat restoration offers a way to regain ecosystem services lost as a result of acute or chronic injuries.

NCCOS is a leader in coastal restoration science, and will continue to develop scientific tools and evaluate methods to guide restoration of impacted habitats. This includes research to improve the scientific framework for natural resource damage assessment and restoration, and developing sound mitigation and remediation strategies. NCCOS will continue to establish national and international guidelines on conservation and restoration of corals, seagrasses, and other critical habitats.

NCCOS social science research focuses on the study of connections between people and the environment. Image credit: NCCOS

Image credit: NOS

Social Science

Coastal communities depend on natural resources for food, health, economic security, cultural and spiritual benefits, and recreation, in addition to the less obvious benefits such as carbon sequestration, clean water, and storm protection. Society and coastal ecosystems are intertwined, so it is important that we identify and describe the connections using the social sciences so that consequences and benefits of our policies and actions are considered and understood.

Social science refers to a range of disciplines focused on the study of people and their associated social systems. NCCOS has a team of economists and sociologists who work across our MSE, SIM, and Coastal Change portfolios to ensure that the human element is considered in the science we conduct. NCCOS social science research focuses on the study of connections between people and the environment. We prioritize investigations into these connections within three interconnected sub-priorities of research.

Ecosystem Services Valuation

Ecosystem services are the goods and services from ecological systems that are of benefit to people. These benefits include storm protection, nursery grounds for young or small fish and shellfish, and pure enjoyment through use or aesthetics. Valuation is defined by NCCOS as the act or process of assigning an economic (market or non-market), social or cultural worth, utility or importance to special places or particular ecosystem products, services, or functions. The value of these special places or ecosystem services, products, or functions may be deemed relative, absolute, inferred, or estimated depending upon the research questions or management needs.

Assigning a value to services provided by ecosystems provides a common language for decision making, allowing clear trade-off discussions between such ideas as development vs. conservation. NCCOS identifies, documents, measures and/or estimates the social, cultural, and/or economic value to stakeholders, coastal communities, or society of special places and important ecosystem services, products, or functions. Coastal communities, planners, managers, regulators, and industry can use this social, cultural, and economic value information to make holistic business and management decisions.

Assessing Human Use

Community managers need to understand how people are using and impacting natural resources in a particular ecosystem. Managers who include data on the impacts of human use to complement the biological assessments of their coastal ecosystems are better equipped to address multiple-use issues or conflicts between competing stakeholders or user groups.

NCCOS focuses on the identification, documentation, and characterization of how people understand, interact with, and use coastal and marine environments, including special places. Community managers need NCCOS to identify and predict patterns of social, cultural, and economic behaviors and dependencies that influence how places and spaces are used, valued, managed, protected, and preserved.

Assessing Vulnerability and Resilience

The history, culture, and economy of communities in the coastal zone are deeply intertwined with their natural resources. Climate and coastal hazard impacts can threaten property, and the fishing, tourism, and shipping industries, among others, which generate billions annually to the U.S. economy. Understanding the vulnerabilities of communities to climate and coastal hazard impacts – like sea level rise, coastal erosion, and increased frequency of severe storms – requires an integrated approach.

NCCOS generates tools and information to improve community resilience to a changing climate as well as other coastal hazards. NCCOS provides coastal communities, planners, managers, regulators, and marine industries with the social science research needed to plan, recover, and adapt to events, disturbances, and changes in ecological conditions.

PEOPLE

NCCOS's strength lies in the people who do the research, management, and administrative work that results in the delivery of science that serves the Nation's environmental, social, and economic goals. We are committed to supporting our people by: 1) moving toward an inclusive workforce that is more reflective of the Nation we serve; 2) training; and 3) succession planning.

Every day, we will use words and actions to promote a culture of inclusivity at all levels of the organization. NCCOS will work together to make all employees feel respected, welcomed, and empowered in the workplace. Through training and succession planning we will support the retention and advancement of a diverse workforce.

Diversity and Inclusion

NCCOS science incorporates a diversity of expertise and serves the needs of diverse communities around the Nation. We know the next generation of scientists will be more diverse than they have been in the past, and they will possess new skills and use emerging technologies that will be imperative to advance our ability to conduct future science.

NCCOS is committed to promoting diversity through actions such as the promulgation of recruitment opportunities to a broad swath of qualified individuals, in positions from entry level science staff to senior leadership. We will continue to build and maintain partnerships with academic institutions and science organizations to broaden access to diverse networks of science professionals and potential stakeholders. This outreach will include continued hosting of summer interns at our facilities, collaboration with faculty scientists and students, and engagement with diverse communities with needs that complement our science capabilities. NCCOS recognizes that diversity comes in many forms; we seek to make sure opportunities in our organization are open to all who have the interest and ability to contribute to the NCCOS mission.

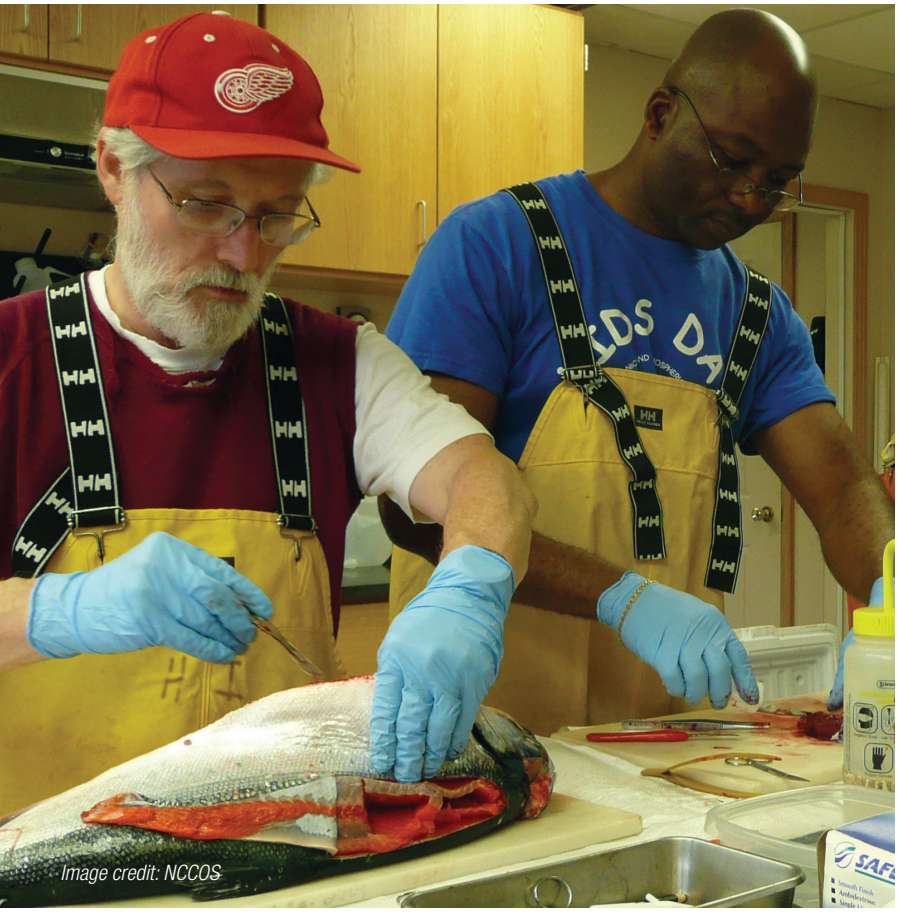

Image credit: NCCOS

Training

NOAA relies on the technical, administrative, and policy skills of the NCCOS staff to ensure that taxpayer-funded science is conducted safely, efficiently and legally in support of the Nation's highest needs. We are committed to providing NCCOS employees appropriate training to ensure requirements are met, and to offer mentoring and other developmental opportunities to improve and enrich our employees' skills and competencies.

Succession Planning

We employ world-class scientists, many of whom have retirement on their horizons. NCCOS is committed to supporting the professional development of current and future scientists who will serve as eventual leaders in the national and international science community.

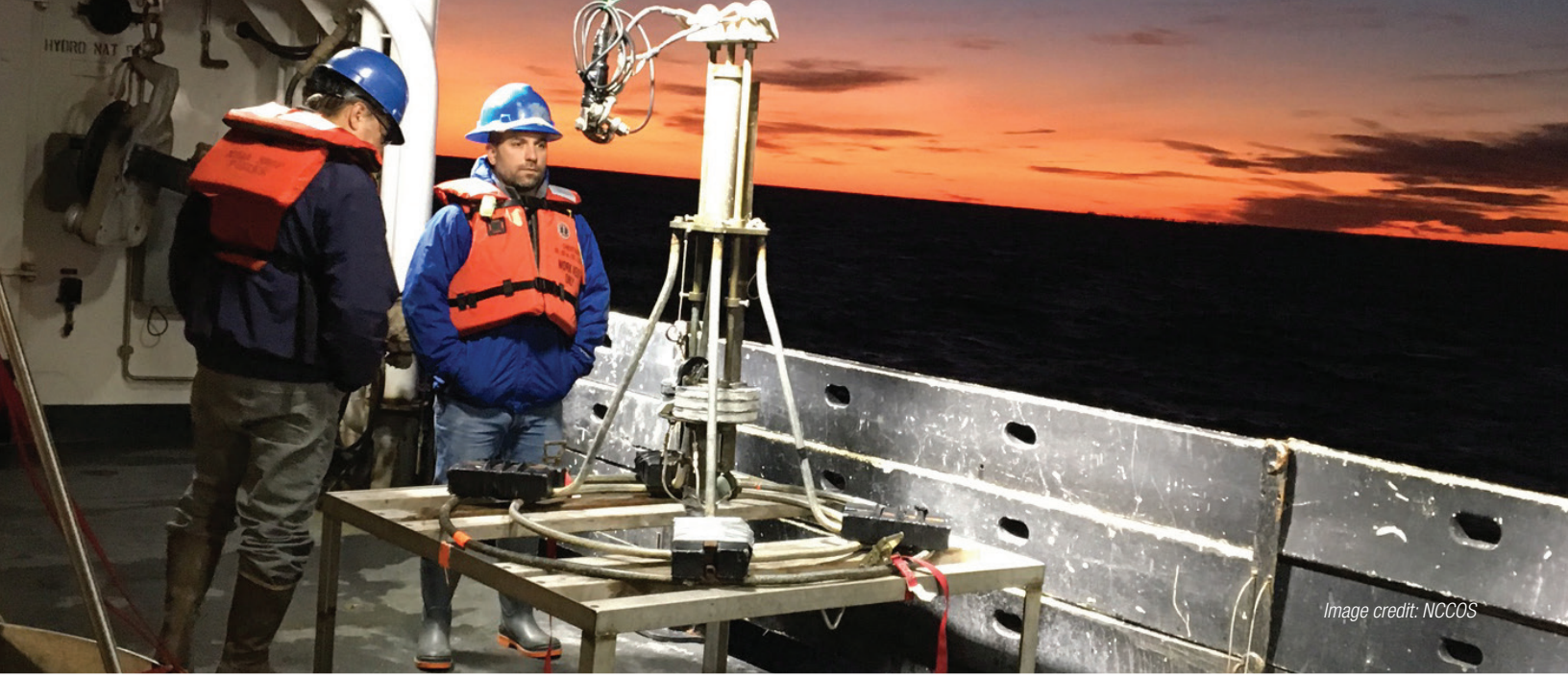

Image credit: NCCOS

Image credit: NCCOS

Image credit: NCCOS

Aerial view of The NOAA Beaufort Lab
Image credit: NCCOS

OUR FACILITIES

NCCOS Program Office and Headquarters - Silver Spring, Maryland

NCCOS leadership, scientists, and support staff are co-located with other NOAA offices in Silver Spring, MD. NCCOS employees plan, manage, and execute the budget, set information technology policy, and provide policy and communications support to NCCOS leadership in its internal and external partnerships, and in its interactions with Congress. The program office components manage the Competitive Research Program and the RESTORE Act Science Program, and supervise or conduct science, research, and associated model, tool, and product development.

The NOAA Beaufort Laboratory - Beaufort, North Carolina

The NOAA Beaufort Lab, opened in 1899, is the second oldest federal marine laboratory and home to scientists from NOAA's National Marine Fisheries Service and National Ocean Service. Operated by NCCOS, the Beaufort Lab is recognized for an extensive array of research including seagrasses, coral reefs, harmful algal blooms, seafloor mapping, aquaculture, and salt marsh ecology. The combination of world-class scientists with an ideal location has expanded our research to include understanding the effects of a changing climate on coastal and offshore ecosystems. The NOAA Beaufort Lab also houses the North Carolina Coastal Reserve and National Estuarine Research Reserve, which serve as living laboratories for scientists and students to learn about coastal systems. About 100 staff work out of the 60,000 square-foot laboratory resting on 13 acres of Pivers Island, an island shared with Duke University Marine Laboratory. Because of the variety of research and activities conducted here, the lab has a full SCUBA diving roster, small boats, aquaculture systems, high-tech laboratories for cell analysis, necropsy facilities, electronics workshops, classrooms, and a large auditorium.

NOAA Charleston and Hollings Marine Laboratories - Charleston, South Carolina

NCCOS's Charleston Laboratory is a 45,000 square-foot facility that includes chemistry, toxicology, molecular, microbiology, and ecology laboratories. The laboratory has separate facilities for culture of coral species, as well as challenge laboratories to simulate and assess impacts of climate and stress changes. There is a similar building for the challenge of fish and invertebrates to chemical contaminants, and a greenhouse-enclosed salt marsh mesocosm with tidal influence, to assess the effects of contaminants under conditions simulating a southeastern U.S. estuarine habitat.

The Hollings Marine Laboratory (HML) is a partnership between NCCOS, the National Institute of Standards and Technology, the Medical University of South Carolina, South Carolina Department of Natural Resources, and the College of Charleston. Researchers from all partner institutions work side-by-side, combining expertise to conduct research they could not accomplish otherwise. HML is built on an approximately 8-acre site within the Fort Johnson campus of the South Carolina Marine Resources Center in Charleston, South Carolina. Dedicated in December 2000, the laboratory is a NCCOS-run facility that promotes collaborative and interdisciplinary scientific research to sustain, protect, and restore coastal ecosystems. About 130 staff work out of the 103,000 square-foot laboratory.

Image credit: NCCOS

The Cooperative Oxford Laboratory - Oxford, Maryland

The Cooperative Oxford Laboratory (COL) is located on the shores of Chesapeake Bay in Oxford, Maryland. The COL was established in 1960 by the U.S. Bureau of Commercial Fisheries for the primary purpose of investigating oyster diseases that struck the Chesapeake and Delaware Bays in the late 1950's. The facility became the Cooperative Oxford Laboratory in 1987, through an agreement between the Maryland Department of Natural Resources and the National Ocean Service to share the facility and cooperate in research. NCCOS operates the 16,000 square-foot main laboratory, with onsite partners including NOAA's Chesapeake Bay Office, the Maryland Department of Natural Resources, and the U.S. Coast Guard. The laboratory has a 55' research vessel used for regional research.


Image credit: NCCOS

Kasitsna Bay Laboratory - Seldovia, Alaska

The Kasitsna Bay Laboratory (KBL) is the Alaska field station for both NCCOS and the National Marine Fisheries Service since the late 1950's. The University of Alaska Fairbanks helps NCCOS operate the Kasitsna Bay Laboratory. A wet/dry laboratory building which includes a 1,400 square-foot running seawater laboratory hosts research on the coastal impacts of climate change, ocean acidification, harmful algal blooms, and monitoring and change of nearshore biodiversity. The laboratory also serves as a testbed for underwater technology in high-latitude coastal ecosystems and under rugged conditions. Because of its remote location, the Kasitsna Bay Laboratory facilities include dormitory buildings with housing, kitchen, laundry and internet for up to 48 people.


Image credit: NCCOS

APPENDIX I: DRIVERS

The directives and planning documents catalogued in this appendix are the major legislative, mission and policy drivers for the science and research conducted by NCCOS. These drivers, as well as needs expressed by key stakeholders, guide the efforts and activities for the accomplishment of various aspects of NCCOS's mission and goals.

Legislative Drivers

- Clean Water Act, 1972
- Coastal Zone Management Act (CZMA), 1972
- Coral Reef Conservation Act (CRCA), 2000
- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 1980
- Endangered Species Act, 1973
- Estuary (Estuarine) Protection Act, 1968
- Harmful Algal Bloom and Hypoxia Research and Control Amendments Act (HABHRCA), 2014
- Invasive Species Executive Order, 1999, 2016
- Magnuson-Stevens Fishery Conservation and Management Act, 1976
- Marine Mammal Protection Act, 1972
- National Coastal Monitoring Act, 1992
- National Contaminated Sediment Assessment and Management Act, 1992
- National Environmental Policy Act (NEPA), 1970
- National Marine Sanctuaries Act (NMSA), 1972
- Oceans and Human Health Act, 2004
- Oil Pollution Act (OPA), 1990
- Resources and Ecosystems Sustainability, Tourist Opportunities, and Revived Economies of the Gulf Coast States Act (RESTORE Act), 2012

National and NOAA Drivers

- The National Science and Technology Council Subcommittee on Ocean Science and Technology's Comprehensive HAB and Hypoxia Research Plan and Action Strategy
- Coastal Green Infrastructure and Ecosystem Services White House Task Force Recommendations
- NOAA and National Ocean Service mission, vision, priorities
- NOAA's Natural Infrastructure Strategy
- NOAA-wide efforts in Integrated Ocean and Coastal Mapping (IOCM)
- NOAA Ecological Forecast Roadmap
- NOAA Habitat Conservation Team through the Habitat Science and Ecological Forecasting technical team
- NOAA's Ecosystem Based Fisheries Management Roadmap
- NOS Roadmap

APPENDIX II: CITATIONS

[1, 5] *NOAA Office for Coastal Management*: Fast Facts, Economics and Demographics, https://coast.noaa.gov/states/fast-facts/economics-and-demographics.html

[2] *USDA National Institute of Food and Agriculture*: USDA Announces $1.2 Million in Available Funding for Aquaculture Research (April 6, 2016), https://nifa.usda.gov/announcement/usda-announces-12-million-available-funding-aquaculture-research

[3] *NOAA National Centers for Environmental Information*: Billion-Dollar Weather and Climate Disasters: Overview (July 2017), https://www.ncdc.noaa.gov/billions/

[4] *The Nature Conservancy, Coastal Wetlands and Flood Reduction*: Using Risk Industry-Based Models to Assess Natural Defenses in the Northwestern USA (October 2016), 9.

Image credit: NCCOS

APPENDIX III: ACTIVITIES

Over the next 5 years, NCCOS will focus on the following activities related to its priorities:

Marine Spatial Ecology (MSE)

Ecological and Biogeographic Assessments

- Integrated bio-physical and socio-economic indicators to evaluate the status and trends of ecological conditions of coastal and marine ecosystems
- Robust statistical models – and measures of their uncertainty – to describe and predict conditions and/or changes in response to environmental and management actions
- New remote sensing and mapping technologies to support spatial model development to improve the understanding of ecological connectivity

Habitat Mapping

- Characterization and assessment of benthic and pelagic, and coastal and marine habitats to provide baseline habitat conditions, enable monitoring activities, and evaluate management actions
- Spatial-temporal model development to improve understanding of connectivity of living marine resources between ecosystems
- Maps and inventories of critical habitats and associated species; spatial patterns of ecological "hotspots"; data analysis and visualization techniques that support spatial management

Regional Ecosystem Science

- Indicators, characterizations and models that couple social, governance, and natural systems to support ecosystem-based management
- Investigate ecological connectivity to evaluate the efficacy of marine protected areas and associated management options

Coastal Aquaculture Siting and Sustainability

- Research on the interactions between aquaculture and the environment
- Research on aquaculture's contribution to ecosystem services and social science issues
- Spatial products and services supporting aquaculture siting and management

Stressor Impacts and Mitigation (SIM)

Harmful Algal Bloom (HAB) Detection and Forecasting

- Forecasts and early warnings of HAB extent, trajectory, and toxicity, so managers can implement early action to more cost-effectively and efficiently mitigate the impacts of HABs
- Scenario-based predictive models of HAB abundance and toxicity to establish their relationship to causal factors, to improve management strategies for preventing and mitigating HABs, and to assess the effectiveness of prevention and control practices
- New detection technologies such as test kits, autonomous sensors, and portable instruments to enable local observations to support forecasts, and that provide states, municipalities and tribal Nations with the skills and tools to identify and quantify HAB species and toxicity
- Guide and support cost-effective volunteer observation opportunities through the "Phytoplankton Monitoring Network" to educate citizens, test new technologies, and inform managers of the onset of toxic bloom events
- Produce analytical methods and reference materials in concert with other federal agencies to support development of standardized methods and training for testing laboratories and validation of their use to assure accurate and reproducible measurements nationwide

Biological Effects of Contaminants and Nutrients

- Field-based investigations that examine chemical, biological, and abiotic metrics that characterize stressor exposure and effects to key marine organisms, and application of biomarkers to assess physiological response to stressors
- Contaminant biological effects characterizations to support oil and chemical spill response and injury assessments, to include laboratory controlled studies to predict the environmental fate of and to determine effects thresholds for chemicals of concern
- Tools for the assessment and prediction of stressor impacts to include ecological forecasting, biomarker development, analytical methods development for chemical contaminant concentrations, and promulgating new/revised threshold guidance
- Consultative expertise in environmental toxicology and physiology, analytical chemistry, coastal ecology, statistical analysis, and modeling on issues related to stressor-related bioeffects in coastal ecosystems

Coastal Change: Vulnerability, Mitigation, and Restoration

Vulnerability and Risk Assessment

- Scenario-based modeling integrating biological, hydrologic, physical, socio-economic and other factors to improve predictions of coastal vulnerability and risk under varying climate, adaptation, and response scenarios
- Inclusion of "well-being" and other social indicators to provide communities with longitudinal information that can be used to improve community planning, response and adaptation
- Impacts of hazards on particular populations, infrastructure, and industries measured to determine potential for recovery
- New or enhanced climate risk assessment and vulnerability tools useful to coastal managers and private industry

Natural and Nature-based Features

- Research ecosystem services of natural coastal ecosystems vs. nature-based infrastructure
- Couple hydrodynamic and biological/physical modeling platforms and the integration of field-based studies of relevant coastal processes to advance sea level rise and inundation predictive capabilities
- Science-based guidance to inform and empower effective decision-making related to the use of natural features
- Science support for policy development and permitting decisions related to nature-based infrastructure implementation


Image credit: NOS

Climate Impacts on Ecosystems

- Field and laboratory-based studies on the ecological responses of coastal habitats and species to climate-scale changes in conditions to improve understanding of how changes in natural systems affect a coastal community's resilience, health and economy
- Change detection and early warning systems for community decision makers, coastal managers, and the public that identify changes in coastal conditions that may alter ecosystem services and undermine the resilience of coastal communities, ecosystems, and economies

Restoration

- Establish thresholds for environmental injury and recovery to habitats and/or species and resource valuation approaches for primary or compensatory mitigation efforts
- Developing GIS decision support tools to prioritize restoration siting and provide analysis and visualization that support planning or siting of potential restoration options for natural resource recovery and management decisions

Social Science

Ecosystem Services Valuation

- Identify, document, and measure baseline economic, social, or cultural values of special places or of particular ecosystem services, products, or functions
- Characterize place-based social and cultural attachment to special places or particular ecosystem services, products, or functions
- Estimate and/or predict change to economic, social, or cultural values due to changes in ecosystems or to particular ecosystem services, products, or functions

Assessing Human Use

- Identify, document, and characterize patterns pertaining to human use of coastal and marine places and spaces, as well as particular natural resources
- Assess reliance of stakeholders and coastal communities on special places, as well as the natural resources, features, and uses that make these places special or important
- Link patterns of human coastal and marine use to valuation of ecosystem services, products, and functions

Assessing Vulnerability and Resilience

- Research and assess vulnerabilities to coastal hazards and impacts of climate variability in coastal regions
- Research impacts of severe storm events on particular populations, infrastructure and industries measured to determine potential for recovery

NCCOS

NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE

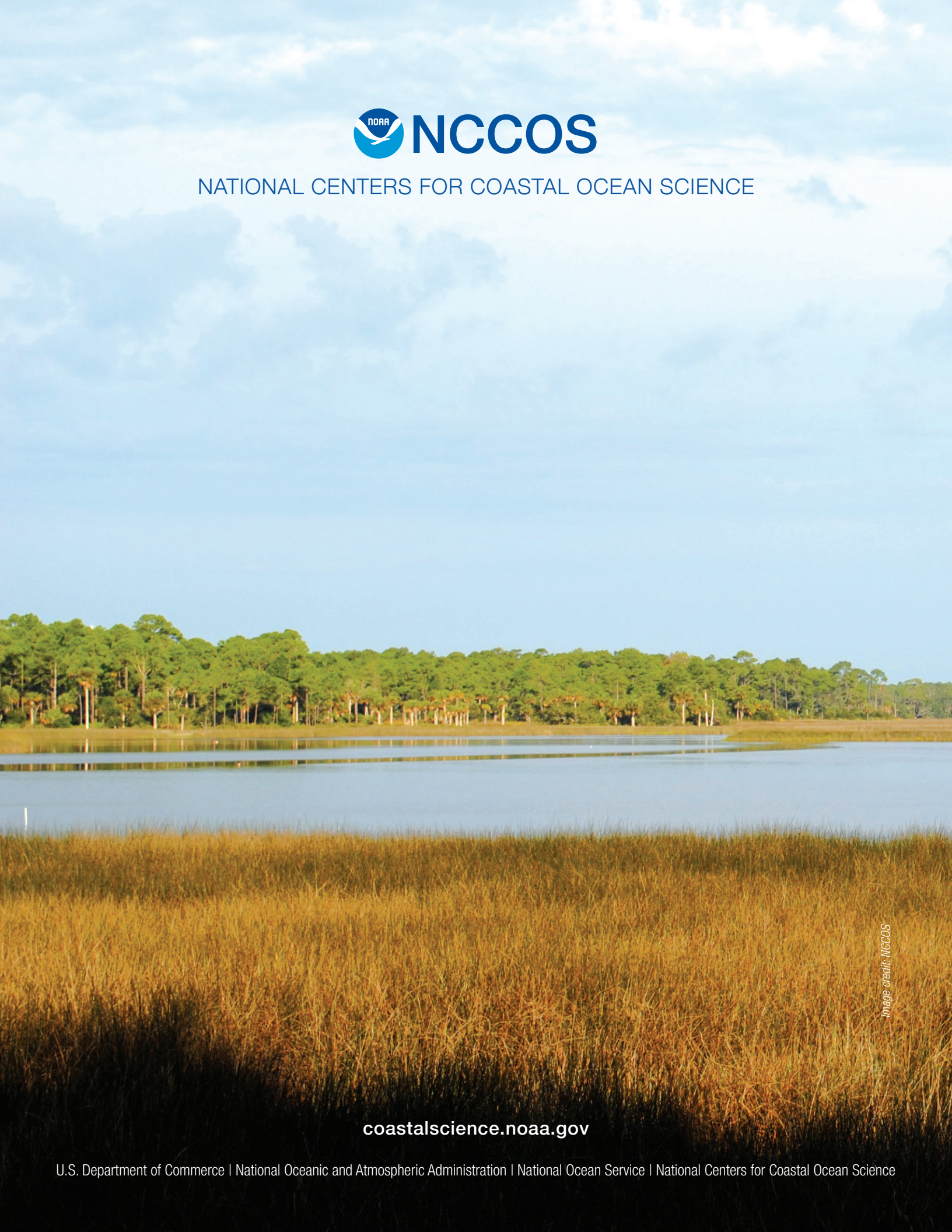

Image credit: NCCOS

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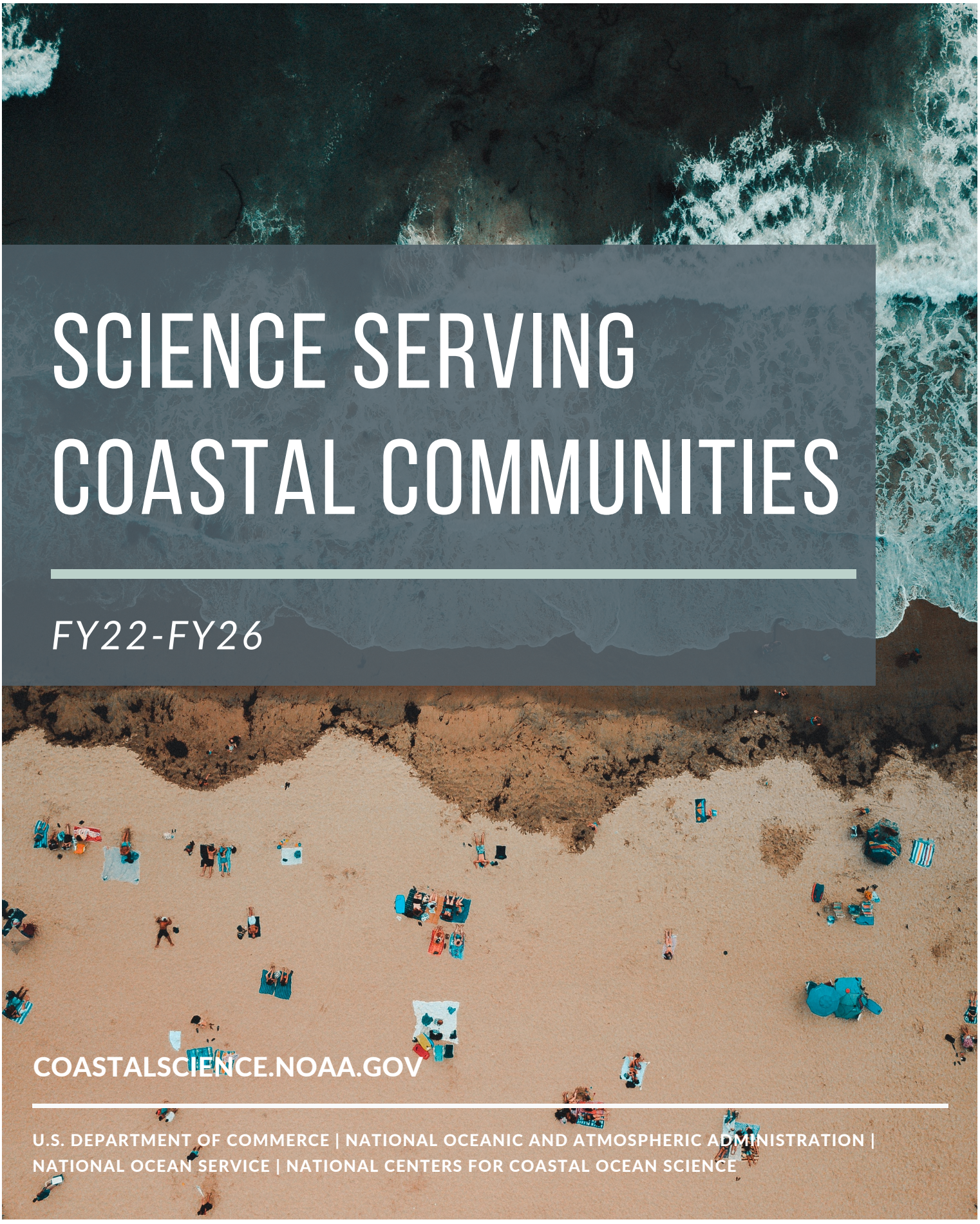
U.S. Department of Commerce | National Oceanic and Atmospheric Administration | National Ocean Service | National Centers for Coastal Ocean Science

NCCOS | NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE



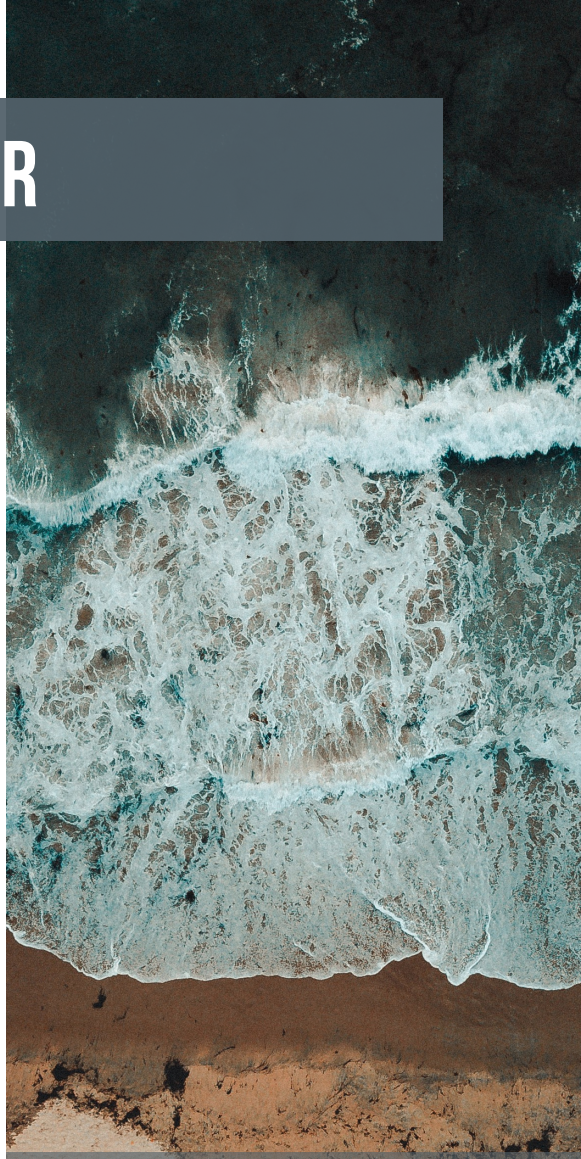
SCIENCE SERVING COASTAL COMMUNITIES

FY22-FY26

COASTALSCIENCE.NOAA.GOV

U.S. DEPARTMENT OF COMMERCE | NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION | NATIONAL OCEAN SERVICE | NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE

LETTER FROM THE DIRECTOR



Curiosity. Creativity. Commitment. Innovation. Diversity of thought and perspective. Acceptance of a bit of risk. A dash of daring. Being willing to challenge the status quo. These are the hallmarks of both the scientific process and, to a large extent, the individuals that have been called to a career in the sciences. To this list I will add service, as we are a government agency that provides information and tools for the public good. We need to embrace each of these traits to be successful as individuals and as an organization. This strategic plan outlines how the National Centers for Coastal Ocean Science will foster that success and create an environment in which our scientific, business operations, and communication staff can thrive.

Science Serving Coastal Communities: FY2022–2026 articulates our six priorities for the next five years:

- Advancing Ecosystem Science for Conservation and Sustainable Use
- Developing and Implementing Advanced Observation Technologies and Ecological Forecasts
- Facilitating Resilience and Adaptation to Inundation and Climate Impacts
- Detecting, Monitoring, and Mitigating Impacts of Chemical and Biological Stressors
- Advancing Social, Economic, and Behavioral Approaches to Coastal Stewardship
- Investing in our People and Achieving Organizational Excellence

These will guide our investments in research, facilities, and our people. They will also be the basis for partnership development and inform how we strategically staff the organization, including efforts to diversify our workforce and foster an inclusive atmosphere.

Arguably, the demand for coastal science has never been greater. The human population living in coastal communities and the associated demands on coastal ecosystems are projected to increase. So too are ocean-based industries with economic activity along our coasts, including residential and commercial development, marine transportation, tourism, energy, and food production. A changing climate will continue to impact where and how citizens live and their quality of life, such as what they do for a living and how they choose to recreate. And, our nation's environmental legacy will be influenced by the thousands of decisions that are made on a daily basis. This is the context within which we conduct our science—one that is full of challenges, but also rich with opportunities to make scientific advances that meaningfully contribute to society.

With this background, I invite you to explore *Science Serving Coastal Communities: FY2022–2026* and learn what NCCOS seeks to achieve over the next five years!

Steve Thur, Ph.D
Director
National Centers for Coastal Ocean Science

"THIS IS THE CONTEXT WITHIN WHICH WE CONDUCT OUR SCIENCE—ONE THAT IS FULL OF CHALLENGES, BUT ALSO RICH WITH OPPORTUNITIES TO MAKE SCIENTIFIC ADVANCES THAT MEANINGFULLY CONTRIBUTE TO SOCIETY."

NCCOS VISION:

SCIENCE SERVING COASTAL COMMUNITIES

NCCOS MISSION:

The National Centers for Coastal Ocean Science delivers ecosystem science solutions for stewardship of the nation's ocean and coastal resources in direct support of National Ocean Service (NOS) priorities, offices, and customers to sustain thriving coastal communities and economies.

NCCOS VALUES

Value #1. We stand for scientific and professional integrity

- We conduct our business in accordance with the highest standard of professional behavior and ethics.
- We conduct our science in a manner that ensures objectivity, reproducibility, and accessibility of data and freedom of scientific expression.

Value #2. We serve the American people by making a difference in all we do

- We strive to contribute to a sustainable, healthy coastal environment that strengthens communities and ecosystems.
- We maintain a strong fiduciary responsibility and utilize our resources intelligently and with purpose.

Value #3. We value people and embrace diversity

- We appreciate the perspectives, attributes, and contributions of staff, colleagues, partners, and stakeholders.
- We treat everyone with respect, civility, and dignity and actively create an inclusive, supportive, and welcoming workplace.
- We support a healthy work-life balance.

INTRODUCTION

The complex challenges of sea level rise, coastal flooding, harmful algal blooms (HABs), and water pollution, among other hazards, pose increasing risks to coastal communities. In the five-year period spanning 2016–2020, weather and climate-related natural disasters cost the U.S. over $616 billion. Losses of this magnitude are projected to become commonplace due to a changing and increasingly turbulent climate. The expected increases in the severity of coastal hazards will reshape our coastal ecosystems, and the coastal communities and economies that rely on them. The concentration of human activities on our coasts leads to additional pressure and inevitable competition over the use of our natural resources for commerce, food, energy, recreation, and conservation. With 40 percent of the U.S. population living in coastal counties and projected to increase, it is clear that a significant portion of the nation's population, including some of the most disadvantaged communities, are increasingly vulnerable to these coastal hazards.

Providing evidence-based science products and tools that support informed decision-making is at the heart of NCCOS's mission. Our stakeholders look to us to provide relevant, timely, and actionable products and tools they need to make informed decisions. We conduct nationwide, multidisciplinary research that integrates a broad spectrum of physical, biological, chemical, and social sciences to inform and guide resource and community managers, while seeking a balance among resource use, economic development, restoration, conservation, and human health. For example, our marine spatial planning products inform offshore aquaculture and wind energy placement, sanctuary site designations, and community vulnerability. By providing science products and tools, NCCOS helps communities plan for, adapt to, and reduce risks from the multiple challenges facing coastal communities. NCCOS's mission has never been more important than it is today.

Over the next five years, the 2022–2026 Strategic Plan outlines our six science and organizational priorities that will guide our prioritization and the alignment of our internal and external science portfolios. Equally important, to provide flexibility in research plans and encourage innovation, these priorities will be used to develop NCCOS's Priority Research Plans and support our Programmatic Approach to Funding each year. These priorities will also directly inform external funding opportunities during this time.

Solutions to the multi-faceted challenges of the 21st century require making strategic investments, organizational excellence, and innovative methods and approaches. As part of our strategic investments, NCCOS will focus on increasing the diversity of our staff and cultivating an inclusive culture that encourages different perspectives. We support NCCOS staff to be innovative in their area of expertise—both scientific and business operations—to achieve organizational excellence and advance scientific objectives.

Finally, NCCOS remains committed to the highest standards of scientific integrity to provide science products, tools, and information that are evidence-based, free of political influence, and produced by the best available science and data as described in the 2021 Presidential Memorandum on Scientific Integrity.

NCCOS STRATEGIC PRIORITIES

NCCOS was formed in 1999 as the focal point for NOAA's coastal ocean science efforts. NCCOS helps NOAA meet its coastal stewardship and resource management responsibilities by working closely with coastal managers and other stakeholders to determine research needs and ensure the science and research products we are delivering are valuable to their decision-making and society. Our stakeholders are often engaged in our project planning and execution, and provide guidance throughout the research process to ensure our products meet their needs. NCCOS science is guided by NOAA's legislative mandates, executive orders, and NOS priorities, as well as stakeholder engagement. NCCOS's research integrates a broad spectrum of physical, biological, and social sciences to inform and guide resource managers seeking a balance between resource use, economic development, restoration, and conservation. Over the next five years NCCOS will focus on the following science priority areas. It is important to note that due to the dynamic nature of coastal ecosystems and management needs, sub-priorities may change over time.

NCCOS PRIORITY — ADVANCING ECOSYSTEM SCIENCE FOR CONSERVATION AND SUSTAINABLE USE

NCCOS is a nationally recognized leader in conducting management-driven ecosystem science in the nation's oceans, coasts, and Great Lakes, including coral reefs, estuaries, National Marine Sanctuaries, and National Estuarine Research Reserves. Ecosystem science is the study of interrelationships among living organisms, physical features, biogeochemical processes, natural phenomena, and human activities. Ecosystem-based management approaches are required to link natural and social-economic systems to support resource management. NCCOS will continue to advance ecosystem science by using innovative technologies and ecological modeling to develop products that support coastal managers.

The Ecosystem Science priority is broad due to the complex nature and geographic extent of coastal ecosystems and the myriad dynamic natural resource conservation issues. As a result, NCCOS has developed four sub-priority focal areas of importance to managers. These are

- Marine Spatial Planning (MSP),
- Habitat Mapping,
- Biogeographic/Ecological Assessments and Research, and
- Monitoring and Research in Coral Reef Ecosystems.

Coral ecosystems are called out given NCCOS's investments in corals and NCCOS's significant role in executing research supported by NOAA's Coral Reef Conservation (CRCP) and Deep Sea Coral Research and Technology Programs.

MSP is a process of analyzing and allocating the spatial and temporal distribution of human activities to balance ecological, economic, and social objectives for specific locations. The other three sub-priorities, and other parts of the NCCOS science portfolio, support the tenets of MSP and many other key aspects that inform ecosystem-based management. NCCOS's habitat mapping uses a suite of remote sensing technologies to acquire acoustic and optical data to develop digital species distributions and habitat maps. In addition, various technologies are used to assess and map ecosystem conditions, such as impacts of coastal pollution and location of marine debris. Defining the conditions of coastal environments and locations of human use activities, enables ocean industries (e.g., aquaculture, wind energy), regulators, and conservation planners to come together using common and authoritative data and information to make comprehensive MSP decisions.

Biogeographic assessments and research examine the spatial and temporal distributions of organisms, habitats, and the historical and biological factors that produce ecological patterns. Ecological assessments and research are more broad-based activities and range from defining the status of ecosystem components to determine baseline conditions to detecting change in those conditions over time. NCCOS's ecosystem science portfolio includes defining boundaries and evaluating the efficacy of marine protected areas (MPAs) (e.g., NOAA National Marine Sanctuaries) based on species home ranges and habitat use patterns (e.g., animal acoustic telemetry) and ecological connectivity research (e.g., larval transport and post-recruitment spillover, and marine mammal health assessments).

NCCOS is a major contributor to NOAA's CRCP's portfolio, serving the science needs of U.S. states and territories with corals. We conduct a suite of natural and social science investigations, including determining the impact of pollution and diseases on coral reef ecosystems, restoration science, and increasing our overall understanding of reef ecology. NCCOS continues to lead components of CRCP's National Coral Reef Monitoring Program, including monitoring of reef fishes, habitats, and understanding people's perceptions and uses of coral ecosystems. NCCOS is an active partner with the Deep Sea Coral Research and Technology Program through our scientific leadership of regional initiatives, participation in field expeditions, contributions

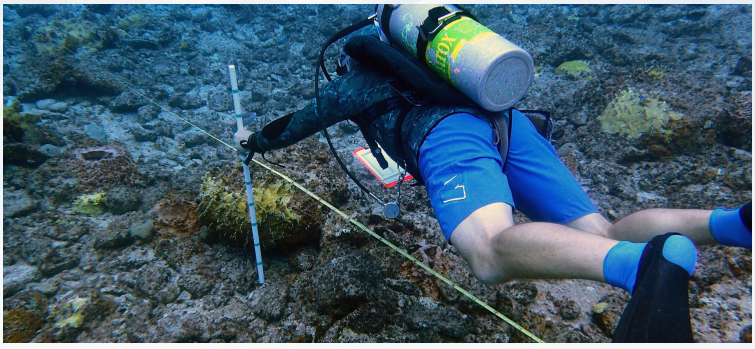
to research projects, and work in our laboratories to understand the biology and ecology of deep sea corals and their vulnerability to environmental stressors.

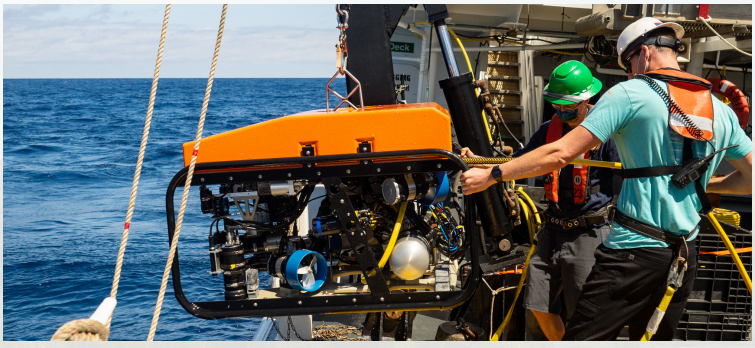
Given NCCOS's role to support the science needs of NOS, over the next five years, our research portfolio will include MPA assessments, coastal community and habitat vulnerability assessments, understanding habitat and ecosystem connectivity, mesophotic and deep coral research, predicting climate-related changes in species distributions and connectivity, and conducting science to support coastal resiliency and habitat restoration.

Habitat mapping products will continue to advance the use of machine learning techniques and artificial intelligence to increase the accuracy and efficiency in producing habitat maps. Many aspects of biogeographic and ecological assessments, research, and monitoring will continue to evolve, including advanced ecosystem models to forecast potential results of alternative management decisions. We will use new technologies for data collection to define the status and trends in conditions of coastal ecosystems. This will result in "big data" and analytics (e.g., imagery) requiring increased investments in data management. NCCOS will enhance our remote sensing capabilities through use of uncrewed systems (e.g., satellites, gliders, and drones) to monitor pelagic and benthic environments and evaluate habitat restoration activities. As part of NOAA's Natural Resource Damage Assessment (NRDA) response to the *Deepwater Horizon* oil spill, NCCOS has a significant role to map and restore mesophotic and deep benthic communities and support other science and restoration efforts associated with NRDA investigations.

ECOSYSTEM-BASED MANAGEMENT

NCCOS's Ecosystem Science portfolio supports the overall tenets of Ecosystem-Based Management (EBM) in the ocean across multiple spatial and temporal time scales. EBM is an integrated approach that recognizes a broad array of interactions within social-ecological systems (rather than considering single issues, species, sectors, or ecological services in isolation) and is guided by an adaptive management approach. The need to coordinate human uses of the ocean across sectors calls for ecosystem-based coastal and Marine Spatial Planning (MSP). MSP is a process of analyzing and allocating the spatial and temporal distribution of human activities to balance ecological, economic, and social objectives for specific locations. EBM requires MSP to empower decision makers to plan for increased investments in renewable energy, mitigate the impacts of climate change, support the blue economy, and increase conservation (e.g., marine protected areas). For example, NCCOS's MSP services recently provided data and maps that facilitated defining the location and designation of the Wisconsin Shipwreck Coast National Marine Sanctuary. NCCOS's MSP research and integrated ecosystem assessments advance the understanding of current and future human use patterns in coastal and marine waters and attempt to ensure high quality and relevant science is delivered in formats suitable for managers. NCCOS's Ecosystem Science activities will advance EBM through MSP, habitat mapping, and regional research, and will ensure data and information support management decisions to balance conservation and economic needs by minimizing resource use conflicts.





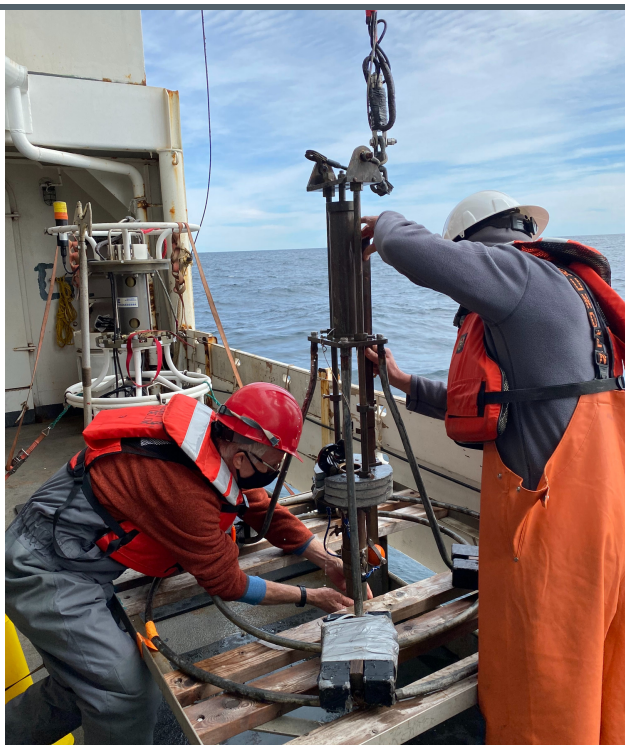
NCCOS PRIORITY — DEVELOPING AND IMPLEMENTING ADVANCED OBSERVATION TECHNOLOGIES AND ECOLOGICAL FORECASTS

Harmful algal blooms (HABs), hypoxia, and pathogens have major impacts on coastal and Great Lakes ecosystems and communities, and pose risks to economies, public health, and coastal resources, including protected wildlife. Climate change (e.g., sea level rise, warming oceans, extreme temperatures, changing precipitation patterns), coastal development and other environmental stressors, such as chemical contaminants, ocean acidification, and hypoxia, also drive coastal habitat and ecosystem changes that impact coastal communities. The delivery of timely, relevant, and actionable information and forecasts, allows coastal resource managers, public health officers, emergency officials, and the public to mitigate impacts to coastal ecosystems and communities.

Ecological forecasting is an interdisciplinary science capability that relies on observation technologies, the data they provide, and models to make predictions about ecological processes (i.e., the interrelationships among living organisms, physical features, biochemical processes, environmental drivers, natural phenomena, and human activities) and their impacts on people, economies, and communities. NCCOS is a leader in developing and providing ecological forecast products for HABs, hypoxia, pathogens, and coastal habitats to federal, state, tribal, local, and territorial authorities, as well as to the public, so that they can make decisions that protect and support thriving coastal economies, communities, and ecosystems.

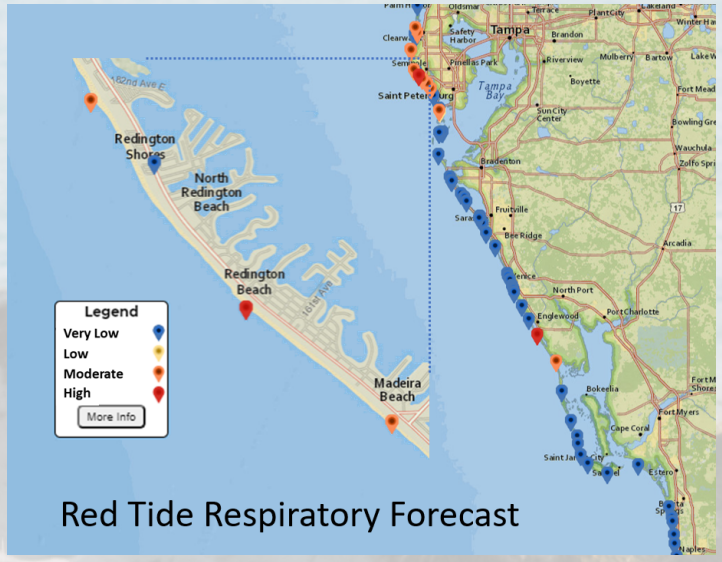
For FY22–FY26, NCCOS will strengthen its capability to predict *where*, *when*, *magnitude/severity*, *and socioeconomic impacts* of HABs, hypoxia, pathogens, and coastal habitat changes (which also determine the abundance and distribution of species) on coastal ecosystems, communities, and economies by investing in:

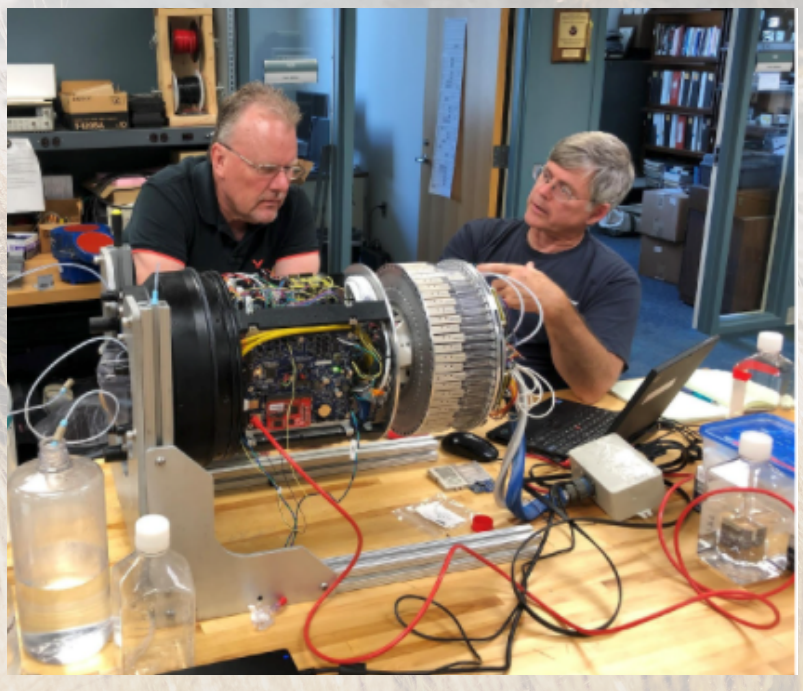
- Developing and using models that integrate a more diverse set of data (e.g., biological, physical, chemical, environmental, socioeconomic, spatial, temporal, etc.);
- Using advanced observation platforms such as satellites, uncrewed systems, and field-portable devices;
- Developing and deploying more capable and cost-effective passive and active sensors that deliver real-time data at finer spatial and temporal resolutions Reducing the time between data collection and processing to make data available for use in early warning systems and forecasts;
- Increasing the accuracy and extending the time period covered by forecasts;
- Expanding forecasting and observing capabilities to serve new regions and addressing emerging ecological concerns; and
- Integrating models (e.g., HAB, ocean acidification, hypoxia, pathogen, climate, biogeochemical, habitat, and socioeconomic models) that individually capture sub-components of coastal ecosystems and communities, but once linked and working together will deliver more comprehensive, powerful, and useful ecological forecasts.

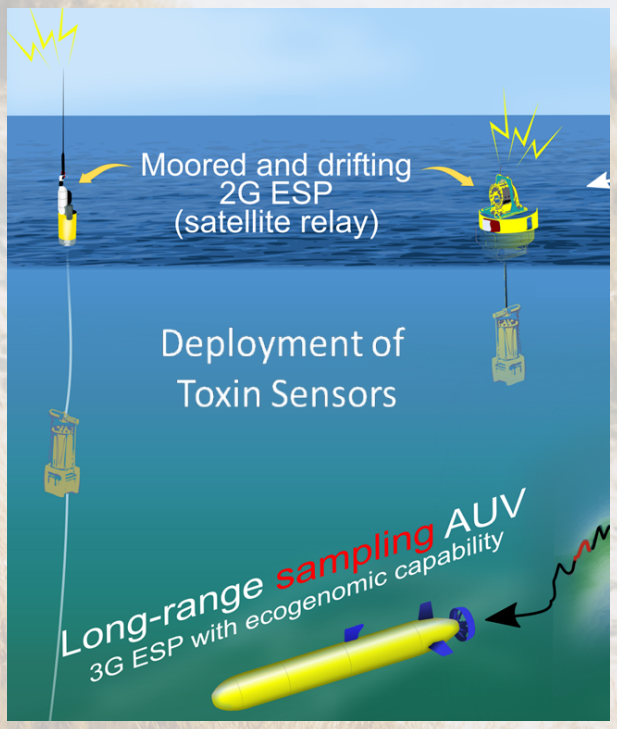


HAB FORECAST AND OBSERVATION SENSOR TECHNOLOGY

Many coastal resources, communities, and economies are adversely affected by harmful algal blooms (HABs) to the tune of tens of millions of dollars annually. HABs occur in every coastal state, when algae proliferate, sometimes due to increased nutrient concentrations, warmer temperatures, and low water circulation. HABs produce toxins that can remain in freshwater and marine environments and accumulate throughout the food web, enter drinking water supply systems, and become aerosolized. These toxins: 1) endanger humans (with multiple forms of acute poisoning to longer term disease) and animals, including protected species, domestic animals, and pets; 2) foul public water supplies; and 3) reduce or block sunlight that is essential for the survival of many benthic marine flora and fauna. HAB forecasts integrate environmental, hydrographic, atmospheric, and biological data that are obtained using water and field sampling methods, and advanced observing/sensor technologies (e.g., satellites, uncrewed systems [aerial, surface, and sub-surface], and artificial intelligence–assisted HAB identification technologies). Forecasts inform natural resource and water treatment facility managers, public health officials, aquaculture farmers, seafood harvesters, coastal communities, beachgoers, and the public on the size (i.e., spatial extent) and toxicity of HABs, where they are located and likely to go, and if they are likely to persist, or become more severe, so actions can be taken to minimize HAB impacts.







NCCOS PRIORITY — FACILITATING RESILIENCE AND ADAPTATION TO INUNDATION AND CLIMATE IMPACTS

Climate change alters coastal ecosystems and the services those ecosystems provide to coastal communities and economies. The increasing rate of sea level rise and frequency of extreme weather events means increasing damage to our coasts. Globally, natural disasters caused $210 billion in damage in 2020, showing a growing cost of climate change. Losses of this magnitude are projected to become commonplace; 2020 was the 10th year in a row with eight or more weather events that each resulted in losses of $1 billion or more in the U.S. A resilient community is able to prepare and plan for, absorb, recover from, and adapt to adverse events. NCCOS's research efforts inform resource management and policy decisions that support ecosystem services that improve a coastal community's resilience to the impacts of weather and changing climate conditions. NCCOS accomplishes this through timely and actionable scientific assessments, information, and tools to help coastal communities plan for and mitigate climate-related risks.

The NCCOS climate and resilience portfolio complements NOS capabilities and maintains partnerships within NOAA and with external stakeholders. NCCOS's science niche includes advancing understanding of ecosystem and community vulnerability to climate impacts and evaluating potential mitigation actions that include natural approaches. Projects regularly leverage water level observations and future water level scenarios delivered by NOS's Center for Operational Oceanographic Products and Services (CO-OPS) and collaborate with the Office for Coastal Management in stakeholder service delivery. Projects include coverage of National Estuarine Research Reserves and National Marine Sanctuaries, supporting management of NOAA's reserves and leveraging their regional networks.

Within this priority, NCCOS will focus on three sub-priorities:

- Ecosystem Change,
- Community and Ecosystem Vulnerability, and
- Restoration and Natural and Nature-based Features.

NCCOS will continue to support interdisciplinary research to advance our understanding of the vulnerability and value of wetlands, coral reefs, and other natural coastal infrastructure under varying sea level rise, storm, and adaptation scenarios. Quantifying the ability of natural and nature-based features to mitigate coastal inundation impacts and maximize protective value will be an increasing focal area. We will continue to expand our collaborations that support land management and engineering projects, translating science to inform action, particularly with the U.S. Army Corps of Engineers (USACE), Federal Emergency Management Agency (FEMA), and Department of Transportation. This research will emphasize the production of actionable science products, including models and tools, guidance documents, and visualizations.

In addition, we will evaluate climate impacts on ecosystems in combination with stressors identified in our other science priorities, such as the effects of increased ocean temperatures on harmful algal bloom distribution and changes in ecosystem system function. We will partner across NOAA to assess the compounding effects of climate change on other stressors such as acidification, hypoxia, and harmful algal blooms, particularly in already impaired systems and marine protected areas. Our research teams will continue to collaborate directly with state and local resource managers to ensure that our products meet their specific needs.

These efforts will build on and leverage the suite of science activities identified throughout this Strategic Plan. This will ensure that areas of emphasis, such as marine spatial planning and harmful algal blooms, are examined within the context of climate change to better facilitate adaptation to future conditions, impacts, and assess mitigation needs. A core component of this cross-priority integration will be incorporation of our human use, community vulnerability, and other social science with biological and physical science to provide coastal communities more holistic products to inform resilience and adaptation planning.

NATURAL SOLUTIONS FOR SEA LEVEL RISE MITIGATION

NCCOS ecosystem science capabilities include a focus on evaluating the response of coastal habitats to sea level rise and quantifying the ability of natural and nature-based features (NNBF) to mitigate the effects of sea level rise and inundation. NNBF are increasingly recognized as potential risk mitigation solutions that have the added benefit of providing a suite of additional ecosystem services. NCCOS is working to quantify the coastal protection and habitat benefits provided by NNBF relative to those of traditional shoreline protection approaches, like breakwaters and seawalls. Projects complement and leverage inundation data products and tools produced through other NOS offices, including: particular sea level rise scenarios, water level data, community engagement approaches, and installation or management of NNBF. This results in holistic NOS capacity that provides a suite of services that include a broad range of geographically representative habitats and communities, transferable capabilities and approaches to other relevant locations across the U.S., and the inclusion of co-benefits that provide a more holistic context to inform community decision-making.

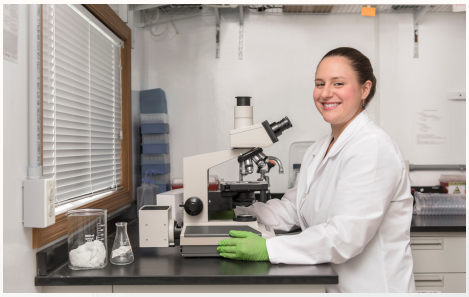



WHERE WE'RE LOCATED: NCCOS FACILITIES

NCCOS COOPERATIVE OXFORD LABORATORY

Centrally located in Chesapeake Bay on the Tred Avon River, the laboratory was established in 1960 primarily to investigate oyster diseases that devastated the fishery in the late 1950s. The facility became the Cooperative Oxford Laboratory in 1987 through an agreement between NOAA and the Maryland Department of Natural Resources to share the facility and cooperate in research. Partners include NOAA, (NCCOS and NOAA's Chesapeake Bay Office), Maryland Department of Natural Resources Fishing and Boating Services, and U.S. Coast Guard Station Oxford. The lab's assets include a 58-foot research vessel, a 500-foot pier, a designated oyster sanctuary for research, a seawater system, a challenge lab, BSL-2 labs, histopathology equipment (MD DNR), necropsy labs, and scuba capability.

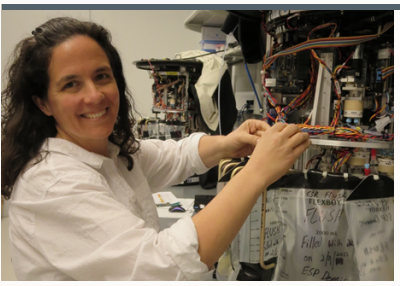




NCCOS HOLLINGS MARINE LABORATORY

HML is a NOAA-owned facility operated by NCCOS as a fully collaborative enterprise, governed by the five partner organizations through a Joint Project Agreement. HML partners consist of NOAA, the National Institute of Standards and Technology, the South Carolina Department of Natural Resources, the College of Charleston, and the Medical University of South Carolina. Scientists from all partner institutions work side-by-side in the laboratory, taking advantage of each other's special expertise.

HML was among the first to launch omics into the marine world emphasizing microbes, harmful algae, coral, aquaculture, and protected species. HML researchers move across omics domains of genomics (first time sequencing of more than twenty marine mammals and first microarrays for HAB species); transcriptomics (identifying transcriptome as the regulatory control for algal blooms), proteomics (protein markers for disease in humans and marine mammals and corals), and metabolomics (productivity analysis of multiple aquaculture species and temperature dependency of coral pathogens).




WHERE WE'RE LOCATED: NCCOS FACILITIES

NCCOS KASITSNA BAY LABORATORY

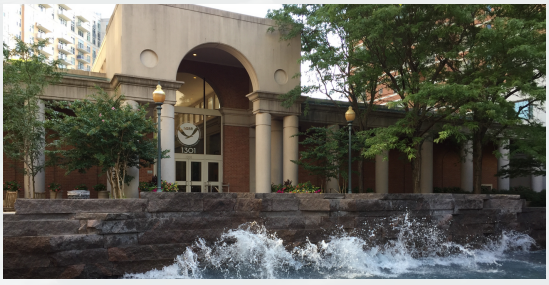
The Kasitsna Bay Laboratory has been the Alaska field station for both NCCOS and the National Marine Fisheries Service since the late 1950s. The University of Alaska Fairbanks helps NCCOS operate the lab. The facility includes a 1,400-square-foot, running seawater lab that hosts research on coastal impacts of climate change, ocean acidification, harmful algal blooms, and monitoring and change of nearshore biodiversity. The lab also serves as a testbed for underwater technology in high-latitude coastal ecosystems and under rugged conditions. This facility includes dormitory buildings with housing, kitchen, laundry, and internet for up to 48 people.

NCCOS BEAUFORT LABORATORY

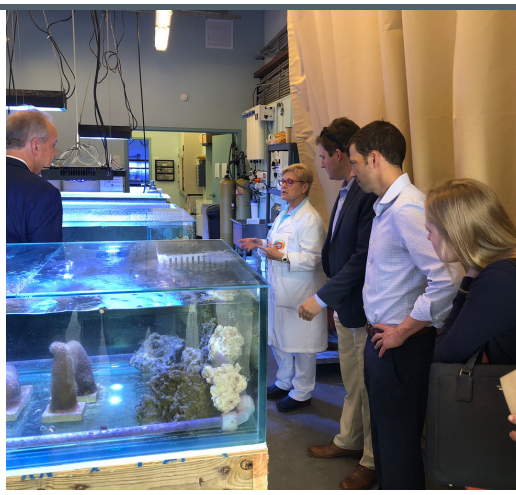
The NOAA (NCCOS) Beaufort Laboratory, opened in 1899, is the second oldest federal marine laboratory and home to scientists from NOAA's National Marine Fisheries Service and National Ocean Service. Operated by NCCOS, this 60,000-square-foot lab on Pivers Island is recognized for a variety of research, including: harmful algal blooms, salt marsh ecology, coral reefs, seafloor mapping, and aquaculture planning. The lab also houses the North Carolina Coastal Reserve and National Estuarine Research Reserve, which serve as living labs for scientists and students to learn about coastal systems. The lab has a full SCUBA diving roster, small boats, seawater systems, high-tech labs for cell analysis, necropsy facilities, electronics workshops, a classroom, and a large auditorium.

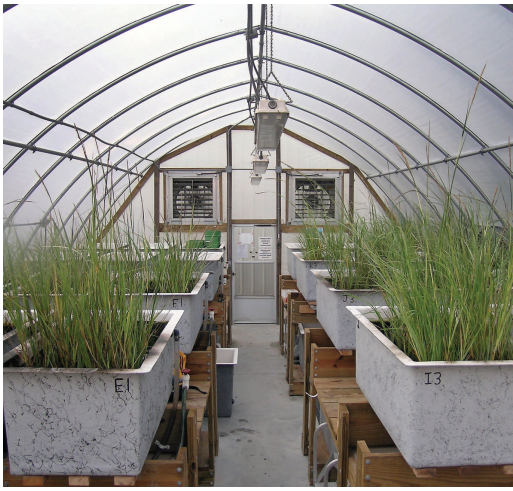
NCCOS HEADQUARTERS SILVER SPRING

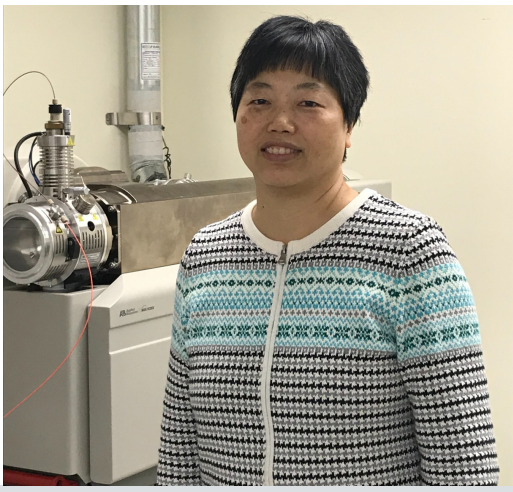
NCCOS leadership, scientists, and support staff are co-located with other NOAA offices in Silver Spring, Maryland. NCCOS employees plan, manage, and execute the budget; set information technology policy; and provide policy and communications support to NCCOS leadership in its internal and external partnerships and in its interactions with Congress. The program offices manage the Competitive Research Program and the NOAA RESTORE Science Program, and supervises or conducts science, research, and associated product development.



NCCOS PRIORITY — DETECTING, MONITORING, AND MITIGATING IMPACTS OF CHEMICAL AND BIOLOGICAL STRESSORS







Coastal ecosystems and communities are increasingly subjected to human-intensified stressors that degrade environmental quality and ecological integrity, and disrupt ecosystem benefits (e.g., food, water, economic, recreational, and cultural benefits) valued by the public. NCCOS conducts research and delivers scientific information and technologies to resource managers and public health officials for detecting, monitoring, and mitigating the impacts of chemical and biological stressors, including pathogens and harmful algal blooms (HABs) and their many toxins.

The detection, quantification, and monitoring of chemical contaminants and HAB toxins relies on NCCOS's advanced analytical capabilities (with biological, sediment, and aquatic samples), including bioassays and the development of validated methods and standards. These results are used to guide and validate ecological forecasts and are also entered into national and global reference databases. Test methods are transferred to local communities and resource managers to increase their capacity to monitor chemical contaminants and toxins in coastal ecosystems. In the case of the recreational and subsistence harvest of seafood in areas where HAB toxins (e.g., those responsible for paralytic shellfish poisoning) exist, accepted regulatory methods are provided to local authorities who determine if FDA food safety standards are being met.

NCCOS is a leader in determining toxicity thresholds and effects of chemicals on key coastal and estuarine species, corals, habitats, and the role of environmental factors (e.g., ultraviolet radiation, temperature, salinity) in exacerbating these effects. These efforts also support the evaluation and identification of chemical alternatives that have less of an impact on coastal ecosystems.

NCCOS develops technologies to prevent and control harmful algal blooms and adapt technologies and tools to restore water quality and coastal habitats impacted by oil spills. Research using marine species in their early life stages is also conducted to assess toxic and environmental threats present in ecological communities prior to the start of restoration activities.

The following sub-priorities for FY22–FY26 will focus on the most pressing needs (including the identification of new and emerging threats) where NCCOS can have the most impact:

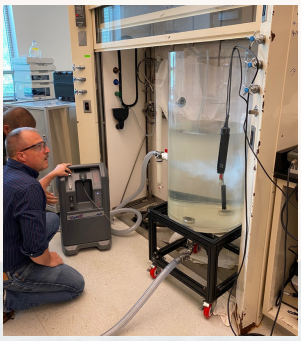
- Detecting, monitoring, quantifying, and assessing the impact of:

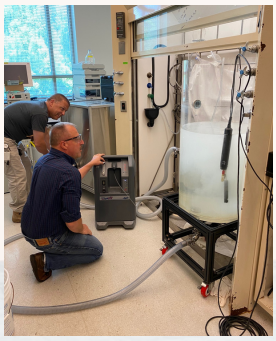
  1) priority chemicals (including crude oil, pesticides, personal care products, pharmaceuticals, flame retardants and microplastics, and their alternatives), ocean acidification, and hypoxia on coastal ecosystems;
  2) disease agents on corals; and
  3) the role of climate and environmental factors in exacerbating these impacts.

- Developing and validating HAB and toxin analytical methods and reference materials, advancing holistic approaches to understanding the causes and reducing the impacts of HABs and HAB toxins, ensuring community preparedness for HAB events, and supporting the transition of HAB control and prevention methods to application and commercialization.

NANOBUBBLE OZONE TECHNOLOGY (NBOT) COMBATS CHEMICAL AND MICROBIAL STRESSORS

Reducing chemical and microbial impacts where and when they are happening is one of the most challenging scientific requests from coastal communities. In response, NCCOS research has unleashed the unique biocidal power of ozone and placed it into a safe and targeted delivery mechanism of ultrafine microbubbles that is highly effective, but also ensures human and environmental safety. Through a Cooperative Research and Development Agreement, multiple companies are designing increasingly efficient and higher capacity NBOT components to test and demonstrate the best proprietary components that industry can engineer. Initially shown to be effective to eliminate harmful algal blooms with increasing scale of operation, NCCOS research has expanded NBOT application to a broad portfolio of chemical and microbial stressors, including pathogens and pollutants, to improve water quality, nutrients to prevent blooms from occurring, and elimination of invasive species in ballast water to protect biological diversity.



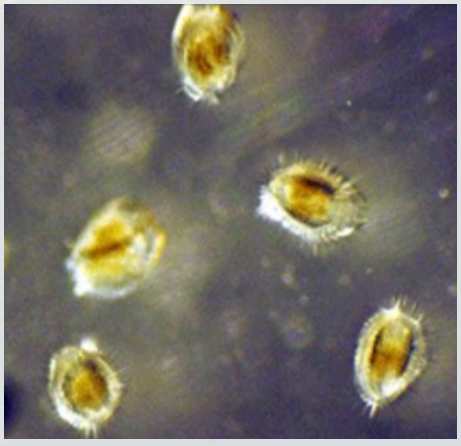


Nanobot 7.5 hp-60 treatment technology as installed at montreal pier facility. univ. wisconsin lsri/great waters research collaborative

Researchers scale up technology to reduce the introduction of algae, bacteria, and motile zooplankton invasive species in the Great Lakes (2021).

EVALUATING THE TOXICITY OF CHEMICAL ALTERNATIVES

Per- and polyfluoroalkyl substances (PFAS) are chemicals found in many commercial and industrial products and are known as “forever chemicals” based on their extreme persistence in the environment. Due to the harmful and persistent environmental impacts of these chemicals, there is a need to find PFAS-free chemical alternatives (e.g., PFAS-free fire-fighting foams). However, chemical alternatives, especially those that may occur in marine and coastal ecosystems, must be assessed for their toxicity to marine species. NCCOS assesses the toxicity of these chemicals, including quantifying bioaccumulation and establishing acute and chronic effects thresholds for fish, shrimp, oysters, and copepods. These toxicity data can inform decisions on the use of chemical alternatives and assist in the protection and conservation of coastal resources.



Oyster larvae in pfas toxicity tests

NCCOS PRIORITY — ADVANCING SOCIAL, ECONOMIC, AND BEHAVIORAL APPROACHES TO COASTAL STEWARDSHIP

Coastal ecosystems provide many benefits, known as ecosystem services, to coastal communities. These services can be categorized by the benefits they provide: cultural (e.g., recreation), regulating (e.g., nutrient removal), provisioning (e.g., food), and supporting (e.g., nutrient cycling). These ecosystems face many risks, including from climate change, and the interactions between humans and the ecosystems are becoming more complex. As an ecosystem's conditions degrade, its ability to provide these services is diminished, and dependent human populations become threatened. Coastal decision makers and the public need to understand and mitigate the risks and vulnerabilities not only to ecosystems, but also to the services they provide and the human communities that depend on them. Assigning a value—whether economic, social, or cultural—to the services provided by ecosystems allows managers to compare management options, such as whether to develop or conserve a natural area. It also makes communicating the value of ecosystems to policy makers and the general public easier. Additionally, communicating the risks through community engagement can yield a less vulnerable population.

NCCOS is uniquely positioned to apply social, economic, and behavioral approaches to support thriving and vibrant coastal communities, attending to their needs to support a diverse and flourishing economy, resilient infrastructure, secure food chains, social networks, and community well-being. As a leader in NOAA citizen science, establishing and engaging community networks, NCCOS continues to advance communities' understanding of the relationships between coastal ecosystems and human behaviors.

NCCOS research sub-priorities underpinning these science needs include:

- Ecosystem Service Valuation,
- Resilience and Vulnerability Assessments,
- Assessing Human Uses,

with a cross-cutting commitment to provide ecosystem solutions through highlighting and providing for the scientific needs of underserved communities.

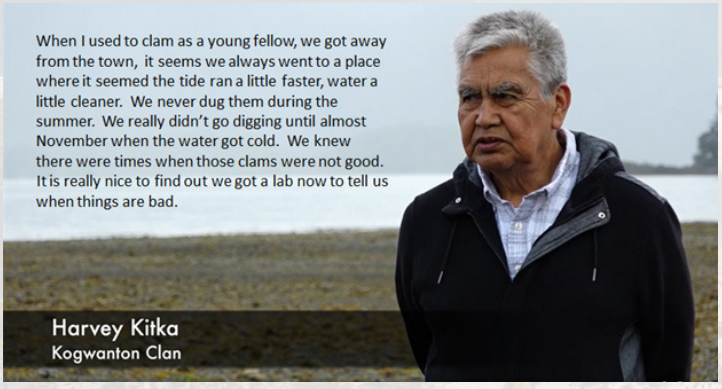
The research priorities also include shared goals that include long-term monitoring of coastal community well-being (e.g., National Coral Reef Monitoring Program) and understanding the impacts of threats to ecosystem services and ways to mitigate those threats (e.g., integrated ecosystem assessments). NCCOS also develops tools and approaches to increase the capacity of coastal communities to adapt to changing coastal ecosystems, giving communities the information they need to assess climate-driven risks and tools to implement adaptation strategies. By engaging communities as stakeholders from the beginning, NCCOS ensures research goals will meet community needs. For example, NCCOS has an extensive stakeholder engagement strategy for climate vulnerability assessments to ensure the assessments meet community concerns and dovetail into local adaptation plans. Additionally, NCCOS is deploying harmful algal bloom toxin detection tools directly to communities that will help them address issues related to social, behavioral, and economic stewardship by providing safe access to marine foods and recreation waters.

From FY22–FY26, NCCOS research efforts and priorities will continue to advance coupled social and natural sciences, emphasizing their interdependencies in light of changing climate and human needs, with a continued commitment to underserved communities and the unique economic and environmental challenges they face. NCCOS will continue to evaluate, measure, and map a wide suite of ecosystem services and vulnerabilities to meet the diverse ways in which communities value, depend on, and interact with coastal resources. Establishing and engaging community networks will advance the understanding of relationships between coastal ecosystems and human behaviors. Further, by providing training and technology transfer of tools and products, NCCOS will enhance access to the decision-making process and enable communities to consider a suite of risks in their mitigation and adaptation plans and consider new ones as they arise.These research efforts and priorities are tightly connected with NCCOS efforts to facilitate resilience and adaptation to inundation and climate impacts. By leveraging our ability to harness extramural expertise, NCCOS scientists will work collaboratively with partners and coastal managers to tailor research efforts to answer critical science needs.

SOCIAL SCIENCE IN SPECIAL PLACES

The NCCOS social science priorities support National Ocean Service special places, such as National Marine Sanctuaries, National Estuarine Research Reserves, and Habitat Focus Areas. These places are an opportunity for NCCOS scientists to understand how people use and interact with the coastal environment. They are living laboratories to measure values associated with a wide range of ecosystem services, such as recreational fishing along the Florida Keys Reef Tract and storm protection by coastal wetlands in the Northeast. In addition to special places, our work as a leader in NOAA citizen science and our community engagement also helps identify vulnerable and underserved communities to help address disparities in access to and use of the nation's coastal spaces. Our vulnerability mapping project in Los Angeles identified communities that lack access to natural spaces and are at particular risk in the case of natural disasters, supporting local and regional managers in addressing these quality of life and health issues. NCCOS provides social science research—including, long-term monitoring, data synthesis, and primary data collections—for the assessments necessary for adaptive management of these places and supports management of the regions around them.

PARTNERING WITH TRIBAL COMMUNITIES



> **"MY FAMILY HAS BEEN HERE FOR COUNTLESS GENERATIONS. SOME OF OUR EARLIEST STORIES GO BACK TO THIS: FOOD IS OUR LIFE. YOU TAKE WHAT'S THERE, YOU TAKE CARE OF IT, AND IT WILL TAKE CARE OF YOU. THAT'S OUR WHOLE PHILOSOPHY."**
>
> Harvey Kitka, Sitka Conservation Society "Voices of the Tongass." https://www.seator.org/safe-shellfish/

NCCOS is committed to inclusive, co-developed science that ensures tribal community ownership of products and services to meet local and regional needs. Understanding and incorporating local knowledge of natural areas and how non-marketed, traditional resources are used increases the social value of ecological research to the communities we serve. We support the development of community-led monitoring and forecasting capabilities for algal toxins in their subsistence, traditional, and recreational harvests. This includes facilitating phytoplankton identification trainings and workshops, expanding and validating toxin detection methods, and funding research that explores the transfer of HAB toxins within food webs. The Southeast Alaska Tribal Ocean Research (SEATOR) partnership is an example of a long-term outcome of these efforts. Since the SEATOR laboratory has been in operation, members of the 16 tribes have successfully avoided toxic shellfish beds with no human poisonings. Based on this success, regional programs have spread throughout Alaska tribal communities from the southeast to the Arctic, meeting specific tribal needs of aquaculture, dive fisheries, and place-based non-marketed traditional resources.

NCCOS PRIORITY — INVESTING IN OUR PEOPLE AND ACHIEVING ORGANIZATIONAL EXCELLENCE

Our commitment to our people and organizational excellence (i.e., standards, procedures, and practices for ensuring the effective use and management of our resources and assets and the motivation of staff to exceed expectations) ensures the successful delivery of scientific products and services of the highest quality. NCCOS applies innovative approaches to both research and science support functions and our staff, because their in-depth expertise and willingness to collaborate and contribute are sought after by a broad range of stakeholders and partners.

Our response to current and future environmental challenges, and our goal of supporting NOAA's mission and the U.S. economy, require strategic investments in our scientific portfolio in a holistic and systemic manner and the implementation of innovative recruitment strategies to meet diversity goals. With our commitment to training staff and modernizing our facilities and information technology (IT) infrastructure, we will ensure that we have staff, facilities (including research equipment), and an IT infrastructure with capabilities that will allow us to adapt and excel in meeting existing and emerging research and operational challenges. In the next five years, NCCOS will use its newly developed Strategic Workforce Plan to recruit and retain a workforce that reflects America's diverse population and cultivate an innovative culture in both the scientific and operational/business sides of NCCOS.

Resources include, but are not limited to, people, funding, facilities, and time. We will align and manage our resources with our scientific priorities through improved communication and a programmatic approach to funding research activities that are aligned with the NCCOS Strategic Plan. Investments in laboratories and facilities will be guided by a new Facilities Assessment Plan, and we will operate and manage our facilities as scientific assets in cooperation with co-located federal, state, and university partners. Safety, environmental stewardship, and security will be hallmarks of our facility operations.

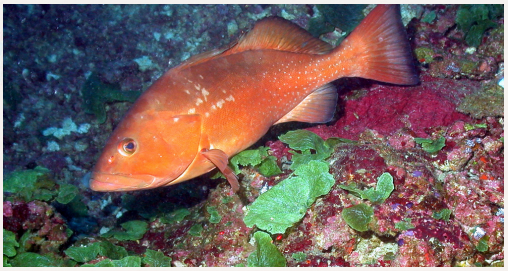
We will expand our partnerships and strengthen our stakeholder engagement activities to improve our scientific capabilities and ensure that we are meeting the needs of coastal decision makers and the public. Increasing the diversity of the federal NCCOS workforce has begun with early career researchers through Special Hiring Authorities in the STEM disciplines. We will increase our ability to quickly and effectively respond to changing and emerging coastal environmental challenges by improving our business practices, in areas such as optimizing agreements with coastal managers and the extramural scientific research community, and by increasing resource sharing. NCCOS scientists and staff will provide support, guidance, and expertise to achieve cooperation and collaboration on scientific research with our partners.

NCCOS is committed to communicating our science activities, findings, and products to the public, stakeholders, partners, NOAA leadership, and Congress. We will apply our expertise to inform coastal planning and management, federal policy and legislation, the scientific community, and the public (through social and traditional media). A cohesive communication effort is critical to develop consistent communication and outreach products for social and traditional media, web, internal and external information sharing as well as gathering input from public, stakeholders and partners to identify gaps in our efforts, identify opportunities, and ensure alignment with their ongoing or changing needs.

HOW WE DO OUR SCIENCE

INTERNAL AND EXTERNAL SCIENCE: A DUAL MODEL FOR SCIENCE DELIVERY

NCCOS uses a dual model for science delivery to coastal managers. Substantive internal science capacity is complemented by competitive external funding programs that use the expertise of scientists from across the country, including NCCOS scientists. NCCOS has over 200 active projects involving hundreds of internal and external scientists who actively engage with stakeholders to provide actionable coastal science products. While operated separately to maintain the competitiveness of external programs, these projects allow NCCOS science to cover a diverse portfolio in communities across every coastal state and territory. For example, NCCOS maintains a suite of capabilities that are available to assist state, local, and other partners in responding to harmful algal bloom events. These capabilities include direct funding support through the Event Response program, bloom forecast products, and analytical toxin detection services.



NOAA RESTORE SCIENCE PROGRAM

The NOAA RESTORE Science Program was authorized by the U.S. Congress in 2012 in the wake of the *Deepwater Horizon* oil spill to carry out research, observation, and monitoring to support the long-term sustainability of the Gulf of Mexico ecosystem, including its fisheries.

This cross-NOAA program administered by NCCOS offers an opportunity to improve our understanding of the Gulf of Mexico ecosystem and, simultaneously, use that knowledge to manage it sustainably. In practice, this means the program supports teams of resource managers and researchers who work together to produce science that helps answer the questions resource managers are facing.

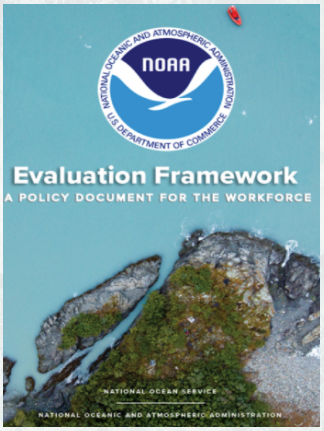
By investing in relationships, supporting actionable science, and promoting the practice of co-production over the next two decades, the Science Program is transforming over $133 million of the penalties from the oil spill into applied ecosystem science in the Gulf of Mexico. In doing so, the program is building a community of resource managers and researchers committed to this type of work in the region.

The Science Program has led four funding competitions since 2012 and expects to run several more competitions over the next five years, including one on scientific synthesis in 2022.

To learn more about the program, please visit restoreactscienceprogram.noaa.gov.

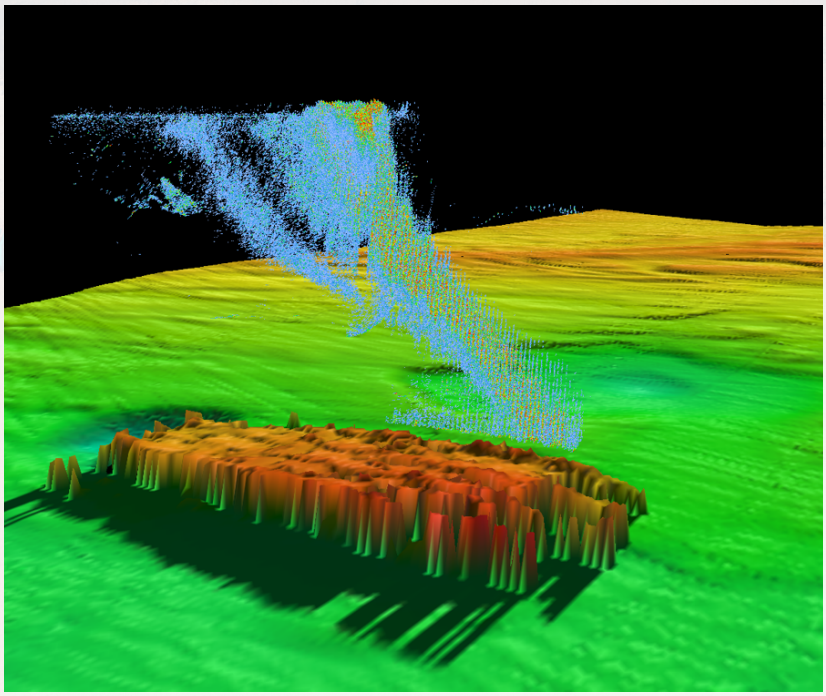
A CULTURE OF CONTINUOUS IMPROVEMENTS

NCCOS reviews and evaluates the quality, relevance, and performance of its programs to ensure that objectives are being met, and strengths and opportunities for improvement are identified based on feedback and insight from external experts and our partners. NCCOS adheres to NOAA's Administrative Order 216-115A for reviewing scientific and research programs and NOS's Evaluation Framework for reviewing business management practices and organizational structures. NCCOS is committed to a "culture of evaluation" to promote a cycle of continuous improvements.



A CULTURE OF TECHNOLOGICAL AND ORGANIZATIONAL INNOVATION

NCCOS recognizes the importance of innovation in the U.S. Government in each priority and all facets of our service. Within this framework we explicitly encourage technological and organizational innovation. We accept calculated risks that are often prerequisites for innovation, to more effectively and efficiently achieve our mission. Through our innovative culture, which we cultivate, we embrace and stimulate organizational innovation through dialogue, redefine success and failure, and reward innovative approaches to our work. In addition to building a culture of innovation through intentional communication on the subject and removing the disincentives that may have constrained innovation, NCCOS incentivizes creativity through two annual prizes: one each for technological and organizational innovation.



NCCOS's investments in innovative approaches, such as cloud computing, have significantly increased our efficiency in running ecological and physical models, thus reducing the time needed to get products to coastal managers.

Innovation in acoustic technology: NCCOS scientists quantified oil and gas release at the MC20 site to originate from wells rather than from contaminated sediments. With this conclusion, containment and collection methods are now collecting approximately 30 barrels (1260 gallons) of oil per day.

APPENDIX – STRATEGIC PLAN PRIORITY OUTLINE

1. Advancing Ecosystem Science for Conservation and Sustainable Use
- a. Marine Spatial Planning
- b. Habitat Mapping
- c. Biogeographic/Ecological Assessments and Research
- d. Monitoring and Research in Coral Reef Ecosystems

2. Developing and Implementing Advanced Observation Technologies and Ecological Forecasts
- a. HABs and Hypoxia
- b. Pathogens
- c. Coastal Habitat Changes
- d. Observation technologies

3. Facilitating Resilience and Adaptation to Inundation and Climate Impacts
- a. Ecosystem Change
- b. Community and Ecosystem Vulnerability
- c. Restoration and Natural and Nature-based Features

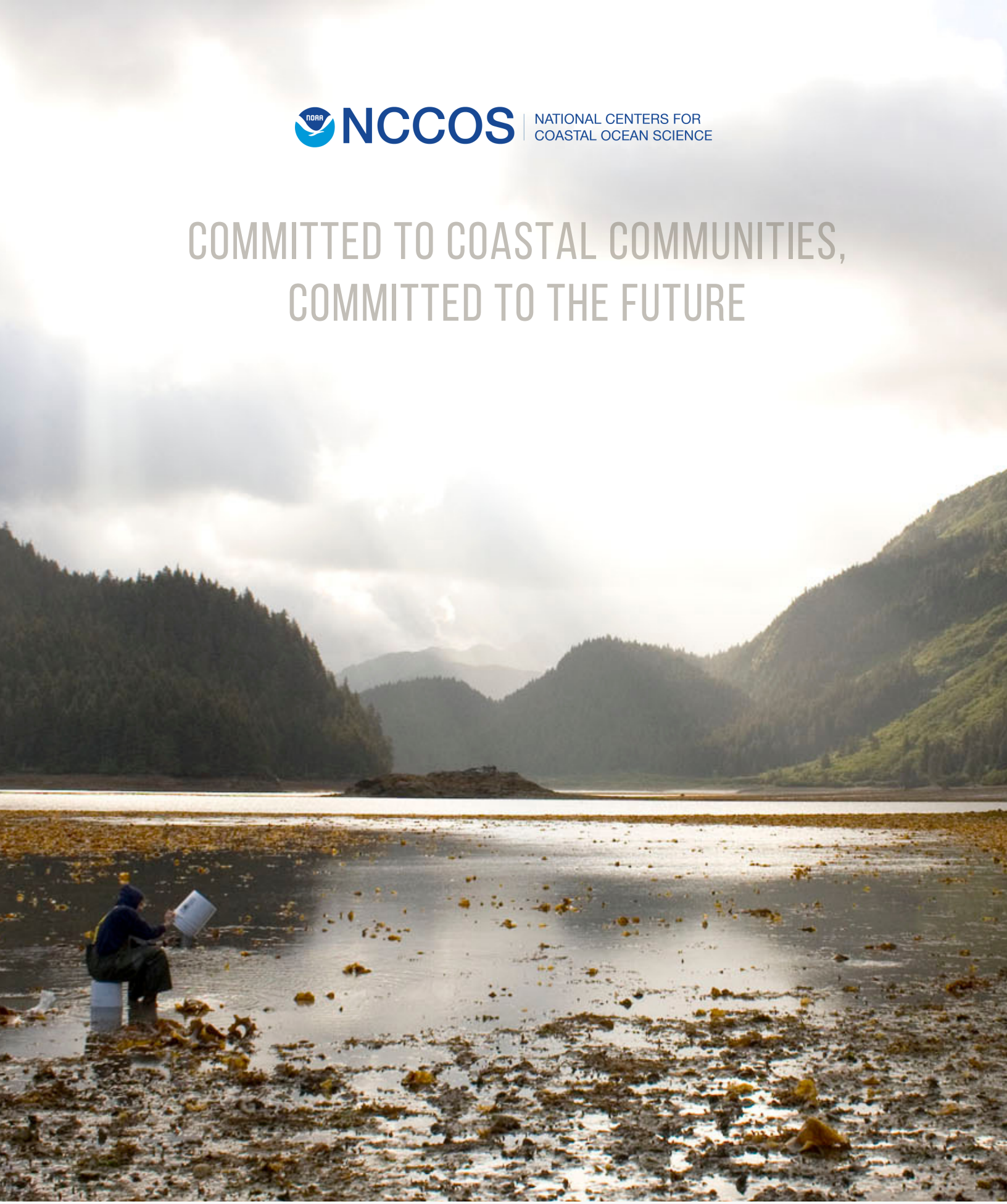
4. Detecting, Monitoring, and Mitigating Impacts of Chemical and Biological Stressors
- a. Priority Chemicals, Ocean Acidification, and Hypoxia
- b. Disease Agents on Corals
- c. Climate and Environmental Factors
- d. HAB and Toxin Analytical Methods and Reference Materials
- e. HAB Prevention and Control

5. Advancing Social, Economic, and Behavioral Approaches to Coastal Stewardship
- a. Ecosystem Service Valuation
- b. Resilience and Vulnerability Assessments
- c. Assessing Human Uses

6. Investing in our People and Achieving Organizational Excellence
- a. Cultivating Innovative Organizational Culture
- b. Aligning and Managing Resources Tied to our Scientific Priorities
- c. Leveraging Diversity and Inclusion for Mission Effectiveness
- d. Building and Strengthening Productive Partnerships and Engaging Stakeholders

NCCOS | NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE

COMMITTED TO COASTAL COMMUNITIES, COMMITTED TO THE FUTURE



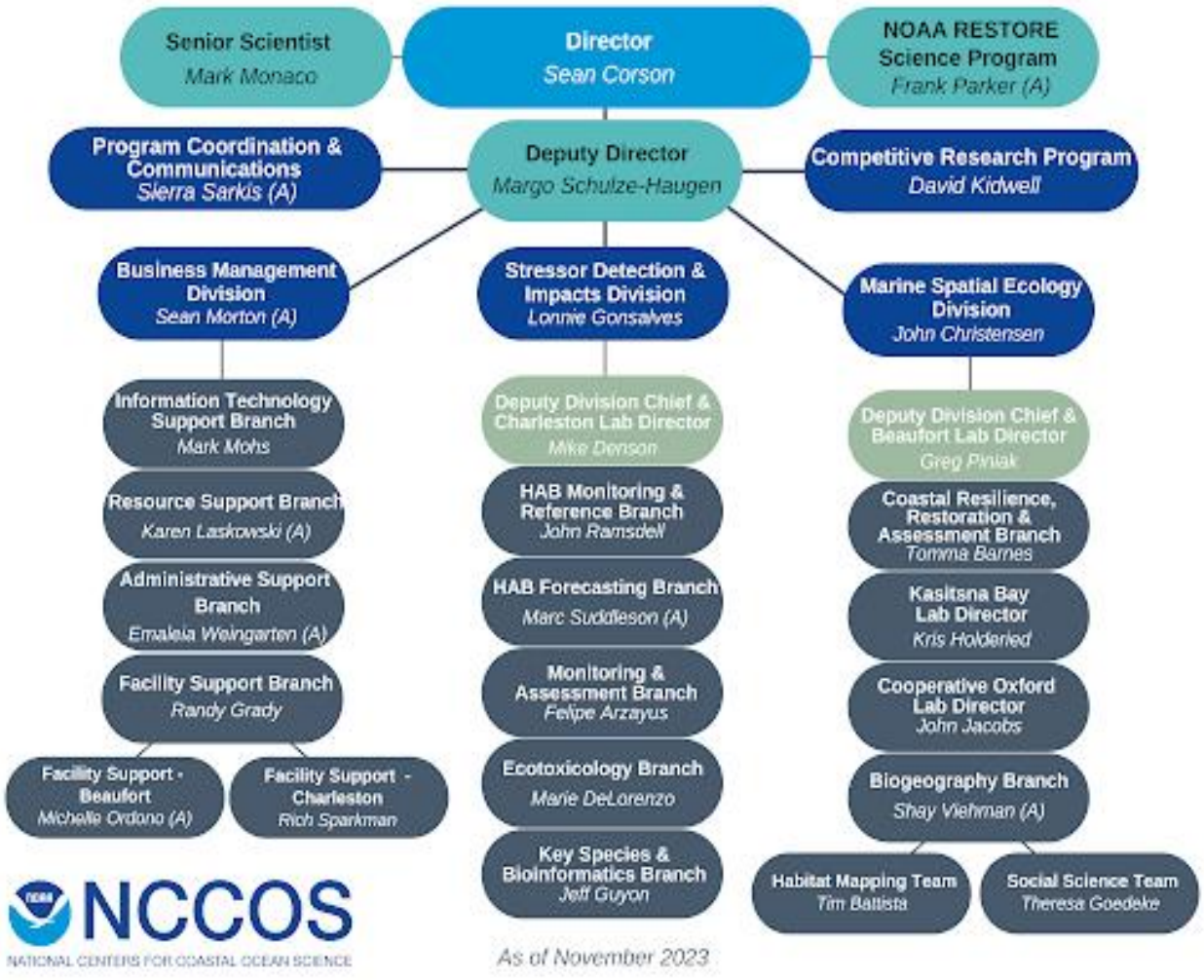
U.S. DEPARTMENT OF COMMERCE | NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION | NATIONAL OCEAN SERVICE | NATIONAL CENTERS FOR COASTAL OCEAN SCIENCE

APPENDIX E: NCCOS Formation

Background

The National Oceanic and Atmospheric Administration (NOAA) formed the National Centers for Coastal Ocean Science (NCCOS) in 1999 as the focal point for NOAA's coastal ocean science efforts. We help NOAA meet its coastal stewardship and management responsibilities, and provide coastal managers with the scientific information necessary to decide how best to protect environmental resources and public health, preserve valued habitats, and improve the way communities interact with coastal ecosystems. NCCOS has six strategic priorities, developed through a comprehensive stakeholder engagement process. These priorities guide NCCOS's science and competitive research investments and provide the information necessary to address complex coastal challenges. See Appendix C for the full Strategic Plan documents.

Organizational Chart

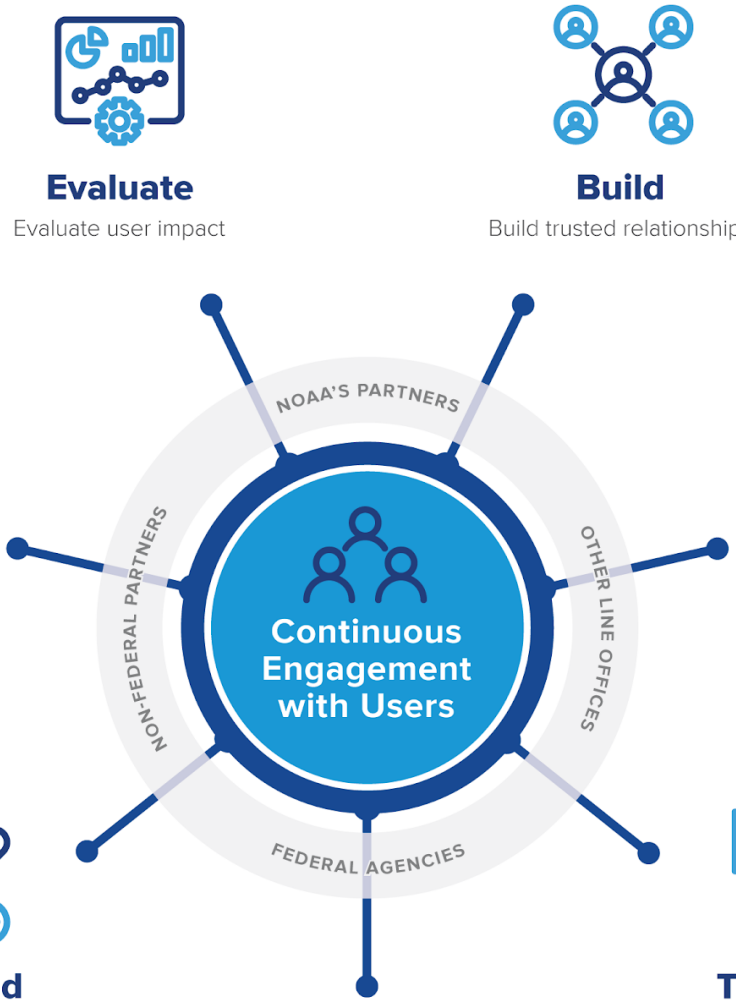


APPENDIX F: A Model of Service Delivery for the NOAA Water Initiative

The NOAA Water Initiative (NWI) was launched in December 2016 with one overarching goal to transform water information service delivery to better meet and support evolving societal needs. This service-oriented approach, working across the existing network of line offices and affiliated partners, is focused on understanding the challenges users face and helping to address society's needs. The purpose of this framework is to guide and improve decision support products and services and their delivery. The full PDF document can be found at this link. For reviewers' convenience we have also included the full document below.

A Model of Service Delivery for the NOAA Water Initiative

A proven framework for integrating service delivery and decision support



Evaluate
Evaluate user impact

Build
Build trusted relationships

Deliver
Deliver products to the user

Gather
Connecting lessons about use of information with user needs

Respond
Respond to user needs

Translate
Review and consider NOAA's capacity to respond

Review
Review and prioritize product and service development

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Recommended Citation. National Oceanic and Atmospheric Administration (NOAA), Water Initiative. 2020. "A Model of Service Delivery for the NOAA Water Initiative: A Proven Method for Integrating Decision Support and Service Delivery." Authored by the NOAA Water Team.

INTRODUCTION

The NOAA Water Initiative (NWI) was launched in December 2016 with one overarching goal: To transform water information service delivery to better meet and support evolving societal needs.[1] As the nation experiences increasing variability and change in precipitation patterns, flooding, drought, and other complex water issues, NOAA's mission of science, service, and stewardship becomes of even greater importance. In 2019 alone there were three billion-dollar flooding events, and since 2015 there have been 15 drought and flood events that together caused more than $60 billion dollars in damage.[2] In addition, many communities are facing increased disruptions to their daily lives as a result of recurring flooding along our coasts. NOAA must coordinate a unified service delivery approach that leverages partnerships and informs the development of use-inspired products and services. This service-oriented approach, working across the existing network of line offices and affiliated partners (see Appendix A for definitions), is focused on understanding the challenges users face and helping to address society's needs.

The purpose of this framework is to guide and improve decision support products and services and their delivery. This document captures the shared language (see Appendix A), components, and best practices that make NOAA service delivery and decision support successful.

> "In the United States and around the world, water security is increasingly in jeopardy. **Too much water, too little water, or water of poor quality** can endanger life, property, economies, and ecosystems."[3]

NOAA's Mission
Science: to understand and predict changes in climate, weather, oceans, and coasts
Service: To share that knowledge and information with others
Stewardship: To conserve and manage coastal and marine ecosystems and resources

THE DRIVERS FOR INTEGRATING SCIENCE AND SERVICES

Service delivery lies at the heart of NOAA's mission and is critical in all that it does. Users look to NOAA for a range of data, information, tools and services, but sometimes find them difficult to efficiently and effectively access and understand. Some users seek additional support to apply NOAA's data, information, and tools to their situation. They want answers, guidance, training, and a helping hand. Through continuous customer engagements, NOAA personnel glean important information about how data, products and tools are, or are not, serving specific localities or sectors. (Successful examples are provided in Appendix B).

NOAA Water Initiative Outcomes

SERVICE DELIVERY
Objective 1: Build Strategic Partnerships for Water Information Services

Outcome 1.1: Within three years, NOAA agencies will identify, establish, or strengthen three or more partnerships to engage stakeholders in an ongoing and sustained manner. These partnerships will build on and add value to existing stakeholder frameworks and activities.

Outcome 1.2: Within five years NOAA will establish a new model of service delivery for its water information services, building on the partnerships in Outcome 1.1, conducting targeted risk and vulnerability assessments, and building collaborative solutions for advancing water information service delivery.

[1] https://www.noaa.gov/water/explainers/noaa-water-initiative-vision-and-five-year-plan
[2] https://www.ncdc.noaa.gov/billions/
[3] Ibid

NOAA has been transforming from a scientific and technologically constrained set of products and services, to valuing user needs as a critical input for developing useful, actionable information. Timely and specific user needs are essential inputs for advancing and deploying new technologies, models, tools, and resources. This framework will enable NOAA to consistently understand user needs and prioritize responses to the evolving decisions in society.

The nation benefits from enhanced service delivery through improved decision making; reduced risk to lives, property, and the economy; and increased resilience and strengthening of water-sensitive sectors such as agriculture, water management, transportation, natural resources, recreation, and energy. The benefit of enhanced service delivery for NOAA is a more efficient and effective agency that is better able to fulfill its mission by:

- Prioritizing investments in its product lines (e.g., science (observations and data), services (technical assistance, engagement, training), and stewardship (resource management, place-based);
- Leveraging the capabilities/roles of NOAA and our partners to help meet the needs of our users;
- Developing new, and refining existing, products and services that are informed by user needs; and
- Transmitting and translating information for decision-makers across multiple sectors.

This framework describes a consistent approach that will enhance NOAA's delivery of water-related services, and could also be applied to other NOAA initiatives that cite the need to understand and apply user needs to guide product and service development (e.g., subseasonal-to-seasonal predictions, climate services, Blue Economy, and Weather-Ready Nation). Institutionalizing and integrating these processes to align with other weather-, ocean-, coast-, climate-, and fisheries-related initiatives and activities will better equip NOAA to fulfill its vision of developing and sustaining resilient ecosystems, communities and economies.

MODEL FOR SERVICE DELIVERY

Effective implementation of service delivery requires relationships between information producers and consumers built on mutual trust and respect. Key to developing and maintaining these relationships is sustained engagement and collaboration that will facilitate the integration of services into actionable information. NOAA's existing network of line offices and affiliated partners is a critical asset to support improved service delivery. Many of these entities already have the desired level of trust and frequent engagement with their community members. This new model for service delivery offers a guiding concept to transform interaction among these groups. It documents best practices for service-oriented approaches, processes, and tools to improve how NOAA's products and services are developed and delivered to society.

Framework Vision

U.S. residents understand and use the breadth of NOAA's information for their decisions

Framework Mission

NOAA will continuously build a network of trusted experts who engage internally and externally with partners to inform NOAA's product and service development to be useful, usable, and used

The foundational element, central to the effectiveness of this model (Figure 1), is the principle of continuous user engagement. As evidenced from the literature (Appendix C), NOAA must embrace the coordinated production of information as a critical part of product and service development. This requires that NOAA services entities continuously engage with users in order to fully understand their evolving needs and the accuracy and timeliness of NOAA's response to their needs.

Figure 1. To achieve this vision, NOAA's service providers must (1) continue to build trusted relationships with NOAA's internal and external users and partners; (2) understand the decisions of those users, their use of NOAA information, and be able to gather the user's information needs; (3) evaluate user needs (that cannot be quickly satisfied) through a lens of both NOAA and its partners' capacity; (4) review and prioritize NOAA's products and services to meet the needs; (5) respond to user needs by developing new, or refining existing, products and services across NOAA; (6) deliver these products and services to users; and (7) evaluate user impact of NOAA's tools and services. These elements represent a process. It is imperative that as each element is conducted, interaction occurs between the trusted NOAA entity, end users, and various partners. It is also likely that elements will co-evolve and loop forward, across, and behind in the diagram to verify needs and capabilities, and ensure the provision of the best products and services.

Additionally, successful service delivery includes an awareness of relevant NOAA products and services that would be responsive to the user needs. Service entities need to be prepared to, and have the capacity to, transfer the products and services in such a way that the users have the knowledge and skills to apply them to their needs.

The detailed model documents a clearly-defined, high-impact approach for NOAA offices and their core partners to capture and be responsive to a suite of user needs. The model includes components of shared feedback received during constituent engagements, the identification and adjudication of user needs, the integration of needs into agency science, service, and stewardship requirements, and ultimately relies on Line Offices to respond with credible, use-inspired products that are then delivered and evaluated by the engagement entities. This framework will enable NOAA to continue serving as a trusted source for science and information. Through technical assistance, training, personal engagement, evaluation, and customer service, NOAA will guide its partners, users, and stakeholders across all sectors in applying and interpreting NOAA's vast collection of weather, climate, and water information and tools to build resiliency.

THE FRAMEWORK FOR INTEGRATING DECISION SUPPORT AND SERVICE DELIVERY WITH PRODUCT DEVELOPMENT

Foundation // Continuous Engagement

Continuous engagement is the central element for successful service delivery. Engagement is a process that is developed and nurtured through ongoing interactions and results in trusted relationships. Critical to the success of engagement is communication that fosters mutual learning and facilitates joint dedication to achieving agreed upon needs and goals. Like any relationship, engagement takes time. It does not occur as the result of one call or meeting. Trust is built with iterative, frequent, and consistent interactions in local settings, that embody dedication and commitment to the user and their priorities. Over time, trust and relationships are built between individuals and organizations. Personal involvement in all interactions with the users and partners is critical because they are the personification of the Agency's interest and commitment. Further, the first hand involvement of the trusted NOAA entity in all steps (with users, colleagues within NOAA, and with partners, throughout all stages of service delivery) builds trust and streamlines processes, as they have the best understanding of the complex needs of the users. The trusted NOAA entity has spent years understanding the scope and context of needs via continuous two-way communication, and can thus assist with the translation and development (and co-development, where appropriate) of products and services, and best facilitate delivery and use.

Build // Building Trusted Relationships

NOAA's relationships with new and existing partners (e.g., other governmental agencies, academia, the private sector, non-profits, and the public) must be built through frequent two-way communication and continuous respectful engagement. Central to this is fostering listening, dialogue, and understanding with users to help address our shared mission. As a result, NOAA and our partners will better understand and use the broad suite of water information and tools already available, as well as the continuously evolving needs of users. Under the best circumstances, practitioners and providers jointly assess the utility of services and identify useful next iterations.

As NOAA considers the next generation of data and information production, delivery, and research and development, it is incumbent upon the organization to understand, use, and expand upon the existing array of NOAA partners. These entities are its first and most valuable resource. Utilizing these partnerships and integrating the experiences they bring to water resources challenges, will allow a more informed process in evolving and developing products and services that better serve the American public.

Gather // Connecting Lessons about Use of Information with User Needs

Continuous investment in engagement, within NOAA and with external users and partners, allows us to fully understand the use of NOAA's information and the scope of information needs. Engagements, as outlined above, are conducted for the purposes of building trust and understanding the use of NOAA's information in the context of what needs still exist. In order to clearly capture and articulate user needs, NOAA relies on continuous engagement with the end user. It is crucial that the trusted NOAA representative also work directly with NOAA's subject matter experts and science teams to ensure the needs are correctly understood. Additionally, NOAA's subject matter experts and science teams must understand that user needs are not limited to specific information. Needs also include the ability to understand when and how users will best receive, and thus use, the information. Gathering needs and understanding how NOAA's products and services are used is a key step in using trusted relationships to build products and services that will be used. To do this, NOAA must (1) leverage the existing efforts, knowledge, and expertise from across the agency and from its partners; and (2) transfer user experience and needs in a systematic and useful way across NOAA. Users can grow weary of their needs being assessed without follow through on NOAA's part in developing solutions. When this occurs, NOAA risks losing the trust of its constituents.

Translate // Review and Consider NOAA's capacity to respond

As relationships are built and user needs are identified, NOAA subject matter experts will translate the needs identified above into technical aspects NOAA will use to make decisions for mission improvement or enhancement. In order for NOAA to produce products that will be used, analysis teams will study, prioritize, and translate the needs as articulated from the user into the development, or refinement, of products and services. NOAA examines not only the mission relevance, but the capacity to be responsive and adapt to the user needs expressed. In this step, NOAA and teams would review, iteratively with the customer, their capacity, and the capacity of NOAA's partners, to respond. This may be accomplished through a formal process, or through less formal structures directly accountable to the user. Regardless of the mechanism, processes must be focused on transparency, responsiveness, and accountability. Understanding the capacity ensures entities who may be tasked with service development receive actionable information to determine existing product value as well as future considerations for maintenance and sustainment.

Assess // Review and Prioritize Product and Service Development

Once user needs are translated and defined, they must be aligned with NOAA's mandates and mission. Once the needs are determined to be within NOAA's mission, they may be further assessed based upon criteria such as applicability and alignment with NOAA priorities. The criteria also must account for the urgency of user needs.

Within the framework of NOAA's strategic priorities and goals, subject matter experts, and/or project teams with knowledge of underlying or consensus user needs, will prioritize solutions. This involvement can better direct development to the entity best positioned to respond, while ensuring outcomes are addressed in an effective manner. Investing in resources (either monetarily or through staff time) must be justified in implementing the request. Proposed solutions will be balanced against potential risks along with opportunities to combine or coordinate efforts to optimize NOAA's outcomes. The results will be documented for reference, particularly, those needs that are not prioritized. Open, transparent communication with our constituents as to NOAA's ability to meet the need identified is critical in maintaining trust. This informs and fosters transparent engagement activities and capitalizes on relationships to keep NOAA cognizant of the context for user needs.

Address // Respond to User Needs

Being responsive to the user's requests and needs is one of the most critical elements in effective service delivery. After the need has been identified and NOAA has decided that it is well positioned (mission and resources) to meet the need, the work of developing the product or services can begin. In identifying and developing the most effective and efficient product or service to address the need, there is regular engagement with the users and partners. Sometimes the need calls for building a new product or service, sometimes it is adjusting or enhancing an existing one, sometimes it is initiating a process such as joint fact finding and, or sometimes it is building the capacity of the users to apply the product via technical assistance, training, or other learning mechanisms. There are times it will require multiple complementary products and services such as a new decision support tool paired with training to ensure end users can best apply. The important piece is that there is a commitment to both develop and deliver a product and or service that addresses the need.

During the process of developing the product or service, communication with the end users is critical. Once they have expressed their needs and NOAA has agreed to develop a product or service, the end users need routine engagement to understand the length of time it will take, how often they will be consulted with, and who is their contact. The more connected the intended users feel during the development time, the more likely they will be to use the end product or service. Interactions between experts and users can drive innovation. The development process should be iterative providing feedback to the developers along the way and understanding to the end users. The NOAA development process needs to ensure the products and services are responsive, relevant, and actionable to the evolving users needs and considers the potential impact of product/service changes on our partners.

Deliver // Deliver Products to Users

NOAA data, information, and tools are developed to enhance users' understanding and decision making. Unless that data, information, and tools are delivered in such a way that the potential end users are aware of, can access, understand how they can be best used to address their issues, and have the knowledge and skills to appropriately apply them, the data, information, and tools risk not being used. The on-going engagement element in the proposed model is key in the delivery element. Targeted outreach and communication can help users know that a specific product or service is available and user-friendly websites assist in an end users ability to access the data, information, and tools.

Increasingly high touch (in person or virtual) delivery mechanisms are sometimes needed for end users to be able to understand and have the skills to apply the data, information, and tools to their decisions. Long term or power users of NOAA water products and services are able to assimilate and apply new products and services more easily and can serve as peer mentors. High touch delivery mechanisms include technical assistance, learning tools (such as case studies, job aids, quick references, tutorials, and community of practices), as well as workshops and training. These mechanisms are most effective if development of them are grounded in the learning sciences. Continuous engagement with the end users will ensure the delivery mechanisms are strategic, relevant, responsive, and timely. The value of the data, information, and tools are not realized until they are being applied by the end users to decisions.

Evaluate // Evaluate User Impact

Evaluating NOAA's efforts on service delivery is a continuous process. Front-end evaluation, or needs assessments, are key in gathering needs and distinguishing between the needs and wants of the end users. Formative evaluation happens as the products and services are being developed and includes the back and forth between developers and the end users. It is through the formative evaluation that NOAA ensures that the end users needs are being met appropriately. Summative evaluations are completed after the products and services have been delivered to document the results. Evaluations can assess the results or examine the process. A return on investment study can be then done to monetize the results.

There are many methods to collect information about how users are applying the products and services delivered. The first questions are typically around if they are using, then how they are using and then importantly, if the use of the products and services are assisting them in reaching their goals more effectively and efficiently. The scope and scale of the products and services can help determine which products and services receive summative evaluations. The science of evaluation is best accomplished through proven social science methods (survey, focus group, interviews, observations) done by expert evaluators particularly for summative and ROI studies. NOAA social scientists, partners, and others specializing in evaluation must work together to leverage resources and capabilities that will ensure products and services accomplish the desired outcomes.

CONCLUSION

The purpose of this framework is to strengthen NOAA's service delivery enterprise so that users can clearly understand and use the breadth of NOAA's information for their decisions. This framework describes the service delivery concept and the activities required to inform use-inspired products and services. NOAA's strength is commitment to service. As an agency, NOAA must fully engage society, utilizing its extended network and partners to leverage knowledge, expertise and resources. The overall value of enhanced service delivery for NOAA is a more efficient and effective agency that is better able to fulfill its vision of healthy ecosystems, communities, and economies that are resilient in the face of change. The NWI Service Delivery and Decision Support Teams (see Appendix D) are committed to developing the implementation and next steps needed to realize the vision of a new service delivery model for NOAA.

APPENDIX A: DEFINITIONS

Definitions for commonly-used terms from the NWI Vision and Five-Year Plan were developed through research and synthesis of existing definitions derived from multiple Line Offices.

Audience. Targeted group for whom NOAA develops and serves information, products and services.

User(s). A person(s), group, or organization who accesses and applies information, products, or services.

User Group. A set of people who have common interests, goals, or concerns about NOAA products and services.

Partners. Organizations and individuals with whom NOAA shares a mission and/or has regular, substantive interaction in order to effectively achieve both of our missions. This definition includes the following terms which may refer to specific LO usage: Core, Close, Key, Primary, Federal, Traditional Line Office; Weather, Water, and Climate Enterprise, etc.

Product. A tangible piece of information (printable, visible) that enables a user to learn or take action.

Service Delivery. The continuous process of engaging with users in order to provide relevant and timely information via appropriate mechanisms.

Stakeholder. Anyone with an interest in the process or outcome, or who is affected by water resources.

Technical Assistance. Targeted coaching for users to help them access, understand, and use NOAA products and services for their own decisions.

Training. Instructionally designed activity aimed at imparting information and building participants skills to attain a specified level of knowledge or skill.

APPENDIX B: SERVICE DELIVERY FRAMEWORK IN ACTION

The following are three successful NOAA examples of implementing this framework.

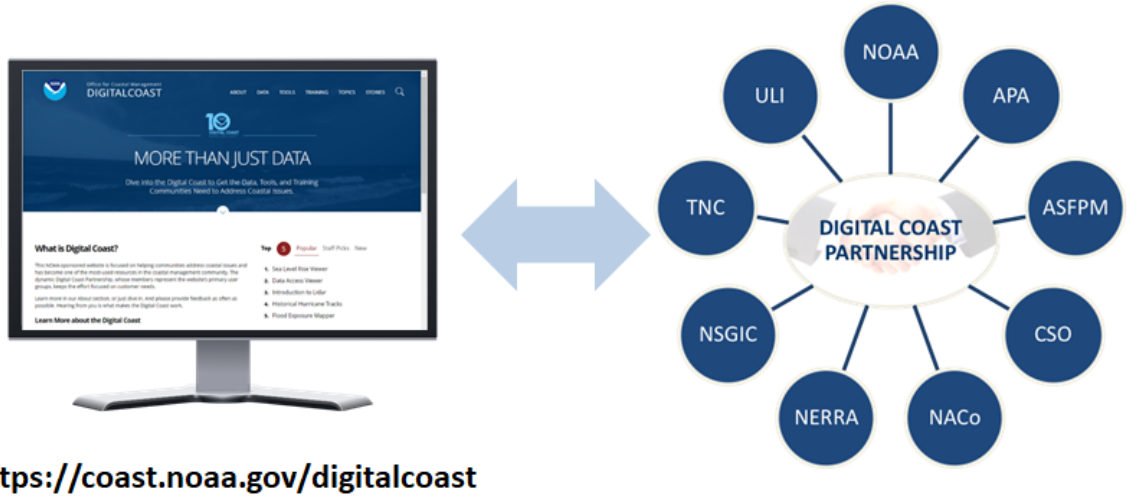
DIGITAL COAST // NOAA developed the Digital Coast to serve those who manage our nation's coastal resources. This digital resource provides not only data, but also the tools, training, and information coastal communities need if they are to use these data in the decision-making process. This centralized repository is cost effective and easy to use. While the Digital Coast was developed and is currently maintained by the NOAA Office for Coastal Management, hundreds of organizations and federal, state, and local agencies contribute content. This resource is a first stop for the nation's coastal management community.

The Digital Coast, however, is more than just a website. The Digital Coast provides the framework, through the Digital Coast Partnership, that allows groups that might not otherwise work together to join forces to address coastal issues. The Digital Coast Partnership, which is composed of membership organizations who represent Digital Coast users, is essential for the success of this effort, since partner input ensures the relevance of the Digital Coast in the face of the constantly changing needs of the coastal management community.

CONNECTION TO KEY ELEMENT(S):

- **Foundation // Continuous Engagement -** NOAA's Office for Coastal Management has dedicated points-of-contacts who routinely speak to and coordinate with the partnership organizations. In addition, quarterly calls are held along with annual face-to-face meetings. This highly successful partnership approach is based on clear expectations and roles for all partners and NOAA.
- **Build // Building Trusted Relationships -** The Digital Coast Partnership was formed in 2007 to help guide the scope and content of what Digital Coast has evolved to be. Dedicated, long-term, continuous engagement; shared expectations; clear roles; transparency; joint strategic planning; and shared credit and shared opportunity has built trust among all partner organizations. Even with staff turnover, the relationship has continued because of the relationships built.
- **Gather // Connecting Lessons about Use of Information with User Needs -** Partnership members routinely discuss information needs and priorities. This direct feedback leads to product and service delivery improvements for the Digital Coast.
- **Translate // Review and Consider NOAA's Capacity to Respond -** NOAA's Office for Coastal Management assesses the organization's capacity to address identified needs. Critical to success is sharing what can be done, but equally importantly, what cannot be done and why.
- **Review // Review and Prioritize Product and Service Development -** User needs and capacity to respond are reviewed to determine products and services to enhance, develop, or in some cases, abandon. Transparency back to the partnership organizations is a key component of this element.

- **Respond // Respond to User Needs -** Using routine meetings and other forms of engagement and outreach to demonstrate products and services and provide answers to expressed needs shows responsiveness and is critical.
- **Deliver // Deliver Products to Users -** The Digital Coast provides products and services in accessible, and many times multiple, formats for the target audiences. Each product also includes, as appropriate, training, tutorials, and metadata that enable the user to apply the product and services with confidence.
- **Evaluate // Evaluate Impact -** Continuous feedback and evaluation lead to improved products and services. The Digital Coast Partnership represents well over 100,000 potential users; one of their primary roles is to evaluate products during development and after release.



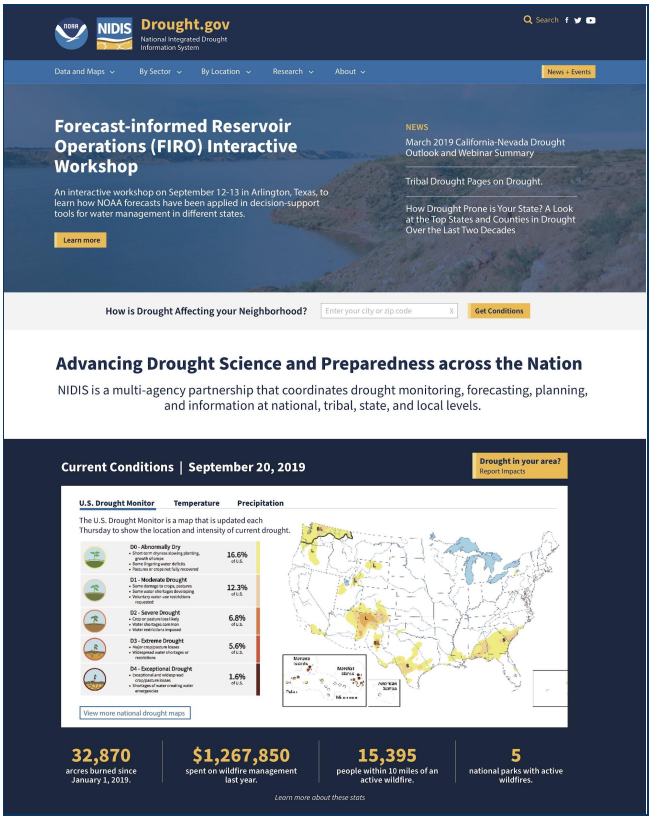
https://coast.noaa.gov/digitalcoast

The Digital Coast Enabling Platform is built on the interaction between the Digital Coast Partners and users and the website. This connection is critical to the platform's success.

NATIONAL INTEGRATED DROUGHT INFORMATION SYSTEM (NIDIS) // The National Integrated Drought Information System (NIDIS) Act was authorized by Congress in 2006 (Public Law 109-430) and reauthorized in 2014 and 2019 with an interagency mandate to develop and provide a national drought early warning information system, by coordinating and integrating drought research, and building upon existing federal, tribal, state, and local partnerships. NIDIS is led by the National Oceanic and Atmospheric Administration (NOAA). NIDIS's mission is to improve the nation's capacity to proactively manage drought-related risks, by providing those affected with the best available information and resources to assess the potential for drought and to better prepare for, mitigate, and respond to the effects of drought. Service delivery and stakeholder engagement are key components of NIDIS implementation.

CONNECTION TO KEY ELEMENT(S):

- **Foundation // Continuous Engagement** - Partnerships are a foundational element of NIDIS, with numerous mechanisms for engagement. For example, NIDIS has regional Drought Early Warning System (DEWS) coordinators that are continuously speaking and coordinating with a wide range of regional partners.
- **Build // Building Trusted Relationships** - NIDIS builds and sustains relationships to implement an integrated drought monitoring and forecasting system at federal, tribal, state, and local levels. At the national level, NIDIS has an Executive Council with a broad representation of federal and non-federal partners. At the regional level, the DEWS serve as the primary platform for building and sustaining relationships.
- **Gather // Connecting Lessons about Use of Information with User Needs** - NIDIS has supported several assessments related to the use of drought information, which has informed future research investments.
- **Translate // Review and Consider NOAA's capacity to respond** - NIDIS fosters and supports a research environment focusing on risk assessment, forecasting, and management.
- **Review // Review and Prioritize Product and Service Development** - Regional needs for drought early warning information is routinely collected in each regional DEWS through workshops and sustained dialogue with partners. These needs, and actions required to meet those needs, are further reviewed and prioritized by the regional network and articulated in regional DEWS Strategic Action Plans.
- **Respond // Respond to User Needs** - **Deliver // Deliver Products to Users** - NIDIS provides a framework for public awareness and education about droughts, which includes the U.S. Drought Portal located at drought.gov.
- **Evaluate // Evaluate Impact -** The NIDIS implementation plan details the evolution and lessons learned in moving towards a national drought early warning information system, and highlights the thoughtful feedback and participation of NIDIS's partners.



Drought.gov is the U.S. Drought Portal and serves as the public face of NIDIS by providing timely information on drought to the country. An updated drought.gov portal will be launched in 2020 following extensive user feedback outreach.

WATER RESOURCES DASHBOARD // To ensure a safe and secure supply of clean water and to protect the health and safety of residents, water resource managers and urban planners need to monitor and respond to the potential for flooding and drought in their regions. Federal weather and climate data and tools keep decision-makers informed, but sometimes finding information poses a challenge to water managers. In response to requests from decision and policy makers from the water resource management and city planning communities, NOAA's Climate Program Office (CPO), National Centers for Environmental Information (NCEI), EPA, and several water and planning-oriented NGOs have been working together since 2014 to develop the Water Resources Dashboard (Dashboard). The Dashboard provides an integrated information resource for a wide variety of weather, climate and water information that NOAA and other federal agencies provide for the water sector (https://toolkit.climate.gov/topics/water/water-resources-dashboard).

CONNECTION TO KEY ELEMENT(S):

- **Foundation // Continuous Engagement** – All regions and economic sectors in the US depend on adequate and reliable water supplies. Too much or too little water can endanger the health and welfare of citizens and businesses. Driven by feedback from user communities and federal agencies, NOAA and partners have developed the Water Resources Dashboard: a one-stop location for water-relevant data sets. The effort began in 2014. The planning group for this effort met (and continues to meet) periodically, both in person and virtually, to continue to enhance NOAA's ability to provide climate/weather data to water resource managers who make decisions at various time scales from minutes to centuries, or basically, from today's intense storm impact on water quality to designing water infrastructure that should last into the next century. The original dashboard was completed two years later. Through continuous engagement, the dashboard has been enhanced (as described below) with educational and outreach activities, and currently through interactions with a subset of users.
- **Build // Building Trusted Relationships** – With the help of several non-governmental organizations—including the American Planning Association, American Water Works Association, Association of Metropolitan Water Agencies, Water Environment Federation, Water Environment Research Foundation and the Water Research Foundation -- NOAA worked to combine resources on flooding, drought, and other extreme precipitation events into one location to better serve the needs of stakeholders. This process took two years in which these organizations queried their key constituents on how they used climate/weather information, how they would like to use these data, and other suggestions for improved use of these resources to help water resource managers and urban planners build resilience to extreme precipitation events. The group then met with NOAA scientists to discuss the available and newly released data. Based on these discussions, a team, consisting of water/planning NGOs, NOAA scientists and web developers developed the Water Resources Dashboard, which was released in 2016.
- **Gather // Connecting Lessons about Use of Information with User Needs** – Members of the planning team meet periodically to discuss updates to the Dashboard, communication strategies, and future steps to improve the reach and use of the tool.
- **Translate // Review and Consider NOAA's Capacity to Respond** – There have been continuous updates to the Dashboard. However, after the initial release of the Dashboard, the committee discussed how to increase the use of climate data by water utilities. Prominent in this discussion was a dearth of education and outreach materials. The team worked over the next few years on a series of webinars that are now used to "teach" about the individual data sources that appear on the Dashboard. Each webinar is ½ hour

in length with a scientist involved in developing the data source explaining in lay terms the data set including potential uses and limitations. This is followed by a 5-10 minute response by a water resource manager who describes how they use the data in their decision-making processes. The final part of the webinar contains questions and answers from the speakers and the audience. Each webinar was recorded and currently resides as a thumbnail on the Dashboard beneath the description of the data; these recordings are also available on Youtube and have been accessed numerous times after the initial airing of the videos.

- **Review // Review and Prioritize Product and Service Development** – Once the webinars were added to the Dashboard, the planning team met and discussed other improvements. NOAA staff interviewed these members separately and found that overwhelmingly, they felt that the Dashboard could be enhanced to better address the needs of small – medium size water utilities.
- **Respond // Respond to User Needs** – The NOAA Water Initiative was able to provide funding for a study to better understand the needs of smaller water utilities. Currently, CPO and NESDIS are leading a study with the water and planning foundations (and with additional financial and in-kind support from the Water Resources Foundation and US Water Alliance) to better understand gaps and opportunities with working with this population. As part of NWI's decision-support services, supported by NOAA's Office of Coastal Management and executed by CPO and NESDIS, regional meetings are being planned to access and understand the information needs of small- to medium-scale water utilities, to improve existing tools, and to build additional resources to meet water sector needs at different scales. Additional tools will be developed and a final report, complete with suggestions for next steps will be delivered in December 2020.
- **Deliver // Deliver Products to Users** – Currently, links to over twenty datasets relevant to water managers reside on the Dashboard accompanied in most cases with at least one webinar tutorial of the uses and applications of the discrete data. When available, case studies are also listed to increase utilities' understanding of the use and application of the data sets.
- **Evaluate // Evaluate Impact** - Feedback and evaluation led by NGOs with direct ties to users continues to help improve the content and application of data that resides on the Dashboard. The current study of small-medium water utilities includes evaluation of users understandings, needs, and desires that will lead to continued enhancements to the Dashboard as well as other NOAA data and tools.

U.S. Climate Resilience Toolkit

Steps to Resilience | Case Studies | Tools | Expertise | Regions | Topics

Topics › Water › Water Resources Dashboard ›

Water Resources Dashboard

SHARE

TWEET

PRINT

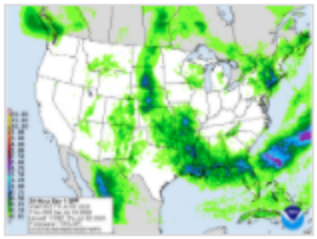
Water resource managers and urban planners can use this dashboard to access maps and data that help them monitor the potential for extreme precipitation and drought in their regions. A similar set of information is available via an Esri Story Map, Climate Information for Water Utilities. The Climate Resilience Toolkit's Acknowledgments page lists the individuals who contributed to this collection.

Note that this is a dynamic page: **the scope and content of dashboard entries are driven by input from users**. We welcome your suggestions and additions to improve its usefulness. **Please email us with your suggestions**.

Forecasts, Outlooks, and Future Projections

National Weather Service Forecasts

View current conditions and short- to medium-range (1-7 days) forecasts for precipitation, temperature, wind, and clouds. These forecasts often identify potential hazards such as heavy precipitation three or more days in advance.



Quantitative Precipitation Forecasts

View forecasts of cumulative precipitation for periods from 6 hours to 7 days into the future. Monitoring this site can alert decision makers of the potential for wet weather and/or flooding.

View tool demo >

Visit data source >

NWS Hydrologic Forecasts

View predicted flood status at more than 3,700 gauges in the United States. Click to zoom in on a region, and then roll your cursor over gauge locations to view hydrographs of recent and forecast discharge levels

Visit data source >

APPENDIX C: ADDITIONAL RESOURCES

Theory Behind It, Guides, and resources on engagement and user-driven product and service development:

- The shape of engagement, by Scott Gould (HBS)
- What customers want (customer theory, outcome theory), by Anthony Ulwick
- Adler, Peter and Juliana Birkhoff. (2002) Building Trust: When knowledge from “here” meets knowledge from “away”. National Policy Consensus Center: Washington DC.
- Forester, John. (2006). Making Participation Work When Interests Conflict: Moving from facilitating dialogue and moderating debate to mediating negotiations. *Journal of the American Planning Association*. 72:4. 447-456.
- Gray, B. (1989). Collaborating: Finding common ground for multiparty problems. San Francisco: Jossey-Bass Publishers.
- Innes, J.E., Booher, D.E. (2010). Planning With Complexity: An introduction to collaborative rationality for public policy. New York: Routledge.
- Karl, H., Susskind, L., & Wallace, K. (2007). A Dialogue, Not a Diatribe: Effective integration of science and policy through joint fact finding. Environment, 49(1), 20-34.
- Creighton, James L. 2005. The Public Participation Handbook: Making Better Decisions through Citizen Involvement. Jossey-Bass. San Francisco, CA.
- 2020 Special Edition of the Journal for Current Opinion in Environmental Sustainability on Making Knowledge Actionable for Environmental Sustainability from the Aspen Global Change Institute
- Accelerate-- The science of lean software in DevOps (agile modifications, updates quickly, fixing pieces)
- Andrea J. Ray and Robert S. Webb (2016) Understanding the user context: decision calendars as frameworks for linking climate to policy, planning, and decision-making, NOAA Earth System Research Laboratory

APPENDIX D: NWI SERVICE DELIVERY/DECISION SUPPORT OBJECTIVE TEAM MEMBERS

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*Service Delivery Writing Team Member
Members of this team represent all of NOAA's line offices, and years of experience in the field of engagement and the development of user-driven science, products, and services.

NOAA Water Initiative