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External Peer Review: Harmful Algal Blooms and Hypoxia Portfolio

February 26-28, 2018

NCCOS Response to Review Panel Recommendations

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Introduction

The external peer review of the National Centers for Coastal Ocean Science (NCCOS) harmful algal blooms (HABs) and hypoxia portfolio represents an important step in ascertaining quality, performance, and relevance of the body of work. The review was held from February 26-28, 2018, in Silver Spring, MD. It covered NCCOS HAB- and hypoxia-related science and associated activities from 2013 through 2017 (5 years). The agenda, presentations, briefing book materials, guidance documents, and more <u>are available here¹</u>.

NCCOS appreciates the time and effort that review panel members devoted in advance of, during, and after the review, for conducting their thorough evaluation of NCCOS' science and technologies. The recommendations are well-founded and thoughtful based on the information provided and will be a key factor in developing priorities and future activities under the NCCOS HAB and hypoxia portfolio.

Evaluation criteria: Quality, performance, and relevance

Quality, performance, and relevance formed the basis for the review. These are the three criteria for research and development (R&D) program reviews required by NOAA policy and procedures (NOAA Administrative Order 216-115A). Reviewers focused on these criteria in providing their assessment to NCCOS. The criteria are summarized as follows:

- <u>Quality</u> is a measure of soundness, accuracy, and reproducibility of a specific body of research. It is the most widely and traditionally used criterion evaluated by peer review committees. In general, it refers to the merits of research and development (R&D) within the scientific community research publications, awards, innovations, and patents and implies adherence to values of objectivity, fairness, and accountability (NAS, 2017). It also requires evidence of established procedures for competitive, merit-based research funding and assuring scientific integrity.
- <u>Relevance</u> refers to the value and significance of the NCCOS HAB and hypoxia portfolio to NOAA's mission, and the benefits of related products and services to stakeholders and broader society. In essence, relevance asks, "What would not have happened if NCCOS did not exist, and how much would society have missed?" Program personnel identify public benefits of the program, including added benefits beyond those of any similar effort that has been or is being funded by others. Benefits include increasingly more skillful and reliable program output, technology, or methodology that satisfies legal mandates and user needs, and facilitates effective expert counsel and technology transfer, as well as new options for the future.
- <u>Performance</u> refers to an ability to manage in a manner that produces identifiable results effectively (achieving desired results) and efficiently (with maximum productivity and minimum wasted effort or money). This is evaluated by program management structures that produce the desired results, guidance, or framework for tracking progress toward agency's strategic goals and objectives, flexibility to address events or changing priorities, interaction with stakeholders, and extramural collaboration.

¹ https://coastalscience.noaa.gov/about/reviews/

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Reviewers' Summary Findings

A compilation of reviewers' comments was submitted by the chair of the review panel on May 8, 2018. The report contained individual observations, comments and recommendations, based on the background material furnished by NCCOS, individual presentations by NCCOS staff and external principal investigators, private discussion sessions held by panel members, and extra sessions between the panel members and selected NCCOS staff and external presenters. The reviewers' report included common observations in the form of a strengths, weaknesses, opportunities, and threats (SWOT) analysis. The main observations and salient points from the reviewers' report are noted below:

Quality -

- HABs
 - <u>Strengths</u>: The reviewers determined that NCCOS' efforts on HABs are of high-quality and produce significant contributions to relevant literature and scientific understanding. Program scientists—in-house and extramural – as well as program managers have excellent qualifications and expertise. Services in different regions have direct links to public health protection and are vital for resource management, and reviewers stated that these should be expanded to other areas in the US. NCCOS' HAB event response program is a low-cost, nimble, and highly effective approach that should be a model for other agencies engaged in rapid response to environmental events.
 - <u>Weaknesses</u> Some aspects of NCCOS' portfolio are acknowledged as being excellent in their applicability, but have issues in how they provide sources of scientific information or can be sustainable over the long term. In particular, reviewers noted the need for concrete mechanisms for transitioning technologies from federal use in a manner that states and other stakeholders could easily incorporate into their own monitoring and mitigation efforts.
- Hypoxia
 - <u>Strengths</u> Given that hypoxia represents a small component of NCCOS' scientific portfolio, its quality is considerable. As with HABs, the researchers working on this effort are some of the strongest in the field, and have built connections with the key players. NCCOS' forecasts are reliable, and they are a management tool that has many uses for a number of stakeholders. Models are at the forefront of science, and provide reliable and useful output.
 - <u>Weaknesses</u> There is limited ability of program scientists to successfully measure and articulate the real impacts of the program; staff training on this topic would also address other shortcomings, for example, lack of understanding of the socio-economic knowledge base.

Relevance

- HABs
 - <u>Strengths</u> The reviewers noted that NCCOS' efforts provide a wide variety of stakeholders – from academics, to resource managers, fishermen, and the public – with valuable tools for providing forecasts and assessing the presence of HAB toxins in the air, water, and food products. To this end, the relevance of NCCOS' work is unparalleled, as its science has played a direct role in protecting human and ecological health. A particular strength of the organization is that its products are timely, and are better because they have been created in consultation with a variety of stakeholder groups.



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Scientists and managers have fostered strong communication with the HAB community and, in turn, built a community of colleagues and strategic partnerships. Furthermore, reviewers stated that NCCOS should continue to engage with the Interagency Working Group on Harmful Algal Bloom and Hypoxia Research and Control Act (IWG-HABHRCA) in order to prevent duplicating efforts, encourage interagency collaboration, and provide forums for agencies to interact with non-federal entities.

- <u>Weaknesses</u> NCCOS should reexamine its approach to developing new environmental sensors and monitoring platforms in light of transitioning the technologies to users or commercialization.
- Hypoxia
 - <u>Strengths</u> NCCOS' work has demonstrated its usefulness in addressing some of the foremost issues associated with hypoxia, as well as some of the root causes. One reviewer in particular indicated that the hypoxia modeling efforts and research conducted by NCCOS have made significant progress in assisting resource managers and policymakers.
 - <u>Weaknesses</u> The reviewers were concerned about a lack of focus on documenting the importance of hypoxia work, particularly in the northern Gulf of Mexico, which is quite expansive and expensive. NCCOS is encouraged to seek partners and explore new technologies for monitoring the hypoxic zone, as well as to engage in greater public communication efforts.

Performance

- HABs
 - <u>Strengths</u> NCCOS should be commended for "designing [a] program that is making real headway to develop, demonstrate and transfer that good science to effectively address the problems created by HABs." Despite changing and reduced funding over the years, NCCOS has maintained a high-quality program, and continues to demonstrate a positive trajectory with respect to its relevance. This likewise is true regarding how NCCOS has adapted its scientific methods and goals as ecological conditions and stakeholder needs have changed.
 - <u>Weaknesses</u> Individual reviewers expressed concerns regarding the appearance of preference for certain regions or primary investigators in extramural funding. Some also felt that problems lay with a lack of standardization or criteria employed for toxin method validation to ensure the developed or optimized methods are fit for their intended use.
- Hypoxia
 - <u>Strengths</u> Some hypoxia programs have broad appeal for protecting coastal resources and local economies; the Lake Erie, Narragansett Bay, and Chesapeake hypoxia research programs were particularly noted in this regard.
 - <u>Weaknesses</u> The hypoxia funding programs need to improve how sites are identified and prioritized for funding. In part, the reviewers indicated that the programs suffer from not having enough connections to, and engagement with, management communities and the actual users of the products.



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NCCOS Response to Recommendations

NCCOS did not solicit consensus statements or recommendations from the review panel, although the reviewers voluntarily provided a summary of their observations and two recommendations common across the reviews. As a result, the review report consisted of comments, observations and recommendations from individual members of the panel. Each member offered notes on his/her comments, observations, and recommendations that at a minimum addressed the three core evaluation criteria: quality, relevance, and performance. As expected, individual panel members addressed each subject based on their own knowledge and perspective; yet, many of their statements contained salient points, recurring themes, and similar recommendations. For example, there were eight different statements on updating or producing a new national plan for HAB research and response, as the original HARRNESS (Harmful Algal Research and Response National Environmental Science Strategy) report was published in 2005. Instead of responding to eight recommendations or observations separately, NCCOS consolidated them into a coherent statement on the topic and developed its response. Individual reviewers' statements have been preserved and are listed under each consolidated recommendation along with reference to the page number in the reviewers' report. This is followed by a response narrative from NCCOS staff and an action item or items. Not all recommendations were deemed appropriate for identifying an action item; i.e., progress was already being made on the subject of the recommendation.

NCCOS did not request "evaluation ratings" for different components of the HAB and hypoxia portfolio, e.g., Exceeds Highest Expectations, Exceeds Expectations, etc.

The following recommendations are in the order in which NCCOS identified them in the reports received from the reviewers. The order is not meant to represent a hierarchy or ranking.

HAB recommendation #1

Revise or produce a different HARRNESS report, a.k.a. a National Plan for Algal Toxins and Harmful Algal Blooms.

- i. It is clear that NCCOS strives to engage with stakeholders to inform research decisions, yet the last formal, in-person community engagement activity (i.e., National Plan for Algal Toxins and Harmful Algal Blooms: HARRNESS) is outdated and in need of revisiting. [Page 4]
- ii. Update the National Plan for Algal Toxins and Harmful Algal Blooms (i.e., HARRNESS) by gaining the input of a wide range of stakeholders [Page 6]
- The HAB research and stakeholder groups have changed with new people joining their ranks. It is my strong recommendation that new version of the 2005 HARRNESS Plan be developed. [Page 11]
- Suggestions and recommendations for addressing the human dimensions associated with this unit were also contained in the HARRNESS report completed prior to the evaluation period, which can continue to be consulted for ideas. [Page 29]
- v. Consider revisiting the HARRNESS report and recommendations included therein. It is likely that many remain relevant and applicable. [Page 33]
- vi. NCCOS should consider updating the HARRNESS report to ensure research and funding is appropriately targeted towards stakeholders needs. [Page 43]



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- vii. The last national plan development with stakeholder input is outdated. Further, the latest amendment to HABHRCA emphasizes inclusion of stakeholder engagement. As such, it is time to revisit the national plan by holding an in-person workshop akin to HARRNESS to ensure current stakeholder needs are considered and addressed, thereby improving the relevance of the program. [Page 60]
- viii. Update the National Plan for Algal Toxins and Harmful Algal Blooms (i.e., HARRNESS) by gaining the in-person input of a wide range of stakeholders. [Page 60]

NCCOS Response

NCCOS recognizes that this is an important topic that should be discussed within the IWG-HABHRCA, as well as in consultation with the university community and other stakeholders.

From 1993-2018, federal and non-federal experts have produced 15 reports on HABs (most reports available either at https://coastalscience.noaa.gov/research/stressor-impacts-mitigation/habhrca or http://www.whoi.edu/redtide/research/publications-reports/national). Many, but not all, were mandated by HABHRCA, and all were produced with federal funds. Among these was the 2005 HARRNESS report, which differed from the reports and plans produced in response to HABHRCA in that it was written by federal representatives, academics, and resource managers. It was research-focused, and provided a holistic, community-wide ten-year plan for ways to address HABs and algal toxins. To date, the HABHRCA reports have been developed based on feedback that the Interagency Working Group on HABHRCA (IWG-HABHRCA) received regarding specific stakeholder needs pertaining to HABs and hypoxia, but they were written by federal staff. They emphasize how the federal government - rather than the HAB community as a whole - should work to address these issues.

Of note, HARRNESS established the National HAB Committee (NHC), which now represents the U.S. HAB community. Accordingly, NCCOS will convey the panel's recommendation to the NHC, and will work with that group and the IWG-HABHRCA to assess whether a revised plan is in the interests of the U.S. HAB community.

Action items:

- Following receipt of this feedback from the reviewers, and in order to begin to address this specific recommendation, NCCOS led the IWG-HABHRCA in convening a meeting with the National HAB Committee (NHC) on August 1, 2018 to discuss the need for an updated community HAB plan. We invited the NHC perspective on the types of revisions and products that may best meet the needs of the community over the coming ten years. The groups have agreed to continue discussing whether, and how, to produce an update to HARRNESS. It was explicitly noted that HABHRCA requires several Reports to Congress from either NOAA or the IWG-HABHRCA, and an update of HARRNESS is not one of those. Given the number of required reports and limited resources for both producing those required reports and simultaneously advancing HAB-related science nationally, NCCOS and our partners must balance the benefits of a community engagement effort to update HARRNESS with the costs of that effort. In addition, it was also noted that, while originally developed as a decadal plan, many research needs identified in HARRNESS still exist and it continues to serve as a useful guide.
- NCCOS will continue to periodically engage with NHC (through meetings of the two groups' cochairs) and with other stakeholders, for example, at the National HAB Symposium, to determine the need or urgency for producing the next HARRNESS report.



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HAB recommendation #2

Reconsider "biological controls" as important HAB remediation tools, including efficacy of products currently available in the market.

Individual Recommendations or Comments

- While the Prevention Control and Mitigation (PCM) Program within NCCOS is relatively new, it would benefit greatly by focusing Ecology and Oceanography of HABs (ECOHAB) projects to answering some of the key questions that have stalled advances to this important arena. [Page 11]
- ii. However, I was disappointed to hear during the course of the presentations to the panel that NCCOS has backed away from HAB control at least in regard to a statement that biological control proposals are no longer being considered for funding. [Page 14]
- iii. An amendment by the same Congressman that added the specific language addressing control and mitigation into HABHRCA that resulted in PCMHAB. If my participation in the review panel has any value I hope it can be to focus more of NCCOS attention in this direction. Perhaps this focus can occur best within the PCMHAB program, but truly it should also be considered throughout the NCCOS HAB portfolio. While investigations into HAB control and prevention will likely be controversial and difficult, the public and Congress wants AND needs NCCOS to step up to this challenge. If the excellent scientists at NCCOS and NOAA as well as throughout the HAB community cannot find solutions to these issues I do not know who can. [Page 15]
- iv. HABHRCA's most recent reauthorization requires that NOAA "shall identify ways to reduce the duration and intensity of harmful algal blooms and hypoxia including deployment of response technologies in a timely fashion" [Section 603A (3) (b) (3)]. [Page 16]
- v. Work with partner agencies to reevaluate the NEPA FOSI assumptions for biological HAB controls, including via independent research. Biological controls are an important HAB remediation tool, especially in freshwater systems. Currently these controls are being utilized based upon research conducted primarily by manufacturers, and labels have broad application ranges. There is a need for independent research on efficacy of these products and appropriate application rates for targeted HAB control. [Page 40]
- vi. HAB management and response are less well understood than the causes and would also benefit from additional investment in the PCM program. [Page 46]

NCCOS Response

Biological intervention is an approach to controlling HABs, with the others including chemical and physical intervention. The use of biological controls must be approached with great caution. There are many examples of humans' attempts to address environmental challenges through the intentional introduction of biological controls that have had unintended, negative consequences. The importance of controlling HABs is paramount to the NCCOS legislative mandates per HABHRCA.

NCCOS continues to conduct or fund research on chemical and physical/mechanical control, but the office does not foresee conducting or funding significant field research on biological control, except in very limited circumstances. At this time, we do not believe sufficient information exists for us to complete National Environmental Policy Act (NEPA) requirements for significant field research on biological control and believe there are viable chemical and physical/mechanical control techniques or technologies for which additional research is necessary. In 2017, NCCOS redirected funds to investigate control and suppression strategies, and to advance promising technologies from the laboratory to the



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field.

NCCOS continues to conduct intramural research and fund extramural research (PCMHAB program) on HAB control, focusing primarily on chemical and physical/mechanical control. Two examples are:

- Intramural: NCCOS scientists have provided scientific foundation for using nanobubbles infused with ozone technology (NBOT) to eradicate harmful algae and toxins and determine its safety to wildlife and ecosystems. The technology has been successfully field tested in FY18 and shown to remove algae and toxins without significant adverse effects to wildlife in retention ponds in South Carolina, Ohio and Florida.
- Extramural: A PCMHAB project is testing the environmental impacts of a dinocidal compound produced by naturally-occurring bacteria.

A new NCCOS Innovation Incentive program is intended to promote innovative technologies and novel ideas to address unresolved scientific questions and environmental issues, and it likely will spur new projects on HAB control as well.

Action Item:

• NCCOS will continue to sponsor research to validate the use of technologies for controlling HABs, and encourage new scientific approaches and technologies for preventing, controlling, and mitigating HABs.

HAB recommendation #3

Event Response Program is highly impactful as it provides timely data to understand and mitigate HAB impacts; the program needs to be funded at a much higher level.

- i. This branch (Monitoring and Reference) of NCCOS has a strong history to being quick to respond and assist local managers, or existing state or local HAB monitoring programs, etc. with their knowledge and expertise. Without this group, national response to HAB events would be greatly hindered. [Page 8]
- ii. NOAA should consider improving access to existing resources for response through better information sharing, communication, and coordination and provide essential new resources"...with a new "regionally based, federal HAB Event Response Program linked to a network of Regional HAB Coordinators." The bones of the program are there and it is time for NOAA to dust off the RDDTT workshop report and put some life to it. [Page 16]
- iii. Analytical Response Team Overview: This is a needed lab for standards and QA/QC- a true backbone national lab. Quality: Excellent. Relevance: This is not one of the 'sexy' services (until there is a UME [unusual mortality event]) most lay folks would not understand the need, but it is essential that there be one Lab that is the national standard. Performance: Excellent. Conclusions/Recommendations: This is a vital piece of HAB bloom/response action that needs to be continued to be supported. [Page 24]
- iv. The HAB Monitoring and Reference Branch provides valuable analytical method development and support for HAB programs in both the U.S. and abroad and helps advance innovations in HAB monitoring technology. The applied research conducted by this branch has direct benefits to stakeholders. This branch also plays a critical role in timely HAB event response and helps to fill knowledge gaps on emerging HAB contaminants of concern. [Page 37]
- v. The public expects a response to charismatic marine mammal poisonings, and this branch provides that valuable service. [Page 38]



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- vi. The minimal event response funds should be continued at the expense of other extramural funding in tight budget years. If funding increases, consider increasing event response funding allocation. [Page 40]
- vii. The HAB Event Response program provides a big bang for a small buck, and all these programs could benefit from better communications of their impact to decision makers and the public. [Page 46]
- viii. The Events Response grant program clearly provides a large impact for a relatively small amount of money. Even though it was not specifically designed for wide coverage, the result is excellent coverage in space and HAB type. There was discussion of how to cap individual responses. A possible new direction was given in the presentation, which would focus on "Events of National Significance" this seems reasonable. [Page 51]
- ix. More funds should be dedicated to the Event Response Program area, especially as HABs appear to be increasing in frequency, range and duration. [Page 60]

NCCOS response

- Analytical Response Team (ART)
 - The ART continues to provide coordinated assistance to coastal managers during HABs and related health incidents. It performs overflow analysis during event response and small sample sets when states lack sufficient capabilities to ensure accurate, sciencebased decision-making. Additionally, the ART accurately identifies HAB species and associated toxins using high-throughput toxin class-specific assays (e.g., receptor, neuroblastoma cytotoxicity, and ELISA) to rapidly determine whether toxin activity is present. Liquid chromatography with tandem mass spectrometry is used to quantitatively determine specific toxin composition. The ART strives to promote the transfer of validated detection method to user groups in need of routine testing methods for algal toxins in a variety of matrices. This has been conducted in Alaska over the last several years, and transfer projects are underway in Washington State and Ohio.
 - States, tribes, and local communities often need toxin analyses because they either lack the capacity themselves or are using testing methods which do not meet regulatory standards. A reconstituted ART would fill a need to support states' and local communities' decision-making and provide training to support monitoring programs conducted by these entities.
- Competitive Research Program (CRP) Event Response Program
 - The current bills for reauthorizing HABHRCA (S 1057 and HR4417) include a section on providing responses to HAB and Hypoxia Events of Significance. NCCOS has submitted Technical Drafting Assistance to Congress that lays out a program and process similar to that used for responding to unusual marine mammal mortality events and oil spills.
 - The HAB Research Development, Demonstration, and Technology Transfer Report (<u>RDDTT, 2008</u>; see Chapter 3), which was developed by representatives of all sectors of the HAB community, outlines a national event response program that could be used as a guide if more funding were to become available.

Action Items:

- NCCOS increased event response funding for FY18 to \$100,000 in response to recommendations from the external review panel. If HABHRCA is reauthorized with enhanced event response authorities, we will incorporate the recommendations of the review panel in any such program.
- The intramural program increased funding for a mass spectrometrist in the ART in FY18.



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• NCCOS will integrate event response such that coordination links CRP funding and ART support.

HAB recommendation #4

Conduct studies that improve socioeconomic understanding of impacts from HABs, utilizing established methods and providing information on economic value and benefits to specific stakeholders and segments of society.

Individual Recommendations or Comments

- i. There is an obvious lack of socio-economic understanding of whether/how NCCOS HAB and hypoxia research adequately addresses the most critical needs. [Page 4]
- ii. Aligning with the overall NOAA Blue Ocean strategy [Blue Economy White Paper] may be an opportunity to resolve the challenges faced to date related to understanding socio-economics for this topic specifically. [Page 4]
- iii. Fund an economic workshop or series of workshops. Work with IOOS RAs, Sea Grant programs or both. [Page 26]
- iv. Consider at the onset of a project the diversity of socio-economic methods that may be needed to value the project. [Page 32]
- v. When funding external projects, perhaps require all of them provide impact statements and/or investigate the socio-economic impacts as part of the project (versus standalone or subsequent social science studies). [Page 33]
- vi. Evaluate the opportunity to assess licensing fees for development of products that use information (including data) generated from public funding. Commercialization is an indicator that the program is providing economic value; if not from past projects, can this be considered as a goal in future projects? [Page 33]
- vii. The Cyanobacteria Assessment Network (CyAN) project has the potential to have wide-reaching economic and public health protection benefits once available nationwide. Inland lakes provide economically important recreational opportunities, support local fisheries, and are the source of drinking water for millions. [Pages 36 and 37]
- viii. A value of the PCMHAB program is that it is using a socioeconomic approach and values the acceptability of approaches, not just the technology. In my experience, it is difficult to hire social scientists and to conduct social science surveys in the federal government, so the effort through this program is notable. [Page 52]

NCCOS Response

NCCOS agrees that there is a need for better estimates to compare the costs and benefits of various mitigation strategies following HAB [or hypoxia] events. Estimates of socioeconomic impacts and public health costs are needed, based on many local estimates that capture all of the impacts and appropriate methods of aggregating the results regionally and nationally. The PCMHAB Program has requested proposals for socioeconomic research since 2010; however, NCCOS concluded that the paucity of highly-rated proposals is due in part to failure of the Federal Funding Opportunity to lay out clear research agendas. It also is a result of a lack of awareness about HABs and their impacts within the socioeconomic community.

Action Items:

• NCCOS will include NCCOS and other NOAA social scientists in NOAA HAB coordination and collaboration efforts (e.g. NCCOS HAB workshop series) in order to better integrate them into the planning and execution of HAB research.



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- NCCOS is planning a National HAB economics workshop in 2019 and has allocated funding in FY18 to support the workshop. This will provide "HAB social science" research priorities, which will be used to initiate projects in FY20. In addition, the workshop will determine effective approaches and facilitate development of partnerships between economists and HAB scientists.
- NOAA's Northwest Fisheries Science Center (lead) and NCCOS are developing a story map of HAB economic impacts. The viewer will see a map of the US with information on where HAB events have occurred. By clicking on the map, users will be taken to a description of the event and the economic impact. It is expected to be available in late 2018.

HAB recommendation #5

The Phytoplankton Monitoring Network (PMN) should be more strategic in program expansion, targeting high priority HAB impacted regions of the country where HAB data is limited and NCCOS should use the PMN as an example to improve the reputation and credibility of citizen science programs.

- PMN program should be supported in the future. I would recommend that new technology (i.e., phone apps, etc.) be constantly improved on, and take it beyond an outreach program so it can make a real contribution to HAB monitoring. [Page 22]
- II. I believe citizen science programs are the answer to our spatial and temporal monitoring of HABs. This is a sustained, low cost program that had National relevance and impact and has received numerous NOAA and other national awards. The work done in conjunction with the Environmental Protection Agency (EPA) is an excellent model- would love to see more Federal agencies working together. [Page 22]
- iii. Excellent as an outreach program, Fair to poor as a science program [Page 22]
- iv. Supplement PMN with new technologies (e.g., phone apps) to make a real contribution to HAB monitoring. [Page 23]
- v. Collaboration between this NCCOS branch and USEPA-ORD and USEPA Office of Water
 Technical Support Center is necessary to ensure limited resources are focused effectively,
 technical expertise is best utilized, and duplication of effort is avoided. This is especially critical
 for freshwater HAB monitoring, response, and remediation. [Page 38]
- vi. If there ever was a great example of bang for your buck, the PMN is it. Through an effective citizen-science based monitoring network useful data is obtained at very modest cost, providing early warning of HABs, public health protection, excellent educational opportunities for project partners, and increased public awareness of HAB issues. [Page 38]
- vii. The PMN should be more strategic in program expansion, targeting high priority HAB impacted regions of the country where HAB data is limited. This is especially critical for expansion of the network to include additional freshwater monitoring sites (should partner with USEPA and states on focusing site selection). [Page 39]
- viii. Ideally, NCCOS will be in position to expand both efforts [PMN-like and developing high-tech devices] but should also look to potential example collaborators (there are also others) like Sea Grant for outreach, and marine technology programs like NSF's Ocean Technology and Interdisciplinary Coordination [GD1] program, as possible opportunities for leveraging funding. [Page 49]
- ix. The PMN is an innovative and strong citizen science program that seems to have many benefits. It appears that there is strong and growing participation, notably in Alaska. Good coordination is evidenced by the use of PMN data in the FY18 Northeast Fisheries Service



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Center State of the Ecosystem report. This is a significant step when citizen science data can be used in Agency reporting. [Page 52]

- x. Quality control measures have been developed for the PMN, which significantly improves the quality and use of data generated from this citizen science program. Such emphasis on quality control has been lacking in many citizen science endeavors. I have experience aiming to include data generated through a citizen science program where the lack of quality assurances rendered the data insufficient. It is important to maintain quality control in the program, but it is equally as important to share and articulate the quality control measures to users of the data. [Page 57]
- The PMN has an opportunity to influence a paradigm shift in the use of citizen science.
 Training materials and quality control measures should be shared with other citizen science programs and should be highlighted as a part of the program to improve the reputation of such programs [Page 58]

NCCOS response

The PMN has improved its strategic recruitment of volunteer groups in high-priority HAB impacted regions of the country.

- A focus on southeast Alaska was tied to specific subsistence and cultural needs of 16 tribal entities in one of the highest paralytic shellfish poisoning (PSP) risk regions in North America.
- A focus on freshwater HABs was developed through a formal agreement with the U.S. EPA. At the direction of the EPA, the monitoring groups were initiated in Lake Erie, and in subsequent years the other Great Lakes and then select inland lakes across the U.S.
- A focus of monitoring groups in the Alaska Arctic Regions is underway with attention on concerns in freshwater lakes.
- PMN consults regularly with the EPA Office of Water HAB team to plan volunteer monitoring and communication. PMN utilization of high-tech devices requires support of collaborators and businesses. Several new devices are under development and listed under action items.

As a science program the PMN is a testing ground for new monitoring technologies.

- PMN and the NCCOS CRP are working together to transition the *Karenia* "tricorder" from PCMHAB to readiness level 7-8 for integration into the PMN by FY19.
- PMN is partnering with the National Institute of Standards and Technology to add new measures of quality to PMN data by developing an image library of archival data using Fluid Imaging Technologies FlowCam in FY18 and FY19.

Action Items:

- PMN is partnering with industry (MBio Diagnostics, Inc.) and academic (Queen's University Belfast, Dublin City University) partners to develop, validate, and demonstrate an economical, user-friendly waveguide-based MCY detection kit; NCCOS plans to distribute kits to EPA-supported PMN volunteers for field trials in FY19.
- NCCOS will continue to seek opportunities to expand PMN in collaboration with other federal and state agencies.

HAB recommendation #6

NCCOS should focus on developing observational and monitoring technologies that are easily transferable to, and affordable by, non-federal entities. They should also work to ensure that technologies that are developed are transitioned to applications, with applications defined broadly.



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Individual Recommendations or Comments

- i. While I remain excited and very impressed with many of the new technologies developed by the branch, I am concerned that not all tools are repeatable and operable outside of NOAA (with the ESP as an example) simply because of the cost and expertise to operate them. While they have great potential for improving early warning of HAB events, without the on-going and long-term operational support of NOAA these technologies will likely sit on the shelf. [Page 9]
- ii. I commend this group's work to modify technologies to help make them less expensive, as in the case of the ESP mountable on a glider platform that does not require expensive "big ship" time to deploy. I recommend more work in this direction and a focus of technologies that are transferable to non-NOAA funding sources. I also recommend continued focus on projects that engage citizen scientists around the nation as the group has so effectively demonstrated they are capable of. [Page 9]
- iii. More work needs to be conducted at the beginning of projects to put serious thought into the design of implementable monitoring tools and programs that can be sustained by a non-federal fund source. For monitoring tools and forecasting programs that simply cannot be transitioned outside of a federal agency, a dedicated operational fund source is badly needed. [Page 11]
- iv. There are both spatial and temporal sampling issues with HABs for which complicated and cumbersome sampling approaches (such as the ESP) are not the long term solution. [Page 22]
- v. NOAA lab chose to focus on this one technology and render internal support to a commercially available product. It appears to me that McLane has received much financial support with Dr. Doucette and staff's efforts [Page 23]
- vi. There is concern about ESPs being "finicky" and "always breaking" and whether they are appropriate for monitoring over large areas. [Page 23]
- vii. I do not believe the support of the ESP, a commercially available product, should be supported by Internal NOAA funds without a competitive bid process with all commercially available HAB detection products. [Page 23]
- viii. The ESP technology is currently cost-prohibitive, but advances continue to be made to help ensure the technology can be more widely adopted in the future. The AUV ESP is a profound advancement in monitoring capability and again has the potential to revolutionize how waters are monitored. [Page 38]
- ix. Advanced scientific instruments like the ESP and Flow Cytobot are great scientific research and monitoring tools and can have important management uses. However, with a few exceptions they are unlikely to be affordable or useable by state or local managers alone without continuing outside technical and monetary support. Therefore, increased partnerships with the regional IOOS programs, already important collaborators, should be further encouraged. These and subsequently developed instruments will likely continue to be important research tools, however, they would be need to be much simpler and cheaper to be of wide use outside the scientific community. [Page 44]
- x. Relevance of ESP data could be improved by providing specific information on the real impact and doing so quantitatively when possible. [Page 60]

NCCOS Response

Developing better monitoring and observing capabilities and technologies is a very high priority for NCCOS. A considerable amount of effort and funding has gone towards addressing this goal. The Environmental Sample Processor (ESP) has been an NCCOS focus for autonomous toxin sensor development during the past five-years. This has been a joint effort with the intramural and extramural programs and many other partners.



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- NCCOS acknowledges the limitations of relying just on this technology. The ESP has its strengths and benefits for protecting public health, including providing real-time, offshore monitoring of toxic blooms. However, NCCOS agrees with the reviewers that the ESP is expensive and requires considerable expertise to operate.
 - NCCOS' objectives have been to target application of this technology to maximize costeffectiveness and fill critical gaps not currently addressed by cheaper, simpler technologies.
 - Based on the commercial and scientific success of the ESP, NCCOS intramural research has two lines of smaller, faster, more cost-effective toxin sensor technologies besides ESPs that are directed toward communities and individual users. As such, NCCOS is committed to advancing sensor technology and monitoring platforms beyond ESP.
- NCCOS agrees with the need to enhance spatial coverage in a region and improve operational cost-effectiveness and is transitioning ESP technology to an autonomous underwater vehicle (AUV)-based platform. A wider regional coverage is intended to be interfaced with the ESP level of specificity (i.e., whether a subsurface bloom is forming, the species, if it is toxic, the level of toxicity) that is of equal or greater value to informing time-sensitive management decisions.

Action Items:

- Produce faster, more cost-effective toxin sensor technologies
 - NCCOS is partnering with the Monterey Bay Aquarium Research Institute (MBARI) to transition the analytical core of the AUV-based 3rd Generation Environmental Sample Processor (3G ESP) to a hand-held, field-portable instrument. Referred to as the "Tackle Box", this device is capable of autonomously processing a water sample and conducting a molecular biological analysis (e.g., genetic probe assay, toxin ELISA). A prototype of this device has been fabricated in FY18 and it is currently being validated in the laboratory, with initial field trials pending to assess value to aquaculture and field use.
- Better communicate the value of NCCOS sensor technologies, as follows:
 - NCCOS will produce a one-pager/ webpage/ other outreach product that demonstrates NCCOS HAB research to applications accomplishments, as well as the feasibility for implementing these technologies.

HAB recommendation #7

NCCOS should reexamine the need, and its in-house capabilities, for conducting genomics and other molecular techniques for diagnosing and testing algal toxins.

- i. Support for molecular methods and genomic approaches is needed and should be reinstated. Advances in molecular biology have exceeded Moore's law and continued federal support for applied research in these areas is necessary. Molecular methods show huge promise in advancing our understanding of triggers for toxin production (with potential management implications) and can provide more cost-effective monitoring options compared to traditional chemical analytical methods. This branch should re-prioritize funding in this area. [Page 38]
- ii. Big data is sometimes necessary to make more holistic observations and revelations (especially true for molecular data). [Page 43]
- iii. While molecular capabilities are now widespread among extramural researchers, a question remains as to whether there is a need for such capabilities within the NCCOS intramural



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program. The methods are now so powerful they are essential for any biological research. [Page 48]

iv. I do not think the genomics program should be reinstated for the sake of having one. NCCOS already has quite a diverse portfolio. I would caution reinstating the program if it means taking funds away from other areas that are performing well and/or if it means not having adequate staff or resources to support a genomics program that is of high quality, relevance, and performance. [Page 58]

NCCOS Response

- NCCOS does not presently envision reinstituting an internal, substantial HAB genomic capability.
- Over the 5-year review period, our genomics team was assigned responsibility for the genomics core lab as part of the NCCOS partnership with the Hollings Marine Laboratory (HML). Among other capabilities, NCCOS was able to develop and apply emerging genomic technologies to HAB/toxin issues. Its genomic investigations of bloom growth and termination, toxin biosynthesis, and gene expression in response to toxin poisonings revealed unanticipated complexities of dinoflagellate gene regulation and toxin response pathways. HAB-related genomic research has been discontinued following a refocusing of the intramural HAB portfolio, and retirements of key staff.

Action Item:

None

Hypoxia recommendation #1

Seek innovative, alternative approaches (e.g., user fees, use of other platforms, use of citizen science) to sustain long-term monitoring surveys such as Gulf of Mexico hypoxic zone monitoring.

- i. In regard to the funding of the annual monitoring of Gulf of Mexico hypoxic zone size, as I understand the situation, state university scientists had been conducting this work, with NCCOS/NGOMEX competitive funds. However, for reasons that I do not fully understand that work has now been transitioned to NCCOS operational funds. If in doing so, NCCOS is reducing funding for other competitive HABHRCA mandated competitive programs, I recommend NCCOS revisit this practice. [Page 19]
- ii. Continue exploration of novel ways to acquire data needed to help validate models. The glider research was important, and NCCOS should continue to evaluate more cost- effective monitoring options (which could also be applied in other regions). This should include evaluating other autonomous vehicle options and partnering with the fishing fleet on data acquisition. This is a lower priority compared to the first recommendation (pursue if impacts are better quantified and local support is obtained). [Page 42]
- iii. The Gulf hypoxia monitoring program, particularly the annual monitoring cruise, should be made more cost effective, so hopefully additional monitoring can be done. I know there has been some effort with gliders in this environment, but it is challenging with shallow depths and steep gradients. Additional efforts should be made with either gliders or other new technology. [Page 46]
- iv. There will be turnover in the monitoring teams in the next few years and hopefully this transition will be an opportunity to improve cooperation among the different monitoring teams that has not always been evident in the past. [Page 46]



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- v. In the future NCCOS might consider running the more routine monitoring programs in house, perhaps including even the Gulf hypoxia monitoring, but only if it can be done more efficiently that way. [Page 49]
- vi. It seems that a data repository needed for accessibility and reuse. It would be useful to facilitate integration of modeling and data streams. [Page 54]
- vii. It would be useful to have federal scientists within NCCOS with the expertise to parameterize, run, calibrate and interpret results from the mechanistic model(s) that were mentioned and presented at the review (e.g., FVCOM, WASP), following the successful example of transitioning the four empirical gulf hypoxia models to operational status. [Page 55]
- viii. NCCOS was able to ensure continuation for a period time of the long-term monitoring of hypoxia in the Gulf of Mexico. NCCOS transitioned to use operational funds to keep the monitoring efforts going. While this allowed the monitoring to continue, NCCOS is encouraged to seek innovative means to sustain long-term observations. Funding is becoming more difficult to support routine, long-term monitoring. Greater adaptability, leveraging opportunities, and innovation will be necessary to prevent interruption in the generation of valuable datasets. [Page 61]

NCCOS Response

The annual measurement of the hypoxic zone in the Gulf of Mexico is the sole metric used by the Hypoxia Task Force (HTF) to monitor the "official" size of the dead zone. It is used to gauge progress toward attaining its hypoxia area reduction targets and to measure responses of the Gulf ecosystem to watershed nutrient reduction efforts. The dataset is also used to calibrate and validate the accuracy of the suite of models used by the HTF to set nutrient reduction targets.

NOAA has provided the majority of the support for the annual ship-based measurements with occasional support from EPA. NCCOS continues to support science towards a more cost effective approach for maintaining this crucial metric of the HTF. This includes building upon previous research on understanding the potential benefits and limitations of AUV technology for mapping the hypoxic zone and supporting NOAA Small Business Innovation Research (SBIR) topic areas around developing new AUV technologies to map this area cost effectively and accurately. Other efforts are aimed at developing a standardized operating protocol for mapping the hypoxic zone that are independent of platform and utilize statistical techniques to overcome the potential loss of particular sample locations.

Long-term, sustained, and multi-partner support of the annual Gulf of Mexico survey effort is the ultimate goal and NCCOS will continue to look for leveraging opportunities, primarily through the HTF and other monitoring efforts in the region (e.g., RESTORE Act, state monitoring efforts). A particularity promising grass roots effort is the Cooperative Hypoxia Assessment and Monitoring Program (CHAMP), which is aimed at maintaining a robust and sustainable monitoring program for the Gulf by leveraging of monitoring efforts across the region. Progress and stakeholder interest around CHAMP is additional evidence of the desire to reduce monitoring costs and maximize current support to meet the hypoxia related management needs across the Gulf.

NCCOS will continue to work through the CHAMP program to identify leveraging opportunities to support development of monitoring initiatives and platforms.



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Action Items:

- NCCOS will continue to engage with the HTF on monitoring and other Federal and State efforts on hypoxia related monitoring coordination and short- and long-term support. An agenda item about monitoring as included in the HTF meeting scheduled for September 2018, which had to be postponed due to participants' response-related duties associated with Hurricane Florence. This issue will be on the agenda for the rescheduled HTF meeting, expected in winter 2019.
- NCCOS staff are engaged in the oversight of newly awarded SBIR projects aimed at overcoming some of the limitations associated with AUVs and monitoring hypoxia across strong salinity gradients and near the bottom.
- NCCOS staff will increase coordination efforts with other monitoring programs internally (e.g., SEAMAP, fisheries sampling surveys, ocean acidification) and externally (RESTORE program, state monitoring programs, National Oceanographic Partnership Program) to expand utilization of other monitoring data sources that have broad applicability to ongoing surveys.

Hypoxia recommendation #2

Articulate hypoxia research relevance and stakeholder engagement, including potential and realized environmental and socioeconomic impacts of the hypoxic zone.

Individual Recommendations or Comments

- i. Major work needs to be done to clearly articulate who the stakeholders are [for hypoxia work] and identify the socioeconomic impacts. [Page 27]
- ii. Evaluate hypoxia nationwide and identify critical areas based on public health and resource impacts and stakeholder engagement. Any new or continued funding should focus on projects within critical areas. [Page 41]
- iii. Focus efforts on better quantifying potential and realized impacts of the hypoxic zone; engage local stakeholders. If hypoxic zone impacts cannot be quantified and local stakeholders do not support program, efforts should be focused elsewhere. [Page 42]
- iv. Consider the research relevance or impact of hypoxia research with respect to the overall research portfolio for NCCOS to balance funds accordingly. [Page 61]

NCCOS Response

As authorized under HABHRCA, NOAA currently manages the nation's only two dedicated hypoxia programs, one focused on the Gulf of Mexico (Northern Gulf of Mexico Ecosystems and Hypoxia Assessment Program – NGOMEX) and the other focused on other regions around the country (Coastal Hypoxia Research Program – CHRP). Stakeholders at the federal, state, and local levels are active participants including the three primary user groups: water quality managers, fishery managers, and regional task forces.

Of particular interest to stakeholders, including fisheries and water quality managers, are the short- and long-term impacts of hypoxia to recreational and commercially important fish species. Ongoing studies by CHRP and NGOMEX programs have been and continue to examine these issues and their impacts to growth, survivorship, fecundity, catchability; and ultimately to key management endpoints such as stock assessments, ecosystem-based management, and socioeconomic impacts. Other needs include mandates to protect and restore coastal water quality and impacts of hypoxia to water treatment facilities, as well as changes in hypoxia due to water diversions or the implementation of watershed nutrient management practices. Nowhere is this more evident than with the HTF in the Gulf of Mexico,



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which uses science and models developed by NGOMEX to set nutrient management targets for a watershed draining 40% of the US land area. NCCOS' NGOMEX projects and model outputs have been used by the HTF state members in developing their individual state nutrient reduction strategies.

While there has been substantial success at the federal scale for incorporation of hypoxia results and model forecasts into management decisions, more work needs to be done at regional and local scales to determine and demonstrate the relevance of NCCOS research to these important constituent groups. Some of these activities are in the early stages but are beginning to show promise for providing actionable information to regional entities such as the Chesapeake Bay program and Great Lakes Commission, and local state agencies and water quality managers in Maryland and Rhode Island. New, non-traditional users of hypoxia information are seeing the value of having readily available hypoxia tools to forecast hypoxia events, an example being in Lake Erie for water intake operations. Other users include recreational and commercial fisherman who are beginning to use the information to determine when and where to fish or harvest.

Overall, NCCOS will continue to support studies on the impact of hypoxia on fish, fisheries, and ecosystems. Through targeted workshops focused on identifying key socioeconomic needs followed by focused federal funding opportunities (FFOs) to support the best science to address those needs, the programs will help to ensure the acceleration and advancement of information and tools to address socioeconomic impacts of hypoxia around the nation. Current NGOMEX projects include management transition advisory groups composed of fishery and nutrient managers. These groups inform NCCOS of the most useful and impactful research products in achieving nutrient reductions in the Mississippi River basin on the Gulf of Mexico hypoxic zone, and in improving impacts on fisheries.

Action Items:

- Awards starting in September 2018 will include fishery management-relevant impacts in the Pacific Northwest crab fishery, the impacts of hypoxia on coral survivorship and performance, and quantification of the effects of hypoxia exposure on hard clams and oysters. Projects will work with local fishery management groups to facilitate the incorporation of results into fisheries management council and/or commission deliberations and ultimately, where appropriate, into formalized stock assessments.
- NCCOS' competitive research programs will accelerate the advancement of information and tools to address socioeconomic impacts of hypoxia by holding and participating in targeted workshops whose mission will be to identify key relevant needs. NCCOS will then support focused research addressing those needs.

Hypoxia recommendation #3

Reexamine CHRP strategy and structure to improve coordination with local and state managers, and for developing models or approaches that can be formulated and developed for transfer to additional areas.

Individual Recommendations or Comments

i. CHRP is clearly separated from NGOMEX, and is focused on coastal managers as stakeholders, which aligns clearly with the NCCOS vision/mission and with HABHRCA. It is clear that CHRPsupported research is relevant to local stakeholders, such as in Narragansett Bay. In some cases, CHRP supports studies in areas that have place-based programs (e.g., Great Lakes, Chesapeake



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Bay), and the results are designed for use in-place. The Lake Erie work seems like a particularly successful project, in particular because of the links to the managing bodies (IJC, Great Lakes Fisheries Commission), and this is easier for a single place and bounded set of stakeholders. [Page 54]

- Develop in-house capabilities for complex mechanistic hydrodynamics and water quality models, perhaps in coordination with NOAA's National Marine Fisheries Service (NMFS).
 Continue to pursue linkage of hypoxia and fisheries work. [Page 56]
- iii. Consider transferability in the CHRP program, e.g., the development of transferable tools and approaches, and the identification of coordinated groups of stakeholders/coastal managers that can be targeted for technology transfer. [Page 56]

NCCOS Response

Since the inception of the CHRP program, establishing and maintaining linkages to local and state managers has been embedded into funded projects. For the 2016 CHRP FFO, priority area one fully focused on ecological and socioeconomic impacts of hypoxia, building on existing research and expanding to new regions. Priority area three was directed at supporting decision-making by state and local managers. All projects were encouraged to have explicit local and state partners involved with the research, including plans for regular meetings and interactions throughout the course of the projects so that relevant management scenarios are incorporated into project outputs directly and were targeting the highest and most relevant management priorities for the affected stakeholder groups.

In addition to the direct linkages with stakeholders mentioned above, the CHRP program also attempts to leverage existing capabilities and platforms within NOAA where appropriate, or more broadly to support development of tools that are transferable to other systems impacted by hypoxia. For example, models developed through the CHRP program are encouraged to build upon existing capabilities at NOAA, or to transition the developed model capability to NOAA for potential incorporation into routine use. NCCOS also seeks out partnerships with the National Weather Service (NWS), the National Marine Fisheries Service (NMFS), and other entities with operational modeling and forecasting programs to transition research models to management applications with a particular emphasis on fishery applications. We continue to develop such a capacity for both the Gulf of Mexico and other regions, with each regional approach building on existing models and concepts that are widely transferable among regions. For instance, methods developed in Chesapeake Bay are now being applied in the northern Gulf of Mexico.

NCCOS ultimately aims to incorporate developed modeling capabilities into platforms run operationally by other NOS and NOAA offices and also is developing in-house expertise to run mechanistic hydrodynamic models that may only be needed on an infrequent basis, and are not appropriate or wellsuited for daily operational platforms.

Action Items:

- NCCOS will include increased emphasis on management relevance and connection to local and state stakeholders in future FFOs for FY20 and beyond.
- As future hypoxia funding becomes available, NCCOS will expand CHRP to other regions to allow regionally-targeted management advice.
- NCCOS will expand efforts to pursue linkages, integration and the leveraging of hypoxia efforts with complementary and connected activities across other NOAA offices dealing with related



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issues such as nutrient enrichment, riverine runoff, ocean acidification, habitat loss and fishery impacts.

Hypoxia recommendation #4

Continue CHRP strategy for targeting technology transfer and communicating scientific information to coastal managers and stakeholders.

Individual Recommendations or Comments

- i. It is not clear how priority hypoxic regions of the U.S. are selected for further research and funding. [Page 41]
- ii. Evaluate hypoxia nationwide and identify critical areas based on public health and resource impacts and stakeholder engagement. Any new or continued funding should focus on projects within critical areas. [Page 41]
- iii. An overall conceptual model, map, and/or framework could be useful to show how all of the different activities (e.g., those listed in Appendix III of the "Advancing Coastal Science" publication) fit together to collectively achieve the NCCOS vision and lead to coordinated solutions for coastal management. [Page 51]

NCCOS Response

As mandated through HABHRCA, the CHRP program was established to address this national need and to improve the understanding of hypoxia throughout the nation's estuaries, coasts, and Great Lakes. As part of these efforts, and through multiple peer-reviewed and competitively awarded projects, the CHRP program has been successful in supporting critical research targeted at the major hypoxic areas around the country. Outcomes have included the development and transfer to application of project results and tools to coastal managers and stakeholders that have aided decision-making in affected water bodies. Much of this success can be attributed to funding the best science possible while also having managers and stakeholders as integral participants in the project from the start, either as a funded PI or as part of a management oversight committee. Many projects also incorporate annual stakeholder meetings that are very effective at communicating the scientific information directly to these user groups. CHRP will continue to incorporate these effective strategies into projects associated with future funding announcements. In addition, future funding priorities for CHRP will be explicitly linked to national and regional priorities identified by stakeholders. This may be accomplished through the leveraging of existing management plans, targeted workshops, or stakeholder engagement. Other NCCOS programs with national research needs (e.g., HABs) have successfully employed regionally-based FFO's or regional rotations and this approach may be considered in the future if there is sufficient funding and need.

Action Items:

- NCCOS will work with other Federal agencies, Congress and stakeholders to assess continuing hypoxia science and management priorities.
- NCCOS will have future CHRP FFOs that explicitly incorporate regional and location specific management needs.

General Recommendations

General recommendation #1

Engage and collaborate with other agencies to avoid duplication and define respective roles and responsibilities more clearly.



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Individual Recommendations or Comments

- i. The Phytoplankton Monitoring Network work done in conjunction with the Environmental Protection Agency (EPA) is an excellent model- would love to see more Federal agencies working together. [Page 22]
- A technical advisory committee is a good mechanism to help recommend strategic investments in projects that benefit the U.S. public (seafood safety and public health agencies, waterfront home owners, recreational fishermen, coastal park managers, fish/seafood consumers, etc.).
 [Page 29]
- iii. Better articulate that the business model is one of collaborations due to the need for external support/investigators, and opportunities with other government agencies. Theme could be around success in "leveraging" by showing estimated cost share; what is the value of in-kind contributions? Such information would show efficiencies in meeting the mission. While it is not possible to easily query all federal agencies or state partners to identify complementary programs, it is in the best interest of this program to do so. [Page 32]
- iv. Collaborate with other agencies on overlapping funding priorities to help ensure complementary, not duplicative, RFPs. This could be formalized in Memoranda of Understanding (MOUs), if possible. [Page 40]
- v. Encourage University collaboration, not competition. This could help with technology and knowledge transfer, development of junior PIs, and possibly help initiate work in HAB affected regions with limited existing HAB monitoring or assessment support. [Page 40]
- vi. It would be useful to involve other interested agencies, both state and federal, in developing and coordinating a national research strategy. [Page 47]
- vii. Cross-agency coordination may be pursued through virtual workgroups, at scientific meetings (e.g., CERF), and possibly through special programs (e.g., USGS Powell Center). [Page 53]
- viii. Ensure continued coordination in the Gulf of Mexico with other agencies and with land/watershed work through the Hypoxia Task Force. [Page 56]
- ix. Consider interagency involvement to improve transparency, align with agency missions, and reduce duplication of effort and improve transparency. [Page 60]
 - a. Collaborate with other Agencies on overlapping funding priorities to help ensure complementary, not duplicative, RFPs. This could be formalized in Memoranda of Understanding (MOUs), if possible. [Page 40]
 - b. Pursue cross-agency coordination through workgroups, scientific meetings, special programs, and the HABHRCA infrastructure. [Page 53]

NCCOS Response

NCCOS engages and collaborates with other agencies, as well as with academics, in a number of ways. We work through numerous forums, such as conferences and webinars, where we interact with stakeholders and coordinate with federal and non-federal entities. The NCCOS director serves as one of the two co-chairs of the IWG-HABHRCA, and a number of staff are actively involved. NCCOS staff also participate in the HTF, which is comprised of federal, state, and academic representatives; NCCOS director also serves as the NOAA representative on the HTF. The HABHRCA legislation mandates this level of cooperation and for agencies to use the groups to prevent duplicating efforts and improve coordination. Furthermore, NCCOS staff participate in the planning of the biannual HABs Symposium, the only national, HABs-specific conference. Each of the aforementioned forums foster interagency collaboration and have led to numerous projects between offices. They are valuable opportunities, as well, for agencies to clearly define roles and responsibilities pertaining to specific projects, events, or other scenarios.



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The NHC, an overall representative of the HAB community, serves as a convening body among all of the relevant federal agencies and academics, as well as resource managers and other relevant stakeholders. Its primary purpose is to provide technical advisory assistance, foster communications between all HABs groups, and improve national visibility and understanding of HABs. Several NCCOS staff are members of the NHC.

Starting in FY 2019, NCCOS will developing memoranda of understanding (MOU), or other instruments of collaboration, on research on algal toxin analysis. For instance, in FY 2019, NCCOS will set up an MOU with the Centers for Disease Control and Prevention to identify and develop algal toxin analytical methods, reference materials, and HAB event response methods.

Action Item:

• NCCOS will draft an MOU in FY19 with the U.S. Centers for Disease Control and Prevention to leverage capabilities and increase efficiency on HAB toxin analytical method development, reference materials and event response.

General recommendation #2

Institute mechanisms and identify funds to successfully transition research to operations and management use, and to implement monitoring tools and programs by non-federal entities.

Individual Recommendations or Comments

- i. Ensure complete transition of research to its end goal/use. [Page 4]
- ii. In order for much of the science that is developed by many of the expensive research projects funded by ECOHAB to be truly beneficial to society is the successful transition of this science to management. The identification of operational fund sources is key to transition. [Page 11]
- iii. My one critique of MERHAB projects is the general lack of successful transition to operational funding sources that are not NOAA related. One answer would be to have NCCOS set aside dedicated operational funds. [Page 12]
- Appointment of a transition manager or a transition team is an excellent step in the right direction; [make] federal funding award contingent on the eventual transition to state funding. [Page 13]
- v. As more forecast systems go operational, I highly recommend they go to the IOOS RAs nationwide. [Page 22]

NCCOS Response

NOAA has a long-standing policy to optimize the timely and efficient use of its research and development, including transition of output to operations, commercialization, and management use (NOAA Administrative Order 216-105B (2016) and its earlier editions). In the case of HAB and hypoxia forecasting, limited funding has precluded NCCOS's ability to smoothly transition forecasts beyond a few fully operational products that deliver information on a continuous, real-time basis. Some NCCOS operational products have not progressed past the demonstration stage.

NCCOS, NOAA's Center for Operational Oceanographic Products and Services (CO-OPS), and NWS are working to implement a more flexible service delivery model aimed at leveraging resources and expertise of the different line offices and external partnerships. NOAA line offices will utilize their core strengths to produce ecological forecast products that are beneficial to key stakeholder groups, but that do not necessarily require the delivery schedule required for operational and navigation service



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products typical for other applications. Instead, the delivery schedule is based on user need. In some cases, IOOS Regional Associations in collaboration with academic institutions or states will deliver the forecast product/service. In those cases, long-term operation is largely dependent on user groups providing necessary resources to transition and sustain operations, with limited input from the developers. IOOS associations, in collaboration with CoastWatch, are already helping in transition and will ultimately deliver the "Florida Every Beach, Every Day" HAB toxin forecast, the California-Harmful Algae Risk Mapping Forecast, and the Pacific Northwest Harmful Algal Bloom Forecasting Bulletin. Another avenue used by NCCOS to successfully transition products is the SBIR Program, which allows commercialization of NOAA research results and products. It has been successfully used to produce rapid HAB detection test kits and qPCR standards that will allow more rapid adoption of molecular methods for detecting and quantifying HAB species in field samples to provide early warning of a developing bloom and potential toxicity risk. NCCOS also provides states with fully processed satellite images of cyanobacterial biomass in their lakes. The process is automated and requires minimal investment. The images are in a GIS format easily download and displayed. California and Ohio are already using the downloaded images to make management decisions and inform the public.

In addition to strengthening current collaborative efforts and leveraging of resources, NCCOS will continue transitioning of research to operations, within available resources, in regions where the occurrence of HAB and hypoxia is a major concern and for which we have products in the R&D pipeline. Despite successful collaboration and leveraging of resources with partners, transitioning highly relevant and meritorious HAB and hypoxia research to a new stage (i.e., demonstration or application) continues to be limited by available funds.

Action Item:

• NOAA's Ecological Forecasting Roadmap (2015-2019), which provides an operational framework for wide-ranging ecological forecasting, is being revised and may be rewritten to better reflect forecast priorities driven by key stakeholder needs and maturation of forecasting capabilities.

General recommendation #3

Improvements are needed to the competitive research programs.

- I. Adjust regional balance:
 - a. My concern/question is how do other communities who have less experience/track record compete with these groups? I believe the regional rotation was an attempt at 'leveling the playing field' a bit. [Page 2]
 - b. Some regions of the US have received a lopsided portion of the limited funding available, not only from ECOHAB, but also from other of the NCCOS competitive programs. For example, while information learned studying *Alexandrium* in the Gulf of Maine will be applicable in other parts of the U.S. and perhaps the world, the limited funding source needs to be shared in more areas around the nation. [Page 11]
 - c. I believe major work needs to be done to clearly articulate who the stakeholders are [for GOMEX and hypoxia in general] and identify the socioeconomic impacts. [Page 27]
 - d. The rotational regional scheduling of funding (MERHAB, ECOHAB, 32; NCCOS HAB & Hypoxia External Peer Review 2018 PCMHAB) was a clever solution to ensuring a well-balanced portfolio (at least until the funding was an issue). [Pages 31-32]



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- e. Increased partnerships with the regional IOOS programs, already important collaborators, should be further encouraged. [Page 45]
- ii. Adjust balance between programs (more PCMHAB & MERHAB, less ECOHAB):
 - a. I believe it is time to switch the ECOHAB and MERHAB budgets. Understand that at the beginning we had to know basics- hence ECOHAB. Believe we have made significant progress and now MERHAB should have the larger budget. [Page 24]
- iii. Make more use of Technical/Transition Advisory Committees
 - a. The technical advisory committee is a good mechanism to help recommend strategic investments in projects that benefit the U.S. public (seafood safety and public health agencies, waterfront homeowners, recreational fishermen, coastal park managers, fish/seafood consumers, etc.) [Page 29]
 - b. Meeting the requirements of HABHRCA? The Act provided a "mandate for NOAA to advance the scientific understanding and ability to detect, monitor, assess, and predict HAB and hypoxia events." Establishing a technical advisory committee was a great idea to obtain ongoing feedback on whether programs are meeting goals in a systematic manner. [Page 31]
 - c. A notable strength is that strong partnerships have been developed and maintained in many areas of the research portfolio, including technical advisory committees. [Page 50]
- iv. Require transition plans as a part of competitive projects, that are designed in coordination with state or regional partners. [Page 14]
 - a. Consider transferability in the CHRP program, e.g., the development of transferable tools and approaches, and the identification of coordinated groups of stakeholders/coastal managers that can be targeted for technology transfer. [Page 56]
 - b. Explore innovative opportunities to leverage or transition long-term activities without compromising the quality of the data and usefulness of the long-term datasets. [Page 61]

NCCOS Response

NCCOS is committed to continual improvement in our programs. The competitive HAB and hypoxia programs have experienced variable funding, which has made it challenging to plan research, which has led to geographic imbalance in funding as well as imbalance between programs. If funding for HABs and hypoxia becomes substantial and sustainable, reinstituting the regional rotation for the HAB programs and incorporating the hypoxia programs into the rotation would resolve these issues.

Each of the competitive programs requires a clear management focus and differing degrees of transition to applications. There have been many transitions to applications in the competitive programs; however, there also have been some problems. For transitions to occur, there needs to be a willing partner with funding that is capable of using the application. In the current funding climate, there often are willing partners with no funding to take over the application. Program managers previously have, and will continue to, maintain major roles in finding transition partners and non-NCCOS funding, and in coordinating plans.

There are means for improving the management benefits and transitions-to-applications of projects. These include having a research principal investigator (PI) and a management PI, a technical/transition advisory committee, annual PI meetings, or workshops with stakeholder groups, among other avenues. The most effective methods will vary depending on the purpose of the project and the composition of the investigators. All proposals currently must have a section on management relevance. The NCCOS funding website could provide a primer on how these methods can be used. Additionally, FFOs could



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require one or more of these methods, or could require management relevance sections to describe the methods that will be used.

Action Items:

- On the NCCOS website funding page, NCCOS will develop a space with information about methods of improving management relevance and the importance of research transition.
- NCCOS will modify FFOs to refer to that page and make specific requirements that will improve management relevance that are appropriate for each program.
- NCCOS will consider reinstating the regional rotation of HAB programs and the possibility of including hypoxia programs in a similar regional rotation, if Competitive Research appropriations are received at a higher level for several years (an indication of a greater likelihood of sustaining the regional rotation).

General Recommendation #4

Improve accessibility of HAB and hypoxia data by developing a data repository at a "national level."

Individual Recommendations or Comments

- i. Submit HAB and hypoxia program data at Regional Information Coordination Entities (RICEs) as a new funding requirement for project. [Page 27]
- All funded projects should be required to input data collected as part of the project into a regional or national publicly accessible database. We need to learn from past projects. Big data is sometimes needed to make more holistic observations and revelations. This would be a start. [Page 40]
- iii. A national HAB database is needed (freshwater and marine). Regional HAB databases could be a start, but they need to be developed in such a way that future integration is possible. Big data is sometimes necessary to make more holistic observations and revelations (especially true for molecular data). In addition, if data is more widely available that can lead to increased stakeholder involvement and support. This should be a joint federal (USEPA/NOAA/USACE/USGS) priority. [Page 43]
- iv. The expanded PMN ensures the collection of HAB data in a range of geographical locations over time, thereby generating a vast dataset that is incredibly useful and needed. The challenge is having a repository for the data, and one that utilizes a common format that could be easily accessed by others. [Page 58]

NCCOS Response

- National HAB Database
 - NCCOS has been asked frequently for maps of where HABs are occurring, including at multiple Congressional briefings. Data are collected by a variety of entities, including states, federal agencies, volunteer networks, NGOs, and educational institutions. There is no mandate that data be submitted to a national repository other than the requirements below for federally funded research. Thus, any effort would rely on voluntary compliance. Also, because HAB occurrences change weekly, such databases and maps need to be constantly updated. The National Office for Harmful Algal Blooms, funded by NCCOS, currently collects data provided voluntarily by the HAB community and makes maps of HAB impact occurrences. The data go into HAEDAT, an international HAB database (http://haedat.iode.org/). There are many gaps in the data and difficulties in defining what



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events should be recorded. National and global maps are publically available at http://www.whoi.edu/redtide/regions.

- If additional HAB funding and further staffing resources become available, NCCOS will consider developing and maintaining a HAB database and maps.
- Research--NCCOS complies with the requirement that data from all federal research projects be made publicly accessible in a timely manner.
 - Extramural: The NOAA HAB FFOs require a data management plan that is reviewed by the panel of experts and the NCCOS data manager. The panel of experts reviews whether data from federal funding has been made public in the past. Proposals that are selected for funding have a Special Award Condition that provides explicit directions for how and when the data should be made public. Grantees are required to make their data publicly visible and accessible in a timely manner. All research publications, including those issued by cooperative institutes or grantees, are archived at the NOAA Institutional Repository (NIR) in accordance with NOAA Public Access Policy for Scholarly Publications, 2015.
 - Intramural: All NCCOS intramural projects are required to submit their observational data and derived data products to the NCEI for long-term preservation and data access, and their publications to the NIR for public access to research results, in a timely manner (typically one year after publication)

Action Items:

• The National Phytoplankton Monitoring database is being expanded in FY18 to include historic and current data of the Maine and California networks.

General Recommendation #5

Develop a staffing and succession plan for NCCOS and fill open positions.

Individual Recommendations or Comments

- i. NCCOS organizational chart showed a high percentage (28%) of vacant or acting positions. This lack of consistent leadership has negative impacts on research quality, relevance, and in particular performance. [Page 4]
- ii. Work aggressively to fill open positions; many of these recommendations are likely to go unaddressed unless previously identified positions are filled. Leaving positions unfilled also prevents succession planning and knowledge transfer, which is an issue with this group as the current expertise is nearly irreplaceable. [Page 33]
- iii. There appear to be several key positions within the program that are either vacant, filled with acting staff, or filled with staff near retirement, so it will be good for NCCOS to have a staffing plan for filling these vacancies. [Page 50]

NCCOS Response

• NCCOS leadership is aware of staffing concerns. It is developing a succession plan for key HAB and hypoxia scientific, programmatic, and program manager positions, and for those working in other research areas.

Action Item:

• NCCOS announced seven supervisory recruitments between May and August 2018. These include the NCCOS Deputy Director, Stressor Impacts and Detection Division Chief (which oversees intramural HAB and hypoxia research), and the Competitive Research Program Director



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(which oversees extramural HAB and hypoxia research), along with four other intramural science branch chiefs. We expect these positions to be fill by the end of calendar 2018.

General Recommendation #6

Place greater emphasis on phytoplankton community structure, particularly in light of changing climate. [Page 25]

NCCOS Response

• Many of our intramural and extramural projects incidentally collect data on phytoplankton community structure. We strive to make our data available widely; phytoplankton community structure is not part of the current NCCOS HAB and hypoxia portfolio.

Action Item:

• None.

General Recommendation #7

Develop criteria for method validation to ensure developed methods are fit for their intended purpose. [Page 57]

NCCOS Response

- We routinely work on improving specific criteria (based on Association of Official Analytical Chemists or Interstate Shellfish Sanitation Conference) for method development and validation.
- U.S. regulatory/financial/political conditions complicate change/acceptance at state levels, at which implementation of policies occur. Support from NOAA, FDA, and other agencies would allow for faster implementation of new or improved methods.

Action Item:

• None.

General Recommendation #8

Consider developing standard templates for PowerPoint presentations, fact sheets, funding recognition, and impact statements. There are several good, generic, guidance documents available from other federal agencies for use by PIs or a staff member charged with conveying impacts to stakeholders. [Page 33]

NCCOS Response:

• We agree with this recommendation, and we will apply it to future science portfolio or program reviews. We have a standard PowerPoint template for NCCOS.

Action Item:

• None.

General Recommendation #9

NCCOS should continue providing support for the National HABs Symposium as it is the main opportunity for the HABs community to transfer knowledge and develop new effective collaborations. [Page 43]



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NCCOS Response:

• We plan to continue to provide financial and content support for the US HAB Symposium.

Action Item:

• None.



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Acronyms

- AOAC -- Association of Official Analytical Chemists
- **CRP** -- Competitive Research Program
- ECOHAB -- Ecology and Oceanography of HABs
- ELISA -- Enzyme-Linked Immunosorbent Assay
- **EPA -- US Environmental Protection Agency**
- FFO -- Federal Funding Opportunity
- GIS -- Geographic Information System
- HAB -- Harmful Algal Bloom
- HABHRCA -- Harmful Algal Bloom and Hypoxia Research and Control Act
- HAEDAT -- Harmful Algal Event Database
- HARRNESS -- Harmful Algal Research and Response National Environmental Science Strategy
- HTF -- Hypoxia Task Force
- ISSC -- Interstate Shellfish Sanitation Conference
- IWG-HABHRCA -- Interagency Working Group on HABHRCA
- MERHAB -- Monitoring and Event Response of HABs
- NBOT -- Nano Bubble Ozone Technology
- NCCOS -- National Centers for Coastal Ocean Science
- NCEI -- National Centers for Environmental Information
- NHC -- National HAB Committee
- NIR -- NOAA Institutional Repository
- NMFS -- National Marine Fisheries Service
- NOAA -- National Oceanic and Atmospheric Administration
- NWS -- National Weather Service
- PCMHAB -- Prevention Control and Mitigation of HABs
- qPCR -- Quantitative Polymerase Chain Reaction, also known as Real Time PCR
- RL -- Readiness level
- SBIR -- Small Business Innovation Research
- SWOT -- Strengths, Weaknesses, Opportunities, and Threats template

