FEDERAL SUPPORT FOSTERS OCEAN WORKFORCE DIVERSITY

THROUGH PROGRAMMATIC INVESTMENTS AND COMMUNITY ACTION

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ABSTRACT. This article highlights efforts across four US federal funding agencies (National Science Foundation, National Oceanic and Atmospheric Administration, National Aeronautics and Space Administration, and Office of Naval Research), each with differing, yet complementary, priorities and approaches to increasing and retaining diverse talent in ocean science education and workforce development. To understand the success and impact of our endeavors, we call attention to the need for meaningful evaluation of supported programs, which requires collecting and analyzing robust demographic data. Finally, we underscore the important role of federal agencies working alongside professional societies, national boards, and academic institutions in effecting cultural change and creating environments where the talents of all ocean sciences students, researchers, practitioners, and faculty can be fully recognized and supported.

INTRODUCTION

A study by Hofstra et al. (2020) shows that even though underrepresented scholars produce scientific novelty at a higher rate, they are less likely to persist in the academic system. The dominant metaphor of a "pipeline," where encouraging more underrepresented students to enter the pipeline results in a more diverse workforce, is not an accurate representation of academia, especially in the geosciences.[1] A re-visioning of how we support students and the faculty who mentor them is necessary if US geoscience departments are to remain vibrant, innovative, and relevant to society at large in the future. Batchelor et al. (2021) envisioned dismantling the pipeline and proposed a new analogy of a braided stream for inclusive and responsive career development in science, technology, engineering, and mathematics (STEM) fields and specifically the geosciences. The braided stream recognizes multiple entry points and individual paths of geoscience careers and outlines the systemic changes needed to develop a diverse, engaged, and supported workforce. Careful attention to both recruitment and retention is essential to academic innovation, and the geosciences continue to lag other STEM fields in our ability to attract and retain those who historically have not been included in this field. A collaborative mentoring culture, authentic research experiences (including cohort-focused and place-based approaches), and overcoming a wide range of barriers (e.g., financial, physical, societal) are all part of the systemic change needed for recruitment and retention in the geosciences (Haacker, 2015; Karsten, 2019; Bell et al., 2021; Jackson, 2021; McGregor et al., 2022).

This invited contribution is an ad hoc collaboration of individuals from the agencies that contributed funding toward publishing this special issue of *Oceanography* on Building Diversity Equity, and Inclusion in the Ocean Sciences. Most of us are program officers or work in a similar capacity to support some of the efforts described in this paper. We are taking this opportunity to collate differing STEM opportunities within each of the agencies. We address how these opportunities are informed by agency structure and mission, and we provide a brief reflection on the formal and informal pathways of communication between our agencies and with the broader community. We highlight the need for robust demographic data collection and analysis as well as meaningful evaluation of our agency-funded programs. We also identify community capabilities that are essential for supporting cultural change. Although this contribution is the result of an informal collective formed in response to an invitation from the editor and guest editors of this special issue, we hope it is useful in informing how our agencies occupy different, yet complementary, spaces in support of STEM and workforce development for the ocean sciences.

[1] We use "geosciences" when text refers to programs or statistics for the broader community. Note, however, that the majority of this contribution is focused on ocean sciences specifically, which is a scientific area of overlap for each of the agencies represented in this paper as well as the focus of this special issue. We use the term "community" to include anyone involved with US education, research, outreach, and development in these fields. This includes individuals working within academia, industry, state and federal agencies, and laboratories, and the nonprofit sector.

AGENCY STRUCTURE, MISSION, AND REPRESENTATIVE PROGRAMS

In the United States, an Administration articulates the priorities it wishes to advance, but funding and implementing its vision can be challenging. The federal budget is at the discretion of Congress and, as such, so is the funding each federal agency can devote to STEM programs and initiatives. Agency leaders do have some discretion to create programs within the guidelines of the Administration and Congress. Additionally, the missions of the agencies differ, and those differences are ultimately reflected in the scope of education and outreach programs of the individual agencies.

National Science Foundation (NSF)

NSF was established in 1950 by Congress "to promote the progress of science, to advance the national health, prosperity and welfare, and to secure the national defense; and for other purposes" (NSF Act of 1950, P.L. 81-507). NSF has eight directorates that are primarily organized by scientific discipline, much like university colleges or departments. The Directorate for Geosciences (GEO) supports research in Earth, ocean, atmospheric, and polar sciences. Within GEO, the newly created Division of Research, Innovation, Synergies, and Education (RISE) supports interdisciplinary research in collaboration with other directorates and external organizations. RISE also supports geoscience education and programs that focus on diversifying participation in the geoscience workforce and changing the culture of geoscience work environments.

In the late 1980s and 1990s, GEO education programs focused on recruitment, primarily of women, into the field and mainly through support of the Research Experiences for Undergraduates (REU) program. The GEO REU program began to track the overall demographics of program participants in 2009, which encouraged the project coordinators to focus on recruitment of diverse cohorts more broadly. While the ocean science REU program has supported about 300 students each year with high (>60%) rates of participation by women since 2010 and relatively high (>40%) participation of students from underrepresented ethnic groups since 2016 (Rodríguez Sepúlveda and Rom, 2023), it is unclear whether these students are entering and successfully completing graduate degrees in ocean science, as the retention of these students is not currently tracked. NSF is implementing a new application system for student programs that may eventually provide information on retention of students over time.

Recognizing the importance of programs specifically designed to include underrepresented groups, GEO supported the Opportunities for Enhancing Diversity in the Geosciences (OEDG) program, which from 2001 to 2013 both developed new strategies for broadening participation in geosciences and highlighted the need for more systemic changes (Karsten, 2019). The need for such approaches is emphasized when considering demographic trends: although women made up half or more of the students graduating with PhDs in ocean sciences by 2010, the ethnic and racial diversity of ocean science graduates has not changed (Bernard and Cooperdock, 2018). A greater understanding of the impacts of implicit bias and academic climates as well as the need for systemic change influenced the development of recent STEM education programs in GEO. Some of these programs are highlighted below and featured in the articles that follow to provide examples of the shift in focus to include recruitment, retention, and climate.

Recently created GEO programs include the GEOPAths program, the Cultural Transformations in the Geoscience Community (CTGC) program, and the Geoscience Opportunities for Leadership Development (GOLD-EN) program. With a focus on learning ecosystems, cultural transformation, and faculty leadership, respectively, these three programs cover a range of STEM community experiences from pre-college through faculty. In addition, NSF developed new programs that seek to improve the capacity of under-resourced institutions to participate in the NSF proposal process and to conduct research. For example, NSF issued a new program solicitation in 2023 for the Growing Research Access for Nationally Transformative Equity and Diversity (GRANTED) program that addresses systemic barriers within the nation's research enterprise by improving research support and service capacity at emerging research institutions.

National Oceanic and Atmospheric Administration (NOAA)

NOAA's mission of science, service, and stewardship is embedded in its work, which ranges from the surface of the sun to the bottom of the sea. Each day, scientists and resource managers work to predict changes in climate, weather, oceans, and coasts and share that information with others to ensure public safety, protect and restore marine resources, and strengthen the economy of the United States. As a result, NOAA's vision of the future includes healthy ecosystems, communities, and economies that are resilient in the face of change.

Since 2001, NOAA has invested in partnerships with and extended scholarship and internship opportunities to students within the Minority Serving Institution (MSI)[2] community though the Educational Partnership Program with Minority Serving Institutions (EPP/MSI). The EPP/MSI program is a NOAA future workforce program that supports the

[2] The US Department of Education description of MSI encompasses Hispanic Serving Institutions, Historically Black Colleges and Universities, Tribal Colleges and Universities, Alaskan-Native Serving Institutions, Asian American and Native American Pacific Islander Serving Institutions, and Native Hawaiian Serving Institutions.

education, training, and professional development of students majoring in NOAA-mission aligned disciplines, including STEM fields, policy, resource management, and social sciences. EPP/MSI-supported students develop skills and competencies through collaborative research and rigorous internships that equip them for qualification as candidates for NOAA's future workforce.

The EPP/MSI program has three components: the Undergraduate Scholarship Program, Cooperative Science Centers, and the Graduate Fellowship program. The EPP/MSI Undergraduate Scholarship provides support for two years of undergraduate study to rising juniors from eligible MSIs who are majoring in STEM fields that directly align with NOAA's mission. Participants conduct research at NOAA during two paid summer internships. Since 2001, 279 students have completed the program and over 75% have gone on to graduate school.

The Cooperative Science Centers (CSCs) are a consortium of academic institutions, led by MSIs, focused on the education, training, and graduation of highly skilled undergraduate and graduate fellows in NOAA-mission-aligned STEM, policy, and resource management disciplines with a focus on students from traditionally underrepresented and historically excluded communities. In addition to conducting graduate-level research, CSC graduate fellows must complete a rigorous 12-week graduate internship at a NOAA facility under the guidance of a NOAA mentor and an academic advisor during their academic careers (see https://www.noaa.gov/office-education/epp-msi/csc for a list of current CSCs).

High achieving CSC students may apply to the EPP/MSI Graduate Fellowship Program, which is designed to serve as a future workforce pipeline. The selected fellows participate in professional development training and yearlong experiential opportunities at NOAA facilities where they work on collaborative research projects aligned with NOAA's mission under the guidance of both their NOAA mentors and their academic institution advisors.

National Aeronautics and Space Administration (NASA)

In 2020, inclusion was added as a core value of NASA. Around the same time, the NASA Science Mission Directorate (SMD), which includes all science related NASA divisions, added the need to "increase the diversity of thought and backgrounds represented across the entire SMD portfolio through a more inclusive environment" to its guiding document, *Science 2020–2024: A Vision for Scientific Excellence* (NASA, 2020). With this addition, institutional support was allocated at the SMD level and more specifically within the Earth Science Division (ESD) to advance diversity, equity, inclusion, and accessibility (DEIA). Here, we highlight three actions that will affect a large percentage of the community: the Transform to Open Science Program (TOPS), the inclusion plan pilot, and the addition of the Equity and Environmental Justice (EEJ) program to ESD.

The TOPS program is designed to increase accessibility of NASA data and funded projects by engaging, enabling, and teaching organizations to better understand and follow NASA open science practices. The goal of TOPS is to increase the understanding and adoption of open science principles and techniques in order to create a more inclusive data discovering and sharing policy that will accelerate major scientific discoveries and broaden participation by historically excluded communities.

The goal of the inclusion plan pilot is to familiarize both the scientific and SMD community with the requirements and expectations of inclusion plans. The inclusion plan pilot, which is being rolled out in select solicitations across SMD, requires a two-page addition to every proposal. Proposing teams are asked to create an environment where all feel welcome and are free to ask questions and challenge actions and ideas. Solicitations ask proposers to consider and discuss what barriers to an inclusive environment might exist, how these barriers can be reduced or removed, and how the proposers can measure success. During the pilot stage, inclusion plans in research proposals are not considered when scoring for an award, but they are reviewed and commented on by a panel of DEIA experts.

The EEJ program was developed to help ensure Earth data can benefit everyone, regardless of race, color, national origin, or income. It includes building new partnerships to support community outreach, training, information, and tools that use Earth observations to create opportunities for people to get involved with Earth observations. To bolster environmental justice applications, this program seeks to build a community of practice around using NASA Earth data to inform actions in the environmental justice community through monitoring and measuring relevant environmental factors.

Office of Naval Research (ONR)

ONR is one element of the Department of the Navy's (DoN's) Naval Research Enterprise. ONR aims "to plan, foster, and encourage scientific research in recognition of its paramount importance as related to the maintenance of future naval power, and the preservation of national security," with focus areas that span topics relevant to the Navy and Marine Corps. Its breadth is wide with research areas including but not limited to mathematical, computational, material, environmental, and human sciences. While ONR is structured in "Codes" (analogous to directorates at NSF; for example, Code 32 houses the environmental sciences), these organizational units do not have formalized STEM programs under them. Instead, DoN efforts focused on STEM development and engagement with Historically Black Colleges and Universities (HBCUs)/MSIs occupy individual spaces within the Naval Research Enterprise alongside ONR. Accordingly, these programs have similarly broad focus.

The DoN's Navy and Marine Corps education and outreach programs lie within the Naval Research Enterprise under the Naval STEM Coordination Office. The objectives of Naval STEM include inspiring, engaging, and educating the next generation of scientists, engineers, and professionals in order to employ, retain, and develop a diverse civilian and military technical workforce (DCN# 43-10535-22). Both the topical areas and the audience for Naval STEM programs are broad—spanning all DoN-relevant STEM fields and focusing on elementary through graduate engagement, including the current DoN workforce. Funding mechanisms vary, but current opportunities include internships and scholarships/fellowships at high school and higher levels as well as support for science programs and symposia for primary and secondary levels. Many of these programs are coordinated across the armed services (e.g., the National Defense Science and Engineering Graduate [NDSEG] Fellowships established in 1989). Beyond these efforts, the Department of Defense's (DoD's) HBCU/MSI program aims to (1) increase the research and educational capacity of HBCUs/MSIs, and (2) foster workforce diversity and entry of underrepresented minorities into [STEM] disciplines important to national defense" (https://basicresearch.defense.gov/Programs/HBCU-MI-Program/).

In addition to the formalized programs mentioned above, individual codes, programs within codes, and even program officers, may direct portions of their portfolios to efforts that support the Naval STEM and HBCU/MSI program objectives. These efforts tend to be of a smaller scale, but they target more focused research areas. Examples relevant to ocean sciences include support for K–12 educational programs organized by societies, hosting undergraduates on ONR-sponsored research campaigns, and targeted undergraduate and graduate educational programs in Naval-relevant environmental sciences.

In 2022, the National Academies of Sciences, Engineering, and Medicine (NASEM) released the report *Defense Research Capacity at Historically Black Colleges and Universities and Other Minority Institutions: Transitioning from Good Intentions to Measurable Outcomes* (NASEM, 2022). This publication identified a significant disparity in funding for infrastructure (e.g., equipment, laboratory facilities, programmatic support to research faculty and students, administrative support) awarded to HBCU/MIs compared to non-HBCUs/MIs, with HBCUs/MIs receiving a disproportionately smaller amount of funding. The committee "determined that current DoD programs, practices, and investments are insufficient to enhance the capacity and competitiveness of HBCU/MIs" and detailed a series of recommendations focused on investing in long-term, targeted institutional capacity building at these institutions. One recommended action was to improve data collection and evaluation regarding research and research capacity at HBCU/MIs and in proposal submission, review, and award processes for these institutions.

Connecting Across the Federal Landscape

The varying opportunities within the agencies represented here are to some extent a reflection of their differing missions and structures. For example, NSF supports multiple programs across each level of the organization, consistent with its broad mission statement to support STEM education for the national workforce. In comparison, NOAA and the DoN host programs that connect scholars with employment opportunities within the federal laboratories of NOAA, NASA, and the DoD, leveraging the connection between funding entities and partner federal research laboratories. The focus on open access within the examples provided above for NASA speaks to its mission of innovating "for the benefit of humanity." These disparate opportunities can be connected, through both formal and informal pathways, and taken together they can result in "collective action" for forward progress. An example of a formal connection is the DoD's Awards to Stimulate and Support Undergraduate Research Experiences (ASSURE) program, which provides DoD support for NSF REU sites that focus on research relevant to the DoD through an interagency agreement with NSF. This special issue represents one example of an informal collective action, with support contributed from each of the agencies represented here. Clearly, more work is needed, and we look forward to engagement with and feedback from the community to inform directions. This communication happens through a variety of mechanisms: published articles, community workshops and town halls, and direct communication lines (emails, panels, and conversations).

HOW DO WE ASSESS PROGRESS AND SUPPORT CULTURAL CHANGE?

Federal Agency Support for Data Collection and Evaluation

Through an initiative called "The Time is Now: Advancing Equity in Science and Technology," launched in 2021, the White House Office of Science and Technology Policy (OSTP) identified core challenges that lead to inequities and systemic barriers throughout the STEM ecosystem, including uneven distribution and "chronic underfunding" for initiatives and programs as well as the lack of a culture of accountability and systems to address these challenges (OSTP, 2022). OSTP outlined a vision with several areas of action, one of which seeks to promote accountability across the science and technology ecosystem and highlights the need to "collect clear, transparent, and disaggregated information" as a resource for understanding whether an intervention has an impact. This action item noted the needs to "expand the scope of what is considered valuable data and knowledge" in evaluating success, and to "improve and coordinate data collection across the

ecosystem." It also emphasized the needs for additional work in developing shared indicators of progress toward equity and for analyzing data to *not* reinforce harmful practices (e.g., obscuring underrepresented communities; OSTP, 2022).

Federal agencies collect a variety of data on the ocean workforce that can be used by the community to identify trends. For example, NSF's National Center for Science and Engineering Statistics (NCSES) collects data related to the STEM enterprise and issues reports that provide information on trends in the scientific community. Data from the "Survey of Earned Doctorates, 2016 NSF 18–304" that included the demographics of graduates at the undergraduate, master's, and PhD levels were used by Bernard and Cooperdock (2018) to identify the lack of progress in diversifying the geosciences. The US Bureau of Labor Statistics collects data on the US workforce, including employed persons by industry, sex, race, and Hispanic or Latino ethnicity and publishes the *Occupational Outlook Handbook* (https://www.bls.gov/ooh/), which provides information on the number of people employed across various sectors. However, because the Department of Labor aggregates most land and ocean occupations, finding information about the ocean science workforce is difficult (Sullivan and Zande, 2011). For example, marine science disciplines are grouped into broader categories (e.g., a search for "oceanographer" will direct the user to "Geosciences") and doesn't allow the user to disaggregate to identify the ocean-relevant workforce.

Government agencies are constrained by guidelines and limits on data collection, including the requirement that participation in demographic data collection is voluntary. The guidelines also stipulate the format of demographic information, including choice selection. While this is understandably frustrating and discouraging for individuals who are not represented in surveys, we encourage the community to continue to participate in these requests as these data offer a critical resource in understanding overall trends. Efforts to encourage better data collection for the ocean workforce are ongoing. At the time of publication, the federal government is working on revising standards for collecting and reporting race and ethnicity data across federal agencies, with updated guidance expected in 2024 (Orvis, 2023).

Effective and meaningful evaluation of federally funded activities designed to increase and retain diverse talent in the ocean sciences (and STEM in general) is essential. Despite limitations of collected data, continued analysis of demographics is a critical step in the evaluation process. However, evaluation of federally funded programs must go beyond tracking of demographics. One recognized challenge with our current evaluation processes is that an evaluation period longer than the grant funding cycle is needed to fully capture the picture of recruitment and retention in the "braided river" analogy described by Batchelor et al. (2021). Although this is possible for federally housed programs like NOAA's EPP/MSI program, the timeline is an issue for assessment of community-led programs, whose evaluation processes are often incorporated under the grant that supports their activities. Additionally, any long-term retention tracking must integrate data across all academic levels and career stages to understand the relative rate of advancement of various underrepresented groups. Quantitative data can only capture one aspect of the narrative when culture change is a necessary goal, and addition of qualitative information, which can be more difficult to collect and analyze, must also be considered.

Federal Agency Support for the Role of Professional Societies, National Boards, and Academic Institutions

While federal agencies have great influence on the cultures of STEM disciplines, professional societies and national boards can also play important roles in making specific disciplines more inclusive (e.g., see Meyer-Gutbrod et al., 2023, in this issue). These entities help supplement federal data collection efforts, lead and maintain analyses of workforce trends, and often are the first to adopt new procedures that foster inclusion. For example, the American Geosciences Institute (AGI) issues regular surveys of geoscience graduates (AGI, 2022) and provides analyses of the geoscience workforce (Wilson, 2019). NASEM has issued numerous reports on the lack of diversity in STEM education and the STEM workforce that summarize a wealth of information and call out actions needed for advancement (https://nap.nationalacademies.org/collection/81/diversity-and-inclusion-in-stemm).

Additionally, professional societies often have direct influence on the culture of science disciplines and are more flexible and nimble than government agencies. Professional societies can issue reports on their related workforces, set policies on scientific integrity and professional ethics, respond to specific incidents, and make statements and policy decisions that have great impact. As an example, the American Geophysical Union (AGU) developed a Scientific Code of Conduct and Professional Ethics whose guidelines include a meetings code of conduct. Violators of the policy may be subjected to a host of consequences and sanctions, including denial or revocation of honors and awards, suspension from publishing in AGU journals, notification to other journals, and immediate removal from scientific meetings (see https://www.agu.org/-/media/files/learn-about-agu/agu_scientific_integrity_and_professional_ethics_policy_document.pdf). Professional societies that support the geosciences have taken steps to improve the climate at professional meetings to encourage recruitment and retention of a more diverse membership and the next generation of geoscientists (e.g., see Cuker and Davis, 2023, in this issue, for a discussion of the ASLO Multicultural Program, and

https://www.agu.org/learn-and-develop/learn/travel-research-grants/agu-bridge-program for AGU's Bridge Program). Society programs are sometimes supported with agency funding. For example, the Directorate for Biological Sciences at NSF has created the Leading Culture Change through Professional Societies of Biology (BIO-LEAPS) program to leverage the work of professional societies towards facilitating necessary culture change in the biological sciences. One of the initial awards supports further development of the Black in Marine Science organization.

In addition, minority-focused scientific societies, including the Society for the Advancement of Chicanos/Hispanics and Native Americans in Science (SACNAS), offer critical pathways for engagement. For example, NOAA took a proactive approach by relying on these societies as a resource to increase the number and diversity of applicants to student and early career job opportunities and increase awareness of NOAA's science mission and intersections with the diverse and interdisciplinary participants at their meetings. NOAA also uses professional meetings to engage and conduct outreach with adjacent academic communities, particularly with institutions serving significant numbers of students who are traditionally underrepresented in NOAA STEM careers.

Academic institutions, often funded to develop new programs for student and faculty recruitment and retention, are following multiple pathways for changing culture (e.g., see articles by Benitez-Nelson et al., Brenner et al., and Jones et al., 2023, all in this issue). Institutions are at the forefront of evaluating the effectiveness of programs they develop, as well as generating new understanding of how to improve learning experiences and engagement through program design and evaluation. Many institutions are making strides toward creating more welcoming and inclusive climates through adoption of holistic application processes, improving accessibility to fieldwork, and redefining the metrics of success for faculty. Ongoing assessment of workplace climates should be incorporated into departmental management and included as part of externally funded projects to implement change.

Culture change across the community requires a collective effort from agencies, academic institutions, professional societies, national boards, and ocean science community members themselves. As community members participate in the development and review of programs, journal articles, conference speaker selections, award selections, and various federal agency advisory committees, they have opportunities to highlight the need for culture change and accountability for including students and faculty from historically underrepresented groups. While this collective effort needs to touch on many areas, publications such as this special issue are a simple demonstration of this potential. Federal agencies, which have a long history of support for special issues of professional journals in which academics disseminate scientific findings, have come together to support the cost of this publication as well as much of the work detailed within it. Professional societies are essential in disseminating best practices as developed and studied by researchers, as evidenced by this issue of *Oceanography*, published by The Oceanography Society, and previous issues of *Oceanography*, such as "Women in Oceanography." The content that comprises such volumes is envisioned, created, implemented, and evaluated by individual community members. No one element works in isolation, and improving the culture within ocean sciences will require all these working together.

CONCLUSION AND NEXT STEPS

Federal funding agencies are focused on developing excellence in the next generation of the ocean science workforce, and that requires a diversity of thought and creation of environments where the talents of all students and faculty can be fully recognized and supported. Federal agencies support these efforts with a variety of programs and with data collection efforts that help identify trends in the workforce. We have a long way to go, but collective actions by agencies, professional societies, national boards, academic institutions, and community members can help identify more effective and innovative methods to ensure we continue to evolve.

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