Engaging Beyond Academia: A Call to Act for Environmental Scientists

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Abstract

The future of our planet relies on scientists' ability to effectively translate knowledge into action, and researchers have an imperative commitment to leverage their understanding. As aquatic early career researchers (ECRs), we draw upon personal experiences to share our learnings about how individuals can drive change. We showcase diverse approaches for ECRs to create meaningful impacts by connecting with other researchers, broader society, and decision-makers. At the same time, institutional challenges inhibit scientific engagement beyond academia, particularly for ECRs. Such barriers include (1) lack of value and support for engagement activities, (2) limited training opportunities, (3) research siloes, and (4) rigid funding structures. We offer potential systemic solutions, from developing and adopting new performance metrics for academic researchers to enhanced flexibility with grant timelines and spending. Academic systems need to change and so does the way scientists engage. Our future depends on it.

Time to act

"To truly help society meet its grand challenges, environmental scientists must now make a quantum leap in engagement with society. It is time for *strategic, collective action* to change the culture of academia and create the enabling conditions for science to serve society better."

– Dr. Jane Lubchenco (Lubchenco and Rapley 2020).

The global climate crisis is at a tipping point. Now, more than ever, scientists must look beyond the myopic focus of their research to pursue creative avenues for informing science-based policies and increasing understanding, appreciation, and respect for the natural environment. *In short, scientists must engage with society*. "Engagement" means connecting science to decision-makers to advocate for environmental actions and policies and/or to the public to foster a deeper awareness and valuation for nature and science. This also encompasses transdisciplinary work with other fields and/or work beyond academia (Strand et al. 2022). Dr. Jane Lubchenco first raised this notion of a science "social contract" over 26 years ago, encouraging researchers to: "(1) address the most urgent needs of society, in proportion to their importance, (2) communicate their knowledge and understanding widely in order to inform decisions of individuals and institutions; and (3) exercise good judgment, wisdom, and humility" (Lubchenco 1998).

By extending findings to the public and policy arenas, scientists can support evidence-informed decision-making (Karcher et al. 2022) and affect greater environmental impacts. For example, a recent analysis of over 20 years of small-scale conservation projects in the Salish Sea revealed that collaborating with government agencies and prioritizing and leveraging networking and stakeholder engagement increased successful conservation outcomes, but publication of a peer-reviewed paper did not (LeFlore et al. 2022). Engaging broad audiences in science, especially younger generations, provides opportunities to learn about the environment, engendering greater respect, nature connectedness, and sense of place (Krasny 2020). Environmental education can dramatically and positively impact individuals' attitudes, behaviors, and actions toward nature (Krasny 2020). Clearly, scientific engagement has real-world impacts and is greatly needed. A survey of the American Association for the Advancement of Science (AAAS) member scientists found that of the 3748 scientists surveyed, 84% believed that limited public scientific understanding is a major issue in the United States (Funk and Rainie 2015).

The need for scientists to be engaged members of society is even more urgent now, in this age of misinformation. As fake facts muddy headlines and social media, scientists have as much of a commitment to debunking myths during lively dinner conversations as they do to contributing their specialized knowledge to timely environmental policies. Indeed, "public engagement and understanding of science should be a priority for all scientists" (West and Bergstrom 2021). How is it that in the decades since Dr. Lubchenco first introduced the social contract for scientists, the academic research enterprise has not collectively moved the needle (Lubchenco and Rapley 2020)?

As aquatic early career researchers (ECRs) from six different countries in the Global North and South, we provide examples of engagement approaches. We draw upon our diverse experiences to recommend practical engagement tips for individuals. Based on our collective experiences and

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identified elsewhere (Cvitanovic et al. 2015, 2017; Lubchenco and Rapley 2020; Davies et al. 2021; Karcher et al. 2022; Satterthwaite et al. 2022; Strand et al. 2022), we also highlight four institutional challenges that limit scientific knowledge exchanges beyond academia and offer recommendations for a way forward. We hope this piece will serve as a rallying cry for academia and scientists—especially ECRs—to look up from their microscopes, embrace the science social contract, and actively extend their work to drive change beyond academia (Fig. 1).

Avenues for individuals' engagement

We provide examples of different approaches for sharing science and making it more societally impactful (Table 1). All examples draw from our personal and colleagues' experiences—all as ECRs—in the field of environmental science. These activities leverage unique university-led, community-led, government-led and scientific community-led opportunities and go beyond traditional, academic avenues for sharing science such as peer-reviewed publications. Notably, engagement strategies can vary considerably depending on career stage, as ECRs face different challenges compared to those that senior, established scientists may experience (reviewed in Satterthwaite et al. 2022; Strand et al. 2022; Nyboer et al. 2023). As such, we highlight activities specific for environmental ECRs to engage with society. We classify these different approaches into a "typology of approaches" that defines their direct impact to enable change. These typologies are:

- *Typology 1: Raising local awareness*. This typology has a limited geographic scope and a narrow audience (i.e., at individual and local community levels). Typology 1requires others to facilitate and enable change because it does not directly engage decision-makers Therefore, it is has the most limited geographic scale of impact of these typologies.
- *Typology 2: Increasing regional/international awareness*. This typology has a broader geographic scope and audience reach (i.e., at regional and global science community levels) and requires others to facilitate and enable change, similar to typology 1. It has a medium level of impact.
- *Typology 3: Enabling broader change*. This typology has the largest geographic scope and audience and, importantly, is targeted toward decision-makers (i.e., influences regional, national, and/or global decision-making). It has the highest level of impact reach and can result in direct environmental change and benefits.

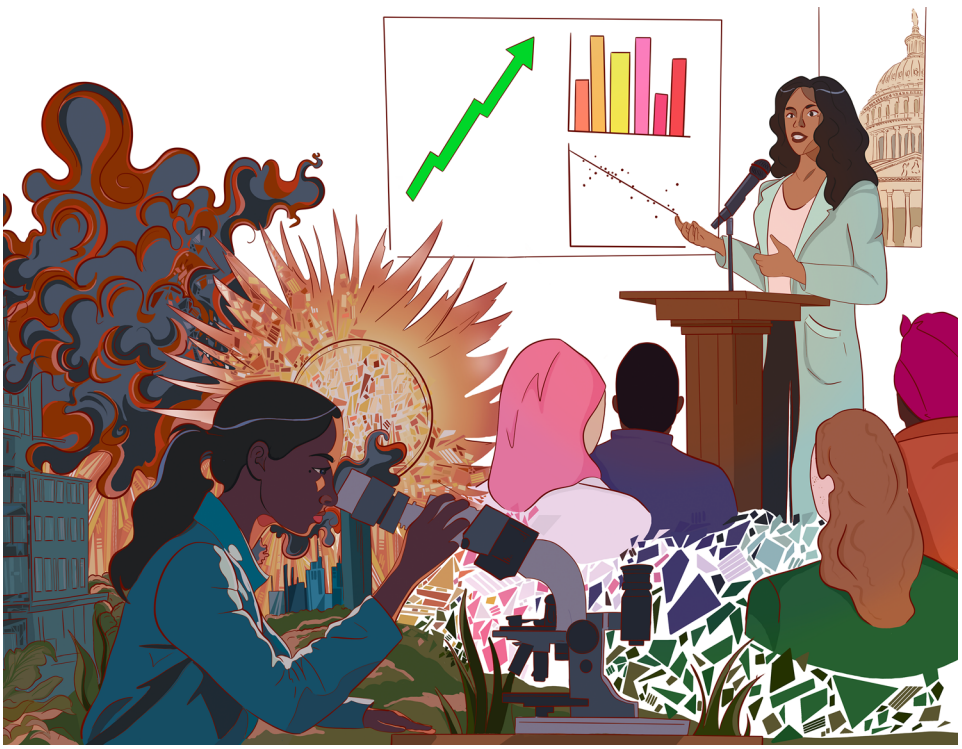

FIG. 1. Advancing research impact. Scientists often myopically focus on their research and struggle to engage with broader society (left dark panel). But when they actively interact with other researchers, policymakers, and the public, they can help actualize real-world impact beyond academia (right bright panel). Figure credit: Raquelle Santamaria Germani.

Here, we provide a summary of the recommendations for individual actions that scientists—especially ECRs—can take to engage with society, ranging in geographic scope, audience, and impact (Fig. 2). These are key actions that scientists can pursue to engage with society and help sustain our planet and future.

Typology 1 is about being an active member of your community by seeking opportunities to engage and connect with people and discovering who could benefit from your research. For example, coordinating and participating in round table meetings with local conservation organizations can facilitate discussions on how to leverage research in environmental management efforts. Engaging with school aged scientists can also be very rewarding. Offer to give a presentation to students. Even better, assist with curriculum development or support teachers to expand their knowledge. Make yourself accessible via social media and by creating a professional website so others can find you.

Typology 2 is about leveraging opportunities within your institution and with external partners (NGOs, government, etc.) and sharing your research widely. Do others in your research group or university have connections to NGOs? If so, jump on their websites and find out what research they are focused on or looking to in the future. Attempt cold calling; it will certainly help to develop your interpersonal skills! Traditional platforms such as radio and television are largely inaccessible to many ECRs and are a product of your connections or your supervisor's. However, media teams at universities will be a good point of contact to see if your work could support topical issues. Well-respected, research-based news articles like *The Conversation* can have broad reach, however publishing with them is competitive. Send a pitch about the relevance of your work to a current topical issue or media platform and use infographics or conceptual figures to help explain your research, findings,

TABLE 1. Typologies of impact for environmental ECRs to enable change. Colors indicate level of impact associated with each engagement approach. *Note*: We acknowledge that there are direct links between national research institutes, like the National Oceanographic and Atmospheric Administration (NOAA) in the USA and the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Australia, and policymakers. However, ECRs seldom have direct access to these institutions to share their science and grow opportunities; such connections often stem from those of research supervisors

Typology	Engagement approaches	Engagement methods	Engagement examples	Individual	Schools (primary and secondary)	Local community	Broad geographic scope	Generalist audience	Science community	Decision-makers	Policymakers	Funders
Typology 1—Local awareness	1. Promotion of science at individual level	Engage with landowner or locals	• Educate individuals when conducting fieldwork in public areas or with landowners when working on private property. • Providing advice to individuals. For example, helping a horse stable to mitigate eutrophication impacts on nearby streams and accessing state government subsidies to fund the work.	×								
	2. Promotion of science to local community through speaking	Give talks and create novel ways to summarize your research	• Public education seminars (e.g., Sound Water Stewards). • Presentation at "Science in the Pub" or "Pint of Science" public seminar series run by local associations or organizations. • Soapbox Science, in which women and non-binary scientists give public talks and demonstrations in Europe using non-traditional methods and creates an arena for public learning and scientific debate.	×	×	×						
	3. Promotion of science to young scientists	Speak with students, give presentations and create media through organized events	• Open campus events for all ages (e.g., Uppsala University's SciFestival, Ruder Boskovic Institute Open Days, Biology Night at University of Zagreb). • Host school excursions (e.g., "Water Days" at Uppsala University's limnological research station). • Zoom with a PhD student and Skype a Scientist Programs. • Expanding Your Horizon, program to promote interest in STEM fields amongst middle and high school girls in USA. • GRASHOPR, an education outreach program wherein graduate students design and lead lessons in local elementary and middle schools in USA. • Natural Sciences and Engineering Research Council of Canada (NSERC) Promoscience program that develops films for high schoolers to illustrate what scientists do. • Letters to a Pre-Scientist, NGO that matches STEM professionals with a schoolkid pen-pal to foster interest in STEM fields.	×	×	×						

(Continues)

TABLE 1. Continued

Typology	Engagement approaches	Engagement methods	Engagement examples	Individual	Schools (primary and secondary)	Local community	Broad geographic scope	Generalist audience	Science community	Decision-makers	Policymakers	Funders
			• STEM games for students in Croatia: graduate students and postdocs organize STEM contests and games that are shared nationally via media platforms with high school, undergraduate, and graduate students to promote science.									
	4. Science advocacy through writing	Write (non)fiction to communicate scientific messages	• Science books/literature for children and general audiences (e.g., "Little Shark Lulu," "The Shark Deck") • Local newsletter or magazine articles geared toward the public (e.g., University of Washington's monthly TideBites). • Science writing competitions (e.g., writing about your PhD thesis for a general audience, such as the one run by the Klaus Tschirna Foundation in Germany).	×	×	×						
	5. Development of interdisciplinary awareness in (non) traditional ways	Develop science collaborations with artists and/or your own artistic skills	• Baltic Sea Festival Science Lab: scientists work with the Stockholm Symphony Orchestra to have their science described by music, and then the concerts are open to the public. • Art for Education's Sake: artists paired with scientists and developed art to share science with local communities.	×		×						
Typology 2—Regional/global awareness	1. Global science initiatives	Share research via (non)traditional methods	• 3 Minute Thesis Competition: graduate students must convey their research to a general audience in 3 min. • Dance Your PhD Competition, Make Your PhD Cake Competition. • Updating Wikipedia pages. • Science-fact-infographics (e.g., PhDcomics.com).	×		×		×	×			
	2. National news platforms or documentaries	Write, create and share science	• Write a research-based news article (e.g., *The Conversation*). • Present on radio/TV (e.g., interviews on National Geographic, BBC, NPR Science Friday).			×	×	×	×			
	3. Social media platforms	Create content	• Twitter/X, LinkedIn, podcasts, YouTube, blog posts, Instagram (e.g., Science and Beers live podcast, which hosts scientists and community members in local pubs to casually share science).				×	×	×			
	4. Public data repositories	Share reports, data and code via open-access platforms repository or platform	• Github, Figshare, Mendeley Data, Dryad Digital Repository, Harvard Dataverse, Open Science Framework, Open Data Repository, Environmental Data Initiative (EDI) Data Repository.	×			×		×			

Typology 3—Enablers of change	1. Global partnership networks	Engage in collaborative research projects, share data and findings	• Geo AquaWatch, an Initiative within the Group on Earth Observations (GEO) that aims to develop and build the global capacity and utility of Earths observation system. • Long Term Ecological Research (LTER) Network: network that aims to support environmental science for the betterment of nature and society. • Ecological Dissertations in the Aquatic Sciences (Eco-DAS) Program. • GLEON (Global Lake Ecological Observatory Network): a global network of researchers, managers, and the public that aims to share and interpret lake sensor data to understand, predict, and communicate the role and response of lakes in a changing global environment.	×		×		×	×		
	2. Collaborative research with government	Undertake research projects that are of direct interest to environmental managers	• Collaborations between researchers at Ruder Boskovic Institute and local park authorities Nature Park Vransko Jezero, Croatia to inform decision-making and share science with the community. • Cache la Poudre River Monitoring Network: a collaboration with Fort Collins, Colorado, USA city hall decision-makers, scientists, and society. Scientists installed high-frequency sensors in an important urban stream (Cache la Poudre River) and make all data available to society and inform water quality management.					×	×		
	3. Research institution training and linkage programs	Participate in professional trainings, leverage skills	• Cornell University's Advancing Science and Policy group that enables PhD students to meet with policymakers on Washington, DC, USA, to advocate for science-policy issues. • COMPASS science communication trainings.	×					×		x
	4. Advocacy for improved environmental management	Join a committee, citizen group or working group and contribute knowledge (oral, written, etc.)	• Advocate at local town halls, meetings, groups, court case testimonials on environmental issues (e.g., volunteer with Marine Resources Committee, Washington, USA, a citizen group to county government to help protect and restore marine resources). • Puget Sound Ecosystem Monitoring Program's meetings and annual report in USA. • Salish Sea Ecosystem Conference: transboundary conference for academics, NGOs, tribal members, state and federal researchers working in and around Washington and British Columbia, Canada.	×		×		×	×		
	5. Intergovernmental organizations and initiatives	Serve as co-author on white papers (data or writing)	• Expert specialist on climate-related reports (IPCC reports). • International Union for Conservation of Nature's (IUCN) publications that are used to assess environmental global priorities and					×		×	×

(Continues)

TABLE 1. Continued

Typology	Engagement approaches	Engagement methods	Engagement examples	Individual	Schools (primary and secondary)	Local community	Broad geographic scope	Generalist audience	Science community	Decision-makers	Policymakers	Funders
			allocate resources (e.g., Species Survival Commission that determines conservation status of species).									
	6. Engagement with policymakers	Write policy briefs on topical issues	• For example, the Hubbard Brook Research Foundation, the science-to-society interface arm of Hubbard Brook Experimental Forest, works with members of U.S. Congress on a yearly basis to write science briefs and factsheets about topical issues, helping inform conservation decisions.					×		×	×	

and impact. Often, media teams are happy to collaborate on compelling scientific stories. The key is to initiate contact and make it clear you are interested and willing to be a science advisor!

Typology 3 is about guiding informed decision-making and leveraging opportunities to influence outcomes on a broader geographic scale. Contributing as a co-author on intergovernmental programs, such as the United Nations Environment Programme (UNEP), provides ways to have an impact because they are drafted by experts and represent the best available information. The International Panel on Climate Change (IPCC) reports represent one of the most robust peer-review processes because they are based on synthesized global meta-data with high robustness and agreement. These documents are also accessible to decision-makers and policymakers and provide a scientific synthesis with clearly articulated management needs. On a personal level, contributing to these reports can help to grow your connections and your reputation as an expert in your field. Again, these opportunities are largely facilitated by your connections. However, if you are a specialist on a species, habitat, or field of global interest then use social media to look for opportunities. For example, look for news articles from global nonprofit organizations or the United Nations Environment Programme (UNEP) to which your work could contribute. If you are not a specialist, you can still contribute to these reports in another capacity (e.g., as a reviewer, data collator, etc.). Writing policy briefs is an underutilized pathway to have impact because many scientists, including ECRs, are unaware of the opportunity or know how to write them. There could be a policy team within your institution or a neighboring institution that provides opportunities (tutorials, workshops, etc.) for you to learn these skills.

Institutional challenges and solutions

Academia largely does not value or support scientific engagement activities

Despite the imperative need for scientists to engage with those beyond academia—and scientists' desires to initiate meaningful change—there is insufficient institutional valuation of engagement activities (Lubchenco and Rapley 2020), particularly for ECRs including graduate students and postdoctoral researchers. Generally, ECRs are encouraged to focus their time and energy on technical publications and presentations, rather than engaging with policymakers or the public (Satterthwaite et al. 2022). While many scientists at various career stages endeavor to impact policy, conservation, and management, few indicate they are supported in doing so. For example, in a survey of 78 early, mid, and senior-level Australian marine scientists, most indicated that engaging with decision-makers and using their science to influence environmental management were personally important, but also reported receiving little organizational support or recognition for these activities (Cvitanovic et al. 2015). Instead, academia centers on a publish or perish culture, rewarding scientists largely based on the number of peer-reviewed publications, citation rates, and impact factor scores (Davies et al. 2021; West and Bergstrom 2021). It is not so much that scientists lack motivation to engage—indeed, many consider it a duty—but more so that they lack institutional support (Davies et al. 2021).

To overcome these challenges, academia needs to shift from a "publish or perish" to "publish and flourish" model that focuses on the quality of publications, experiences, engagement activities (Davies et al. 2021), and meaningful impact (defined here as the ability to make real-world societal, economic, or environmental changes). Culturally, academia must embrace and value scientific engagement activities (Karcher et al. 2022) and "promote a culture that values the use of the best available science in policy and practice" (Cvitanovic et al. 2017). Practically, this change means developing new, more equitable performance metrics that factor in engagement activities into tenure evaluations, for example (Davies et al. 2021; Nyboer et al. 2023). Doing so will acknowledge, encourage, and reward scientists who engage and communicate with decision-makers and broader audiences. This cultural shift will reinforce that engagement activities are amongst scientists' core responsibilities and that they should be recognized and valued at individual and institutional levels, either through promotions and/or awards. We cannot expect scientists to pursue this

type of work—even if they are self-motivated and driven—if their efforts are never acknowledged or rewarded.

Academia has limited engagement training opportunities for ECRs

Given that engagement activities are generally not prioritized in academia, there are usually limited training opportunities for scientists to develop necessary interpersonal, soft skills such as facilitating teamwork, networking, building relationships amongst different collaborators, and resolving conflict (Lubchenco and Rapley 2020). As many graduate research programs do not require or provide formalized training in these skills, many scientists must develop them experientially. As such, ECRs are often ill-equipped to connect their work to broader audiences, including resource managers or policymakers, who could integrate their findings into conservation and management plans or legislation. Furthermore, while there are a growing number of science communication workshops and trainings within and beyond academic institutions, universities often do not value science communication to audiences beyond academia, again prioritizing peer-reviewed publications over policy briefs or newspaper articles. As such, many scientists do not receive formal instruction on how to effectively engage society in science.

Institutions must recognize the gravity of our current environmental crises and support burgeoning scientists to be agents of change. Academia needs to provide expanded, enhanced resources and training for scientists on how to effectively engage with diverse audiences (Karcher et al. 2022), especially ECRs who often are more motivated to spearhead engagement activities (Cvitanovic et al. 2015). This education also includes trainings on effective transdisciplinary engagement between scientists, practitioners, and policymakers (Satterthwaite et al. 2022; Strand et al. 2022). Graduate courses or workshops focused on navigating the science-policy interface would also be incredibly valuable for burgeoning transdisciplinary scientists and would create a knowledge pathway for scientists to inform decision-making. Doing so, scientists will be well armed with both technical, scientific skills and soft skills.

Academia siloes people and their products

Primary literature is valuable in communicating fundamental research amongst the scientific community. Yet, paradoxically, resource managers who could incorporate key findings from scientific manuscripts into their conservation plans often cannot access manuscripts, which are locked behind paywalls. Furthermore, the public generally does not read primary scientific literature (e.g., scholarly journal articles), again underscoring the critical need to make academics and their scientific findings—including papers, data, and code—broadly accessible and digestible. Of course, open-access journals, databases, and repositories are not enough to enhance knowledge exchanges. Scientific writing itself must be more approachable to broad audiences. Beyond peer-reviewed manuscripts, lay summaries and significance statements can help communicate scientific findings to non-technical audiences. Researchers should be encouraged and supported to develop communications to share science in interpretable formats. Furthermore, collaborating with artists can facilitate creative science communication through different media, though there are often limited, established channels to connect scientists and artists.

More broadly, institutes must prioritize support for knowledge exchange and transdisciplinary collaboration beyond academia (Cvitanovic et al. 2017). As end-users may not even know where or how to begin accessing relevant work, academia needs to increase intentional support for building connections with non-academic groups and individuals. This could mean hiring "knowledge brokers" to serve as effective mediators between researchers and decision-makers. Knowledge brokers play key roles in cultivating relationships and networks between "producers and users of knowledge" and in facilitating knowledge exchange to inform evidence-based actions (Cvitanovic et al. 2017). Some universities in Australia (e.g., the University of Tasmania) already employ knowledge brokers, reflecting a progressive initiative to engage with end-users to support real-world impact. University extension programs that engage students beyond campus can also provide valuable connections between academic researchers and their communities. For example, Cornell University's Cooperative Extension has a presence in each of New York state's counties and leverages academic understanding to improve economic, ecological, and social well-being (Cornell Cooperative Extension n.d.). Together, these are potential avenues for connecting researchers with society for data-driven impact.

Current funding structures are restrictive and do not support building relationships between academia and different actors

Conducting impactful and transdisciplinary work inherently relies on cultivating lasting relationships amongst scientists in academia with those in agencies, NGOs, indigenous tribes, and other groups (Strand et al. 2022). However, most research grants operate on shorter timeframes and often have stringent requirements for the distribution of funds (Strand et al. 2022). These traits can be problematic: transdisciplinary work rarely follows a linear path and necessitates agility and adaptability to meet project and collaborators' needs (Cvitanovic et al. 2021).

To facilitate successful collaborations and translate research outcomes into meaningful real-world impacts, funding agencies will need to adapt. In addition to increasing funding opportunities for transdisciplinary work, funding agencies should also allow greater flexibility in grant timelines and spending (Karcher et al. 2022; Strand et al. 2022). Greater funding opportunities, timelines, and flexibility would allow more time to develop partnerships, research, and impact beyond academia (Karcher et al. 2022; Strand et al. 2022). Indeed, *sustained* partnerships are essential for driving real-world conservation impacts. Likewise, philanthropic support could complement existing research grants, extending the life of collaborative projects to allow for meaningful relationship-building (Shekhtman et al. 2024). To affect significant impacts, funding agencies also need to adapt.

A way forward

Scientists have an essential role to play in safeguarding our planet from mounting stressors. The key is in what scientists do with their knowledge. However, there are inherent institutional barriers that hinder scientists' abilities to engage more widely

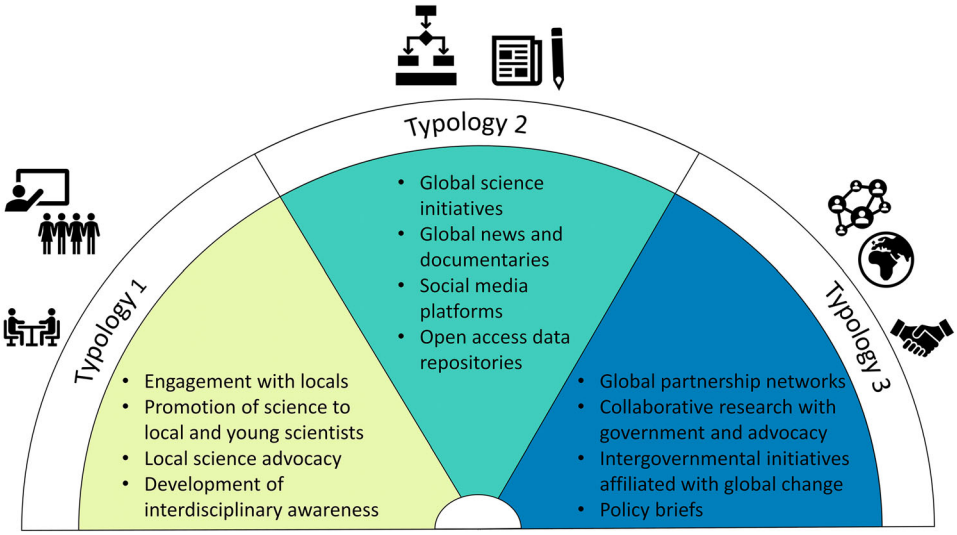

FIG. 2. Conceptual diagram of mechanisms for driving research impact and examples of opportunities to increase societal impact for scientists. Figure credit: Karla Münzner.

with society, particularly for ECRs (Satterthwaite et al. 2022; Strand et al. 2022; Nyboer et al. 2023). Academia needs a cultural shift (Lubchenco 1998; Lubchenco and Rapley 2020) and to dismantle these barriers that undermine collective scientific action. But we cannot wait for change. The immense scale and gravity of current environmental threats necessitate that scientific institutions and individuals assume responsibility and be active changemakers in society (Lubchenco 1998; Lubchenco and Rapley 2020). There are proactive individuals who want to engage with their communities and decision-makers and find ways to do so, despite institutional challenges. But, for many of us, finding pathways to create impact is challenging and not at the forefront of our minds. Here, we aim to make those pathways a little clearer for those up to the challenge. We share our learnings about how to make science more accessible by classifying engagement actions into a "typology of approaches" and provide examples defined by their scope of impact. Although many of these actions can be time-consuming and require self-motivation, they are worth the effort once you start to see changes develop. Remember, persistence is key.

We urge all scientists to critically consider how their research is more broadly applicable to society, especially ECRs and scientists who have a desire to engage but are unsure how to begin. Scientists should also realize that they will likely need to push beyond their comfort zone when communicating with different groups, especially policymakers and journalists. There are risks associated with stepping out from the shadows of the laboratory and into the public sphere. Scientists are trained to report the certainty of results and avoid speculating and can also provide informed expert opinions in a relatable way. This type of communication requires courage and practice, but in doing so, scientists can make their work easily digestible to broader audiences and actualize rapid, effective societal impacts. Time is of the essence, and we earnestly call our fellow scientists to act. How will you mobilize?

Acknowledgments

The authors would like to warmly thank the Association for the Sciences of Limnology and Oceanography, the National Science Foundation (Award #OCE-1925796), the University of Hawai'i at Manoa, and Dr. Paul Kemp, coordinator for the Eco-DAS XV 2023 program, from whence this paper was born. We also thank Raquel Santamaria Germani for offering her incredible artistic skills in developing Fig. 1, helping bring our message to life. Finally, we appreciate thoughtful comments from Dr. Laura Falkenberg and an anonymous reviewer; these strengthened our paper.

Author contributions

OJG and LG conceived and drafted the manuscript. All co-authors provided input for Table 1 and reviewed and revised the manuscript. LG coalesced author responses into Table 1; KM developed Fig. 2.

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