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Escalating uncertainties require institutional transformation to support epistemological pluralism

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As marine conservation challenges intensify with accelerating anthropogenic change, informing public deliberation about difficult trade-offs requires commitment to epistemological pluralism. Robust integration of social sciences can improve the realism of policy debates by explicating a range of potential social-ecological outcomes. Funders have long incentivized interdisciplinarity, yet progress is insufficient and embedded in a political economy of knowledge production. Failure to substantively address inequities can stymie collaboration. Institutional expectations for promotion and tenure rarely recognize the extent to which deep engagement transforms epistemological norms and scholarly outputs. Several organizations and programs offer relevant experience and resources. Senior scholars can use their privilege to broaden the public accountability of science.

As marine conservation challenges intensify with accelerating anthropogenic change, informing public deliberation about difficult trade-offs requires commitments to epistemological pluralism, integrating contributions from a broad range of knowledge-making traditions. Recent contributors to this journal have noted that these unprecedented times require greater openness to transformative change and “novel imaginaries” of alternative futures^{1,2}. If scientists want our hard-won insights to inform new evidence-based policy directions, our daily practices and institutional norms must evolve quickly to better support more expansive understandings of knowledge production and scholarship.

Global transformation, including ocean warming, is outpacing even sophisticated analyses of large datasets³. As a result, it is increasingly unrealistic to hope that quantitative models can by themselves provide clear solutions to cross-scalar social-ecological problems such as fishery management, biodiversity conservation, coastal management, mineral extraction, and marine spatial planning. Notwithstanding prospects for methodological innovation, even with artificial intelligence, it is virtually impossible to quantitatively predict social phenomena such as redoubled efforts to extract dwindling resources, financial and political instabilities due

to the rising cost of intensified hazards, abandonment of failing physical infrastructure and economic activities, resulting human dislocation and migration, adoption of novel technologies, and corresponding ethical debates.

The need for social science and humanistic perspectives

Although natural sciences can provide pivotal information about anticipated biological and physical consequences of various policy choices, thoughtful decisions ultimately require broadly democratic consideration of human values, especially the relative importance of multiple, simultaneously held values that often conflict, both across social groups and within the multi-valent worldview of any one individual. Whereas many natural scientists studiously avoid mention of values in their scholarship, having been trained to believe these are a threat to “the” scientific method, values, and their ever-changing and contested relationship to social relations, systems of meaning, and decision making, are a central focus of social sciences and humanities⁴. Human beliefs and perceptions are notoriously variable, being strongly shaped by social settings across time and space and thereby manifesting a great range of complex interactions. As a result, the most responsible, accountable, and useful ways to understand this social-cultural domain often use qualitative methodologies and inductive or abductive logic wherein a breadth of accumulated observation supports generalized, most-likely, or less-than-universal conclusions. By contrast, exclusive reliance on hypothetico-deductive logic requires predicted outcomes to follow inevitably and universally under specified conditions that may be artificially narrowed to permit quantitative proof⁵.

Robust integration of social sciences can therefore improve the realism of policy debates by explicating a range of potential social-ecological outcomes. It can strengthen democratic norms by stimulating public articulation of social values. If analyses fail to substantively consider pervasive human behaviors, such as inevitable tensions between competition and cooperation, and the socio-cultural values people attach to particular resource-use practices, then groups better endowed with financial resources, information, or social-political leverage more easily subvert policy intentions, legally or illegally⁶. For decades, even before anthropogenic changes overwhelmed more moderate environmental fluctuations, social scientists, disenfranchised groups, and pluralistically-inclined natural scientists have lamented maladaptive risks of management systems that prioritize computation over civic deliberation, e.g. maximum sustainable yield^{7,8}, transferable quotas for species harvests^{9,10}, biodiversity offsets¹¹, and exclusive marine parks¹¹. Yet reductionist support for these policies persists, privileging observations amenable to statistical proof despite ostensible recognition of social-ecological uncertainties.

As anthropogenic change transforms our marine ecosystems, we have a choice: science can continue to offer avowedly value-free and apolitical advice, avoiding complex and contentious questions of equity, justice, and

ethics, and inadvertently privileging those most able to beat the system, or we can develop more nuanced, multi-valent, and epistemologically diverse analyses to support more deliberative and equitable decision processes. Although it may feel awkward to many scientists, the public wants us to engage actively in climate policy debates¹². How might we operationalize this, following decades of intensifying institutional pressures on scientists to mobilize more grant dollars, publish more peer-reviewed articles, and fill larger lecture halls, since these expectations often require that we abandon riskier endeavors with new collaborators, methods, project designs, pedagogies, or intended audiences?

Research and philanthropic funders have long incentivized such innovation, accompanied by waves of new nomenclature, from multi-, inter-, and transdisciplinarity to convergence. Nonetheless, integration across epistemologically divergent disciplines, or even pluralistic respect for different ways of knowing, is still not common^{2,13}. Many who attempt cross-epistemological research and deeply engaged partnerships find it necessary to spend considerable time developing new shared vocabularies and explaining concepts that are fundamental to our own fields but unfamiliar to others. Those of us who attempt to bridge these gaps from a standpoint on the qualitative, social science, or humanistic side face additional hurdles. Academic and legal understandings of best available science rarely include social sciences, much less humanistic understandings of values, meaning, narrative, ethics, or justice, which are often integral to local or Indigenous knowledge systems.

Challenging hierarchies in knowledge production

Academic scholarship takes place within a political economy of knowledge production wherein natural scientists have greater access to funding and other resources than social scientists or humanists. One study found that from 1990 to 2018, natural and technical sciences received more than seven times as much public and private funding for climate-related research worldwide, compared to social sciences¹⁴. Social sciences receive roughly 5% of the US National Science Foundation research budget, even while this amount funds roughly 2/3 of all basic social science in the US¹⁵. Humanities research funding is so low that many scholars hesitate to encourage prospective graduate students. As a result of their ability to attract external funds, most natural scientists have significantly higher salaries (sometimes double those in liberal arts), leverage more internal funding, gain more experience with larger team projects and grant writing, teach less, and more easily obtain staff and student assistance. Research funders replicate these inequities by calculating compensation according to base salaries.

Pursuant to methodological differences, natural sciences, which are able to delegate repetitive tasks such as collection and first order analyses of large quantitative datasets to research assistants, often favor more hierarchical and top-down personnel structures to deliver pre-determined project outcomes efficiently, even though this may inadvertently reinforce pre-existing meritocratic assumptions about authority and status^{5,16}. Social sciences and humanities, especially qualitative scholarship informed by critical theories of race, gender, and power, in which theoretical understanding is fundamental to data collection and processing, tend toward decentralized organizational structures to facilitate emergence of novel conceptualizations¹⁷. Project hierarchies may serve well when scientific tasks have higher certainty, such as when procedures can be routinized, but they can deter overall progress when scientific uncertainties are greater and merit more risk taking^{16,18}.

Hence, epistemologically diverse groups often encounter fundamental differences from first contact, with substantial implications for presumed roles, operations, and outcomes. At such moments, knowledge makers who rely on inductive or abductive logic often find that most natural scientists

assume that interdisciplinary collaborations will instead follow “the” (hypothetico-deductive, quantitative) scientific method, since that is the only one they know or have seen respected in their professional communities. Those of us unable to leverage the institutional and public status that natural scientists enjoy have long found our contributions relegated to the sidelines of collaborative projects in translational, outreach, or application roles, rather than in knowledge-making per se. If such power differentials are not recognized, discussed, and accommodated with mutually agreeable group norms that support both co-learning and accountability, including mechanisms for project members to revisit and revise those norms as their relationships and understandings evolve, tensions can accumulate and divert team energies into overt or latent conflict¹⁶, low morale, and little incentive to invest in future collaborations reliant on the largesse of more powerful colleagues. Science suffers as a result.

Transformative strategies

Research on “team science” offers strategies to overcome these problems¹⁹. Authors encourage openness to diversity, innovation, and co-learning, balance between knowledge breadth and depth, time required to establish mutual understanding and trust, training in empirically supported models of leadership and group process, and substantive support for scholars across career stages, including recognition that outcomes of cross-disciplinary research do not necessarily match closely with conventional metrics of academic success^{13,16,19–21}. From a more structural perspective, some note that deeper integration requires broad institutional changes to support researcher investments in ethical and ontological reflection to inform more equitable collaborative relationships across not only disparate fields of scholarship but also demographic differences such as race and gender^{19,20,22}.

Although many scholars broadly agree with all these points, few institutions have substantially modified their expectations, goals, or career advancement incentives enough to inspire epistemological diversity to the degree merited by current global challenges. Many have added interdisciplinarity and community engagement to lists of optional promotion and tenure considerations, but fewer have grappled with how profoundly robust epistemological pluralism transforms the nature of scholarly outputs in ways that are not measured by most existing performance metrics²³. The time and energy required for this deeply challenging work, both intellectual and emotional labor, almost inevitably lowers the number of resulting publications, grant dollars, student contact hours, and disciplinary presentations. It requires that we become newly accountable to multiple publics, scholarly and civic, not only our own disciplinary communities and departmental promotion and tenure committees. It requires that scholars reinvent our professional identities to “code switch” across epistemologies with ease, not only on a few days carved out for outreach and engagement led by an extension staff member, but as daily practice. We must learn multiple vernaculars, similar to the way members of multi-ethnic groups develop such fluencies, to establish belonging, trust, and understanding across subgroups.

Academia must reward such professional investments as valued activities and skills, not distractions from our “real” work. To encourage sharing of ideas laterally, upward, and from the margins, it must recognize those embracing inductive and abductive logic, especially those from underrepresented groups, as makers of foundational knowledge, therefore meriting central roles as lead proposal authors and principal investigators on projects conceived with social theory as a central organizing principle. In tandem, project leaders with less relevant experience need compensatory support, such as releases from teaching or service obligations and mentorship from colleagues or institutional staff with team science experience. Institutional expectations must correspondingly accommodate the

nonlinearity of learning and skill development in tenure and promotion pathways. Without such restorative actions, scholarly commitments to broader social impacts can easily become merely performative, without challenging underlying inequities or restoring public trust in academic scholarship²³.

Fortunately, researchers and administrators with experience in epistemologically pluralist, policy-engaged projects and programs are developing professional networks to share foundational approaches, presenting opportunities at multiple institutional levels. Members of the International Network for the Science of Team Science (INSciTS) review empirical evidence on structural and policy innovations within universities, funders, and academic journals. Accumulated experience of the Belmont Forum (an international partnership of funders, science councils, and regional consortia advancing transdisciplinary science), the International Science Council (ISC), and NORFACE (New Opportunities for Research Funding Agency Cooperation in Europe), lays essential groundwork, crediting successes of their joint Transformations to Sustainability (T2S) program to formative involvement of social sciences and humanities^{24,25}. The ISC similarly notes that achieving the United Nations Sustainable Development Goals requires transformative, systemic change in science systems, including prominent roles for the social sciences, arts, and humanities²⁶. Lessons learned from transdisciplinary funding programs and the projects they fund are increasingly available through conferences, workshops, trainings, consultancies, mentorships, and peer-reviewed and gray literatures, including contributions from the US National Science Foundation cross-directorate programs on Dynamics of Integrated Socio-Environmental Systems, Coastlines and People, Smart and Connected Communities, and Growing Convergence Research and facilitative groups such as the National Socio-Environment Synthesis Center (SESYNC), Navigating the New Arctic Community Office, and Toolbox Dialogue Initiative. Although some universities offer dedicated research support for transdisciplinary capacity building, many researchers and staff nonetheless perceive that progress is slow, institutional vision and budgets are often insufficient, and social sciences and humanities remain under-represented.

In this time of accelerating global change, scientists and other scholars cannot wait for those in formal academic leadership positions to chart this new course. Upper administrators may be deeply concerned about how academia can retain its prominence amid global uncertainties and public critiques, but most are appointed by boards that expect them to focus on fundraising, managing budgets, and avoiding public controversy. Given the precarity of untenured and adjunct faculty, the responsibility falls to those of us with tenure and seniority. Just as some elders who feel new responsibility for past decisions that ensured comfortable lives at the expense of global climate are now using their privilege as “third act” activists²⁷, shouldn't scholars who enjoy the long-term benefits of tenure also rethink our remaining life agendas? If we believe that tenure is an important institution to protect those who speak the truth, does it not fall on us to replace academia's elitist history with more pluralistic knowledge communities for broader social accountability?

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J.B. and H.H. conceptualized, wrote, and revised the manuscript.

Competing interests

The authors declare no competing interests.

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