Promoting equity in scientific recommendations for high seas governance

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Roughly two-thirds of the world's ocean is located beyond national boundaries. Although these areas (known as the high seas and international seabed Area) support diverse ecosystems and host abundant reservoirs of biodiversity, they remain among the least protected habitats on our planet. In the coming months, international negotiations under the 1982 United Nations Convention on the Law of the Sea (UNCLOS) will enter their fourth and final session to establish a legally binding agreement for the conservation and sustainable use of marine biodiversity in one of our largest global commons, areas beyond national jurisdiction (BBNJ) (1). While the main purpose of this international treaty is to promote conservation and sustainable use of marine biodiversity, we are simultaneously entering the United Nations Decade of Ocean Science for Sustainable Development (2021-2030) which aims to facilitate "global ocean science needed to support the sustainable development of our shared ocean" (2). In this context, scientists have proposed data-driven optimization algorithms (hereafter algorithmic approaches) to assist in maximizing the protection of BBNJ while considering specific economic costs and risks (3, 4, 5).

Algorithmic approaches to global environmental issues are attractive and useful because of their capacity to integrate a wide scope of data and complex objectives into definitive policy suggestions. However, because data-driven scientific recommendations at a global scale largely consider the costs and benefits of conservation action to only a subset of human actors their application in the context of international conservation decisions raises critical questions that we must address as a scientific community: exactly for what, and for whom, are these algorithms optimizing? These are age-old questions in conservation decision making, but a pending global agreement on the management of our greatest global commons creates unique challenges and opportunities for the equitable application of algorithms in conservation planning.

We argue not that these tools should be avoided, but that at present, algorithmic approaches for prioritizing BBNJ protections do not necessarily promote equity due to socio-political and geographic disparities reflected in both inputs (which largely consist of global datasets) and values (weightings of data in pursuit of a narrow subset of economic and biodiversity targets). While scientific recommendations are only one part of a complex negotiation process laden with equity concerns, as a scientific community we must be aware of inequalities in this process and avoid reinforcing them (6). Instead, scientific recommendations on the management of BBNJ should be

developed to promote equity based on principles of environmental justice. Drafted and adopted in 1991 at the First National People of Color Environmental Leadership Summit in Washington, DC, these principles have become the guiding document for environmental justice movements worldwide, with the aim of ensuring that all people and communities benefit equally from protection against environmental and health hazards, regardless of their racial and economic backgrounds (7). In the international marine context, striving for equity through principles of environmental justice includes rebalancing decision-making processes to center coastal communities in developing countries whose livelihoods and well-being are most directly impacted by BBNJ management decisions (2).

Here, we 1) highlight equity oversights in algorithmic approaches to BBNJ protection and 2) propose ways in which current algorithmic approaches can be integrated into a broader and more inclusive prioritization process for the conservation and sustainable use of BBNJ. The tools and approaches proposed here provide a starting point for addressing equity issues in scientific recommendations to BBNJ protection, but these recommendations are not comprehensive. The continued refinement and development of approaches to prioritize equity in systematic conservation planning will be a key challenge for ocean scientists during the UN Decade of Ocean Science for Sustainable Development.

Recognizing data disparities

While algorithmic approaches to conservation are not inherently destined to produce inequitable recommendations, key data disparities must be addressed in order to begin more equitably harnessing the promise of these tools for multilateral conservation decision making.

Developers of algorithmic approaches for the prioritization of BBNJ protection have attempted to integrate biodiversity and socioeconomic data to propose solutions, while acknowledging significant limitations of their data inputs (3, 4). For example, biodiversity data may overrepresent highly studied regions of the ocean (3). In the context of socioeconomic data, standardized global inputs tend to disproportionately represent human activities (e.g., high seas fisheries) conducted by relatively few corporate actors under the flags of a select few globally powerful nations (8),

representing the interests of only a small fraction of nations that are party to UNCLOS (Figure 1). As a result, these approaches propose "optimal" solutions to managing BBNJ that explicitly exclude the human dimensions of high seas management most important to small nations and Indigenous communities. This disparity exists not because information on these dimensions is scarce, but rather because it is difficult to represent Indigenous and local knowledges in reductionist data formats amenable to algorithmic approaches (9). Failures to account for the complexity of multiple knowledge systems and inequitable representation in scientific decision-making processes can lead to exclusionary inputs into, and therefore outputs from, optimization algorithms.

The sources of disparities in algorithmic approaches extend beyond data inputs. Subjectivity in scientists' goals and perceptions based on discipline, culture, and values is well documented (10). As a result, the values and positionalities of those funding, designing, and implementing algorithms can shape the encoded objectives of these algorithms at the expense of those whose knowledges and experiences are not represented. Such top-down approaches to setting optimization objectives do not promote the inclusion of values held by the full range of diverse parties to the negotiations on managing BBNJ.

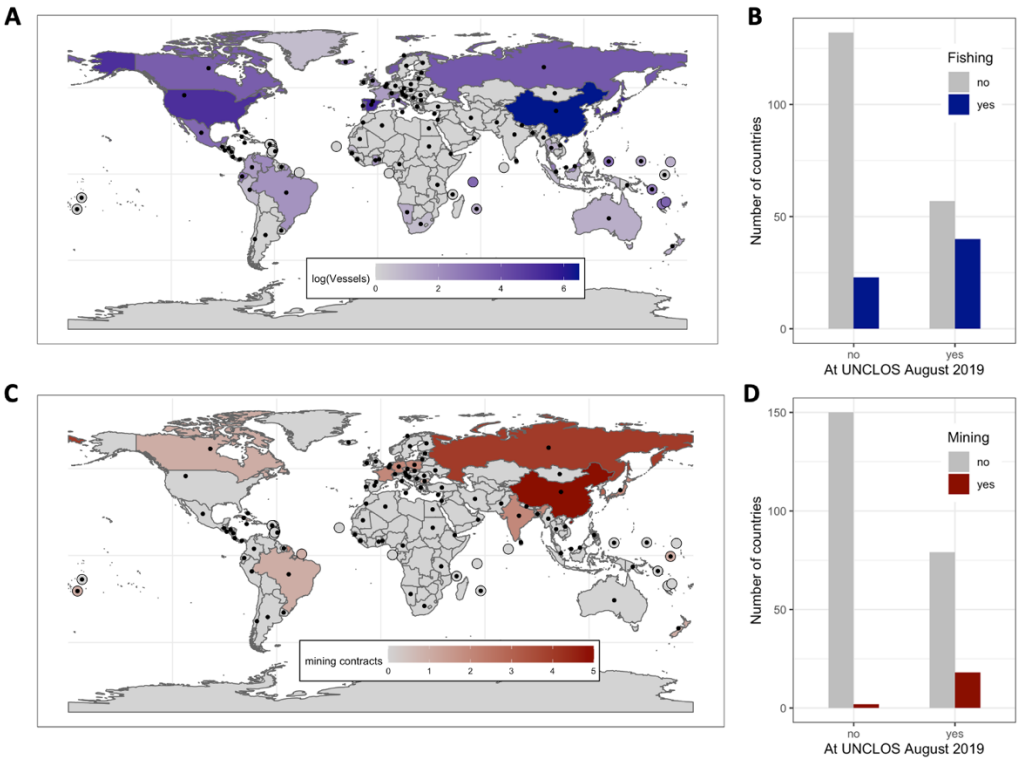

Figure 1: Global socioeconomic data layers largely center the concerns of highly industrialized nations who are parties to UNCLOS. (A) High seas fishing effort (log(vessels); 8) by national flag of corporate operator. (B) Number of nations participating in the most recent BBNJ treaty negotiation session, sorted by participation in high seas fishing effort. (C) International Seabed Authority deep seabed mining exploration contracts (https://www.isa.org.jm/exploration-contracts) by nation, as of December 1st, 2020. (D) Number of nations participating in the most recent UNCLOS session, sorted by participation in ISA mining exploration contracts. In both (A) and (C), nations with black dots were represented at the third session of the BBNJ treaty negotiations (Aug 19-30, 2019, New York, USA).

Power asymmetries

Disparities in the inputs and values of algorithmic approaches in the BBNJ context are not randomly distributed — they often give disproportionate consideration to human dimensions which benefit the most powerful actors in international negotiations. For example, algorithmic consideration of socioeconomics in the management of BBNJ has centered on protecting biodiversity, while minimizing the impact of protection on high seas fishing activity (3, 4). This is a convenient starting point given the availability of global data layers for assessing tradeoffs between these goals. But fishing activity in the high seas does not occur in isolation; the ocean is an open system with significant ecological connectivity between the high seas and the exclusive

economic zones (EEZs) of individual nations. Thus, high seas fisheries management can influence fish abundance in the EEZs of less wealthy nations that do not partake in high seas fishing (11). Regional Fisheries Management Organizations (RFMOs), many of which outline management principles in their charters based in part on equity, provide a potential opportunity for the inclusion of often-marginalized nations and Indigenous communities in high seas fisheries management. But at present, RFMOs largely do not allocate fisheries resources in a manner consistent with their stated commitment to such guidelines; harvest controls based predominantly on historical catch and effort levels often function to advance the interests of the most powerful actors (12). Even if algorithmic approaches consider high seas fishing activity as a risk to biodiversity rather than an opportunity to be preserved (supporting information of (3)), failing to also consider socioeconomic and cultural costs and benefits to the vast majority of stakeholders to the BBNJ treaty can unintentionally reinforce this power asymmetry.

The reinforcement of existing power asymmetries can manifest in ways that are not easily addressed simply by changing optimization targets. For example, algorithmic approaches to prioritizing high seas protection can readily set objectives to maximize food provisioning to EEZs via spillover rather than high seas fishing opportunities (5). These targets (objectives) do not directly reinforce power asymmetries in current BBNJ management negotiations. Yet it remains unclear whether the potential for increased food provisioning via spillover will actually improve the nutritional availability of high-seas-dependent coastal resources to small nation and Indigenous communities, or simply reduce the price of seafood exported from developing nations to middle-class consumers (primarily in North America and Asia). Potential international seabed mining presents another case in which power asymmetries might influence the distribution of costs and benefits under different management targets. Similar to nations engaged in high seas fishing, exploration contracts with the International Seabed Authority (ISA) primarily involve several highly-industrialized and powerful nations (Figure 1C-D). Notably however, several small island nations (e.g., the Cook Islands, Kiribati, Nauru, and Tonga) have also entered exploration contracts with the ISA. Yet in each of these cases, state-sponsored exploration contracts for the small island nations involve joint ventures with private corporations from western industrialized nations. Will small island nations receive significant socioeconomic benefits from these joint contracts, or will primary benefits go to private corporations from wealthier nations? And to what extent should any

such socioeconomic benefits be weighed against the potentially irreversible loss of unique ecosystems and their associated ecosystem services due to seabed mining (13)? Complex socioeconomic and cultural dynamics highlight the difficulties of constructing targets for optimization algorithms in an equitable manner without explicit inclusion of those groups most impacted by the answers to these questions.

A more equitable path forward

Targeted and thoughtful combination of a broader suite of scientific tools can help address the inequities present elsewhere in the BBNJ negotiation process. We propose that three steps can provide the cultural context, diverse perspectives, and humanistic frameworks necessary for promoting equity in scientific recommendations on protecting BBNJ (Figure 2).

Inclusion of diverse voices (and their associated perspectives and values) is a critical first step in enhancing the equity of algorithmic conservation approaches. Algorithmic solutions are inherently bound by the objective functions encoded by those who design and implement these methods. In order to center the values of often-marginalized communities, meaningful consultation with communities is needed to ensure their needs and concerns are included in the objectives for which an algorithm is optimizing (Figure 2; 9). Ultimately, attention to process may be of equal or greater importance in promoting equity as compared to any resulting products or policy recommendations (10).

Second, equity considerations can also be injected into algorithms when deciding which data sources to include (Figure 2). Incorporating local and Indigenous knowledge on species of critical cultural and nutritional value, which travel between the high seas and coastal waters (6, 11), is one way to reduce disparities among the groups represented by data inputs. While attempts at incorporating such knowledge in Western scientific frameworks can often be both challenging and extractive, first including Indigenous and local representatives from small nations in objective-setting can aid in representing this knowledge in a meaningful way (9). Social sciences methods (14), including participatory mapping, semi-structured interviews, and participant observation can help identify local values, priorities, and knowledge, and be used to further include voices from

resource-dependent communities in recommendations on spatial management of areas beyond national jurisdiction. Given that these data sources exist at fundamentally different spatial scales (regional) than those primarily considered by algorithmic approaches to BBNJ protection (global), regional optimization algorithms could be useful for including these additional and invaluable data sources (3).

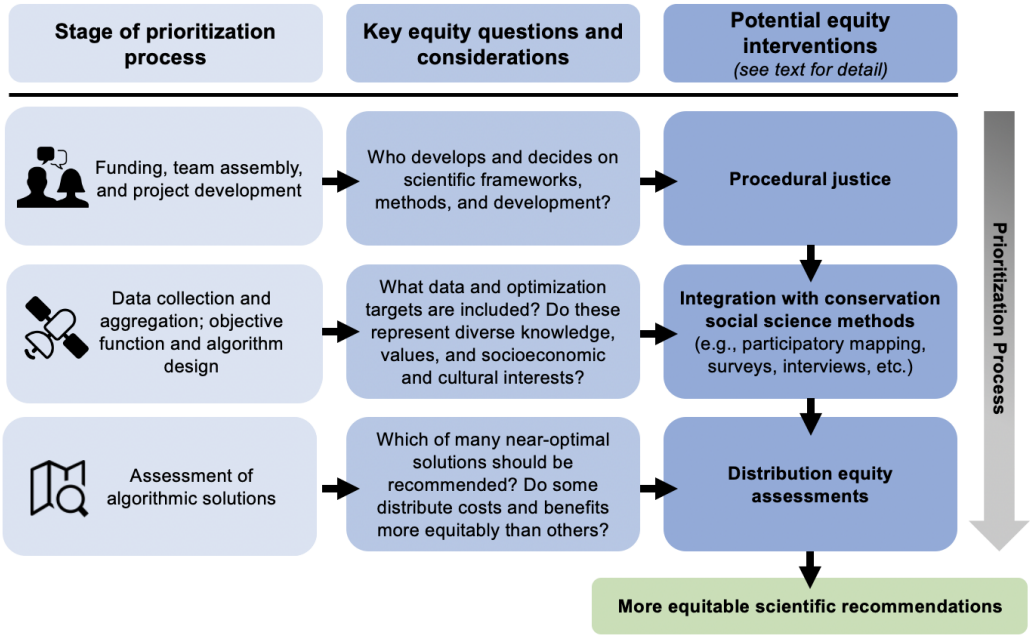

Figure 2: Key equity considerations to explore and interventions to implement along the process of developing scientific recommendations for BBNJ protection. Algorithmic approaches can play a valuable role in a broader prioritization process that promotes equity.

Finally, even with integration of a broader suite of data sources, algorithmic approaches remain sensitive to data deficiencies and translation of diverse objectives into quantitative weightings of variables. Because agreement between "optimal" and equitable solutions is not guaranteed, any number of near-optimal solutions can be screened on the basis of equity criteria. Assessing equity in the distribution of costs and benefits of multiple "near-optimal" solutions provides a post-processing step which centers values that might be overlooked within a global prioritization framework (15; Figure 2). Integration of social science methods and environmental justice frameworks can help provide the appropriate data and theory for assessing distribution equity through participatory conservation processes (14, 15) and central concepts from conservation ethics (16). Employing these widely used methods and frameworks in tandem with algorithmic

approaches can provide tangible scientific recommendations while promoting equity in policy outcomes.

Conclusion

As a scientific community we must acknowledge, understand, and mitigate the inequities that are inherent to the methodologies and data we use to create conservation recommendations, particularly in the global arena. It is also critical that researchers acknowledge and account for their own positionalities e.g., becoming more aware of how one's social position (race, class, gender, etc.) may influence the design, implementation, and interpretation of optimization algorithms (16). If management agendas do not better align with the priorities of coastal communities who rely on these resources most, ocean governance may further amplify global power imbalances and deepen existing vulnerabilities. Recognition of how optimization inputs and targets can exacerbate existing power asymmetries will require not only stepping away from rigid data-driven algorithmic approaches and towards approaches that integrate established social science methodologies, but also critical and continued engagement with environmental justice principles. Scientific recommendations on ocean management in the UN decade of ocean science for sustainable development (2021-2030) have the potential to safeguard biodiversity, while also learning from promoting the well-being of those most reliant on ocean resources and most vulnerable to global change. By integrating powerful algorithmic approaches with tools from the conservation social sciences that allow for the consideration of diverse interests in this global treaty, scientists can help ensure that our greatest global commons is managed in a more equitable manner, not just for the values and benefit of a select powerful few.

Author background statement: As an author group primarily from academic research institutions in the United States, we recognize that our frameworks, paradigms, and perspectives are limited in scope. While we represent a wide range of academic disciplines across fields in the natural sciences, social sciences, and international law and policy, our perspectives on these global conservation issues are influenced by our education and experiences in western academic institutions.

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Data and analysis: https://github.com/milliechapman/abnj_value_typologies

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