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Commentary

Promoting equity in the use of algorithms for high-seas conservation

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Spatial optimization algorithms show potential for prioritizing conservation areas on the high seas. Yet algorithmic approaches stand to reinforce global power asymmetries without careful consideration of process. We explain this problem's origin and provide recommendations for a more equitable path forward in the application of algorithms to high-seas conservation.

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 what is meant to be their 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 (ABNJ).[1] Parties to this treaty are meant to be guided by the best-available science, including "scientific information and relevant traditional knowledge of Indigenous peoples and local communities" (see Annex I of UN General Assembly[1]). Western science and conservation institutions have increasingly proposed data-driven spatial optimization algorithms to assist in prioritizing the protection of biodiversity beyond national jurisdiction (BBNJ) while considering specific economic costs and risks.[2–4]

Algorithms are applied across a variety of conservation contexts; therefore, the term "algorithm" can refer to a range of tools that present diverse and distinct challenges. In this commentary, we focus specifically on the growing use of spatial prioritization algorithms (hereafter referred to as algorithmic approaches) as a decision support tool when considering candidate areas for conservation protection. Although algorithmic approaches range in complexity, their capacity to integrate a wide scope of data and objectives into definitive policy suggestions is both attractive and useful in the context of global environmental issues. However, because algorithmic approaches 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: exactly what, and for whom, are these algorithms optimizing? Although these are age-old questions in conservation decision-making, a pending transnational agreement on the management of a 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 algorithm inputs (which largely consist of global datasets) and values (weightings of data in pursuit of a narrow subset of economic and biodiversity targets). The use of these algorithms can redistribute and/or concentrate power among stakeholders and, without explicit design considerations, further entrench existing vulnerabilities.[5] Although algorithmically determined scientific recommendations are only one piece of a complex international negotiation process, they are poised to play a substantial if uneven role in determining the subsequent allocation and designation of marine space at regional levels once global conservation targets have been set. Even when a conservation decision-making process itself is not algorithmic, algorithms can determine which data sources and potential solutions decision-makers consider. As a result, scientific recommendations designed to support decision-making in this process should be developed to promote equity based on principles of environmental justice[6] and in support of the rights of Indigenous Peoples.[7] In the international marine context, striving for equity through principles of environmental justice includes rebalancing value-based target setting to center coastal communities in developing countries whose livelihoods and well-being

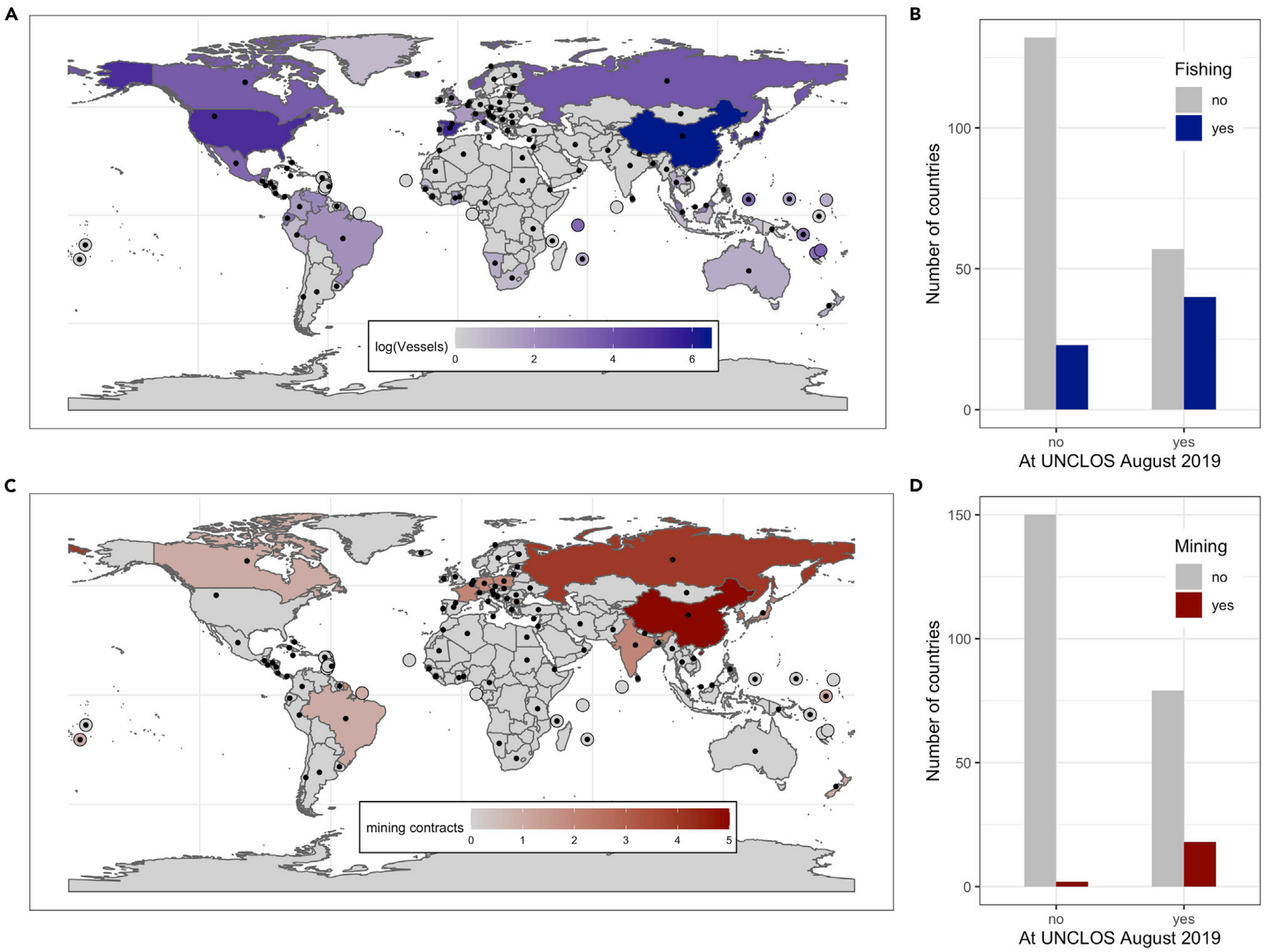

Figure 1. Global socioeconomic data layers largely center the concerns of highly industrialized nations who are parties to UNCLOS
(A) High-seas fishing effort (log(vessels)[8]) by national flag of corporate operator.
(B) Number of nations participating in the most recent BBNJ treaty negotiation session, 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 1, 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 (August 19–30, 2019 in New York, USA).

are most directly impacted by BBNJ management decisions.

Algorithmic approaches to prioritization of areas for protection in ABNJ do not currently center equity and in fact might function to reinforce existing power asymmetries in the global marine governance sphere. These equity concerns are not driven by the specific algorithmic methods currently used but rather by the values for which they optimize. The primary goal of our commentary is to shed light on the origin of this problem and provide insights on a more equitable path forward in the application of algorithms to conservation prioritization on the high seas. The approaches proposed here provide a starting point for addressing equity issues in scientific recommendations to BBNJ protection. The continued refinement and development of approaches to prioritize equity in systematic conservation planning will also be a key challenge for ocean scientists during the ongoing UN Decade of Ocean Science for Sustainable Development.

Recognizing data disparities on the high seas

Although algorithmic approaches to conservation are not inherently destined to produce inequitable recommendations, key data disparities must be addressed to more equitably harness the promise of these tools for supporting 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 data inputs.[3,4] For example, biodiversity data could overrepresent highly studied regions of the ocean.[3] In the context of socioeconomic data, standardized global inputs tend to disproportionately represent human activities conducted by relatively few corporate actors under the flags of a select few globally powerful nations.[8] For example, global data layers on two major high-seas industries (fisheries and international seabed mining) represent 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 potentially 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 their 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] For example, culture and scientific background can alter the perceived success of marine protected areas even when presented with the same data—a situation that is most likely to arise in problems for which solutions might not be falsifiable due to significant data gaps (e.g., protection of high-seas biodiversity).[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.

Existing 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 that 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.[11] Thus, high-seas fisheries management can influence fish abundance in the EEZs of less-wealthy nations that do not partake in high-seas fishing. Even if algorithmic approaches consider high-seas fishing activity as a risk to biodiversity rather than an opportunity to be preserved (see supporting information of Visalli et al.[2]), 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 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.[4] These targets (objectives) might 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 nations and Indigenous communities or whether it will simply reduce the price of seafood exported from developing nations to middle-class consumers (primarily in North America and Asia). 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. This issue is not exclusive to fishing activity on the high seas and is a problem likely to arise across global industrial uses of ocean resources (Figures 1C and 1D).

A more equitable path forward for BBNJ protection

Addressing biases in spatial optimization algorithms is not a simple task, but a necessary one to equitably harness their potential to contribute to conservation solutions. We propose three steps to help provide the cultural context, diverse perspectives, and humanistic frameworks necessary for promoting equity in the use of algorithms for high-seas conservation (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. In order to center the values of often-marginalized communities in objectives, meaningful consultation with communities is needed[9] (Figure 2). International fisheries management in the Central Arctic Ocean (CAO) provides an instructive international governance example.[12] In the case of CAO fisheries management, Indigenous perspectives were not originally included in a sequence of multilateral declarations, leading to demands from the Inuit Circumpolar Council (ICC) for the inclusion of Indigenous knowledge in management of CAO fisheries. As a result, a subset of Arctic States included Indigenous representatives in their delegations for the negotiation of the Central Artic Ocean Fisheries Agreement (CAOFA). This agreement established a "Joint Program of Scientific Research and Monitoring" to explicitly include a range of Indigenous knowledge and perspectives in the development of scientific recommendations to ecosystem and fisheries management in the CAO. Subsequent meetings on assessment of CAO fish stocks have made explicit reference to the value of Indigenous and local knowledge and have invited ICC input, yet precisely how (and to what degree) this input is used remains unclear.[12] This example highlights how attention to process might be of equal or greater importance in promoting equity as compared to any resulting products or policy recommendations.[10] Therefore, inclusion of diverse voices and values in objective setting is key to promoting equity in algorithmic approaches to BBNJ conservation.

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,[11,13] is one way to reduce disparities among the groups represented by data inputs. Attempts at incorporating such knowledge in Western scientific frameworks can often be both challenging and extractive. As a result, Indigenous and local knowledges and data should only be included with the consent and continued engagement of these communities. Further, first

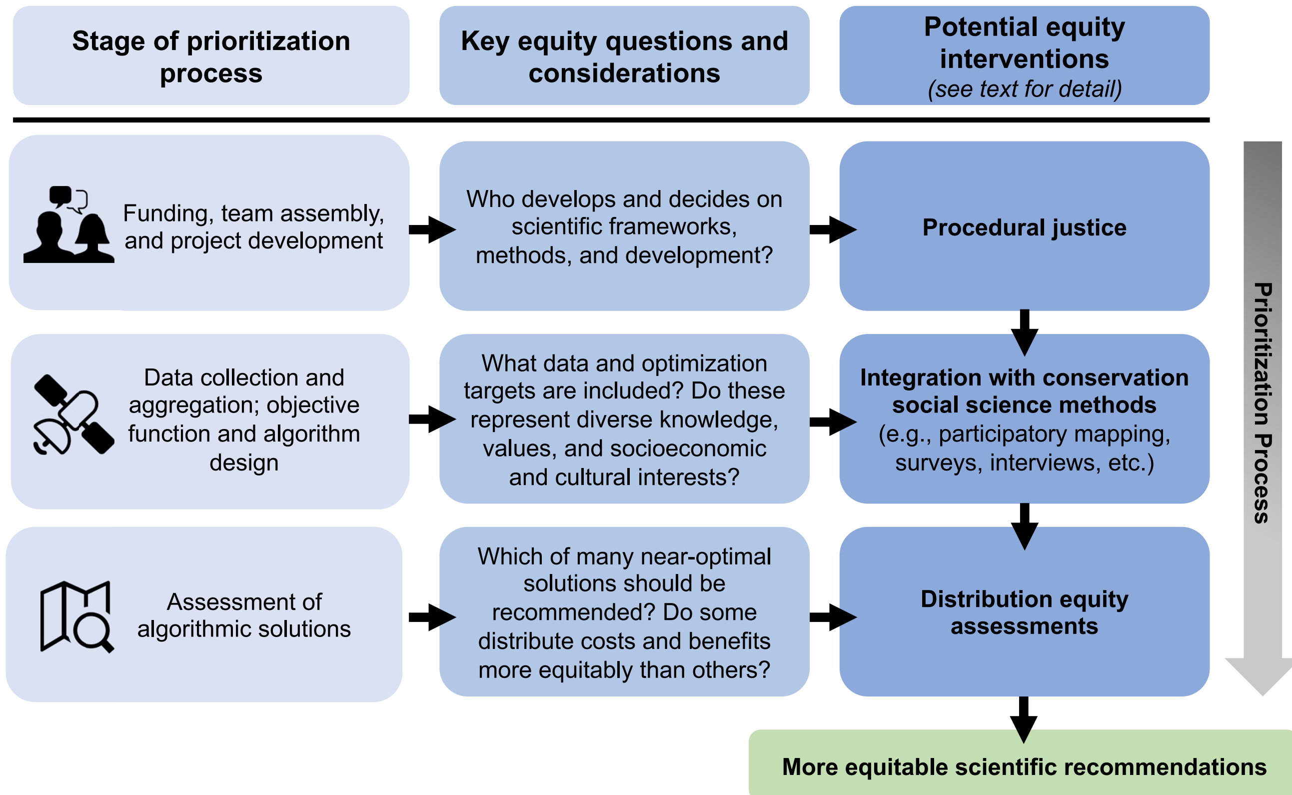

Figure 2. Key equity considerations to explore and interventions to implement along the process of developing scientific recommendations for BBNJ protection

Algorithmic approaches can play a valuable role in a broader prioritization process that promotes equity.

including Indigenous and local representatives from small nations in objective setting can aid in representing this knowledge in a meaningful and sensitive way.[9] Methods from the social sciences,[14] including focus group discussions, participatory mapping, interviews, and surveys can help identify local values, priorities, and knowledge and also be used to further include voices from resource-dependent communities in recommendations on spatial management of ABNJ. 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.[2,3]

Finally, even with the 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 based on equity criteria. Assessing equity in the distribution of costs and benefits of multiple "near-optimal" solutions provides a post-processing step that 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 (e.g., community-based research on potential outcomes of proposed solutions, focus group discussions weighing near-optimal solutions).[14,15] Employing these widely used methods and frameworks in tandem with algorithmic approaches can provide tangible scientific recommendations while promoting equity in policy outcomes.

Conclusion

The challenges and opportunities raised by algorithmic approaches to large-scale spatial conservation planning are not confined to the high-seas context—these topics are relevant to a number of 21st century transnational conservation initiatives. Recognition of how algorithm inputs and targets can exacerbate existing power asymmetries will require critical and continued engagement with environmental justice principles, with particular attention to the unique governance and power dynamics at play in this global arena. It is also critical that researchers acknowledge and account for their own positionalities—i.e., acknowledging how one's social position (race, class, gender, etc.)—might influence the design, implementation, and interpretation of optimization algorithms. In the case of BBNJ, if development of algorithmic approaches does not ensure alignment between algorithm objectives and the priorities of coastal communities most reliant on marine resources, ocean governance implementing resulting recommendations could further amplify global power imbalances and entrench existing vulnerabilities. By amending the implementation of algorithmic approaches in the BBNJ negotiation context with genuine inclusion of diverse perspectives, knowledges, and values, we 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.

EXPERIMENTAL PROCEDURES

Resource availability

Lead contact

Further information and requests for resources should be directed to and will be fulfilled by the lead contact, Melissa Chapman (mchapman@berkeley.edu).

Materials availability

No novel materials were developed as part of this study.

Data and code availability

The code generated during this study is available via GitHub: https://github.com/milliechapman/abnj_value_typologies.

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