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PERSPECTIVE

An actionable guide to the United Nations' Biodiversity Beyond National Jurisdiction Agreement for research scientists

Jeffrey Marlow [1*] **Arianna Broggiato,** [2] **Janine Felson,** [3] **Harriet Harden-Davies,** [4] **Rebecca Helm,** [5] **Marcel Jaspars** [6]

[1]Department of Biology, Boston University, Boston, Massachusetts, USA; [2]European Commission, Brussels, Belgium; [3]Melbourne Climate Futures, University of Melbourne, Parkville, Victoria, Australia; [4]Ocean Voices Programme, School of Geosciences, University of Edinburgh, Edinburgh, UK; [5]Earth Commons Institute, Georgetown University, Washington, DC, USA; [6]Marine Biodiscovery Centre, Department of Chemistry, University of Aberdeen, Aberdeen, Scotland, UK

Abstract

The United Nations' "Biodiversity Beyond National Jurisdiction" (BBNJ) Agreement establishes a broad framework regulating activities—including scientific research—in marine Areas Beyond National Jurisdiction (ABNJ), with the aim of advancing long-term conservation and sustainable use. Here, we offer a practical guide for researchers hoping to understand how the BBNJ Agreement will impact their work upon entry into force, highlighting relevant *requirements*, *recommendations*, and *opportunities*. Researchers will be required to submit pre- and post-cruise reports to a centralized online repository, as well as information about downstream research and development, including commercialization. Capacity building efforts to bolster the scientific proficiency of developing countries will also be required, though the guidance on precise modalities is broad and allows for customization. The BBNJ Agreement recommends a range of activities around capacity building and technology transfer that individual researchers could initiate, including research exchanges and infrastructure improvement. There are also many opportunities for researchers to support the Agreement's conservation and sustainability objectives through, for example, proposing marine protected areas, conducting environmental impact assessments, or joining technically oriented subsidiary bodies that will add practical detail to the Agreement's implementation in the years to come. Overall, many of the BBNJ Agreement's prescriptions align well with current best practices regarding collaboration, cruise operation, and data sharing. Given the deep integration of science into the BBNJ Agreement, marine scientists aiming to work in ABNJ are poised to both benefit and benefit from the Agreement's forward-looking objectives.

On June 19, 2023, member states of the United Nations adopted, by consensus, the text of a new Agreement under the United Nations Convention on the Law of the Sea (UNCLOS) on the Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction. The Agreement, often referred to as "Biodiversity Beyond National Jurisdiction," or "BBNJ," was developed at a series of five intergovernmental conferences that convened over several years in New York City with the aim of filling key gaps in international ocean governance.

The BBNJ Agreement, which will enter into force on January 17, 2026, 120 days after the 60th ratification, attempts to fill notable gaps in UNCLOS (United Nations Convention on the Law of the Sea 1982), which is the main framework for governance of Areas Beyond National Jurisdiction (ABNJ) in the ocean. UNCLOS was adopted in 1982 and ratified in 1994. It prescribes rules applicable to the high seas, including conditional freedom of navigation and research, and the "Area" (a term that refers to the seabed and ocean floor in ABNJ), including the principle of the common

*Correspondence: jjmarlow@bu.edu

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heritage of mankind, as well as the obligation to protect the marine environment. Despite the application of these overarching principles, UNCLOS has left many gaps in high seas governance. In particular, UNCLOS does not include procedures for conducting environmental impact assessments, establishing marine protected areas, or regulating access to and use of marine biodiversity. While more focused Agreements like Regional Fisheries Management Organizations limit fish catches and, in some cases, include environmental measures, their geographical and material scopes are mainly regional and sectoral. Thus, in today's era of dramatic global change, environmental degradation, and stark capacity discrepancies among the world's nations, progress and enhanced collaboration on biodiversity management, conservation, and technical capacity building are particularly necessary.

The BBNJ Agreement is organized around four main pillars (see Box 1 for commonly used terms). The *Marine Genetic Resources* (MGR) section (Part II: Articles 9–16) outlines ways in which biological samples in ABNJ, and their resulting genetic sequence data (termed digital sequence information, or DSI), should be collected and recorded, and how the benefits derived from research and development on such samples and data must be shared. The *Area-Based Management Tools* (ABMT) section (Part III: Articles 17–26) describes how ABMTs, including Marine Protected Areas (MPAs), can be established to conserve and sustainably use particularly important or vulnerable areas of the high seas and the Area. The *Environmental Impact Assessment* (EIA) section (Part IV: Articles 27–39) contains guidance on when and how to conduct scientifically informed studies of environmental harm before, during, and after a qualifying activity in ABNJ. The *Capacity-Building and Transfer of Marine Technology* (CB & TMT) section (Part V: Articles 40–46) promotes and facilitates the creation and enhancement of Parties' scientific, technological, human, financial management, organizational and institutional capabilities. The purpose of these efforts is to enable equitable implementation, including in relation to scientific access to ABNJ, and fulfill the objectives of the Agreement.

Taken as a whole, the BBNJ Agreement aims to ensure that benefits accrued from ABNJ are shared equitably with all countries. By formalizing many existing best practices in terms of sample and data sharing, mitigation of negative environmental impacts, and capacity building, the Agreement will benefit the scientific community worldwide.

The BBNJ Agreement is a dynamic framework that leaves many of the technical and logistical details to the Conferences of the Parties (COPs) and subsidiary bodies including a Scientific and Technical Body. This approach allows for "future-proofing" through the consideration of new priorities and changing environmental realities. For researchers, the fluid state of the regulatory details provides an exciting opportunity to incorporate cutting-edge scientific findings and best practices into the implementation of the Agreement's provisions.

This paper serves as a guide to the BBNJ Agreement for scientists conducting marine research. While many sea-going scientists are unaware of the Agreement's details (or even its existence), their work in ABNJ, as well as in their laboratories, will be subject to its rules (if they are working under the auspices of a country that is a Party to the Agreement).

Box 1. Commonly used terms and their acronyms/initialisms.

Term		Definition
UNCLOS		The United Nations convention on the law of the sea
BBNJ agreement		Agreement under the United Nations convention on the law of the sea on the conservation and sustainable use of marine biological diversity of areas beyond National Jurisdiction (upon entry into force, the "agreement" becomes a "treaty.")
Four "pillars" of the agreement	**MGR**	Marine genetic resources
	ABMT	Area based management tool
	CB & TMT	Capacity building and transfer of marine technology
	EIA	Environmental impact assessment
State party		A country that has ratified the agreement/treaty and is thus subject to its provisions and responsible for data collection and reporting
DSI		Digital sequence information: no agreed-upon definition, but currently assumed to refer to the sequences of DNA and RNA
CHM		Clearing-house mechanism: a centralized online repository of information to be managed by the BBNJ secretariat, whose exact configuration remains to be determined

The remit of the BBNJ agreement

The provisions of the Agreement apply to marine areas beyond national jurisdiction, which "means the high seas and the Area" (Article 1.2). As delineated in UNCLOS, the "high seas" include all areas beyond a coastal country's exclusive economic zone, which extends up to 200 nautical miles (~ 230 miles) from shore (Fig. 1). Each country is also entitled to explore and exploit its continental shelf, defined as "the seabed and subsoil of the submarine areas that extend beyond its territorial sea throughout the natural prolongation of its land territory to the outer edge of the continental margin" (UNCLOS Article 76.1). "The Area" comprises "the seabed and ocean floor and subsoil thereof, beyond the limits of national jurisdiction;" this domain is also regulated by the International Seabed Authority, but while that body governs mineral resource use (as well as associated research and TMT), the BBNJ Agreement oversees questions pertaining to biodiversity and genetic resources. Put simply, activities taking place in the water column, seafloor, or subsurface more than 200 nautical miles from a country's coastline (unless the territorial continental margin extends beyond that range) are within the scope of this Agreement.

The BBNJ Agreement contains some important exceptions (Articles 4 and 10). The Agreement as a whole does not apply to "any warship, military aircraft or naval auxiliary," and a State Party's military activities are exempt from Part II on MGR (Article 10.3). For "other vessels or aircraft owned or operated by a Party and used, for the time being, only on government non-commercial service," only Part II of the Agreement (on MGR) applies (Article 4). The Agreement however does not clarify the distinction between government research activities, law enforcement activities, and military activities (Humphries 2025).

Furthermore, despite its overarching geographical scope, the BBNJ Agreement is to be "interpreted and applied in a manner that does not undermine relevant legal instruments and frameworks" and "that promotes coherence and coordination with those instruments, frameworks and bodies," (Article 5.2). Researchers are thus encouraged to look beyond the BBNJ Agreement to ensure that they are compliant with other "relevant legal instruments and frameworks" (e.g., the International Seabed Authority).

One of the most scientifically complicated parts of the Agreement pertains to the access, use, and benefits of MGR.

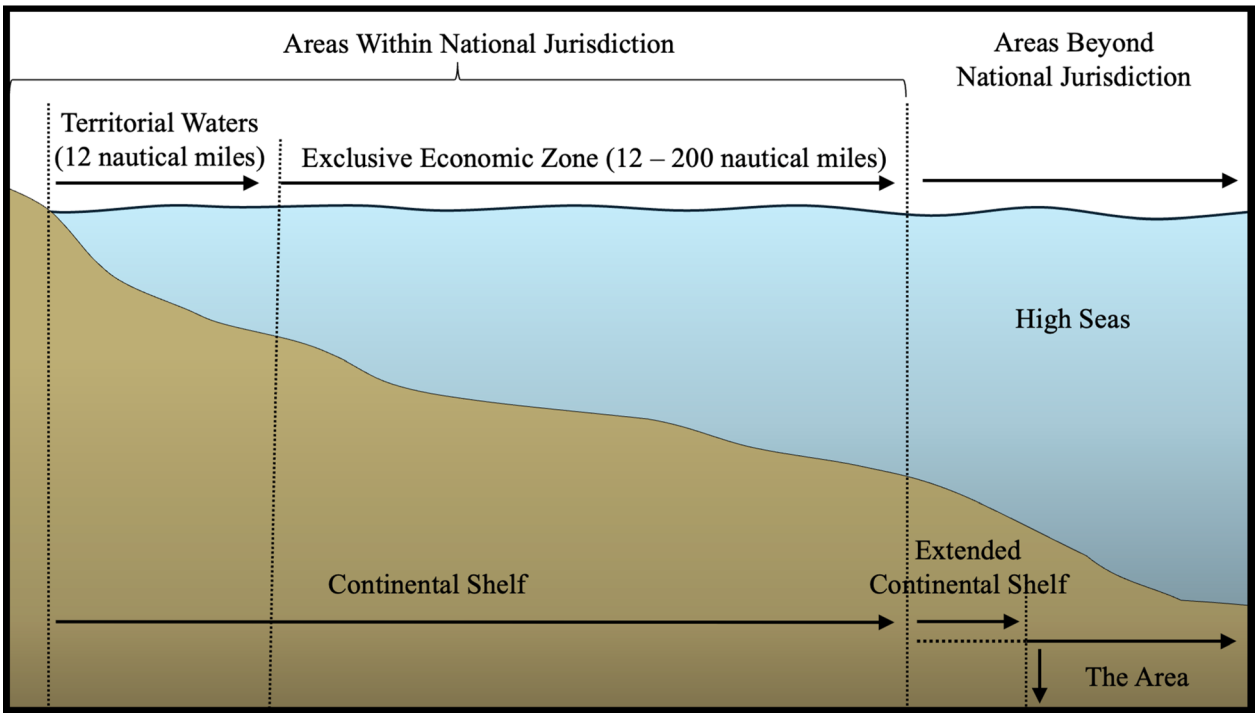

Fig. 1. A schematic diagram of the ocean and seafloor, as delineated in international law. "Territorial Waters" are areas over which a country has full sovereignty and legal control (while allowing for "innocent passage" of foreign ships). Within the "Exclusive Economic Zone," a country has control over scientific research activities as well as the exploration, exploitation, and conservation of natural resources. The "Continental Shelf" includes the seabed extending to the edge of the continental margin, a more geologically defined boundary that marks the transition from continental to oceanic crust. If this boundary is beyond the EEZ, then a country may make a claim to its "Extended Continental Shelf" based on sedimentary and bathymetric arguments spelled out in Article 76 of UNCLOS. Combined, these domains constitute the "Areas Within National Jurisdiction" for each country. The rest of the seafloor ("The Area") and ocean are "Areas Beyond National Jurisdiction," which fall under the remit of the BBNJ Agreement. (The nautical mile is the standard unit of distance used in maritime legislation, and is equivalent to 1852 m, or ~ 1.15 miles.)

Marine biological resources have increasingly been used for applications in biotechnology, pharmaceuticals, nutrition, and personal care over the last half century. Some notable successes are the clinical approval of over 15 pharmaceuticals for human diseases (Francesch et al. 2024), predominantly cancer, and the use of low-temperature enzymes in laundry detergents. Most of these products have been derived from marine organisms collected within various countries' EEZs, but ABNJ contain a vast repository of unexplored biodiversity that may possess biotechnologically promising genes that move beyond the capabilities of those discovered to date.

MGR is defined as "any material of marine plant, animal, microbial or other origin containing functional units of heredity of actual or potential value" (Article 1.8). Two phrases in this definition warrant explication. "Other origin" includes naturally occurring viruses and extracellular material. "Functional units of heredity" is a definitional phrase that has important historical heritage: it first appeared in Article 2 of the Convention on Biological Diversity. This definition was likely originally intended to mean all genetic material (DNA and RNA), and while this framing retains some inherent imprecision (e.g., not all DNA has a known "function," and not all genetically encoded functions are heritable), we believe it remains the most appropriate operational way to think of MGR.

Some parts of the Agreement text take a more expansive view by citing the "utilization of marine genetic resources" rather than MGR themselves. Such "utilization" entails "research and development on the genetic and/or biochemical composition of marine genetic resources, including through the application of biotechnology," (Article 1.14). Biotechnology, in turn, includes "any technological application" that uses biological material—including "derivatives" such as proteins and small molecule metabolites modified in the lab—"for specific use" (Article 1.3). Distinctions between MGR and the *utilization* of MGR (which includes research on the composition of any biological material, as well as the application of organisms or biomolecules for specific aims) will be highlighted in the sections to follow.

The MGR portion of the Agreement (Articles 9–16) applies not only to the physical MGR molecules defined above, but also to "digital sequence information" (DSI) on MGR (Article 10.1). Despite multiple attempts in the past (CBD/DSI/AHTEG/2020/1/3), there is no internationally agreed-upon definition of DSI. And while further clarification will likely come from CBD and BBNJ discussions in the future, DSI is currently assumed to refer to the sequences of DNA and RNA. (Whether it includes proteins and possibly small molecule metabolites as well is open to interpretation.) DSI can be transmitted via electronic files and is often stored in online repositories, making it a critical and highly transferable expression of MGR: once an actual physical sample is sequenced, that sequence can be shared as a set of letters and reconstituted via lab-based synthesis. Thus, the benefits derived from sampling efforts in ABNJ can be realized by scientists (and companies) who were not involved with the collection or initial research study.

In addition to covering MGR and DSI "collected and generated" after the BBNJ Agreement enters into force (i.e., 120 days after 60 countries officially ratify it, becoming "State Parties," and 30 days after ratification for each successive country), the MGR provisions as well as other relevant provisions of the Agreement (such as funding, and capacity building and transfer of marine technology) also apply to the utilization of MGR and DSI collected and generated at any time prior (Article 10.1), unless a written exception is declared "when signing, ratifying, approving, accepting or acceding" to the Agreement. It is thus important for researchers to determine which jurisdictions have secured exceptions regarding retroactivity, as the default is that all MGR and resulting sequences ever collected from ABNJ are beholden to the BBNJ Agreement (detailed below). The details of how previously collected and/or previously utilized MGR and DSI would be integrated into the Agreement's enactment (such as supplying data to the CHM, or identifying cases of commercial use) remain uncertain, and will likely be clarified in future COPs (Rabone et al. 2025).

One of the most substantial "carve outs" in the Agreement is for fishing: while commercially relevant fish inherently possess MGR, their collection is not regulated under the BBNJ Agreement (Article 10.2.a). Neither are "fishing-related activities"; like "fishing," this term is not defined, but is generally interpreted to include fisheries-related research, such as efforts to track toxins in commercial fish, quantify fish stocks, measure fecundity, or otherwise inform and support fisheries. However, if any MGR/DSI resulting from fishing or fishing-related activities reaches the level of "utilization" (application-driven research or commercialization), then those activities would indeed fall under the scope of the Agreement (Article 10.2.b).

Because the BBNJ Agreement is an international accord, its regulations and strictures apply to State Parties—that is, national governments—rather than individuals or institutions (e.g., Articles 53, 54). State Parties are in turn obligated to take legislative, administrative, or policy measures to create expectations or obligations for actors falling within their jurisdiction. Since the activities specified in the Agreement are conducted largely by researchers at a wide range of governmental or non-governmental institutions, much of the encouraged activity and required reporting will stem from the work of "on-the-ground" practitioners. For example, while State Parties must submit periodic reports on MGR-related activities, the information for such reports (e.g., where and how samples were collected), will come from researchers. The precise format, mechanism, and frequency of required actions is likely to vary among State Parties, but given the common text from which such requirements will be derived, we can still highlight some general guidelines to help researchers

prepare for work on the high seas and the Area in the decades to come.

The Agreement's provisions encompass a range of certainty (e.g., what exactly will be included as the Agreement takes shape via the Conference of the Parties), compulsion (what will be required as opposed to encouraged), and precision (how specific a given directive is). With this in mind, we structure this study around the actionable impact of the Agreement on researchers engaging with ABNJ. Put simply, we aim to address the questions marine scientists are asking: *What does the BBNJ Agreement mean for me and my research? What, if anything, do I need to do differently?*

Researchers' relationship with the BBNJ Agreement can be separated into three categories, which we use to structure the remainder of this paper. *Requirements* are legally binding actions that all work in ABNJ, including scientific research, must follow (often denoted in the Agreement text with language such as "shall"); failure to satisfy these requirements may result in both national and international penalties (details of which may become more clear through further elaboration of the Agreement). *Recommendations* are suggested actions that researchers can take that would bolster the overall aims of the BBNJ Agreement (and are typically indicated by terms such as "should" or "may"). *Opportunities* are ways in which scientists might proactively contribute to the science needs of the Agreement to ensure that the best available knowledge is incorporated into the enactment of the BBNJ Agreement. Throughout, we take a "scientific researcher-centric" perspective on the Agreement. For example, while EIAs are *required* for activities in ABNJ that "may cause substantial pollution of or significant and harmful changes to the marine environment," these activities are likely to be non-research-related endeavors. Thus, individual scientists may see *opportunities* to contribute to EIAs, even if their own research projects do not require them.

Requirements

The most prescriptive requirements affecting sea-going researchers pertain to MGR access and use. There are also provisions mandating EIAs under certain conditions, as well as CB and TMT, in some cases identifying particular modalities. Countries that ratify the agreement (State Parties) will be responsible for complying with the BBNJ requirements. Individual scientists will not be providing required information directly to the United Nations, but rather to a national agency or organization whose exact procedures will vary by State.

Marine genetic resources

While the focus of this report is on the implications of the BBNJ Agreement for academic (or otherwise non-commercial) researchers, substantial MGR-related work is conducted by corporate actors that secure patents on genetic sequences (Blasiak et al. 2018; Oldham et al. 2025). The BBNJ Agreement stipulates that no "sovereign rights" (i.e., legal authority) over MGR in ABNJ can be claimed by any State Party (Article 11.4), and all MGR/DSI related work must be done "exclusively for peaceful purposes" (Article 11.7).

When conducting work related to MGR / DSI from ABNJ, including research cruises, there are several notification requirements described in Article 12 that researchers must keep in mind. At least 6 months in advance of sample collection, the following information must be provided by each State Party to the "Clearing-House Mechanism" (CHM)—a centralized online repository of information to be managed by the BBNJ Secretariat, whose exact configuration remains to be determined (see Fig. 2).

- The "nature and objectives" of the cruise, including the overall goals of the project and any larger programs with which it is affiliated (Article 12.2.a).
- The "subject matter of the research" (what is being studied). If known, the specific MGR to be collected, along with a rationale for their collection, must be provided (Article 12.2.b).
- The location where the sample collection will happen (Article 12.2.c). (Depending on the nature of the research, EIA actions may be necessary; see "Opportunities" section below.)
- A summary of the collection methodology, including "the name, tonnage, type and class of vessels, scientific equipment and/or study methods employed" (Article 12.2.d).
- Planned contributions to "major programs," which may include initiatives that are broader in time or scope than the individual cruise in question (Article 12.2.e).
- The expected dates of the cruise, as well as dates of any equipment deployments (Article 12.2.f).
- The "name(s) of the sponsoring institution(s) and the person in charge of the project" (Article 12.2.g).
- Which opportunities are available for scientists from other countries, "in particular scientists from developing States," to be involved with the cruise and larger project (Article 12.2.h). For countries that may need technical assistance in order to be involved in the project, a description of how such participation could be enabled is needed (Article 12.2.i).
- An "open and responsible" data management plan (Article 12.2.j).

The exact format for this required information, including the necessary degree of detail, will be clarified as the CHM takes shape in the years to come. Once this pre-cruise information is provided, a "standardized batch identifier" will be generated by the CHM (Article 12.3). This unique identification code will be used to track MGR samples and DSI from collection through their lifetime of study, analysis, dissemination, and, potentially, commercialization. In effect, the standardized batch identifier is a "tag" that identifies material or data arising from a particular research cruise or collection event. This way, any data and products derived from ABNJ can be

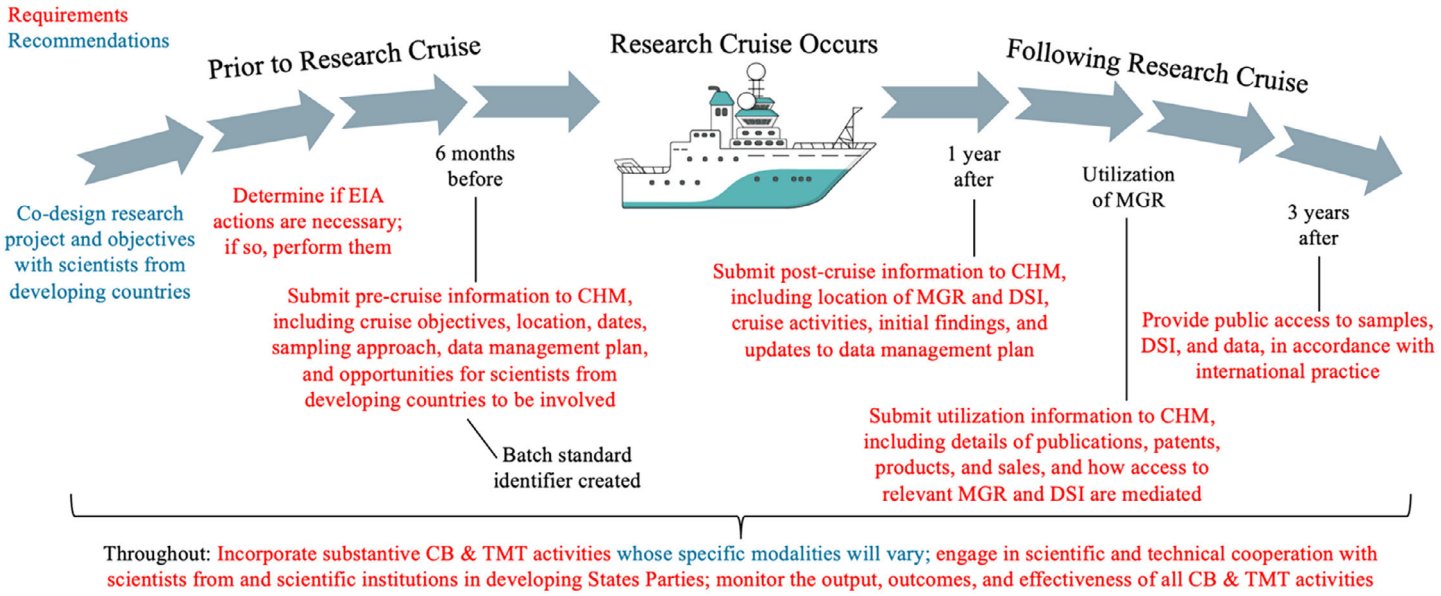

Fig. 2. Specific requirements and recommendations directly related to research cruise activities in ABNJ (for full details, see text). These requirements pertain to State Parties, but their enactment is likely to be performed, necessarily, by researchers conducting the associated work. The additional requirements, recommendations, and opportunities detailed in the text may occur in indirect relation to cruises.

distinguished, and resulting benefits can be shared accordingly (Rabone et al. 2025).

Any changes to the information provided in the pre-cruise notification must be shared with the CHM "within a reasonable period of time and no later than the start of collection *in situ*, when practicable" (Article 12.4). Given the myriad challenges associated with cruises in ABNJ, the precise nature of research activities frequently changes with little notice: bad weather or malfunctioning equipment, for example, may lead to opportunistic sampling in a less stormy area, or with different techniques than originally planned. The "when practicable" allowance of Article 12.4 recognizes this need to adapt to dynamic conditions at sea. It provides helpful leeway for researchers to deviate from the initial plan, within the broader remit and overall objectives of the pre-cruise plan.

Within 1 yr of the completion of the cruise (or sooner, if available), the following information must be provided to the CHM (Article 12.5; Fig. 2):

- The database where DSI is or will be deposited. (Relevant appropriate databases include the members of the International Nucleotide Sequence Database Collaboration: GenBank at the US National Center for Biotechnology Information, the European Nucleotide Archive, and the DNA DataBank of Japan.)
- Where MGR are or will be kept. (Potential locations include university, regional, or national sample repositories, such as museum collections.)
- A report that includes the location(s) (latitude, longitude, and water depth) from which MGR were collected. Initial findings derived from the cruise should also be included.
- Any updates to the data management plan.

Researchers will be required, through national legislation implementing the Agreement, to make sure that all physical samples and resulting DSI can be identified by subsequent users as originating from ABNJ "to the extent practicable" (Article 12.6). This aim could be achieved by, for example, using the unique batch identifier assigned to the cruise in all sample/DSI labeling in the same way that any cruise ID number is typically appended to all samples and downstream data products derived from said cruise. (The batch identifier is distinct from an overarching cruise ID in that it is linked only to samples (and associated DSI) collected in ABNJ, therefore differentiating them from the samples and DSI collected in areas *within* national jurisdiction by the same cruise.)

When MGR and DSI are used for genetic and/or biochemical research and development, including application-oriented work ("subject to utilization," as described in Article 12.8) and commercialization, the following information, if available, must be provided to the CHM as soon as possible (Fig. 2):

- The nature and location of resulting publications, patents, and commercial and non-commercial products (Article 12.8.a).
- Where the original sample is being kept (Article 12.8.c).
- How access to the MGR and DSI that are being "utilized" will be mediated, along with a data management plan (Article 12.8.d).
- Details on sales numbers and further product development, should the MGR / DSI in question be commercialized (Article 12.8.e).

One of the Agreement's central tenets is that activities pertaining to MGR and DSI of ABNJ are intended "for the benefit of all humankind" (Article 11.6), and that any benefits must be shared "in a fair and equitable manner" (through a special fund established by Article 52). Furthermore, these benefits are to be used to "contribute to the conservation and sustainable use" of biodiversity in ABNJ (Article 14.1)—for activities such as funding capacity-building projects and assisting developing countries in implementing the Agreement (see Article 52.6 for a full list of activities).

The benefit-sharing goals of the Agreement are particularly relevant for individual researchers, as many research-based activities constitute the so-called "non-monetary benefits" illustrated in Article 14.2. This Article provides a non-exhaustive list of non-monetary benefits that researchers need to consider and implement, including providing access to samples, DSI, and data (Articles 14.2.a, b, c); providing the pre-cruise and post-cruise notifications in publicly accessible venues (Article 14.2.d); engaging in marine technology transfer (Article 14.2.e); and capacity building, through research partnerships with developing countries (Articles 14.2.f, g) (Broggiato et al. 2025). (The different non-monetary benefits are described in detail below.) Considering that the benefits included in Articles 14.2.a-c are, to some extent, already being shared according to the best scientific practices, the implementation of the BBNJ Agreement is a promising opportunity to further improve sample and data sharing, and to harmonize and standardize these practices at the international level. In this sense, the BBNJ Agreement will enhance scientific capacity for researchers around the world.

To further support the implementation of benefit sharing, MGR and DSI on MGR must be deposited in public repositories or databases within 3 yr of the start of utilization (as opposed to the date of collection) (Article 14.3). While researchers are required to make remaining biological samples and DSI from ABNJ publicly available in this way, universal access might be limited through "reasonable conditions" that are normally applied, such as the need to maintain the physical integrity of samples, or the need to recoup costs associated with maintaining repositories or online databases (Article 14.4). State Parties must submit regular reports detailing the ways in which they enacted the benefit-sharing aspects of the Agreement, and will likely solicit such information from repositories, databases, and individual research teams. The ways in which this information is requested will no doubt vary among countries, but researchers would be well-advised to keep close track of their benefit-sharing activities (see Fig. 2).

Environmental impact assessments

EIAs are important tools to help "prevent, mitigate and manage" environmental damage that could be caused by the wide range of activities occurring in ABNJ (Article 27.b). To determine if an EIA process is required for scientific research (or any other) project, proponents must evaluate whether the activity "may have more than a minor or transitory effect on the marine environment, or the effects of the activity are unknown or poorly understood" (Article 30.1). If this threshold is surpassed, a four-part EIA process (described in more detail in the "Environmental Impact Assessments" section) would be triggered. While some extremely large research projects (e.g., testing effects of geoengineering) may require evaluation for an EIA, the vast majority of scientific research expeditions would be exempt, given their "minor or transitory" effects on the environment. Since most EIAs will thus be associated with larger commercial projects and not scientific research, we highlight the ways in which individual scientists might interface with EIAs in the "Opportunities" section below.

Capacity building and transfer of marine technology

The final set of requirements likely to involve researchers conducting work in ABNJ pertains to the capacity building (CB) aims of the Agreement, which include the "transfer of marine technology" (TMT). Guidance on this topic is necessarily non-specific since opportunities are highly dependent upon individual needs and priorities, particular methods, or research goals. Nonetheless, the need for substantive CB and TMT efforts is clear, as reflected in the obligations relating to cooperation in CB and TMT (Article 41), and the obligation on States Parties, "within their capabilities", to "ensure" CB and "cooperate to achieve" TMT (Article 42.1). Regardless of how State Parties support their researchers to enact CB and TMT (potential recommended approaches are detailed below), they must ensure that such activities do not involve "onerous reporting requirements" (Article 41.3) and do not impinge upon pre-existing rights (Article 43.4). (For example, receiving patented marine technology as a donation for research purposes would preclude its use for commercial gain.)

Recommendations

Capacity building and transfer of marine technology

The implementation of the Agreement's framework for CB & TMT activities will necessitate guidance and active engagement from scientists all over the world, leveraging best practices and context-specific dynamics to promote productive partnerships. CB & TMT is intended to benefit developing countries "that need and request it" (Article 42.1). Such activities should be transparent and iterative, participatory, and gender-responsive (Article 42.3); they should not be one-way transactions, but should rather respond to specific needs. Scientists working in developing countries are well-positioned to identify and convey such needs to their governments as well as to potential partners. It is also important that any shared technology is usable—neither too complex and challenging to maintain, nor ineffective or in disrepair (Article 43.5). To support long-term usability, the sharing of technical support,

manuals, and technology training programs is all listed as potential CB & TMT activities in Annex II.

To give researchers an idea of the type of activities that constitute CB and TMT, Article 44 provides a non-exhaustive list, which includes the following:

- Sharing "relevant data, information, knowledge and research results" (Article 44.1.a).
- Disseminating research-related information, including traditional knowledge attained with informed consent (Article 44.1.b).
- Improving infrastructure for biodiversity and sustainable use research in ABNJ. This could include enhanced labs, research vessels, hardware and software for DSI analysis, and so on, as well as training and payment of personnel to maintain and use these tools (Article 44.1.c).
- Strengthening institutional capacity (Article 44.1.d), which could benefit from researchers' experience in designing complex research cruises, managing large data sets, and other aspects of institutional culture that bolster marine research.
- Conducting direct researcher-to-researcher exchanges and collaborations, as well as larger educational training programs around the use of marine technology (Article 44.1.e).
- Developing and sharing manuals and guidelines for relevant protocols (Article 44.1.f).
- Operating collaborative research and development programs (Article 44.1.g).

Annex II provides dozens of additional specific examples of CB and TMT activities, spanning topics such as data exchanges, operational research cruise assistance, and education and training programs. These extensive but non-exhaustive lists demonstrate that there are many points of entry to CB and TMT activities; identifying opportunities that are well aligned with research efforts is unlikely to be a major challenge.

CB and TMT efforts will be monitored using indicators to be developed at future Conferences of the Parties, with reports submitted by each Party (Articles 45.2, 3). While many details remain to be clarified, the "output, outcomes, progress and effectiveness" of CB and TMT will be evaluated (Article 45.2.d), so researchers should consider conducting their own initial monitoring to keep track of such measures and identify follow-up activities. To further "future-proof" research activities with respect to capacity building, we recommend involving scientists from developing countries as early and substantively as possible in research cruises to ABNJ, guided by needs assessments performed by developing States Parties (Article 45.2). In doing so, researchers should be mindful of the long-term vision of fully realizing technology development and transfer for inclusive, equitable participation in the activities undertaken by the Agreement (Article 43.1).

Opportunities

At its core, the BBNJ Agreement is predicated on strong and sustained engagement with scientific research. The Agreement is intended to safeguard and promote research opportunities for all countries, and requires high-quality scientific input to realize its ambitions of conservation and sustainable use. In this context, there are many opportunities for researchers to get involved and support the BBNJ Agreement's goals, either by leveraging their current expertise or by adjusting research activities to address key knowledge gaps.

Area-based management tools

The development and evaluation of area-based management tools (ABMTs) such as marine protected areas (MPAs) requires robust scientific input. Proposals for MPAs are submitted by State Parties, but national representatives "shall collaborate and consult" with stakeholders including "the scientific community" (Article 19.2), and the proposals themselves must include "relevant scientific input" (Article 19.4.j). Since proposals need to be based on "the best available science" and "relevant traditional knowledge" (Article 19.3), there is a clear need for researchers to help identify high seas and seabed habitats most in need of protection. Data on the 22 factors listed in Annex I—which include an area's biodiversity, biological productivity, vulnerability to environmental threats, and contingent of threatened or endangered species, among many other characteristics—can all be used to bolster an MPA application (Article 19.4.b, d; Annex I). "Emergency" MPAs can be designated if a natural or anthropogenic disaster—like a hurricane, submarine landslide, or oil spill—has or is likely to cause "serious or irreversible harm" to marine biodiversity in ABNJ (Article 24.1). These emergency measures, whose purpose is to stem continuing harm caused by the acute disaster, will be based on scientific input (Article 24.1, 3). Researchers should be aware of this route for environmental protection, and can take a forward-looking perspective to identify threatened sites. Researchers could also be instrumental in proposing the research needs of a required draft management plan (Article 19.4.f) to help the MPA achieve its conservation goals. Such needs could include regular monitoring of ecosystem health indicators, such as animal size and abundance, rates of biogeochemical fluxes, and connectivity among trophic levels.

Once an ABMT/MPA proposal has been submitted, consultations will occur to help Parties to the Agreement decide if it should be accepted. These discussions are an opportunity for scientists to provide additional relevant information about ways in which proposed MPAs would enhance or protect biodiversity in ABNJ (Article 21.1, 2). After an ABMT/MPA is enacted, it will be "periodically" reviewed by the STB, which will consider input from individual State Parties (Article 26.1–3). Since any decisions resulting from the review (which may include amendments to the terms of a given MPA) are to be based on the "best available science" and "relevant traditional

knowledge" (Article 26.5), researchers can play key roles in determining the priorities and ultimate success of MPAs.

Finally, one objective of the Agreement is to empower developing countries to implement, monitor, manage, and enforce MPAs on their own (Article 17.e), which could inform researchers' CB and TMT strategies. For example, enhancing capacity for biodiversity surveys, genetic sequencing, or satellite-based primary productivity or ship-tracking monitoring capabilities would support this goal.

Capacity building and transfer of marine technology

The objectives of CB and TMT include developing the marine scientific and technology capacity of Parties, in particular developing States Parties (Article 40.e) and increasing, disseminating, and sharing knowledge on the conservation and sustainable use of BBNJ (Article 40.d). The establishment of institutional mechanisms to implement CB and TMT (such as the CB and TMT Committee, the Clearing-House Mechanism, and the financial mechanism) could offer opportunities to promote, support and advance science and knowledge. The preparatory phase is an important time for scientific researchers to consider how such mechanisms might work in practice, including, for example, how research partnerships could be supported with and between researchers from developing States Parties, how data might be shared, and how needs and opportunities relating to research might be best understood, matched, and met.

Environmental impact assessments

It is the responsibility of each State Party to ensure that projects taking place "under their jurisdiction or control" are properly assessed before being authorized (Article 28.1). As noted above, scientists are more likely to contribute to the implementation of EIAs for other, non-research activities, than for their own research cruises. While the details of the EIA process will differ by Party, substantial scientific input is likely to be required on all manner of biodiversity and ecosystem health metrics—for example, toxicity effects, biogeochemical cycling, biodiversity and biogeographic patterns—to properly evaluate possible impacts.

As envisioned by the Agreement's text, a full EIA is a four-part process:

1. *Screening*. If "a planned activity may have more than a minor or transitory effect on the marine environment, or the effects of the activity are unknown or poorly understood," (Article 30.1), a screening must be conducted. (Note: most typical research cruises that visit a particular site intermittently would not surpass the threshold of potential harm needed to trigger a screening.) This process includes an initial analysis of potential environmental impacts; if there is sufficient evidence that the activity "may cause substantial pollution of or significant and harmful changes to the marine environment," then a full EIA will be required (Article 30). If an EIA is not deemed necessary, the screening results must be submitted to the CHM for 40 days of public comment. Any rebuttals should marshal the "best available science" to support a different perspective on the potential impacts, and the STB will ultimately issue a recommendation on whether a full EIA is required (Article 31.a).
2. *Scoping*. Once an EIA is triggered, the scoping exercise uses the "best available science" to ensure that key environmental, social, economic, and human health impacts are considered in the assessment (Article 31.b).
3. *Impact assessment and evaluation*. This step is the core of an EIA, in which the environmental impacts of a proposed activity are measured and evaluated using the "best available science" (Article 31.c). Among other more logistical components, the report should include a baseline characterization of the environment in question, the potential impacts, and scientific uncertainties and knowledge gaps (Article 33.2).
4. *Prevention, mitigation and management of potential adverse effects*. Plans to prevent, mitigate, and manage possible environmental damage are considered, and incorporated into an environmental management plan (Article 31.d).

Once an activity begins, regular studies "shall monitor the environmental and any associated impacts" using "the best available science" (Article 35). EIA reports and monitoring reports must be submitted to the CHM (Article 28.2.c), and will be open to public comments. The scientific community in particular is encouraged to provide input (Article 32.3), and all substantive comments will require responses from the delegation that submitted the EIA. Review of authorized activities is also highlighted in the Agreement: a Party can register concerns that the activity may indeed cause significant environmental damage, either because a key factor was not considered in the EIA process, or because the activity is being conducted in a way that was not accounted for in the EIA (Article 37.4.a).

Clearly, scientific input will be required throughout this process, from the initial determination of whether a screening is required, to the screening itself, potential rebuttals to screening reports, scoping, the quantitative analyses of the EIA (including the environmental baseline), and plans to handle negative effects. Researchers and environmental consultants are poised to play key roles, as existing EIA processes are extended to ABNJ, with all of the technical complexity and data limitation that entails. For the sake of consistency and to accommodate countries with limited capacity, the STB will assemble a "roster of experts" that can be called upon to help with all parts of the EIA process (Article 31.3).

Institutional arrangements and subsidiary bodies

In addition to providing substantive contributions to the enactment of the Agreement's provisions, there are also many

opportunities for researchers to support the Agreement's infrastructure. Some of the subsidiary bodies—such as the CB & TMT committee (Article 46.2), the Scientific and Technical Body (Article 49), and the Access and Benefit Sharing Committee (Article 15)—will consist of members with relevant expertise, much of which is housed in the science research community. These participants will serve "in the best interest of the Agreement" (Articles 46.2, 49.2) in their "expert capacity" (Article 49.2) rather than as representatives of countries. The CHM will serve as a centralized online platform with information related to all four main pillars of the Agreement (Article 51.3.a). It will also help link CB and TMT needs with provisioners (Article 51.3.b), facilitate needs assessments (Article 42.4), and provide links to MGR-associated gene banks and repositories (Article 51.3.c). Scientists can use their first-hand experience with CB & TMT and genetic sequence databases to make sure the CHM is as straightforward, user-friendly, and accurate as possible. Finally, given the many ways in which the BBNJ Agreement relates to and benefits from scientific research, we urge scientists to proactively work with their national authorities handling the Agreement's implementation to understand how to most effectively provide input.

Conclusion

The BBNJ Agreement signifies an important recalibration of our relationship with the ocean in the context of heightened anthropogenic use and rapidly intensifying global environmental pressures. When the treaty enters into force, researchers conducting work in and about ABNJ will be subject to its provisions, which comprise a range of requirements, recommendations, and opportunities. Required activities are broadly consistent with standard international practice regarding cruise notifications, reports, and data and sample sharing. Samples and data from each cruise to ABNJ will be assigned a "batch identifier" to keep track of downstream research and commercial use. Substantive capacity building is also a required component of work in ABNJ, and a wide range of recommended qualifying activities is described in the Agreement, meaning that research teams can tailor such efforts to their interests, expertise, and scientific objectives.

More broadly, however, science and scientific research will play critical roles in helping the Agreement reach its conservation and sustainable use goals, and we see many pathways for researchers to both contribute to and benefit from the Agreement's enactment. In particular, BBNJ envisions a more even playing field of research in ABNJ, and provides a legal basis to bolster the research interests and capacity of developing countries. Scientific expertise will also be essential in proposing and monitoring MPAs and other ABMTs, conducting and evaluating EIAs, and clarifying operational details for the CHM. The BBNJ Agreement is a forward-looking framework that places science at the center of conservation- and sustainability-minded engagement with our ocean, and marine scientists have a unique opportunity—and responsibility—to play a key role in facilitating this process.

Author Contributions

Jeffrey Marlow conceptualized the study and prepared original text and figure drafts. Arianna Broggiato, Janine Felson, Harriet Harden-Davies, Rebecca Helm, and Marcel Jaspars contributed independent analyses and participated in manuscript writing and editing.

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Conflicts of Interest

None declared.

Data Availability Statement

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

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