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The Voice of Science on Marine Biodiversity Negotiations: A Systematic Literature Review

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Over one hundred governments are currently negotiating a new legally binding instrument for the conservation and sustainable use of marine biological diversity in areas beyond national jurisdiction (BBNJ). The new agreement is to address four broad themes: marine genetic resources (MGRs); area-based management tools (ABMTs), including marine protected areas (MPAs); environmental impact assessments (EIAs); and capacity building and the transfer of marine technology (CB&TT). Although a large corpus of scientific BBNJ literature exists, a comprehensive overview and critical analysis of the academic debate is currently missing. This systematic review seeks to fill this gap by examining the main priority topics and recommendations in a sample of 140 multidisciplinary, geographically diverse publications. As an up-to-date summary and analysis, it is intended for researchers from diverse academic disciplines in the natural and social sciences, policy-makers, and practitioners. It untangles the complex BBNJ negotiations, highlights the policy relevance of existing work, and facilitates links between science, policy, and practice. It presents recommendations made in the literature sample for each of the four package elements of the future treaty and identifies four overarching themes: ocean connectivity, institutional design, the role of science, and digital technology. This paper identifies two important gaps that need to be addressed if we are to conserve marine biodiversity in international waters: the science-policy interfaces and the need for transformative change.

Keywords: international negotiations, marine biodiversity, ocean protection, BBNJ, ABNJ, high seas, science-policy interfaces, transformative change

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INTRODUCTION

Marine biodiversity and ecosystems are facing threats from various sources, including shipping, fishing, climate change, and emerging human activities, such as bioprospecting and deep-sea mining (Rayfuse, 2012; Druel and Gjerde, 2014; Rochette et al., 2014a; Ma et al., 2016). Moreover, scientific and technological innovations introduced since the adoption of the United Nations Convention of the Law of the Sea (UNCLOS) have created legal uncertainty for stakeholders regarding the exploration and exploitation of marine genetic resources (MGRs). The ocean, as a global commons, belongs to, and can be used by all (Ranganathan, 2016). Problems of overexploitation of the global commons can be prevented or reversed by international multilateral agreements setting global rules, regulations, and standards under which states change their behavior accordingly (Keohane, 1982; Oberthür, 1997; Vollan and Ostrom, 2010).

A new legally binding agreement on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction (BBNJ), whose pre-negotiations started in 2006, is currently being negotiated among UN member states. This "BBNJ treaty" is an attempt to preserve vulnerable marine ecosystems, use the ocean and marine species in a sustainable manner, legally regulate access to and benefit sharing of marine genetic resources in international waters, and strengthen ocean science and marine technology around the globe. The negotiations are a response to the fragmented framework of ocean governance, including four "package elements": marine genetic resources (MGRs); area-based management tools (ABMTs), including marine protected areas (MPAs); environmental impact assessments (EIAs); and capacity building and marine technology transfer (CB&TT).

The first academic publications on BBNJ started before the pre-negotiations and a corpus of academic literature has emerged in the past decades, addressing different aspects of the future ocean treaty. BBNJ authors have addressed the closing up of governance gaps regarding the exploitation of MGRs (Scovazzi, 2016; Blasiak et al., 2018, 2020; Humphries et al., 2020), the effective conservation of marine ecosystems (Sander, 2016; Davies et al., 2017; De Santo, 2018; Dunn et al., 2018, 2019; Johnson et al., 2018; O'Leary and Roberts, 2018; Warner, 2018; Crespo et al., 2019; Gownaris et al., 2019; Popova et al., 2019; Maxwell et al., 2020), and capacity building and the strengthening of scientific research in international waters (George and George, 2018; Collins et al., 2019; Harden-Davies and Gjerde, 2019; Rabone et al., 2019).

This article systematically considers all peer-reviewed literature related to the BBNJ process, covering 140 multidisciplinary, geographically diverse publications in the time frame 2004–2020 (hereafter "the BBNJ literature"). As an up-to-date summary and analysis, it is intended for researchers from diverse academic disciplines, policy-makers, and practitioners, untangling a complex issue, highlighting the policy-relevance of existing work, and facilitating links between science, policy, and practice.

After a section on the methodological approach, followed by a description of the sample of BBNJ publications that this systematic review is based on, this paper first examines the main challenges facing the current ocean governance framework identified in the BBNJ literature. Secondly, the review provides for each of the BBNJ package elements: (a) a compilation of scientific findings and identified priority areas, (b) suggested guiding principles, approaches and recommendations, (c) references to existing law, (d) best-practice examples and lessons learnt, and (e) recommended institutional entities for implementation. Thirdly, the review elaborates on overarching topics across package elements named by BBNJ authors, which need to be taken into account in the negotiations if objectives are to be met. These include: ocean connectivity; the relationship between BBNJ and existing instruments, and institutional design; the role of science in BBNJ; and digital technology. Finally, we identify two important gaps in the current BBNJ literature: science-policy interfaces; and a connection between the BBNJ process and the need for "transformative change" (Diaz et al., 2019).

METHODS AND LITERATURE SAMPLE

The review is of academic literature dealing with the BBNJ negotiations and process at large. Systematic reviews are valuable to prevent replication of research effort, provide new insights into established areas of research through the comparison or combination of existing evidence, as well as to discover gaps in the literature and future research potential (Dacombe, 2018). Systematic reviews are particularly relevant in the "early stages of development of a policy," and when "a general overall picture of evidence [. . .] is needed to direct future research efforts," both of which is the case in light of the ongoing BBNJ negotiations (Petticrew and Roberts, 2005, p. 21).The aim of this review is to analyze the corpus of BBNJ literature to identify main debates and priority areas within the scientific community and to discuss research needs and future trajectories for the study of BBNJ related issues.

Data Collection and Sample

We collected data and created our sample in a three-stage process, being aware of the PRISMA-P guidelines (Moher et al., 2015). First, we developed keywords and undertook a search in the Web of Science database to obtain a comprehensive sample of publications on BBNJ.

The keyword search in Web of Science was undertaken in May 2020, including all available records, with the following search words:

- "BBNJ" (36 results)
- "biodiversity beyond national jurisdiction" (38 results)
- "marine biodiversity" AND "ABNJ" (29 results)
- "marine biodiversity" AND "areas beyond national jurisdiction" (52 results)
- "marine biological diversity" AND "ABNJ" (15 results)
- "marine biological diversity" AND "areas beyond national jurisdiction" (24 results)
- conservation and sustainable use of biological diversity in areas beyond national jurisdiction (31 results)
- conservation and sustainable use of biodiversity in areas beyond national jurisdiction (55 results)
- "biodiversity" AND "beyond national jurisdiction*" (135 results)
- "biological diversity" AND "beyond national jurisdiction*" (51 results)
- "biodiversity" AND "ABNJ" (50 results)
- "biological diversity" AND "ABNJ" (26 results)
- "biological diversity" AND "beyond national jurisdiction*" (51 results)

After removing duplications, the original sample stood with 172 publications. In a second step, we screened titles, abstracts and keywords of all publications to follow a systematic inclusion and exclusion before the coding process. Criteria for inclusion were that the publication either dealt with the BBNJ negotiations directly by mentioning the agreement or process; or with direct

TABLE 1 | Categories and codes for the coding process.

Categories	Codes
Topic	FOCUS (MGRs, ABMTs, MPAs, EIAs, CB&TT, MSR, fisheries, EBSAs) ASSUMPTION KEYWORDS
Contribution	TYPE METHOD ORIGINAL DATA NORMATIVE/DESCRIPTIVE/ANALYTICAL
Standpoint	THEORY SUPPORTIVE/NEUTRAL/NEGATIVE
References	LEGAL REFERENCE REFERENCE TO SCIENCE REFERENCE TO HISTORY CONCEPTS

TABLE 2 | Overview of number of publications per group in the literature sample.

Group	Number of publications
ABMTs/MPAs	45
MGRs	27
EIAs	7
CB&TT	6
BBNJ	26
Framework interplay	10
Fishing/Fisheries	8
Institutional arrangements	5
Other	6
Whole sample	140

relevance to the BBNJ negotiations. The third step involved an assessment for eligibility of all full texts of publications that were not already immediately included in the sample. Publications which did not meet the aforementioned criteria, were excluded from the sample[1]. The sample was complemented by the inclusion of further relevant publications, obtained during the research process, using the snowball method[2]. The final sample contains 140 publications from 42 journals by 99 first authors, including academic articles and book chapters, all of which were published in English and underwent peer review[3].

While we acknowledge the existence of a significant body of literature that is relevant to BBNJ topics without directly referring to the political process, this review maps out the academic literature that explicitly refers to the agreement—i.e., draws explicit links between research and the future BBNJ treaty, presents original research on the process itself, or comments on different aspects of the agreement, making concrete recommendations and proposing solutions. Since we exclusively focused on marine biodiversity in areas *beyond* national jurisdiction and the current BBNJ negotiations, remaining articles go beyond the scope of this study.

Data Analysis

The articles from the sample were then qualitatively analyzed, using the atlas.ti research software for computer-based qualitative analysis. Firstly, the sample was coded "*in vivo*" and categories were created. These categories were further developed and codes grouped under each category following an iterative and collaborative process. Secondly, after having obtained the final list of categories and related codes, we systematically re-coded the whole sample, including titles, abstracts, keywords, and full texts (see **Table 1**).

According to our analysis, most publications from the sample either address (1) one of the four package elements of the future BBNJ treaty, (2) the general BBNJ process, or (3) links between the treaty and existing frameworks. For the purpose of our literature review, we classified all publications and analyzed their content to get an overview of the state of the art in relation to each of the groups (see **Table 2**).

In the following, we describe the results of the review, firstly, structured according to the common issues contained in the four package elements, namely the challenges facing the current ocean governance framework and the potential of the BBNJ agreement to overcome them. Secondly, we present overarching themes that authors addressed across the BBNJ package elements.

OVERCOMING THE FAILINGS OF THE OCEAN GOVERNANCE FRAMEWORK

The BBNJ literature points to the fact that the ocean governance framework is too fragmented and incomplete to effectively conserve and sustainably use marine biodiversity. Prior to the start of formal intergovernmental conferences (IGCs) on BBNJ, academic literature pointed to gaps in the current framework and published recommendations (Pecot, 2005; Warner and Rayfuse, 2008; Gjerde, 2012; Gjerde and Rulska-Domino, 2012; Freestone et al., 2014; Töpfer et al., 2014). All authors in the comprehensive sample of BBNJ literature, without exception, are in favor of a new legally binding BBNJ instrument. Around 60% of the sample publications (85 papers) deal with one particular package element, with a majority focusing on ABMTs/MPAs and MGRs, with 45 and 27 publications, respectively (see **Table 2**).

This section gives an overview of the scientific debates regarding the deficiencies of the current ocean governance framework and the potential of individual package elements. It presents priority areas identified by BBNJ authors, as well as references to existing law, best-practice examples, lessons learnt, recommendations, and official entities in charge of implementation.

[1] 11 publications, i.e., publications concerning particular local cases without direct connection to BBNJ; two books, as only relevant book chapters were included for qualitative analysis, 14 inaccessible publications.

[2] Use of snowball method: Inclusion of 17 additional relevant publications cited in the reference lists of articles in the sample which were not found through the Web of Science search (due to e.g., use of different terminology: *beyond national boundaries*).

[3] See the PRISMA flow diagram and the final sample in the Annex.

Lack of Regulation of Marine Genetic Resources

Literature from our sample identifies several issues regarding MGRs that are problematic under the existing ocean governance framework. While minerals in ABNJ fall under the concept of the common heritage of humankind (regulated under UNCLOS) and genetic material *within* areas of national jurisdiction fall under the authority of the relevant state party (regulated under the Convention on Biological Diversity), there is legal uncertainty about the access to and use of MGRs in ABNJ (McLaughlin, 2010; Tvedt and Jørem, 2013). Regulations under UNCLOS do not include activities related to MGRs and divergent views exist on the concepts to build on regarding the access to and sharing of benefits of MGRs (Scovazzi, 2016).

The potential economic value of MGRs is still unclear (Harden-Davies, 2017b; Tiller et al., 2019, 2020; Yu, 2019); nonetheless, the literature detects an increasing interest in their exploration and exploitation among various stakeholders (McLaughlin, 2010; Nurbintoro and Nugroho, 2016; Van Dover et al., 2016; Becker-Weinberg, 2017). Considering the freedom of the High Seas under UNCLOS and the almost limitless opportunity to collect biological material from ABNJ, BBNJ authors emphasize the fact that this status quo increases inequality between developed and developing countries: they mention the advantage enjoyed by developed nations when it comes to scientific research and profit from the development of products derived from ABNJ marine genetic material (Merrie et al., 2014; Nurbintoro and Nugroho, 2016; Scovazzi, 2016; Broggiato et al., 2018; George and George, 2018). The BBNJ agreement, thus, faces the task of establishing a fair and equitable regulatory regime for MGRs in international waters, and to prevent biopiracy by few nations or companies (Merrie et al., 2014; Heffernan, 2020).

The main areas discussed in the BBNJ literature on MGRs are as follows: convergence and divergence in BBNJ negotiations (Leary, 2019); definitions of MGRs and related terms (Jorem and Tvedt, 2014; Blasiak et al., 2020); the relationship between MGRs and marine scientific research (MSR) (Broggiato et al., 2014; Jorem and Tvedt, 2014; Merrie et al., 2014; Scovazzi, 2016; Rabone et al., 2019); and MGRs and intellectual property rights (Drankier et al., 2012; Chiarolla, 2014; Jorem and Tvedt, 2014). In this regard, the BBNJ literature identifies potential responsible entities and points to best practices and lessons learnt; it also makes suggestions for a clearing-house mechanism to share data (see **Table 3**; see section Institutional Arrangements). The overarching, most discussed topic, however, concerns options for an access and benefit sharing (ABS) system for MGRs, including discussions on the inclusion of monetary and non-monetary benefits, obligatory vs. voluntary benefit sharing, and benefit sharing for the conservation of biodiversity (Tvedt and Jørem, 2013; Yu, 2019). Some BBNJ authors discuss the concept of common heritage of humankind regarding the access to, and benefit sharing of MGRs in ABNJ (Becker-Weinberg, 2017; Peña Neira, 2017; Ridings, 2018).

In order to effectively regulate access to and benefit sharing of MGRs, the BBNJ literature points to the need for a responsible entity. Such an authorized body would need to provide legal certainty to stakeholders and consider the types, size, and timing of benefits, the cost of benefit sharing, be enforceable, implementable and inclusive (Sun, 2019), and be competent to negotiate permits on a case-by-case basis (Voigt-Hanssen, 2018). BBNJ research analyzes international law regimes, including the International Seabed Authority (ISA) (Tvedt and Jørem, 2013; Voigt-Hanssen, 2018), the Convention on Biological Diversity (CBD) and its Nagoya Protocol (Harden-Davies, 2017a; Medaglia and Perron-Welch, 2019; Humphries et al., 2020), the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) (Drankier et al., 2012; Voigt-Hanssen, 2018; Medaglia and Perron-Welch, 2019), the Food and Agriculture Organization (FAO) Treaty (Drankier et al., 2012), the Antarctic Treaty System (ATS) (Drankier et al., 2012), and UNCLOS and regional agreements (Medaglia and Perron-Welch, 2019).

The ISA is already responsible for granting rights for the exploration and exploitation of mineral resources from "the Area[4]" and could take on additional responsibilities related to the ABS scheme (Tvedt and Jørem, 2013; Voigt-Hanssen, 2018). In this respect, the principle of "due regard for the rights and legitimate interests of the relevant coastal states," which applies to mineral resources found in the Area that straddle the limits of national jurisdiction, could also be applied to MGRs in ABNJ (Becker-Weinberg, 2017).

While one idea for a potential ABS entity is the CBD with its Nagoya Protocol (Tvedt and Jørem, 2013; Peña Neira, 2017), more recently other authors have warned against tasking institutions responsible for genetic resources transactions in *national* jurisdictions, such as the CBD or the ITPGRFA (Voigt-Hanssen, 2018) with the regulation of MGRs in ABNJ because conditions *beyond* national jurisdictions are inherently different and such existing ABS schemes are therefore not applicable to MGRs in ABNJ (Harden-Davies, 2017a; Tladi, 2019; Humphries et al., 2020). In the ABNJ case—given the absence of a provider state to grant access and share benefits—an international organization could serve as the responsible entity for overseeing prior informed consent and mutually agreed terms (Harden-Davies, 2017a).

Multilateral institutions with existing ABS schemes are identified in the literature that could potentially serve as blueprints for a future ABS scheme of MGRs. The FAO Treaty is another example of how the international community has been able to create a multilateral system for handling (plant) genetic resources (Drankier et al., 2012). The ATS provides legal mechanisms for ABS that ensure the sharing of scientific knowledge generated by biological prospecting (Drankier et al., 2012). While ATS instruments do not include MGRs, provisions regarding environmental protection and scientific research, such as the preservation and conservation of living resources (Antarctic Treaty), the comprehensive protection of the Antarctic environment (Protocol on Environmental Protection), and the conservation of Antarctic marine living resources and its rational

[4]"Area" means the seabed and ocean floor and subsoil thereof, beyond the limits of national jurisdiction (UNCLOS Art. 1).

TABLE 3 | MGR BBNJ Literature.

	Recommendations for international legally binding instrument	Identified responsible entities	References to law	Best practices/lessons learnt
Definitions of MGRs/ABS/IPR/Legal & scientific challenges/ Relationship between MGRs and marine scientific research, capacity building and marine technology transfer and fish	Cataloging of MSR in ABNJ: activities, monitoring of impacts and sharing of research results (Hassanali, 2018) Open access to MGR data (Rabone et al., 2019) Common *ex situ* collection (Tvedt and Jørem, 2013) Facilitate cooperation through international scientific networks (INDEEP, DOSI) (Harden-Davies, 2017a) Strengthen best practice in MGR Access, Sharing, and Transparency (Rabone et al., 2019) Duty of care when collecting MGRs (Voigt-Hanssen, 2018); Code of conduct for responsible sampling (Yu, 2019) Benefit entire global community (Nurbintoro and Nugroho, 2016); Common heritage of mankind for MGRs in ABNJ (Becker-Weinberg, 2017) Inclusive innovation (Collins et al., 2019); Inclusion of developing countries in: cruises, laboratory work, product development (Voigt-Hanssen, 2018) Importance of non-monetary benefits for utilization of MGRs to reduce technological gaps between states (Rabone et al., 2019; Yu, 2019; Collins et al., 2020) Legal certainty and stability, enforceability, implementation, inclusiveness (Sun, 2019) A tiered approach (Humphries et al., 2020) Institutional model for MPAs to also include MGRs (Tladi, 2019) Mare Geneticum (Broggiato et al., 2018) Extended embargo period (Broggiato et al., 2018; Voigt-Hanssen, 2018; Yu, 2019) Suspended obligation (Tvedt and Jørem, 2013; Voigt-Hanssen, 2018) International royalty system (McLaughlin, 2010) Identifying the key actors registering patents involving MGRs (Blasiak et al., 2018)	Clearing House Mechanism IOC (Voigt-Hanssen, 2018); International Oceanographic Data and Information Exchange (IODE) Program of IOC-UNESCO (Rabone et al., 2019) Obligatory Prior Electronic Notification (OPEN) (Broggiato et al., 2018) ABNJ Activity Notification and Monitoring System (ANeMONe) (Humphries et al., 2020) Facilitated Information and Sample Sharing Hub (FISSH) (Humphries et al., 2020) Ocean Biogeographic Information System (OBIS) (Harden-Davies, 2017a) Genbank for DNA and protein sequencing (Harden-Davies, 2017a) UN Register of BBNJ Activities under UNDOALOS (George and George, 2018) Ethics committee (Hassanali, 2018) ABS entity ISA (Tvedt and Jørem, 2013; Voigt-Hanssen, 2018) Secretariat (Voigt-Hanssen, 2018) CBD (Tvedt and Jørem, 2013); Not CBD (Humphries et al., 2020) Marine Genetic Resources Body (Tvedt and Jørem, 2013; Voigt-Hanssen, 2018) World Environmental Organization (WEO) or a global genetic resources ombudsman (Tvedt and Jørem, 2013) International Organization (Harden-Davies, 2017a) Working group under CPPS for a regional framework for MGRs access, use, and benefit-sharing (Durussel et al., 2017) Scientific and Technical Body Scientific and technical committee (Tladi, 2019) Funding Mechanism Biodiversity Fund (Tvedt and Jørem, 2013); Trust Fund (Ridings, 2018)	CBD Ecosystem approach, sustainable use and protection of the environment (Drankier et al., 2012) Nagoya Protocol Art.10 for the establishment of a multilateral benefit-sharing mechanism (Drankier et al., 2012)	United Nations Office for Outer Space Affairs with its "1962 UN Register of Objects Launched into Outer Space" (George and George, 2018) ATS (Drankier et al., 2012) FAO (Drankier et al., 2012) ITPGRFA (Voigt-Hanssen, 2018) CBD and Nagoya Protocol (Peña Neira, 2017) TRIPS (Drankier et al., 2012; Chiarolla, 2014; Nurbintoro and Nugroho, 2016) Plant Treaty and PIP framework under WHO (Humphries, 2018) Intergovernmental Committee on Intellectual Property and Genetic Resources, Traditional Knowledge Folklore under WIPO (Nurbintoro and Nugroho, 2016; Medaglia and Perron-Welch, 2019)

Intergovernmental Oceanographic Commission of UNESCO (IOC).

use (CAMLR Convention) can serve as best-practice examples for the ABS of the new instrument (Johnson, 2017).

An alternative option would be to task the BBNJ Secretariat with ABS regulation (Voigt-Hanssen, 2018), to create a World Environmental Organization (WEO), set up a global genetic resources ombudsman (Tvedt and Jørem, 2013), or establish a separate Marine Genetic Resources Body (Tvedt and Jørem, 2013; Voigt-Hanssen, 2018). More recently, a "tiered approach" has been recommended for MGR governance to reconcile states' positions on ABS while strengthening scientific research on samples and data, protecting traditional and local knowledge, promoting consistency with existing ABS frameworks in national jurisdictions, and taking conservation concerns into consideration (Humphries et al., 2020).

An Ocean in Need of Protection: Area-Based Management Tools

Many papers from our sample refer to and emphasize an increasing number of threats to marine biodiversity in ABNJ, including climate change and other anthropogenic stressors, such as overfishing, destructive fishing practices, shipping, and pollution (Ban et al., 2014b; Rochette et al., 2014a; Warner, 2018; O'Leary et al., 2020). It pinpoints emerging human activities that affect marine biodiversity, evaluates management options, and calls for urgent action on biodiversity loss (Gjerde et al., 2016;

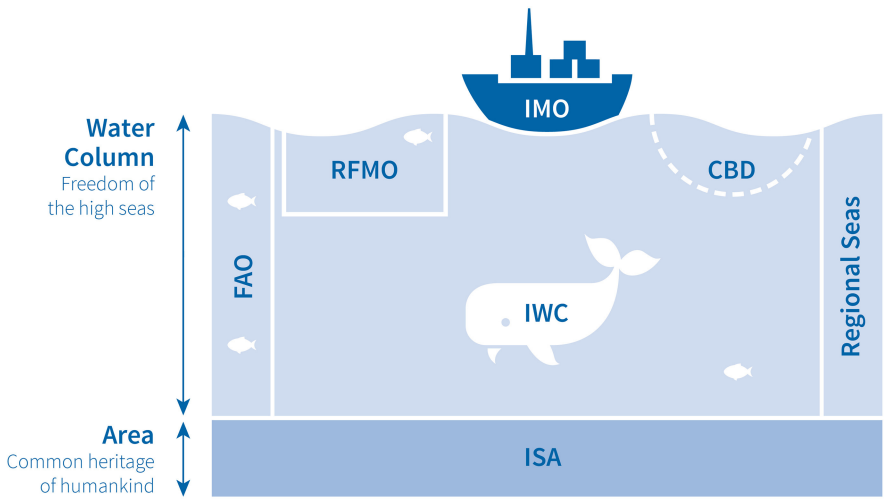

FIGURE 1 | Patchwork of sectoral and regional organizations in ABNJ.

Dias et al., 2017; O'Leary and Roberts, 2018; O'Leary et al., 2020). There is an overall consensus within the scientific community that marine protected areas (MPAs) constitute an important biodiversity conservation tool by preventing overexploitation and limiting adverse human impact on marine ecosystems (Evans et al., 2015; Tladi, 2015; Wright and Rochette, 2017; O'Leary and Roberts, 2018; Smith and Jabour, 2018; Popova et al., 2019; Wang, 2019; Blasiak et al., 2020). Apart from MPAs, also other area-based management tools can be used to govern the conservation and sustainable use of marine life.

Currently, however, there is no official global body in charge of the identification and management of area-based management tools on the High Seas (Van Dover et al., 2016; Becker-Weinberg, 2017; De Santo, 2018; Elferink, 2019). As a result, such conservation and sustainable use measures are currently implemented within a fragmented framework by regional and sectoral organizations with different management competences (See **Figure 1**) (Drankier, 2012; Durussel et al., 2017). At the regional level, regional fisheries organizations (RFMOs) can manage fishing in spatial and/or temporary closure areas, for instance by protecting vulnerable marine ecosystems (VMEs) (Durussel et al., 2017; De Santo, 2018). Moreover, regional instruments, including OSPAR, Noumea, and CAMLR, and the UNEP Regional Seas Program can introduce tools within their respective mandates (Ardron et al., 2014).

At the global level, the International Maritime Organization (IMO) can establish Particularly Sensitive Sea Areas (PSSAs) and Special Areas under the International Convention for the Prevention of Pollution from Ships (MARPOL), while the International Seabed Authority can designate Areas of Particular Environmental Interest (APEIs), and the International Whaling Commission (IWC) has a mandate to establish sanctuaries and other ABMTs regarding cetaceans (Durussel et al., 2017; De Santo, 2018). The FAO can develop technical guidelines on MPAs for fisheries management, including closed seasons and areas reserved for selected fisheries (Gjerde and Rulska-Domino, 2012). All of the above-mentioned bodies can implement conservation and sustainable use measures in ABNJ within their specific mandates. However, there is no centralized responsible entity to date.

The Aichi targets under the CBD aim to put 10% of the ocean under protection and under the CBD, Ecologically or Biologically Significant Marine Areas (EBSAs) were identified and their descriptions adopted by the Conferences of the Parties (Dunn et al., 2014; Dunstan et al., 2016; Gjerde et al., 2016; Van Dover et al., 2016; Warner, 2016, 2017, 2018; Durussel et al., 2017; Friedman, 2017; Laffoley and Freestone, 2017; Ribeiro, 2017; Shirayama et al., 2017; De Santo, 2018; Johnson et al., 2018). The CBD, in this way, actively promotes marine protected areas in ABNJ, however does not have the mandate for their designation and management (Ardron et al., 2014). The BBNJ treaty has the potential to remedy this lack of an official global body in charge of the identification and management of ABMTs in ABNJ. Other relevant conservation agreements with a potential future role for BBNJ are the Convention on the Conservation of Migratory Species of Wild Animals (CMS), which seeks to protect habitat and remove obstacles to migration but has been focused on areas within national jurisdiction and, similarly to the CBD, lacks regulatory competence; and the Convention on International

Trade in Endangered Species of Wild Fauna and Flora (CITES), which has no area-based management element, but deals with restricting trade of endangered species, increasingly including marine species (Ardron et al., 2014).

Deficiencies of the current framework are identified as an important reason why there is a need for the potential new instrument to fill the gaps (Gjerde et al., 2019). The place of the new instrument in the existing governance framework has been intensively discussed in the strand of literature discussing what the principle of not undermining existing institutions involves (Ardron et al., 2014; O'Leary and Roberts, 2017; Quirk and Harden-Davies, 2017; Scanlon, 2018; Friedman, 2019), as well as in research on regional initiatives and cooperation (Rochette et al., 2014b; Warner et al., 2014; Durussel et al., 2017; Wright and Rochette, 2017). The literature discusses potential models for the new ocean governance framework, including the notions of ocean connectivity and climate change impacts (O'Leary et al., 2012; Ban et al., 2014b; Evans et al., 2015; O'Leary and Roberts, 2017; De Santo, 2018; Johnson et al., 2018; Hofman, 2019; Popova et al., 2019).

Policy recommendations based on experience with past international agreements, including the CBD and the United Nations Fish Stocks Agreement (UNFSA), emphasize the need for the BBNJ agreement to apply a long-term ecosystem-based approach and mention requirements such as: a precautionary and science-based approach, the concept of compatibility, mechanisms for international cooperation, and the duty to cooperate (Gjerde et al., 2019).Various BBNJ publications refer to already-identified **EBSAs** as a potential basis for MPA and marine spatial planning (MSP) implementation on the High Seas (see **Table 4**). These include criticisms of evidence gaps within EBSAs that are due to "political" reasons (Johnson et al., 2019b). A large body of BBNJ literature explicitly recommends an ecosystem-based approach for the effective conservation of BBNJ, including a representative network of MPAs (see section Overarching Themes Across All Package Elements) (Gjerde and Rulska-Domino, 2012; Cordonnery et al., 2015; Johnson et al., 2018, 2019a).

Measuring the Human Footprint on the High Seas: Environmental Impact Assessments

Human activities are affecting marine biodiversity and ecosystems; their impacts can be predicted, reduced and even prevented through environmental impact assessments, if a strong legal framework is in place. EIAs can evaluate likely adverse impacts on the environment of proposed activities, serve as a basis for decisions in this regard and ensure monitoring of unexpected impacts (Durussel et al., 2017). Definitions differentiate between EIAs and SEAs (strategic environmental assessments); the latter incorporate a more holistic, overarching, long-term environmental protection, including whole sectors of activities or geographical areas, whereas the former are often site-specific and limited in time (Warner, 2012). EIAs are a well-established environmental protection tool and various international agreements, including UNCLOS (and its UNFSA) and the London Protocol, include obligations to assess the potential impacts of human activities in the marine environment (Warner, 2012).

There is criticism that EIAs in ABNJ are not comprehensively and effectively carried out (Ma et al., 2016). While legal and institutional frameworks for EIAs are well-established in areas *within* national jurisdiction, collaborative structures and mechanisms for EIAs in areas *beyond* national jurisdiction are fragmented and underdeveloped (Warner, 2018); no global institution is in charge of the development of best-practice standards for EIAs and SEAs or the monitoring of their implementation (Gjerde and Rulska-Domino, 2012; Warner, 2012; Scott, 2019). Many ABNJ activities, including oil and gas exploration, marine scientific research, survey activities, marine geoengineering, deep-sea tourism, and military activities are not subject to any EIA process (Warner, 2012). Currently, the IMO is responsible for opening new shipping routes; however, it lacks an enforcement mandate and relies on national legislation by contracting parties (O'Leary et al., 2020). Analyses of regional experiences show that, in most cases, Regional Seas Conventions do not include ABNJ within their geographical scope and therefore do not require EIAs by member states, which calls for a more comprehensive institutional coverage (Warner, 2012). The main EIA gap in the Southeast Pacific concerns the implementation of the ecosystem approach in fisheries management (Durussel et al., 2017).

During BBNJ negotiations, EIAs have been acknowledged as a valuable tool for the conservation and sustainable use of marine biodiversity (Elferink, 2019; O'Leary et al., 2020). Despite voices against making EIAs compulsory for submarine cable operations (Friedman, 2017) and marine scientific research (Broggiato et al., 2018) on the High Seas, arguably owing to their minimal impact, human activities can inherently affect the marine environment, disturb processes, and destroy prestige ecosystems (Warner, 2018). The BBNJ literature portrays the negative impact of fisheries and deep-seabed mining (see section It Is One Ocean- It Is One Planet), and calls for mandatory EIAs on the basis of the precautionary principle prior to new and emerging activities, including new shipping lanes, marine bioprospecting, and deep-sea tourism (Ma et al., 2016). Human activities being discussed during BBNJ negotiations for which EIAs may become mandatory are, among others, submarine cable operations, high-seas aquaculture, and offshore power generation (Friedman, 2017).

Analyses of EIAs under existing instruments present best practice examples and lessons learnt to inform the BBNJ agreement (see **Table 5**) (Gjerde and Rulska-Domino, 2012; Warner, 2012, 2014; Marciniak, 2017). The BBNJ literature includes reviews of existing EIA provisions at regional and global levels, including specialized EIA instruments, references to EIAs in UNCLOS, and biodiversity and sectoral applications (Sander, 2016), as well as recent EIA developments regarding the deep-sea mining of mineral resources (Shirayama et al., 2017).

With the exception of one publication, the BBNJ literature on environmental impact assessments consensually points to the need to consider cumulative impacts and integrate climate change issues into discussions regarding EIAs and SEAs (Warner, 2014, 2017, 2018; Gjerde et al., 2016; Ma et al., 2016; Sander, 2016; Marciniak, 2017). Regarding the importance to notify adjacent

TABLE 4 | ABMT/MPA BBNJ literature.

	Recommendations for international legally binding instrument	Identified responsible entities	References to existing law	Best practices/lessons learnt
Definitions/Criteria and process/Gaps in current framework/Interplay with existing instruments/ Regional cooperation/Possible models/ABMTs-MPAs and climate change/ Connectivity	Potential models: Regional, Hybrid, and Global (Quirk and Harden-Davies, 2017; Elferink, 2019; Gjerde et al., 2019; Scott, 2019); Global-Hybrid Model (Vithanage, 2017) Improve potential of RFMOs (Scanlon, 2018) MPAs to be based on transparent, best-available science (O'Leary et al., 2012; Evans et al., 2015; Dias et al., 2017; Gjerde et al., 2019; Gownaris et al., 2019) Consideration of Marine ecological connectivity, Circulation connectivity, Migratory and cultural connectivity (O'Leary et al., 2012; Evans et al., 2015; O'Leary and Roberts, 2017; De Santo, 2018; Hofman, 2019; Popova et al., 2019); Full protection of MPAs (O'Leary and Roberts, 2018; Gownaris et al., 2019) Identification: Using pelagic birds to identify MPAs (Dias et al., 2017); Designation of EBSAs based on occurrence of Tropic Seamounts (Ramiro-Sanchez et al., 2019); biogeographic classifications (Rice et al., 2011); Consider climate change in MPA design (Johnson et al., 2018; Warner, 2018; Dunn et al., 2019) Long-term, precautionary and ecosystem approach (Marciniak, 2017; Johnson et al., 2018; Gjerde et al., 2019), setting aside more extensive areas and limiting human uses and/or adopting high protection thresholds (Johnson et al., 2018); Integrated management (Becker-Weinberg, 2017; Goodman and Matley, 2018); Importance of MSP in ABNJ (Altvater et al., 2019) Near real-time tracking data, considering ethical responsibilities to inform policy-makers (Sequeira et al., 2019); Unique deep-sea locations (Lost City) should be ruled as 'of limits' (Johnson, 2019) Dynamic marine spatial management for MPA designation and administration (Sequeira et al., 2019); Mobile MPAs (Maxwell et al., 2020) Global network of MPAs (Rochette et al., 2014a; Cordonnery et al., 2015; Gjerde et al., 2016, 2019; Dias et al., 2017; Wright and Rochette, 2017; O'Leary and Roberts, 2018);	RFMOs (Tladi, 2015) Secretariat (DOALOS) (Tladi, 2015) legal, scientific and/or technical commission (Tladi, 2015) COP for adoption (Marciniak, 2017); decision-making body (Tladi, 2015; Gjerde et al., 2016, 2019) Involvement of all relevant sectors stakeholders (De Santo, 2018), including the fisheries industry and scientific community, in monitoring, control and surveillance activities through e.g., data collection and sharing (Blasiak et al., 2016)	UNCLOS Duty to "protect and preserve the marine environment" (Tladi, 2015) Art. 194(5): Legal basis for the establishment of MPAs in ABNJ, but no provision regarding procedures for their designation and management (Elferink, 2019) *Due regard* and *adjacency*: "Due regard" provides the general benchmark for addressing the relationship between coastal States and States carrying out activities in ABNJ (necessary for BBNJ, otherwise not consistent with UNCLOS); "adjacency" only in the context of the regime for fisheries (Elferink, 2018) UNFSA "Duty to cooperate" to influence organizations without undermining them; "ecosystem approach"; "precautionary approach"; "science based approach" (Art.5); mechanisms for international cooperation (Part III) (Gjerde et al., 2019) *Compatibility* and *adjacency* of Article 7, ensuring that measures for the high seas "do not undermine the effectiveness" of measures adopted by coastal State; "compatibility" elaborates on rights and obligations of States to cooperate in relation to straddling fish stocks and highly migratory fish stocks (Elferink, 2018) Adoption of additional measures/agreements recognized in Art. 44, acknowledging that States parties may conclude agreements modifying or suspending operation of provisions of UNFSA under three conditions, and upon notification of other States parties (Gjerde et al., 2019) FAO International Guidelines for the Management of Deep-sea Fisheries in the High Seas (2009) define *vulnerability* as: "related to the likelihood that a population, community, or habitat will experience substantial alteration from short-term or chronic disturbance, and the likelihood that it would recover and in what time frame." (Johnson et al., 2018) FAO guidelines assist RFMOs and States in identifying VMEs on the basis of the best available scientific knowledge and expert judgment (measures to protect VMEs, sustainably manage bottom fisheries) (Johnson et al., 2018) CBD	Capacities of regional organizations vary (Ribeiro, 2017; De Santo, 2018; Mossop, 2018) Limited geographical coverage of ABNJ through existing instruments: Abidjan convention (Dias et al., 2017; Ribeiro, 2017), Cartagena Convention (Ribeiro, 2017); abyssal regions in OSPAR MPAs (Evans et al., 2015); no coverage of South American Atlantic waters (Dias et al., 2017) Limited powers of OSPAR and NEAFC to prosecute individuals and need commitment of commercial industries, such as fishing and shipping (Evans et al., 2015) Failure of South Orkney Islands MPA, which leaves several pelagic bioregions and geomorphic zones unrepresented and adjacent regions with highest conversation value unprotected in order not to interfere with krill fishery (Smith and Jabour, 2018) OSPAR NEAFC/OSPAR MoU (Scanlon, 2018); OSPAR's register of MPAs and an expert group (ICG-MPA) (Johnson et al., 2019b) Sargasso Sea Project illustrates the value of a global approach for strengthening the current regional/sectoral approach (Gjerde et al., 2019); ICCAT's collaboration with the Sargasso Sea Alliance (Scanlon, 2018) EBSAs to inform ABMT/MPA processes in ABNJ (Drankier, 2012; Dunn et al., 2014, 2019; Warner et al., 2014; Dunstan et al., 2016; Van Dover et al., 2016; Warner, 2016, 2018; Durussel et al., 2017; Laffoley and Freestone, 2017; Johnson et al., 2018, 2019b; Voigt-Hanssen, 2018; Altvater et al., 2019; Gjerde et al., 2019; Gownaris et al., 2019; Ramiro-Sanchez et al., 2019) under existing institutional frameworks, including CMS, ISA, IMO, RFMO and UNESCO, and provide scientific input for ABMTs/MPAs and EIA (Ribeiro, 2017) ATLAS standardized protocols for predictive mapping of species and habitats for marine spatial planning (MSP) consideration (Johnson et al., 2018) Regional Governance (Rochette et al., 2014b; Durussel et al., 2017; Quirk and Harden-Davies, 2017; Ribeiro, 2017) Lessons to be applied to other regional seas programs when establishing a network of MPAs in ABNJ (Smith and Jabour, 2018)

(Continued)

TABLE 4 | Continued

	Recommendations for international legally binding instrument	Identified responsible entities	References to existing law	Best practices/lessons learnt
	MPA network needs adaptive management, reducing endogenous stressors, with a focus on protection of ecological function rather than key species (Johnson et al., 2018) Monitoring, control and surveillance for compliance (De Santo, 2018; Dunn et al., 2018): Need for VMS and AIS satellite tracking on ships, and via optical or radar satellites to monitor illegal, unreported and unregulated (IUU) fishing vessels (De Santo, 2018)		"Global instrument with most relevance to MPAs in ABNJ" applicable to Parties "[i]n the case of processes and activities, regardless of where their effects occur, carried out under its jurisdiction or control," including ABNJ (Elferink, 2018) Preamble recognizes the "intrinsic value" of biodiversity and the "ecological, genetic, social, economic, scientific, educational, cultural, recreational and aesthetic values of biological diversity and its components, including its importance for evolution and for maintaining life sustaining systems of the biosphere" (Gjerde et al., 2019) Art. 5 requires cooperation among Parties in ABNJ "for the conservation and sustainable use of biological diversity" for implementation of Art. 8 on *in situ* conservation, including the establishment of MPAs (Elferink, 2018; Gjerde et al., 2019) Art.6 provides an example of a way to encourage biodiversity action at the sectoral level (Gjerde et al., 2019) 10 % of coastal and marine areas to be protected by 2020: provides a foundation for conservation decisions (Evans et al., 2015; Blasiak and Yagi, 2016); provides broad ABM obligations for States to establish a system of protected areas (Durussel et al., 2017) OSPAR commission signed statement for establishment of "ecologically coherent, representative network of well-managed MPAs" with main assessment criteria being adequacy/viability, representatively, replication, and connectivity" (Evans et al., 2015)	

TABLE 5 | EIA BBNJ literature.

	Recommendations for international legally binding instrument	Identified responsible entities	References to existing law	Best practices/lessons learnt
EIAs and fisheries/Cumulative impacts and SEAs/ EIAs and climate change/ Institutional arrangements	Identification of anthropogenic activities in ABNJ and their environmental impacts (Ma et al., 2016) Accounting for a broader analysis of what to protect and cumulative impacts (Marciniak, 2017) Incorporating climate change impacts into EIAs in ABNJ (Warner, 2018) Articulate best practice standards for EIAs, SEAs and MSP (Gjerde et al., 2016); Development of standards and a default system of EIA for all activities that are currently not subject to EIA in ABNJ (Warner, 2016) International legal obligations to conduct EIAs and SEAs (Sander, 2016) Integrated ecosystem-based ocean governance on the high seas with global rules on basic requirements in UNCLOS and CBD for EIAs relating to existing and emerging activities (Warner and Rayfuse, 2008) Link between fisheries and EIAs (Barnes, 2016) Arctic EIA Guidelines (Warner, 2012)	Arctic working group to ensure adoption and implementation (De Lucia, 2017) COP - as decision-making body to consider EIAs, review reports and assess progress, serve as basis for SEAs, and broader-scale regional planning and integrated management initiatives; coordinating role by ensuring prior notification, consultation, transparency, participation, and inclusive planning, and support the goals of other conservation bodies (CITES, CBD, and CMS) (Gjerde et al., 2016, 2019) - adopting special rules for the Arctic on the basis of scientific recommendation by the Scientific and Technical Body (De Lucia, 2017) Institutional working groups in the South East Pacific (Durussel et al., 2017) Regional committees in charge of overseeing the performing of SEAs and evaluating EIAs (Hassanali, 2018) Reporting system for the notification of potential risks, identified through EIAs (Mossop, 2018) Rehabilitation/Liability fund for reparation (Long, 2019)	Special Arctic Provision modeled on UNCLOS Art. 234 and Art. 211 (De Lucia, 2017) Minimum EIA requirements adopted under the CBD to be implemented by all RFMOs (Durussel et al., 2017) Espoo Convention model to list activities requiring EIAs (Marciniak, 2017) UNFSA Art. 5 c; Art. 6; Annex ii: Requirements for Applying a Precautionary Approach (Gjerde et al., 2019) Protocol on Environmental Protection to the Antarctic Treaty (Annex VI) on liability (Long, 2019)	CBD to inform rules, standards, and recommend practices and procedures with respect to ABMTs and EIAs (Gjerde et al., 2019) CBD guidelines for biodiversity-inclusive EIAs and SEAs to reflect environmental, social, and governance conditions in marine areas, including ABNJ, and provide practical and precautionary advice for operating in ABNJ (Gjerde and Rulska-Domino, 2012; Warner, 2014) Scientific/technical data from RFMOs and from the Census of Marine Life and other scientific initiatives, to inform the conduct of EIAs and SEAs (Warner, 2014) Regional Seas Conventions often do not cover EIAs in ABNJ, limited implementation and institutional coverage of ABNJ (Warner, 2012) UNEP principles: minimum requirement for how to conduct EIA in all zones of the Arctic Ocean; biodiversity assessments according to the CBD (Sander, 2016) EIA obligations (UNCLOS Art. 204-206; UNFSA) Risk assessment processes requirements (London Protocol) (Warner, 2012) Madrid Protocol to the Antarctic Treaty as a best practice with its complex screening process, including a preliminary assessment, initial environmental evaluation, and comprehensive environmental evaluation (Warner, 2012). Japan's Initiatives for EIAs (Shirayama et al., 2017) 2003 Protocol on SEA to the Convention on EIA in a Transboundary Context (Kiev Protocol): the main instrument including SEA obligations, otherwise limited impact at the global level (Warner, 2012) Liability Court Case of Costa Rica and Nicaragua (Long, 2019) Civil liability and compensation mechanism (IMO), draft regulatory code on seabed mining, the EU Environmental Liability Directive, national regimes including the United States Resources Act.186 (Long, 2019)

states at the stage of proposals for activities, literature points to the term "potentially affected States" as being more appropriate (Mossop and Schofield, 2020).

An Imbalanced World—An Unequal Ocean: Capacity Building and Transfer of Marine Technology

The BBNJ literature on capacity building and marine technology transfer (CB&TT) points to inequality between regions of the world when it comes to conserving and using the ocean and its resources. Marine technology transfer is a major gap in UNCLOS owing to fragmentation and lack of coordination (Harden-Davies, 2016; Sun, 2019). Even though UNCLOS lists requirements for CB&TT, developing states have a limited capacity to study, protect, and benefit from the marine environment and its resources (Gjerde et al., 2019). ABNJ biodiversity is remote and often inaccessible for countries lacking required technology (Campbell et al., 2013). The UN Assessment of the Ocean names global uneven

research capabilities as the primary source of inequity among states and of disparities in accessing resources *in situ*, which calls for capacity development regarding MGR exploitation (Broggiato et al., 2018).

Only very few countries have the institutional, human, financial, and technological resources, as well as the molecular and oceanographic means, to conduct deep-sea research (Nurbintoro and Nugroho, 2016), publish in international databases, and access open data (Bax et al., 2018), let alone develop marine biotechnologies (Broggiato et al., 2014). Moreover, studies demonstrate that developing states are underrepresented in BBNJ negotiations and related meetings, while 97% of the authorship of academic literature on BBNJ topics originates from Organization for Economic Cooperation and Development (OECD) member states (Blasiak et al., 2016). Asymmetry also exists between powerful industries and developing states as regards information access and policy influence, for which CB&TT may offer a solution (De Santo et al., 2019).

The resulting disadvantage for developing states is particularly evident in the case of access and utilization of MGRs but, also, across all package elements. Indeed, research depicts poverty as "by far the greatest barrier to the conservation and sustainable use of marine biodiversity in the South Atlantic," leading to ineffective measures (Ribeiro, 2017). With a lack of financial capacity to protect their own biodiversity, some countries will not be able to implement ambitious measures of the future treaty without CB&TT (Peña Neira, 2017). Due to a lack of expertise, only a few countries have the capacity to effectively set up and manage MPAs (Wang, 2019). Developing states often lack the resources and capacity to participate fully in RFMOs and effectively implement their obligations (Warner, 2014), which hinders compliance (Pecot, 2005). For the implementation of complex measures, such as ABMTs, including MPAs, the ecosystem approach, and EIAs, developing states require CB&TT (Ribeiro, 2017). Coastal states—especially developing ones—face the challenge of obtaining information about the biodiversity on their extended continental shelves given that MSR in the deep sea is costly and most research is conducted by developed states (Mossop, 2018; Tiller et al., 2020).

BBNJ literature on CB&TT emphasizes the potential to rebalance the unequal financial, technical, and scientific capacities among states and ensure the participation of developing and geographically disadvantaged states in ABNJ research, commercial use, and management (Durussel et al., 2017) and, hence, contribute to inter- and intra-generational equity (Harden-Davies, 2016; Blasiak et al., 2018; Collins et al., 2019; Harden-Davies and Gjerde, 2019; Yu, 2019). Various papers in the sample jointly address the topic of CB&TT with benefit sharing of MGRs (Harden-Davies, 2016, 2017b, 2018; Collins et al., 2019; Harden-Davies and Gjerde, 2019; Yu, 2019; Tiller et al., 2020) and MSR to identify different forms of scientific and technological capacity building (Harden-Davies, 2017b; Harden-Davies and Gjerde, 2019; Rabone et al., 2019). CB&TT and access to MGRs can ensure that marine biodiversity beyond national jurisdiction can "be enjoyed and benefit not only a handful of nations, but the entire global community" (Nurbintoro and Nugroho, 2016).

In this regard, apart from monetary benefits, CB&TT also includes non-monetary benefits such as training, education programs, knowledge transfer, and access to equipment and long-term support for infrastructure to provide all states with fairer opportunities in terms of capability to utilize MGRs from ABNJ (Collins et al., 2019), as well as research collaborations (Harden-Davies, 2017b). The strengthening and growth of scientific networks, as well as linkages between bio repositories and databases, are necessary to guarantee open access to MGRs in ABNJ (Collins et al., 2019).

BBNJ authors also analyze international legal instruments concerning genetic resources (Nagoya Protocol and ITPGRFA Treaty), examining the role of capacity building as a form of benefit-sharing, and explore the role of technology transfer (Harden-Davies, 2018; Harden-Davies and Gjerde, 2019).

OVERARCHING THEMES ACROSS ALL PACKAGE ELEMENTS

The BBNJ negotiations' objective is to agree on future regulations to remedy the above-mentioned failings of the ocean governance framework for the High Seas. With 49 publications, 35% of publications in the literature sample focus on the overall BBNJ process and cross-cutting issues (see **Table 2**). Research in this regard includes: analyses of discussions *before* (Campbell et al., 2013; Houghton, 2014) and *during* formal IGCs (Vithanage, 2017; Tiller and Nyman, 2018; Mendenhall et al., 2019; Tiller et al., 2019; De Santo et al., 2020); the role of NGOs in the negotiations (Blasiak et al., 2017); summaries and relevance of workshops and meetings concerning the BBNJ negotiations (Rochette and Bille, 2008; Houghton and Rochette, 2014; Goodman and Matley, 2018; Sun, 2019); and publications on current or recommended positioning or the role of certain states and country blocks in the negotiations, such as China (Zhu, 2009; Yu, 2014; Ma, 2018), Brazil (Barros-Platiau et al., 2019), and the Caribbean Community (CARICOM) (Hassanali, 2018).

Cross-cutting literature can be categorized according to the following topics: fisheries, eight publications (see section Implications for Fisheries Management in Connected Ecosystems), framework interplay, 10 publications (see section BBNJ Within an Ocean Governance Patchwork), and institutional arrangements, 5 publications (see section Institutional Arrangements). The following section reviews four overarching BBNJ themes that extend beyond individual package elements.

It Is One Ocean- It Is One Planet

Ocean Connectivity

Authors in our sample point to the interconnectivity of the world's ocean, a notion that concerns all package elements. Scientific papers show ecological and environmental connections throughout the water column as well as between the water column and the seafloor (O'Leary and Roberts, 2017, 2018; Popova et al., 2019). They show that the exploitation of the

water column is expected to produce a significant and widely distributed footprint in the deep-sea. Several authors (O'Leary and Roberts, 2018; Popova et al., 2019) emphasize the importance of considering such vertical connectivity when striving to protect highly migratory fish stocks, explaining that traditional MPAs would not be effective in international waters. Therefore, it is recommended to focus MPAs on surface-to-seabed protection, coupled with a precautionary approach to protect ecosystems (Ban et al., 2014a; De Santo, 2018; O'Leary and Roberts, 2018; O'Leary et al., 2020).

Besides the ecological connectivity between seabed and surface, the oceans are also connected horizontally and constitute the habitat of migratory species. Some authors (Dunn et al., 2019; Maxwell et al., 2020) review the concept of migratory connectivity, arguing that measures to conserve critical species failing to take it into consideration will have limited effect and that connectivity knowledge (gained from e.g., animal tracking) needs to be included in decision-making on the design and management of ABMTs. Dynamic ABMTs including MSP and MPAs take into consideration the movements of marine species to offer more effective protection (Sequeira et al., 2019; Maxwell et al., 2020).

Moreover, apart from such "active," the ocean has also "passive" connections, as papers on circulation connectivity discuss, indicating that the level of exposure to influences in ABNJ varies between countries and coastlines are thus unequally affected (Popova et al., 2019). Ocean modeling can be used to quantify the connectivity of ABNJ to the coastal zone and identify areas in urgent need of protection according to their potential impacts on the coastal populations of least developed countries (Popova et al., 2019).

In addition to vertical and horizontal ecological connectivity, authors point to cultural and historical ocean connectivity, calling for ABNJ governance to take into consideration the cultural and ceremonial importance of highly migratory species for coastal and island nations (Popova et al., 2019).

BBNJ authors contribute to the debate by pointing out existing law and best-practice examples and lessons learnt, as well as by recommending responsible entities and the inclusion of relevant stakeholders in the process. Connectivity research and experience gained on existing bodies could serve to advice negotiators and improve implementation success. Results of studies of the different forms of connectivity are of value to policy-makers involved in BBNJ negotiations because they inform the access and benefit sharing system for MGRs (Broggiato et al., 2018), the identification and creation of ABMTs, including MPAs, and the EIA process. Not only natural scientists but, also, increasingly, social scientists are calling for a precautionary approach and surface-to-seabed protection within MPAs (De Santo, 2018; O'Leary and Roberts, 2018; Dunn et al., 2019). Interdisciplinary BBNJ publications point to the importance of ecologically connected networks of MPAs when striving to provide comprehensive ocean protection in international waters (see **Table 4**). Lessons drawn from the experience of existing bodies can be used to support such networks in regional seas programs (Smith and Jabour, 2018).

Implications for Fisheries Management in Connected Ecosystems

The BBNJ literature identifies fishing as one main factor affecting marine biological diversity (Blanchard et al., 2019; Elferink, 2019). It shows that the greatest ecological benefits are achieved through no-take marine reserves that offer full protection and that fishing the water column will limit those benefits (O'Leary and Roberts, 2018; Gownaris et al., 2019). There is, hence, an overlap between biodiversity conservation and sustainable fisheries management (Crespo et al., 2019; Haas et al., 2020b). On the basis of studies on linkages between upper-ocean communities and seabed ecology and biogeochemistry, authors prove that the exploitation of resources in the water column will likely affect the deep-sea environment (O'Leary and Roberts, 2017). Marine species interact among each other and with the environment, but single species management does not consider such connectivity, which discredits the concept of maximum sustainable yield (Hofman, 2019). The literature points to the counterproductive fact that MPAs increasingly focus on seabed protection while the water column remains open to fishing (O'Leary and Roberts, 2018). Splitting marine areas into different zones and only partially protecting ecosystems will fail to adequately conserve marine life and safeguard the ocean's goods and services (O'Leary and Roberts, 2018).

The BBNJ sample includes studies on the impact of the future treaty on fisheries (Barnes, 2016), its relationship with the mandates of RFMOs, and potential solutions to avoid conflicts with these organizations (Tladi, 2015); insights into the benefits and challenges of taking a regional approach to ABMTs by looking at the example of the UNFSA (Blasiak and Yagi, 2016; Gjerde et al., 2019); and ideas to improve the regional governance of fisheries and biodiversity conservation (Warner, 2014).

Some studies assess the effectiveness of RFMOs regarding the conservation and sustainable use of marine biodiversity beyond national jurisdiction (Bell et al., 2019; Haas et al., 2020b), while other studies focus on their capacity to fulfill their mandates concerning the impact of climate change on the marine environment (Pentz et al., 2018). Literature reviews on the effectiveness of RFMOs show that, despite arguments that RFMOs have the legal mandate and competence to manage fisheries, they have failed to safeguard fish, are often limited to certain species, establish measures only for member states, and do not cover all areas of the ocean (O'Leary and Roberts, 2017; De Santo, 2018).

There are significant geographical and taxonomic gaps in the current fisheries governance framework, resulting in an incomplete coverage of marine biodiversity impacted by fisheries (Warner, 2016; Crespo et al., 2019). The FAO's Deep Sea Fishing Guidelines do not apply to all high seas fishing and aquaculture activities, but only to bottom fishing activities and rely on flag state compliance (Warner, 2012). Lessons learnt show that ABMTs, including MPAs are often introduced in fisheries only when other measures have failed and that regarding closures scientific advice has been ignored (De Santo, 2018). Successful examples of ABMTs through cooperation with RFMOs include mitigation of bycatch in fishing gear (Dias et al., 2017) and

the integration of fisheries into marine spatial planning by comparing the economic value of fishing with the ecological value of diversity, and developing mutually agreeable spatial plans (Johnson et al., 2019b).

Nonetheless, there is strong resistance to including fisheries in the BBNJ agreement (Elferink, 2019). Potential conflict between fisheries and mechanisms for the creation of High Seas MPAs have been studied extensively in the BBNJ literature (Cordonnery et al., 2015; Tladi, 2015; Barnes, 2016; Warner, 2016). Analyses suggest that traditional fishing states see MPAs as a threat, as made visible in their opposition to MPA proposals in Antarctica; resistance is also expected in further areas beyond national jurisdiction in the absence of a BBNJ instrument (Cordonnery et al., 2015). BBNJ authors criticize the fact that regardless of the consequences of the exploitation of mesopelagic fish for the wider ecosystem, economic interests are prevailing as regards these species (O'Leary and Roberts, 2017). A case study of a CAMLR MPA shows that political agendas and fishing interests in the Southern Ocean have been "the major contributing factors to MPA opposition" (Smith and Jabour, 2018). While the BBNJ literature concedes that excluding fish from the definition of MGRs might be politically desirable, such an exclusion from marine biodiversity would need to be explained (Marciniak, 2017; Leary, 2019). Moreover, if fish was not included in the agreement, the impact of fisheries on non-fish biodiversity and fish species that do not fall under existing instruments would be excluded from new BBNJ regulations (Crespo et al., 2019), and access to and sharing of RFMO information would remain unregulated (Blanchard et al., 2019).

Climate—Ocean Interaction

Scientific studies point to the interconnections between the ocean and the climate, and the need to take this into account in policy-making (Johnson et al., 2018; Warner, 2018; Maxwell et al., 2020). Findings in the BBNJ literature sample show the importance of marine biodiversity for climate regulation. Scientific evidence on ecological connectivity reveals that mass migration of mesopelagic fish influences climate regulation by promoting carbon uptake and storage (O'Leary and Roberts, 2017). Furthermore, authors also point to the adverse impacts of climate change on marine biodiversity, which may arise across large distances and different maritime zones (Warner, 2018) by affecting migration routes; this, in turn, influences the effectiveness of MPAs (Dunn et al., 2019; Maxwell et al., 2020). Scientists have an increasing understanding of the variation of megafauna movements caused by environmental changes (Sequeira et al., 2019). Conservation planning requires climate models with a 20–50 years time horizon, incorporating oceanographic variables applied to the full water column and seafloor (Johnson et al., 2018), baseline information on migratory connectivity under future climate change scenarios (Dunn et al., 2019), and information on the nature and extent of climate change impacts (Warner, 2018).

Johnson et al. (2018) and Warner (2018) point to the importance of incorporating climate change issues into the development of ABMTs and EIAs in international waters. Warner (2018), for instance, reviews existing international law and policy frameworks for EIAs in ABNJ and discusses such options, including MPAs and MSP that could reduce climate-induced changes to habitats by protecting migratory corridors and facilitating connections between fragmented environments. There is a need to acknowledge and account for the full range of impacts, including climate change, on marine ecosystems and species over time at the screening and scoping phase of EIAs (Johnson et al., 2018; Warner, 2018), as well as for baseline studies and, even, during monitoring after approval of an activity (Warner, 2018). Besides biodiversity considerations, including species habitats and ecosystems, climate change vulnerability, such as ocean warming, deoxygenation, and acidification also need to be assessed (Warner, 2018).

BBNJ Designs Its Place in Ocean Governance

Many scholars of our sample have researched the institutional interplay between the future BBNJ agreement and existing legal instruments, and made design recommendations for the agreement itself. Ways to meet BBNJ objectives are often coupled with recommendations for responsible entities. Around 10% of the BBNJ literature dedicates itself to specifics of the current ocean governance framework and potential institutional arrangements under the future BBNJ agreement (see **Table 2**). Authors have studied possible institutional arrangements, including a Conference of the Parties (COP), a Scientific and Technical Body, a clearing-house mechanism (CHM), a financial mechanism, and made recommendations regarding compliance and implementation.

BBNJ Within an Ocean Governance Patchwork

The BBNJ's institutional framework is largely emphasized in the literature. Since UNCLOS already includes the duty for states to both individually and collectively "protect and preserve the marine environment" (Tladi, 2015, p. 657), and several organizations are adopting ABMTs in ABNJ, the merits of a new institution vs. enhancing coordination among existing instruments have been analyzed (Barnes, 2016). BBNJ authors emphasize the need for an official body in charge of implementing ABMTs in international waters (Gjerde et al., 2019), and for a clarification of the role of actors in cases where MPAs are located both within and beyond national jurisdiction (Becker-Weinberg, 2017). The interplay between frameworks receives much attention, namely: between the future BBNJ agreement and the existing fisheries framework (Matz-Luck and Fuchs, 2014; Marciniak, 2017), UNCLOS (Gjerde et al., 2019), and the ATS (Johnson, 2017; Li, 2018). Other issues include how the BBNJ agreement can enhance the performance of existing governance frameworks in the southern hemisphere (Warner, 2017), the special circumstances of the Arctic and implications for the BBNJ agreement (De Lucia, 2017; Kraabel, in press), "forum shopping" in institutions (Tsuru, 2017), the role of coastal states in BBNJ, and adjacency and due regard (Elferink, 2018; Mossop, 2018; Mossop and Schofield, 2020).

Three institutional models have been envisaged for BBNJ within existing mechanisms and organizations: Regional, Hybrid and Global (see **Table 4**). Leaving identification, establishment,

implementation, and enforcement to existing regional and sectoral organizations, the regional model eliminates the need for any BBNJ decision-making or scientific body (Gjerde et al., 2019) and is cost effective (Elferink, 2019). The global model would require at least the creation of a decision-making body, a scientific and technical body, and a secretariat—e.g., to establish High Seas MPAs or approve EIAs (Gjerde et al., 2019). The hybrid model lies half-way between the regional and global approaches; it would entail consultation, along with regional and global cooperation (Friedman, 2019).

Although implementation can be improved through better cooperation and coordination among existing regimes (Ardron et al., 2014) and a case study of the UNFSA shows how existing structures could contribute to the establishment of MPAs under the BBNJ agreement (Blasiak and Yagi, 2016), it has been noted that without a global instrument, ocean protection would depend on existing organizations, whose capacities vary, which do not cover all areas of the ocean (Dias et al., 2017; Mossop, 2018), and would fail to establish a representative global network of MPAs (Elferink, 2019). Past resistance and the slow progress of MPA designation in international waters demonstrate the restrictions of relying on existing instruments, leading to calls for a long-term, global approach that nevertheless does not undermine current mandates (Cordonnery et al., 2015; Tladi, 2015; Scott, 2019). Experience gained by the UNFSA provides principles for managing straddling and highly migratory fish stocks; however, review mechanisms lack decision-making power regarding regional organizations (Elferink, 2019).

All BBNJ authors writing on framework interplay would prefer the future BBNJ agreement to play a role in establishing ABMTs; some underline the importance of additionally strengthening regional and sectoral bodies for implementation and regional cooperation, without a narrow interpretation of "not undermining" (Warner et al., 2014; Durussel et al., 2017; Wright and Rochette, 2017; Scanlon, 2018).

Institutional Arrangements

Descriptive contributions to the corpus of BBNJ literature on the ongoing negotiations summarize the states' positions on possible institutional arrangements, including the role and functioning of the Conference of the Parties (COP), the Scientific and Technical Body, the clearing-house mechanism (CHM), and a financial mechanism (Becker-Weinberg, 2017; Hassanali, 2018; Tiller et al., 2019, 2020; De Santo et al., 2020).

A Conference of the Parties (COP) is envisaged as the decision-making body for all BBNJ package elements (Tladi, 2015; Gjerde et al., 2016, 2019). To enhance compliance, recommendations concerning ABMTs and MPAs would involve interaction between the secretariat of the COP (DOALOS) and the secretariat of the RFMOs or similar organizations and state parties, as well as the submission of MPA proposals to the COP by states, RFMOs, and other organizations (Tladi, 2015).

International law contains requirements for scientific evidence as a basis for policy decisions (Gjerde et al., 2019). Recognized scientific experts or bodies could provide advice on a potential MPA network in international waters (Gjerde et al., 2019). A Scientific and Technical Body could help "foster a strong epistemic community around BBNJ" (De Santo et al., 2019). The BBNJ literature defines the role and characteristics of a legitimate, new scientific body and existing bodies serve either as models or as potential responsible entities (see **Figure 2**). However, while the literature supports the establishment of a new body to contribute to the BBNJ science-policy interface (Ban et al., 2014a; Marciniak, 2017; Blanchard et al., 2019; Gjerde et al., 2019; Tladi, 2019; Maxwell et al., 2020), a comprehensive analysis of appropriate institutional and representative aspects of the scientific body is lacking. In ongoing negotiations, questions remain about the role of such a body, ranging from advisory to decision-making (De Santo et al., 2019).

Moreover, a clearing-house mechanism is recommended as a data collection and sharing platform to strengthen scientific research capacity and knowledge exchange. Authors make suggestions for its functions and structure (Harden-Davies, 2017b; Broggiato et al., 2018; Ridings, 2018; Blanchard et al., 2019; Collins et al., 2019; Rabone et al., 2019) and provide overviews of existing, emerging, and new data-sharing platforms as well as proposals for possible responsible entities (see **Figure 2**).

To guarantee the avoidance of harm through scientific research in ABNJ, an ethics committee could be in charge of the prior approval of planned activities (Hassanali, 2018). It is recommended to set up international scientific networks (Harden-Davies, 2017b), intra-regional and inter-regional platforms (Blasiak and Yagi, 2016), and regional marine scientific and technological centers (Hassanali, 2018), as well as build on existing bodies and examples provided by international law (See **Tables 3**, **6**). Drawing inspiration from the UNFSA (Art. 5; Art. 14) and UNCLOS (Art. 244; Art. 242; Art. 202), the BBNJ agreement could elaborate on the obligations to cooperate in scientific research and to publish or share data for CB&TT with developing states (Gjerde et al., 2019).

Authors emphasize that funding for ocean management is needed (Durussel et al., 2017; Harden-Davies, 2017b; Bax et al., 2018; Hassanali, 2018) and propose potential entities (see **Figure 2**). A biodiversity fund fed by revenues from the exploitation of MGRs in international waters (Tvedt and Jørem, 2013; Broggiato et al., 2014; Peña Neira, 2017; Ridings, 2018; Voigt-Hanssen, 2018) could constitute a way to transfer benefits to stakeholders—including state and non-state actors at the national, regional, and global level—involved in conservation projects, such as research on biodiversity and the creation of MPAs (Tvedt and Jørem, 2013).

One part of the BBNJ literature detects the challenges of compliance and provides recommendations for an effective implementation of the agreement (Ma et al., 2016; Li, 2018; Long, 2019). Authors examine geopolitical considerations surrounding BBNJ (Kaye, 2004), point to the difficulties of conducting EIAs in ABNJ (Ma et al., 2016), and argue that compliance can be achieved through economic incentives (Blasiak and Yagi, 2016). Academic output deals with the economic benefits of MPAs when spillover effects for fisheries spurring self-interested implementation (Blasiak and Yagi, 2016), as well as the commercial and ecological benefits of MGRs— the "ocean genome" (Blasiak and Yagi, 2016; Blasiak et al., 2020).

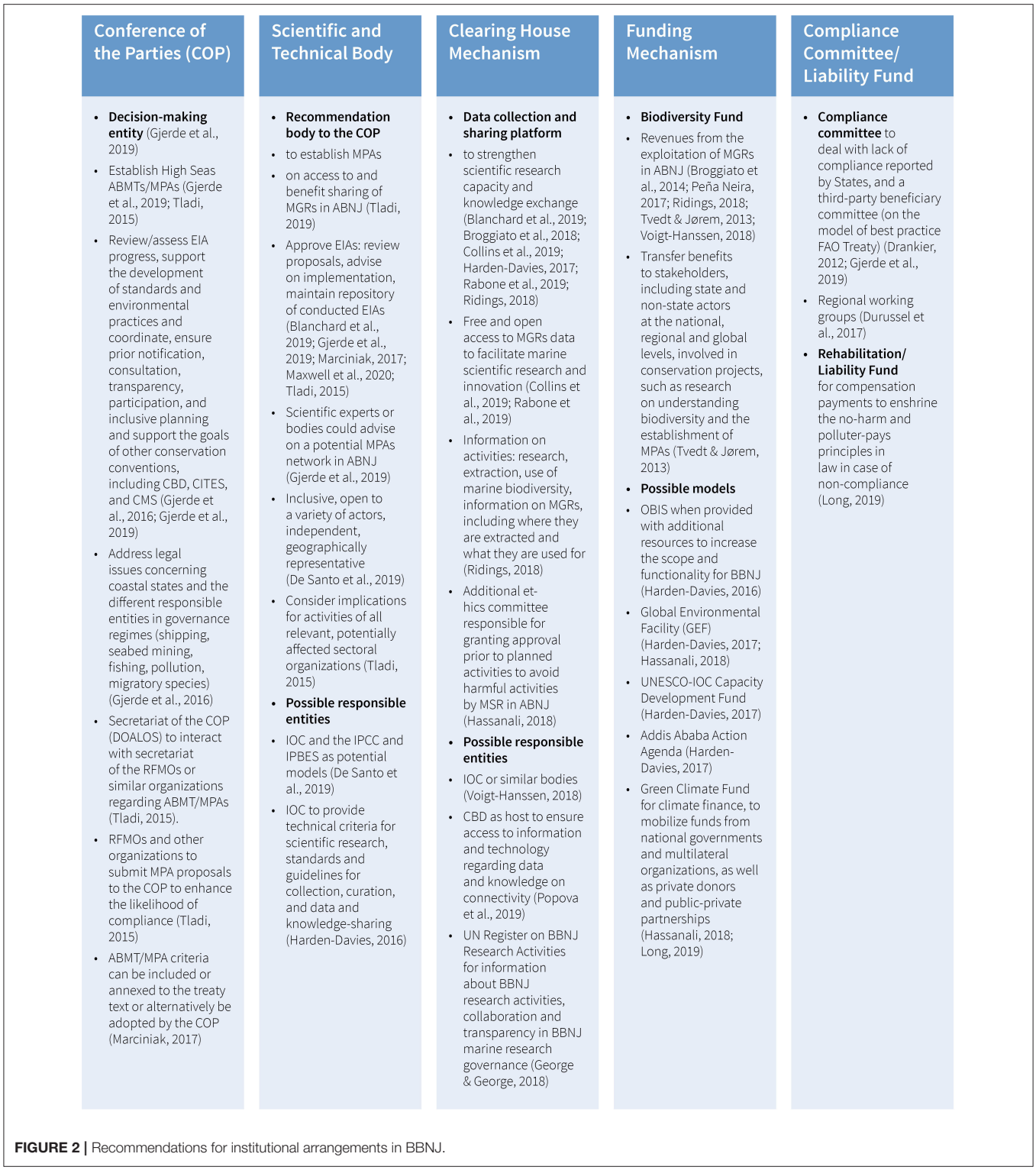

FIGURE 2 | Recommendations for institutional arrangements in BBNJ.

Apart from incentives, monitoring and control are identified as crucial for compliance (Blasiak and Yagi, 2016; Altvater et al., 2019). To deal with non-compliance, the literature discusses the possibility of a compliance committee (Drankier et al., 2012; Durussel et al., 2017; Gjerde et al., 2019). It also recommends compensation payments into a rehabilitation or liability fund to enshrine the no-harm and polluter-pays principles in law (Long, 2019).

TABLE 6 | CB&TT BBNJ literature.

	Recommendations for international legally binding instrument	Identified responsible entities	References to existing law	Best practices/ lessons learnt
Imbalance in capacities between States/CB&TT and MGRs/CB&TT and MSR/digital technology	Funding crucial for advancing scientific research and cooperation in the South East Pacific (Durussel et al., 2017) "Findable, accessible, interoperable, and reusable information" (FAIR) (Kraabel, in press)	Clearing House Mechanism (Ridings, 2018; Blanchard et al., 2019; see **Table 2**) Financial Mechanism for BBNJ (Hassanali, 2018) GEF, UNESCO-IOC Capacity Development Fund and the Addis Ababa Action Agenda (Harden-Davies, 2017b) Scientific and Technical Body: IOC (Harden-Davies, 2016; De Santo et al., 2019); Created on the model of IPCC and IPBES and building upon the role of the current IOC (De Santo et al., 2019)	1992 Rio Declaration on the need for States to 'cooperate to strengthen endogenous capacity-building for sustainable development by improving scientific understanding through exchanges of scientific and technological knowledge, and by enhancing the development, adaptation, diffusion and transfer of technologies, including new and innovative technologies' (Durussel et al., 2017) 2012 "The Future We Want" document (Durussel et al., 2017) *UNCLOS* Obligations regarding CB&TT on the protection of the marine environment (Part XII), on the Area (Part XI), on marine scientific research (Part XIII), and on marine technology transfer (Part XIV) (Durussel et al., 2017) Art. 82: example for a benefit-sharing model from the exploitation of minerals in ABNJ to fulfill a CB&TT obligation (Blasiak and Yagi, 2016) Art. 143 (3) contains principles for international cooperation, including encouragement of personnel from different countries and of the Authority to participate in marine scientific research, programs developed through the Authority or any other international organization for the benefit of developing countries and technologically less well-developed states to strengthen their research capabilities, research techniques and applications and encourage qualified personnel doing research in the Area and dissemination of research results and analysis when available through the ISA or any other international channel (George and George, 2018) Art. 202: Scientific and technical assistance to developing States (Gjerde et al., 2019) Art. 242: Duty to cooperate in scientific research, including through competent international organizations (Gjerde et al., 2019) Art. 244: Duty to publish and share data (Gjerde et al., 2019) Based on Art. 276, suggestion for regional marine scientific and technological centers to facilitate coordination of access to CB (Hassanali, 2018) *UNFSA* Technical and scientific cooperation obligations with regard to the conservation and management of straddling and highly migratory fish stocks (Durussel et al., 2017) Art. 5: Requirements for data collection and sharing by coastal states and states fishing on the high seas; duty to collect and share, in a timely manner, complete and accurate data concerning fishing activities, to promote and conduct scientific research, and to develop appropriate technologies in support of fishery conservation and management (Gjerde et al., 2019) Art. 14: Obligation for States to "ensure that fishing vessels flying their flag provide such information as may be necessary in order to fulfill their obligations under this Agreement"; Art. 14 (3): Further elaboration on obligation to cooperate in strengthening scientific research capacity for the benefit of all (Gjerde et al., 2019) Annex i: Requirements for data collection and sharing (Gjerde et al., 2019) *CBD* Technical and scientific cooperation obligations regarding the conservation of biodiversity (Durussel et al., 2017) Nagoya Protocol (non-monetary benefits definition) (Harden-Davies and Gjerde, 2019) Art. 22: Provision on capacity building with regard to the access to and benefit sharing of genetic resources (Durussel et al., 2017) *FAO* Soft law FAO International Plans of Action (IPOAs), FAO Code of Conduct for Responsible Fisheries, and the legally binding FAO Compliance Agreement: capacity building with regard to fisheries (Durussel et al., 2017)	IPCC and IPBES and IOC as examples for Scientific and Technical Body (De Santo et al., 2019) Arctic Council: Scientific Cooperation agreement and CAO Fisheries Agreement with scientific cooperation provisions (Kraabel, in press) Arctic Observatory Network: submarine communication cables (Norway- US West Coast- Japan) for ocean monitoring (Kraabel, in press)

The Role of Science

Science has a significant place in each of the package elements of the future BBNJ treaty. Knowledge about the ocean and its ecosystems is still limited, with a majority of marine species being new to science (Rabone et al., 2019). Marine research is therefore needed in order to understand the world's ecosystems (Rochette and Bille, 2008). Moreover, marine genetic compounds have been used to develop products for the pharmaceutical, biofuel, and chemical industries (Blasiak et al., 2018). It is widely argued that scientific and other forms of knowledge ought to contribute to decision-making and the implementation of policies (Van Dover et al., 2016; Gjerde et al., 2019; Gownaris et al., 2019) and that scientific cooperation is needed (Harden-Davies and Gjerde, 2019; Rabone et al., 2019).

Marine Scientific Research for Exploration and Exploitation

Marine scientific research (MSR) is intrinsically linked to marine genetic resources, which can either be part of samples or the object of study. UNCLOS guarantees the "freedom of scientific research" on the High Seas (UNCLOS, Art. 87) under certain environmental standards and restrictions. Despite uncertainty concerning monetary benefits from MGRs (Blasiak and Yagi, 2016; Harden-Davies, 2017b; Yu, 2019), most of the literature expects promising economic gains to be derived from MGRs (Nurbintoro and Nugroho, 2016; Scovazzi, 2016; Van Dover et al., 2016; Becker-Weinberg, 2017). Current literature on the relationship between MSR and MGRs is biased toward a preference for keeping the status quo, i.e., allowing free and open access to MGRs in order not to impede scientific research and developments of new products.

A small share of the literature mentions access to otherwise restricted areas through MSR in the ATS case (Li, 2018), and the threat of overexploitation of marine biodiversity—including MGRs—through (or in the name of) research (Kaye, 2004). It recommends introducing a "duty of care when collecting MGRs" and restricting access to vulnerable marine ecosystems, such as EBSAs and MPAs (Voigt-Hanssen, 2018), or "standards and criteria for responsible sampling activities, e.g., in form of a code of conduct" (Yu, 2019).

Many scholars, however, emphasize the opportunity provided by the BBNJ agreement to strengthen best-practice MGR access, sharing, and transparency (Broggiato et al., 2014, 2018; Collins et al., 2019; Rabone et al., 2019). The sharing of information regarding planned research activities (type, purpose, scope, and timeline) and the monitoring and regulation of impacts, as well as the sharing of research results, are viewed as useful tools to prevent environmental harm, as is reporting on research and exploration activities in international waters (Hassanali, 2018).

Science-Policy Interfaces for Ocean Protection

As much as science is needed to explore and exploit the marine environment, it also lays the foundation for efficient ocean protection, including the identification and creation of High Seas ABMTs, including MPAs (Dias et al., 2017; Mossop, 2018). Scientific evidence can inform effective MPA establishment to maintain and restore populations, increase resilience of the ecosystem, and provide socio-economic benefits (Gownaris et al., 2019). A literature review by Gownaris et al. (2019) shows that such benefits can only be achieved if "MPAs are appropriately sited, strongly protected and effectively managed." Given that their establishment has, in the past, not always relied upon best available science, the quality of MPAs varies significantly (Gownaris et al., 2019). Large scale MPAs, larger than 30,000 km², seek to meet quantitative global targets set by the CBD and Sustainable Development Goal 14.5, however, their contribution to biodiversity conservation has been debated (Davies et al., 2017). It has been argued that "quality" goals, including equitably and effectively managed, well-connected, and ecologically representative networks of MPAs, will not be met (O'Leary and Roberts, 2018).

Since the "best available science" is needed to identify MPAs, various scientists have published their findings with the aim to contribute to effective MPA establishment (O'Leary et al., 2012; Ban et al., 2014a; Selig et al., 2014; Evans et al., 2015; Dias et al., 2017; Gjerde et al., 2019; Gownaris et al., 2019). Their publications contribute to the BBNJ process by providing guidance on suitable sites for MPAs, i.e., those with a high biodiversity value that—regardless of their well-known prestige ecosystems—are lacking in comprehensive MPA coverage (Selig et al., 2014; Dias et al., 2017). Scientific studies highlight the policy relevance of biogeographic classifications (Rice et al., 2011; Gjerde et al., 2016), point to certain deep-sea habitats in need of protection (Johnson, 2019), and to over 76 million km² of unprotected ABNJ that have already been identified as important and could act as a starting point for the BBNJ process (Gownaris et al., 2019). A geospatial analysis of existing ABMTs in deep-sea environments seeks to inform ecosystem-based management on the High Seas (Menini and Van Dover, 2019). BBNJ authors point out that the 1972 World Heritage Convention does not include international waters, but science has identified various sites in need of protection (Laffoley and Freestone, 2017). To prevent the designation of MPAs in areas of low biodiversity value and support conservation, objective criteria must be used, such as the presence of pelagic seabirds, which indicate greater marine biodiversity (Dias et al., 2017), or the occurrence of prestige sponges on tropical seamounts (Ramiro-Sanchez et al., 2019). A combination of VME taxa records and predictive habitat models can provide scientific evidence to support sustainable management, avoid the adverse impacts of exploitation, and suggest new sites for MPAs, serving as the basis for EBSAs and large VMEs nomination (Ramiro-Sanchez et al., 2019).

One part of the BBNJ literature examines lessons learnt and best-practice examples of the use of "best available science" in decision-making. Case studies of the OSPAR and CAMLR scientific committees show that scientific advice is often disregarded or wrongly implemented and that input from social science is completely missing, although it is regarded as essential for the design of effective conservation measures (De Santo, 2018). Thus, advocates of giving strong decision-making powers to a future BBNJ Scientific and Technical Body call for a "politically highly influential" design (De Santo, 2018). Increasingly, there are calls to include other forms of knowledge into policy-making across all package elements,

including traditional knowledge of Indigenous Peoples and Local Communities (Dunstan et al., 2016; Ridings, 2018; Voigt-Hanssen, 2018; Johnson et al., 2019a; Scott, 2019; Humphries et al., 2020) and the perspectives of resource managers, interest groups (De Santo, 2018), civil society actors, and the private sector (Kraabel, in press). This part of the BBNJ literature points to existing instruments (see **Tables 4**, **5**), including: the Aarhus convention, with its general principles and approaches of public participation, transparency, and information availability (De Santo, 2018); the FAO's 2009 International Guidelines for the Management of Deep-sea Fisheries in the High Seas criteria for VME identification based on the best available scientific knowledge and expert judgment (Johnson et al., 2018); the CAMLR Scientific Committee (De Santo, 2018); scientific advice for decision-making in OSPAR and the North-East Atlantic Fisheries Commission (NEAFC) by the International Council for the Exploration of the Sea (ICES) (De Santo, 2018); and the Permanent Commission for the South Pacific (CPPS) with its climate-related scientific research across the region (Durussel et al., 2017).

Scientific Cooperation

Scientific expertise, combined with capacity building, supports the global community's understanding of how the ocean is changing (Bax et al., 2018). Scientific research may be seen as a "vehicle for benefit-sharing through scientific and technological capacity building" (Harden-Davies and Gjerde, 2019). It is argued that capacity development and technology transfer toward sustainable ocean use have to focus on "actionable information", requiring emphasis on "elements of the ocean that are most relevant to the global community, such as fisheries and living habitat" (Bax et al., 2018).

Research on science diplomacy grants science an opportunity to give way to more pragmatic discussions of scientific capacity development and technology transfer, rather than to focus on an ideological divide in the negotiations (Harden-Davies, 2018), and to engage actors on Arctic issues (Kraabel, in press). Under the future BBNJ agreement, international marine scientific research can generate knowledge; technology transfer can be used to share this knowledge; and capacity development enables the application of knowledge in practice (Harden-Davies, 2018). Suggestions include participation in research programs and the exchange of scientists (Ridings, 2018).

The sharing of knowledge about activities that affect marine biodiversity in areas beyond national jurisdiction, including research and extraction, is crucial for the conservation and sustainable use of BBNJ (Ridings, 2018), can give greater access to patented genetic resources, and strengthen research capacity and support the conservation of wild stocks (Humphries, 2018). Scientific capacity building enables global monitoring, management and adaption to ocean change (Bax et al., 2018; Mossop, 2018). Research on the BBNJ negotiations highlights the link between the CB&TT element and all other treaty topics: MGR access and utilization, monitoring and enforcement of ABMTs, and the evaluation of EIAs (De Santo et al., 2020). New instruments of the Arctic Council, namely the Scientific Cooperation Agreement and the Agreement to Prevent Unregulated High Seas Fisheries in the Central Arctic Ocean (CAO), include key provisions for scientific cooperation and can be regarded as best-practice examples (Kraabel, in press).

Digital Technology for Implementation of the BBNJ Agreement

Digital technology plays a role for each of the package elements. Advances in technology and increased demand have added stressors on the marine environment (O'Leary and Roberts, 2017), resulting in biodiversity loss as well as the destruction of prestige marine ecosystems (O'Leary and Roberts, 2018; O'Leary et al., 2020). Scientific research on MGRs is heavily dependent on new technology to take samples in the deep sea (Broggiato et al., 2018) and retrieve genetic sequence data (Rabone et al., 2019). Online databases provide worldwide access to data and genetic material, including for developing countries that were not initially involved in the access of the MGRs "*in situ*", namely, at sea.

Simultaneously, digital technology can support ocean conservation measures by identifying marine biodiversity occurrences and threats. Novel genetic technologies offer opportunities to conserve the ocean genome (Blasiak et al., 2020). It therefore plays a significant role as regards ABMTs and MPAs. Satellite tracking, combined with open and near real-time accessibility, will assist the protection of highly migratory marine vertebrates (Sequeira et al., 2019). Marine and aerial autonomous systems, satellite-based remote sensing, telemetry, and systems combining Automatic Identification Systems (AIS) with satellite tracking can predict high-seas fishing effort and assess the potential exposure of coastal regions to adjacent fishing pressure (Popova et al., 2019). BBNJ authors also examine the spatial ecology and drivers of the global distribution of the high-seas long-line fishing fleet by using newly available AIS data to predict fishing effort distribution (Crespo et al., 2018). As regards the interconnectedness of the ocean, one way to identify MPAs that take into account migratory connectivity is to establish mobile MPAs informed by satellite data (Maxwell et al., 2020). Partnerships with the military, or industries with access to crucial technologies to study or manage remote ocean areas, including remote sensing technologies, can provide new resources for the conservation and monitoring of ABNJ (Gjerde et al., 2016).

Technology will also be needed for MPA surveillance purposes and compliance with the BBNJ agreement (Rochette et al., 2014a; Rowlands et al., 2019). Studies by BBNJ authors that are based on monitoring, control and surveillance mechanisms used by RFMOs argue that the new instrument could be an opportunity to introduce AIS technology for monitoring, control and surveillance on the High Seas, which would improve biodiversity conservation and management in international waters and enhance compliance (Dunn et al., 2018). Digital technology allows for near real-time monitoring of fishing vessels (Popova et al., 2019). New technologies include vessel tracking systems, e.g., the vessel monitoring system (VMS) and AIS, which facilitate the surveillance and monitoring of marine fisheries even in remote waters (Crespo et al., 2018). BBNJ authors point out that currently not all vessels

are required to carry AIS devices, and regulations vary according to vessel type, size, nationality, and fishing location (Crespo et al., 2018). MPAs larger than 100,000 km² require improvements in satellite monitoring to detect violations (Rowlands et al., 2019).

The role of technology in the implementation of the BBNJ agreement underscores the importance of the CB&TT package. Technology transfer can facilitate access to satellite databases such as AIS to track the location of fishing activities and increase the management capacity of states and RFMOs (Dunn et al., 2018). In this way, it can support developing states in managing and monitoring fishing activities and impacts (Bax et al., 2018). For an effective implementation of High Seas ABMTs, the involvement of a range of stakeholders will also be crucial, including the fisheries industry and scientific community; for instance, data collection and sharing might demonstrate the added value of MPAs and generate self-interest in their implementation (Blasiak and Yagi, 2016). With the help of AIS data, governance gaps can be identified, ABMTs monitored, and the states' and RFMOs' management capacity strengthened (Dunn et al., 2018).

DISCUSSION AND CONCLUSION

The following section discusses the results of the BBNJ literature review; it also offers some critical reflections on the corpus and the authors' findings and recommendations. We identify two important gaps that will need to be addressed in future research on the effective conservation of marine biodiversity in ABNJ: Firstly, research on science-policy interfaces in BBNJ governance, and secondly, linking the BBNJ process to the need for transformative change.

Closer Interplay Between Science and Policy Is a Must

The findings and recommendations from the scientific community publishing on BBNJ issues show that there is a need for a stronger interplay between science and policy, and a systematic identification of "windows of opportunities" for a more efficient uptake of science into the BBNJ process and, later, treaty implementation (Rose et al., 2017). This encompasses the need for (1) formalized processes to facilitate science-policy interfaces in the BBNJ negotiations and, (2) an independent international expert body representing multiple scientific disciplines, expertise from various regions and diverse knowledge forms to ensure the inclusion of science and knowledge for the implementation of the treaty.

This literature review has revealed the willingness of the "BBNJ scientific community" to contribute to the negotiations and shape their outcome, as shown by its readiness to provide relevant scientific data and recommendations concerning the new instrument. Our findings indicate that the community is concerned about how the new treaty might shape the conservation and use of BBNJ. The corpus of normative papers mostly calls for a strong and ambitious agreement. Concretely, the "voice of science" in BBNJ affairs is calling for a more holistic, ecosystem-based, and precautionary perspective to ocean governance that takes into account ocean connectivity and climate change impacts. While the BBNJ scientific community is pointing to marine biodiversity threats and offering possible solutions, some of these calls are opposed by policy-makers involved in the BBNJ negotiations. The current draft of the BBNJ treaty—with only one further IGC planned—has, so far, only incorporated the requirements defined by the BBNJ scientific community to meet the treaty's objectives to a limited extent. Moreover, parallel political international processes on ABNJ-related issues (such as climate and biodiversity Conferences of the Parties (COPs) or negotiations of the ISA) will also have to be connected if a holistic solution is to be found.

Our findings also indicate, that the BBNJ scientific community needs to expand and diversify. The literature sample of this review mainly consists of academic output by authors affiliated with Europe (46%), Oceania (21%), and North America (20%), but lacks input from Asia (8%), Latin America (4%), and Africa (1%). While authors have a variety of academic backgrounds, law is the most prevalent discipline throughout the sample with more than half of BBNJ authors from that discipline. Information from participant lists and side-event programs of BBNJ negotiations shows that 35 of the 99 authors were directly involved—attending at least one of the three intergovernmental conferences (IGCs)[5], either as observers from universities or non-governmental organizations, or at the negotiation table within national delegations, which influences the interrelation between negotiations and academic output. With the limitation of looking explicitly at peer-reviewed academic literature in English, the main "voice of science" is that of authors and research institutes from the Global North, providing scientific findings, as well as suggestions regarding the emergence, development and implementation of the agreement. Given that our sample only includes scientific literature explicitly referring to the BBNJ process, there is a large body of marine and climate science literature missing from this analysis that may be relevant for the negotiations.

This reveals the need to further encourage links between marine scientific research and the ongoing BBNJ process. Recent science and knowledge should be brought to the decision-makers' negotiating table, such as research on deep-sea environments and the characteristics of marine species. In this regard, potential communication barriers need to be bridged to identify the significance of the findings, and results need to be connected to the political realities at hand for the policy-makers to perceive science as relevant. This could inform policy-making regarding access to, and utilization of MGRs, the identification of ABMTs, including MPAs, and the need for EIAs. Since there is a shortage of BBNJ research originating from the Global South, we recommend facilitating cooperation to guarantee their inclusion in the scientific community. The CB&TT element of the negotiations can significantly contribute to this aim. Scientists working on topics related to areas further than 200 nautical miles away from the shore, on marine species migrating into those

[5]Information on affiliation, academic background and BBNJ involvement only concerns the first author and disregards collaborations.

areas, or on genetic material from these areas, are encouraged to link their research to the political BBNJ process to make their work policy-relevant and engage in the science-policy interfaces. Moreover, policy-makers are encouraged to reach out to experts working on the above-mentioned topics even if these are not aware of, or involved in the political process. In this way, the BBNJ scientific community could grow and include other forms of knowledge relevant for the BBNJ negotiations.

In this regard, science and knowledge can notably shape the applicability of treaty provisions, regarding the processes of how to govern MGRs, establish ABMTs, including MPAs, conduct EIAs, and ensure CB&TT. Yet, we need future research on designing science-policy institutions by identifying the social relevance of science and knowledge for the international community when seeking to regulate global commons. Research on effective science-policy interfaces emphasize the need for "salient, credible and legitimate" information-base in policy-making (Cash et al., 2003). However, perceptions of saliency, credibility and legitimacy can differ in "certain political situations within particular political and cultural settings" (Lidskog and Sundqvist, 2002). This underlines the importance of understanding the different values and norms behind the production and interpretation of science and knowledge (Jasanoff, 2004), especially in international negotiations where representatives from around the world are expected to jointly agree on the way forward. While literature exists on such "social relevance" in the climate and biodiversity fields (Beck et al., 2014; Vadrot, 2020a), research on effective science-policy interfaces in BBNJ in this regard is still lacking and constitutes significant potential for the protection of marine global commons.

Transformative Change for BBNJ Objectives

While literature in our sample exemplifies the need for an ambitious BBNJ treaty, based on precaution, and recognizes the need for a holistic, ecosystem-based approach to ocean governance, it tends to limit itself—with a few exceptions—to a narrow interpretation of the Law of the Sea. While the BBNJ Treaty will indeed be an implementing agreement of UNCLOS and should "not undermine" its provisions, the dramatic acceleration of environmental degradation in the ocean should encourage us to think beyond existing legal and institutional structures and to acknowledge that the institutions we have established to tackle the loss of marine biodiversity are embedded in political and economic contexts. Literature from our sample seems to recognize the need for transforming the institutional and legal conditions for ocean protection, however, no connections have yet been made to the ongoing debate on transformative change within the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). Authors of the first global IPBES assessment concluded that global biodiversity loss could only be reversed by addressing both direct and indirect drivers, and by introducing transformative change into our societies (IPBES, 2019). The underlying—economic, sociocultural, demographic, political, institutional, and technological—indirect drivers behind the direct drivers are the root causes of biodiversity loss in our societies (Diaz et al., 2019). Transformative change would entail a "fundamental, system-wide reorganization across technological, economic, and social factors, making sustainability the norm rather than the altruistic exception" (Diaz et al., 2019).

Using this ambitious framework—which already guides debates within the CBD—to govern BBNJ affairs would open up a new pathway toward the effective conservation and sustainable use of marine biodiversity. Thus, we propose that future research by the BBNJ scientific community should concentrate on exemplifying the kind of transformative change that would be needed and how indirect drivers of marine biodiversity loss can be considered in the new BBNJ treaty and its implementation. As scientific findings on ocean connectivity and the interaction between the ocean and the climate show, existing political and legal structures cannot guarantee the conservation and sustainable use of marine biodiversity. The traditional way of drawing borders in the marine environment and the desire to privatize and nationalize marine space and resources does not account for such interconnections and is failing to ensure governance aims for marine biodiversity.

Academic literature from the social sciences may help us bring together the ongoing BBNJ debate and transformative change (Vadrot et al., 2018). This includes research on our international system, economy, politics, and structural factors that led to the current state of the oceans in need of protection and regulation. Especially the politics behind some of the tensions that we see in the negotiations would benefit from research on the negotiation dynamics themselves, including struggles over environmental knowledge (Vadrot, 2020b). While the ocean lays mostly outside of national jurisdiction, still, states are the actors that will decide on the future of marine biodiversity. As shown in the literature, political and economic interests have in the past prevented marine protection in spaces that from an ecological point of view were identified as vulnerable. A change in these structures would require a critical view on the status quo of international negotiations, the critical appraisal of the limits and the future of multilateralism, consideration of diverse knowledge forms, and the imagination for new ways of governing areas that belong to all (Vadrot, 2020b). Alternative ideas (Wyborn et al., 2020) on using and sharing ocean resources, including other forms of knowledge- such as local and indigenous knowledge and philosophical insights into the question of humankind's right to "own" the ocean and its resources—could help us arrive at alternative solutions that have so far not been sufficiently considered. These could greatly enrich international policy-making options and broaden the scope of debate.

Given its focus on the potential economic value of MGRs and its aim to counterbalance inequalities between the Global North and the Global South, the BBNJ literature has failed to consider the intrinsic value of marine biodiversity. Although conservation and sustainable use are discussed at length in the debate on how the ocean's resources may be efficiently used and how an equitable sharing of benefits may be guaranteed, the fact that biodiversity has a value in itself—without being monetized—is only touched on by few authors (Gjerde et al., 2019; Harden-Davies et al., 2020). Ethical considerations whether and how to explore and

exploit marine life and reflections on who has decision-making power to govern ocean activities fall short in current scientific debates, as well as in the negotiations themselves. These ethical questions, however, need to be addressed in the light of governing a global commons.

BBNJ Outlook

The BBNJ literature is quickly growing and we observe a significant increase in publications while we approach the next—planned to be final—negotiation round of BBNJ. Recent publications—only accessible to us after completion of the systematic review—cover important and timely issues related to diverse elements of the BBNJ Treaty. Regarding the package element MGRs, this includes valuable insights on stakeholder perspectives on access and benefit sharing for MGRs (Collins et al., 2020) and the consideration of digital sequence information as a marine genetic resource (Lawson and Rourke, 2020). Concerning the ABMTs package and more specifically, marine protection, recent publications include the identification of priority areas for protection in ABNJ (Visalli et al., 2020), the importance of the protection of High Seas coral reefs (Wagner et al., 2020), scientific and legal considerations for dynamic ABMTs (Crespo et al., 2020) and a network of seamount MPAs (Marsac et al., 2020). As regards to EIAs, new research evaluates the prospects for effective environmental assessment under the new instrument and proposes a standard against which to measure the environmental assessment process being developed in the BBNJ negotiations (Doelle and Sander, 2020). Recent publications considering the CB&TT package include the link between marine technology transfer and MSR (Harden-Davies and Snelgrove, 2020), synergies between policy agreements and the BBNJ agreement (Vierros and Harden-Davies, 2020) and an analysis of global and regional collaboration networks in marine biodiversity research (Tolochko and Vadrot, in press).

Furthermore, research discusses overarching themes such as convergence and divergence in the negotiations (Humphries and Harden-Davies, 2020; Wang and Chang, 2020), ocean resilience to climate change and other human activities (Yadav and Gjerde, 2020), science-policy interfaces (Gaebel et al., 2020), the interplay between institutional frameworks (Balton, 2019; Clark, 2020; Gardiner, 2020; Haas et al., 2020a; Nickels, 2020; Papastavridis, 2020), dispute prevention and settlement (Payne, 2020; Shi, 2020), pathways for strengthening monitoring, control and surveillance in ABNJ (Cremers et al., 2020), the relevance of traditional knowledge (Mulalap et al., 2020) and first ideas to grant non-state actors rights to represent the interests of humanity (Payne, 2020) and nature rights on its own on the global scale (Harden-Davies et al., 2020) when governing the global commons.

Also in the political sphere—despite the postponement of the fourth and planned to be last IGC—there is a significant willingness of stakeholders, including state and non-state actors- to keep the momentum and stay engaged in discussions around BBNJ. This can be seen in extensive and active participation by state delegates in online webinars and dialogues organized by individual state actors and civil society, as well as in semi-formally organized intersessional work by the UN Secretariat to engage delegations in diving deeper into unresolved issues in all package elements. Involvement in discussions on textual work, interest in clarifications on BBNJ issues, and collaboration among BBNJ stakeholders over the past months show the motivation of state delegations to be engaged in the multilateral dialogue and offer hope for the upcoming formal negotiation round - that will decide over the future of marine biodiversity—to take the calls from the scientific community into account.

Ongoing intersessional work and engagement with scientists and the civil society until the next IGC can serve consensus-building among state representatives, insofar as it grants more time to discuss contentious issues and let the voice of science and civil society play a more central role. It is also in this regard that our systematic literature review may enrich ongoing negotiations and serve stakeholders interested in the BBNJ process and its diverse elements to navigate smoothly through the already existing research and recommendations that cover a broad range of issues and ideas. Scientists may identify new avenues for research and policy-makers may find novel approaches already circulating among the BBNJ community. While intersessional online meetings and final multilateral discussions at the upcoming IGC indeed offer the opportunity to design an ambitious agreement fit to fulfill its objectives, it remains to be seen to what extent the voice of science will be heard during the BBNJ negotiations.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

ITvW data collection, data analysis, and drafting and writing. AV: design of study, contribution to data anylsis, and drafting and writing. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

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