



OPEN ACCESS

EDITED BY

Di Jin,
Woods Hole Oceanographic Institution,
United States

REVIEWED BY

Mehran Idris Khan,
University of International Business and
Economics, China
Porter Hoagland,
Woods Hole Oceanographic Institution,
United States

*CORRESPONDENCE

Wei Wang
✉ wang1997@whu.edu.cn

RECEIVED 07 December 2024

ACCEPTED 08 May 2025

PUBLISHED 03 June 2025

CITATION

Rometius S and Wang W (2025) Unlocking the global commons: legal analysis of benefit-sharing for marine genetic resources in the BBNJ agreement.
Front. Mar. Sci. 12:1541331.
doi: 10.3389/fmars.2025.1541331

COPYRIGHT

© 2025 Rometius and Wang. This is an open-access article distributed under the terms of the [Creative Commons Attribution License \(CC BY\)](#). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Unlocking the global commons: legal analysis of benefit-sharing for marine genetic resources in the BBNJ agreement

Steel Rometius¹ and Wei Wang^{1,2*}

¹Guanghua Law School, Zhejiang University, Hangzhou, China, ²Melbourne Law School, The University of Melbourne, Parkville, VIC, Australia

The Biodiversity Beyond National Jurisdiction (BBNJ) Agreement marks a significant step in governing global commons, yet faces implementation challenges regarding marine genetic resources (MGRs). Key limitations include ambiguous definitions of derivatives, tension between freedom of high seas and common heritage principles, and uncertain benefit-sharing models. In response, this paper proposes three improvements: (1) expanding MGRs interpretation under the Vienna Convention to include derivatives, accompanied by a clarifying negative list; (2) implementing a phased benefit-sharing mechanism that progressively incorporates common heritage principles as MGRs approach commercialization; and (3) developing a hybrid model combining monetary and non-monetary contributions with minimum standards to ensure benefits for developing States. These solutions would enhance marine biodiversity protection while ensuring equitable distribution of MGR benefits.

KEYWORDS

the BBNJ agreement, marine genetic resources, digital sequence information, benefit-sharing, the common heritage of mankind, the freedom of the high seas

1 Introduction: the international legal dilemma of governing MGRs

On June 19, 2023, after 17 years of preparation and negotiation, the BBNJ Agreement was formally adopted by all 193 UN member states. As the first legally binding international instrument governing the high seas, the BBNJ Agreement establishes a unified legal framework for the governance of marine biodiversity in areas beyond national jurisdiction (ABNJ) (Chang et al., 2024). It has been widely praised as “the dawn of a new era for the oceans” and “a victory for international law, the global commons and multilateralism.” (Intergovernmental Conference, 2023). However, the BBNJ Agreement marks the conclusion of negotiations rather than the realization of fair and equitable benefit-sharing (Morgera, 2018). Key ambiguities remain, particularly regarding the governance of MGRs (Khan, 2023). Due to their significant potential in

pharmaceuticals and biotechnology, MGRs in ABNJ are increasingly valued in scientific research and the emerging blue economy (Tiller et al., 2019a). Yet access to and control over these resources—particularly through patents—remain largely concentrated in developed States, prompting concerns among developing nations about exclusion and inequity (Chang et al., 2024).

Three core issues remain unresolved: first, whether derivatives should be legally classified as part of MGRs; second, whether the applicable legal principle should be the freedom of the high seas or the common heritage of humankind; and third, whether benefit-sharing should be mandatory or voluntary, and monetary or non-monetary in form. Against this backdrop, this article begins with a comprehensive assessment of the strengths and weaknesses of the BBNJ Agreement. It then examines the core controversies surrounding benefit-sharing of MGRs in ABNJ and analyzes their underlying legal and political causes. The article proceeds to critically evaluate the Agreement's relevant provisions and institutional design, and concludes with targeted recommendations to address global imbalances in benefit-sharing and promote a more equitable and sustainable regime for governing MGRs in ABNJ.

2 Comprehensive evaluation of the benefit-sharing mechanisms in the BBNJ agreement

The newly enacted BBNJ Agreement protects the status of the ABNJ as a global ecological commons and effectively eliminates the fierce disputes between States over benefit-sharing. However, the benefit-sharing of MGRs in ABNJ under the BBNJ Agreement will be of limited utility and proceed slowly. From a biological perspective, the restriction of MGRs to genetic functional units may fail to meet benefit-sharing requirements adequately. From an ecological view, the principle of the common inheritance of mankind applies solely in the ABNJ, ignoring the coordination with legal practice within national jurisdictions. Politically, the principle of the common heritage of mankind poses a challenge to the prioritization of national interest (Taylor, 2019). In economic terms, the premise of benefit-sharing is the generation of benefits, while excessive monetary benefits may hinder the formation of commercial interest chains of MGRs in ABNJ. As a result, more negotiations will be required to perfect the benefit-sharing in the BBNJ Agreement. As scholars have noted, exploitative interests can work rapidly, whereas building democratic will and consensus typically takes time (Jacquet et al., 2023).

2.1 The positive impact of the BBNJ agreement on MGRs

First, the BBNJ Agreement clarifies the legal status of digital sequence information, aligning with the broader shift toward recognizing the digitalization of genetic resources. Traditional international legal norms have often focused primarily on the

material form of MGRs in ABNJ, thus overlooking the informational nature of genetic material (Liu and Shi, 2024a). The BBNJ Agreement pays attention to the significant impact of modern biotechnology on marine living resources and recognizes the dynamic scalability of the concept of MGRs (Li, 2024a). In other words, the BBNJ Agreement holds that if something can express or perform a certain genetic function, regardless of its form, it should be considered a genetic resource (Humphries, 2016a). In essence, digital sequence information contains the genetic expression of marine organisms, unlocking the value of genetic resources in digital form (Laird et al.). The digitization procedure is actually the process of converting the materialized genetic information into a digital format. As a result, even digital sequence information that lacks physical form can still obtain physicality through the digitalization process. The BBNJ Agreement covers the digital sequence information in the characterization of genetic resources, effectively avoiding the narrow interpretation of the benefit-sharing of MGRs in ABNJ by some developed States, and further protecting the marine rights and interests of developing States (Yan and Guo, 2024a).

Second, The BBNJ Agreement incorporates the principle of the common heritage of mankind and introduces adjustments to the established application of the principle of freedom of the high seas (Aseeva, 2017). Although many scholars consider these two principles to be in tension or even in conflict (Vadrot et al., 2022), in fact the principle of the common heritage of mankind provides “a legal regime based on a stronger competitive equilibrium” while ensuring freedom of the high seas (Toledo, 2022). Specifically, in order to avoid the adverse effects of maritime power on other States on the high seas, and to take due account of the “residual maritime rights” (Liao et al., 2023) of others, the scope of the freedom of the high seas ought to be qualified by law (Anderson, 2006). The BBNJ Agreement lists the principle of the common heritage of mankind among the general principles, indicating that the freedom of the high seas would be further constrained to a certain extent. On the one hand, the common heritage of mankind embodies the common good of all mankind, comprising the concepts of sustainable development, distributive justice and intergenerational equity (Tladi, 2014a). It compresses both qualitatively and quantitatively the applicable space of the freedom of the high seas. On the other hand, under the reasonable constraints of the principle of the common heritage of mankind, the worldwide community will steadily shift from unrestricted sharing of maritime space to organized and supervised sharing of natural resources, and the *Mare Liberum* of the 17th century will also evolve into the *Mare Geneticum* of the 21st century (Broggiato et al., 2018).

Third, the various forms of benefit-sharing stipulated in the BBNJ Agreement respond to the interests of different States and are highly acceptable and operable. On the one hand, monetary benefits might provide developing States with an adequate, stable and predictable source of financing for the development of marine resources. In the case of obvious discrepancies in the ability of the international community to acquire MGRs in ABNJ, monetary benefits could to some extent adjust the unfair initial distribution

of marine rights and interests (Liu, 2020a). On the other hand, non-monetary benefits may contribute to the free global flow of technology and information and may deepen international cooperation on MGRs in ABNJ. Even least developed States and landlocked developing States have opportunities to participate in the development and utilization of MGRs in ABNJ through capacity building and research cooperation (Yan and Guo, 2024b). At the same time, the enthusiasm for research and development in developed States may be continued (Hu, 2020).

2.2 Critical analysis of the benefit-sharing mechanisms in the BBNJ agreement

The BBNJ Agreement incorporates a benefit-sharing system in open and inclusive legislation designed to promote intergenerational equity, international solidarity, and sustainable development. However, each State plays a dual role in the negotiations: as an interpreter of the international community interests and a guarantor of its special interests (Abegón-Novella, 2022). This has prevented the core issues of the “package deal” from being substantively resolved.

First, the BBNJ Agreement adopts a restrictive definition of MGRs in ABNJ, potentially limiting the scope of benefit-sharing. This narrower scope has been criticized for undermining the principle of “equitable and efficient utilization of their resources” in the UNCLOS preamble and the “fair and equitable sharing of the benefits arising out of the utilization of genetic resources” set out in the CBD. By requiring the presence of genetic functional units, the Agreement effectively excludes derivatives from being considered genetic resources. However, derivatives—while lacking functional units—are still closely linked to the inheritance of marine organisms. They can be understood not only as metabolic by-products but also as forms of genetic information or as results of the human use of genetic resources (Ad Hoc Open-ended Working Group, 2018). With the diversification of biotechnology, recent studies emphasize the need for a broader conceptualization of MGRs to ensure inclusive benefit-sharing (Andreone et al., 2024). Rather than defining derivatives as genetic resources, the BBNJ Agreement classifies them under the undefined category of derivatives within the notion of “utilization,” thereby subjecting them only to notification requirements while excluding them from access and collection provisions (Humphries, 2025). This approach has raised concerns regarding the Agreement’s capacity to address the complexity of MGRs. The Nagoya Protocol, in contrast, may offer a more flexible framework that some scholars view as better aligned with evolving scientific and legal interpretations (Morgera et al., 2014).

Second, the provisions of the BBNJ Agreement on the common heritage of mankind remain only at the level of abstract principles and lack operational details for national practice to follow. To begin, the BBNJ Agreement puts forward the principle of the common heritage of mankind only in a general manner without clarifying what basic elements it contains and how the different elements

should be understood. Although the “ordinary meaning” of words is inevitable to some extent, too vague a concept of the common heritage of mankind could easily lead to disagreements in interpretation (Walker and Noyes, 2003). Moreover, the BBNJ Agreement fails to provide quantitative tools or allocation mechanisms to operationalize the principle of the common heritage of mankind, rendering benefit-sharing implementation highly uncertain. For example, scholars have long debated whether this principle implies preferential treatment for developing States or placing all States on an equal footing (Noyes, 2012a). Without a clear legal framework, the common heritage of mankind may be more subject to political discretion rather than legal certainty, potentially undermining equitable governance of MGRs (Li, 2018). Ultimately, the principle in the BBNJ Agreement remains highly abstract, rendering it challenging to impose concrete constraints on state practices in ABNJ. While some scholars argue that the principle has been progressively formalized within the UNCLOS framework and partially evolved toward customary international law—particularly through its application to regional mineral resources and extension to MGRs—traditional customary law necessitates consistent and widespread state practice accompanied by *opinio juris* (Zhang, 2022). Essentially, the principle of the common heritage of mankind is neither the product of “instant custom” nor *jus cogens*, but functions more as a philosophical ideal (Joyner, 1986a). This underlying divergence is distinctly evident in the BBNJ negotiation records. Developing States assertively advocate for the principle’s status as customary international law, while developed States emphasize its foundation in treaty law (Liu and Qi, 2022). Although the principle has gained a certain degree of normative traction, the precise nature of its obligations remains contingent on the nuanced implementation and robust enforcement mechanisms within the agreement.

Third, the benefit-sharing model in the BBNJ Agreement may not fully align with the construction of a fair and equitable international economic order. On the one hand, while MGR derivatives in ABNJ possess potential economic value, their commercialization process is highly uncertain, and their monetary value at the research and exploration stage is not as immediately apparent as mineral resources (Leary and Juniper, 2013). Many MGRs may never generate substantial economic benefits, as their value often depends on extensive research, technological breakthroughs, and successful integration into commercial applications. Therefore, the direct imposition of monetary benefit-sharing obligations on MGR exploitation without considering the long and unpredictable research and development cycle may create unintended disincentives for marine biotechnology research (Shi, 2023). Empirical studies in innovation economics have shown that excessive financial burdens on early-stage biotechnological research can deter private sector investment and slow down scientific progress (Bloch and Guigues, 2014). In this context, balancing monetary benefit-sharing with incentives for continued R&D remains a critical challenge. On the other hand, the implementation of non-monetary benefit-sharing

provisions in the BBNJ Agreement faces practical difficulties. The development and application of genetic resources are closely linked to intellectual property rights and proprietary technologies, making it unrealistic to expect nations or private entities to freely or indiscriminately share advanced biotechnologies. Lessons from existing international frameworks, such as UNCLOS and the Nagoya Protocol, demonstrate that while these agreements include provisions on non-monetary benefits such as knowledge transfer and capacity-building, their enforcement has been inconsistent and often limited in effectiveness (Lü, 2024). Furthermore, the mere transfer of sophisticated technology to nations lacking the infrastructure or expertise to utilize it does not necessarily contribute to equitable benefit-sharing. Therefore, it has been proposed that a pragmatic consensus is needed to implement benefit-sharing, ensuring that all parties have opportunities to participate and benefit without rigid adherence to equal or monetary exchange models.

3 Core disputes over benefit-sharing of MGRs in ABNJ

Given that the UNCLOS serves as the cornerstone of international law for global ocean governance, marine activities, including benefit-sharing of MGRs in ABNJ, should adhere to its provisions. However, the “deepest of ironies” lies in the fact that while MGRs in ABNJ are increasingly attracting commercial and scientific interest, UNCLOS does not mention them at all (Broggiato et al., 2025); although they can be freely acquired on the high seas, there are no official international mechanisms to ensure their fair and equitable utilization (Glowka, 1996). This situation gives rise to diverse interpretations and irreconcilable divergences among nations regarding the benefit-sharing of MGRs in ABNJ. Behind these significant divergences lies a complex interplay among States characterized by differing economic strengths, geographical locations, resource endowments, and developmental capacities. The following outlines substantive differences that persist unresolved within the BBNJ “package deal”.

3.1 The legal ambiguity of derivatives of MGRs

Derivatives of MGRs in ABNJ are considered to have potential socio-economic value. Some studies suggest that the DNA and RNA derivatives extracted from MGRs in ABNJ exhibit multiple functions, including anti-cancer, anti-oxidation, anti-fungal, anti-viral, anti-tuberculosis, and anti-ultraviolet properties (UN General Assembly, 2007). While research on these derivatives is still at a relatively early stage, and the likelihood of obtaining monetary benefits from MGRs in ABNJ remains highly uncertain, the possibility of significant economic value has drawn substantial attention from various States (Harden-Davies, 2017). However, since the international community has not reached a consensus

on the legal status of MGR derivatives, their role in the benefit-sharing framework for MGRs in ABNJ remains unresolved. Some developed States argue that the genetic information contained in the derivative and the derivative itself are two distinct subjects of rights (UN Headquarters, 2019). Consequently, they assert that only the genetic resource itself—rather than its derivatives—should be subject to the benefit-sharing mechanism.

However, many developing States argue that derivatives are composite resources consisting of tangible biological vectors and intangible genetic information (UN Headquarters, 2018). Therefore, they assert that derivatives should be included in the benefit-sharing mechanism. For instance, member states of the Caribbean Community (CARICOM), including Haiti, Antigua, and Jamaica, have proposed to the Preparatory Commission that gene sequencing data and derivatives belong to MGRs in ABNJ. According to their position, neither the samples collected *in situ* nor *ex-situ* samples, data, and related information obtained through computer simulation should be excluded from MGRs in ABNJ (CARICOM, 2017). Similarly, biodiversity-rich States such as South Africa contend that the exclusion of derivatives, biochemicals or metabolic extracts from international law would significantly reduce benefit-sharing opportunities. Reflecting this stance, many of these states have enacted benefit-sharing laws that extend beyond the scope of the CBD (Wynberg and Mandy, 2009). Additionally, several developing States advocate defining derivatives by referencing international legal instruments like the Nagoya Protocol to ensure a more uniform concept of “genetic resources”. Article 2(C) of the Nagoya Protocol defines the technological application of biological systems, organisms, or their derivatives as the “utilization of genetic resources”, without requiring that the derivatives contain functional units of heredity (Secretariat of the Convention on Biological Diversity, 2011). Based on this understanding, many developing states maintain that derivatives should be recognized as part of MGRs in ABNJ and thus be subject to benefit-sharing.

The reasons are as follows: on the one hand, derivatives exist in many forms and have various connections to naturally occurring genetic resources (Humphries, 2016b). On the other hand, the criterion for determining whether derivatives fall within the scope of benefit-sharing obligations seems to be biological origin rather than biological form (Humphries, 2018). In recent years, derivatives of MGRs in ABNJ have begun to become “de-materialized” and are moving towards “digitalization.” Some developed States employ cutting-edge biotechnology to sequence specific genetic resources and synthesize the extracted genetic sequence information into derivatives, thus facilitating the development and utilization of MGRs in ABNJ (Chen, 2020). This activity bypasses the benefit-sharing regulations on tangible genetic resources in the CBD and the Nagoya Protocol, significantly harming the marine interests of developing States (Bagley, 2022). Although experts agree that digital sequence information is merely a placeholder that may be replaced by other terms in the future, there is ongoing debate over its concept and legal attributes, which hinders the implementation of benefit-sharing (Ad hoc technical expert, 2018).

3.2 Theoretical tensions in the application of legal principles

The international community holds varying opinions regarding the legal principles applicable to MGRs in ABNJ. In practice, some states contend that MGRs in ABNJ should be governed by the principle of the common heritage of mankind, similar to mineral resources in the international seabed area (the Area) (Liu, 2020c). Conversely, others argue that MGRs in ABNJ should be subject to the principle of freedom of the high seas, as enshrined in UNCLOS, without the need to establish a new international legal regime (UN general assembly, 2010). There are also heated controversies and divergent positions on applicable principles, without a predominant viewpoint (Leary, 2012).

3.2.1 The modern applicability limits of the freedom of the high seas principle

The freedom of the high seas evolved from freedom of the seas. Since Hugo Grotius advanced the “freedom of the seas” theory in *Mare Liberum*, the freedom of the high seas from national jurisdiction and the freedom of activities on the high seas have been the dominant paradigms of international maritime law (Rometius, 2023). Regarding the applicable principle in ABNJ, States like the US and Japan advocate adhering to the custom of freedom of the high seas, which operates on a first-come, first-served basis, benefiting all States (International Institute for Sustainable Development (IISD), 2011). This argument is reasonable to some extent. The freedom of the high seas allows MGRs in ABNJ to remain characterized as common property. In the ancient Greek view, Aristotle stated that water is not bounded by a boundary of its own substance (Sokolowski, 1970). In Roman law practice, the sea was regarded as “*res communis omnium* or common and free to all” (Ku, 1990). According to natural law theory, Grotius also explained that the free-flowing and inexhaustible ocean was the common property of mankind, reinforcing the historical foundation of the freedom of the seas (Reppy, 1950). Treating MGRs in ABNJ as common property means that they are enjoyed by the global community as a whole and are not subject to exclusive control. In other words, while states may access and utilize these resources, the common property approach generally prevents any single state from acquiring exclusive jurisdiction through pre-occupation (Wang and Sun, 2019).

However, the freedom of the high seas cannot be adequately adapted to the current context of international ocean governance. First, Grotius’ assertion of the freedom of the high seas was based on the limited capacity for ocean development and the perceived inexhaustibility of ocean resources. However, advancements in modern marine technology and a growing world population have led to the overexploitation of marine resources, revealing the limitations of Grotius’s concept of common goods and the freedom of the high seas (Schrijver and Prislán, 2009). Second, the principle of the freedom of the high seas is relative and has been diminished in the evolution of international maritime law (Scovazzi, 2007). Numerous international agreements and legal

instruments indicate a general trend towards the erosion and conceptualization of the freedom of the seas (Young, 2016). Therefore, the exploitation of MGRs in ABNJ is unlikely to be exclusively governed by the principle of the freedom of the high seas, given the increasing regulatory constraints under international agreements. Third, the traditional principle of freedom of the high seas faces growing challenges from emerging concepts of equity and shared responsibility in ocean governance. Developing States contend that broad interpretations of this freedom perpetuate unequal access to marine resources, indicating that this principle alone cannot satisfy modern demands for fairness and sustainability (Liang, 2020). Thus, while the principle of the freedom of the high seas remains foundational to contemporary international maritime law, its application is increasingly constrained by numerous multilateral treaties and evolving customary international law (Wang, 2019). Scholars have noted that, from the perspective of positive law, whether in peacetime or wartime, regardless of geographical space or the content of rights, restrictions on the freedom of the high seas have persisted for hundreds of years and are becoming increasingly stringent (Zhang, 2015).

3.2.2 The equity challenges of the common heritage of mankind principle

The potential exploitation of MGRs in ABNJ presents significant economic and governance challenges. Unlike traditional resource extraction, the primary concern is not the physical depletion of MGRs but rather the competitive rush to collect, sequence, and privatize digital sequence information through intellectual property rights (Liu and Shi, 2024b). This open-access nature of MGRs has led to a race among developed States and private entities to secure exclusive control over valuable genetic information. Some scholars characterize this rush as an economic inefficiency or market failure, where the costs of excessive sampling, data collection, and patenting far outweigh the potential long-term benefits to society (Zhang, 2024a). In this context, the real issue is not resource depletion but rather the economic waste caused by the rush to identify, capture, and protect information.

In response to these concerns, many States advocate applying the principle of the common heritage of mankind to the exploitation of MGRs in ABNJ, emphasizing sustainable development and equitable benefit-sharing. For instance, G77/China has argued that this principle should serve as the legal foundation for distributing the benefits derived from MGRs, asserting that it is crucial for biodiversity conservation and the sustainable use of genetic resources (Group of 77 and China, 2016). Similarly, the African Group contends that the common heritage of mankind is a fundamental principle of UNCLOS, designed to establish a fairer and more resilient framework for ocean governance. According to this perspective, the benefit-sharing mechanism for MGRs should reflect this principle to prevent the monopolization of genetic resources by a few technologically advanced States (The BBNJ preparatory committee, 2016).

The rationale for applying the common heritage of mankind principle to MGRs lies in the attributes of genetic resources, the universal dispersal, and the historical practice of reciprocity (Brush,

2012). When landlocked States, geographically disadvantaged States, African coastal states, and small island developing states cannot equitably share the benefits of MGRs in ABNJ, this principle can help correct the inequity of benefits among States (Zhang and Zheng, 2018). Additionally, this principle not only reconciles the imbalance of maritime interests between a few developed States and developing States but also fully considers the rights and opportunities of future generations to utilize marine resources from a long-term perspective of intergenerational equity. However, the principle of the common heritage of mankind has not yet developed into international customary law due to its unclear content (Qureshi, 2019). For example, the US has historically interpreted the common heritage of mankind as another expression of the freedom regime through an “open access interpretation” (Goldie, 1983). Similarly, the “equitable sharing of benefits, implying distributive justice” under the common heritage of mankind is widely controversial (Noyes, 2012b). These examples reflect that the principle of the common heritage of mankind has not yet met the two main elements of international custom. Nevertheless, since the principle has an institutional basis in instruments such as UNCLOS and the Moon Agreement, it has gained the support of many States and is applied in specific fields.

The value of the common heritage of mankind is broadly acknowledged (Song and Zhang, 2021), but its application to MGRs in ABNJ faces numerous obstacles. First, intellectual property rights regimes may undermine its effectiveness. If MGRs are considered part of the common heritage of mankind, no State should be able to appropriate them exclusively (Hu, 2023). However, developed States and private entities can establish de facto control over MGRs through patents on digital sequence information, exacerbating the North-South divide and reinforcing existing economic imbalances (Greiber, 2011). Second, MGRs are not explicitly recognized as part of the common heritage of mankind in international law. The scope of the common heritage of mankind is currently restricted to mineral resources and excludes biological resources. Although some academics have attempted to use the interpretive tools of the Vienna Convention on the Law of Treaties to demonstrate that MGRs can be included in the common heritage of mankind, these interpretations do not offer compelling evidence to support or refute their claims (Marciniak, 2017). Third, the principle of the common heritage of mankind does not provide effective guidance for the conservation of BBNJ (Wang L. Q., 2024). Its focus on benefit-sharing through resource utilization offers limited tools for addressing the ecological imperatives of long-term biodiversity protection. Finally, the principle of the common heritage of mankind advocates the “community” of MGRs, which opposes the will of sovereigns to “nationalize” them. Sovereignty is restricted by the sovereign itself, and requiring sovereign States to undertake heavy benefit-sharing obligations means that States must relinquish sovereign rights. This partly explains why the US, Russia, and Japan consistently insisted during the formulation of the BBNJ Agreement that the common heritage of mankind applies to the mineral resources in the Area, but not to the MGRs in ABNJ (The BBNJ preparatory committee, 2017).

3.3 Implementation challenges in benefit-sharing mechanisms

Benefit-sharing reflects the pursuit of a fair and equitable framework by developing States and their refusal to accept a situation where a few States seek the majority of benefits from MGRs in ABNJ. However, some economically developed States argue that the essence of benefit-sharing is rooted in the movement of developing States to promote a new international economic order (Tladi, 2014b). Regarding the specific implementation mechanism, there are evident divergences among stakeholders on the mode and type of benefit-sharing.

3.3.1 Voluntary vs. mandatory benefit-sharing modes

Currently, the necessity for benefit-sharing is widely acknowledged in the international community, but there is considerable disagreement on the model of benefit-sharing to be chosen. At the second session of the intergovernmental meeting to agree on options for the BBNJ Agreement, participants proposed two types of benefit-sharing models: voluntary and mandatory (UN General Assembly, 2018). The voluntary model entails the signing of a contract by the Parties after discussion and negotiation to specify their respective rights and obligations, whereas the mandatory model involves the adoption of binding international legal instruments to facilitate the realization of benefit-sharing objectives. The positions of States regarding the selection of a benefit-sharing model are widely divergent and remain polarized (Humphries et al., 2020). For instance, G77/China prefers a mandatory model, while the US, Japan, South Korea, and Russia favor a voluntary model. Despite a more moderate stance, the EU, Norway, Canada, and Singapore are inclined to remain anti-regulatory (De Santo et al., 2020).

By contrasting and evaluating the benefit-sharing models, it becomes evident that both models have their own advantages and disadvantages when applied to the actual utilization of MGRs in ABNJ. Consequently, the voluntary model aligns more with the traditions of the market economy and the requirements of biotechnology development, making it conducive to promoting and implementing the benefit-sharing mechanism. In the Nagoya Protocol, States can share benefits according to the terms of the contract, and this mechanism is underpinned by the voluntary model (Hanssen, 2018). However, the voluntary model tends to result in users of genetic resources exploiting their dominant position to coerce developing States into accepting inequitable terms. The absence of a comprehensive monitoring mechanism could render the voluntary model a means for developed States to abuse the interests of the marine, and the concept of benefit-sharing would lose its meaning (Zhang and Zhang, 2020).

In contrast, the primary feature of the obligatory model is that it requires resource users to undertake benefit-sharing activities within a legal framework, thereby aiming to create a relatively equitable pattern of benefits. For example, the International Treaty on Plant Genetic Resources for Food and Agriculture (PGRFA) stipulates in its benefit-sharing mechanism that the acquirers of

genetic resources should pay benefits from commercialization according to a specific mechanism and a reasonable share (Food and Agriculture Organization of the United Nations, 2009). The mandatory model establishes a minimum standard for benefit-sharing, which aims to reverse the unfavorable position of the relatively weak and avoid the rising transaction costs associated with constant negotiations. However, there is greater resistance to setting up mandatory model legislation at the international level, and reaching a consensus among States on the benefit-sharing standards that can be followed is difficult. Therefore, even if mandatory arrangements can be made for the benefit-sharing of MGRs, it may not produce the expected binding force (Zhang, 2024b).

3.3.2 Monetary vs. non-monetary forms of benefit-sharing

Benefits arising from the utilization of MGRs in ABNJ may be monetary or non-monetary (Morgera, 2018-2019). The former is expressed in currencies such as biological development fees and sample acquisition fees, while the latter is expressed in non-monetary forms such as technology, databases, and publications. This classification is stipulated in international law-making experiences such as CBD and PGRFA. While the sharing of non-monetary benefits was largely endorsed by delegates during the BBNJ Agreement's negotiation phase, significant debates arose regarding the sharing of monetary benefits (UN General Assembly, 2019). Some States believed that both monetary and non-monetary benefits could have a positive impact on stakeholders, while others claimed that the burden of monetary benefits would exceed the potential benefits of the entire system, potentially inhibiting the research and development of MGRs in ABNJ, and ultimately leading to the failure of realizing even non-monetary benefits (Collins et al., 2020). In this regard, the US expressed its opposition to including monetary benefits and emphasized that benefit-sharing should focus on capacity building and protection (the U.S. Delegation, 2016).

In comparison to non-monetary benefits, monetary benefits can directly and pragmatically address the unfair initial distribution of maritime rights and interests in ABNJ. When some developed States commercialize MGRs in ABNJ, monetary benefits can make up for the unfairness caused by the monopoly of intellectual property rights (Yuan and Ma, 2022a). However, the limitation of monetary benefits lies in its failure to account for the significant manpower, material, and financial resources required for the actual development of MGRs in ABNJ. Regardless of the development cost of MGRs, focusing solely on the sharing of monetary benefits could discourage marine powers from pursuing further research and development (Morris, 2018). Additionally, monetary benefits alone do not fully adhere to the fair principle of benefit-sharing, which is generally based on the idea of "input more, gain more." For these reasons, non-monetary benefits such as cooperative research, personnel training, and technology transfer are essential components of an effective benefit-sharing mechanism. However, it is important to note that while non-monetary benefits may not substantially burden resource development States, marine

technology is closely tied to a State's core competitiveness and sensitive commercial secrets. Consequently, it is practically challenging to require States that acquire MGRs in ABNJ to fulfill non-monetary benefit-sharing obligations.

4 Legal analysis of benefit-sharing rules in the BBNJ agreement

Based on the above analysis, States with diverse national conditions and geographical regions have substantial disputes over the legal characteristics of derivatives, the applicable principles, and the implementation mechanism of benefit-sharing. However, if the dispute over the legal nature of derivatives cannot be resolved, the scope of benefit-sharing as a legal system cannot be determined (Tvedt and Schei, 2014). Without clarifying the principle and implementation mechanism of benefit-sharing, the goal of achieving a fair and equitable distribution of marine benefits cannot be realized. As the third implementing agreement of UNCLOS, the BBNJ Agreement addresses the core disputes in ABNJ in a flexible manner, and to some extent, restructures the pattern of high seas and regional maritime interests.

4.1 Normative reconstruction of the legal status of MGRs

The BBNJ Agreement defines MGRs in its "use of terms" section of Part I as "any material of marine plant, animal, microbial, or other origin containing functional units of heredity of actual or potential value" (UN General Assembly, 2023). This definition consolidates the CBD definitions of "genetic material" and "genetic resources", with the additional qualifier "marine". According to the BBNJ Agreement, determining whether something qualifies as an MGR must consider both its value and functional attributes. Regarding value attributes, MGRs must possess economic, ecological, or other forms of value. However, this does not imply that intrinsic or potential value should be disregarded, as the value of MGRs is not easily dismissed due to human cognitive limitations. Marine derivatives have demonstrated multifunctional utility in various research studies. For instance, microbial exopolysaccharides isolated from deep-sea hydrothermal vents are currently being evaluated for their potential applications in tissue regeneration and cardiovascular disease treatment. Research on hydrothermal vent microbes has also contributed to the development of cosmetic ingredients, such as anti-aging creams already available on the market (Leary et al., 2009). Therefore, derivatives may not be categorically excluded from the category of MGRs, as they may possess value attributes similar to those of genetic resources (Rabone et al., 2025). In terms of functional attributes, only those with identifiable genetic functions are generally recognized as MGRs. Even if marine derivatives lack genetic material but display biological activity, they are often classified as general biological resources. Consequently, arguments for including derivatives within the scope of genetic resources tend

to reflect practical considerations as much as, or even more than, biological science (Brogiato et al., 2014). However, the debate about whether derivatives fall under the scope of genetic resources remains unresolved, with ongoing discussions suggesting that they may need to be clarified by treaty bodies once the agreement is operational.

While the BBNJ Agreement does not explicitly classify derivatives as genetic resources, it acknowledges that digital sequence information can be deemed equivalent to MGRs in ABNJ for benefit-sharing purposes. From the perspective of value attributes, digital sequence information circumvents the developmental constraints of MGRs and enables recurrent utilization in biological research and manufacturing. In terms of functional attributes, although digital sequence information exists solely in digital form without the carrier of marine organisms, it is based on information generated by decrypting or transcribing genetic units (Li, 2024b). Therefore, digital sequence information may not necessarily contravene the fundamental nature of MGRs. While digital sequence information is sometimes classified as a source distinct from physical MGRs or excluded from conventional definitions due to the absence of a material carrier, its contribution to the development and commercialization of MGRs suggests that it could reasonably be subject to fair and equitable benefit-sharing (Sun et al., 2021). From this standpoint, the legal implication of utilizing digital sequence information of MGRs is to undertake the obligation of benefit-sharing.

4.2 Systematic deconstruction of the common heritage of mankind principle

The principle of common heritage of mankind, initially excluded from the Draft BBNJ Agreement (UN General Assembly, 2019), was ultimately reinstated in the final text under the section on “General Principles and Approaches.” Article 7(2) of the BBNJ Agreement explicitly states that Parties shall be guided by this principle as outlined in the UNCLOS (Liu, 2020d). Given its significance in shaping international ocean governance, a systematic analysis of this principle is necessary. This analysis examines the three constitutive elements of legal relationships: legal subjects, legal objects, and normative content.

First, with regard to legal subjects, the principle of common heritage of mankind is understood to encompass “all humanity,” including both present and future generations. However, under existing international legal doctrine, recognizing humanity as a whole as a legal subject remains challenging. This is because it has not yet been acknowledged as a subject of international law, and the concept itself is overly abstract and broad. From the perspective of positive international law, the implementation of the common heritage of mankind principle primarily depends on State consent. As collective representatives of humanity, States manage and equitably share MGRs in ABNJ (Li, 2017). While they are empowered to develop these resources (Joyner, 1986b), they cannot claim exclusive ownership. To facilitate the effective implementation of this principle, the BBNJ Agreement introduces

a Clearing-House Mechanism as a centralized governance platform (Kim, 2024). This mechanism requires Parties to adopt necessary legislative, administrative, and policy measures to fulfill obligations such as information dissemination and environmental impact assessments. Notably, it also addresses the unique challenges faced by Small Island Developing States, ensuring the principle is applied equitably across nations with varying capacities. Overall, the principle of common heritage of mankind is particularly well-suited for conservation efforts, as it “encloses” a global commons within a regulated access regime, rather than free access (Massimi, 2024). This framework prioritizes the collective interests of humanity, integrating the rights of future generations and broader considerations of global fairness into marine resource governance.

Second, regarding legal objects, the concept of the common heritage of mankind is neither private property in civil law nor public property in political science, but an ancient concept rooted in Roman law. This concept requires that no State “should acquire more than its equitable share of resources” and the world community “should be entitled to take such steps as might be necessary to ensure such an equitable sharing”, which is also in line with the modern principles of the common heritage of mankind (Park, 1976). Initially, the common property of mankind in the BBNJ Agreement must be extraterritorial, and its geographical scope is strictly limited to the ABNJ. The polar region, the deep sea, and the Area have become the main exploration sites for the common heritage of mankind within national law of the sea. Furthermore, the common property of mankind has a shared attribute, meaning it must be open to all States, natural persons and legal persons without distinction (Wang L. Q., 2024). Although MGRs in ABNJ are currently exploited and utilized by a few developed States, developing States are not excluded from accessing or benefiting from these resources under international law. Finally, the common heritage of mankind has legal attributes, and it must be regulated and adjusted by international law (Jin, 2015). MGRs in ABNJ, as the common heritage of mankind, shall be bound by the BBNJ Agreement and cannot be amended or derogated from the principle of the common heritage of mankind in violation of Article 311(6) of UNCLOS.

Third, in terms of normative content, the common heritage of mankind should be used peacefully for the benefit of all humanity. As one of the principles of the high seas, the principle of the common heritage of mankind is inherently linked to peaceful use of ocean space (Tsarev, 1988). This connection is explicitly reflected in the BBNJ Agreement. Regarding proactive provisions, Article 11 of the BBNJ Agreement stipulates that activities related to MGRs and digital sequence information in ABNJ should be conducted solely for peaceful purposes, with due regard for the interests of other States in ABNJ. This provision echoes the preamble of UNCLOS to “promote the peaceful uses of the seas and oceans, the equitable and efficient utilization of their resources” and “takes into account the interests and needs of mankind as a whole”. In addition, Articles 57 and 58 of the BBNJ Agreement require the Parties to settle disputes by peaceful means. Given the many discrepancies and contradictions in maritime claims, legal applications, and the understanding of objective facts among States, the peaceful

settlement of maritime disputes is of special practical significance for ensuring peaceful utilization (Zhang and Xie, 2010). In terms of negative provisions, the BBNJ Agreement mandates that Parties shall not claim or exercise sovereignty over MGRs in ABNJ. The extension of a State's sovereignty over the common heritage of mankind would be detrimental to the construction of a long-term stable marine environment and would contradict the purpose of peaceful use.

4.3 Institutional innovation of inclusive benefit-sharing models

Regarding the mode of benefit-sharing, the BBNJ Agreement adopts a combination of mandatory mode and voluntary mode. On the one hand, the mandatory model ensures that the acquisition, generation and utilization of MGRs in ABNJ can be carried out within the fair and equitable framework by determining the rights and obligations in advance. For example, the BBNJ Agreement requires the Parties to apply to the Clearing-House Mechanism for standardized batch identifiers, so as to ensure that MGRs and digital sequence information can be identified as originating from ABNJ. Moreover, the Parties should prepare a summary report every two years and submit it to the newly established access and benefit-sharing committee to promote transparent monitoring. On the other hand, the voluntary model, with its flexible and efficient features, can facilitate a consensus on benefit-sharing. For example, the Parties should establish mutually agreed terms with indigenous peoples and local communities when utilizing traditional knowledge in ABNJ. Mutually agreed terms give room for free negotiation between the Parties and create a more equitable trading environment for benefit-sharing of MGRs (Qin, 2006). However, the mutual agreement does not mean that the Parties can agree on any benefit-sharing conditions without restriction, and they must nonetheless abide by the minimal legal requirements, principles, and goals of the BBNJ Agreement.

The BBNJ Agreement insists on the parallel existence of monetary and non-monetary benefits when it comes to benefit-sharing types. Article 14(2) of the BBNJ Agreement outlines the main forms of non-monetary benefits, including but not limited to the provision of samples of genetic resources, the sharing of digital sequence information, the disclosure of scientific data, and the transfer of marine technology. However, non-monetary benefits are not typically accompanied by onerous reporting requirements in order to accommodate the special requirements and priorities of least developed States, small island developing States, coastal African States, etc. In addition to non-monetary benefit-sharing, the BBNJ Agreement also requires the Parties to fulfill monetary benefit obligations under the newly established financial mechanism. The Parties shall make payments and contributions related to the product commercialization in stages through the special fund. The access and benefit-sharing committee ought to formulate benefit-sharing guidelines and might make recommendations to the Conference of the Parties on the rate and mechanism of monetary benefits. The above two types of

benefit sharing take into account the national conditions and actual needs of different States to the maximum extent, ensuring that all parties can share the results of MGRs in ABNJ.

5 Conclusion and recommendations

The traditional UNCLOS-centered ocean governance system faces significant challenges in addressing non-traditional security issues within global commons (Wang W, 2024). The BBNJ Agreement represents a paradigm shift, transforming the benefit-sharing of MGRs from a merely ethical practice to a comprehensive legal framework deeply intertwined with sustainable development, indigenous community interests, and intergenerational equity. By establishing a novel legal foundation for global ocean governance, the Agreement seeks to harmonize the diverse and often conflicting interests of individual nations with the collective interests of humanity. Nonetheless, as analyzed above, the Agreement still faces significant gaps: the lack of a clear definition of MGRs and their derivatives creates legal uncertainty; the coexistence of competing principles without coordination mechanisms leads to interpretive conflicts; and the absence of a balanced, operable benefit-sharing model may hinder fair and efficient implementation. This paper offers specific recommendations to strengthen the Agreement's operability and equity.

5.1 Expanding MGR definitional scope to encompass derivatives

First, it is recommended to adopt a broad interpretative approach that includes derivatives within the benefit-sharing framework. On one hand, this can be justified through the Vienna Convention on the Law of Treaties' interpretative rules (Gottlieb et al., 2025). From a systematic interpretation perspective, although UNCLOS Article 133 restricts "resources" to minerals, the BBNJ Agreement's implementation framework should maintain consistency with the CBD regarding the definition of "genetic resources." According to a purposive interpretation, the BBNJ Agreement's core objectives are protecting marine biodiversity and equitably sharing MGR benefits." Excluding derivatives from the benefit-sharing mechanism could create potential loopholes that might allow some corporations to evade obligations through chemical modifications of MGRs, potentially affecting funding for marine conservation and challenging principles of equitable sharing (Broggiato et al., 2014). On the other hand, the Conference of Parties could establish a negative list explicitly excluding derivative categories that do not constitute MGRs, such as entirely artificially synthesized molecules. Additionally, the framework could initially incorporate direct derivatives with close, traceable relationships to MGRs—such as gene expression products and natural metabolites—before gradually expanding to indirect derivatives. However, this approach may encounter practical difficulties, such as how to clearly distinguish between derivatives that occur naturally in marine organisms and those that are artificially synthesized in laboratories, as well as how to set clear criteria for determining which types of derivatives should be

subject to benefit-sharing. For contested derivatives, an expert committee comprising scientists, legal specialists, and industry representatives could issue determinations based on scientific facts and technological capabilities (See [Table 1](#) below).

5.2 Implementing a phased benefit-sharing mechanism

Second, to reconcile principle divergences within the BBNJ Agreement's benefit-sharing provisions, a phased benefit-sharing mechanism is recommended. This mechanism integrates the freedom of the high seas principle with the common heritage of mankind principle across different MGR utilization stages, thus avoiding a binary choice dilemma ([Tiller et al., 2019b](#)). In the initial stage, a flexible management approach aligned with high seas freedom principles would permit nations to freely access MGRs after simple registration, facilitating deep-sea biodiversity research. As MGR development progresses toward commercialization, the common heritage principle should be gradually introduced, with clear trigger conditions established at patent application, product development, or market sale stages to activate benefit-sharing obligations. For instance, post-market launch, companies would contribute a percentage of sales revenue as monetary returns to a global fund supporting ocean conservation and developing States' capacity-building initiatives. To ensure efficient mechanism implementation, a blockchain-based MGR tracking system ([Sustainability directory, 2025](#)) could record comprehensive information from sample collection and gene sequencing to product commercialization ([Humphries et al., 2021](#)). Through smart contracts, companies selling MGR derivatives would automatically calculate applicable royalties for transfer to the BBNJ fund. However, implementing a blockchain system to track MGRs from collection to commercialization requires robust technical infrastructure, interoperability across jurisdictions, and data privacy safeguards ([Yuan and Ma, 2022b](#)). Developing a universal system that integrates diverse national databases and ensures real-time transparency is complex ([Howson, 2020](#)). For example, blockchain's energy consumption and scalability limitations may pose challenges in

resource-constrained regions. Simultaneously, differentiated responsibilities could be assigned to various users, with pure research institutions bearing distinct benefit-sharing obligations from commercial entities. This phased approach respects developed States' concerns regarding early-stage R&D burden reduction while addressing developing States' demands for equitable commercial revenue sharing. However, this distinction could create loopholes, such as companies outsourcing MGR collection to academic partners to avoid obligations, or researchers being disincentivized from disclosing commercially valuable discoveries ([Brogiato et al., 2014](#)). This issue is reflected in the biotech sector, where pharmaceutical firms often collaborate with universities to access genetic resources, leading to ambiguity about who should bear the benefit-sharing responsibilities.

5.3 Structuring a hybrid Benefit-Sharing Model

Third, the BBNJ implementation mechanism should balance equity and operability by constructing a hybrid benefit-sharing model accommodating all stakeholders' interests. Regarding monetary benefits, establishing an MGR Benefit-Sharing Fund with progressive allocation mechanisms for commercial revenues would ensure reasonable returns from genetic resource development to global ocean governance ([Druel and Gjerde, 2014](#)). Specifically, enterprises and research institutions utilizing MGRs and achieving commercial outcomes should contribute a percentage of sales to the fund, supporting developing States' marine scientific research capacity. For non-monetary benefits, promoting global marine genetic resource database development would enhance data sharing and international scientific cooperation. Developed States should provide developing States with open access to genetic data, experimental techniques, and relevant intellectual property licenses while encouraging regional research center establishment to improve technology transfer feasibility ([Vierros and Harden-Davies, 2020](#)). To further bridge monetary and non-monetary benefit-sharing divergences, resource developers could be permitted to fulfill obligations through direct monetary payments or non-

TABLE 1 Derivative types of MGRs and their inclusion in benefit-sharing.

Type of Derivative	Definition/Example	Suggested Inclusion	Potential Challenges
Direct derivatives	Gene expression products, proteins, natural metabolites	Mandatory inclusion	High cost of technical traceability; limited monitoring capacity in developing States
Indirect derivatives	Molecules modified through chemical or synthetic biology methods	Conditional inclusion	Ambiguity in the "substantive function" criterion; disputes over technical determination
Artificially synthesized derivatives	Fully synthetic products based on digital sequence information from MGRs	Inclusion based on DSI provisions	Unclear definition of DSI; disputes over data sovereignty and intellectual property
Hybrid-source products	Products combining MGRs with other resources	Inclusion based on proportional contribution	Lack of standardized quantification methods; risk of responsibility evasion through fragmented R&D
Negative list exclusions	Synthetic products entirely unrelated to MGRs and not using any associated information	Explicit exclusion	Lag in list updates relative to technological development; potential expansion by developed States to protect industry

monetary contributions within certain parameters, while establishing minimum contribution standards ensuring developing States receive substantive benefits from MGR utilization.

In conclusion, BBNJ Agreement implementation should prioritize advancing all humanity's welfare rather than solely serving developing States' interests. The benefit-sharing mechanism must address vulnerable groups' marine welfare while providing maritime powers with practical incentives to balance stakeholder interests. Only through international community collaboration can the BBNJ Agreement protect marine biodiversity while constructing a more equitable, rational, and sustainable global ocean governance system.

Author contributions

SR: Writing – review & editing. WW: Writing – original draft.

Funding

The author(s) declare that financial support was received for the research and/or publication of this article. This research was funded by the Zhejiang Province Philosophy and Social Science Leading

Talents Cultivation Project (Grant No. 23YJRC02ZD) and China Scholarship Council (CSC) Program (Grant No. 202406320076).

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Generative AI was used in the creation of this manuscript.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

- Abegón-Novella, M. (2022). Negotiating an international legal instrument on biodiversity beyond national jurisdiction: A look ahead. *Environ. Policy Law* 52, 25. doi: 10.3233/epl-210082
- Anderson, D. (2006). "Freedoms of the high seas in the modern law of the sea," in *The Law of the Sea: Progress and Prospects*. Eds. D. Freestone, R. Barnes and D. Ong (Oxford University Press, Oxford), 331–332. doi: 10.1093/acprof:oso/9780199299614.003.0017
- Andreone, G., Rossi, V., and Ardito, G. (2024). "Legal regime of marine genetic resources in areas beyond national jurisdiction," in *Diatom photosynthesis: from primary production to high-value molecules*. Eds. J. W. Goessling, J. Serôdio and J. Lavaud (Wiley-Scrivener, Hoboken, NJ, USA), 588. doi: 10.1002/9781119842156.ch19
- Aseeva, A. (2017). *It should be noted that the freedom of the high seas and the common heritage of mankind are not in absolute opposition. Mexico emphasized in its submission to the Working Group that the two principles are "complementary and harmonious."* A(n) (im)possibility of justice in the case of conservation of marine biodiversity of areas beyond national jurisdiction. iCourts Working Paper Series No. 89. at 28. (University of Copenhagen, Faculty of Law, Copenhagen). Available at: <https://ssrn.com/abstract=2943963> (Accessed 17 May 2024).
- (2008). *Ad hoc open-ended working group on access and benefit-sharing, report of the meeting of the group of legal and technical experts on concepts, terms, working definitions and sectoral approaches*. Available online at: <https://www.cbd.int/kb/record/meetingDocument/67478?FreeText=CBD%20Technical%20Series%2010> (Accessed 7 August 2024).
- (2017). *Caribbean community, submission on behalf of the member states of the caribbean community (CARIBCOM) for the development of an international legally-binding instrument under the convention on the law of the sea on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction*. Available online at: https://www.un.org/depts/los/biodiversity/prepcom_files/streamlined/CARICOM.pdf (Accessed 29 July 2024).
- (2011). *Secretariat of the Convention on Biological Diversity, The Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity*. Available online at: <https://www.cbd.int/abs/doc/protocol/nagoya-protocol-en.pdf> (Accessed 30 July 2024).
- (2018). *Ad hoc technical expert group. Report on digital sequence information on genetic resources*. Available online at: <https://www.cbd.int/doc/c/4f53/a660/20273cadac313787b058a7b6/dsi-ahteg-2018-01-04-en.pdf> (Accessed 31 July 2024).
- (2010). *UN general assembly, letter dated 16 march 2010 from the co-chairpersons of the ad hoc open-ended informal working group to the president of the general assembly*. Available online at: <https://documents-dds-ny.un.org/doc/UNDOC/GEN/N10/277/20/PDF/N1027720.pdf?OpenElement> (Accessed 14 August 2024).
- (2016). *The Group of 77 and China, Development of an International Legally Binding Instrument Under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction-group of 77 and China's Written submission*. Available online at: https://www.un.org/depts/los/biodiversity/prepcom_files/rolling_comp/Group_of_77_and_China.pdf (Accessed 1 August 2024).
- (2016). *The BBNJ preparatory committee, the elements of a draft text of an international legally binding instrument under the UN convention on the law of the sea on the conservation and sustainable use of marine biodiversity of areas beyond national jurisdiction*. Available online at: <https://enb.iisd.org/events/1st-session-bbnj-preparatory-committee/summary-report-28-march-8-april-2016> (Accessed 1 August 2024).
- (2017). *The BBNJ preparatory committee, summary of the informal working group on marine genetic resources 27 March 2017*. Available online at: <https://enb.iisd.org/events/3rd-session-bbnj-preparatory-committee/daily-report-27-march-2017> (Accessed 2 August 2024).
- (2016). *The U.S. Delegation, Views Expressed by the United States Delegation Related to Certain Key Issues Under Discussion at the Second Session of the Preparatory Committee on the Development of an International Legally Binding Instrument Under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity 9 September 2016*. Available online at: https://www.un.org/depts/los/biodiversity/prepcom_files/USA_Submission_of_Views_Expressed.pdf (Accessed 3 August 2024).
- (2025). *Sustainability directory, blockchain for transparent marine resource benefit*. Available online at: <https://prism.sustainability-directory.com/scenario/blockchain-for-transparent-marine-resource-benefit-sharing/> (Accessed March 30, 2025).
- Bagley, M. A. (2022). Just Sharing: the virtues of digital sequence information benefit-sharing for the common good. *Harvard Int. Law J.* 63, 19–20. Available at: https://www.researchgate.net/publication/357028113_Just_Sharing_The_Virtues_of_Digital_Sequence_Information_Benefit-Sharing_for_the_Common_Good (Accessed 30 March 2025).
- Bloch, J. F., and Guigues, E. T. (2014). Marine biotechnologies and synthetic biology, new issues for a fair and equitable profit-sharing commercial use. *Mar. Genomics* 17, 80. doi: 10.1016/j.margen.2014.07.003
- Broggiato, A., Arnaud-Haond, S., Chiarolla, C., and Greiber, T. (2014). Fair and equitable sharing of benefits from the utilization of marine genetic resources in areas

beyond national jurisdiction: bridging the gaps between science and policy. *Mar. Policy* 49, 177. doi: 10.1016/j.marpol.2014.02.012

Broggiato, A., Dunshirn, P., Jaspars, M., and Pena-Neira, S. (Eds.) (2025). "Discussions on the economic significance of MGRs in ABNJ primarily focus on their potential rather than demonstrated economic value, with interest in their exploration and utilization remaining at an emergent stage," in *Monetary and non-monetary benefit sharing under the BBNJ agreement*. In: F. Humphries (eds), *decoding marine genetic resource governance under the BBNJ agreement. Sustainable development goals series* (Springer, Cham), 162–163. doi: 10.1007/978-3-031-72100-7_6

Broggiato, A., Vanagt, T., Lallier, L. E., et al (2018). Mare geneticum: Balancing Governance of Marine Genetic Resources in International Waters. *Int. J. Mar. Coast. Law* 33, 6. doi: 10.1163/15718085-13310030

Brush, S. B. (2012). "The demise of "Common heritage" and protection for traditional agricultural knowledge," in *Biodiversity and the law*. Ed. C. R. McManis (Routledge, London, United Kingdom), 299.

Chang, Y. C., Javid, M., and Khan, M. I. (2024). BBNJ agreement in the purview of developing countries: A case study of Pakistan. *Mar. Policy* 165, 1–2. doi: 10.1016/j.marpol.2024.106201

Chang, C., Javid, M., and Khan, M. I. (2024). Patents confer exclusive rights for a limited term—typically 20 years—after which the invention enters the public domain. In contrast, trade secrets may last indefinitely if confidentiality is maintained, potentially creating longer-term access barriers for developing States. *BBNJ Agreement Purview Developing Countries: A Case Study Pakistan Mar. Policy* 165, 2–3. doi: 10.1016/j.marpol.2024.106201

Chen, Z. B. (2020). On the legal nature of digital sequence information of biological genetic resources. *Jiangxi Soc. Sci.* 40, 186.

Collins, J. E., Vanagt, T., and Huys, I. (2020). Stakeholder perspectives on access and benefit-sharing for areas beyond national jurisdiction. *Front. Mar. Sci.* 7. doi: 10.3389/fmars.2020.00265

De Santo, E. M., Mendenhall, E., Nyman, E., and Tiller, R. (2020). Stuck in the Middle with you (and not Much Time Left): The Third Intergovernmental Conference on Biodiversity Beyond National Jurisdiction. *Mar. Policy* 117, 4. doi: 10.1016/j.marpol.2020.103957

Druel, E., and Gjerde, K. M. (2014). Sustaining marine life beyond boundaries: options for an implementing agreement for marine biodiversity beyond national jurisdiction under the united nations convention on the law of the sea. *Mar. Policy* 49, 93. doi: 10.1016/j.marpol.2013.11.023

Food and Agriculture Organization of the United Nations (2009). *The international treaty on plant genetic resources for food and agriculture*. Available online at: <https://www.fao.org/3/i0510e/i0510e.pdf> (Accessed 3 August 2024).

Glowka, L. (1996). *The deepest of ironies: genetic resources, marine scientific research, and the area, ocean yearbook online*, Vol. 12. (Brill | Nijhoff, Leiden), 155. doi: 10.1163/221160096x00111

Goldie, L. F. E. (1983). A note on some diverse meanings of "the common heritage of mankind". *Syracuse J. Int. Law Commerce* 10, 80–81. Available at: <https://surface.syr.edu/jilc/vol10/iss1/7> (Accessed 17 May 2025).

Gottlieb, H. M., Kachelriess, D., and Slobodian, L. (2025). "Understanding the preamble, objectives and principles of the BBNJ agreement: A focus on the fair and equitable sharing of benefits of marine genetic resources," in *Decoding governance of marine genetic resources under the BBNJ Agreement*. Ed. F. Humphries (Springer, Cham), 95–124. doi: 10.1007/978-3-031-72100-7_4

Greiber, T. (2011). *Access and benefit sharing in relation to marine genetic resources from areas beyond national jurisdiction: A possible way forward*. (Bundesamt für Naturschutz, Bonn), 8. Available at: https://bf.n.bsz-bw.de/frontdoor/deliver/index/docId/482/file/Skript_301.pdf (Accessed May 17, 2025).

Hanssen, G. (2018). Current 'Light' and 'Heavy' Options for benefit-sharing in the context of the united nations convention on the law of the sea. *Int. J. Mar. Coast. Law* 33, 15. doi: 10.1163/9789004391703_011

Harden-Davies, H. (2017). Deep-sea genetic resources: new frontiers for science and stewardship in areas beyond national jurisdiction. *Mar. Policy* 137, 506–507. doi: 10.1016/j.marpol.2016.05.005

Howson, P. (2020). Building trust and equity in marine conservation and fisheries supply chain management with blockchain. *Mar. Policy* 115, 103873. doi: 10.1016/j.marpol.2020.103873

Hu, B. (2020). Controversies in BBNJ marine genetic resources exploitation and their resolution: on the role of China in the "South-north divides". *Pacific J.* 28, 68. doi: 10.14015/j.cnki.1004-8049.2020.06.005

Hu, B. (2023). Returning to its Original Position as Functional Concept: Expanding Application of the Concept of Common Heritage of Mankind in other International Legal Fields. *J. SJTU (Philosophy Soc. Sciences)* 31, 30. doi: 10.13806/j.cnki.issn1008-7095.2023.03.003

Humphries, F. (2016a). Technology transfer of aquatic genetic resources under the convention on biological diversity and nagoya protocol: "Sponging" off patent law defences. *Univ. New South Wales Law J.* 39, 254. Available at: <https://ssrn.com/abstract=2882944> (Accessed May 18, 2025).

Humphries, F. (2016b). For example, derivatives can be understood as the products of an organism's metabolism (natural compounds), the results of human activities

utilizing genetic resources (physically synthesized compounds), and genetic resource information (intangible digital information). *Technol. Transfer Aquat. Genet. Resour. Under Convention Biol. Diversity Nagoya Protocol: "Sponging" off Patent Law Defences Univ. New South Wales Law J.* 39, 249–250. Available at: <https://ssrn.com/abstract=2882944> (Accessed May 18, 2025).

Humphries, F. (2018). "Banking on a patent solution for sharing ex situ genetic resources from antarctic waters," in *Biodiversity, genetic resources and intellectual property: developments in access and benefit sharing*. Ed. K. Adhikari (Routledge, Oxfordshire, United Kingdom), 61.

Humphries, F., Muraki Gottlieb, H., Laird, S., Wynberg, R., Lawson, C., Rourke, M., et al. (2020). A tiered approach to the marine genetic resource governance framework under the proposed UNCLOS agreement for biodiversity beyond national jurisdiction (BBNJ). *Marine Policy* 122, 103910. doi: 10.1016/j.marpol.2020.103910

Humphries, F. (2025). "Marine genetic resources beyond national jurisdiction: the expansive scope of the BBNJ agreement," in *Decoding marine genetic resource governance under the BBNJ agreement. Sustainable development goals series*. Ed. F. Humphries (Springer, Cham), 74–76. doi: 10.1007/978-3-031-72100-7_3

Humphries, F., Rabone, M., and Jaspars, M. (2021). Traceability approaches for marine genetic resources under the proposed ocean (BBNJ) treaty. *Front. Mar. Sci.* 8. doi: 10.3389/fmars.2021.661313

Intergovernmental Conference (2023). *Summary of the further resumed fifth session of the intergovernmental conference to adopt an international legally binding instrument under the UN convention on the law of the sea on the conservation and sustainable use of marine biodiversity of areas beyond national jurisdiction*. Available online at: <https://enb.iisd.org/marine-biodiversity-beyond-national-jurisdiction-bbnj-igc5-further-resumed-summary> (Accessed July 29, 2024).

International Institute for Sustainable Development (IISD) (2011). *Daily report for the fourth meeting of the BBNJ working group on marine biodiversity beyond areas of national jurisdiction*. Available online at: <https://enb.iisd.org/events/4th-meeting-bbnj-working-group/summary-report-31-may-3-june-2011> (Accessed 31 July 2024).

Jacquet, J., Carmine, G., and Jackson, J. (2023). UN multilateral agreement offers an opportunity to protect high seas biodiversity. *Sci. Adv.* 9, 1. doi: 10.1126/sciadv.adj1435

Jin, Y. M. (2015). Research on the legal nature of the common heritage of mankind. *J. Soc. Sci.* 3, 60.

Joyner, C. (1986a). Legal implications of the concept of the common heritage of mankind. *Int. Comp. Law Quart.* 35, 199. doi: 10.1093/iclqaj/35.1.190

Joyner, C. C. (1986b). "Article 157 of UNCLOS stipulates that the International Seabed Authority "is the organization through which States Parties shall organize and control activities in the Area", which clearly shows that the participants n utilizing the common heritage are States and not "mankind" subject to the jurisdiction of the State. Accordingly, a scholar directly asserted that under the system of the common heritage of mankind, the state "save as the representative agent of all mankind. Legal implications of the concept of the common heritage of mankind, . *Int. Comp. Law Quart.* 35, 191.

Khan, M. I. (2023). Law of the sea: normative context and interactions with other legal regimes, edited by nele matz-lück, øystein jensen and elise johansen. *Int. J. Mar. Coast. Law* 39, 199–200. doi: 10.1163/15718085-bja10146

Kim, R. E. (2024). The specific operating mode of the Clearing-House Mechanism shall be determined by the Conference of the Parties, and this mechanism may provide links to relevant global, regional, subregional, national and sectoral clearing-house mechanisms and other gene banks, repositories and databases, and where possible links with publicly available private and non-governmental platforms. See Kim, R. E. (2024) The likely impact of the BBNJ Agreement on the architecture of ocean governance. *Marine Policy* 165, 4. doi: 10.1016/j.marpol

Ku, C. (1990). The concept of res communis in international law. *History Eur. Ideas* 12, 460. doi: 10.1016/0191-6599(90)90002-V

Laird, S., Wynberg, R., Rourke, M., et al. . doi: 10.1126/science.aba9609

Leary, D. (2012). Moving the marine genetic resources debate forward: some reflections. *Int. J. Mar. Coast. Law* 27, 439–440. doi: 10.1163/157180812x633645

Leary, D. K., and Juniper, S. K. (2013). "Addressing the marine genetic resources issue: is the debate heading in the wrong direction?," in *The limits of maritime jurisdiction*. Eds. C. H. Schofield, S. Lee and M. Kwon (BRILL, Leiden), 769–785.

Leary, D., Vierros, M., Hamon, G., Arico, S., and Monagle, C. (2009). Marine genetic resources: A review of scientific and commercial interest. *Mar. Policy* 33, 187–188. doi: 10.1016/j.marpol.2008.05.010

Li, Z. W. (2017). The justification of the international sea-bed area resources as the common heritage of mankind. *J. Soc. Sci.* 6, 91–92. doi: 10.13644/j.cnki.cn31-1112.2017.06.009

Li, Z. W. (2018). International legal order for marine genetic resources distribution in certain areas: perspective of community of shared future for mankind. *Jilin Univ. J. Soc. Sci. Edition* 6, 37. doi: 10.15939/j.jujss.2018.06.f3

Li, Y. D. (2024a). Digital sequence information on genetic resources under the kunming-montreal framework: issues, current developments, and responses. *Academic Exchange* 7, 61.

Li, Y. D. (2024b). Digital sequence information on genetic resources under the kunming-montreal framework: issues, current developments, and responses. *Academic Exchange* 7, 58.

Liang, Y. (2020). *The relativity of the freedom of the high seas, journal of Jiangsu university (Social science edition)*, 22. 82–83. doi: 10.13317/j.cnki.jdskxb.2020.008

- Liao, B. Y., Chang, Y. C., and Khan, M. I. (2023). Jurisprudence in mixed maritime disputes suggests that States and tribunals may rely on interpretative flexibility to advance maritime claims beyond UNCLOS's text, reflecting the practical emergence of residual maritime rights, as illustrated by *Mauritius v. Maldives*. *Impact Monetary Gold Principle Determination Jurisdiction Mixed Maritime Disputes Sci. Prog.* 106, 1–14. doi: 10.1177/00368504231179814
- Liu, S. Z. (2020a). On the benefit-sharing system for marine genetic resources beyond national jurisdiction. *J. Political Sci. Law* 5, 78–79.
- Liu, S. Z. (2020c). On the benefit-sharing system for marine genetic resources beyond national jurisdiction. *J. Political Sci. Law* 5, 75.
- Liu, S. Z. (2020d). “Even in UNCLOS, the connotation and extension of the principle of the common heritage of mankind are vague, which limits this principle's further development. One scholar pointed out that the property rights expression and monetary distribution practice of this principle conceal its rich ethical significance in international law and further widen the distance between this principle and its original vision,” in *On the benefit-sharing system for marine genetic resources beyond national jurisdiction*, *Journal of political science and law*, vol. 5, 77–78.
- Liu, H. R., and Qi, X. W. (2022). An analysis on the common heritage of mankind principle's appearance or not in the BBNJ international agreement. *Legal Forum* 37, 156.
- Liu, Y., and Shi, Y. B. (2024a). Regulatory innovation of the BBNJ agreement to international law of the sea. *Pacific J.* 32, 95. doi: 10.14015/j.cnki.1004-8049.2024.05.007
- Liu, Y., and Shi, Y. B. (2024b). Regulatory innovation of the BBNJ agreement to international law of the sea. *Pacific J.* 32, 95. doi: 10.14015/j.cnki.1004-8049.2024.05.007
- Lü, Q. (2024). Balance on governance of marine genetic resources and protection of intellectual property rights. *Wuhan Univ. Int. Law Rev.* 8, 64–65. doi: 10.13871/j.cnki.whuirl.2024.02.004
- Marciniak, K. (2017). “Marine Genetic Resources: Do they Form Part of the Common Heritage of Mankind principle?,” in *Natural resources and the law of the sea: exploration, allocation, exploitation of natural resources in areas under national jurisdiction and beyond*, *Juris*. Eds. L. Martin, C. Saloniadis and C. Hioureas (Juris Publishing, Huntington, New York, USA), 384–397.
- Massimi, M. (2024). The fraught legacy of the common heritage of humankind principle for equitable ocean policy. *Environ. Sci. Policy* 153, 4. doi: 10.1016/j.envsci.2024.103681
- Morgera, E. (2018). In existing international treaties, benefit-sharing is always accompanied by qualifiers such as “fair” or “equitable”. However, there is considerable ambiguity in the usage of these fundamental terms in international documents and academic literature. From a theoretical perspective, some scholars have pointed out that “the use of the two expressions ‘fair and equitable’ serves to make explicit both procedural dimensions of justice (fairness) that determine the legitimacy of certain courses of action, as well as substantive dimensions of justice (equity) to balance competing rights and interests to the benefit of all”. See, Fair and Equitable Benefit-sharing in a New International Instrument on Marine Biodiversity: A Principled Approach Towards Partnership Building? *Maritime Saf. Secur. Law J.* 5, 60–62. Available at: <https://strathprints.strath.ac.uk/65414/> (Accessed May 17, 2025).
- Morgera, E. (2018–2019). It should be stressed that non-monetary benefits actually involve economic costs and values, and the binary classification of benefits into monetary and non-monetary is inaccurate. For instance, open access to digital sequence information of MGRs in ABNJ also requires sufficient infrastructure and financial support. Fair and Equitable Benefit-sharing in a New Treaty on Marine Biodiversity: A principled Approach Towards Partnership Building? *Maritime Saf. Secur. Law J.* 2, 54. Available at: <https://strathprints.strath.ac.uk/65414/> (Accessed 17 May 2025).
- Morgera, E., Tsioumani, E., and Buck, M. (2014). *Unraveling the nagoya protocol A commentary on the nagoya protocol on access and benefit-sharing to the convention on biological diversity*. (Brill, Leiden), 66. doi: 10.1163/j.ctt1w6vvq
- Morris, A. (2018). Marine Genetic Resources in Areas Beyond National Jurisdiction: How Should the Exploitation of the Resources be Regulated? *New Z. J. Environ. Law* 22, 81. Available at: <http://www.nzlii.org/nz/journals/NZJEnvLaw/2018/4.pdf> (Accessed May 17, 2025).
- Noyes, J. E. (2012a). The common heritage of mankind: past, present, and future. *Denver J. Int. Law Policy* 40, 452–453. Available at: <https://scholarlycommons.law.cwsl.edu/fs/21/> (Accessed May 17, 2025).
- Noyes, J. E. (2012b). The common heritage of mankind: past, present, and future. *Denver J. Int. Law Policy* 40, 451. Available at: <https://scholarlycommons.law.cwsl.edu/fs/21/> (Accessed May 17, 2025).
- Park, Y. O. (1976). Res communis versus res nullius. *J. East West Stud.* 5, 80. doi: 10.1080/12265087609432820
- Qin, T. B. (2006). Research on legal issues of access and benefit sharing of genetic resources, 1st ed. *Wuhan Univ. Press Wuhan* pp, 400–401.
- Qureshi, W. A. (2019). Protecting the common heritage of mankind beyond national jurisdiction. *Arizona J. Int. Comp. Law* 36, 93. Available at: <http://hdl.handle.net/10150/658779> (Accessed May 17, 2025).
- Rabone, M., Horton, T., Humphries, F., Lyal, C. H. C., Muraki Gottlieb, H., Scholz, A. H., et al. (2025). “BBNJ agreement: considerations for scientists and commercial end users of MGR at research, development and commercialization stages,” in *Decoding governance of marine genetic resources under the BBNJ Agreement*, Ed. F. Humphries (Springer, Cham), 292. doi: 10.1007/978-3-031-72100-7_14
- Reppy, A. (1950). The grotian doctrine of the freedom of the seas reappraised. *Fordham Law Rev.* 19, 269–270. Available at: <https://ir.lawnet.fordham.edu/flr/vol19/iss3/1/> (Accessed May 17, 2025).
- Rometius, S. (2023). Forty years' Reflection of the legislative features of the UNCLOS: A critical analysis. *J. East Asia Int. Law.* 16, 41. doi: 10.14330/jeail.2023.16.1.02
- Schrijver, N., and Prislav, V. (2009). From mare liberum to the global commons: building on the grotian heritage. *Grotiana* 30, 176. doi: 10.1163/016738309X12537002674484
- Scovazzi, T. (2007). The concept of common heritage of mankind and the genetic resources of the seabed beyond the limits of national jurisdiction. *Agenda Internacional* 14, 22. doi: 10.18800/agenda.200702.001
- Shi, Y. B. (2023). A step to victory: main divergences of and prospects for intergovernmental negotiations on marine biological diversity of areas beyond national jurisdiction. *Asia-Pacific Secur. Maritime Aff.* 151, 42. doi: 10.19780/j.cnki.ytaq.2023.1.3
- Sokolowski, R. (1970). Matter, elements and substance in aristotle. *J. Hist. Philos.* 8, 268. doi: 10.1353/hph.2008.1672
- Song, J., and Zhang, H. Y. (2021). Malta and the concept of the common heritage of mankind: formulate, push forward and develop. *J. Int. Law* 4, 1–3.
- Sun, M. H., Li, Y. S., and Zhao, F. W. (2021). Current status and challenges of protection, access to and benefit sharing of bio-genetic resources of China. *Environ. Prot.* 49, 32–33. doi: 10.14026/j.cnki.0253-9705.2021.21.002
- Taylor, P. (2019). The common heritage of mankind: expanding the oceanic circle. *Future Ocean Governance Capacity Development Brill Nijhof* p, 143. doi: 10.1163/9789004380271_025
- Tiller, R., Santo, E. D., Mendenhall, E., et al (2019a). The once and future treaty: towards a new regime for biodiversity in areas beyond national jurisdiction. *Mar. Policy* 99, 241. doi: 10.1016/j.marpol.2018.10.046
- Tiller, R., Santo, E. D., Mendenhall, E., et al (2019b). The once and future treaty: towards a new regime for biodiversity in areas beyond national jurisdiction. *Mar. Policy* 99, 241. doi: 10.1016/j.marpol.2018.10.046
- Tladi, D. (2014a). The principle of common heritage of mankind implies a trust and legal obligation to protect the earth's heritage for future generations. It is the pursuit of a more equitable framework and also reflects intergenerational and intragenerational equity and the convergence of the two. This contrasts sharply with the Westphalian model of international law. *Common Heritage Mankind Proposed Treaty Biodiversity Areas Beyond Natl. Jurisdiction: Choice Between Pragmatism Sustainability Yearbook Int. Environ. Law* 25, 127–130.
- Tladi, D. (2014b). The common heritage of mankind and the proposed treaty on biodiversity in areas beyond national jurisdiction: the choice between pragmatism and sustainability, yearbook of international environmental law. doi: 10.1093/yiel/yvv060
- Toledo, A. P. (2022). BBNJ agreement: high seas biodiversity as a common heritage (of mankind). *Meridiano 47-J. Glob. Stud.* 23, 6. doi: 10.20889/M47e23006
- Tsarev, V. F. (1988). Peaceful uses of the seas: principles and complexities. *Mar. Policy* 12, 156. doi: 10.1016/0308-597X(88)90042-5
- Tvedt, M. W., and Schei, P. J. (2014). “The term ‘Genetic resources’: flexible and dynamic while providing legal certainty?,” in *Global governance of genetic resources: access and benefit sharing after the nagoya protocol*, Eds. S. Oberthür and G. K. Rosendal (Routledge, London/New York), 18.
- UN General Assembly (2007). *Oceans and the law of the sea report of the secretary-general*. Available online at: <https://documents-dds-ny.un.org/doc/UNDOC/GEN/N07/266/94/PDF/N0726694.pdf?OpenElement> (Accessed 29 July 2024).
- UN General Assembly (2018). *President's aid to Negotiations of Intergovernmental Conference on an International Legally Binding Instrument Under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction*. Available online at: <https://documents.un.org/doc/undoc/gen/n18/413/20/pdf/n1841320.pdf?OpenElement> (Accessed August 2, 2024).
- UN General Assembly (2019). *Oral reports of the facilitators of the informal working groups to the plenary*. Available online at: <https://Documents-Dds-Ny.Un.Org/Doc/UNDOC/GEN/N19/281/55/PDF/N1928155.pdf?OpenElement> (Accessed 3 August 2024).
- UN General Assembly (2023). *Agreement under the united nations convention on the law of the sea on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction*. Available online at: <https://documents-dds-ny.un.org/doc/UNDOC/GEN/N19/146/28/PDF/N1914628.pdf?OpenElement> (Accessed 4 August 2024).
- UN Headquarters (2019). *Summary of the third session of the intergovernmental conference on the conservation and sustainable use of marine biodiversity of areas beyond national jurisdiction*. Available online at: <https://enb.iisd.org/events/3rd-session-intergovernmental-conference-igc-conservation-and-sustainable-use-marine/summary> (Accessed September 3, 2024).
- UN Headquarters (2018). *Summary of the first session of the intergovernmental conference on an international legally binding instrument under the UN convention on the law of the sea on the conservation and sustainable use of marine biodiversity of areas*

beyond national jurisdiction. Available online at: <https://enb.iisd.org/events/1st-session-intergovernmental-conference-igc-international-legally-binding-instrument-12> (Accessed 3 September 2024).

Vadrot, A. B. M., Langlet, A., and Wysocki, I. T. V. (2022). Who owns marine biodiversity? *Contesting World Order Through "Common Heritage Humankind"* *Principle Environ. Politics* 31, 227–233. doi: 10.1080/09644016.2021.1911442

Vierros, M. K., and Harden-Davies, H. (2020). Capacity building and technology transfer for improving governance of marine areas both beyond and within national jurisdiction. *Mar. Policy* 122, 10–11. doi: 10.1016/j.marpol.2020.104158

Walker, G. K., and Noyes, J. E. (2003). Definitions for the 1982 law of the sea convention. *California Western Int. Law J.* 33, 236. Available at: <https://scholarlycommons.law.cwsl.edu/cwilj/vol33/iss2/4> (Accessed May 18, 2025).

Wang, Y. (2019). "On the one hand, the principle of the freedom of the high seas is mainly limited by multilateral treaties, such as the 1958 Geneva Conventions on the Law of the Sea, the 1973 International Convention for the Prevention of Pollution from Ships and the 1982 Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks. On the other hand, customary international law may also restrict the principle of the freedom of the high seas. For example, warships or military aircraft have the right to combat piracy and to board and inspect stateless vessels," in *Reasonable restrictions on freedom of high seas by "Marine protected areas on the high seas": an empirical research, journal of east asia and international law*, (Yijun Institute of International Law in Journal of East Asia and International Law) 12 (2), 248–249. doi: 10.14330/jeail.2019.12.2.0

Wang, L. Q. (2024). Typical questions, refutations and implementation strategies of the principle of common heritage of mankind. *Environ. Law Rev.*, Vol. 2, 32–33.

Wang, W. (2024). Innovative strategies and forward thinking on China's digital maritime law enforcement. *Mar. Policy* 169, 106369. doi: 10.1016/j.marpol.2024.106369

Wang, M. Y., and Sun, X. Y. (2019). On the legal status of international seabed mineral resources. *J. Renmin Univ. China* 33, 70–72.

Wynberg, R., and Mandy, T. (2009). "Finding a path through the ABS maze: challenges of regulating access and ensuring fair benefit sharing in South Africa," in *Traditional knowledge and the law: solutions for access and benefit sharing*, earthscan.

Eds. E. C. Kamau and G. Winter (Earthscan, London, United Kingdom, and Sterling, Virginia, USA), 213.

Yan, L. C., and Guo, P. (2024a). A study on construction a view of inclusive maritime order: from the perspective of the BBNJ agreement. *J. Boundary ocean Stud.* 9, 36.

Yan, L. C., and Guo, P. (2024b). A study on construction a view of inclusive maritime order: from the perspective of the BBNJ agreement. *J. Boundary ocean Stud.* 9, 23.

Young, M. (2016). Then and now: reappraising freedom of the seas in modern law of the sea. *Ocean Dev. Int. Law* 47, 175–176. doi: 10.1080/00908320.2016.1159088

Yuan, X., and Ma, L. (2022a). Study on the compound benefit sharing mechanism of ABNJ marine genetic resources: based on intellectual property and blockchain technology. *Pacific J.* 30, 100. doi: 10.14015/j.cnki.1004-8049.2022.03.008

Yuan, X., and Ma, L. (2022b). Study on the compound benefit sharing mechanism of ABNJ marine genetic resources: based on intellectual property and blockchain technology. *Pacific J.* 30, 96. doi: 10.14015/j.cnki.1004-8049.2022.03.008

Zhang, L. (2015). On the reasonable restrictions of national sovereignty on freedom of navigation-taking the historical evolution of "Freedom of the sea" as a perspective. *Stud. Law Business* 5, 182. doi: 10.16390/j.cnki.issn1672-0393.2015.05.019

Zhang, H. (2022). Is the regime of international seabed area universally binding? *Wuhan Univ. Int. Law Rev.* 6, 17–19. doi: 10.13871/j.cnki.whuilr.2022.06.002

Zhang, S. B. (2024a). Monetary benefit-sharing of marine genetic resources in BBNJ agreement: construction logic, deficiency and perfection. *J. Boundary Ocean Stud.* 9, 24.

Zhang, S. B. (2024b). Monetary benefit-sharing of marine genetic resources in BBNJ agreement: construction logic, deficiency and perfection. *J. Boundary Ocean Stud.* 9, 36–37.

Zhang, C. J., and Xie, D. H. (2010). Peaceful use of the seas and maritime military operations. *J. Polit. Sci. Law* 27, 6.

Zhang, L. N., and Zhang, T. Y. (2020). Research on funding mechanism under the international agreement on marine biodiversity beyond national jurisdiction. *J. Ocean Univ. China (Social Sciences)* 4, 4. doi: 10.16497/j.cnki.1672-335x.202004001

Zhang, X. Y., and Zheng, M. Z. (2018). On the applicable regime of marine genetic resources in areas beyond national jurisdiction: with a focus on the applicability of marine scientific research regime. *Chin. Rev. Int. Law* 5, 17.