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Traditional knowledge and its incorporation in the exploitation regulations

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This article examines how traditional knowledge (TK) would be effectively incorporated into regulations for the exploitation of mineral resources in the International Seabed Area (Exploitation Regulations). It first synthesizes references to TK within international law and instruments, highlighting its relevance to deep-sea mining (DSM) by defining its four core elements (subject, time, content, context) and demonstrating its value in filling scientific data gaps and informing environmental decision-making. Building on this foundation, the article analyzes the current status of TK in the Exploitation Regulations, revealing its fragmented and non-binding inclusion, and identifies three incorporation challenges: definitional absence, lack of systematic implementation mechanisms and epistemic tensions with scientific paradigms. To address these challenges, it proposes a structured framework of recommendations: 1) establishing a TK identification system; 2) developing implementation mechanisms for TK guided by “use as the priority, with protection as the secondary” principle; 3) establishing a four-step integration model to synergize TK and science. The article contributes by proposing a systematic framework for TK identification and incorporation, elevating it from an ancillary information source to a governance resource on par with science in the Exploitation Regulations, providing a viable way for ecologically resilient DSM governance.

KEYWORDS

deep-sea mining, indigenous peoples and local communities, IPLC, TK, traditional knowledge

1 Introduction

Traditional knowledge (TK) of Indigenous Peoples and Local Communities (IPLCs) are considered as a body of collective wisdom, developed through centuries of interaction with natural ecosystems ([Secretariat of the Convention on Biological Diversity \(CBD\), 2021](#)). Rooted in sustainable practice and holistic understandings of ecological balance, this knowledge has long supported the stewardship of marine environments, offering insights into resilience, interdependence, and long-term sustainability that complement scientific inquiry ([Sutherland et al., 2014](#)). In the era marked by accelerating climate change and

resource scarcity, its relevance to global governance, particularly in relation to fragile ecosystems, has become increasingly evident.

This relevance extends to the emerging field of deep-sea mining (DSM), a frontier industry spurred by the discovery of valuable metal deposits on the International Seabed Area (the Area)¹ and promoted as essential for meeting the growing demand for critical minerals in sustainable energy transitions (Zalik, 2018). However, DSM activities cause considerable scientific uncertainties and ecological risks to the global marine ecosystem. TK, derived from their enduring connections to ocean systems, holds significant potential. It illuminates cumulative impacts, species interactions, and ecosystem thresholds that often elude short-term scientific assessments (Sutherland et al., 2014), thereby enhancing the capacity to balance resource exploitation with environmental protection.

In this context, the ongoing development of regulations for the exploitation of mineral resources in the Area (Exploitation Regulations) under the United Nations Convention on the Law of the Sea (UNCLOS) offers an opportunity to integrate such knowledge (Aguon and Hunter, 2019). Since 2014, the International Seabed Authority (ISA) has sought to establish a regulatory framework for the sustainable development of mineral resources in the Area. In 2019, the Federated States of Micronesia (FSM) formally proposed incorporating traditional and local knowledge into regulatory components, such as the definition of “Best Environmental Practices” (BEP) and transparency measures, marking the institutional effort to embed such perspectives (Earth Negotiations Bulletin (ENB), 2019a; ENB, 2019b). This momentum was reinforced by a 2020 joint submission from Germany, the Netherlands, and Costa Rica, which called for TK to inform regional environmental management plans (REMPs) (ISA, 2020). Reflecting this shift, the evolution of the Exploitation Regulations—from omitting TK in 2019 to explicitly referencing it 12 times in the latest version (ISA, 2025)—demonstrates a growing recognition of its role in deep-sea governance.

Nevertheless, significant challenges remain. A common objection is that TK has little relevance to the deep sea, often described as an “untouched wilderness” with little historical human presence (Powell, 2024). Even advocates acknowledge the complexities of applying ecological insights derived from coastal marine contexts to deep-sea environments. Practical obstacles, including issues of implementing TK and its incompatibility with modern science, further complicate efforts to incorporate TK into DSM governance.

Against this background, this article explores how to effectively incorporate TK into the Exploitation Regulations. Section 2 focuses on TK’s definition and operationalization, establishing its value in DSM. Section 3 discusses the current status and challenges of incorporating TK into the Exploitation Regulations. Section 4 proposes recommendations to advance such incorporation to

ensure its systematic and substantive into the Exploitation Regulations. Section 5 concludes the paper with key points.

2 Traditional knowledge in international law and instruments

TK has been increasingly acknowledged in international instruments, yet its definitions and implementation vary across regimes. This section examines TK’s core definitional elements and operationalization within key frameworks, highlighting implications for deep-sea governance.

2.1 Definition of traditional knowledge

There is not yet an accepted definition of TK at the international level (World Intellectual Property Organization (WIPO), 2015). Different international instruments, depending on their objectives and scope, provide similar yet nuanced descriptions of TK. Among these international instruments, only the Convention on Biological Diversity (CBD) and the World Intellectual Property Organization (WIPO) provide explicit TK’s definitions. The CBD Secretariat characterizes TK as: “Traditional knowledge refers to the knowledge, innovations and practices of indigenous and local communities around the world. Developed from experience gained over the centuries and adapted to the local culture and environment, traditional knowledge is transmitted orally from generation to generation.” (Secretariat of the CBD, 2021) WIPO demonstrates a primary focus on the legal aspects of TK among international organizations, having issued research reports and draft provisions concerning TK. (WIPO, 2001, 2025) In 2000, it established the Intergovernmental Committee on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore (WIPO-IGC) to conduct in-depth research on intellectual property issues concerning genetic resources and TK. Since its inception, WIPO-IGC has consistently advanced legislative efforts toward TK protection. In June 2019, it released “The Protection of Traditional Knowledge: Draft Articles”, which consolidates years of research by WIPO-IGC and incorporates input from delegations. This document constitutes a significant advancement in the legal framework for TK protection, and it formally defines TK as “knowledge originating from indigenous [peoples], local communities and/or [other beneficiaries] that may be dynamic and evolving and is the result of intellectual activity, experiences, spiritual means, or insights in or from a traditional context, which may be connected to land and environment, including know-how, skills, innovations, practices, teaching, or learning (WIPO, 2024a, p.5)”.

Other international agreements, such as the 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 (BBNJ Agreement) and the Paris Agreement, mention TK in their official texts but do not offer a clear definition of it. Therefore, scholars propose working

1 Including polymetallic nodules, polymetallic sulphides, Cobalt-Rich Ferromanganese Crusts, rare earths, metal-rich muds, and hydrosulfide deposits. See Hein and Koschinsky (2014). Deep-Ocean Ferromanganese Crusts and Nodules. In: Scott, S. (Ed.), *Treatise on Geochemistry*. Elsevier, Amsterdam, pp. 273–291. Doi: 10.1016/b978-0-08-095975-7.01111-6.

definitions of TK in their respective fields of study. For example, scholars propose a TK's working definition in the BBNJ Agreement as "a living body of knowledge, practices, skills, and innovations, including intangible cultural heritage such as dance, story, and song, passed down through generations continuously and in locally meaningful contexts by IPLCs who act as the creators, developers, preservers, guardians, and custodians (Mulalap et al., 2020, p.3)" Similarly, Berkes's widely cited definition of TK in climate change initiatives (Savaresi, 2018, p.36) as 'a cumulative body of knowledge, practice and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment' (Berkes, 2012, p.7).

Synthesizing definitions or descriptions of TK from representative fields reveals its four core elements: 1) Subject element: TK originates from IPLCs and has a collective nature; 2) Time element: it is a knowledge system transmitted among generations through oral tradition or practical imitation over a long period and evolves dynamically; 3) Content element: it is an experiential and practical knowledge system derived from and applied to real-life practices, closely linked to the survival and development of IPLCs; 4) Contextual element: it is deeply rooted in and dependent on specific natural environments, geographical locations, and cultural contexts.

The above international instruments differ in their descriptions of TK due to their distinct mandates and functions. In the context of DSM, the concept of TK should not only satisfy the four aforementioned elements but also incorporate the unique characteristics of the deep sea and the regulatory objectives of Exploitation Regulations. First, the subject element is embodied by coastal IPLCs, especially from Pacific Islands such as the Māori of Aotearoa/New Zealand, Native Hawaiians of Hawaii, Chamorro of Guam and the Northern Mariana Islands, and Marshallese of the Marshall Islands, (Tilot et al., 2021) whose lives and livelihoods have been dependent on the ocean for millennia. Second, the time element is reflected in how this marine-related TK has been passed down through generations via oral traditions, navigational skills, and observational experience, continuously evolving alongside observations of oceanic changes. Third, the content element consists of experiential knowledge derived from practice, focusing on marine ecological connectivity, marine resource management and environmental changes, such as Māori mātauranga moana (ocean knowledge) for ecosystem monitoring (Paul-Burke et al., 2020), which will provide practical insights for environmental impact assessments (EIAs) and ecosystem management in DSM. Fourth, the contextual element lies in the inseparability of TK from the marine environment and cultural identity, where the ocean is regarded as an integral part of cultural cosmology and worldview.

In sum, drawing from the various references and working definitions of TK discussed above, TK in the context of DSM is defined as a body of experiential knowledge, practices, and belief systems collectively held by IPLCs closely connected with the ocean, and transmitted across generations in a dynamic and evolving manner. It arises from IPLCs' long-term interactions with the marine environment, through which they have developed

profound understandings of marine ecosystems, resources, and processes, and is deeply rooted in their specific maritime cultures and regional contexts. This knowledge system is of critical importance for understanding marine ecological connectivity, establishing environmental baselines, and assessing the potential long-term and cumulative impacts of DSM activities. It is therefore essential for ensuring environmental protection and upholding the precautionary principle under the Exploitation Regulations.

When discussing the deep sea as a "terra nullius", many people question how this remote and inhospitable realm could have human inhabitants, let alone IPLCs. What relevance could IPLCs' TK have to the deep sea? This perspective segregates the deep sea from the broader marine ecosystem, overlooking its ecological continuity with coastal ecosystems. TK, especially elements embodying centuries of ecological management wisdom, provide critical perspectives for understanding this continuity. Traditional ecological management principles embedded in the knowledge systems of Pacific Islanders – such as seasonal fishing closures² with philosophy to respect the ecological restoration cycle and avoid excessive development – could be adaptively applied to deep-sea governance through contextual modifications.

Accumulated through long-term practices, TK will fill spatio-temporal gaps left by short-term scientific observations and contribute to a better understanding of complex deep-sea ecosystems. The deep sea is considered the least explored biome on Earth. Conditions within the deep sea are a combination of low temperatures, darkness, and high pressure, which make the environment difficult to access and explore (United Nations Environment Programme (UNEP), 2007). Given the enigmatic nature and limited scientific investigation of the deep sea, incorporating different knowledge systems to enhance the comprehension of the Area is necessary. TK will provide complementary perspectives, borne from long periods of shared observation and experimentation that are often lacking in scientific information, which typically relies on observations or experiments conducted over relatively short time-scales by groups of people detached from the environmental context. TK, such as spawning times, locations, and behaviors of coral reef and lagoon fish (Liang, 2021), has been repeatedly shown to extend our understanding of the spatial and temporal dynamics of biodiversity (Sutherland et al., 2014).

Furthermore, TK contributes to environmental assessment through contextual insights and early warnings for EIAs, REMPs, and the designation of Areas of Particular Environmental Interest. For instance, the navigational knowledge of Polynesian voyagers regarding seamount locations and biological distributions provides

2 For example, throughout much of the Pacific, traditional fisheries management practices have been used for many centuries. One of these practices includes the establishment of a tabu (taboo) area, an area of reef in which all fishing is prohibited. See *Fiji Shore & Marinas*. FLMMA: Fiji Locally Managed Marine Protected Area Network. Available at: <https://www.fijimarinas.com/flmma-fiji-locally-managed-marine-protected-area-network/> (Accessed 16 November 2025).

critical baseline information for identifying ecologically sensitive zones (Eckstein and Schwarz, 2018; Ey and Sherval, 2016). Indigenous observations of marine species behavior, such as fish migration patterns and acoustic signatures of coral ecosystems, could refine the design of area-based management tools like REMPs.

2.2 The operationalization of traditional knowledge

An examination of TK's operationalization in international instruments reveals that they invariably pursue two objectives: on the one hand, to protect TK holders from the misappropriation of their knowledge; and on the other, to promote the diffusion and use of TK in order to advance the global public goods (Savaresi, 2018, p.38).

To achieve the first objective, international instruments adopt three main approaches: 1) preventing the misappropriation of TK; 2) granting rights to TK holders, including the rights to authorize, prohibit, and benefit from the use of such knowledge; 3) preserving and transmitting TK (Das, 2024). First, the "preventive type", seeks to deter third parties from appropriating TK through mechanisms such as patent examination or mandatory disclosure, as exemplified by the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS Agreement)³ and the frameworks of WIPO (WIPO, 2024b). Second, the "granting rights type", respects and protects the cultural identity of TK holders by granting them the rights to authorize, prohibit, and benefit from the use of their knowledge, as represented by Convention concerning Indigenous and Tribal Peoples in Independent Countries (No. 169, abbreviated as ILO Convention No. 169) (ILO, 1989), United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) (United Nations General Assembly, 2007), the Nagoya Protocol⁴, and the BBNJ Agreement⁵. Third, the "preserving and transmitting type," emphasizes the living continuity of TK systems, with the

Convention for the Safeguarding of the Intangible Cultural Heritage⁶ serving as a key example.

In achieving the second objective, namely promoting the diffusion and use of TK, the BBNJ Agreement provides an exemplar. For broadly defined marine TK, which encompasses all knowledge accumulated by IPLCs through their marine activities, such as navigational knowledge, environmental management knowledge, and ecosystem knowledge, the BBNJ Agreement establishes an approach of "use as the priority, with protection as the secondary." For the first time, it elevates the "use of TK" to the level of a general principle and approach, underscoring the foundational role of TK within the entire BBNJ Agreement. Notably, prioritizing use does not preclude protection. The "use" of TK itself will serve to achieve its protection. By establishing the "use of TK" as a general principle and approach, the BBNJ Agreement recognizes that such use facilitates the preservation, diffusion, and development of TK. Through this approach, the BBNJ Agreement advances the protection of TK by fostering its active use (Huang and Gao, 2024, pp.54-55).

The operationalization of TK within international frameworks faces the challenge of reconciling its epistemological and practical applications with those of modern science, where conflicts in validation methods, data interpretation, and worldviews emerge as central obstacles to its integration.

In terms of validation methods, TK is localized, holistic, and transmitted orally across generations, emphasizing qualitative observation and cultural context. In contrast, modern science prioritizes objectivity, reproducibility, and quantitative metrics (Sutherland et al., 2014). This divergence creates tensions in validation approaches: the scientific framework tends to assess TK through empirical testing, and if it fails to meet positivist standards, it risks being dismissed as "subjective" or "anecdotal" (Mistry and Berardi, 2016). For instance, in marine governance, attempts to assess indigenous fishing knowledge solely through scientific indicators may overlook its adaptive and context-specific nature, potentially undermining its perceived validity within scientific frameworks (Caldeira et al., 2025).

Data interpretation further highlights these tensions. Rooted in cultural practices and spiritual values, TK offers insights into ecological patterns through long-term experiential wisdom, while science often pursues universal, scalable data models (Mistry and Berardi, 2016). For example, in marine management, Fijian fisherwomen's knowledge of seasonal fishing and taboo areas integrates ecological and cultural factors. Translating such localized insights into global policy frameworks like the BBNJ Agreement requires navigating different scales and types of knowledge (Caldeira et al., 2025).

Divergent worldviews further amplify these challenges. TK often embodies a holistic and reciprocal relationship with nature, while Western science tends toward reductionism and compartmentalization. Moreover, the dominance of the Western scientific paradigm has historically perpetuated systemic biases, suppressing indigenous knowledge systems by labeling them as "superstitious" or "unscientific", as exemplified by the historical

3 "... patents shall be available for any inventions, whether products or processes, in all fields of technology, provided that they are new, involve an inventive step and are capable of industrial application." World Trade Organization (WTO), 1994. Agreement on Trade-Related Aspects of Intellectual Property Rights. 1869 UNTS 299, 33 ILM 1197, article 27(1).

4 It requires benefit-sharing between users and providers of traditional knowledge through the provisions on Prior Informed Consent (PIC) and Mutually Agreed Terms (MAT). See 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 (Nagoya Protocol, 2010). UN Doc. CBD/CP/DEC/X/1, Article 5(5), article 6(1).

5 Article 13 of the BBNJ Agreement regulates that traditional knowledge "shall only be accessed with the free, prior and informed consent (FPIC) or approval and involvement of these Indigenous Peoples and local communities". "Access to and use of such traditional knowledge shall be on mutually agreed terms." See BBNJ Agreement, 2023. New York, United Nations Publication, A/CONF.232/2023/4.

6 It focuses on the documentation, inventory, education, and transmission of traditional knowledge. See UNESCO, 2003. Convention for the Safeguarding of the Intangible Cultural Heritage, articles 12-18.

suppression of indigenous medical practices to uphold the “superiority” of Western systems (Ray, 2023). Thus, without addressing power imbalances and ensuring equitable participation, the integration of TK risks becoming superficial or symbolic rather than transformative (Caldeira et al., 2025).

Analysis of TK’s operationalization across international instruments suggests adaptable methods for its application in DSM. As defined in the context of DSM above, TK encompasses experiential knowledge related to marine ecological connectivity, resource management, and environmental changes, but excludes marine genetic resources requiring benefit-sharing. Consequently, TK implementation in DSM should draw on the BBNJ Agreement’s approach to broadly defined marine TK, prioritizing use alongside protection and integrating this knowledge into environmental management and policy-making.

In the aforementioned international agreements, such as the Nagoya Protocol and the BBNJ Agreement, the use of TK requires obtaining prior informed consent (PIC) or free, prior, and informed consent (FPIC) from the knowledge holders—IPLCs. Scholars therefore argued that PIC/FPIC should also apply when incorporating TK into Exploitation Regulations, given the disproportionate and potentially far-reaching effects of DSM on the rights, livelihoods, and cultural integrity of coastal IPLCs (Aguon and Hunter, 2019; Jiménez, 2024). This article, however, contends that PIC and FPIC are not applicable in DSM. First, other international agreements apply PIC/FPIC specifically to TK associated with genetic resources. These agreements mandate that users are required to obtain explicit authorization from IPLCs and ensure equitable benefit-sharing. By contrast, TK relevant to DSM does not involve genetic resources and thus does not generate the need for benefit-sharing or the protection of IPLCs’ rights, making PIC/FPIC inapplicable.

Second, the impacts of DSM on IPLCs are largely indirect and speculative, lacking a direct causal link sufficient to establish legal obligation. Proponents of incorporating FPIC into DSM argue that, though DSM occurs in the high seas, its potential environmental effects, such as sediment plumes, noise pollution, and biodiversity loss, could indirectly affect the livelihoods and cultural practices of coastal IPLCs through marine food webs, thereby triggering FPIC obligations under Article 32 of UNDRIP (Aguon and Hunter, 2019, pp.32-33). However, this reasoning overlooks the legal threshold between “impact” and “rights-based” within international law. The application of FPIC presupposes a direct interference with IPLCs’ lands, territories, or resources. Yet, under Article 136 of the UNCLOS, the Area is the “common heritage of mankind” (UNCLOS, 1982, article 136), falling outside the sovereign or exclusive rights of any state or non-state entity. Within this framework, IPLCs hold no legally recognized territorial or resource rights over the Area, making it difficult to establish a valid legitimate basis for FPIC in this context. Expanding FPIC to activities with potential indirect or remote impacts risks diluting its normative clarity and undermining its effectiveness in cases involving direct impacts on land, territories and resources.

Third, regarding whether FPIC has crystallized into customary international law and should automatically apply to DSM, the existing evidence does not support such a claim. As Ward states, “a customary international legal principle that addresses indigenous peoples’ full

right to FPIC does not yet exist.” (Ward, 2011, p.54) Although the UNDRIP enjoys widespread acceptance, its legal nature remains that of soft law (Davis, 2008, p.461) and does not directly bind non-state actors such as the ISA or contractors. More importantly, no state practice indicates the implementation of FPIC obligations in the context of DSM. Neither the draft of Exploitation Regulations, legislation of Sponsoring State, nor corporate due diligence standards have incorporated FPIC as a binding requirement. Against this background, the claim that FPIC should be treated as part of a second wave of due diligence (Aguon and Hunter, 2019) is better characterized as normative advocacy than established law. Imposing FPIC absent consistent state practice and *opinio juris* lacks legitimate basis, risks significant jurisdictional confusion, and imposes impractical burdens on contractors to obtain consent from potentially affected IPLCs worldwide. This would result in substantial program delays, ultimately undermining the public interest in marine scientific research and sustainable resource development.

While acknowledging the supplementary role of TK in deep-sea governance, extending the FPIC principle to DSM is legally untenable, institutionally impracticable, and operationally unworkable. A viable alternative includes strengthening environmental standards in Exploitation Regulations, establishing multi-stakeholder consultation mechanisms, and integrating TK as a source of information alongside scientific assessments. Only through such measures will it be possible to respect IPLCs while safeguarding the integrity of the “common heritage of mankind” principle and ensuring the feasibility of ocean governance.

DSM also faces the challenge of integrating TK with scientific information. Scientific methods often struggle to effectively guide decision-making amidst the complexity of DSM, characterized by high uncertainty, non-linear changes, and multiple perspectives. Unlike scientific methods, TK, developed through long-term, multivariable qualitative synthesis, offers a holistic understanding of complex systems. Moreover, through community dialogue, TK facilitates the development of practical and contextually adaptable rules, enhancing flexibility and applicability.

DSM could draw on the approaches of the BBNJ Agreement and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) by granting TK equal status to science. This would be achieved through multiple mechanisms, such as establishing working groups, issuing multilingual calls for input contributions, organizing dialogue sessions, and providing translation services (Caldeira et al., 2025). Validation should occur within each knowledge system’s own framework, not by measuring TK against scientific standards.

3 The current status and challenges to incorporate traditional knowledge in the exploitation regulations

Reflecting the emerging recognition in international frameworks, the Exploitation Regulations have introduced TK into provisions, yet the integration remains fragmented and contested, exposing definitional, operational, and epistemological challenges.

3.1 The current status of traditional knowledge being incorporated into the exploitation regulations

The latest version of the Exploitation Regulations contains 12 references to TK and IPLCs, covering dimensions from principles to application assessments, EIAs, and environmental management, indicating an institutional acknowledgment and systematic incorporation of their contributions (Table 1) (ISA, 2025).

In the Exploitation Regulations, the current status of incorporating TK could be examined from three dimensions: implementation levels, wording strength, and functional positioning. With respect to implementation levels, TK has been incorporated into general principles (Reg. 2(4)(h)), EIA procedures (Regs. 46, 47bis, and Annex III bis), environmental decision-making obligations (Reg. 44 (1)(c) ter), standard-setting mechanisms [Reg. 94(4)], and definitions of key terms (such as “best environmental practice” and “serious harm” in the Schedule). This demonstrates multi-layered integration spanning macro-level guidance to operational measures. Nevertheless, its distribution remains fragmented, lacking a unified framework or a dedicated section for systematic governance.

In terms of wording strength, apart from the provision on consultation in Annex IV, which employs mandatory language (“shall be inclusive ... including IPLCs”), the remaining ten provisions referring to TK are all qualified by the flexible phrase “where available.” This restricts TK implementation to scenarios where it is accessible, imposing no obligation on contractors to actively obtain such knowledge and leaving undefined both the criteria for determining its “availability” and alternative measures to be taken in its absence. As a result, the enforceability of these provisions is substantially diminished.

Regarding functional positioning, the Exploitation Regulations generally treat TK as a supplementary source of information to complement environmental baseline data, or to refine environmental management decisions. This underscores its instrumental value over rights-based dimension, aligning with a pragmatic orientation of “use as the priority, with protection as the secondary”. However, this positioning also exposes a lack of integration mechanisms: Exploitation Regulations fail to specify how TK should be validated, reconciled, or integrated with scientific information, nor do they clarify how it should be incorporated into spatial planning or risk mitigation measures for DSM. Consequently, despite being referenced, TK exerts limited substantive impact on environmental assessments or decision-making processes.

In sum, Exploitation Regulations have established a multi-tiered TK incorporation in form, but deficiencies remain in operability, coherence, and effectiveness.

3.2 Challenges to the incorporation of traditional knowledge in the exploitation regulations

The attempt to incorporate TK in the Exploitation Regulations reveals three major challenges: the lack of a clear definition,

undeveloped mechanisms of implementation, and epistemological tensions with modern science.

3.2.1 No definition of traditional knowledge

During negotiations on the Exploitation Regulations, some delegations proposed defining TK (ENB, 2023). Yet, in the latest draft of the Exploitation Regulations (ISBA/30/C/CRP.1), no definition of TK is included. This is not solely an issue of the Exploitation Regulations themselves; existing international instruments also lack a unified definition of TK and often deliberately avoid defining it.⁷ There are two main reasons. First, the inherent complexity and dynamism of TK. Unlike a static or archaic collection of information, TK is rather living and evolving knowledge system (Matsui, 2015, p.10), whose holistic and fluid nature makes it difficult to capture within the fixed language of legal texts. Second, defining TK is directly linked to Indigenous governance rights and sovereignty. An overly narrow definition could be used to restrict IPLCs’ claims over resources or territories, while an overly broad one might challenge state sovereignty or commercial interests (Matsui, 2015, p.16). Thus, strategic ambiguity prevails as a compromise, avoiding fixed positions until broader consensus emerges. Since 2000, WIPO has been negotiating instruments for TK’s protection within its Intergovernmental Committee, there is not yet an accepted definition of TK at the international level (WIPO, 2015). Scholars widely acknowledge the challenges inherent in defining TK (Matsui, 2015, p.2). Against this background, many international instruments opt for deliberately vague wording or delegate the authority to define the term to contracting parties, to keep the momentum of negotiations.

Another reason for the lack of a clear definition of TK in the Exploitation Regulations is the ambiguity surrounding the identification and definition of knowledge holders. As discussed above, TK comprises four elements: the subject, time, content, and contextual elements. The failure to define TK in the Exploitation Regulations stems partly from the fact that IPLCs, the subject element, are not defined or identified anywhere in the draft.

The term IPLCs is a composite concept encompassing two distinct groups with different legal statuses but shared roles in ecological governance: “Indigenous Peoples” and “Local Communities”. The definition of Indigenous Peoples primarily draws on Martínez Cobo’s Study of the Problem of Discrimination against Indigenous Populations (Cobo, 1987, para.379) and ILO Convention No. 169 (ILO, 1989, Article 1), and is characterized by four core features: historical continuity with pre-colonial societies; a non-dominant and marginalized position within contemporary society; self-identification as Indigenous with distinct cultural patterns and legal systems; and a close connection to specific ancestral territories and ethnic identity. In comparison, under the summary of expert meetings within the CBD framework, the term “Local Communities” is defined as social units residing in specific geographic areas, sharing common history, culture, language, and

⁷ For example, the BBNJ Agreement does not provide a definition of traditional knowledge. See *BBNJ Agreement*, 2023. New York, United Nations Publication, A/CONF.232/2023/4.

TABLE 1 TK and IPLCs in the exploitation regulations text.

No.	Regulation number	Specific text
1	Regulation 2 Principles, approaches and policies	4(h): The following principles and approaches shall guide the application of these Regulations: The use of relevant traditional knowledge of Indigenous Peoples and local communities where available.
2	Regulation 13 Assessment of applicants and application	9(d)(vii): Whether the Plan of Work ensures effective Protection of the Marine Environment, in accordance with all applicable environmental requirements in the Convention, Agreement, and the rules, regulations and procedures of the Authority, taking into account: Traditional knowledge or cultural interests relevant to the Protection of the Marine Environment;
3	Regulation 44 General Obligations	1(c) ter: Use relevant traditional knowledge of Indigenous Peoples and of local communities in decision-making, where available;
4	Regulation 46 The Impact Assessment Process	3(b) bis: The process for Environmental Impact Assessment shall: Be based on the Best Available Science and Scientific Information and, where available, relevant traditional knowledge of Indigenous Peoples and of local communities ;
5	Regulation 47 bis Scoping	3(e): In undertaking the Environmental Impact Assessment scoping, the applicant or Contractor, shall: Use the best available science and scientific information and, where available, relevant traditional knowledge of Indigenous Peoples and local communities ;
6	Regulation 94 Adoption of Standards	4: Standards or amendments thereto adopted by the Council shall be legally binding on Contractors, member States and the Authority from the date of their adoption and the Commission shall review these Standards at least every five years from the date of their adoption or revision and advise the Council, in the light of improved knowledge or technology and new contributions from Indigenous Peoples and local communities , as to whether any revision is required.
7	Annex III bis Scoping Report	(e): A summary of existing environmental baseline studies, and, where available, relevant traditional knowledge of indigenous peoples and local communities ;
8	Annex III bis Scoping Report	(g): A description of the socioeconomic and sociocultural aspects of the project including sociocultural uses of the Mining Area (e.g., traditional navigation routes, migratory paths of culturally significant marine species, sacred sites and waters associated with ritual or ceremonial activities of Indigenous Peoples and local communities);
9	Annex IV Environmental Impact Statement Executive summary	13. Consultation and stakeholder engagement and methods (paragraph 2): Consultations and engagement shall be inclusive, transparent and open to all Stakeholders, including States, global, regional, subregional and sectoral bodies, as well as civil society, the scientific community, indigenous peoples and local communities and in accordance with this Regulation and the applicable Standards and taking into consideration the Guidelines.
10	Annex VII Environmental Management and Monitoring Plan	(l) ter: Details of any plans outside of the Contract Area to increase scientific knowledge and other knowledge/information in the relevant region, including in collaboration with other Contractors or via international cooperation efforts, as well as in collaboration with Indigenous Peoples and local communities ;
11	Schedule Use of terms and scope	“ Best Environmental Practices ” means the application of the most appropriate combination of environmental control measures and strategies, for purposes of ensuring the effective protection of the Marine Environment, and based on the Best Available Scientific Information and Best Available Technology that will change with time in the light of improved knowledge, understanding or technology, as well as the incorporation of the relevant traditional knowledge of Indigenous Peoples and local communities and in accordance with applicable Standards taking into account the relevant Guidelines.
12	Schedule Use of terms and scope	“ Serious Harm ” means any effect from activities in the Area on the Marine Environment which represents an unlawful significant adverse change in the Marine Environment determined according to the rules, regulations and procedures of the Authority on the basis of internationally recognized standards and practices informed by Best Available Scientific Information and, where available, relevant traditional knowledge of Indigenous Peoples and local communities .

customs, and possessing self-identification while being relatively independent of other social groups (CBD, 2011, pp.12-13). Both Indigenous Peoples and Local Communities, through long-term interaction with nature, hold rich TK, making them the core holders and primary sources of TK (Shi and Zhuang, 2025, pp.8-9).

The legitimate participation of IPLCs in DSM decision-making does not depend on their geographic proximity to DSM sites, but rather on whether their cultural continuity and knowledge systems are substantially affected by DSM activities. The definition and identification of IPLCs should not rely only on geographic proximity, but instead adopt a composite standard centered on TK holders. Identifying IPLCs should consider five criteria: 1)

Geographical connection, whether they depend on marine areas ecologically linked to the mining site, for example through species migration or fisheries; 2) Cultural reliance, whether the ocean is integral to their cultural identity, rituals, or beliefs; 3) Knowledge possession, whether they hold TK relevant to the associated ecosystems; 4) Self-identification, whether the group self-identifies as Indigenous or as the local community; 5) Vulnerability, whether socio-economic disadvantages impede their participation in highly technical decision-making processes (Shi and Zhuang, 2025, pp.6-10). This framework transcends the “land–ocean” dichotomy, emphasizing the integration of ecological connectivity and cultural dependence.

3.2.2 Issues of implementing traditional knowledge

The current Exploitation Regulations face three main issues of implementing TK, rooted in the compromise-driven nature of international law, challenges in addressing cultural sensitivities, and limitations in implementation capacity. First, the provisions are highly fragmented and lack systematic integration. TK-related regulations are scattered across the sections (Regs. 2, 13, 44, 46, 47, 94), some annexes (Annexes III bis, IV, VII), and the Schedule, without a unified framework for implementation. This fragmentation impedes coordination among EIA, environmental decision-making and monitoring processes, increasing risks of inconsistency and redundancy. Second, there is an absence of operational guidance for collecting, validating, and respecting TK. Although Annex III bis requires a summary of TK in the scoping report and Annex IV mentions inclusive consultations, the Exploitation Regulations do not specify how to ensure the accuracy of knowledge, avoid cultural misinterpretation, or establish collaborative mechanisms with knowledge holders. Third, IPLCs' participation mechanisms remain tokenistic. Although Annex IV mandates inclusive consultations and engagement with IPLCs and Regulation 94 mentions incorporating their "new contributions", neither provision grants IPLCs substantive decision-making influence nor mandates legal consequences for disregarding their input, rendering participation largely procedural.

The root causes of these issues stem from four key drivers. First, the inherently framework-based and compromise-driven nature of international instruments favors principled language to maintain consensus among members, thereby avoiding specific, operational provisions. Second, the highly contextual and culturally sensitive character of TK causes policymakers to worry that uniform standards might infringe on IPLCs autonomy or trigger cultural conflicts. As a result, deliberate vagueness preserves flexibility but generates implementation uncertainty. Third, there is a lack of resources and political will. The ISA lacks sufficient technical and financial capacity to support the systematic collection and integration of TK, while members vary in their prioritization of it, with some relying more heavily on scientific data, leading to its marginalization in negotiations. Fourth, there is the absence of mature precedents for integrating TK into deep-sea governance. Though the BBNJ Agreement incorporates TK throughout its provisions, it has only recently entered into force, without associated practical experience yet. Moreover, the unique challenges of DSM, such as operations being far from coastal areas and the uncertain direct relevance to IPLCs, pose hurdles for TK implementation, pushing a conservative design in the Exploitation Regulations.

In summary, while the Exploitation Regulations recognize TK's value, implementation deficiencies hinder its effective utilization, highlighting the need for detailed guidelines and improved procedural coordination.

3.2.3 Incompatibility between traditional knowledge and modern science

TK and modern science exhibit epistemological and methodological incompatibilities. As outlined above, TK is rooted in generations of lived experience, characterized by holism and

context-dependence, and often embedded in ritual or seasonal practices⁸. While modern science emphasizes empirical validation, quantitative data, and universality, such as statistical models (Sutherland et al., 2014).

This is also reflected in the debates among delegations during the negotiations on the Exploitation Regulations concerning TK. On the contention of whether TK is usable and whether the phrase "where available" should be deleted, those in favor of deletion argue that TK is both available and essential (ENB, 2025), whereas those in favor of retaining the phrase express concerns about its "operability" or "verifiability." This reveals the epistemological differences between TK and scientific systems. Besides, delegations are divided over whether TK should be treated as part of "Best Environmental Practices" (BEP) or be separately defined and addressed, highlighting their methodological divergences. The current draft of the Exploitation Regulations presents TK and scientific knowledge as complementary components of BEP. However, some delegations worry that this framing risks subordinating TK to science, potentially weakening its cultural, spiritual, and rights-based dimensions (ENB, 2023).

This incompatibility means that although the Exploitation Regulations place TK alongside the "best available science", in substance they separate the two, undermining the effectiveness of TK. The Exploitation Regulations subordinate TK under the qualifier "where available", while designating "Best Available Science" as the primary, and often the sole, reliable basis for environmental assessment, decision-making, and standard-setting. Such an arrangement implies that science is objective and verifiable, whereas TK is merely "supplementary" or "contextual" information. As a result, even when submitted, TK struggles to carry equal weight within science-dominated assessment frameworks, leaving it vulnerable to marginalization or selective adoption.

The relationship between TK and science in international agreements is undergoing a shift from a "science-dominant, TK-supplementary" model to one of "equal emphasis and complementary integration". Early models, such as REDD+ projects⁹, often reduced TK to "data" verifiable by science, embedding it into governance systems centered on markets and incentives. This simplification stripped TK of its complexity and marginalized IPLCs (Mistry and Berardi, 2016). While emerging frameworks like IPBES and the BBNJ Agreement advocate for equal integration. IPBES adopts a "Multiple Evidence Base Approach", emphasizing validation within each knowledge system and substantially enhancing the participation of TK holders through working groups, multilingual consultations, and community dialogues (Caldeira et al., 2025). The BBNJ Agreement

⁸ For example, the traditional wisdom of Pacific Islanders in managing marine resources through the use of "taboo zones." See King, J.K.K., Riera, L., 2022. The 'Right Place' for sharks in the South Pacific: Marine spatial planning in a more-than-human ocean. *Planning Practice & Research* 37(3), 299–316. <https://doi.org/10.1080/02697459.2022.2035918>

⁹ REDD+ is a United Nations climate change mitigation program for countries to reduce emissions from deforestation and forest degradation, and foster conservation, sustainable management of forests, and enhancement of forest carbon stocks.

elevates TK to the same level as science, stipulating the “use of the best available science and scientific information” and the “use of TK” as general principles and approaches, which are embedded throughout the BBNJ Agreement (Huang and Gao, 2024, p.56).

Overall, the international community is gradually recognizing the uniqueness and governance value of TK. For the Exploitation Regulations, adopting approaches akin to those of IPBES and the BBNJ Agreement, placing TK on equal footing with science, would enhance its role in environmental governance.

4 Recommendations to the incorporation of traditional knowledge in the exploitation regulations

Given the challenges discussed above, the following recommendations aim to establish clearer identification criteria, more robust implementation mechanisms, and integrative approaches for bridging TK with modern science.

4.1 Establishing a traditional knowledge identification system

TK resists rigid definition due to its dynamic nature, context-dependency, and politically sensitive issues involving the governance rights of IPLCs. Therefore, instead of seeking a static definition, the Exploitation Regulations should establish an operational system for identifying TK. This could be advanced in two ways.

First, identification criteria should be developed based on four elements: 1) subject, whether the knowledge belongs to IPLCs, as determined by their identity standards discussed above); 2) time, whether it has been accumulated through long-term practice and intergenerational transmission; 3) content, whether it is transmitted through oral traditions, practices, or rituals etc.; 4) context, whether it is tied to specific marine areas or ecosystems and carries value for environmental management or resource use.

Second, a participatory identification mechanism should be established to ensure IPLCs lead the self-identification of their knowledge during the initial program stages through workshops, narrative documentation, or mapping exercises, safeguarding the subjectivity and authenticity of TK. Additionally, the Exploitation Regulations should acknowledge the evolving nature of TK by setting up a periodic review mechanism, under which the ISA and IPLCs jointly assess and update the identification criteria to achieve adaptive management.

4.2 Developing implementation mechanisms for traditional knowledge

At the macro-guiding level, one viable approach to implementing TK in DSM is to adopt the “functional use” of TK as reflected in the BBNJ Agreement. It advocates a “use as the

priority, with protection as the secondary” principle, treating TK as a critical decision-support system. Active and responsible use will facilitate deeper and more sustainable protection. Scholars argue that the “use” of TK itself would become an effective means of achieving protection objectives (Chen, 2018, pp.49–50 and pp.87–88). The concept of “protection” requires a multi-layered understanding. In a narrow sense, protection refers primarily to preventing unauthorized access and use by third parties through legal procedures such as PIC. In a broader sense, protection carries richer connotations, including the preservation, transmission, and revitalization of TK, preventing its loss or degradation, safeguarding the rights of IPLCs, and promoting its sustainable development and economic utility (Huang and Gao, 2024, pp.54–55). Establishing “use of TK” as a fundamental principle follows the logic that, under the parallel principle of “respecting the rights of IPLCs and other stakeholders”, responsible use supports TK preservation, diffusion and vitality, thereby achieving broader protection goals. The paradigm of the BBNJ Agreement demonstrates that a well-designed utilization mechanism will serve as tools for TK preservation and development.

However, current TK provisions in the current Exploitation Regulations are fragmented, lacking concrete operational guidelines. Moreover, IPLCs participation is largely symbolic, severely limiting the implementation of the aforementioned principles. To enhance operability, it is urgent to develop a dedicated TK guideline to systematically integrate the processes of identification, implementation, and protection. This guideline should specify TK collection methods, such as in-depth IPLCs interviews and participatory observation, to respect the socio-cultural context in which the knowledge originates (Trisos et al., 2021). At the same time, a consensus-based knowledge validation mechanism involving IPLCs should be established to prevent TK from being assessed or validated by Western scientific standards. This safeguards the integrity and value systems inherent in TK (Agrawal, 1995).

Additionally, substantiating IPLCs participation mechanisms is essential. A key measure is to establish the observer seat for IPLC representatives on the Council of the ISA, ensuring their participation in critical decision-making processes such as license approvals, EIA reviews, and the designation of REMPs. To maximize effectiveness, these representatives should have formal channels at specific procedural stages, including submitting written comments during EIA review processes, participating in workshops preceding Council decisions on exploitation applications, and being empowered to request additional TK-focused studies when existing assessments fail to reflect indigenous perspectives (Morgera, 2024). To address IPLCs capacity and resource constraints, the ISA should consider providing targeted financial support to fund IPLCs’ capacity-building initiatives, systematic documentation of TK, and necessary legal assistance. Furthermore, the ISA is encouraged to support pilot programs exploring co-management models that integrate TK with modern science in governing seabed resources. Successful cases should be compiled into a scalable knowledge repository, providing a practical reference for the implementation of the Exploitation Regulations.

4.3 Establishing mechanisms for integrating traditional knowledge and science

Epistemological and methodological differences between TK and modern science often result in nominal rather than substantive integration. A four-step participatory integration framework has been developed to address this: 1) IPLCs engagement; 2) identification of vulnerability factors with IPLCs; 3) identification of both indigenous and scientific strategies to cope with factors affecting the vulnerability of IPLCs; 4) the development of an integrated strategy (Magni, 2017, p.443). This framework offers a reference for bridging knowledge systems in DSM.

During the “IPLCs engagement” phase, the Exploitation Regulations should move beyond consulting IPLCs to establish structured “knowledge co-production platforms”. This would require DSM programs to include IPLC representatives as experts in key processes such as EIAs, REMPAs and environmental management and monitoring plans (EMMPs). Collaborating with scientists to design assessment and monitoring indicators would integrate traditional ecological indicators with scientific data. Such institutional arrangements ensure that IPLCs are equal knowledge producers from the outset of decision-making, rather than merely information providers (Tengö et al., 2017).

During the “identification of vulnerability factors” phase, a “Multiple Evidence Base Approach” should be adopted. This approach respects the intrinsic validity of different knowledge systems: scientific knowledge is validated via peer review, while TK is established through IPLCs consensus, thereby avoiding the use of scientific standards to “validate” or marginalize TK (Tilot et al., 2021). In joint vulnerability assessments, IPLCs’ narrative knowledge of species behavioral changes should be treated as a parallel and complementary evidence alongside scientific environmental baseline data. Findings that may appear “contradictory” should be viewed as opportunities to deepen understanding of complex ecosystems, enabling more comprehensive identification of social-ecological vulnerabilities.

In the third phase, IPBES’s gradient integration approach should be adopted to establish a cross-scale knowledge integration mechanism. Specifically, a joint expert group comprising cross-cultural experts and IPLC representatives could facilitate the translation and spatial integration of knowledge (Caldeira et al., 2025). For example, GIS technology would overlay fishermen’s records of the seasonal occurrence of pelagic species and taboo zones with scientific data such as ocean current models and species gene flow patterns, creating a deep-sea-nearshore ecological connectivity knowledge base. This visualized complementarity would reveal ecological connectivity and risks imperceptible to one single knowledge system, enabling the co-design of more resilient monitoring and mitigation strategies (David-Chavez and Gavin, 2018).

Finally, in the “developing an integrated strategy” phase, the goal should be to establish a sustainable and adaptive governance framework that effectively incorporates co-produced knowledge into decision-making. It is recommended that provisions on

EMMPs adopt a performance-based management approach. Instead of mandating specific TK indicator use, the EMMP should require contractors to demonstrate, through the above participatory processes, adequate consideration and mitigation vulnerabilities and risks jointly identified by IPLCs and scientists (Jaecel, 2017). Furthermore, mutual capacity-building programs using cross-cultural training to enhance scientists’ comprehension of TK and strengthen IPLCs’ capacity for scientific and regulatory engagement, ensuring the sustainability of knowledge co-production (Tilot et al., 2021). Through this interlinked institutional design, DSM governance will shift from viewing TK as ancillary to recognizing it as complementary and co-constructed alongside scientific knowledge.

The above four-step framework should be embedded within DSM regulatory procedures to ensure implementation. During license application reviews, contractors should be required to demonstrate engagement with potentially affected IPLCs in accordance with the first two steps of the framework. For EIAs, findings of the third step (identification of indigenous and scientific strategies) should be incorporated into baseline studies and impact prediction models. In addition, the Council should establish clear criteria for how co-produced knowledge from the fourth step (integrated strategy development) will inform approval decisions, monitoring requirements, and adaptive management triggers. This procedural embedding transforms the integration framework from a theoretical approach into an operational requirement with concrete decision points in the DSM regulatory process.

5 Conclusion

This article explores how to effectively incorporate TK into Exploitation Regulations. Through analyzing relevant provisions in international law and instruments, it outlines the current status of TK within the Exploitation Regulations. The article identifies three core challenges to TK incorporation: no definition, implementation issues, and limited integration with modern science.

To address these challenges, this article proposes an identification framework for TK based on subject, time, content, and contextual elements. It clarifies the TK’s functional role in deep-sea environmental governance and establishes a tripartite system encompassing identification, implementation, and integration. The article links the institutional embedding of TK with deep-sea governance practice. It advocates an operational approach that “use as the priority, with protection as the secondary”, and promotes the TK-science integration through a knowledge co-production strategy.

Future research should focus on three areas. First, empirically evaluating the feasibility of TK-science collaborative governance through pilot programs. Second, developing institutional mechanisms to enhance the participation and capacity building of IPLCs. Third, refining TK validation mechanisms and cross-cultural integration methods to strengthen its effectiveness in deep-sea environmental governance.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding author.

Author contributions

ML: Writing – original draft, Writing – review & editing.
GX: Writing – review & editing.

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References

- Agrawal, A. (1995). Dismantling the divide between indigenous and scientific knowledge. *Dev. Change*. 26, 413–439. doi: 10.1111/j.1467-7660.1995.tb00560.x
- Aguon, J., and Hunter, J. (2019). Second wave due diligence: the case for incorporating free, prior, and informed consent into the deep sea mining regulatory regime. *Stanford Environ. Law J.* 38, 3–55.
- BBNJ Agreement. (2023). A/CONF.232/2023/4. in *The 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 (BBNJ Agreement)* (New York: United Nations Publication).
- Berkes, F. (2012). *Sacred Ecology*. 3rd ed (Abingdon: Routledge).
- Caldeira, M., Sekinairai, A. T., and Vierros, M. (2025). Weaving science and traditional knowledge: Toward sustainable solutions for ocean management. *Mar. Policy*. 174, 106591. doi: 10.1016/j.marpol.2025.106591
- CBD. (2011). In *Report of the Expert Group Meeting of Local Community Representatives Within the Context of Article 8(j) and Related Provisions of the Convention on Biological Diversity. Doc. UNEP/CBD/WG8j/7/8/Add.1*. Montreal. Available online at: <https://www.cbd.int/doc/meetings/tk/wg8j-07/official/wg8j-07-08-add1-en.pdf> (Accessed November 16, 2025).
- Chen, Y. (2018). *On the international legal protection of traditional knowledge* (Beijing: Intellectual Property Publishing House).
- Cobo, J. R. M. (1987). In *Study of the Problem of Discrimination against Indigenous Populations, Vol. v, Conclusions, Proposals and Recommendations. UN Doc E/CN.4/Sub.2/1986/7/Add.4*.
- Das, P. K. (2024). Protection of traditional knowledge by international legal instruments: A review from legal perspective. *Int. J. Judicial Sci. Res. Stud.* 1, 57–62. doi: 10.63090/IJJSRS/3049.0618.0012
- David-Chavez, D. M., and Gavin, M. C. (2018). A global assessment of Indigenous community engagement in climate research. *Environ. Res. Letters*. 13, 1–17. doi: 10.1088/1748-9326/aaf300
- Davis, M. (2008). Indigenous struggles in standard-setting: the United Nations declaration on the rights of indigenous peoples. *Melbourne J. Int. Law*. 9, 439–471. doi: 10.2139/SSRN.2298527
- Earth Negotiations Bulletin (ENB). (2019a). In *Summary report, 25 February – 1 March 2019 – 1st Part of the 25th Annual Session of the International Seabed Authority*. Available

Conflict of interest

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Eckstein, L., and Schwarz, A. (2018). The making of Tupaia's map: A story of the extent and mastery of Polynesian navigation, competing systems of wayfinding on James Cook's endeavour, and the invention of an ingenious cartographic system. *J. Pacific History*. 54, 1–95. doi: 10.1080/00223344.2018.1512369

ENB. (2019b). In *Summary report, 15–26 July 2019 – 2nd Part of the 25th Annual Session of the International Seabed Authority*. Available online at: <https://enb.iisd.org/events/2nd-part-25th-annual-session-international-seabed-authority-isa/summary-report-15-26-july> (Accessed November 16, 2025).

ENB. (2023). In *Summary of the 1st Part of the 28th Annual Session of the International Seabed Authority*, Vol. 25. Available online at: <https://enb.iisd.org/international-seabed-authority-isa-council-28-1-summary> (Accessed November 16, 2025).

ENB. (2025). In *Summary of the 1st Part of the 30th Annual Session of the International Seabed Authority*, Vol. 25. Available online at: <https://enb.iisd.org/international-seabed-authority-isa-council-30-1-summary> (Accessed November 16, 2025).

Ey, M., and Sherval, M. (2016). Exploring the minescape: engaging with the complexity of the extractive sector. *Area* 48, 176–182. doi: 10.1111/area.12245

Fiji Shore & Marinas. *FLMMA: Fiji Locally Managed Marine Protected Area Network*. Available online at: <https://www.fijimarinas.com/flmma-fiji-locally-managed-marine-protected-area-network/> (Accessed November 16, 2025).

Hein, J. R., and Koschinsky, A. (2014). “Deep-ocean ferromanganese crusts and nodules,” in *Treatise on Geochemistry*. Ed. S. Scott (Elsevier, Amsterdam), 273–291. doi: 10.1016/b978-0-08-095975-7.01111-6

Huang, Y., and Gao, C. (2024). Utilization and protection of traditional knowledge under the BBNJ Agreement and China's response. *Acad. Res.* 11, 53–61 + 2.

ILO. (1989). In *Convention concerning Indigenous and Tribal Peoples in Independent Countries (No. 169)*. 72nd ILC session, 1650 UNTS 383.

ISA. (2020). In *Proposal for a template with minimum requirements for regional environmental management plans: A proposal for a standardized approach*. ISBA/26/C/7. (International Seabed Authority (ISA). Available online at: <https://www.isa.org/jm/wp-content/uploads/2022/06/isba-26c-7-en.pdf> (Accessed November 16, 2025).

ISA. (2025). In *Draft regulations on exploitation of mineral resources in the Area Revised Consolidated Text (ISBA/30/C/CRP.1)*. (International Seabed Authority (ISA)).

Available online at: <https://www.isa.org/jm/wp-content/uploads/2025/01/10012025-Revised-Consolidated-Text-2.pdf> (Accessed November 16, 2025).

- Jaeckel, A. (2017). In *The International Seabed Authority and the Precautionary Principle: Balancing Deep Seabed Mineral Mining and Marine Environmental Protection*, Brill, Leiden, Netherlands (Leiden, Netherlands: Publications on Ocean Development, no. 83).
- Jiménez, E. G. (2024). Ownership in the deep seas: An old dilemma in deep seabed mining—Free, prior, and informed consent of Indigenous peoples in areas beyond national jurisdiction. *AJIL Unbound*. 118, 83–87. doi: 10.1017/aju.2024.10
- King, J. K. K., and Riera, L. (2022). The ‘Right Place’ for sharks in the South Pacific: Marine spatial planning in a more-than-human ocean. *Plann. Pract. Res.* 37, 299–316. doi: 10.1080/02697459.2022.2035918
- Liang, J. (2021). The development of regional ocean norms from the perspective of pacific islanders’ Ocean governance models and ideas and its enlightenment. *Pacific J.* 29, 53–65. doi: 10.14015/j.cnki.1004-8049.2021.11.005
- Magni, G. (2017). Indigenous knowledge and implications for the sustainable development agenda. *Eur. J. Education*. 52, 437–447. doi: 10.1111/ejed.12238
- Matsui, K. (2015). Problems of defining and validating traditional knowledge: A historical approach. *Int. Indigenous Policy J.* 6, 1–25. doi: 10.18584/iipj.2015.6.2.2
- Mistry, J., and Berardi, A. (2016). Bridging indigenous and scientific knowledge. *Science* 352, 1274–1275. doi: 10.1126/science.aaf1160
- Morgera, E. (2024). Participation of indigenous peoples in decision making over deep-seabed mining. *AJIL Unbound*. 118, 93–97. doi: 10.1017/aju.2024.12
- Mulalap, C. Y., Frere, T., Huffer, E., Hviding, E., Paul, K., Smith, A., et al. (2020). Traditional knowledge and the BBNJ instrument. *Mar. Policy*. 122, 104103. doi: 10.1016/j.marpol.2020.104103
- Nagoya Protocol. (2010). In *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* (Nagoya, Japan: UN Doc. CBD/CP/DEC/X/1). Available online at: https://treaties.un.org/doc/source/docs/UNEP_CBD_COP_DEC_X_1-E.pdf (Accessed November 16, 2025).
- Paul-Burke, K., O’Brien, T., Burke, J., and Bluett, C. (2020). Mapping Māori knowledge from the past to inform marine management futures. *New Z. Sci. Review*. 76, 31–40. doi: 10.26686/nzsr.v76i1-2.7831
- Powell, J. (2024). In *Norway’s Govt backs controversial deep-sea mining* (China Daily Global). Available online at: <https://www.Chinadaily.com.cn/a/202401/12/WS65a099c0a3105f21a507bf03.html>.
- Ray, S. (2023). Weaving the links: Traditional knowledge into modern science. *Futures* 145, 103081. doi: 10.1016/j.futures.2022.103081
- Savaresi, A. (2018). Traditional knowledge and climate change: A new legal frontier? *J. Hum. Rights Environment*. 9, 32–50. doi: 10.4337/jhre.2018.01.01
- Secretariat of the CBD. (2021). *Traditional Knowledge and the Convention on Biodiversity*. Available online at: <https://www.cbd.int/doc/publications/8j-brochure-en.pdf> (Accessed November 16, 2025).
- Shi, Y., and Zhuang, Y. (2025). Participation of Indigenous Peoples and local communities in the BBNJ Agreement: Legal basis, performance, and prospects. *Int. J. Mar. Coast. Law*, 1–36. doi: 10.1163/15718085-bja10244
- Sutherland, W. J., Gardner, T. A., Haider, L. J., and Dicks, L. V. (2014). How can local and traditional knowledge be effectively incorporated into international assessments? *Oryx* 48, 1–2. doi: 10.1017/S0030605313001543
- Tengö, M., Hill, R., Malmer, P., Raymond, C. M., Spierenburg, M., Danielsen, F., et al. (2017). Weaving knowledge systems in IPBES, CBD and beyond—Lessons learned for

sustainability. *Curr. Opin. Environ. Sustainability*. 26–27, 17–25. doi: 10.1016/j.cosust.2016.12.005

- Tilot, V., Willaert, K., Guilloux, B., Chen, W., Mulalap, C. Y., Gaulme, F., et al. (2021). Traditional dimensions of seabed resource management in the context of deep sea mining in the Pacific: learning from the socio-ecological interconnectivity between island communities and the ocean realm. *Front. Mar. Science*. 8. doi: 10.3389/fmars.2021.637938
- Trisos, C. H., Auerbach, J., and Katti, M. (2021). Decoloniality and anti-oppressive practices for a more ethical ecology. *Nat. Ecol. Evolution*. 5, 1205–1212. doi: 10.1038/s41559-021-01460-W
- UNCLOS. (1982). In *United Nations Convention on the Law of the Sea. 1833 UNTS 397*. Available online at: https://www.un.org/depts/los/convention_agreements/texts/unclos/unclos_e.pdf (Accessed November 16, 2025).
- UNESCO. (2003). In *Convention for the Safeguarding of the Intangible Cultural Heritage*. (UNESCO). Available online at: <https://ich.unesco.org/en/convention> (Accessed November 16, 2025).
- United Nations Environment Programme (UNEP). (2007). In *Deep-Sea Biodiversity and Ecosystems: A scoping report on their socio-economy, management and governance* (Cambridge: UNEP-WCMC). Available online at: https://www.unep-wcmc.org/resources/publications/UNEP_WCMC_bio_series (Accessed November 16, 2025).
- United Nations General Assembly. (2007). In *United Nations Declaration on the Rights of Indigenous Peoples. A/RES/61/295*. (New York: UN). Available online at: <https://docs.un.org/en/A/RES/61/295> (Accessed November 16, 2025).
- Ward, T. (2011). The Right to Free, Prior, and Informed Consent: Indigenous Peoples’ Participation Rights within International Law. *Northwestern Law J. Hum. Rights*. 10, 54–84. Available online at: <http://scholarlycommons.law.northwestern.edu/njihr/vol10/iss2/2> (Accessed November 16, 2025).
- WIPO. (2001). Intellectual property needs and expectations of traditional knowledge holders: WIPO report on fact-finding missions on intellectual property and traditional knowledge, (1998–1999). Available online at: https://www.wipo.int/edocs/pubdocs/en/tk/768/wipo_pub_768.pdf (Accessed November 16, 2025).
- WIPO. (2015). Traditional knowledge. Available online at: <https://www.wipo.int/tk/en/tk/> (Accessed November 16, 2025).
- WIPO. (2024a). In *The Protection of Traditional Knowledge: Draft Articles* (Geneva: WIPO/GRTKF/IC/40/18 ANNEX). Available online at: https://www.wipo.int/edocs/mdocs/tk/en/wipo_grtkf_ic_40/wipo_grtkf_ic_40_18.pdf (Accessed November 16, 2025).
- WIPO. (2024b). In *WIPO Treaty on Intellectual Property, Genetic Resources and Associated Traditional Knowledge* (Geneva: WIPO Doc. SCT/49/7).
- WIPO. (2025). In *Glossary of Key Terms Related to Intellectual Property and Genetic Resources, Traditional Knowledge and Traditional Cultural Expressions* (Geneva: WIPO/GRTKF/IC/51/INF/7). Available online at: https://www.wipo.int/edocs/mdocs/tk/en/wipo_grtkf_ic_51/wipo_grtkf_ic_51_inf_7.pdf (Accessed November 16, 2025).
- World Trade Organization (WTO). (1994). In *Agreement on Trade-Related Aspects of Intellectual Property Rights. 1869 UNTS 299, 33 ILM 1197*. (Marrakesh, Morocco). Available online at: <https://www.wipo.int/wipolex/en/text/305907> (Accessed November 16, 2025).
- Zalik, A. (2018). Mining the seabed, enclosing the area: ocean grabbing, proprietary knowledge and the geopolitics of the extractive frontier beyond national jurisdiction. *Int. Soc. Sci. J.* 68, 343–359. doi: 10.1111/issj.12159