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Unseen and unheard: the invisibility of kelp forests in international environmental governance

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Kelp forests are one of the most extensive coastal ecosystems in the world. They serve a myriad of ecological functions, support substantial biodiversity, and contribute to a multitude of services essential to our contemporary society. Unfortunately, they are in decline. International governance regimes and institutions play an important role in addressing threats to marine ecosystems and combatting declines. However, not all ecosystems receive the same level of global governance attention. There is a growing interest in coastal ecosystems, and an overall increase in conservation targets and restoration programmes on many international platforms. We demonstrate that kelp forests consistently receive the least global governance attention compared to other dominant marine habitats. To address the disconnect between kelp science and environmental governance, we make five recommendations for the future.

KEYWORDS

kelp forests, coastal ecosystems, global environmental governance, international governance, science-policy interface

Introduction

The global environmental and climate crises pose significant threats to coastal ecosystems (Wernberg et al., 2023). Kelp forests are one of the most extensive coastal ecosystem in the world, with a biome covering more than a third of the world's coastline (Feehan et al., 2021). They fulfil many ecological functions, support vast biodiversity, and contribute to a multitude of services to our contemporary society (Bennett et al., 2016; Feehan et al., 2021; Filbee-Dexter et al., 2022). Long-term time series from sites across their global range suggest between 40–60% of the world's kelp forests have declined in the past half-century (Wernberg et al., 2019), with a 2% annual instantaneous global average rate of loss (Krumhansl et al., 2016; UNEP, 2023).

International governance regimes and institutions play an important role in addressing global environmental threats to natural ecosystems, such as climate change and the global biodiversity decline, by providing binding rules and standards, priorities and targets, technical reports and guidelines and a forum for collaborative decision-making, sharing expertise and highlighting best practices (Techera and Klein, 2014; Richardson, 2016; Yu, 2022). For ecosystems, there is no single regime of relevance and instead the governance landscape is comprised of multiple legal instruments, institutions, and programmes. Of relevance are those that protect habitats and areas (e.g., the World Heritage Convention, the Ramsar Convention on Wetlands), those that seek to conserve and manage biodiversity (e.g., the Convention on Biological Diversity) and those that focus on climate change (e.g., the UN Framework Convention on Climate Change, the Paris Agreement, the Intergovernmental Panel on Climate Change). Added to this are key global inter-governmental (e.g., the Food and Agriculture Organisation, the UN Educational, Scientific and Cultural Organisation) and non-governmental institutions (e.g., the International Union for Conservation of Nature) that seek to provide assessment, guidance, and scientific evidence on global environmental challenges.

While there is growing interest in coastal ecosystems in general, and an overall increase in conservation targets and restoration programmes, not all ecosystems receive the same level of attention. Here we provide a quantitative analysis of the number of times kelp forests, coral reefs, seagrass meadows, mangrove forests, and salt marshes – all globally dominant biogenic marine ecosystems – are mentioned on global environmental governance regime and institution websites. We find that kelp forests consistently receive the least mentions and are sometimes not referred to at all. This discrepancy is concerning because kelp forests are among the most extensive coastal ecosystems on Earth, and their continued decline will result in the loss of substantial and valuable ecosystem functions and services for future generations. This paper explores these mentions and provides recommendations for potential ways in which the challenge of including kelp forests in these regimes and institutions may be overcome.

Problem

Scientific research on kelp forests has expanded almost exponentially in recent decades (Wernberg and Filbee-Dexter, 2019). This research has shown that kelp forests have considerable value as habitat, for regulating coastal processes, and providing many cultural benefits (Feehan et al., 2021), but also that these ecosystems are declining rapidly due to climate change and its related impacts such as marine heat waves (MHW) (Arafah-Dalmau et al., 2019; Wernberg et al., 2019; Wernberg, 2021) yet receive limited conservation and restoration effort compared to other iconic ecosystems (Saunders et al., 2020; Filbee-Dexter et al., 2022).

International environmental governance (IEG) regimes can mandate conservation actions, but most often act more as an incentive that relies on self-compliance by nations. Treaties are often worded in aspirational (or soft) language, such as “shall” or

“may”, rather than regulatory language such as “must” or “will” in order to garner the participation and signature of a majority of nations (Guzman and Meyer, 2010; Shaffer and Pollack, 2010; Weismann, 2017). As an example, the Paris Agreement’s only legally binding requirement for the parties (nations) is to provide Nationally Determined Contributions (NDCs) that outlines the commitments to mitigation and adaptation actions to meet the agreement’s targets, but there are no binding obligations to deliver on those pledges. These regimes can still be important influencers of conservation interventions. For example, despite its soft language the Convention on Biological Diversity has triggered global action through work programmes – e.g., the Marine and Coastal Biodiversity programme of work adopted in 1998 at the COP IV (Secretariat of the CBD, 1998) – as well as domestic law, policy and projects including the preparation of National Biodiversity Strategies and Action Plans (UN General Assembly, 1992a; Biodiversity Working Group, 2019). The influence of IEG regimes and institutions also often affects the allocation of resources and funding for management, conservation, and restoration efforts at the national level. International environmental governance regimes such as the Ramsar Convention (United Nations, 1971) and the World Heritage Convention (United Nations, 1972) provide a framework that requires implementation of obligations and justification of actions locally, facilitating the allocation of resources and funding to the protection and conservation of sites of significant importance. Underrepresentation of ecosystems in such regimes may lead to inadequate and insufficient resources (technical and financial) dedicated to conservation and restoration, compared to other coastal ecosystems that receive more attention.

In cases where global governance regimes focus attention on narrow issues, significant conservation advances have been made. One example is the moratorium on whaling adopted under the International Convention for the Regulation of Whaling. In some instances, specific marine biogenic ecosystems have received global attention. Salt marshes and wetlands have been identified at an international level for their global importance as waterfowl habitats since the 1960s and have received international protection since 1972 when the Ramsar Convention was adopted (United Nations, 1971). Coral reefs were initially identified in international law and policy in 1981 when the Great Barrier Reef became the first coral reef to be listed under the World Heritage Convention (Queensland Government, 2020). Later, following the Rio Conference in 1992 as part of the Agenda 21 guidelines, coral reefs were again singled out for conservation (United Nations, 1992a), and a few years later in 1996 through the creation of the International Coral Reef Initiative (Dight and Scherl, 1997). This recognition has resulted in diverse interventions down to the local level that range from protection measures to active restoration practices (Saunders et al., 2020).

To explore the global governance attention given to different coastal ecosystems, we identified the most relevant governance regimes and institutions for marine biogenic ecosystems (cf. Figure 1) and investigated how often these ecosystems were mentioned on the online communication platforms of these governance regimes and institutions. This approach aimed to provide a high-level picture of the representation of different ecosystems in the public communication of the established

governance regimes and institutions (including international scientific and environmental authorities) that were considered as a point of reference for the public, national governments and/or environmental non-government organizations. The search was repeated two times, in August 2021 and again in January 2023, assessing the representation of kelp forests before and after the official launch of two United Nations decades of considerable relevance to kelp forests: The UN Decade of Ecosystem Restoration (UNEP and FAO, 2020) and the UN Decade of Ocean Science for Sustainable Development (UNEP and UNESCO-IOC, 2017; Ryabinin et al., 2019). Moreover, these time points also represent a period of rapidly increasing published research underscoring the potential role of seaweeds and kelp forests in carbon sequestration (Krause-Jensen and Duarte, 2016; Duarte et al., 2022; Pessarrodona et al., 2022), and their critical role in aquaculture, a keystone sector in a burgeoning blue economy (Duarte et al., 2021).

In total 13 international environmental governance (IEG) regimes (7 institutions and 6 treaties) were explored for their mentions of the investigated marine biogenic ecosystems (Figure 1). The 13 IEGs were selected based on their relevance in terms of incentivizing and influencing actionable interventions for marine biogenic ecosystems (such as kelp forests) at local, national or international levels. This was determined for the institutions using their principal or mission statement and core areas of activity and was determined for the treaties by identifying any articles within the treaties relevant for conservation, management and/or restoration of marine biogenic ecosystems (Supplementary Material). For each IEG we calculated the number of 'mentions' for each ecosystem, which was the number of results obtained when searching for kelp, seagrass mangrove, salt marsh or coral on the publicly accessible platforms of each of the 13 IEGs. These platforms were used as proxies to investigate the IEGs communication focus about marine ecosystems. To explore the breadth and relevance of these mentions, for the 'kelp' 2021 search each mention was examined and categorized into a report, manual, legislation, article, scientific paper, agenda, speech, submission, NDC, action, news, event, or webpage (Supplementary Material). The item with the specific mention was described and classified based on whether it was focused on kelp or simply included kelp in the text. For the other marine ecosystems, we did not evaluate the relevance or accuracy of the actual mentions, but just compared the total number of mentions with total number of mentions for kelp. Our approach also did not account for potential variations of spelling, names, or language other than English. The platform used for the Ramsar Convention and the World Heritage Convention were the site registries, which provide information on all the sites under their authority, including all member nations' applications to the convention. Between 2021 and 2023, three of the other platforms changed: the Intergovernmental Science-Policy Platform for Biodiversity and Ecosystem Services added a search engine which did not exist in 2021 hence the results were extracted from their annual report (IPBES, 2019). The resulting numbers changed in 2023 likely due to the use of a search engine on the platform, which directs users to a single result containing the keyword rather than the number of mentions within a report. In addition, the UN Framework Convention on Climate Change

changed the available documentation which was limited to a maximum of 100 results; and the Paris Agreement platform (Nationally Determined Contributions Registry) relocated to their own platform which lacks a specific keyword search engine.

The five coastal ecosystems received a total of 15,931 and 7,722 mentions in 2021 and in 2023, respectively (Figure 1). In general, kelp forests received the least attention among coastal ecosystems across most of the regimes and institutions. The UN Framework Convention on Climate Change (UNFCCC) (Figure 1C) had the highest number of mentions for kelp in both 2021 (55) and 2023 (88) followed by the Food and Agriculture Organisation (Figure 1K) with 10 mentions in 2021 and 28 mentions in 2023, and by the Convention on Biological Diversity (CBD) (Figure 1A) with, respectively, 17 and 21 mentions. All UNFCCC mentions of kelp in 2021 were reports, submissions, presentations or other items that were not focused on kelp, whereas 9 out of 10 of the FAO mentions were reports, legislation or manuals focused on kelp or seaweed and all mentions on the CBD website were news articles or events focused on kelp (Supplementary Material). Kelp forests were still mentioned the least compared to other coastal habitats in both the UNFCCC and the CBD. Beside those three IEGs, kelp forests results remained similar or declined slightly between 2021 and 2023 in the other regimes and institutions.

Overall, between 2021 and 2023, most regimes or institutions demonstrated consistency in the proportion of references to each ecosystem (Figure 1). Some treaties and institutions showed a large increase in the number of mentions during that period for specific ecosystems: the International Union for Conservation of Nature (IUCN) for seagrass meadows and mangroves forests (Figure 1I), or the Sustainable Development Goals for mangroves forests and coral reefs (Figure 1G). Others were relatively consistent over time, such as the CBD (Figure 1A) or had slightly decreased across all five ecosystems (e.g., the UN Education, Scientific, and Cultural Organisation (Figure 1D)). Mangrove forests and coral reefs were the most frequently mentioned ecosystems across the majority of the international environmental governance regimes and other institutions. In 2021, they were particularly prominent in the communications platforms of the UNFCCC and the IUCN. In 2023, their overall mentions decreased (See Figures 1C, I), but they still maintained the highest results compared to other ecosystems. The Ramsar Convention on Wetlands (Figure 1F) appears to focus primarily on salt marshes, with the highest number of mentions in both 2021 (1,847) and 2023 (1,871). This was not surprising, as the Ramsar Convention specifically addresses the conservation and sustainable use of wetlands, even though the convention's definition for "wetlands" establish the boundaries to up to six meters depth at low tide (United Nations, 1971).

Kelp forest made up 2% (± 0.5 SE) of all mentions in 2021 and 5% (± 2 SE) in 2023, averaged across the 13 platforms (Figure 2). In contrast, coral reefs made up 43% (± 6 SE) and 39% (± 7 SE), and mangrove forests 28% (± 5 SE) and 26% (± 5 SE) of mentions in 2021 and 2023. Seagrass made up 8% (± 2 SE) and 10% (± 2 SE), and salt marshes 8% (± 6 SE) and 10% (± 2 SE) of mentions in 2021 and 2023 (Figure 2).

Across all regimes and institutions, for every mention of kelp forests in 2021, seagrass meadows were mentioned seven times,

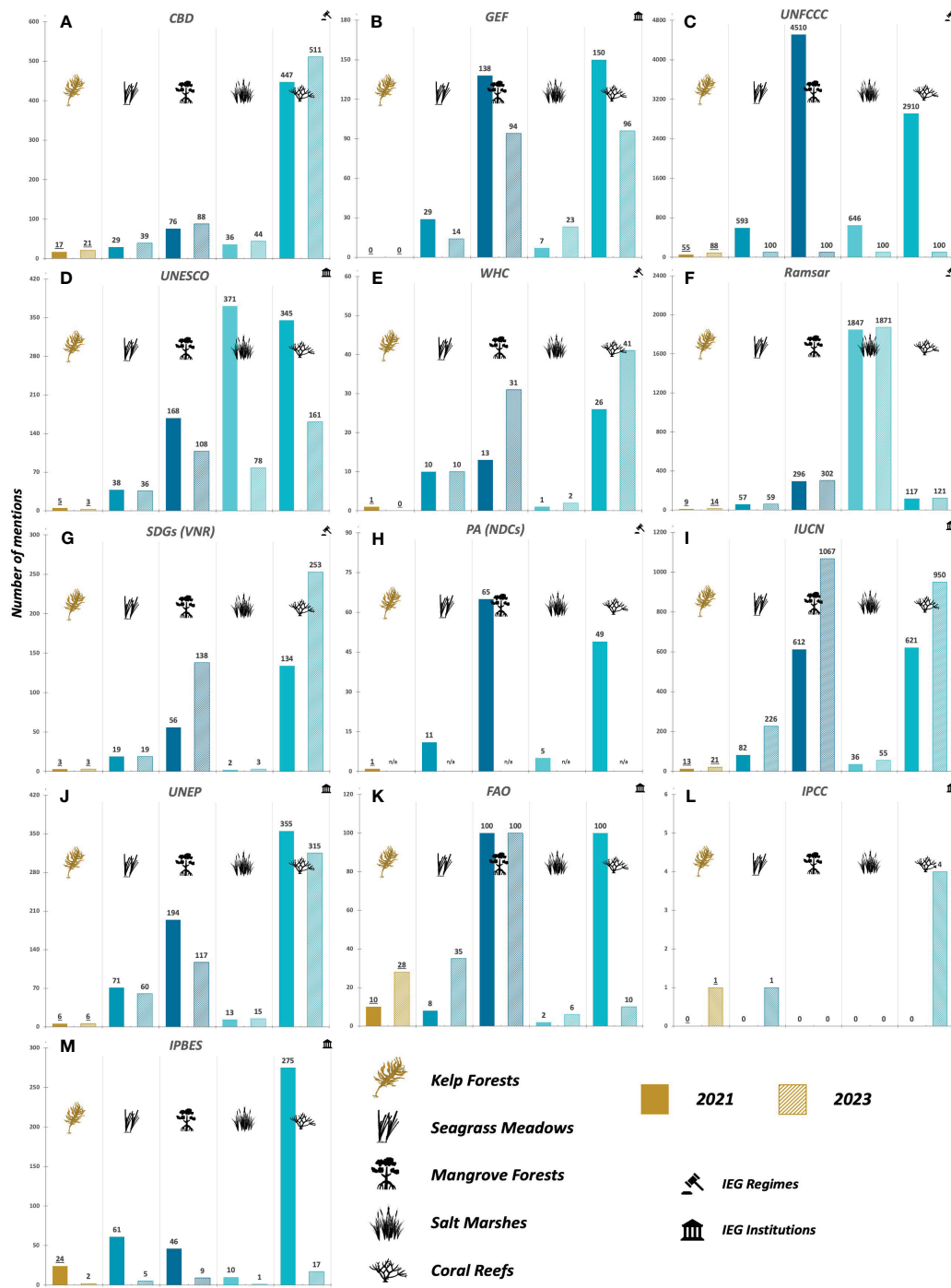


FIGURE 1 Number of mentions of each iconic coastal ecosystem (kelp forests, seagrass meadows, mangrove forests, salt marshes, and coral reefs) resulting from a keyword search on the public online platforms of the selected international environmental governance regimes and institutions [(A) Convention on Biological Diversity - CBD; (B) Global Environmental Fund - GEF; (C) United Nations Framework Convention on Climate Change - UNFCCC; (D) United Nations Educational, Scientific, and Cultural Organisation - UNESCO; (E) World Heritage Convention - WHC; (F) Ramsar Convention on Wetlands; (G) Sustainable Development Goals Voluntary National Reviews - SDGs (VNR); (H) Paris Agreement National Determined Contributions - PA (NDCs); (I) International Union for Conservation of Nature - IUCN; (J) United Nations Environment Programme - UNEP; (K) Food and Agriculture Organization - FAO; (L) Intergovernmental Panel on Climate Change - IPCC; (M) Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services - IPBES]. Mentions results were investigated in August 2021 and January 2023. Each graph is specific to a regime or institution and present the mentions for each ecosystem for both years.

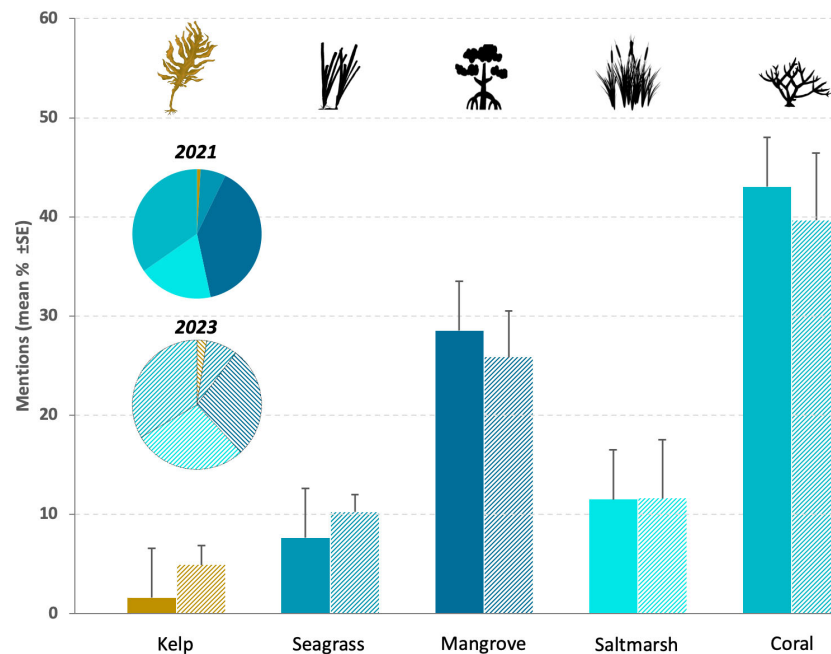


FIGURE 2

Overall percent of mention across all regimes and institutions of each dominant marine biogenic ecosystem (kelp forests, seagrass meadows, mangrove forests, salt marshes, and coral reefs) between 2021 and 2023. Total recorded mentions for all five ecosystems: 2021 = 15,931; 2023 = 7,722.

mangroves 43 times, salt marshes 20 times and coral reefs 38 times (Figure 2). In 2023, the margins decreased but the overall pattern remained; for every mention of kelp forests, seagrass meadows were mentioned three times, mangroves, and salt marshes 11 times and coral reef 13 times (Figure 2). While this change may be interpreted as a sign of a growing acknowledgment of kelp forests among international environmental governance regimes, it is likely also the result of a change in the communication of several of the regimes and institutions' platforms, such as the Science-Policy Platform for Biodiversity and Ecosystem Services, the UNFCCC and the Paris Agreement, which reduced the total recorded mentions for all five ecosystems from 15,931 (2021) to 7,722 (2023). Importantly, the overall distribution trend, especially the position of kelp in comparison to other ecosystems, remained consistent (Figure 2).

Implications

International environmental governance regimes play a vital role in influencing and incentivizing nations, non-governmental organizations, and the public in general, to address global environmental challenges (UN General Assembly, 1992b; United Nations, 1992b; United Nations, 1992c). By creating priorities, guidelines and obligations, and by setting standards and targets, global governance shapes the discourse around conservation, management and restoration efforts, driving policy and decision-making at local and national scales (High-Level Political Forum on Sustainable Development, 2013). Here we show unequal visibility of specific ecosystems in IEG regimes and institutions, which may

have consequences for resources allocation, public perception, and the prioritization they receive. Saunders et al. (2020) investigated the proportion of restoration projects undertaken for coastal ecosystems globally over the last five decades. Every marine biogenic ecosystem experienced an increase in both the spatial scale of projects and the number of projects undertaken, yet kelp forests – the least visible ecosystem in IEGs – have been consistently lower and not experienced similar increases (Saunders et al., 2020). Their underrepresented status in IEG treaties and organizations may not be the only reason behind this global lack of interest. It is possible that kelp forests received less policy attention because they are not as frequently discussed in the literature as other biogenic ecosystems (Feehan et al., 2021). Yet, increased international recognition and support could influence and promote initiatives to protect, conserve and restore kelp forests. Importantly, the limited mentions of kelp forests by IEG regimes and institutions could result in reduced awareness of their ecological importance and the threats they face. This lack of awareness could hinder the development of effective advocacy efforts and conservation aspirations focusing on kelp forests (United Nations Environment Programme, 2020) and may lead to reduced resources dedicated to their conservation.

Additionally, international environmental governance regimes establish binding obligations and institutions often set global policy agenda and targets that are translated at the national and local scale. For example, the Sustainable Development Goals have been mirrored in the national policies of many countries around the world (The White House, 2016; Angus, 2018; Höhne et al., 2018); and the Paris Agreement has triggered national commitments

submitted in the form of Nationally Determined Contributions. The limited focus on kelp forests may result in less attention and priority being given to them, and limited inclusion in national and local governance frameworks and actions plans.

IEG regimes and institutions also play an important role as facilitators and vehicles for knowledge sharing, capacity building, and the development of best practices in the context of ecosystem conservation and restoration. The regular Conferences of the Parties (COP) for several regimes offer opportunities to collaborate and share knowledge (Secretariat of the CBD, 2004; Llewellyn et al., 2016; Ritchie and Reay, 2017; Selmoni et al., 2020). Several of these regimes and institutions also endorse or catalyse global initiatives such as the UN Decade for Ecosystem Restoration (UNEP and FAO, 2020), or the UN Decade of Ocean Science for Sustainable Development (UNESCO, 2021), that are fundamentally based on global exchange and cooperation (Trakadas et al., 2019; UN Decade of Restoration, 2021). The underrepresentation of kelp forests in these contexts limits opportunities to exchange knowledge and experiences related to their conservation or restoration practices, leading to slower progress in addressing the challenges they face. Practitioners are limited to relying solely on bottom-up initiatives and networks such as the Green Gravel Action Group (GGAG, 2021) or the Kelp Forest Alliance (Kelp Forest Alliance, 2023) to collaborate and advance their knowledge.

Finally, IEG regimes and institutions can shape and create research priorities and focus areas by highlighting the significance of specific ecosystems. The role of mangroves and seagrass in coastal defense (Lecerf et al., 2021), seagrass meadows for carbon sequestration (United Nations Environment Programme, 2020), or coral reefs for biodiversity conservation (IPBES, 2019) are a few of many examples. The limited mention of kelp forests by these treaties and organizations, even if they play some part in promoting the significance of kelp, may result in fewer research projects investigating their ecology, stressors, and potential solutions to address their decline, which in turn could slow down the development of innovative conservation and restoration strategies. For example, in Australia the Great Southern Reef, an 8000 km stretch of temperate reef dominated by kelp forests, received 13 times less annual funding for research than its tropical counterpart (4M \$A vs 55.3M \$A), the Great Barrier Reef (Bennett et al., 2016).

Actionable recommendations

We make five recommendations to draw greater attention to kelp and kelp forests, and explore how conservation, management and restoration can be advanced.

1. IEG regimes and institutions could utilize research and funding mechanisms to ensure continuous monitoring, identify data gaps, and promote research areas such as proactive management and conservation, sustainable uses, and long-term restoration methods. For example, kelp forests currently have not received Global Environmental

Fund funding, whereas coral reefs and mangroves forests represent a large majority of the projects funded (Figure 2).

2. IEGs could commission international reports focused on kelp forests that are relevant to global initiatives and challenges outlined in the treaties and organizations. This was recently done by the United Nations Environment Programme with the “*Into the Blue*” report focused on kelp (UNEP, 2023). This publication has the capacity to become a steppingstone for the state of knowledge and recognition of kelp forests at the international level of benefit to multiple treaties and organizations.
3. The global community should consider a potential agreement or Memorandum of Understanding (MOU) on the preservation of kelp forests and/or a common work programme across the key regimes and institutions. This has been done for coral reefs and highlighted by UNEP 20 years ago (UNEP, 2003). Indeed, the legal mechanisms and tools already exist, it is only a matter of international agreement to focus their use on kelp forests.
4. International institutions could initiate and operate a database/portal/clearinghouse, to collate existing research and knowledge including scientific baseline data, as well as trends and predictions/modelling, laws, policies, economic instruments to promote collaboration and research on kelp forests. Again, several such databases exist and gather scientific information – e.g. MPA Atlas – and international legal instruments support clearinghouse mechanisms and data sharing (e.g. Cartagena Protocol under the CBD).
5. Finally, researchers studying kelp forests should actively engage with international institutions and regimes wherever possible, through their ongoing initiatives, as expert reviewers, contributing authors, pledge makers, committee members, or by contributing invited submissions or peer reviewed articles on these ecosystems.

Conclusions

Kelp forests have largely been invisible in international environmental governance regimes despite expanding and emerging scientific knowledge. If more severe declines are to be avoided, focused effort by the global community is needed. Given the value that kelp forests provide, their extensive global coverage and their declining conservation status, kelp conservation, management, and restoration warrant similar attention to other marine biogenic ecosystems by the international community.

Author contributions

All authors contributed to conception and design of the study. JV performed the study and the analysis of the data under ET, KF-D, and TW supervision. JV wrote the first draft of the manuscript.

All authors contributed to manuscript revision, read, and approved the submitted version.

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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.

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fmars.2023.1235952/full#supplementary-material>

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