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New frontiers of marine governance in the ocean decade

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New frontiers of marine governance in the ocean decade

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Editorial: New frontiers of marine governance in the ocean decade

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Editorial on the Research Topic
New frontiers of marine governance in the ocean decade

The ocean is threatened by various human stressors, from global warming to pollution, overfishing, and biodiversity loss, impacting marine socio-ecological systems. A key challenge, as recognized by the United Nations (UN) Decade of Ocean Science for Sustainable Development, is how to balance an increasing appetite for Blue Growth — and the related intensification of ocean use by renewable offshore energies, fisheries, aquaculture, tourism, blue biotechnology, shipping or deep seabed mining — with the targets of the UN 2030 Agenda for Sustainable Development and the Kunming-Montreal Global Biodiversity Framework (KMGBF). Both establish a new framework, calling for 30% of coastal and marine areas to be effectively conserved and managed by 2030. This Research Topic addresses some of the challenges raised by such a framework, providing insights into new ocean governance approaches and tools. These approaches range from adaptive management of marine protected areas (MPAs) to international instruments for biodiversity protection in Areas Beyond National Jurisdiction (ABNJ) to new carbon dioxide removal technics.

This Research Topic begins with an article by Marques et al., who review governance settings in a comparative analysis of the national ocean strategies of five different Atlantic nations—France, Ireland, Portugal, Spain, and the United Kingdom (UK). In the European Union (EU), the challenge of balancing Blue Growth with marine biodiversity conservation was addressed through its Integrated Maritime Policy (IMP), which is characterized by regional approaches, particularly in the Atlantic. The authors highlight that key priorities of the analyzed ocean strategies pertain to climate change mitigation and adaptation and nature conservation (in line with the EU Green Deal), together with investigation, development, and innovation. The ocean strategies of France and Portugal are the only ones that are aligned with the UN Sustainable Development Goals (SDGs) and the Atlantic Action Plan and that follow the guidelines of the EU IMP. The suggestion to create a regional working group as a way forward for a better alignment among national ocean strategies of Atlantic basin countries (Marques et al.) represents a new pathway for a regional scale governance discussion.

The article by Troya et al. reviews the evolution of marine governance in the case of Ireland in response to EU policy requirements related to a sustainable Blue Economy. With the introduction of its National Marine Planning Framework and the Maritime Area Planning Act (2021), Ireland intended to reform the consent regime for key Blue Economy sectors such as offshore renewable energy (ORE). The exclusion of aquaculture from the new consent regime could hinder the full integration of the sector into a broader marine spatial planning (MSP) framework, potentially mitigating compliance with environmental goals established by EU Directives. By identifying policy and legal gaps related to aquaculture integration and aquaculture licensing cases, the authors highlight that the legal framework underpinning MSP in Ireland may hinder the achievement of sustainability across all marine sectors (Troya et al.). Their paper provides a sharp vision of the needs and challenges of Ireland's current governance picture.

Boemare focuses on the interconnectedness of anthropogenic infrastructure, such as offshore wind farms (OWFs), and the marine environment, seeing OWFs as places for recreating relations with marine life. The rise of ORE as a structural component of the energy transition is also a call for a new Blue Deal, particularly in what concerns OWFs. ORE represents a climate-friendly process to produce electricity and an opportunity for shifting paradigms. Wind turbines are perceived as more than physical artifacts but also a location for engaging economic activities and marine life. A potentially useful advance places the idea of interconnectedness at the core of research, focusing on creating interspecific assemblages around offshore wind turbines that increase biological diversity, thereby expanding benefits for humans (Boemare). This vision represents an interesting approach aligned with the concerns of co-allocation/multiple use of ocean space.

Taking an entirely different and more critical perspective, Khan et al. raise the question of what Brexit means for the relations among China, the UK, and the EU, focusing on port governance and shipping within the context of China's Maritime Silk Road initiative (MSR). Shipping intensity is increasing, now accounting for 80% of world trade. China is one of the largest countries conducting its trade through shipping, but the EU and the UK are also key players. Brexit will likely change this situation, as a new division of port governance between the EU and the UK may impact maritime trade. This is particularly relevant considering China's and the UK's interests in the Indian Ocean, as well as new trade routes that open China to the Indian Ocean *via* the Arabian Sea (Khan et al.).

While a global transition to clean energy advances gradually, and the need for ocean-based actions for climate change adaptation and mitigation is increasingly recognized, scientists and policymakers are starting to look toward carbon dioxide removal (CDR) methods as potential solutions. In this context, Loomis et al. emphasize the need for a code of conduct related to ocean CDR research, and they propose fifteen critical components for such a code of conduct. Attention has increasingly focused on ocean CDR techniques, which enhance or restore marine systems to sequester carbon. Ocean CDR research may, however, impose risks to the environment and human welfare. A code of conduct that establishes principles for responsible research, fairness, and equity is needed, as there are no domestic regulations to ensure the safety and efficacy of this research (Loomis et al.).

Based on examples of good governance and adaptive management at the Great Barrier Reef (GBR) Marine Park, Day presents and discusses nine governance principles that can be applied to MPAs globally. The decades of experience at the GBR Marine Park include intergovernmental arrangements that enable federal and state governments to cooperate effectively across adjoining marine jurisdictions. In addition, applying multiple layers of management helps lead to an effective integrated approach, considered the most appropriate approach for managing large MPAs. The nine governance principles identified can be extrapolated to other MPAs, with the acceptance that there will be variations in how principles will be applied to different spatial scales and contexts (Day).

When considering governance frameworks for marine conservation, the levels of restriction of human use lie at the heart of the debate about MPAs' effectiveness. Based on an analysis of MPAs' regulations from thirty-one different countries, Andradi-Brown et al. found that partially protected MPAs can offer effective and equitable pathways for biodiversity conservation if tailored to the local context. Rather than focusing primarily on fully protected areas for achieving new global MPA targets, the authors recommend that countries use a blend of locally-appropriate protection levels – from fully to partially protected areas to achieve positive biodiversity outcomes (Andradi-Brown et al.). This shift in MPA management goals may serve as the basis for new discussions on restriction-level options.

Tomás and Sanabria contribute further insights into MPA effectiveness in conserving specific groups and species, such as marine mammals. The authors conclude that area-based protection measures can be effective for diverse types of marine mammals and that adaptive management, being context-specific, is more effective than the precautionary principle (Tomás and Sanabria). This conclusion further backs up the findings by Andardi-Brown et al. (2023), providing new insights into conservation strategies' effectiveness.

MPA effectiveness is closely connected to financing, as insufficient funding leads to "paper park" situations. Casimiro et al. argue that ecotourism development and community participation are paramount in achieving sustainable development in MPAs because they increase funding sources. Yet, there is a knowledge gap regarding the enhancement of natural capital through ecotourism, and governance models of MPAs might not be ready to promote ecotourism fully. There is a need for new advances and improvements in marine governance (Casimiro et al.). With the continuously growing numbers of eco-tourists worldwide, this is a call worthy of attention.

A key marine conservation challenge pertains to the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction. Santos et al. argue that the new treaty on biodiversity beyond national jurisdiction (BBNJ) will likely dramatically transform environmental stewardship on the High Seas, making it essential that the BBNJ treaty is supported vigorously. The authors highlight that such support can strengthen multilateral institutions and boost international cooperation

towards common environmental goals, enhance the health of shared marine ecosystems and resources, and drive truly sustainable ocean-based economic growth. The treaty further provides an opportunity to engage equity as a critical principle to tackle global ocean inequalities meaningfully (Santos et al.).

Finally, the tension between Blue Growth and marine conservation requires exploring new frontiers in marine governance. A key challenge is the need for a transdisciplinary approach considering the complexity of global maritime and marine systems. Based on an analysis of ocean development-financed projects in Fiji and the Solomon Islands, Hills and Maharaj highlight this need by acknowledging the "indivisibility" of the UN SDGs, arguing that enhanced integration of ocean governance supports this transformation. Nevertheless, for regions highly dependent on development finance, a powerful leverage point would be the design of development investments in place, moving from "business-as-usual" to transdisciplinary and transformational approaches. Expanding ocean-based knowledge may not be sufficient to ensure transdisciplinary and transformational outcomes; this has implications for filling the financing gap in the UN Ocean Decade and shaping significant investments by development partners in the ocean (Hills and Maharaj).

Viewed through a scientific lens, this Research Topic provides space and voice to a myriad of management visions and challenges. Our hope for a broader scope of analysis led to a collection of transdisciplinary articles covering different geographic realities and ocean sustainability-related topics. The diversity and complexity of the topics and analyses included in this Research Topic further mirror the variety and complexity of marine social-ecological systems, ocean-related challenges, and potential solutions requiring innovative approaches to governance.

Author contributions

JG: Lead writing. HC: co-writing, revision and editing. MB: co-writing, revision and editing. CS, co-writing, revision and editing. JT, co-writing, revision and editing. All authors contributed to the article and approved the submitted version.

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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A Code of Conduct Is Imperative for Ocean Carbon Dioxide Removal Research

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As the impacts of rising temperatures mount and the global transition to clean energy advances only gradually, scientists and policymakers are looking towards carbon dioxide removal (CDR) methods to prevent the worst impacts of climate change. Attention has increasingly focused on ocean CDR techniques, which enhance or restore marine systems to sequester carbon. Ocean CDR research presents the risk of uncertain impacts to human and environmental welfare, yet there are no domestic regulations aimed at ensuring the safety and efficacy of this research. A code of conduct that establishes principles of responsible research, fairness, and equity is needed in this field. This article presents fifteen key components of an ocean CDR research code of conduct.

Keywords: carbon dioxide removal, ocean, policy, research governance, geoengineering

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INTRODUCTION

Industrial development has unequivocally altered the Earth's climate, unleashing widespread changes in natural systems that have increasingly inequitable outcomes for humans (IPCC, 2021). Limiting global warming to the 1.5° C goal at the heart of the 2015 Paris Agreement — or even to the Agreement's "avoid at all cost" upper limit of 2° C — requires that drastic and rapid emissions cuts be supplemented with carbon dioxide removal (CDR) to eliminate historically emitted anthropogenic carbon dioxide that continues to warm the planet (Rogelj et al., 2018). However, CDR techniques may have profound adverse social and environmental impacts, such as disruption to ecosystems and food webs, pollution, and high energy costs. To avoid exacerbating the already-inequitable impacts of climate change, climate mitigation must be pursued *via* methods that maintain biodiversity and support social equity (Pörtner et al., 2021). Research codes of conduct help ensure these goals can be equally upheld throughout the process of developing solutions (Hubert, 2021).

Although attention surrounding CDR has traditionally focused on land-based techniques to reduce atmospheric carbon dioxide levels, interest in various ocean-based CDR solutions is now skyrocketing among policymakers, funders, scientists and entrepreneurs (Boettcher et al., 2021). Ocean CDR approaches differ widely in their potential scales, the ways they aim to manipulate or restore ocean systems, and the degree of human intervention they require. Vast, relatively unpeopled ocean spaces have inspired an array of proposals from political leaders, investors, and

marine researchers. Some of these proposals rely on intensive technological manipulations of ocean chemistry or biology, representing a form of climate engineering; these include fertilizing the ocean with iron, redistributing nutrients or organic matter within the ocean to stimulate algal blooms through artificial upwelling, adding minerals to rivers, beaches or ocean water to enhance ocean alkalinity through mineral weathering, and using electrical currents to generate alkalinity in seawater, which can locally induce additional CO_2 absorption by the ocean. Other proposed ocean CDR methods, such as the restoration of populations of large marine animals, including epipelagic fishes and whales, and the cultivation of vast quantities of kelp or other seaweeds in the open ocean, could involve less intensive manipulation. Amid this explosion in interest, the National Academies of Sciences, Engineering, and Medicine (NASEM) released a *Research Agenda for Ocean Carbon Dioxide Removal and Sequestration* in early December 2021, which sets priorities for research and development of several of these CDR pathways (National Academies of Sciences, Engineering, and Medicine, 2021a).

Because many proposed ocean-based CDR approaches share certain features with other types of climate engineering — including potential impacts over vast spatial scales, long timelines, and the risk of unintended planetary-scale effects (National Academies of Sciences, Engineering, and Medicine 2021b)— a code of conduct for ocean CDR research must be developed immediately. Codes of conduct establish sets of norms and best practices, encouraging responsible research among public and private actors (Hubert, 2021). By encouraging researchers to assess, minimize, and publicize the impacts of their experiments, a code of conduct could reduce the harm done by field experiments. And by promoting principles that would encourage the growth of a rigorous body of research — such as rules requiring the disclosure of funding or the peer review and publication of results — a code of conduct could help researchers transparently and honestly determine the efficacy of ocean-based CDR technologies, which they must do if those technologies are to play a meaningful role in climate mitigation. Indeed, the NASEM ocean CDR panel identified as its top immediate priority the development of a code of conduct to prevent "ill-considered" studies: those that would fail to advance scientific knowledge or pose significant social and environmental risks (National Academies of Sciences, Engineering, and Medicine, 2021a). Ultimately, policymakers could use an ocean CDR code of conduct as a starting point for future regulations that are managed by institutions accountable to the public (Hubert, 2021).

A SEA OF RISKS, UNCERTAINTIES, AND OPPORTUNITIES

Existing national and subnational regulatory frameworks do not ensure that ocean CDR research will be carried out in a manner that minimizes harm and transboundary impacts. Jurisdiction over the ocean varies depending on distance from shore: nations, and to a lesser extent, subnational regions (e.g. states or provinces), regulate areas within 200 nautical miles from shore, while the high seas do not fall under the jurisdiction of any one nation (UN General Assembly, 1982). This creates a patchwork of regulation over ocean activities that is both complicated and incomplete. Alarmingly, regulation on ocean CDR research and development — the critical oversight needed to guide relevant research toward demonstrating efficacy, ensuring equity, and reducing environmental and social harm — is lacking domestically and internationally. In the United States, there are no domestic regulations aimed at ensuring that ocean CDR is effective and safe. Some ocean CDR research activities may fall under existing regulatory schemes such as those related to emission of pollutants into water or impacts to protected species, but these regulations have not yet been applied to CDR (Webb et al., 2021).

Further, much of the world's ocean — including, for example, parts of the Southern Ocean most attractive for deployment of interventions such as ocean iron fertilization — lie beyond national jurisdiction, in zones that are especially vulnerable to ungoverned, independent research. International instruments may govern some of the activities associated with ocean-based CDR, such as discharge of minerals for ocean alkalinization or injection of CO_2 into sub-seabed geological formations. However, there are no binding international instruments that expressly regulate these methods (Webb et al., 2021). Much of the existing, non-binding international framework is specific to ocean iron fertilization, reflecting the comparatively longer history of scientific research into the biogeochemistry surrounding that pathway (National Academies of Sciences, Engineering, and Medicine, 2021a).

Moreover, a full appreciation of the risks, tradeoffs, opportunities and potential co-benefits of ocean CDR research — let alone its full deployment at scales large enough to affect the Earth's climate — cannot be directly obtained from the more mature body of research on land-based CO_2 sequestration because of fundamental differences in how marine environments function (Steele et al., 2019; Canadell et al., 2021). The fundamental physical and biogeochemical properties of the ocean — including its vast scale and high degree of connectivity — make it very different from the terrestrial or coastal settings in which CDR has traditionally been deployed. Chief among these is that water is a fluid, allowing the ocean and nearly everything in it to move across political boundaries. Even CDR experiments conducted close to shore within a nation's exclusive economic zone could plausibly have international or global impacts. In addition, the majority of proposed ocean CDR techniques leverage natural biogeochemical processes, and the likelihood of harmful ocean consequences from these approaches is still unclear. Depending on their scale, field experiments involving these techniques could affect both near and distant marine ecosystems in the same ways as projected for large-scale ocean CDR deployment. Existing literature suggests these consequences could include:

- induction of hypoxic or anoxic water-column conditions due to increased deep-water bacterial activity, possibly as a result of ocean iron fertilization or the intentional sinking of large quantities of macroalgal biomass (Oschlies et al., 2010),

- shifts in phytoplankton diversity and abundances that would have difficult-to-anticipate ecosystem effects (Oschlies et al., 2010; Bach et al., 2019),
- "nutrient robbing," or depletion of macronutrients by phytoplankton or cultivated macroalgae that starves natural plankton and algae nearby (Oschlies et al., 2010; Bach et al., 2019),
- entanglement of marine life (Campbell et al., 2019),
- potential alteration of weather patterns (National Academies of Sciences, Engineering, and Medicine 2021a), local ocean currents, and/or mesoscale ocean circulation patterns (Campbell et al., 2019),
- toxic effects on marine life, including microbiota, from the release of trace metals associated with silicate minerals applied to enhance alkalinity (Hartmann et al., 2013),
- in the case of certain proposed CDR methods, rapid reversals in ocean chemistry following termination (Feng et al., 2016), and
- poorly understood feedbacks involving climate-active marine trace gases that could erode the climate benefit of an ocean CDR intervention (Law, 2008).

KEY COMPONENTS OF AN OCEAN CDR CODE OF CONDUCT

Given the critical need for research coordination amid this sea of risks and uncertainties, we reviewed other codes of conduct to identify crucial responsible research principles that should be included in an ocean CDR research code of conduct. We investigated research fields that have similarly uncertain implications for human or environmental welfare, including nanotechnology, gene editing, and geoengineering. Sixteen research codes of conduct from eight fields reveal fifteen common principles to guide research of new technologies (**Figure 1**). These principles require researchers to assess and minimize potential environmental harms before, during, and after experiments. They also promote a tiered research structure, requiring researchers to demonstrate the potential efficacy of a technology — in the lab, *via* modeling, or in small field trials — before scaling up to larger *in situ* experiments. The principles promote public and stakeholder engagement and consideration of fairness and equity, recognizing researchers' obligation to involve the full community of people who may be impacted by the research, and the overall need to involve the global community in decisions about climate engineering (**Figure 1**).

Principles for code interpretation, including definitions of the purpose and scope of the code, are likewise important (**Figure 1**). The scope of a code of conduct can be limited to specific technologies, or the code's application can depend on the overall purpose or intent of the research. Because new ocean-based CDR techniques continue to be described, the set of available technologies is presently unbounded, and a purpose-focused code of conduct (e.g., Hubert, 2017) would better fit this fast-evolving area of research. A purpose-focused code of conduct will require a definition of CDR, so those applying the code can determine whether a research activity's purpose is to investigate CDR methods. The code may adopt an existing definition of CDR, such as those used by the Intergovernmental Panel on Climate Change (IPCC) or NASEM. IPCC defines CDR as "[a]nthropogenic activities removing CO_2 from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products," including "anthropogenic enhancement of biological or geochemical sinks" but excluding "natural CO_2 uptake not directly caused by human activities" (Rogelj et al., 2018). NASEM similarly defines CDR as methodologies that "remov[e] or captur[e] CO_2 from the atmosphere or some reservoir in close contact with the atmosphere" and durably store it (National Academies of Sciences, Engineering, and Medicine, 2021a). In contrast to the

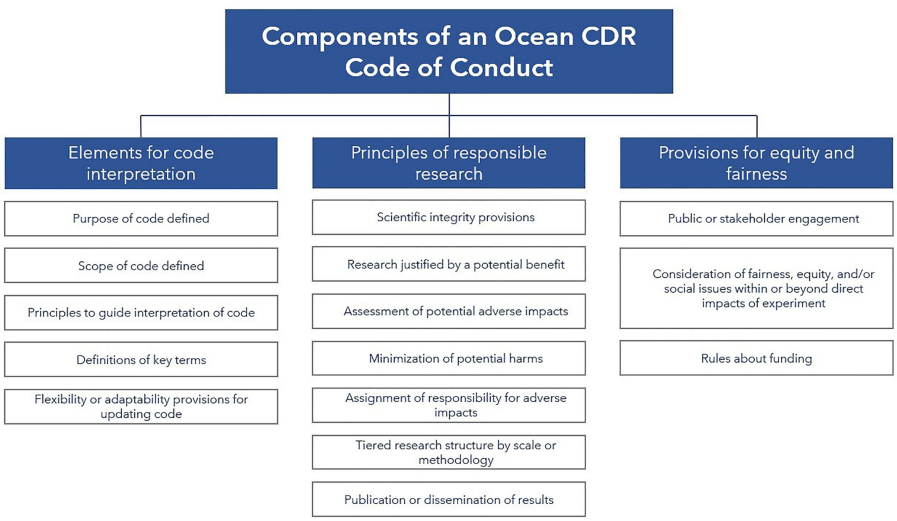

FIGURE 1 | Key components for inclusion in a research code of conduct for ocean CDR.

IPCC definition, the NASEM definition includes pathways that may require less direct anthropogenic manipulation, such as ecosystem protection (National Academies of Sciences, Engineering, and Medicine, 2021a).

There are already two well-developed research codes relevant to ocean CDR that contain most of these principles: the Geoengineering Research Governance Project's *Code of Conduct for Responsible Geoengineering Research* (Hubert, 2017) and NASEM's *Reflecting Sunlight: Recommendations for Solar Geoengineering Research and Research Governance* (National Academies of Sciences, Engineering, and Medicine, 2021b). Additionally, the Aspen Institute recently released a report on developing a code of conduct for ocean-based CDR, which raises questions for researchers to consider that are consistent with the principles we identified (Aspen Institute Energy & Environment Program, 2021). These documents indicate the ocean CDR research community is open to implementing an ocean CDR research code of conduct. And until the appropriate groups are assembled to develop a code of conduct for the oceans, researchers and practitioners can voluntarily adopt guidance based on existing codes.

CONCLUSION

While some ocean CDR solutions may indeed prove to be effective pathways for the sequestration of atmospheric CO_2 while safeguarding biodiversity and supporting equitable human development, the outcomes of most of these approaches are not yet fully understood. Many of these proposed interventions may be powerful enough to affect the Earth's climate, creating the potential for research surrounding ocean CDR to effect tragic or unexpected outcomes. Because codes of conduct help ensure coordination, transparency, and equity of research on technologies with the potential to affect human and environmental welfare, we believe the development of an ocean CDR research code of conduct is a fundamental prerequisite to the design or conduct of any large-scale field experiments of ocean CDR technologies.

A code of conduct will only be effective if it is adopted by the ocean CDR community. Across research disciplines, the most important factor in code uptake is engagement with the parties to whom the code of conduct applies. Code development should involve diverse stakeholders, including researchers, practitioners, funders, environmental NGOs, regulators, and publishers. As ocean CDR research progresses, stakeholders should periodically revisit and update the code of conduct and consider drafting guidelines specific to each type of ocean CDR technology.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

AUTHOR CONTRIBUTIONS

RL, SE, and LS contributed to conception and design of the literature review. RL and SE wrote the first draft of the manuscript. RL, SC, JC, SE, and LS wrote sections of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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Brexit and its Impact on the Co-Operation Along with the 21st Century Maritime Silk Road—Assessment from Port Governance

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Since the Brexit happened in January 2020, it is likely to impact the United Kingdom (UK) and the whole of Europe in different ways. The UK and other European countries will revise their preferences concerning fisheries, ports access and governance, and bilateral diplomatic relationships with the countries alongside the 21st Century Maritime Silk Road (MSR). However, this is not an end to uncertainties, but the beginning to show the double-edged effects of Brexit. This paper focuses on the opportunities and challenges for Sino-UK as well as European Union (EU) relations arising from Brexit. The present study considers Brexit's impact on the MSR countries, especially China, Pakistan, and India. It examines what Brexit means for the Sino-UK/EU relationship, politically, economically, and culturally. It concludes with the potential impacts of Brexit on Sino-UK/EU trade relations, maritime security, marine resources usage, the safety of navigation, port governance and cooperation, and suggests the appropriate strategies that can be put in place to capitalise on opportunities to reap benefits while mitigating the challenges.

Keywords: Brexit, UK-Sino relations, port governance, 21st-Century Maritime Silk Road, Maritime cooperation

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HIGHLIGHTS

- Since the Brexit happened in 2020, it is likely to impact the United Kingdom (UK) and the whole of Europe in different ways. The UK and other European countries will revise their preferences concerning fisheries, ports access and governance, and bilateral diplomatic relationships with the countries alongside the 21st Century Maritime Silk Road (MSR). However, this is not an end to uncertainties, but the beginning to show the double-edged effects of Brexit. This paper focuses on the opportunities and challenges for Sino-UK as well as European Union (EU) relations arising from Brexit in context with the port governance.
- The present study considers Brexit's impact on the MSR countries, especially China, Pakistan, and India. It adopts qualitative means to examine what Brexit means for the Sino-UK/EU relationship, politically, economically, and culturally. It also provides an analysis of the impact of Brexit on maritime security, marine resources usage, the safety of navigation, port governance and coopertion.
- This study concludes with the potential impacts of Brexit on Sino-UK/EU trade relations, and suggests the appropriate strategies that can be put in place to capitalise on opportunities to reap benefits while mitigating the challenges.

- The present study is a unique study of its kind which not only highlights the challenges the world may face after the Brexit but also proposes some prospects in context with the trade and business opportunities with China through Indian Ocean Regions, particularly from the Gwadar port of Pakistan and engaging India simultaneously.

1 INTRODUCTION

In 2015, China officially launched its Belt and Road Initiative (BRI); the goal is to muster new growth services at home as well as abroad. The twenty-first century MSR and the new 'Silk Road Economic Belt' are expected to connect China with countries in Southeast Asia, Central Asia, Europe and Africa (NDRC, 2015). Hitherto, 68 States have signed memorandums of understanding (MoUs) with China aiming to benefit from the BRI (Global Times, 2017; Chang, 2018). The UK was not among these States; nevertheless, numerous projects in trade, energy, finance, and transportation have been planned and enforced under the umbrella of the BRI. The British government claims to be a 'natural partner' of China and has consequently welcomed the BRI as a stimulus to intensify Sino-UK relations. For example, there are four BRI projects in the UK, which are the Yiwu-London freight train route, the Hinkley nuclear power plant, the development of a new business district on the grounds of the London Royal Albert Dock, and the use of the City of London as a top-tier financial centre for financing BRI projects (Heiduk, 2018). However, these projects will have reverberations of Brexit, as the UK will lose its place as an economic, social and cultural centre of the EU. Further, the Chinese administration will also have to rethink about considering London as a financial centre or select one more destination in the EU for financing BRI projects in the EU. Currently, China faces a dichotomy as it has to successfully embed a plan of global cooperation and connectivity in a country that wants to carve a new path for itself by distancing from the EU and European Economic Area.

It is an admitted fact that with around 80% of the global trade volume and over 70% of global value trade at sea, maritime transport, including container shipping, is of fundamental importance for international trade and the global economy (Premti, 2016). Therefore, the maritime industry is also significant for Britain; it contributes to the UK economy for around £ 132 billion a year (Baker, 2019) which represents around 8.1% of the gross value (Stebbings et al., 2020), and secures around 240,000 jobs (Power et al., 2016). Also, on the Asia-Northern Europe routes, 15 out of 17 maritime shipping loops create a British port (John Goods, 2020), which makes it more significant for UK's economy.

In the post-Brexit period, the UK will no longer be a part of the EU and will also lose its preferential status to 27 States that it enjoys under the EU (Her Majesty's Government, 2016). Consequently, the UK government will negotiate trade agreements with Asian exporting States such as China. It may then also be able to devise new legislation and choice to make collaborations with other States along with BRI that suits explicitly to the UK (Braakman, 2017). Over the past 25 years, the value of goods traded in and out of UK ports has steadily increased. In 2017, exports and imports of goods to the UK in a total of £822 billion (ONS-UK, 2017). Not all of this will have passed through seaports; however, around 70% of goods transported into and out of the UK go through a seaport (MDS Transmodal, 2016). There are about 50 seaports, and they have been completed over the years and have become increasingly efficient. The main reason for the drop in the UK's share of trade in the EU is that the growth of the EU's gross domestic product (GDP) during this period was much weaker than elsewhere, especially when compared to China, India and the US. Considering exports and imports of goods to the UK as a relevant measure, trade with China has grown at an average annual rate of 15.6% over the past 15 years, with India 8.6% in a year and with the US of 3.8% a year (Taylor, 2019).

The UK approached China to promote maritime relations, and Brexit was finalised on 31 January 2020, which has led to the disintegration of its unity with the EU (WMN, 2017). Consequently, UK shipping has launched a trade mission to China to enhance the country's investment potentials. The UK's maritime and the Department of International Trade (DIT) will lead such negotiations with China. It could help the UK promote it as a global maritime centre and provide a comprehensive package for global maritime activities. It is pertinent to mention here that the 50 major seaports of the UK represent a successful and competitive private sector industry across the world (Taylor, 2019).

There are appropriate indications that China will adopt its BRI strategy to the UK for a number of reasons. Firstly, the UK will likely lose its preferred position for entry into EU markets. Further, unchanged access to the EU (27 States) is crucial for the Chinese economy, especially given the slowdown in growth rates across the world. In the post-Brexit period, China's BRI strategy for the EU could lead to increasingly rapid infrastructure investments in Central and Eastern Europe (CEE), which could encourage Chinese corporations to move production to this region. Subsequently, Sino-UK trade can be diverted from land transport to passage into the Arctic Sea (Heiduk, 2018). Secondly, BRI investments in the UK energy sector have not yet been reduced. In any case, China must demonstrate how its new nuclear power plant works to obtain orders in other States. This could lead to political negotiation procedures in the context of Sino-UK commercial and investment agreements. Thirdly, London is expected to lose some of its attractiveness as a top-notch financial centre (Fairhead, 2018), creating a need for mega-business strategies such as BRI.

It can be expected that adjustments of activities concerning Chinese BRI in the UK will also lead to a change in various similar activities in the EU. This would be most evident in the commercial and transport infrastructure, and the CEE States could be the principal beneficiaries. China, although the BRI is a longstanding venture, may have to show success in its initial phase. It is a clear sign that China will adopt its BRI stratagem to the UK after Brexit, where it considers this important for its interests, but will maintain the status quo in all other cases. Besides, it is evident that the UK will look for novel associates after Brexit, and the Chinese BRI could offer a promising anchor. However, there are indications, as Kerry Brown (Brown, 2018)

also mentioned, that the UK's government has not convincingly communicated its vision of Brexit, which includes improving relations with China, without being a "Chinese vassal in EU or UK".

While analysing the impact of Brexit on China-UK-EU relations, the role of India and Pakistan is also examined as they were an essential part of the Old MSR and presently sit at the main juncture of the New MSR. Further, China has also developed the ability to strategically engage in a constructive relationship with two or more quarrelling States by restraining itself from directly engaging in their disputes. This experience will help China to deal with changing dynamics of UK and EU relations effectively. Lastly, China needs to appease its neighbouring countries first before going global and engaging with distant countries as stability in the neighbouring region will help China fulfil its global ambitions. To this end, this study follows the qualitative method of content analysis and provides a critical analysis on the research gap concerning the port governance and new trade routes between China and EU/UK through the Gwadar Port and Indian Ocean. After providing an introduction and background, this study discusses the likely potential impacts of Brexit on the Sino-UK maritime economic relationship and Sino-EU post-Brexit relations in sections 2 and 3 subsequently. Whereas, section 4 presents an evaluation form the aspect of Indian port governance, and section 5 deals with the Sino-Pakistan port cooperation, which could connect China to the UK and EU with a shortest maritime route, followed by the way forward and clouding remarks in section 6.

2 BREXIT AND ITS IMPACT ON SINO-UK MARITIME ECONOMICS RELATIONSHIP

Brexit is a by-product of a populous under the current narrative within the UK that it was compromising its sovereignty and national interests by staying in the EU. This belief was the reason the UK waited for 16 years before joining the EU, and this cynicism was also why the UK did not adopt the single currency policy launched in 1999. Nevertheless, two core issues that triggered Brexit were that: Firstly, the growing nationalism and the belief that immigrants were taking up their jobs, and the UK had enough clout to develop its economic relations. Secondly, scepticism and disbelief on the administrative system in Brussels and its ability to face global challenges in the wake of increasing complexity in the international world order. Subsequently, the much-hyped divorce between the UK and the EU took place in January 2020 (BBC, 2020b). Though, the EU Parliament approved the agreement on 29 January 2020 to avoid a "No Deal" Brexit and has provided the much-needed transition time till 31 December 2020. However, there is a lot of ambiguity and uncertainty surrounding the Brexit legislation, whether the designated time would be enough to crack a deal and what happens next (McCarthy, 2020). For example, if yes, then will the UK get access to the EU's single market on the lines of Switzerland? If not, then will it end the era of free movement of goods and services and bring in tariffs, duties and other regulatory restrictions that would be agreeable for both the UK and the EU?

When the UK was an EU member State, it had to legally abide by the EU standards on labour rights, tax, and environmental protection (BBC, 2020a). However, in the Brexit legislation, Prime Minister Boris Johnson has moved these commitments into a separate non-binding political declaration (BBC, 2020a). This move will provide UK liberty in economic and trade policies with non-EU States. In the meantime, this move will make it hard for the UK to get a comprehensive economic deal with the EU as Brussels may not allow the UK access to its single market while undercutting the competitiveness of its member States (Evans, 2019). Hence, the second scenario is more likely to happen, which will result in a tremendous rise in cost and time for goods moving in and out of the English Channel. The UK-EU trade relations is based on a balance in which the UK has a services surplus on the EU, and the EU has a goods surplus in the UK. The second case scenario will result in increased prices of goods imported by the UK from the EU and simultaneously increasing the cost of services provided by the UK (Read, 2020). This scenario will not only have an adverse impact on industries of the UK and the EU but also on the industries of non-EU States who have their offices in the UK and the EU and trade goods and services across the English Channel. Additionally, the UK will also have to invest heavily in upgrading of its ports and entry points to be able to deal with checks, customs and other regulations (Whitfield, 2020). A study conducted by the Imperial College London shows that every extra minute to check goods at the UK ports will lead to additional traffic of 10 miles in queues (BBC, 2018).

All these developments will make the UK develop strong economic relations with non-EU States, and China serves as the best opportunity in the given circumstances. Currently, only China, which has the capacity to invest in the UK's infrastructure development and emerge as a net exporter of commercial goods. In the 2018 bilateral declaration, the UK and China already agreed to safeguard multilateralism and promote an open world economy guided by World Trade Organization (WTO). Also, the UK and China signed around 12 deals in the fields of finance, trade, smart city and health care and pledged to further elevate their relations under the Golden Era (Bo, 2018). Most importantly, Brexit has given more impetus for the UK to combine Britain's National Infrastructure Plan with China's BRI.

2.1 Sino-UK Trade Agreement

The EU had included the UK in its strategies to negotiate a free trade agreement (FTA) with China, an ongoing process since 2013. The EU and China have entered into talks to offer investors predictable opportunities from both sides, longstanding access to the Chinese and European markets, and shelter investors along with their investments (Devonshire-Ellis, 2019). However, these discussions have stopped on various issues, not least concerning access to the markets of China. These talks are currently at a dead-end, and no progress is expected shortly since the Brexit. Consequently, an FTA between the UK and China would undoubtedly be of significance for the UK. However, it may fall

behind the UK-US FTA. For example, in the US-Canada-Mexico Agreement (USMCA), Washington insisted on elements within the agreement that impact and prevent Mexico and Canada to limit their trade agreements with Beijing (Miller, 2018). It is noted that USMCA member States can terminate this agreement with a notice of six months and free to negotiate their new bilateral agreement if one of the partners enters into an FTA with China (Lester et al., 2019). Article 32.10 of the USMCA, has also reported causing controversy in Canada (Massot, 2018).

Given the situation, China may have a new partner for its ambitious plan to expand China's economic cooperation and influence overseas. The UK's Prime Minister Boris Johnson stated in the day before he chaired the country that his government would be very 'pro-China', "we are very excited about the BRI, and promise to keep Britain 'the most open economy in the EU for Chinese investments" (Gehrke, 2019). The BRI is China's strategic project to use infrastructure investments to gain influence over principal seaports, airports, and railways across the globe. On the other hand, Hua Chunying, the Chinese Foreign Ministry spokeswoman, stated that "China attaches importance to the China-UK relations and hopes that the UK will continue to work with China to ensure the sustained, steady, and sound development of China-UK relations in the spirit of mutual respect and win-win cooperation" (Chunying, 2019). The positive talks from both sides signal positive post-Brexit Sino-UK relationships.

2.2 UK–China Post-Brexit Relations

Chinese commitment and response to Brexit will also depend on how the UK and the EU handle the situation and set their priorities. Additionally, the working of the transmission channels concerning trade and foreign direct investments can lead to deviations from the likely impact of the model that requires adjustments by trial and error. The present state of negotiations between the UK and the EU suggests that for various reasons, the Swiss-style bilateral agreement, the Norwegian-style European Economic Area Agreement, and the Turkish-style customs union are unlikely to happen (Dhingra and Sampson, 2020). All models are in a compromise dilemma between economic benefits and political costs. The negotiations to date show that the desire to maximise economic benefits and minimise administrative costs are not the options from the UK. However, the Chinese viewpoint demonstrates that economic relations with the UK as well as market access agreements for capital, goods, and services should be negotiated other than the current EU conditions. Besides, in the case of the Sino-UK trade deal, the UK, as a small State, will have limited bargaining capacity in trade and investment negotiations as compared to China. Consequently, China could negotiate additional approving market access conditions with the UK than the current conditions under the EU's auspices and be able to make the best use of the British port industry to access the European markets. Further, China has an opportunity to invest in development projects of Wales, and Northern Ireland as post-Brexit, the EU's regional development programmes will stop China's funding in these regions (Dhingra and Sampson, 2020). Further, China also has an opportunity to invest in development projects of Wales and Northern Ireland since, in the post-Brexit era, the UK no longer be part of the EU. As a result, the EU's regional development programmes will stop their funding in these regions (Dhingra and Sampson, 2020).

There are already vibes that Britain emphasised its role as a natural partner for the Chinese BRI project. A careful study of the chronological events portrays that the UK is interested in signing an FTA with China when it exited the EU. As China drives forward the BRI from the east, Britain can work as a natural partner in the West and be willing to collaborate with all BRI partner-States. The very aim is to make this initiative successful, maintain close as well as open commercial partnerships with its neighbours in Europe, FTAs with new partners, and protect old allies around the globe, especially China (Connor, 2017).

3 POST-BREXIT—THE EU AND ITS RELATIONS WITH CHINA

The long-pending Brexit divorce finally took place in January 2020. However, there is still much uncertainty surrounding the deal as the above sections clearly show that there are a number of issues that have not been solved yet and will take further one or two years of negotiations to settle them. Further, Brexit will not only affect the UK and the EU but also impact their relations with other major powers across the globe. Since the launch of BRI, China has become the bandwagon of multilateral economic collaborations all over the world. As uncertainty has become the new normal in the 21st century, it is essential to understand the impact of Brexit on the EU and its relations with China. This following (sub)sections will shed light on the challenges and opportunities in front of the EU and China in the post-Brexit world.

3.1 Impact of Brexit on the EU

With Brexit, both the EU and China face few challenges as a well-established system will come to an end. The EU loses its most crucial partner, who had become an economic gateway of the EU to the world (Blockmans and Emerson, 2016). In the meantime, China lost its most crucial patron in the EU, which was enthusiastically negotiating an FTA between China and the EU. Various scholars and research institutions around the world have studied the impact and calculated various scenarios as possible outcomes of Brexit (See, e.g., Moschieri and Blake, 2019). However, whatever the outcome will be, the relationship between the EU and the UK will not be the same as in the pre-Brexit era. According to a study published by Germany's Bertelsmann Foundation, Europeans will lose billions of Euros annually with soft or hard Brexit (Pandey, 2019). In 2018, the EU exported nearly 18 percent of its goods and services to the UK, excluding the trade among the 27 EU States (Walker, 2018). At the same time, the UK's 45 percent total export and 53 percent of total import are sourced from the EU (Walker, 2018). If tariffs and other restrictions come up between them, the EU will suffer a loss of around €40 billion and €57 billion, respectively in their annual income (Pandey, 2019).

Brexit will also have a political impact on the EU; in particular, it will damage the EU image as a stable and robust united front in the aftermath of the second world war (WWII). The EU will also lose one of its two places in the United Nation Security Council (UNSC). Brexit will adversely impact the EU's global status and soft power, which will reduce its ability to play a decisive role in a global security crisis (Blockmans and Emerson, 2016). Whenever the interests of the UK and the EU may differ, there are possibilities they may find themselves in opposite camp during negotiations of a particular issue in the United Nations. However, Brexit has been instrumental in bringing all the 27 EU member States together on one platform, which was never seen during any earlier issues. After seeing the chaotic and painful process of Brexit and its aftershocks, the demands of other States leaving the EU has disappeared. The populist voices of Frexit (France), Nexit (the Netherlands) and Italxit (Italy) have stopped popping up from the populist leaders in these States (Erlanger, 2020). Further, the EU will still remain the most influential transnational union and the single largest market in the world, and various reports are showing that if the EU is able to negotiate a favourable deal with the US and China, they are set to benefit from Brexit (Summers, 2017; Charlemagne, 2020).

3.2 The EU and its Relation with China

Since the establishment of diplomatic ties between the EU and China, the relationship has seen gradual development. In the initial few years, the EU used to propagate its economic and political superiority and was keen to replicate its development model all over the world, and so do in China. However, at the beginning of the 21st century, China becomes the fastest trillion-dollar developing country based on its indigenous Chinese model. During the same period, Europe longed to come out of the US hegemony and proposed an independent foreign policy by engaging with emerging powers, particularly with China (Javier Solana, 2009). In 2003, the EU and China initiated the EU-China Comprehensive Strategic Partnership to strengthen and expand cooperation in a wide range of areas (Maher, 2016). The 2009 economic crisis saw a decline of the European economies, and China emerged as the vanguard of modern commercial and economic relations. Further, in 2013, the EU and China mutually adopted the EU-China 2020 Strategic Agenda for Cooperation to enhance their relationship and develop their new partnership. The year 2015 saw the peak of their relationship; China hosted the 16 + 1 summit for the Eastern European Countries. The UK and Germany became the founding member of the China-backed Asian Infrastructure Investment Bank (AIIB), more so the UK promised to be China's best partner in the West. However, since 2016 their relationship has faced few stumbling blocks, particularly Brexit, FTA, and differences over non-market and market economy status (Ewert, 2018). Now that the UK is out of the EU, it becomes essential for China and the EU to engage themselves with each other and try to develop a new relationship.

The EU-China relationship is of critical economic importance as China is the EU's largest trading partner, and the EU is China's second-largest trading partner. Though post-Brexit, these trade algorithms are set to change, this relationship will remain central to trade and commercial policies for both partners, as they play a significant role in the global economy. The exit of the UK from the EU will initially complicate the relationship between the EU and China, given the central role played by the UK in framing the EU's China policy (Gaspers, 2016). However, given China's growing influence in world affairs, these complications will be sorted out and resolved once the EU and China develop a post-Brexit mechanism for economic engagement either under BRI or FTA. There are different opinions among the EU Member States on the economic relationship with China. Some are in favour of giving China the status of a market economy. In contrast, others argue on practising a protectionist policy to protect their manufacturing industries against the competitive prices of Chinese goods. Nevertheless, they all agree that China has played an essential role in bringing economic prosperity in the region by providing huge investment in European infrastructure and a large market to European brands and companies (European Parliament, 2016).

China has primarily three main expectations from its relationship with the EU: firstly, access to the EU single market; secondly, a secure environment for Chinese investments and, willing partners for China's BRI projects; thirdly, a profound diplomatic relation in the milieu of increasingly peevish relationship with the US (Yu, 2017). In the case of Europe, except Germany, most of the EU Member States are facing economic stagnation. Hence, they are in need of Chinese investment. The EU wants access to the Chinese market, which has become the biggest market for luxurious product reflecting the economic progress in the country. The EU is also dependent on China for rare earth metals. Lately, the EU is facing the wrath of the US, as divergence has increased between them on the issues of tariffs, defence spending, security policies, climate change and many more (European Parliament, 2018).

These conditions and expectancies provide much stimulus for the EU on China in order to overcome their trust deficit and form synergies in the areas of trade, economics and security (Garrie, 2020). In 2019, the EU and China signed a bilateral trade Geographical Indication Agreement on 'hallmark'. It is the first high-level bilateral agreement China has ever signed with foreign businesses (Global Times, 2019). In the backdrop of the US freezing the Appellate Body at WTO, the EU, along with China and other 15 States joined hands to unblock the world's trade arbiter by creating a temporary mechanism to settle trade disputes (Blenkinsop and Baker, 2020; Burden, 2020). The EU Member States, which would have been adversely affected by the Brexit, had already started developing new economic ties among themselves as well as with other States to whom they have shared common concerns and interest.

The trade partnership between China and EU member states has been tremendous as shown in **Figure 1**—China is one of the key trade partners of the EU (in both exports and imports). Many EU Member States which have not fully recovered from the financial crisis have looked at China for investment, for capital generation, infrastructure development and market access. Further, China has heavily invested in infrastructure development and operations of major European ports in Greece, France, Belgium, and the Netherlands. Greece and Hungry have already become close allies of China, Italy became the first

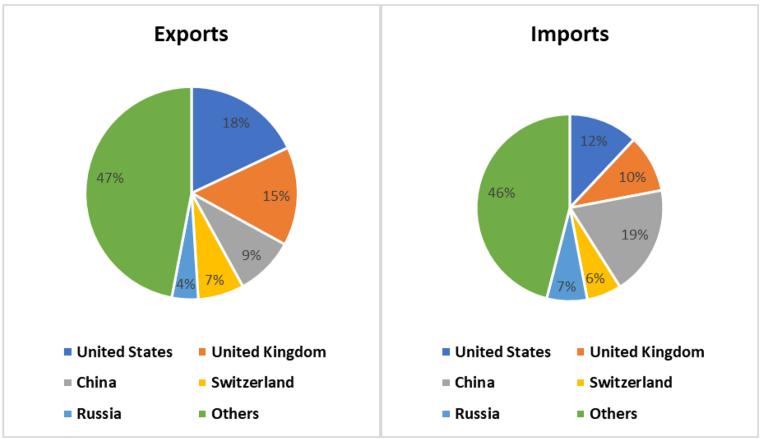

FIGURE 1 | EU-27 Trade Volume with China-2019. Source: European Commission (European Commission, 2019).

G7 States to sign the BRI. If the EU and China overcome their differences and focus on building trust, there is plenty of room to create a win-win situation where everyone benefits.

4 EVALUATION FROM THE ASPECT OF INDIAN PORT GOVERNANCE

With 7500 km of coastal line strategically located at the centre of the most crucial trade lines gives enough logistic leverage to India to develop a trade centre in the Indian Ocean. Further, the Indian Ocean has emerged at the centre of Chinese maritime economic strategy, as most of its trade routes to Europe, Africa, the Middle East and South Asia cross through the Indian Ocean. Sino-Indian maritime cooperation has the potential to shape the economic nature of the Indian Ocean and, most importantly, bring peace and stability to the region (The Print, 2018). India and China's economic relations with the world and especially the EU largely depends on peace and stability in the Indian Ocean region. The time has come for India and China to realise the true potential of their cooperative partnership. In the words of President Xi Jinping, "If the two countries speak in one voice, the whole world will attentively listen; if the two countries join hand in hand, the whole world will closely watch" (MOFA-PRC, 2014).

4.1 Potentials for India-China Co-Operation in the MSR

Currently, India is engaged in massive developments of its ports. If China and India cooperate on port construction and infrastructure development, it will undoubtedly create a win-win situation for both States. Indian ports on the western coast can be connected to West Bengal and have the potential to connect Kunming city in Yunnan Province of China under the Bangladesh–China–India–Myanmar (BCIM) Forum for Regional Cooperation. Further, India-China Transhipment cooperation will help China to reduce its distance not only to European and African continents but also to the eastern coast of North and South America (Valentine, 2017).

In the era of globalisation, the financial activities and trade of any State are highly influenced by the global market and modern technologies. However, most of the trade around the world is still carried out through the waterways, which is the most cost-efficient method. Currently, 90 percent of India's trade by volume and 70 percent by price is handled by Indian ports (PIB-India, 2018). To facilitate its ever-increasing maritime trade, India has recently prioritised the up-gradation of its ports and maritime connectivity. Modern ports will enable India to enhance its cost-effectiveness through the improved maritime logistic system. In the meantime, China is not only ahead of India but has also developed world-class technology in the construction and development of deep seaports and has a desire to invest in development projects all over the world. India is one of the fastest-growing trillion-dollar economies and has the best potential to give out huge returns on Foreign Direct Investments (FDIs) (The Hindu Business Line, 2020). These circumstances have created more than enough reasons for India and China to cooperate in this domain.

On 13 January 2011, the Indian government declared the Maritime Agenda 2010-20 to rationalise measures for the public-private partnership (PPP) process by encouraging confidence in investors and making it more transparent (PIB-India, 2011). In order to accomplish India's maritime infrastructure requirements from 2010-2020, the Maritime Agenda had categorised priority areas for government interference. It aimed at expanding the port capacity to 2,300 million metric tonnes (mmt) by 2016-17 and more than 3,000 mmt by 2020, and hence a comprehensive plan was laid out to meet the prerequisite (MoS-India, 2011). The Agenda focused on developing the existing small ports into all-weather, deep draught ports and encourage the creation of private greenfield ports (MoS-India, 2011). However, the overlapping of regulations among the state government agencies and port authorities in the management of the Indian ports caused huge delays in port development activities. Hence India needed a more robust and simplified regulatory framework to have swift

administration and development of its maritime trade (Global Times, 2020). All these circumstances have created a suitable environment for India to join the MSR. As India played a major role in the ancient MSR, time has resurrected the journey and utilised the various opportunities.

4.2 Overcoming the Stumbling Blocks in the 21st Century MSR

Now the question arises, how will China and India successfully cooperate in their maritime sector in spite of having strategic differences and recent border tensions? It will largely depend on the mutual understanding among the current leadership and cooperative partnership between both the States. The world has become more complex and fragile due to the ongoing clash between the US and China (Swaine, 2019). Under the current circumstances, it becomes essential that India and China do not act against each other in favour of third parties, undermining their own-interest and mutual benefits (Basu, 2020; Hindustan Times, 2020; Zhu, 2020). In the international world order, no country is a permanent friend or foe; the only thing that makes countries cooperate or dispute is their national interest. At present, the national interests of both countries lie in the domestic development and economic prosperity of their combined 2.7 billion population. The US has upped the ante against China as it feels a rising China is a threat to its global hegemony. It has also initiated to beef up its strategic partnership with Japan and Australia. Further, it has urged India to play a bigger role in the Indo-Pacific (Habib, 2020; Zhu, 2020). Unlike Japan and Australia, India has been cautious, not to spoil its relations with China and has been persistent in its efforts, not to make QUAD nations (Japan, US, Australia, and India) into an anti-China alliance (Mehra, 2020).

However, after the recent border clashes, there is an outcry among the Indian nationalist groups to ban Chinese companies as well as cancel engineering and construction contracts given to Chinese companies (Zhu, 2020). Instead of taking decisions in rage, India should calculate its self-interest and act consequently. No one stops India from banning foreign investments in strategic security sectors; however, banning Chinese companies from infrastructure and other non-strategic sectors may harm the Indian economy more in future. Today China has the most advanced engineering and infrastructure technology, and it offers a very competitive price. The infrastructure contracts were given to the Chinese companies as they were the lowest bidders; cancelling such contracts will increase the cost of projects and cause unnecessary delays (Hindustan Times, 2020). If India wants to develop its port infrastructure, China is the best option available which already has experience in constructing and maintaining huge ports.

For China, the time has come, to look beyond its US-centric foreign policy and look for developing a constructive partnership with other developing countries and especially India (Zhu, 2020). Good relations with India will not only provide essay access to Indian markets, but if the trust increases and cooperation deepens, one cannot rule out the possibility India China Economic Corridor connecting Tibet and Yunnan Province of China to Eastern ports of India and further to the Western ports complementing India's Sagarmala Programme (Summers, 2017; Ramesh, 2019). Hence China should also rein in its hardliners and try to develop a cooperative and constructive partnership with India (Feng, 2020; Singh, 2020).

4.3 The Impact of Brexit on India

The Impact of Brexit has been felt around the world, and so do in India. The UK has historical ties with India since the colonial era, and presently, it is the second-largest trading partner of India among the European states. Further, the UK has emerged as the seventh-largest FDI source for India (Statista, 2020). Whereas India, with over 120 projects, has emerged as the second-largest investor in the UK, just behind the US (Sonwalkar, 2020). During his 2019 general elections, UK Prime Minister Borris Jhonson had promised to develop a "Truly Special India-UK relationship" (Sonwalkar, 2020). The UK has also included India in the list of its 'Ready to Trade' campaign launched in February 2020, which aims at developing economic relations around the globe (Rai, 2020).

However, the future of Brexit is ambiguous in the current situation as the UK and EU have still not reached a breakthrough exit deal. Around 800 Indian companies are operating in the UK; most of these countries use it as a single point entry into the European market. If the UK is unable to get an FTA with the EU, Indian companies will have to relocate or establish additional offices in other European countries to access the European market. Further, India will also have to negotiate separate trade arrangements with the UK and EU. Presently, the EU is India's largest trading partner. India and the EU have been in negotiations for a trade agreement since 2007, and in 2018, the EU adopted a new EU-India strategy that emphasis finalising the trade deal and enhance economic cooperation between them (Arthur Sullivan, 2019). The future of the India-UK relationship and the India-EU relationship will highly depend on the future of the UK-EU relationship.

From the aspect of India's port governance and maritime trade, Brexit provides both positive and negative opportunities to India. However, from the aspect of MSR, it is essential to have a stable India-China relationship. The MSR will only be successful if there is stability along the sea lanes it passes, which is only possible when India-China along with other regional powers co-operate with each other. Hence, India and China need to readjust their current policy towards each other and make genuine efforts to utilise the maximum possible benefits from their potential cooperation.

5 EVALUATION FROM THE ASPECT OF SINO-PAKISTANI PORT COOPERATION

Pakistan is heading towards a more robust maritime and port governance with Chinese cooperation under the China-Pakistan Economic Corridor (CPEC) (Chang and Khan, 2019). The corridor will not only provide the roadways to China but also open it to the Indian Ocean and the Arabian Sea from the

Gwadar port, that will tremendously help China to strengthen its maritime metier, and in a broader perspective, will link it to the European locations. The Middle Eastern oil reserves will be only approximately 2,295 miles (545 miles from ocean routes and 1,750 miles from roads) from China *via* the CEPC route, compared to the current distance of 12,537 miles; 9,912 miles from ocean routes and 2,625 miles land route (see **Figure 2**) (The Gulf Today, 2017). Since the sea flow over the port of Gwadar is expected to rise, therefore, maritime security and cooperation are essential. A multidimensional approach requires addressing the security challenges of this maritime region to ensure the security of the Gwadar port. This includes major security forces, coastal exercises and law enforcement agencies seeking to increase the region's growing awareness in which maritime transport, piracy and human trafficking are among the key challenges. As a result, the Pakistani Navy is working with Chinese cooperation and support on three important issues: the security of the port of Gwadar, the safety of the seaways and the safety of the ships (The Value Walk, 2017).

Chinese interest in the port of Gwadar is momentous for several reasons. For example, in order to meet its energy needs more resourcefully, to address economic problems in western China and its unique economic development. China also plans to build a long oil pipeline from Gwadar to Xinjiang along with an oil refinery in Gwadar to facilitate the transport of oil from Africa and the Persian Gulf (The News, 2018). In addition, China has already provided a 3rd 600-tonne patrol vessel to Pakistan under an agreement signed in 2015. Besides, the Pakistani Ministry of Defence Production (MoDP) has entered into an agreement with China's Shipbuilding and Trading Company to build four patrol vessels of 600 tons and two of 1,500 tons for the Pakistan Maritime Security Authority (PMSA). These ships were gained to enhance PMSA's ability to protect the marine resources of Pakistan in its exclusive economic zone (EEZ) in addition to conduct operations against illegal immigration, drug and human trafficking under the provisions of international (maritime) law (Haider, 2015).

Maritime security cooperation between China and Pakistan is vital not only for political stability and regional peace, but also beyond that. With these goals in mind, Chinese collaboration under the CPEC shows that it has achieved its broader goal of gaining a foothold in the maritime sector and economic growth as a whole. For this purpose, the construction of ports and coastal structures represents a significant step forward in expanding China's maritime approach athwart the Indian Ocean through the Suez Canal in the Mediterranean basin. China demonstrates the same collaborative approach across the globe so as to its intention to develop profound cooperation in the maritime sector of the UK after the Brexit. Among all other, one of the main objectives is to ensure the maritime communications route, which accounts for almost 90 percent of China's trade and energy supply (Chang and Khan, 2019). This very Chinese strategy will significantly assist China in securing or remoting access to the European markets through the ports and shipping through the shortest available sea passage to connect China and the EU.

5.1 Gwadar Port Becoming UK's Post-Brexit Trade Destination

In 2017, UK's Minister for International Trade Greg Hands said that the UK is a free trade influenced country and can be an important partner for both Pakistan and China in the implementation of massive infrastructure projects planned between the two countries, such as CPEC (The Economic Times, 2017). He also added that as part of an outward-looking global UK, the country has a clear goal of increasing trade with China and Pakistan, and UK businessmen are well-positioned to take advantage of the country's new opportunities in the region (The Express Tribune, 2017). These developments offer British companies with new opportunities to bring their research and development (R&D) expertise to Pakistan through partnerships with the public and private sectors; there can be numerous ways to attract the UK government as well as private investors to move forward, including education, health, agro-technology,

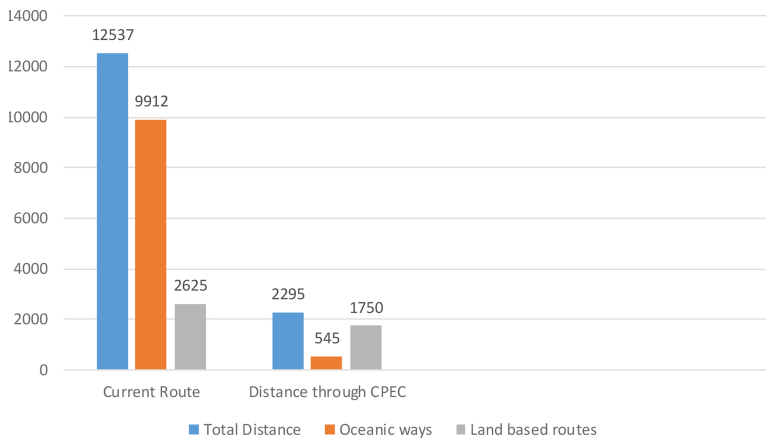

FIGURE 2 | Comparison of Mileage between the Current Route and Proposed Route under CPEC Project (Abu Dhabi to Shanghai, in Miles). Source:Created by the author.

renewable energy, urban transport, including road freight and temperature-controlled logistics, infrastructure development, textile, fabrics and clothing, and so on (Jarral, 2019).

It is also pertinent to mention here that bilateral trade between the UK and Pakistan was £2,043 million in 2019, with Pakistan having an advantage (The Natnation, 2020b). The UK is currently the third-largest source of FDI in Pakistan after China and the Netherlands, and accounts for 8% of FDI in Pakistan (CPEC, 2020a). European investors would like to invest in Allama Iqbal Industrial City—a priority EEZ as part of the CPEC. To take full advantage of these opportunities, UK companies would like to see further progress in lowering corporate tax rates, protecting the privacy and making business easier (CPEC, 2020b). CPEC and Brexit are two significant developments, and as global economic gravity shifts to Asia, Pakistan opens up new prospects for business opportunities that will benefit people in both countries (The Natnation, 2020a). Besides, the UK has overtaken China and is now the second-largest export market and also the largest market in Europe (CPEC, 2020b).

The above facts can help to draw a clearer picture of the significance of the relationship between the post-Brexit UK and Sino-Pakistan maritime cooperation in the Gwadar port. Therefore, it is fair enough to comment that Gwadar is going to become the UK's post-Brexit trade destination in Asia, connecting China and other Asian States connected under CPEC with not only the UK but the whole of Europe as well.

5.2 Way Forward

After the Brexit, UK will freely negotiate and decide its trade-related activities and preferences in terms of agreements with States across the globe through using its ports. As China could be one of the largest UK's trade partners, both States will have to look into the possible feasibilities in their trade through the Sea and Shipping. To this end, the Gwadar port of Pakistan can play a crucial part since it opens China to the Arabian Sea as well as in the Indian Ocean, providing the shortest route to approach the Indian Ocean and reach out to Europe ultimately through the Hormuz Straits. Therefore, China can plight ahead toward the UK and other European countries and vice versa (using the new shortest passage under CPEC) far better than its current MSR route (see **Figure 3**), which connects China to Europe through South China Sea-Malaysia-Singapore (Malacca Straits)-SriLanka-Arabian States-Africa and then heading toward Europe. It is important to mention here that currently, it takes around 16 days to reach out to the Indian Ocean (from Shanghai) as compared to the reduced distance to 3-4 days through the proposed CPEC route (a mix of land-based as well as an oceanic route) though Gwadar Port of Pakistan (Chang and Khan, 2019). This will shorten the distance as well as save time and money on the one hand, and on the other hand, provide a strategic way out to China for international trade if its surrounding coastal neighbours hinder its oceanic routes, for example, uncertain challenges in the South China Sea—ensuring its uninterruptable trade relations with the UK and the EU.

6 CONCLUSION

The context of EU/UK-China relations has changed dramatically over the past few years; China's interest in Europe has increased significantly. While some common patterns exist, new trends in trade and investment relations with China are expected to be widely differentiated across the EU and the UK after Brexit. Chinese players are constantly scrutinising new developments in European markets and are eager to utilise opportunities whenever they arise. So entering into a new trade relationship through ports and shipping could be a great avenue and win-win situation for both sides.

It is a fact that around 80% of the world trade is conducted through maritime routes across the globe, and China is one of the largest countries that largely conduct their trade through

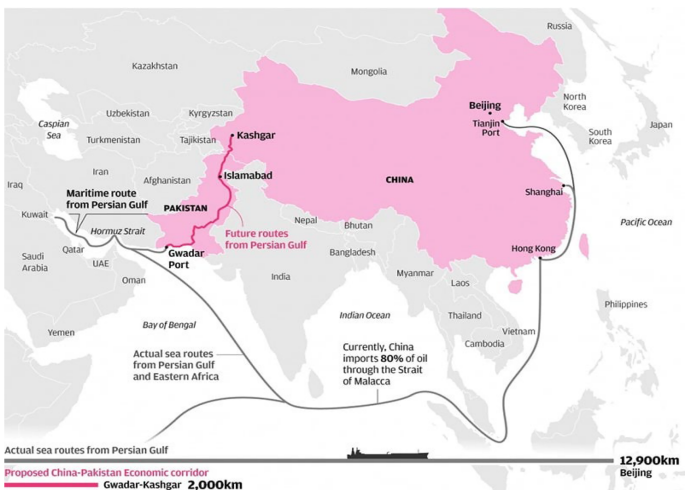

FIGURE 3 | Map of the Maritime Silk Road with New Shortest Route through CPEC. Source: The Dawn (Ebrahim, 2015).

shipping. Similarly, the EU and the UK are the key players in the world's maritime trade. However, Brexit is likely to change the situation since the division of port governance between the EU and UK may impact their maritime trade. The other future challenge that Sino-UK/EU trade may face is the possible blockade by the countries across the Indian Ocean region using the current MSR route through Malacca Straits. However, China has sensibly planned alternative routes to ensure maritime trade security, i.e., through the Indian Ocean *via* Malacca strait with Indian cooperation, and the new and shortest trade route under CPEC, which opens China to the Indian Ocean *via* the Arabian sea. Since the UK, after Brexit, has tremendous trade interests in this region, therefore, branding its ties with China with alternative maritime routes could be beneficial for Sino-UK trade relations ahead. To this end, construction of Gwadar port and connecting China to Indian Ocean through Arabian Sea could serve the multiple purposes to both sides, especially for China including the shortest trade route approaching UK and EU countries and energy security. Therefore, port governance with new trade expectations is the call of the day and the Gwadar port could play a significant role in this transaction. Eventually, both sides need to revise and ensure their maritime cooperation for a win-win trade relation in the coming years.

AUTHOR CONTRIBUTIONS

M.I.K deals with mainly the write-up, revisions and proofreads; S.L deals with the Indian perspective and general proofread; and Y-C.C deals with supervision and general guidelines. All authors contributed to the article and approved the submitted version.

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The diverse benefits of biodiversity conservation in global ocean areas beyond national jurisdiction

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The end of the long and winding road towards a milestone new treaty focused on the conservation and sustainable use of marine biodiversity beyond national jurisdiction (BBNJ) is near. The BBNJ treaty has the potential to dramatically transform environmental stewardship in the high seas, making it essential that vigorous support towards a strong treaty continues, without weakening the agreement's full potential. Historically, the dialogue surrounding the BBNJ negotiations has focused on the agreement's environmental and conservation-related impacts. Here, we begin to highlight the many diplomatic, economic, and social benefits of a vigorous and equitable BBNJ treaty. We found that strong support for the BBNJ treaty could strengthen multilateral institutions and bolster international cooperation towards common environmental goals. It could also enhance the health of shared marine ecosystems and resources and drive truly sustainable ocean-based economic growth. Finally, the treaty provides an opportunity to engage equity as a key principle, to begin tackling global ocean inequalities in a meaningful way. Together, we find that the new treaty has the potential for widespread and diverse benefits for all member nations. It is past time for the international community to address the global governance gap in the high seas in an ambitious and equitable manner.

KEYWORDS

high seas, biodiversity beyond national jurisdiction (BBNJ), international negotiations, multilateralism, conservation benefits, economic, diplomatic, social

Abbreviations: ABMT, area-based management tool; ABNJ, area beyond national jurisdiction; BBNJ, biodiversity beyond national jurisdiction; CBBT, capacity building and technology transfer; EEZ, exclusive economic zone; EIA, environmental impact assessment; IGC, international governmental conference; IMO, International Maritime Organization; ISA, International Seabed Authority; MPA, marine protected area; RMFO, Regional Fisheries Management Organization; SEA, strategic environmental assessment; UN, United Nations; UNCLOS, United Nations Convention on the Law of the Sea.

Introduction

In an era of global environmental change, the conservation and sustainable use of marine biodiversity beyond national jurisdiction (BBNJ) is a key priority for world leaders. United Nations (UN) negotiations are currently underway to finalize a new, legally binding instrument that could transform how the international community collectively safeguards marine biodiversity in areas beyond national jurisdiction (ABNJ) - the part of the global ocean commonly referred to as the high seas, but which also includes the deep-water column and international seabed below.

After 18 years of discussion and negotiation (UN General Assembly, 2005, 59), the fourth international governmental conference (IGC 4) ended in March 2022 with no consensus. However, there has been a renewed sense of urgency and commitment amongst many States (IUCN, 2022). Nearly 50 countries came together at the One Ocean Summit in February 2022 to form a high ambition coalition on BBNJ, pledging to quickly conclude the treaty within the year (High Ambition Coalition, 2022). In May, G7 foreign affairs and climate, energy and environment ministers committed to strive for a treaty that bolsters ocean health and resilience through proactive and adaptive responses to the cascading effects of climate change and other human impacts, including through protected areas on the high seas (G7 Germany, 2022). More recently, governments reiterated the need for a strong BBNJ treaty at the UN Ocean Conference in Lisbon. Closing statements of the IGC 4 echo the urgency to finalize negotiations in 2022 (IUCN, 2022; Malliet, 2022), signifying some of the highest levels of engagement and commitment to the process to date. But several key countries remain wary of the treaty's economic and legal implications, advocating for a more modest approach. Historically, the dialogue surrounding the BBNJ negotiations has focused on the agreement's environmental and conservation-related impacts. In this paper, we highlight the many diplomatic, economic, and social benefits of supporting a strong and equitable BBNJ agreement.

The BBNJ treaty in context

In the early 1980s, negotiators concluded the UN Convention on the Law of the Sea (UNCLOS), crystallizing the sovereign rights and jurisdiction of states regarding the use and exploitation of marine resources within 200 nautical miles from their baselines (known as the exclusive economic zone; EEZ). However, it also left many issues unaddressed. Despite creating an obligation on all States to protect and preserve the marine environment, UNCLOS contained few mechanisms to address threats other than pollution in high sea areas (Humphries and Harden-Davies, 2020). While a "fragmented system" of global sectoral bodies for shipping (the International Maritime Organization; IMO), seabed mining (the International Seabed Authority; ISA), Regional Fisheries Management Organizations (RFMOs), Regional Seas Programmes, and regional treaties exists, these institutions are largely activity-specific, regional or sectoral in nature, operate independently with limited coordination and cooperation, and/or consider conservation as a secondary priority (Freestone, 2018; Gjerde et al., 2019; Hammond and Jones, 2021). This has resulted in an ocean governance structure that has proven inadequate in stemming environmental degradation and loss of biodiversity in ABNJ (Bigagli, 2016). Without a sufficiently empowered treaty and associated Conference of Parties, the high seas will remain primarily governed by this regime of largely sectoral bodies operating in siloes and failing to work cohesively to address global ocean health (Gjerde and Yadav, 2021).

The consequences of this patchwork approach is clear. Fishers are able to catch greater quantities of resources, traveling further and fishing deeper than ever before (Morato et al., 2006; Bavinck, 2011). Today, industrial fishing is estimated to occur in nearly 50% of the global ocean (Sala et al., 2018); however, regardless of this surge in fishing effort, fish landings and values have stagnated (Merrie et al., 2014). Despite the existence of over 20 RFMOs responsible for managing and conserving fish stocks, the ecological consequences of this unmanaged exploitation have been staggering, with 31% of marine fish stocks worldwide over-exploited (FAO, 2016) and ecosystem-level changes observed in multiple open-ocean areas (Ortuño Crespo and Dunn, 2017). Maritime shipping also occurs over much of the world's oceans, including a sizeable number of routes within ABNJ (O'Leary et al., 2020). These activities introduce additional biodiversity concerns, with vessel collisions among the leading human cause of mortality for many large marine mammals (Rockwood et al., 2017). Although the IMO is responsible for regulating international shipping standards, its lack of direct monitoring or enforcement power means that flag state performance varies greatly (Corres and Pallis, 2008). Further, development of regulations for deep-sea mining in ABNJ is currently underway (O'Leary et al., 2020). Deep sea mining activities are likely to have widespread and long-term impacts on the entire marine ecosystem from seabed to surface (Miller et al., 2018). Importantly, many locations of suitable seabed mining operations overlap with areas that are highly important to biodiversity and may be irreversibly damaged (Jones et al., 2017; Harfoot et al., 2018). Although seabed mining activities are regulated by the ISA, there is rising concern about mining impacts, the lack of knowledge to avoid harm, and non-transparency of certain parts of the ISA, leading to increasing calls for greater precaution, accountability, and stewardship (Niner et al., 2018; Deep Sea Mining Campaign, 2019) . Overall, changes in the scope and magnitude of ocean use today demonstrate a need for new legal and political tools and architecture to govern current levels of exploitation. A robust treaty focused on sustainably managing ecosystems to safeguard

ocean life is not just urgently needed, but has the potential for widespread benefits.

Overview of the treaty and its progress

The current draft of the BBNJ agreement addresses four major aspects: (1) marine genetic resources, (2) area-based management tools (ABMTs) including marine protected areas (MPAs), (3) capacity building and technology transfer (CBTT), and (4) environmental impact assessments (EIAs). In combination, these four parts have the potential to transform how we conserve and manage BBNJ. As the international community prepares for a IGC 5 from August 15-26, 2022, it is critical that swift progress and strong support continues. Finalizing an ambitious BBNJ treaty in 2022, which also marks the 40th anniversary of the adoption of UNCLOS, would be a significant milestone for ocean governance and assist in meeting other global goals. Further, this new global ocean biodiversity agreement can help enhance multilateral cooperation for more effective international response to new threats, both environmental and beyond, that were not initially anticipated when UNCLOS was drafted.

How the BBNJ treaty will benefit nations

The BBNJ agreement not only has the potential to better protect vulnerable ocean ecosystems and species, but also would be consistent with the diplomatic, economic, and social interests of States (Figure 1).

Diplomatic benefits

The BBNJ agreement would offer States an opportunity to strengthen multilateral diplomatic institutions and promote international cooperation towards global conservation efforts. Clearly establishing core obligations and principles for high seas conservation and sustainable management through a new agreement can advance global collaboration around common goals (Gjerde and Yadav, 2021), which was noted as a shared key interest that can revitalize efforts to meet Sustainable Development Goals (European Commission, 2022). While differing priorities and power imbalances have historically hindered progress towards meeting global targets (Morrison et al., 2019), a strong BBNJ treaty would mitigate many challenges and inefficiencies inherent in the current regional

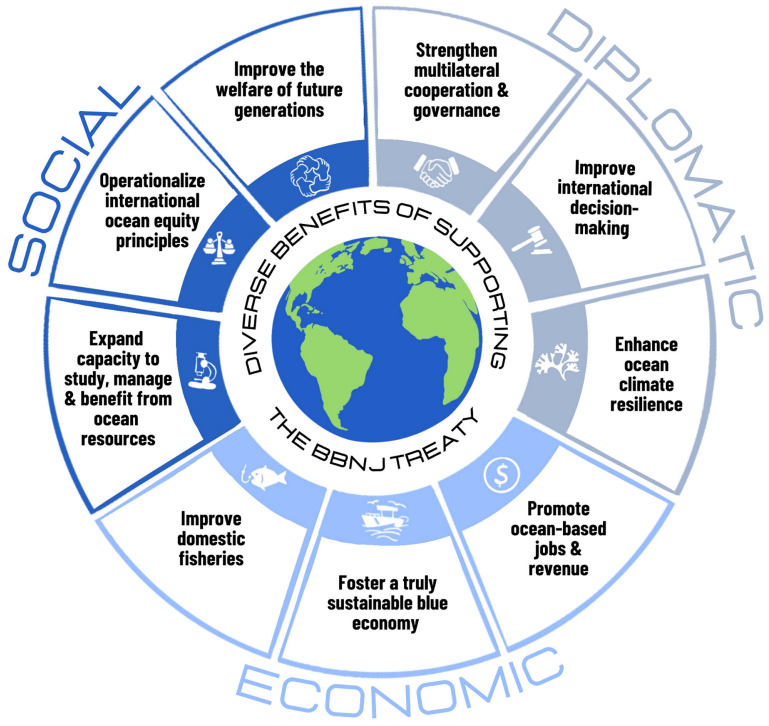

FIGURE 1
Diplomatic, economic, and social benefits for strengthening and supporting the marine biological diversity of areas beyond national jurisdiction (BBNJ) intergovernmental treaty.

and sector-based governance regime (Bodansky, 2010; Tang et al., 2021), by creating a platform for working towards more cohesive integrated management.

UN and European Commission leadership have explicitly called for closer international rules-based cooperation and multilateral governance to address global challenges (European Commission, 2022). The new treaty can signify a new era for multilateralism, modeling how to combat global challenges with internationally coordinated and integrated action. For example, the treaty's framework for implementation can serve as a model for preventing and mediating conflicts, by incorporating common interest building through science-based collaboration as well as formal and informal dispute resolution mechanisms (Gjerde and Yadav, 2021). Developing learning exchange processes can foster coordination, while long-term capacity building can advance integrated ocean management within and across regions more equitably (Gjerde and Yadav, 2021). Formally incorporating such strategies into global conservation approaches can strengthen their use and implementation. These mechanisms could not only catalyze marine research and management in the high seas, but potentially lead to improved science-based decision-making in other global and regional institutions.

The BBNJ agreement can also enhance ocean climate resilience and support nations' commitments to tackling the climate crisis. A healthy ocean is vital to fighting the climate crisis, given its role in the global carbon cycle and aid in slowing the rate of rising temperatures (Denman et al., 2007). The ocean serves as the largest active carbon sink worldwide, sequestering 2.5 billion metric tons of carbon a year and absorbing a quarter of all anthropogenic carbon dioxide emissions (Friedlingstein et al., 2019). Marine vertebrates can move and store carbon in different ways (Wilson et al., 2009) and large animal carcasses, such as whales, can sequester carbon after sinking (Pershing et al., 2010). However, heavy high seas exploitation and overfishing has directly reduced the carbon sequestration potential of our oceans. By removing large quantities of fish, fishing has prevented the sequestration of over 21 million metric tons of carbon since 1950, in addition to releasing at least 0.73 billion metric tons of atmospheric carbon dioxide through fuel consumption (Mariani et al., 2020).

The BBNJ treaty can offer a complementary platform to advance collaboration around international climate goals and agreements, ensuring that climate change is integrated into environmental assessments and area-based management planning, and that proposed new technologies to mitigate climate change consider fully their effects on ocean life and ecosystem services beyond national boundaries. Despite collective pledges by nations to combat climate change (Ghezloun et al., 2017), current levels of ambition are not on track to meet global goals (UNFCCC, 2021). More effective protection of high seas ecosystems is vital for safeguarding habitats and promoting the recovery of fish stocks, which can facilitate the restoration of crucial carbon sequestration processes and support climate adaptation (Gattuso et al., 2018; Mariani et al., 2020). EIAs grounded upon comprehensive strategic environmental assessment processes (SEAs) as elaborated through the BBNJ treaty can ensure that proposed activities consider the effects on biodiversity by evaluating their potential carbon emissions and impacts on carbon sequestration processes. Given the critical link between climate change action and healthy ocean ecosystems, actively supporting the BBNJ agreement could not only directly impact carbon emissions, but also help build momentum towards strengthening multilateral cooperation for this common cause.

Economic benefits

Strengthened biodiversity protections through a strong BBNJ treaty can enhance ecosystem health, preserve genetic diversity, and improve fish stocks, leading to economic benefits for ocean-related industries. The ocean supports a wide-range of renewable economic activities, generating millions of jobs and revenue in sectors including fishing, energy, tourism, shipping and biotechnology (Colgan, 2004; Teh and Sumaila, 2013). In addition, the ocean provides intangible goods, services, and non-market benefits such as atmospheric regulation, carbon sequestration and storage, and global temperature control (Hoegh-Guldberg, 2015). Many coastal countries are motivated to explore how to grow their ocean-based economies, however, the benefits of a growing blue economy will only be realized if regulations and governance adequately protect the ocean's capacity to provide ecosystem goods and services in a holistic manner. While most of this ocean-based economic value comes from coastal areas, biodiversity protection in the high seas will enhance ecosystem services stemming from ABNJ, with benefits that can spillover and lead to more prosperous coastal sectors.

Given the highly interconnected nature of ocean ecosystems, appropriate conservation and management measures must consider levels of risk and protections across all habitats (Dunn et al., 2019). For example, only 1.5% of commercially-targeted taxa are found exclusively within international waters; many more species frequent both the high seas and EEZs of individual nations (Sumaila et al., 2015). These species spend the vast majority of their lives in ABNJ (Harrison et al., 2018), thus, mismanagement in these high sea areas can have cascading impacts that affect the profitability of nearshore fisheries within national jurisdiction. Safeguarding important habitats in adjacent high sea areas can greatly influence the health and availability of migratory marine stocks that spillover to domestic fleets. For example, Sumaila et al. (2015) suggests that closing the entire high seas to fishing could lead to more than an 18% increase in the catch of straddling stocks, improving catch and revenue for at least 120 coastal States. Thus, even the moderate

creation of new and expansive high seas ABMTs could lead to economic benefits for coastal nations.

Investing in the protection of biodiversity in the high seas through protected areas and stronger environmental oversight mechanisms would help high seas ecosystems to rebuild, leading to cascading benefits for coastal economies. The restoration of marine biodiversity loss has been projected to lead to a 23% increase in species diversity, a 21% decrease in community variability, and a fourfold growth in fisheries productivity (Worm et al., 2006). This can result in considerable extractive (e.g., fish catches) and non-extractive (e.g., tourism) revenue (Worm et al., 2006). Fish stocks have greatly improved in areas where fisheries are intensively managed and scientifically assessed, while regions that lack extensive fisheries management systems, such as the high seas, have stock statuses and trends that are much worse (Hilborn et al., 2020). The BBNJ treaty has the potential to enhance the sustainability of existing fisheries management systems, by coordinating spatial efforts, building connectivity into ABMT design, and strengthening capacity for science-based management within current regional and/or sector-based regimes (Crespo et al., 2019). For example, providing common principles and enabling comprehensive assessment processes, coupled with a more robust global review to assess progress and assist with implementation, can aid in ensuring RMFOs are applying a consistent ecosystem-based management approach across ocean areas (Crespo et al., 2019). The BBNJ treaty can also provide a mechanism to address current management gaps within regional fisheries bodies, both geographical and taxonomical (Crespo et al., 2019). Strong BBNJ treaty provisions around ABMTs, EIAs and SEAs can serve as a platform for organizations to comply with global obligations around biodiversity conservation (Haas et al., 2021), aiding to make more robust high seas fisheries management possible.

The economic advantages of strengthened high seas biodiversity management would outweigh the costs for most nations. ABMTs established by the BBNJ agreement will likely have little direct impact on most global fishing catch and revenue. The vast majority of global catch occurs in domestic waters (Sea Around Us, 2016). High seas fishing was estimated to account for only around 6% of global catch and 8% of fishing revenue in 2014, with fishing effort dominated by six countries (Sala et al., 2018). Many of these nations depend on harmful fuel subsidies to be profitable (Sumaila et al., 2021), however, without subsidies and/or low labor compensations, over half of the high seas areas that are currently fished may be unprofitable at present rates (Sala et al., 2018). These former subsidies for high seas fishing can be invested instead in better managing domestic fisheries, further protecting biodiversity, reducing pressures on fishing stocks, and supporting ecosystem health.

Social benefits

Finally, a strong and well-designed BBNJ agreement can promote global equity, a goal of the UN and many of its member States. The legal status quo in the high seas is highly inequitable, where opportunities to explore, extract and acquire wealth from ocean-based resources are not fairly considered or distributed among nations. Only a few wealthy nations possess the legal, institutional, or research capacities to access high seas areas, leading to disproportional benefits from an internationally shared area (Sumaila et al., 2015; Tolochko and Vadrot, 2021). For example, only five of the twenty-two countries within the Southeast Atlantic are active in the high seas, generating 1% of global high seas fishing revenue (Spiteri et al., 2021). Constrained by lack of resources (Tydecks et al., 2018), many of these countries rely heavily on coastal and nearshore artisanal fishing, sectors that may benefit from increased protections in the high seas.

Improving high seas management can benefit developing countries in various ways. Establishing an ocean governance framework that explicitly and carefully addresses equity as a key principle can foster cooperative efforts to tackle current global inequalities. Addressing these issues within the negotiations through both substance and process is critical, given that the new treaty can have direct implications for how ocean science and management are conducted. But references to the common heritage of humankind principle as a legal foundation have been controversial (Vadrot et al., 2022). This debate has primarily centered around the regulation of MGRs, where normative arguments on benefit sharing and equity have come into conflict with concerns about the principle's practical effects on scientific research and international intellectual property law (Harden-Davies, 2017).

Recognizing the interconnectedness of our one ocean, there is a need for financial and other resources to enable capacity building for implementation of all aspects of the BBNJ agreement, from legal and institutional needs for administration, to technical and human resource needs for conducting and reviewing environmental impact assessments, and to the proposal and potential management of high seas MPAs (Cicin-Sain et al., 2019; Harden-Davies et al., 2022). And from a pragmatic perspective, many developing nations, such as small Pacific Island countries, will have limited benefits from marine genetic resources without provisions within the BBNJ treaty that meaningfully supports CBTT (Harden-Davies, 2017).

While an obligation for CBTT already exists, the BBNJ treaty is an opportunity to operationalize principles of both intergenerational and intragenerational equity. Bolstering international cooperation in addition to well-coordinated sharing of knowledge, training, and infrastructure is needed to overcome persisting intragenerational inequalities in global

science capacity (Harden-Davies and Snelgrove, 2020) and resource use. However, without careful consideration of how to address these social issues, developing nations may not be able to thoroughly implement the BBNJ agreement or fully realize its benefits. Countries opposed to the common heritage of humankind can still endorse concepts of intergenerational equity within the treaty. For example, this can include text around investing in activities that enable positive outcomes for future generations, creating meaningful partnerships co-designed to meet local needs, and ensuring open access for acquiring, interpreting, and acting on obtained knowledge (Harden-Davies et al., 2022). In addition, countries that may not have the means to access high seas resources should still be able to meaningfully participate in conversations around their sustainable management, and the interests of all humankind – including Indigenous Peoples and local communities – should be represented in these conversations. The BBNJ treaty could protect the rights of all nations to be involved in decision-making, and set a global expectation for meaningful, widespread participation in international environmental management. Further, the treaty can be used to create an expectation in developing low-cost and accessible high seas technologies to support a wider use, establish funding mechanisms to aid in financing CBTT within the developing world, and support data systems that can integrate traditional and local knowledge.

A central component of the UN 2030 Agenda for Sustainable Development is a commitment for member nations to ensure that no nation is left behind. Given that our ocean is a shared resource, the BBNJ treaty will not be successful in contributing to this global priority without strong provisions that operationalize principles of equity, making this agreement a timely opportunity to launch meaningful progress towards social reform and global ocean equity (Claudet et al., 2021). Policies that promote equity can reduce poverty, promote long-term sustainable economic growth, reduce political discourse, and impact the welfare of future generations (Gupta et al., 1999). A truly sustainable ocean management framework should improve the well-being of all people, shifting historical trajectories that exacerbate inequities in resource and scientific use and access.

Conclusion

Commitment towards a strong BBNJ treaty will have diverse benefits for nations, including those that are diplomatic, economic, and social in nature. While this discussion is not meant to be exhaustive, it highlights reasons beyond conservation as to why it is within the national interests of countries to advocate for a strong and equitable agreement. Bold international support is urgently needed to usher the BBNJ agreement through its final stages, ensuring its terms will sufficiently protect biodiversity and enhance global equity, so that its widespread benefits can be fully realized by all ocean life and nations around the globe.

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 authors.

Author contributions

BS and SD conceptualized and co-wrote the sections of the manuscript. All authors edited and contributed to manuscript revisions, as well as read and approved the submitted manuscript.

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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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Key principles for effective marine governance, including lessons learned after decades of adaptive management in the Great Barrier Reef

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This paper reviews the concept of governance in protected areas, providing details about nine key principles of governance as they relate to marine protected areas (MPAs). Following a theoretical description of each principle, real-world examples of the principles are presented from the Great Barrier Reef (GBR) Marine Park, where marine governance has evolved over 45 years as part of adaptive management. Examples of good governance in the GBR include the intergovernmental arrangements that enable both federal and state governments to co-operate effectively across adjoining marine jurisdictions. In addition, the application of multiple layers of management adds to an effective integrated approach, considered to be the most appropriate for managing a large MPA. The nine governance principles discussed in the paper are applicable to all MPAs, but how they are applied will vary in dissimilar settings because of differing environmental, social, economic, cultural, and political contexts - clearly, one size does not fit all. The analogy of the nine principles being part of an interlaced or woven 'lattice' is also introduced. Collectively the lattice is stronger than any individual principle, and together all principles contribute to the totality of effective governance. The paper provides information for those involved in MPA management who are keen to understand marine governance and how it might apply to their MPA, recognising there will be differences in how the principles will apply.

KEYWORDS

marine, marine protected area (MPA), governance, management, integration, planning

Introduction

What is governance in natural resource management?

In its simplest terms, 'governance' may be described as the process of decision-making, and the subsequent process by which decisions are, or are not, implemented. As Ruhanen et al. (2010) explain, governance is not a synonym for government, as governance involves a multitude of stakeholders and is therefore much broader than government.

Governance is a fundamentally important component of natural resource management. As Borrini-Feyerabend et al. (2013, p. xii) assert, "*Governance is a main factor in determining the effectiveness and efficiency of management. Because of this, it is of great interest to governments, funding agencies, regulatory bodies and society in general*".

The difference between governance and management in natural areas is clarified in the Guidelines published by the International Union for the Conservation of Nature (IUCN):

- "Management is about … what is done in pursuit of given objectives - the means and actions to achieve such objectives;
- Governance is about … who decides what the objectives are, what to do to pursue them, and with what means - how those decisions are taken - who holds power, authority and responsibility - who is (or should be) held accountable." (Borrini-Feyerabend et al., 2013, p. 11)

The concept of governance has been discussed and documented by a multitude of authors; for example, Weiss (2000) provides a wide variety of definitions from various international organisations. Other examples, each defining 'governance' in a slightly different way; include:

- "*The involvement of a wide range of institutions and actors in the production of policy outcomes … involving coordination through networks and partnerships*" (Johnston et al., 2000, p.317).
- "*… a process whereby societies or organizations make their important decisions, determine whom they involve in the process … - that is, the agreements, procedures, conventions or policies that define who gets power, how decisions are taken and how accountability is rendered*" (Graham et al., 2003, p.1).
- "*The processes and structures of public policy decision making and management that engage people constructively across the boundaries of public agencies, levels of government, and/or the public, private and civic spheres in order to carry out a public purpose that could not otherwise be accomplished*" (Emerson et al., 2012, p.2).
- "*Adaptive governance refers to flexible and learning-based collaborations and decision-making processes involving both state and nonstate actors, often at multiple levels, with the aim to adaptively negotiate and coordinate management of social– ecological systems and ecosystem services across landscapes and seascapes*" (Schultz et al., 2015, p.7369).
- "*Governance is generally defined as the institutions, structures, and processes that determine who makes decisions, how and for whom decisions are made, whether, how and what actions are taken and by whom and to what effect*" (Bennett and Satterfield, 2018, p. 2).

Although there are some common elements within all the above definitions, there seems no firm agreement on what precisely constitutes governance. There are different ways in which environmental governance structures and processes may be applied - they may be 'top-down' (driven from the top by governments or private individuals, especially in countries with relatively well developed legal, bureaucratic and political systems), 'bottom-up' (driven by local communities or user-led), or a combination including "…shared decision-making and authority through formal co-management arrangements or informal networks of actors and organizations" (Bennett and Satterfield, 2018, p.6). Jones (2012) notes that top-down approaches tend to dominate, but this does not mean that they cannot be combined with bottom-up approaches. As Christie and White (2007) report, there are advantages of bottom-up strategies as they can engage resource users more effectively, leading to a sense of trust, collaboration and ownership amongst participants. In some countries, top-down strategies may be perceived as having the benefits of a sound scientific basis, or there may be statutory requirements for consultative participation or implementation end-products such as a zoning plan. Jones and Long (2021) assessed 28 case studies of marine protected areas (MPAs) that used a range of governance approaches, and concluded each approach had their respective strengths and weaknesses, and there were benefits if various approaches were functionally integrated.

Given the fact that governance can be applied in different ways, and there appears no firm agreement as to what constitutes governance, the advice of Borrini-Feyerabend et al. (2013), seems appropriate, given they state:

> "*There is no "ideal governance setting" for all protected areas, nor an ideal to which governance models can be compared, but a set of "good governance" principles [that] can be taken into account vis-à-vis any protected area system or site. These principles provide insights about how a specific governance setting will advance or hinder conservation, sustainable livelihoods and the rights and values of the people and country concerned*". (2013, p. xii).

What are the key principles of good governance?

What constitutes the principles of good governance for protected areas have similarly been described by many authors; for example:

- UNDP (1997) listed nine principles of good governance (Table 1)
- Graham et al. (2003) grouped some of the nine principles from UNDP (1997), suggesting there are five principles of good governance
- Lockwood et al. (2010) characterized good governance according to a set of eight principles very similar to those promoted by UNDP (1997)
- Young et al. (2007) proposed four core principles that are particularly relevant to the place-based management of marine ecosystems
- Jones (2014) provided a governance framework that considered 36 incentives grouped into five broad categories; economic, communication, knowledge, legal and participation.
- Ruhanen et al. (2010) conducted a meta-analysis of 53 published governance studies, identifying and ranking 40 different dimensions or principles of governance.
- Bennett and Satterfield (2018) developed a list of 19 attributes that were then assigned to four overarching categories.

When considering what might be the principles of good governance, Graham et al. (2003) recognise "… *these principles often overlap or are conflicting at some point, that they play out in practice according to the actual social context, that applying such principles is complex, and that they are all about not only the results of power but how well it is exercised*" (p. 3). Nevertheless, Graham et al. (2003) concluded that the principles of governance "… *can be usefully applied to help deal with current governance challenges*". *However*, they also warn, *"When they are applied it becomes apparent that there are no absolutes; that principles often conflict; that the 'devil is in the detail'; that context matters."* (p. 6).

Table 1 has been developed to show the correlations between the various governance principles put forward by well-respected authors in the governance field. It lists the nine principles of good governance from UNDP (1997), shows how these principles have been clustered into five broad groups (Graham et al., 2003), and the corresponding principles as defined by others (e.g., Eagles, 2009; Lockwood et al., 2010; Bennett and Satterfield, 2018). As shown in Table 1, there is considerable overlap between the UNDP list and the 40 different dimensions or principles of governance identified by Ruhanen et al. (2010); the relative ranking of each principle is also shown based on a frequency count derived by Ruhanen et al. (2010) from their analysis of the published articles.

As Jones et al. (2013) point out, when considering the various approaches to natural resource governance, there is *"… a vast literature on the relative merits … and many definitions of governance"*. A similar view is expressed by Weiss (2008); Borrini-Feyerabend et al. (2013); Borrini-Feyerabend and Hill (2015), and Bennett and Satterfield (2018). Increasingly there is a focus specifically on marine governance (e.g., Christie and White, 2007; Fanning et al., 2007; Jones et al., 2011; McCay and Jones, 2011; Bown et al., 2013; Day and Dobbs, 2013; Jones et al., 2013; Gaymer et al., 2014; Jones, 2014; Jones and Long, 2021). However, many of these papers are comparatively theoretical, or are so comprehensive that they are consequently less useful for those specifically involved in practical MPA management.

How might this information help those responsible for MPA management?

The principles of 'good governance' outlined in this paper can be applied in all types of protected areas, whether they are in terrestrial or marine environments. However, how some of the principles are applied in the marine environment may differ given the differences compared to the terrestrial realm. As Rice (1985) warned, "marine ecosystems are not simply wet salty terrestrial ones"; problems can arise if it is assumed that knowledge gained from managing terrestrial ecosystems can be applied directly to marine contexts. The fact most of the marine environment is hidden from human sight ('out of sight, out of mind') and the vastness of the oceans have contributed to many misunderstandings about the marine environment and how it needs to be managed. For example, identifying MPA or zone boundaries at sea, and effectively communicating those boundaries to users is far harder than on land. Widely differing components of the marine realm (e.g. littoral, epipelagic, mesopelagic, bathypelagic, benthic) may also need to be managed differently.

Having considered many of the available references, there appears to be no agreed, conclusive or definitive list of principles for good governance that is specifically applicable to MPAs. Given that some principles overlap, and others may conflict at some point (Graham et al., 2003), I have chosen to revert to the original nine principles from UNDP (1997) while recognising there are many similarities with other lists and groupings of principles as shown in Table 1. From my experience, the comparatively simple list of nine key governance principles provides a sufficient level of complexity to be useful for MPA managers.

The specific information relating the principles to the marine environment is intended to provide those involved in all aspects of MPA management with a better understanding of marine governance, thereby enabling them to move

TABLE 1 Nine key principles of good governance [after UNDP (1997) and adapted by Graham et al. (2003)].

Groupings of principles from Graham et al. (2003)	Nine principles of good governance (after UNDP, 1997)	Similar principles discussed in:			Relative ranking (on a scale 1- 40) based on analysis by Ruhanen et al., 2010)
		Eagles (2009)	Lockwood et al. (2010)	Bennett and Satterfield (2018)	
Legitimacy and Voice	**Participation** – everyone should have a voice in decision-making, either directly or through legitimate intermediate institutions that represent their intention. Such broad participation is built on freedom of association and speech, as well as capacities to participate constructively.	Public Participation	Inclusiveness	Participation	9 & 14
	Consensus orientation – good governance mediates differing interests to reach a broad consensus on what is in the best interest of the group and, where possible, on policies and procedures.	Consensus Orientation	Integration	Direction, Informed	23
Direction	**Strategic vision** – leaders and the public have a broad and long-term perspective on good governance and human development, along with a sense of what is needed for such development. There is also an understanding of the historical, cultural and social complexities in which that perspective is grounded.	Strategic Vision	–	Anticipatory, Innovative	26
Performance	**Responsiveness** – institutions and processes try to serve all stakeholders.	Responsiveness	Adaptability	Adaptive, Flexible Capacity	16
	Effectiveness and efficiency – processes and institutions produce results that meet needs while making the best use of resources.	Efficiency & Effectiveness	Capability	Efficient, Coordination Connected	5 & 7
Account-ability	**Accountability** – decision-makers in government, the private sector and civil society organizations are accountable to the public, as well as to institutional stakeholders. This accountability differs depending on the organizations and whether the decision is internal or external.	Accountability	Accountability	Accountable, Learning	1
	Transparency – transparency is built on the free flow of information. Processes, institutions and information are directly accessible to those concerned with them, and enough information is provided to understand and monitor them.	Transparency	Transparency	Recognition, Nested	2
Fairness	**Equity** – everyone has opportunities to improve or maintain their wellbeing.	Equity	Fairness	Just, Polycentric	20
	Rule of Law – legal frameworks should be fair and enforced impartially, particularly the laws on human rights.	Rule of Law	Legitimacy	Legitimate, Fair	17

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incrementally toward more effective governance in their MPA. Having identified these principles, Part 2 explains each principle in more detail providing a marine focus. Some real-world examples (both good and bad) of each principle are then provided in Part 3, drawing upon the experience in the Great Barrier Reef (GBR), a globally recognised MPA that has been functioning since the mid-1970s. Finally, Part 4 discusses how these principles might be applied in an individual MPA, recognising the wide degree of divergence across the world's MPAs.

Explaining the nine key principles of good governance

Participation

Public participation (sometimes referred to as 'public engagement', 'community participation', or 'stakeholder involvement') is widely acknowledged as a key component of effective governance. Defined as the involvement of those affected by a decision in a decision-making process, public participation is an essential part of effective decision-making. VAGO (2015: p.2) maintains "*… the credibility of a decision is enhanced when it is perceived to be the product of an open and deliberative process*", and Appelstrand (2002: p.289) refers to public participation as constituting *"a prerequisite for legitimacy - and thus acceptance of laws … and decisions."*

Some critics, however, suggest that public participation programs only exist to satisfy legal requirements or perceived ethical ones; others maintain public participation is ineffective and inefficient. Considering Arnstein's (1969) 'ladder of participation', public participation needs to be more than simply informing or educating the public, rather it must involve effectively consulting the public and negotiating options, and with more than a few select stakeholders or just the local community. The time and resources required for effective public engagement are not insignificant; consequently, it is not uncommon for effective public engagement to necessitate more time and resources than were initially envisaged (Day, 2017).

Notwithstanding the critics, the value of effective public participation is endorsed by many authors (e.g., Petts and Leach, 2000; Bäckstrand, 2003; Rowe and Frewer, 2005; Petts, 2006; Innes and Booher, 2007; Petts 2008; Reed, 2008; Birnbaum et al., 2015; VAGO, 2015). Advocates maintain it improves the quality and legitimacy of a decision, while building the capacity of all involved to engage more effectively in the policy process (Stern and Dietz, 2008). Lundquist and Granek (2005) also observe that one characteristic emphasized in most successful global marine conservation efforts is the importance of incorporating stakeholders at all phases of the process. Bennett et al. (2019) found that employing good governance processes and managing social impacts was more important than ecological effectiveness for maintaining local support for conservation. Few authors, however, specifically discuss how public participation should be undertaken for different aspects of governance; for example, during different stages of a planning process, or tailoring key messages in different but appropriate ways for different groups of stakeholders. Dehens and Fanning (2018) do discuss ten indicators spread across different stages of the MPA process.

Consensus orientation

Good governance aims to mediate differing interests to reach broad agreement on what is in the best interest of the constituents and, where possible, on policies and procedures. Many decision makers are keen to encourage consensus-based decisions, seeking agreement that meets the interests of all stakeholders. A consensus building approach may maximize possible gains for the stakeholders involved but may not necessarily be the best decision when evaluated against the ecological objectives for an MPA or against what the broader society desires for the area (e.g., the national or international community rather than just the local community). To ensure a consensus view among stakeholders is not in direct opposition to the statutory or regulatory directives or objectives, it is important to clearly explain those objectives before entering any negotiations.

In a similar way, the concept of a 'win-win' for all those concerned may seem a worthy aim, but it is rarely a realistic outcome in large complex MPAs where no single solution is likely to satisfy all users, stakeholders, and rights-holders. Some stakeholders may form coalitions with others who share similar goals, and this may enable them to reach new and innovative solutions to problems; however, sometimes such coalitions fail over time due to power struggles or infighting. Bennett and Dearden (2014) also caution against this win-win way of thinking:

> *'The proposition that MPAs both can and should lead to win-win outcomes for conservation and development thus satisfying the needs of conservationists, governments, fishers, tourism operators, and local communities is becoming the dominant paradigm. However, the successful achievement of this dual mandate is more complex in reality than in theory….'* (Bennett and Dearden, 2014, p.96).

Brueckner-Irwin et al. (2019) describe how many MPA processes fit poorly with the local context because they do not effectively consider social and ecological dynamics. They suggest that decision makers need to consider how communities define effective collaboration and create transparent opportunities for participation to improve perceptions of fairness.

Strategic vision

A strategic vision provides a sense of purpose and a broad direction and goals for any organisation. A good vision needs to define the short and long-term goals *("where we are going")* and guide the decisions that need to be made along the way *("what is needed to achieve this vision?")*. Nanus (1992) and Zaccaro and Banks (2001) consider that to be most effective, a strategic vision should contain five elements:

i. a *picture* of the future that is better than the status quo
ii. a *change*, moving towards something more positive (usually taking the best features of a previous system and strengthening them)
iii. *values* or the ideas and beliefs that people find worthwhile or desirable
iv. a '*roadmap*' that sets out the route and milestones, so followers know if they are on the right course; and
v. a *challenge*.

Covey (1991) suggests having a clear strategic vision is one of the seven habits of highly effective people. An effective leader should therefore be able to successfully communicate their vision, thereby providing a clear direction for their organisation or team. If an organisation is undergoing transformational change (i.e., change that is radical, comprehensive or large scale), the key steps identified by Kotter (1995) include creating a new vision, communicating that vision, empowering others to act on that vision, and institutionalising the necessary changes by revamping the organisational culture.

Responsiveness

Responsiveness means responding to an issue with a timely decision(s) that leads to appropriate and timely action(s). This may contribute to the achievement of existing goals and objectives but may also address an unforeseen issue. Any successful marine management system must be responsive and able to incorporate changes such as new information becoming available or changing circumstances. Irrespective of whether the change results from 'in-the-field' experience, from new data, or because of an unexpected event (e.g., a ship grounding or an oil spill), marine management practices must be periodically reviewed and updated. Some pre-planning should be undertaken (e.g., risk management preparedness), as a complex or unwieldy hierarchical organisation can hamper being able to react quickly, and delays or an inability to respond in a timely way may exacerbate the problem.

As noted by Graham et al. (2003), some governance principles may conflict at some point (e.g., responsiveness can sometimes conflict with either public participation or consensus decision-making); when this becomes apparent, it is important to consider the relevant principles in the overall context and the objectives of the MPA (usually defined in the legislation). When managing natural resources, adaptive management is a responsive approach for simultaneously managing and learning ('learning from implementation'). It is purposely conducted in a manner that explicitly increases knowledge and reduces uncertainty (Rist et al., 2013), and is a key aspect of managing any marine area (Schultz et al., 2015). Adaptive management enables managers to be flexible and to expect and respond to the unexpected.

Effectiveness and efficiency

These two words are often used interchangeably, but both are necessary for effective governance and a well-functioning workplace. Effectiveness is the ability to produce a better result, deliver more value or achieve a better outcome. Efficiency is the ability to produce an intended outcome resulting from the optimal use of time, effort, and/or available resources. Drucker (2001) puts it simply, "Effectiveness is doing the right thing, while efficiency is doing things right". Both assume an MPA practitioner is able to define what is the right outcome and what things need to be done. As with some other principles, effectiveness and efficiency may also potentially be in tension with public participation and consensus decision-making.

Wooll (2022) explains that increased effectiveness may occur in many ways:

- Being open to change (e.g., encourage flexibility in how things are done)
- Embracing collaboration and encouraging new ideas (listen to input from everyone on the team, as everyone has something to offer)
- Relinquishing control and trusting your colleagues to do what they need to do
- Looking at the big picture, not just the problem at hand.

Accountability

Ruhanen et al. (2010) ranked accountability as the #1 aspect of governance (see Table 1). Accountability includes ensuring that tasks and objectives are completed on time and funds are spent appropriately (Dearden et al., 2005). In an MPA, this relates to who holds the main decision-making authority for the area? Who is responsible and can be held accountable for the decisions and outcomes? Sometimes performance standards are used to ensure accountability, but an over-application of such mechanisms can detract from getting on with 'the real work' of

MPA management. A more effective way is when all those involved in the key aspects of MPA management take specific responsibility for their actions and behaviour, and demonstrate their performance by their actions and outcomes. Lockwood (2010) explains accountability requires:

- the allocation of responsibilities to those institutional levels that best match the scale of issues and values being addressed;
- the allocation and acceptance of responsibility for decisions and actions, through clear plans and activities; and
- identifying the extent to which a governing body is answerable to its constituency and also answerable to 'higher-level' authorities.

Decision-makers in government are accountable to the public, as well as to the relevant stakeholders. It is important that this accountability is linked to appropriate reports clearly justifying performance and outcomes. The stakeholders therefore need to know what is at stake in decision-making, who is responsible for what; how their performance can be evaluated, and how those responsible can be made accountable.

NGOs can also play significant roles holding government agencies accountable for their actions (or lack of action) in marine conservation or in a specific MPA. However, unlike governments, NGOs are not elected or dependent upon the support of national citizens, and therefore are less accountable for the results of their actions. NGOs may also inadvertently have negative impacts by "*…overstepping their roles, absorbing all the available resources or centralising upon themselves all technical issues, thereby disempowering the local actors…* " (Borrini-Feyerabend and Hill, 2015, p. 138); this is a particular concern in developing countries.

Transparency

Transparency in governance means an organisation facilitates the availability of information, enabling others to see and understand how the organisation operates in a publicly available, accurate, and timely way. Transparency is becoming an increasingly important element of governance at all levels of society, from global to local (Mitchell, 2011). Sufficient information needs to be available to anyone concerned to understand and monitor the processes, budgets, laws and decisions of an organisation.

Freedom of information (FOI) regulations differ between countries but generally require government agencies to publish a broad range of material and give a citizen the right to request access to government-held information. There may be some exceptions for FOI including private information (e.g., personal records), 'commercial-in-confidence' material, high-level government decisions (e.g., 'Cabinet in confidence' documents) or vexatious requests.

Equity

Equity relates to fairness in the distribution of benefits and costs associated with conservation (Jones et al., 2013). Österblom et al. (2020) maintain that access to ocean resources and sectors is rarely equitably distributed; many of the benefits are accumulated by a few, while most harms are borne by the most vulnerable. Most ocean policies are largely equity-blind, poorly implemented and fail to address inequity. A high level of perceived inequity can undermine resource users' willingness to comply with conservation rules or participate in MPA processes, thus limiting the effectiveness of governance incentives and exacerbating the likelihood of over-exploitation (Jones et al., 2013).

Bennet (2019; p. 10) defines environmental justice and equity as '*… the degree to which stakeholder rights, knowledge and values are taken into account ….in decision making, and distributional to the allocation of benefits (goods) and burdens (bads) of resource-based developments and environmental laws, policies, and management actions'*. Equity also relates to sustainable use that meets the needs of the current generation without compromising the ability of future generations to meet their own needs (WCED, 1987) — these include basic human needs, economic needs, environmental needs, and subjective well-being. Climate change will worsen the challenges of fairness and equity faced by developing countries, and regions and communities reliant on marine livelihoods (Weiss, 2008). Climate change and the continuing depletion of natural resources will also be significant burdens for future generations. Addressing these inequities requires strong leadership, inclusive governance and long-term planning as equity is integral to a sustainable ocean economy.

Bennett et al. (2021) outline a variety of ways that social equity may be better integrated into marine conservation policy and practice. They advocate the need to acknowledge and respect diverse peoples and perspectives; the fair distribution of impacts through maximizing benefits and minimizing burdens; fostering participation in decision-making; championing and supporting local involvement; ensuring benefits to both nature and people; and addressing contextual barriers to and structural roots of inequity in conservation. However, they also recognise these need to be based on the social, economic, cultural and political realities of each context.

Rule of law

At its most basic level, the rule of law is the concept that all persons and organisations (including the government) are

subject to, and accountable to, the law, and that the law is readily accessible and therefore widely known. The principles[1] of the rule of law include: *fairness* (governments and the courts must follow the law); *rationality* (laws must be clear and able to be followed); *predictability* (the outcome for breaking the law must be clear); *consistency* (the law is applied to all in the same way, and no retrospective laws) and *impartiality* (an independent decision maker ensures legal processes are fair and just).

Specific examples of the nine principles of governance from the Great Barrier Reef

As the largest coral reef ecosystem on the planet, the GBR has undeniable scientific, cultural and conservation significance. It is arguably one of the richest and most complex natural ecosystems globally (Day, 2016), and the GBR Marine Park is one of the better known MPAs in the world.

The governance of such a large and iconic area is complex due to its size and the overlapping federal and state (Queensland) jurisdictions. In addition to the involvement of two governments, management of the GBR also involves Traditional Owners, industry, researchers, community organizations, local government, and individuals. Governance is therefore subject to diverse influences that transcend jurisdictional boundaries. Managing the GBR therefore requires balancing reasonable human use with the maintenance of the area's natural and cultural integrity.

As the GBR has been adaptively managed for over 45 years, the governance approach has evolved (e.g., Olsson et al., 2008; Day and Dobbs, 2013; Evans et al., 2014). Morrison (2017) summarises many of the issues influencing GBR governance over the decades, showing that the pinnacle of success as marine managers occurred in 2004 when the GBR-wide rezoning was implemented. Morrison (2017) also outlines some of major influences on GBR governance from 2006 onwards contributing to a decline in management effectiveness; these influences include a reduction in agency independence, budget fluctuations; increased attention from the UNESCO World Heritage Committee, legislative changes and repeals of some policy positions. At the same time, external pressures have also increased including increasing impacts of climate changes and declining water quality.

Outlined below are specific examples (both good and bad) from the GBR against each of the nine principles of governance. Examples of some of the more formal governance arrangements in the GBR are provided in the Supplementary Information. This includes various committees and agreements that have been specifically developed to assist management and coordination in the GBR (this information is too detailed for the main paper but provides an overview of some of the key components of governance in a large and complex MPA like the GBR).

Participation in the GBR

A good example of participation in the GBR was the comprehensive public engagement process associated with the major rezoning program between 1999-2004. The level of effective public engagement was one of four key elements that significantly influenced the rezoning outcome (Day, 2020). This occurred after it was recognized that effective engagement was essential to understand community concerns, and a wide range of engagement techniques were applied to ensure community involvement. This included very high levels of public participation that went way beyond the requirements of the legislation (e.g., 35,000 written public submissions contributed to major changes between the original zoning plan, the draft plan and the final zoning plan, and attest to the participation being more than just token consultation (Day, 2017)).

A wide range of engagement techniques were adopted enabling anyone who was interested to participate constructively (e.g., the community information sessions were shown to be far more effective than public meetings) and the very high levels of participation (including information tailored for specific stakeholders) contributed to the successful outcome of the entire program. Day (2017) provides a detailed analysis of 25 elements of effective public participation programs across all phases of planning and implementation. The effective ongoing engagement of the community through Local Marine Advisory Committees (LMACs) is another example of successful public participation in the GBR.

Consensus orientation in the GBR

In the GBR, consensus operates at many levels of generality and specificity. There is widespread consensus that the GBR is important, with many industries depending upon its health, and accepting that it is worth protecting. It is also one of the most iconic tourist destinations in Australia and that leads to widespread levels of socio-political support. More specific decisions in the GBR, however, lead to a greater fragmentation of interests and less ability to achieve true consensus, shifting governance to acceptable compromises.

A good example of a specific consensus was the comprehensive *2017 Scientific Consensus Statement* (Waterhouse et al., 2017) prepared by a multidisciplinary panel of scientists with expertise in GBR water quality science and management. The panel reviewed and synthesised the significant advances in scientific knowledge from the 2013 Scientific Consensus Statement, drawing upon the regional

1 See https://www.ruleoflaw.org.au/principles/

water quality improvement plans, specific research and monitoring results as well as relevant science published to date on the ecological processes operating in the GBR.

An example of a fragmentation of interests and no clear consensus, was the process to revise the zoning for the entire GBR Marine Park. When the GBR Zoning Plan was finalised in 2004, it included various compromises that left virtually all sectors feeling a little disappointed. There was widespread acceptance that the extent of public engagement and participation had led to significant changes during the planning process (Day, 2017), but no single sector got exactly what they wanted. Any expectation that a comprehensive public engagement process would be either conflict-free or lead to total consensus was unrealistic; there is no easy way of creating a conflict-free consultative mechanism or achieving total consensus when planning an area of such complexity as the GBR.

Strategic vision in the GBR

The overall management approach for the GBR is ecosystem-based management (EBM), including management influence over a wider context than just the federal Marine Park. This vision has existed for decades; the 25-year vision in the 1994 GBR Strategic Plan (GBRMPA, 1994) provided a comprehensive picture of what the GBR should be like, highlighting some key values that were fundamental for the GBR, and outlining various areas where changes were required. In contrast, a poor example of a strategic vision is the one in the current Reef 2050 Plan which simply states: *The Great Barrier Reef is sustained as a living natural and cultural wonder of the world* (Commonwealth of Australia, 2021).

The comprehensive rezoning of the GBR between 1999-2004 had the broad objective to protect the full range of biodiversity across the entire area by increasing the extent no-take zones, ensuring they included examples of all habitat types. This was effectively a strategic vision for a specific program, but it had far wider implications for the entire GBR. Using a range of public engagement methods, this objective became widely known with a high level of public understanding of the GBR being an interconnected ecosystem, the need for increased protection, and the fact there was a systematic planning process in which everyone could be involved.

A previous CEO of the agency responsible for managing the GBR demonstrated that a well-defined strategic vision is not always an essential prerequisite for a new leader. Numerous interviewees in Day (2020) were highly praiseworthy of that particular CEO (who sadly is now deceased); but one said "…she didn't necessarily have a vision to start, but she knew a good vision. She was very good at building on other people's visions … and once she owned a vision, she really owned it". Another interviewee said "… [the CEO] grew to have a vision and a passion for the Reef. I don't think she started that way … but it certainly grew in her…".

Responsiveness in the GBR

There is well developed and integrated management for all relevant federal and state agencies in the GBR, enabling an immediate and effective management response if required (e.g., responding to an incident like a ship grounding or an oil spill).

A widely acclaimed example of a longer-term but widespread response in the GBR was the comprehensive rezoning that occurred following the realisation there was a need to increase protection of the range of biodiversity that existed the GBR. The level of effective engagement outlined above (Participation in the GBR) and the subsequent changes to the draft zoning plan following the public submissions and other sectoral inputs in 2003 is an example of the effective and responsive planning process. The resulting zoning network led to an increase in the extent of no-take zones from 4.6% of the GBR to 33.3% (or 114,530 km^2). More importantly, the new network protected representative example of all 70 bioregions identified within the GBR while minimising the impacts on all users, including fishers.

The grounding of the ship *Shen Neng 1* on a remote reef in the GBR in April 2010 provides both good and poor examples of responsiveness. The initial incident response was relatively well handled, with the ship removed from the reef and three assessments undertaken of the impact area within a month. A longer-term response resulted in the vessel tracking system known as REEFVTS being subsequently extended to apply throughout the entire length of the GBR (for an example of a poor response after the grounding, see below (Accountability in the GBR) which outlines the ineffectual accountability resulting from an unforeseen combination of events).

Effectiveness and efficiency in the GBR

The comprehensive intergovernmental arrangements, both formal and informal, between the federal government and the state government provide for effective ecosystem-level management for all waters in the GBR, irrespective of the jurisdiction (Commonwealth of Australia and State of Queensland, 2015). The fact there is relatively stable governance at all levels of government and many complementary management tools also assists in effective co-management.

One specific and detailed example of integrating efficiency and effectiveness in the GBR was the automated process used to generate the 150 pages of detailed legal boundary descriptions covering every zone boundary in the 2003 Zoning Plan. This needed to occur with a high degree of accuracy and, as explained

by Lewis et al. (2003, p. 7), *"… there is no tolerance for error because the boundary description, not the [zoning] map, is the legal definition of each boundary … we automated the process and generated a boundary description schedule directly from the GIS coverage…".*

Day (2020) highlights other innovative and complex aspects of the rezoning process that were both effective and efficient (e.g., the legal complexities of moving from the old zoning plan to the new plan while ensuring all related legal instruments such as ongoing permits, were seamlessly transitioned). Another example of an effective process is the coordination of a wide range of federal and state enforcement agencies to produce a comprehensive and targeted compliance and surveillance program across the GBR. Various Australian and Queensland government agencies including the Great Barrier Reef Marine Park Authority, Queensland Parks and Wildlife Service, Queensland Boating and Fisheries Patrol, Queensland Water Police and Maritime Border Command, are all coordinated by a central unit – the Field Management Compliance Unit, to ensure an efficient and effective compliance program.

Accountability in the GBR

High levels of accountability are facilitated by the substantial expertise within the managing agencies, including long-standing staff with considerable corporate knowledge. A highly regarded example of long-term accountability is the GBR Outlook Report prepared every five years to fulfill specific legislative requirements[2]. The report is prepared by the managing agency (the Great Barrier Reef Marine Park Authority), is accountable to the Minister, the federal parliament and the people of Australia (GBRMPA, 2019) and is widely acknowledged as being 'best practice' for systematic and transparent reporting.

An admirable short-term example of accountability and teamwork in the GBR was shown by the extremely high level of commitment by staff of the managing agency between August and December 2003. The monumental tasks included assessing 21, 000 written public submissions, amending the draft plan in the light of those submissions, and finalising the Zoning Plan and all the accompanying documentation for submission to Parliament (including the zone boundary descriptions, new legal provisions, and a Regulatory Impact Statement), all within four months. This was because of a 'political window' (unbeknown to staff but due to a forthcoming election) that meant that years of effort could have been wasted if the necessary documentation had not been submitted in time. GBRMPA staff worked incredibly hard, and all essential documentation was finalised and tabled in the Parliament by the Minister by early December 2003, within the required timeframe.

In contrast, an example of ineffectual accountability at various levels (political, legal, organizational) collectively resulted in delays in the remediation of a major ship grounding site after the *Shen Neng 1* went aground in a remote part of the GBR in 2010. A lamentable combination of political uncertainties, international political differences, legal disputes, remoteness, logistical delays, operational difficulties and various personnel, have led to delays in the clean-up of the area for more than a decade. The consequence of this slow response is that some of the antifoulant paints that initially impacted Douglas Shoal may never be recovered, having subsequently been eroded over the years and dispersed by the very strong tidal currents over a broader area.

Transparency in the GBR

One example of transparency in the GBR is the systematic planning process specified in the legislation including the requirement to formally engage the public on at least two occasions during the preparation of a statutory zoning plan. Another is the detailed guidance that is publicly available regarding what activities require a permit to operate in the GBR, how permit assessments are undertaken, and how decisions are made about the acceptable level of environmental impact.

One of the most transparent aspects of current GBR-management is the 5-yearly Outlook Report introduced above (Accountability in the GBR). The assessment grades at the end of each chapter, along with the trend arrows since the last report and the assessment of the level of confidence for each value are all extremely clear, functional and informative. The eight initial chapters in the Outlook Report document the evidence in a systematic way that is then integrated to produce the final long-term outlook for the Region's values (GBRMPA, 2019).

A poor example of transparency was the federal Government's decision in 2018 to grant AUD$444 million to a small charity (the GBR Foundation) for the Foundation to allocate to environmental projects in the GBR. The federal auditor-general subsequently found the responsible federal department did not comply with the procedures designed to ensure transparency and value for money, resulting in "…non-compliance with elements of the grants administration framework" (ANAO, 2019).

Equity in the GBR

For thousands of years, Aboriginal and Torres Strait Islander peoples have used the coastal waters, islands and reefs for traditional resources and customary/spiritual practices in the

2 The Outlook Report is required under legislation to include nine specific assessments covering biodiversity, ecosystem health, heritage values, commercial and non-commercial use, factors influencing the Reef's values, existing protection and management, resilience, risks to the values and the long-term outlook.

area that today is known as the GBR. Aboriginal and Torres Strait Islander people are therefore recognised as the Traditional Owners of the GBR, and today there are approximately 70 Traditional Owner clan groups whose land and sea country ('country') includes the GBR Marine Park.

GBRMPA's stated aims include establishing effective and meaningful partnerships with Traditional Owners to protect Indigenous heritage values, conserve biodiversity and enhance the resilience of the GBR (GBRMPA, nd). Aspects of governance of the GBR which contribute to these aims include Indigenous membership on the Marine Park Authority Board, an Indigenous Reef Advisory Committee (see Supplementary Information), an *Aboriginal and Torres Strait Islander Heritage Strategy* for the Marine Park, a major program of *Traditional Use of Marine Resources Agreements* with specific Traditional Owner groups, funding for Indigenous Rangers and Indigenous compliance training, GBRMPA's *Reflect Reconciliation Action Plan*, and Sea Country values mapping.

During the GBR-rezoning the public engagement process was comprehensive, and overall was considered both equitable and effective (Day, 2020). Among the reasons were the ongoing public engagement throughout the program, the willingness of community members and stakeholders to engage on matters that are important to them, and on the commitment of the GBRMPA staff to the wide range of engagement methods that were used with rightsholders and stakeholders. In hindsight, some improvements in engagement could have been made, particularly given what worked, and what did not work effectively for Traditional Owners and other Indigenous people[3]. This was primarily a mismatch of the timeframes considered adequate for public engagement and the timing some Indigenous groups considered appropriate; lessons have therefore been learned and these need to be applied in future engagement programs.

Gooch et al. (2018) consider that the GBR-dependent industries (e.g., tourism, fisheries, research) generally have comparable equity with other industries because of the rezoning. Marshall and Pert (2017) also suggest that GBR management has considered future generations by the statutory protection of one-third of the entire GBR as no-take zones, effectively providing 'insurance' for the future.

Rule of Law in the GBR

The sound governance/legislative framework specific to the GBR, including complementary state and federal legislation, is fully listed on the GBRMPA webpages; this shows the range of applicable national and state legislation, along with a number of relevant international conventions. One good example in the GBR legislation is the primary objective developed specifically for the Marine Park, which today provides for '… *the long-term protection and conservation of the environment, biodiversity and heritage values of the GBR Region*'. There are also subordinate objectives, but the Act stipulates they must be consistent with the primary objective.

The Zoning Plan and the Regulations are both statutory instruments that have the force of law. When both were recently amended, they needed to be legally compliant and accord with other legislation before they could be passed by both federal Houses of Parliament. The GBRMPA legal team also worked with the Commonwealth Director of Public Prosecutions to ensure the legislation's enforceability.

The comprehensive compliance and surveillance program outlined above (Accountability in the GBR) includes a range of surveillance operations using vessels, aircraft, drones, and land-based activities occurring night and day, remote vessel tracking, as well as compiling intelligence from a wide range of sources. The aim is to achieve high levels of voluntary compliance, while also maintaining a strong enforcement approach to deter and detect illegal activity. Penalties for offences against Marine Park and other environmental legislation are substantial[4] and reflect the environmental value of the GBR and the significant impact that illegal activities can cause.

Another example of how the rule of law is consistently and impartially applied in the GBR is the online feature associated with the Environmental Management Charge (EMC). The EMC is a legal charge associated with most commercial activities, including tourism operations, non-tourist charter operations and facilities, operated under a permit granted by the GBRMPA. EMC Online is a user-friendly way for Marine Park users to manage their EMC obligations (e.g., allowing online remittance of the EMC), while enabling users to customise the system to suit their operations. The penalties for not adhering to the EMC legislation are such that the level of compliance is extremely high.

Applying the principles in your MPA

The nine principles outlined above should be applicable to all MPAs, but how they are applied will differ depending upon the objectives of specific MPAs, varying socio-political expectations, and the social–ecological context in which the MPA exists. As demonstrated by Gaymer et al. (2014), one

3 In addition to the approximately 70 Traditional Owner clan groups whose Country is recognised within the GBR region, there are also other Indigenous people (e.g., Aboriginals from elsewhere and Pacific Islanders) living adjacent to the GBR, but their traditional lands and seas are not within the GBR.

4 One example of the penalties - fishing in a no-take zone can be addressed by an infringement notice of 10 penalty units (currently equivalent to AUD$2,220), but if prosecuted in court, the possible maximum penalty is 1000 penalty units (=AUD$222,000).

size does not fit all. Consequently, the emphasis given to the different principles of governance and how they are applied will vary in dissimilar settings because each society values outcomes and priorities differently (Graham et al., 2003).

Gaymer et al. (2014, p. 138) advocate for "…a good balance and integration between bottom-up and top-down approaches…". Contemporary modes of marine governance now range from a more traditional approach (driven from the top by a government authority), through to a wide variety of partnerships, co-management and informal arrangements involving multiple agencies, NGOs, communities, and individuals. Paraphrasing Lockwood (2010), "…this emerging polycentric regime offers both promises and pitfalls…. [It] has the potential to deliver a more just system of protected areas … [and] more effective management may result from enhanced cooperation and mobilization of local and indigenous communities". There are, however, significant challenges to achieving the right balance, and it is important to recognise that many of the principles of governance are likely to have multiple applications in a specific MPA (as shown by the multiple examples of each principle from the GBR). Most of the principles should also be enduring and ongoing in their application (e.g., the legal frameworks that are part of the rule of law need to be ongoing, as is the need for accountability and transparency). However, some applications of the principles may only occur for a specified period (e.g., a defined period of public participation as part of a planning program, or how responsive an organisation is to specific issue or incident, or if an organisation is undergoing transformational change, a new strategic vision may be required).

For some MPAs, good governance needs to occur utilising various formal arrangements such as those shown in Supplementary Information for the GBR; these include:

- consideration of international environmental conventions at the global level;
- coordination between federal and State/provincial governments at the national and regional level (i.e., vertical integration)
- coordination within federal and State/provincial governments (i.e., horizontal integration)
- active Indigenous involvement;
- community and NGO-driven participation at the local level; and.
- coordinated research and monitoring, prioritised to address agreed priorities.

One useful analogy is to look at the nine principles as being part of an interlaced or woven lattice, with each application of the principle corresponding to one strand in the lattice, remembering there are likely to be multiple applications (i.e., multiple strands) of each principle. Collectively the lattice is stronger than any individual strand, and together all principles contribute to the totality of governance. At certain times, some strands (principles) will be at the front because they are a current priority, while other principles will be less prominent and therefore sit behind. Being a woven lattice, this varies, so at other times, the principles that were at the back will become more prominent (i.e., more current and relevant at that point in time) while other principles may become less relevant.

The planning and ongoing management of an MPA and its values may be the responsibility of a single agency or organisation (whether it is a federal, state or a provincial authority, or at the community level) or be undertaken by a collective of organisations. Most MPAs exist, however, within a context where decisions that affect the MPA may also be made by other agencies and authorities, other jurisdictions and other interested parties, all of which have the potential to influence the ecological, economic and social aspects of the MPA. These all need to be considered as part of the overall governance of the area. Furthermore, where First Nations are involved, effective governance also requires a balanced approach that maintains and incorporates the cultural values, customs and knowledge of First Nation peoples living within and/or adjacent to the MPA. The Indigenous Advisory Committee established in the GBR, and outlined in the Supplementary Information, is one example how this may be addressed.

Finally, and importantly, undertaking all nine principles shown in Table 1 assumes that those responsible for MPA management have sufficient discretion, resources, and authority to ensure most, if not all of these, happen. The reality in most MPAs, however, is that resource constraints and the managerial and legal context are such that it is not easy to implement and achieve 'best-practice' across all nine principles. This paper provides an outline of each principle in a way that all those involved in MPA management (including relevant decision-makers, the MPA agency(ies), the MPA managers and some parts of the community), having made a frank assessment of how their MPA is currently governed, understand each of the key aspects sufficiently well to enable them to incrementally improve their governance.

Conclusion

In most MPAs, there are wide-ranging requirements, incorporating a diverse range of rights-holders, stakeholders, obligations and knowledge. However, the associated actions and decisions will be enhanced and sustained if they are effectively managed through a sound governance framework. This should include:

- a clear and agreed set of arrangements addressing all nine principles of good governance as outlined in this paper;
- the unambiguous prioritisation of any management actions, strategies or procedures;
- an agreed set of arrangements for effective partnerships at all relevant levels enabling the real and transparent sharing of decision-making powers;

- an active role for Indigenous and local communities in MPA management;
- a willingness of all relevant players to adhere to the principles of good governance and to work together toward an agreed goal or a prioritised list of objectives; and
- a means to mediate differing interests to reach a broad consensus on what is in the best interests of all parties and, where possible, on policies and procedures.

The concept of adaptive governance is also an important aspect of ongoing MPA management; as Schultz et al. (2015, p.7373) conclude, "…adaptive governance will always involve a continuous learning process, nurturing of trust, reflection of procedures and structures, and developing collaboration toward common goals. These initiatives are continuously subject to new challenges, whether political, environmental, and economic…"

Finally, while it may be useful to learn from the experience gained in long-standing MPAs like the GBR, it is important to recognise that other MPAs, irrespective of where they occur around the world, will have differing political, economic, social, cultural and managerial contexts and hence are likely to require a different management approach and objectives when compared to the GBR. Every MPA is unique, so it is therefore essential to consider the specific context and objectives of a particular MPA when considering what lessons from elsewhere might apply.

Author contributions

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Conflict of interest

The author declares 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.2022.972228/full#supplementary-material

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Comparative analysis of National Ocean Strategies of the Atlantic Basin countries

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In 2007 the European Union (EU) launched the Blue Book introducing the Integrated Maritime Policy (IMP) for the sustainable growth of the coastal regions of Member States. The IMP has several cross-cutting areas of intervention such as the Blue Growth Strategy, Maritime Spatial Planning, and Strategies for maritime basins. To ensure this policy's implementation, the European Commission requested its coastal members to develop integrated maritime strategies. Furthermore, within the United Nations Decade of Ocean Science for Sustainable Development, it is also a priority of the EU to ensure compliance with the 2030 Agenda, in particular the SDG14. This study focuses on countries from the Atlantic Basin, namely France, Ireland, Portugal, Spain, and the UK (before Brexit) comparing key priorities and objectives of national ocean strategies of these countries and how they match IMP guidelines and the 2030 Agenda. The results show that one of the main focuses of these strategies is the mitigation and adaptation to climate change and nature conservation. On the other hand, desalination, exploration and prospection of oil and gas are the socioeconomic sectors of smaller significance. This study also demonstrated that Spain and UK's ocean strategies cannot be considered as a national ocean strategy in the IMP concept. The national ocean strategy of Ireland was introduced almost 10 years ago, therefore can be considered outdated in several dimensions. France and Portugal are the only countries whose national ocean strategies are aligned with the objectives of the Atlantic Action Plan and the only ones that truly follow the guidelines of the EU Integrated Maritime Policy.

KEYWORDS

integrated maritime policy, blue growth, maritime spatial planning, SDG's, European Union Strategy for the Atlantic Basin, National Ocean Strategies

Introduction

The thousands of kilometers of coastline in Europe make its economy and quality of life reliant on its maritime territory. With the increasing pressure and competition from the Member States (MS) for marine resources, the European Commission (EC) released the 'Green Paper' in 2006. This document was intended to develop an Integrated Maritime Policy (IMP) among the MS, to affirm the European Union (EU) as a sustainable community (EC, 2006; Moreira and Bravo, 2019). The concept of an IMP was introduced the following year, during the Portuguese Presidency of the EU Council, in the so-called 'Blue Book'. In this document, the EC requests for maritime affairs to be treated holistically and, for this, asked the MS to develop integrated national maritime policies (EC, 2007; Meiner, 2010; Moreira and Bravo, 2019; Santos, 2021). For the effective elaboration of integrated actions, the 'Blue Book' established three horizontal tools for Integrated policy-making for the IMP: a European Maritime Surveillance Network, Maritime Spatial Planning (MSP) and Integrated Management of Coastal Zones (ICZM) and the compilation of data and information (EC, 2007; Chintoan-Uta, 2014; Santos, 2021). In 2008, within the framework of the MSP, the EC launched the publication 'Roadmap for Maritime Spatial Planning: Achieving Common Principles in the EU', a guide for the implementation of the MSP in the territories of the MS (EC, 2008).

In 2009, two years after the launch of the 'Blue Book', of the 65 actions proposed by it, around 56 had already been initiated, which proved the success of the implementation of the IMP (EC, 2009; Meiner, 2010; Chintoan-Uta, 2014). In 2012, in Cyprus, the European agenda for growth and job creation in the marine and maritime sectors was adopted, transcribed in the 'Limassol Declaration'. This declaration resulted in two more planning instruments for the IMP: the 'Blue Growth Strategy' and the 'Sea Basins Strategy' (EC, 2012; Guerreiro, 2021; Santos, 2021). The 'Blue Growth Strategy' is a long-term strategy aiming to "harness the untapped potential of Europe's oceans, seas, and coasts for jobs and growth". This way, it expects that maritime economic activities are developed sustainably and in a 'Blue Economy' perspective (EC, 2012).

The main goal of the Sea Basin Strategies is to sustainably develop the maritime economy of countries that share the same geographic region, of all the seas and oceans of the EU. These strategies are therefore developed specifically for each region and according to its intrinsic characteristics. There are seven sea basin strategies within the scope of the IMP: Baltic Sea, Black Sea, Atlantic, Adriatic, Ionian Region, Arctic, and EU Outermost Regions[1]. The European Union Strategy for the Atlantic Area was originally incorporated by France, Ireland, Portugal, Spain, and the UK, with the UK no longer being part of it after Brexit (EC, 2011). The Atlantic region is the foundation for traditional activities such as aquaculture, fishing, shipbuilding, tourism, and transport, but it also reveals enormous potential for renewable energy and marine biotechnology (EC, 2011; EC, 2013; Fernández-Macho et al., 2015; Calado et al., 2019). As a way of guaranteeing the sustainable development of these sectors, this sea basin strategy defined its first Action Plan for a Maritime Strategy in the Atlantic Region (EC, 2013). In 2017 it was revised, concluding that it had a positive impact in all the constituent countries[2]. In 2020, this plan was updated to the Atlantic Action Plan 2.0, which aims to develop the blue economy of Spain, France, Ireland, and Portugal, in line with the preservation of the marine environment and contributing to the mitigation of climate change (EC, 2020).

As mentioned above, in the EU, the notion of National Ocean Strategies was introduced in 2007, within the framework of the IMP. The EC asked its MS to develop integrated national maritime policies, and for that purpose proposed a set of guidelines for the elaboration of National Ocean Strategies (EC, 2008; Meiner, 2010). These guidelines included the implementation of MSP plans, the adoption of the Marine Strategy Framework Directive (MSFD), the need to ensure a link between science and policy decisions, integrated maritime surveillance coordinated between MS, the definition of national and regional authorities in this area, and the need to obtain reliable and comparable data on the different maritime policies of MS (EC, 2008; Meiner, 2010; Marques, 2022). The economic perspective of the IMP was only introduced with the emergence of the 'Blue Growth Strategy', which plays a fundamental role in the National Ocean Strategies, as it ensures the financing of measures that contribute to the implementation of the IMP (Santos, 2021).

The main purpose of this paper is to identify the key priorities and objectives of national ocean strategies of countries belonging to the European Union Strategy for the Atlantic Area (for this study, the UK was considered before Brexit). It is also intended to understand if these priorities and objectives match IMP guidelines and the goals of the UN 2030 Agenda for Sustainable Development. Additionally. The study also aims to understand how the selected countries approach the European Union Strategy for the Atlantic Area and its Action Plan.

Methods

The present study consists of four methodological steps:

1. France, Ireland, Spain, Portugal, and the UK were selected as the case studies once they share the same

1 https://www.europarl.europa.eu/factsheets/en/sheet/121/integrated-maritime-policy-of-the-european-union

2 https://atlanticstrategy.eu/en/atlantic-strategy-glance/atlantic-strategy

area of the Atlantic Basin as EU members (Figure 1). As such, they are included in the 'EU Strategy for the Atlantic Area' and consequently involved in the 'Action Plan for a Maritime Strategy in the Atlantic Region'. Then, a survey of National Ocean Strategies or equivalent legislation of the selected countries was carried out, through bibliographic research and by questionnaires sent to the representatives of each MS that are part of the European group dedicated to the implementation of the European Union Strategy for the Atlantic Area. Afterward, the most relevant socio-economic sectors in the context of the Atlantic Basin were identified (Figure 2). This selection was based on the work developed by Foley et al. (2014) and in the study "Hypercluster da Economia do Mar" (SAER - Sociedade de Avaliação Estratégica de Risco, 2009). Following, the measures and objectives of each National Ocean Strategy were grouped according to the identified socio-economic sectors.

2. A survey of the guidelines of the IMP and the Blue Growth Strategy was carried out. This survey was performed through bibliographic research in the official documents of the EC. A survey of the national legislation of each case study was also carried out, for the MSP and MSFD. The measures and objectives of each case study, collected in the first methodological phase, were then grouped according to the guidelines of the IMP (Figure 3) and the Blue Growth Strategy (Figure 4).
3. At this stage, a detailed review of all 17 SDGs of the 2030 Agenda and their respective targets was carried out, to select the SDGs and targets that meet the objectives and measures of each National Ocean Strategy. This selection allowed the categorization of the objectives and measures of each case study, according to their relevance to the achievement of each SDG and respective goals. The objectives and measures of each National Ocean Strategy were further grouped according to the 10 key challenges of the Decade of Ocean Sciences for Sustainable Development.
4. In the fourth and final stage, the data obtained in the first stage of this study were crossed with the objectives of the Atlantic Action Plan 2013-2020 and the new Atlantic Action Plan 2.0

Results

National ocean strategies

The National Ocean Strategy of France (Stratégie nationale pour la mer et le littoral), dates from 2019 identifies a total of 168 measures and objectives. In this strategy, the socioeconomic sector 'Combating and adapting to climate change and nature conservation', showed the highest number of measures. The 'Desalination' and 'Oil and Gas Exploration and Prospecting' sectors along with the 'Non-living

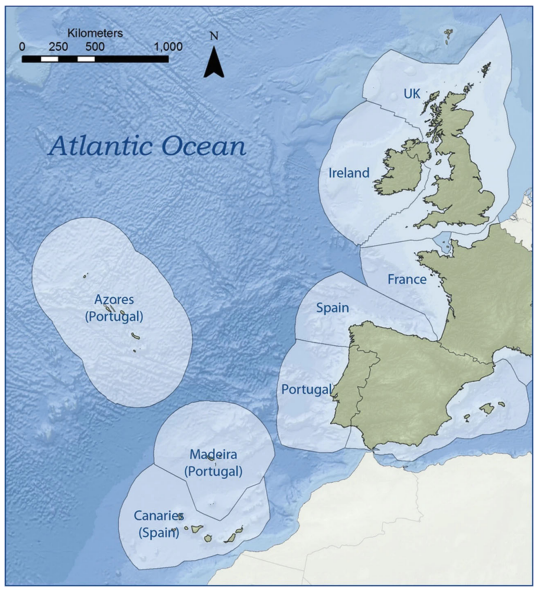


FIGURE 1
Location of the study area (Twomey and O'Mahony, 2019).

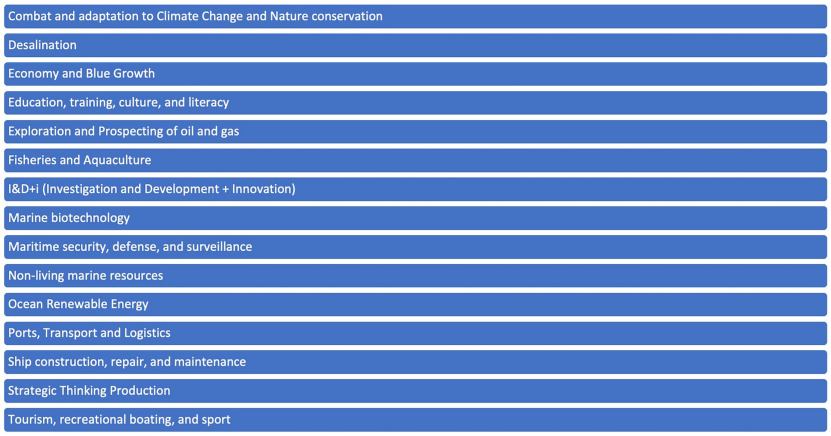


FIGURE 2
Most relevant socio-economic sectors in the context of the Atlantic Basin of the European Union. The socio-economic sectors identified belong to the Blue Growth and Blue Economy intervention areas. However, it was found that most of the countries under study have specific measures for both Blue Growth and Blue Economy, which are not included in the other socio-economic sectors. For this reason, and for this study, the socio-economic sector 'Economy and Blue Growth' was added.

marine resources' sectors were those that registered the fewest number of measures. Most socioeconomic sectors showed intermediate values between 15 and 25% (Figure 5).

The "Harnessing our Ocean Wealth" is Ireland's first Ocean Strategy dated from 2012, with a progress review report dated from 2015, on the 109 measures and goals. "[3]. The most prominent socio-economic sector was 'Combat and Adaptation to Climate Change and Nature Conservation', with 25 measures. On the other hand, for the socioeconomic sectors 'Marine Biotechnology', 'Desalination' and 'Non-Living Marine Resources' it wasn't possible to find any kind of measures. The sectors 'Naval construction, repair and maintenance' and 'Security, defense and maritime surveillance' were the ones with the lowest number of measurements. Most of the socio-economic sectors with intermediate values showed percentages between 9% and 25%. For the remaining sectors, the percentage of measures did not exceed 6% (Figure 6).

The 'Programa Operativo del FEMP 2014-2020' from Spain is a plan designed to structure the funding received from the EU's European Maritime and Fisheries Fund (2014-2020). All the case studies analyzed, have developed similar plans for this Fund. However, only the Spanish representative of the European group dedicated to the implementation of the European Union Strategy for the Atlantic answered in the questionnaire sent, that this plan is the equivalent of a National Ocean Strategy. In this plan, the socio-economic sector that registered the highest number of measures was 'Fisheries and Aquaculture'. For the socio-economic sectors 'Marine biotechnology', 'Ship construction, repair and maintenance', 'Desalination', 'Ocean Renewable Energy', 'Exploration and Prospecting of oil and gas', 'Ports, Transport and Logistics', 'Non-living marine resources', and 'Tourism, recreational boating, and sport' it wasn't possible to identify any kind of measures. The remaining values did not exceed 6% (Figure 7).

The "ENM 2021-2030" is the third Portugal's National Ocean Strategy and its Action Plan identifies 185 measures and objectives. The socio-economic sector with the highest number of measures was 'Education, training, culture, and literacy'. The socio-economic sector 'Exploration and Prospecting of oil and gas' didn't show any measures and the sector 'Desalination' was the one with the lowest number. The other sector's values were mostly between 17,86% and 33,33% (Figure 8).

In 2019 the UK implemented its Ocean Strategy through the "Maritime 2050 – Navigating the Future". This strategy is composed of a total of 188 measures and objectives. The socio-economic sector with the highest number of measures was 'Combat and adaptation to Climate Change and Nature Conservation'. On the contrary, the sector with the lowest number of measures was 'Ocean Renewable Energy'. The sectors 'Marine biotechnology', 'Desalination', 'Exploration and Prospecting of oil and gas', 'Fisheries and Aquaculture', and 'Non-living marine resources' didn't show any kind of measures. The other sector's values were predominantly between 11,90% and 36,90% (Figure 9).

The results obtained for the measures collected in the national ocean strategies, and expressed in the resultant figures, refer to absolute values and their corresponding percentages.

Integrated maritime policy

About 73,81% of the measures of the National Ocean Strategy of France are within the framework of the IMP. An

3 Harnessing our Ocean Wealth – Review of Progress 2015.

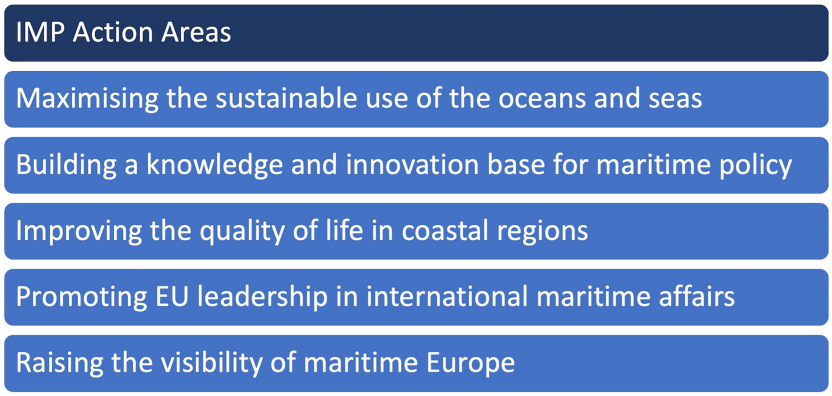


FIGURE 3
Action areas for the implementation of IMP in MS. Source: Created by the author.

example of two measures that stand out in terms of IMP, in the French strategy are "Regional cooperation between States bordering the same maritime area, as well as enhanced cross-border cooperation in regional seas, and in defining and implementing European and international policies" and "Tools for implementing spatial planning of maritime activities and uses must enable going beyond thematic approaches to optimize sustainable exploitation of the sea and the coast, and preservation of its biodiversity". The Action Area with the highest percentage of measures was 'Maximizing the sustainable use of the oceans and seas. 'Raising the visibility of maritime Europe' was the Action Area with the lower percentage (Figure 10).

Ireland's strategy showed a total of 48,62% of measures contributing to the implementation of the IMP. Two of the most prominent IMP measures in this strategy are "Develop an integrated approach to marine and coastal planning and licensing to maximize the potential for Ireland's ocean economy; assist with managing our resources effectively and sustainably; manage potential conflicts; and ensure harmonization with coastal/terrestrial planning" and "Ensure the inclusion of marine research in all relevant Work Programmes developed under HORIZON 2020 to maximize EU marine research funding opportunities and support the implementation of IMP – EU and its Sea Basin Strategies". The Action Areas where it was verified the highest percentage

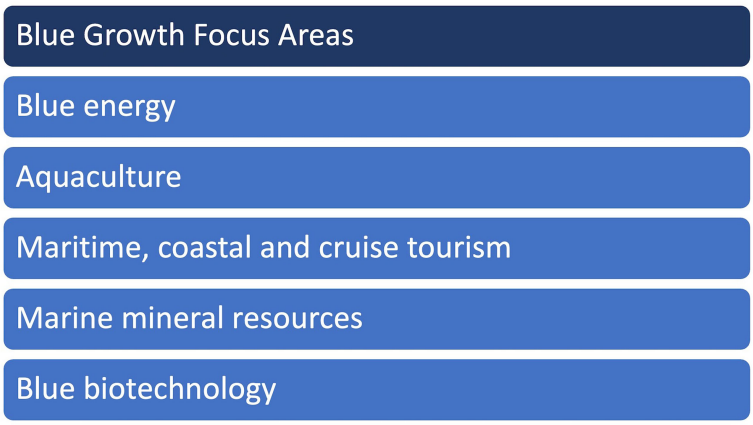


FIGURE 4
Blue Growth Strategy Focus Areas. The 'Blue Economy' was considered as the sixth Focus Area since most countries have specific measures for the Blue Economy in their National Ocean Strategies, which are not included in the Focus Areas of the Blue Growth Strategy. Source: Created by the author.

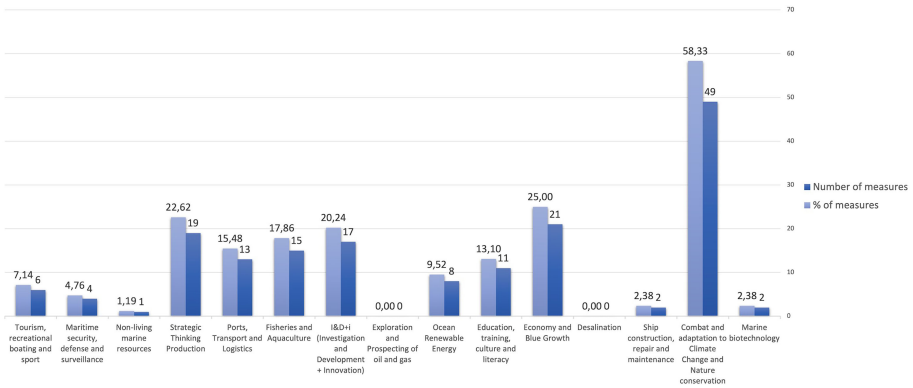


FIGURE 5
Number of identified measures, and corresponding percentage, by socio-economic sector, of France's National Ocean Strategy. Source: Created by the author.

were 'Maximizing the sustainable use of the oceans and seas' and 'Building a knowledge and innovation base for maritime policy'. On the contrary, the Action Area 'Raising the visibility of maritime Europe' exhibits the lowest percentage (Figure 10).

In Spain's case, the percentage of measures that aid the accomplishment of the IMP was 98,81%. An example of one of these measures is "Assist in the design and implementation of conservation and cooperation measures". The Action Area with the maximum percentage was 'Maximizing the sustainable use of the oceans and seas' and the minimum percentage was verified in the Action Area 'Promoting EU leadership in international maritime affairs'. The percentage of the Action Area 'Improving the quality of life in coastal regions' was zero (Figure 10).

69,19% was the percentage obtained in the case of Portugal's strategy. One of the most relevant measures of this strategy, regarding the IMP is "Ensure that the implementation of ENM 2021-2030, the national instrument of the EU Integrated Maritime Policy (IMP), is aligned with the implementation of the other instruments of the IMP (Common Information Sharing Environment), National Maritime Space Planning Situation Plan and DQEM, as an environmental pillar of the IMP)".The Action Area that registered the highest percentage of measures was 'Maximizing the sustainable use of the oceans and seas'. Opposingly, the Action Area 'Improving the quality of life in coastal regions' showed the lowest percentage of measures (Figure 10).

UK's strategy had a percentage of 36,70% of measures that aimed at the implementation of the IMP. One of the main measures of this strategy, concerning the IMP is "Government will continue to support the rules-based international system to build and deepen our relationships with emerging global markets by strengthening alliances and building partnerships.

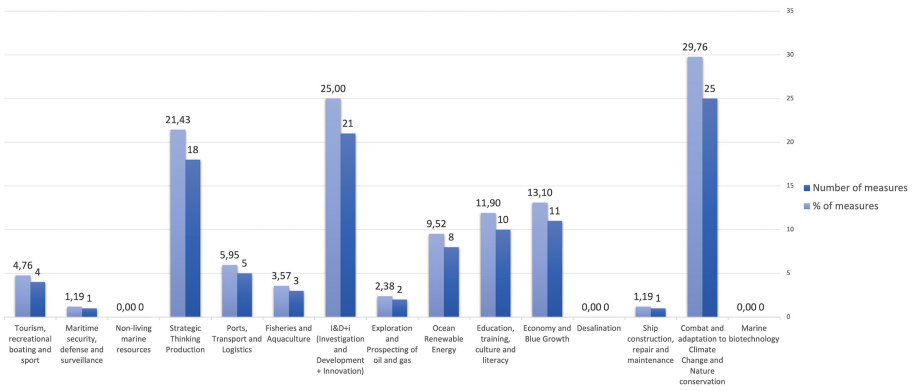


FIGURE 6
Number of identified measures, and corresponding percentage, by socio-economic sector, of Ireland's National Ocean Strategy. Source: Created by the author.

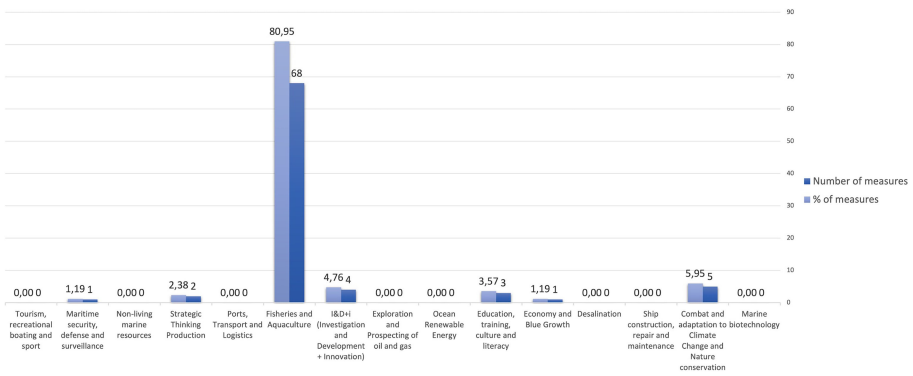


FIGURE 7
Number of identified measures, and corresponding percentage, by socio-economic sector, of Spain's National Ocean Strategy. Source: Created by the author.

We will encourage rational behavior by states and support the peaceful settlement of disputes". Once more, the Action Area with the highest percentage of measures was 'Maximizing the sustainable use of the oceans and seas'. 'Improving the quality of life in coastal regions' was the Action Area with the lowest percentage (Figure 10).

Tables 1, 2 summarize the information regarding the MSP and MSFD legislation for France, Ireland, Spain, Portugal, and the UK.

Blue growth strategy

As mentioned earlier, the Blue Growth Strategy is constituted of five Focus Areas. However, when analyzing the selected national ocean strategies, it was found that some measures were too specific, not fitting into any of the five Focus Areas, and contributing equally to the Blue Economy. Therefore, there was the need to add a sixth Focus Area that included these measures, which was titled "blue economy". The inclusion of the "blue economy" as a Focus Area does not in any way exclude the fact that the Focus Areas of the Blue Growth Strategy formally belong to the Blue Economy.

The percentage of measures of the National Ocean Strategy of France that are within the framework of the Focus Areas of the Blue Growth Strategy was 19,05%. In this strategy is possible to highlight two particular measures, regarding the Blue Growth Strategy: "Be the engine of European blue growth" and "With a view to blue growth and support for maritime employment at the European level, European programs will be used to promote the development of the French maritime sector *via* initiatives in maritime basins such as the Atlantic and the Mediterranean, or regional maritime policies in the overseas basins that have territories eligible for qualification as an extremely remote

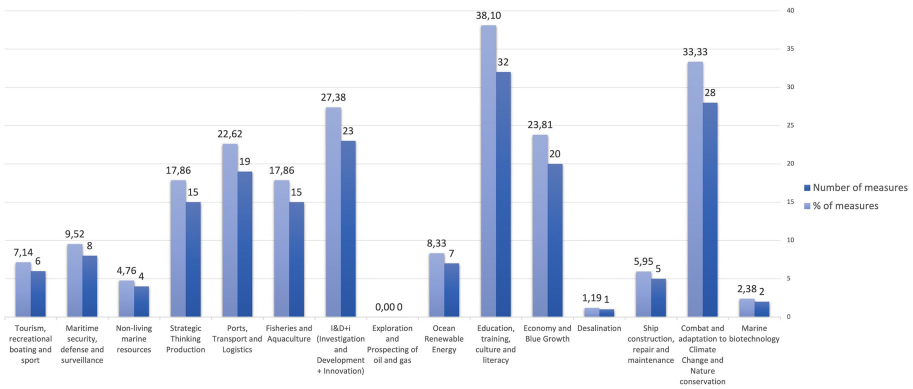


FIGURE 8
Number of identified measures, and corresponding percentage, by socio-economic sector, of Portugal's National Ocean Strategy. Source: Created by the author.

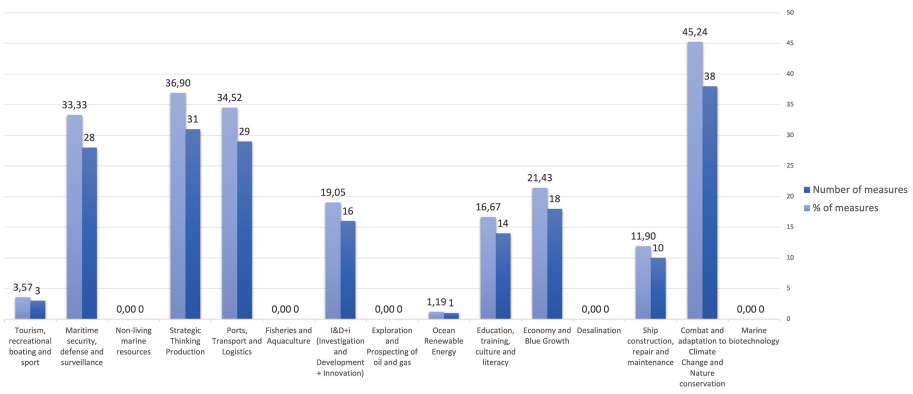


FIGURE 9
Number of identified measures, and corresponding percentage, by socio-economic sector, of UK's National Ocean Strategy. Source: Created by the author.

region". The Focus Area with the highest percentage of measures was 'Blue Energy'. Contrary, 'Marine Mineral resources' was the one with the lowest percentage. Most of the Focus Areas obtained percentages between 18% and 29% (Figure 11).

In Ireland's case, 27,52% of the measures and objectives of the "Harnessing our Ocean Wealth" contribute to the implementation of the Blue Growth Strategy. One of the measures that emphasize the implementation of the Blue Growth Strategy is "Progress a number of targeted emerging business development opportunities (e.g. offshore renewables, offshore services, maritime security, and safety, shipping logistics and transport, ICT and sensors, biotechnology). This would include the collection/collation of market intelligence and foresight and the promotion of clusters using SmartOcean and IMERC as vehicles for innovation-led commercial development". The Focus Area with the greatest number of measures obtained was 'blue economy' (40%). For the Focus Areas 'Aquaculture' and 'Blue Biotechnology' no measures were recorded. 'Marine Mineral resources' was the Focus Area with the smaller percentage (Figure 11).

For the case study of Spain, it was obtained a percentage of 44,05% of measures that have correspondence with the objectives of the Blue Growth Strategy. An example of one of these measures is "Preparatory assistance in promoting economic growth, social inclusion, job creation and support for employability and labor mobility in coastal and inland communities dependent on fisheries and aquaculture, including the diversification of activities carried out in the field

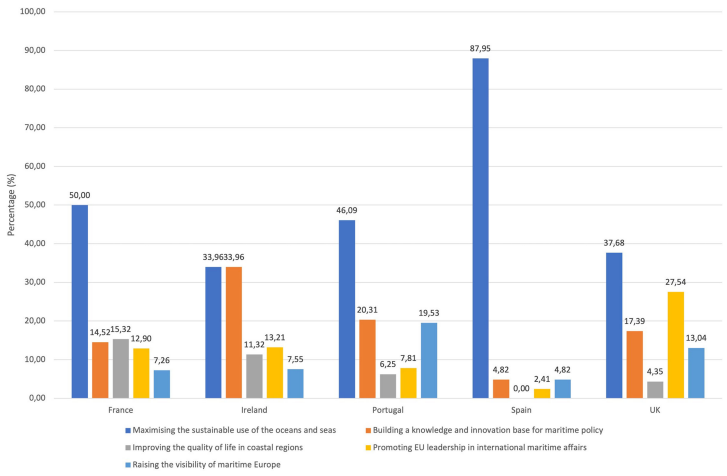


FIGURE 10
Percentage of measures of the five National Ocean Strategies analyzed within the framework of the IMP Action Areas. Source: Created by the author.

TABLE 1 Adopted legislation and MSP plans of the case studies.

MSP	France	Ireland	Spain	Portugal	UK
Legislation	LOI n° 2016-1087 du 8 août 2016	Planning and Development Act 2018	Real Decreto 363/2017, de 8 de abril Ley 41/2010, de 29 de Diciembre	Lei N° 17/2014, de 10 de Abril Decreto-Lei n° 38/2015, de Março	The Marine and Coastal Access Act 2009 The Marine (Scotland) Act 2010 The Marine Act (Northern Ireland) 2013
Plan	Stratégie Nationale Mer et Littorale (2017) & arrêtés inter-préfectoraux approuvant les documents stratégiques de façade (Manche-Est Mer du Nord, Nord-Atlantique Manche)	Draft National Marine Planning Framework	Planes de Ordenación del Espacio Marítimo (In development)	PSOEM - Plano de Situação do Ordenamento do Espaço Marítimo Nacional	The East Marine, South Marine, North West, North East, South East, and South West Plans Scotland's National Marine Plan (2015) Welsh National Marine Plan

of fisheries and with regard to others sea economy sectors". 'Aquaculture' was the Focus Area with the maximum percentage of measures. However, for the Focus Areas 'Maritime, coastal and cruise tourism', 'Marine mineral resources' and 'Blue biotechnology' no measures were identified. The remaining Focus Areas got identical percentages (Figure 11).

Portugal's strategy registered a total of 24,32% of measures within the scope of the Blue Growth Strategy and the 'blue economy' was the Focus Area with the greatest number of measures. 'Marine mineral resources' and 'Blue biotechnology' were the ones with the lowest percentage of measures (Figure 11). One of the measures of the Portuguese strategy that highlights the most, the effort to implement the blue growth strategy is "Develop a development cooperation strategy for the ocean and blue economy".

The UK rate of measures contributing to the Blue Growth Strategy was only 6,38%, although the Focus Area 'blue economy' identified the highest number of measures. On the other hand, in the Focus Areas 'Aquaculture', 'Marine mineral resources' and 'Blue biotechnology' it wasn't possible to recognize any kind of dedicated measures. 'Blue Energy' was the Focus Area with the smallest percentage (Figure 11). An example of a measure from the UK's strategy that contributes to the implementation of the Blue Growth Strategy is "Government will work to better understand the capacity of the UK's energy networks to support an increase in demand for green energy from our ports and shipping sectors. It will also consider the role the maritime and offshore renewables sectors can play in decentralized energy generation".

TABLE 2 Adopted legislation of each case study, regarding the MSFD.

Case Studies	Legislation
France	Code de l'environment Articles R219-2 à R*219-10 Décret n° 2017 – 724 du 3 mai 2017 (2017)
Ireland	S.I. No. 249/2011 – European Communities (Marine Strategy Framework Regulations 2011)
Spain	Ley 41/2010, de 29 de diciembre (2010)
Portugal	Decreto-Lei n° 108/2010 (2010) Decreto-Lei n° 201/2012 (2012) Decreto-Lei n° 136/2013 (2013) Decreto-Lei n° 143/2015 (2015)
UK	Marine Strategy Regulations 2010 2010 No. 1627 (2010)

Sustainable development goals and United Nations decade of ocean science for sustainable development

The National Ocean Strategies of Ireland and Spain were the only ones where it wasn't possible to identify correspondence of measures to all the selected SDGs. The strategy of Spain lacks measures for SDG 7 – Affordable and Clean Energy and SDG 17 – Partnerships for the goals. In Ireland's case, it was SDG 2 – Zero Hunger the one with no match. In every case studied, the targets with the greatest number of measures belonged to SDG 14 – Life below water. Portugal's strategy was the only one showing measures addressing all the targets, and consequently, all the SDGs (Figure 12).

Regarding the United Nations Decade of Ocean Science for Sustainable Development, a total of 60,71% of measures of the National Ocean Strategy of France are within the framework of the Decade. 'Develop a sustainable and equitable ocean economy' was the Challenge with the maximum percentage of measures. Opposite the Challenge 'Create a digital representation of the Ocean' showed no measures. All the other Challenges had percentages between 2% and 17% (Figure 13).

For Ireland, the percentage of measures concerning the objectives of the Ocean Decade are 57,80%, being 'Develop a sustainable and equitable ocean economy' the Challenge with the highest percentage of measures. Regarding the Challenges 'Understand and beat marine pollution', 'Increase community

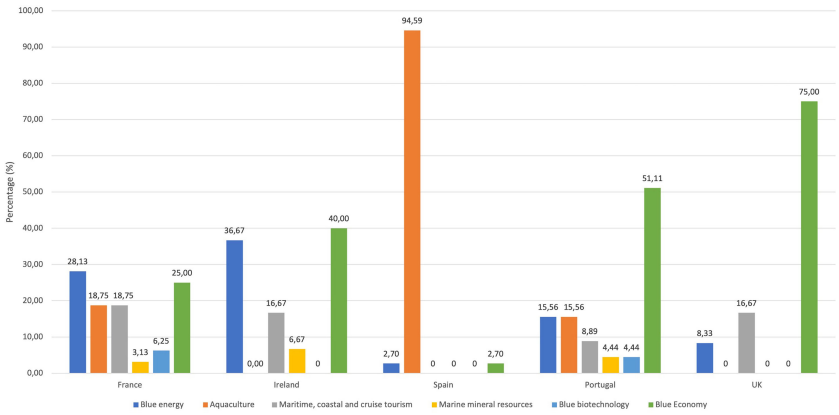


FIGURE 11
Percentage of measures of the five National Ocean Strategies analyzed within the framework of the Blue Growth Strategy Focus Areas. Source: Created by the author.

resilience to ocean hazards', and 'Expand the Global Ocean Observing System' no measures were identified. The remaining challenges did not exceed 24% (Figure 13).

Spain's National Ocean Strategy had a percentage of 89,29% of measures contributing to the objectives of the Ocean Decade. However, only 5 of the 10 Challenges of the Decade showed related measures. The Challenge with the highest percentage of measures was 'Sustainably feed the global population'. All the remaining Challenges obtain percentages below 5,33% (Figure 13).

Portugal's strategy had a very similar percentage of measures contributing to the Ocean Decade to the Ireland Strategy, with 57,30%. Portugal was also the only case study that showed results matching all the 10 Challenges. The Challenge with the dominant number of measures was 'Develop a sustainable and equitable ocean economy' and the Challenge with the lowest number of measures was 'Create a digital representation of the Ocean' (Figure 13).

The UK case study showed the lowest percentage of measures contributing to the implementation of the Ocean Decade, with 30,32%. In this case, the Challenges 'Sustainably feed the global population' and 'Create a digital representation of the Ocean' didn't show any measures. 'Understand and beat marine pollution' was the Challenge with the highest percentage and 'Increase community resilience to ocean hazards' and 'Expand the Global Ocean Observing System' were the ones with the smaller percentages (Figure 13).

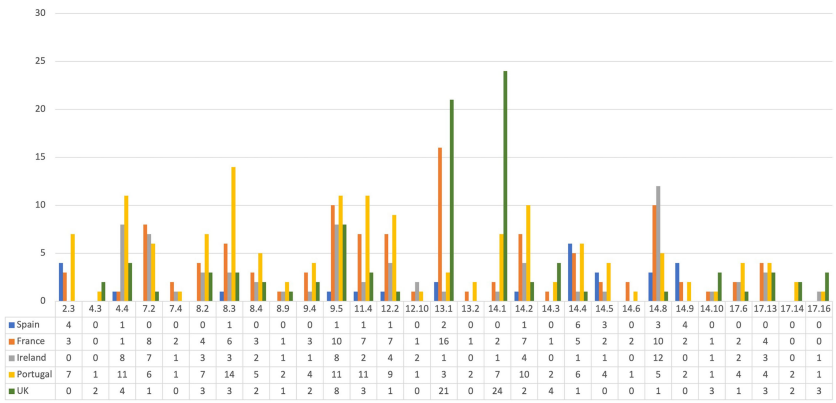
The National Ocean Strategies of France, Portugal, and the UK were the only strategies that exhibited specific measures for the implementation of the SDGs, namely the SDG 14:

> - "The strategy will contribute in particular to objective 14 of the sustainable development objectives" (France)
> - "Monitor the results of the ENM 2021-2030 within the scope of the sustainable development goals (SDGs) of the United Nations 2030 Agenda, in particular at the level of SDG 14, ensuring their respective dissemination" (Portugal)
> - "By 2030, in line with the UN Sustainable Development Goal 14, the UK will have supported the poorest and most vulnerable countries, in particular, Small Island Developing States (SIDS) and Least developed Countries (LDCs), to pursue wider benefits from growth in zero emission shipping, and will encourage other countries major economies to do likewise" (UK)

European union strategy for the Atlantic Basin

The 'Programa Operativo del FEMP 2014-2020' from Spain only contributes to one of the specific objectives of the four Priorities of the Atlantic Action Plan 2013-2020 – "Fostering adaptation and diversification of economic activities by promoting the potential of the Atlantic area". For the Atlantic Action Plan 2.0, this strategy also contributes only to one Goal – "Quality education, training, and life-long learning".

Four specific objectives of the Atlantic Action Plan 2013-2020 are lacking in Ireland's National Ocean Strategy: "enhancement of competitiveness and innovation capacities in the maritime economy of the Atlantic area", "fostering adaptation and diversification of economic activities by promoting the potential of the Atlantic area", "sustainable management of marine resources" and "promoting cooperation between ports". For the Atlantic Action Plan 2.0, the Goals 3 - Ports as gateways for trade in the Atlantic, 2- Ports



	2.3	4.3	4.4	7.2	7.4	8.2	8.3	8.4	8.9	9.4	9.5	11.4	12.2	12.10	13.1	13.2	14.1	14.2	14.3	14.4	14.5	14.6	14.8	14.9	14.10	17.6	17.13	17.14	17.16
Spain	4	0	1	0	0	0	1	0	0	0	1	1	1	0	2	0	0	1	0	6	3	0	3	4	0	0	0	0	0
France	3	0	1	8	2	4	6	3	1	3	10	7	7	1	16	1	2	7	1	5	2	2	10	2	1	2	4	0	0
Ireland	0	0	8	7	1	3	3	2	1	1	8	2	4	2	1	0	1	4	0	1	1	0	12	0	1	2	3	0	1
Portugal	7	1	11	6	1	7	14	5	2	4	11	11	9	1	3	2	7	10	2	6	4	1	5	2	1	4	4	2	1
UK	0	2	4	1	0	3	3	2	1	2	8	3	1	0	21	0	24	2	4	1	0	0	1	0	3	1	3	2	3

FIGURE 12
Number of measures by the target of the selected SDGs, for the five case studies. Source: Created by the author.

as catalysts for business, and 5- Ports as catalysts for business are also missing.

The UK strategy misses six specific objectives of the Atlantic Action Plan 2013-2020: "enhancement of competitiveness and innovation capacities in the maritime economy of the Atlantic area", "fostering adaptation and diversification of economic activities by promoting the potential of the Atlantic area", "exploitation of the renewable energy potential of the Atlantic area's marine and coastal environment", "fostering better knowledge of social challenges in the Atlantic area" and "preserving and promoting the Atlantic's cultural heritage". On the other hand, regarding the Atlantic Action Plan 2.0, the measures identified in the National Ocean Strategy of the UK match all the Goals, apart from Goal 5 – "The promotion of carbon neutrality through marine renewable energy".

France and Portugal are the only case studies where it was possible to identify measures that contribute to all the specific objectives of the Atlantic Action Plan 2013-2020 and all the Goals of the Atlantic Action Plan 2.0.

Discussion

National ocean strategies and integrated maritime policy

Results showed that there is a common guideline in the priorities of all the National Ocean Strategies analyzed as in most of the case studies, the socio-economic sector with the highest number of measures was 'Combat and adaptation to Climate Change and Nature conservation'. In the case of Spain and Portugal's strategies, this was the second socio-economic sector that registered the maximum number of measures, showing the political concerns on the severity of the effects of climate change in the Iberian Peninsula (Camargo et al., 2020). Several studies point to the Iberian Peninsula as one of the territories that will suffer a greater increase in temperatures due to the impact of climate change, until the end of the 21st century (Paniagua et al., 2019). This territory is also susceptible to reductions in precipitation, which can reach 10% in the southernmost regions, and to changes in the intensity of the near-surface wind (Pérez Cutillas, 2018; Martins et al., 2020; Pereira et al., 2021). The increase in temperatures together with the reduction in precipitation will lead to the decline of water stored in the soil, which will consequently impoverish the stability and permeability of soils, resulting in their desertification (Pérez Cutillas, 2018; García-Valdecasas Ojeda et al., 2020; Pereira et al., 2021). Both Spain and Portugal have made efforts to design and implement policies and actions to mitigate the consequences of climate change (Camargo et al., 2020). Spain was one of the first MS to create a plan for climate change. The National Climate Change Adaptation Plan (PNACC) was presented in 2006 and includes a list of impacts, vulnerabilities, and adaptation measures. This plan was updated four years after its first publication. The Spanish government can also count on the Spanish Strategy on Climate Change and Clean Energy published in 2007, which works together with the PNACC. In terms of mitigation, the existing Spanish legislation is mainly sectoral and is mostly derived from European directives (Escribano Francés et al., 2017; Camargo et al., 2020). Regarding climate change, Portugal published in 2015 the National Climate Change Program (PNAC 2020–2030), the National Strategy for Adaptation to Climate Change (ENAAC 2020), and the Interministerial Commission on Air and Climate Change (CIAAC). More recently, in 2019, the National Integrated Energy and Climate Plan (PNIEC) was published for the decade 2021-2030. This plan aims to promote energy efficiency, lead the number of renewable energy sources worldwide and promote equity among energy consumers (Camargo et al., 2020).

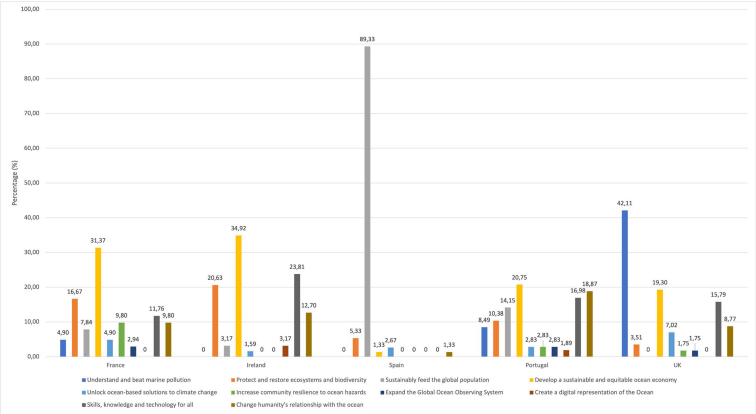


FIGURE 13
Percentage of measures of the five National Ocean Strategies analyzed according to the 10 key challenges of the United Nations Decade of Ocean Science for Sustainable Development. Source: Created by the author.

The 'I&D+i (Investigation and Development + Innovation)' was also a sector with several measures in each case study. On the contrary, for the 'Desalination' sector, measures were not recorded in all National Oceanic Strategies, except for Portugal's strategy. The installation of seawater desalination plants in the southern region of Portugal is being discussed at a regional level, as a way of guaranteeing the water supply for the population, since this region is one of the most problematic areas in terms of water scarcity, in the world (Guerreiro et al., 2017; Neves et al., 2021). Apart from Ireland, the socio-economic sector 'Exploration and Prospecting of oil and gas' was the one with the lower number of measures. These results can be justified by the efforts that the EU has made, regarding combating climate change and reducing the emission of greenhouse gases, as well as the dissociation from fossil energies (Pereira, 2019). The EU has tried to replace fossil energy sources with renewable energy, with an increase from 9.6% to 18.9% of renewable energy from 2004 to 2018. In the transport sector, restrictions were also made on CO2 emissions from car fleets in 2009 (Haas and Sander, 2020). At a national level, MS developed National Energy and Climate Plans instructed and revised by the EC (Perissi and Jones, 2022). The Paris Agreement, adopted in 2015 at the Climate Conference in Paris, can also support the results obtained. This agreement was the first in the world dedicated exclusively to climate change, resulting in the EU's target to reduce greenhouse gas emissions by 40% until 2030 (Soava et al., 2018). In addition to the Paris Agreement, the European Green Deal aims to achieve carbon neutrality by 2050, making Europe the first climate-neutral continent. This agreement aims to guide the establishment of new EU legislation that has as its main priority the reduction of carbon emissions (Eckert and Kovalevska, 2021).

The Spanish plan focuses mainly on fisheries and aquaculture, leaving aside essential maritime sectors for implementing the IMP, such as shipping. According to the EC (2008), "Shipping is vital for Europe's international and domestic trade and remains the backbone of the maritime cluster". Additionally, this plan doesn't approach the socio-economic sectors of naval construction, repair, and maintenance, ocean renewable energy, oil and gas exploration and exploration, non-living marine resources and tourism, recreational boating, and sport, which are fundamental to IMP's structure (EC, 2008). Although not part of the 'Programa Operativo del FEMP 2014-2020', some of the vital socio-economic sectors for the implementation of the IMP are distributed by different sectoral strategies, such as the "Plan Nacional Integrado de Energiía y Clima 2021-2030", which is dedicated to climate change mitigation, renewable energy, and energy efficiency. However, despite the existence of distinct sectoral plans with measures and actions that contribute to the implementation of the IMP, Spain does not truly present a National Ocean Strategy in the context of the IMP, or even a national maritime policy (Quero García et al., 2021). There is a dispersion of measures between sectoral plans that is not in line with the recommendations of the IMP for an integrated approach. Consequently, Spain didn't fulfill the request of the EC for the MS for the elaboration of integrated national maritime policies (Becker-Weinberg, 2015). Although most of the objectives and measures of the 'Programa Operativo del FEMP 2014-2020' contribute to the framework of the Blue Growth Strategy and the IMP, this plan leaves out half of the Focus Areas of the Blue Growth Strategy and the Action Area of the IMP 'Improving' the quality of life in coastal regions'. This Action Area is of extreme importance for the implementation of IMP because "The first goal of an EU Integrated Maritime Policy is to create optimal conditions for the sustainable use of the oceans and seas, enabling the growth of

maritime sectors and coastal regions" (EC, 2007). Spain's lack of alignment with the IMP is reinforced by the fact that it has not yet completed the development of its MSP plans (Quero García et al., 2021).

Identical to Spain's strategy, the UK's 'Maritime 2050' cannot also be considered as a National Ocean Strategy in the IMP framework. This strategy is dedicated to maritime transportation, and the social-economic sector 'Fisheries and Aquaculture 'is missing. This sector is critical to the implementation of IMP. According to the EC (2007) it's necessary "to eliminate Illegal, Unreported and Unregulated fishing in its waters and on the high seas (…), the improvement of on-the-job safety of fishermen must also be addressed in the wider context of maritime working conditions and social policy (…), and the growth of aquaculture to satisfy increasing global seafood demand should be achieved within a regulatory framework that encourages entrepreneurship and innovation and ensures compliance with high environmental and public health standards". This strategy does not identify measures for any of these recommendations. Additionally, the UK's strategy doesn't display measures for half of the Focus Areas of the Blue Growth Strategy and, as Spain's strategy, has a very small number of measures for the IMP Action Area "Improving' the quality of life in coastal regions'. Like Spain, the UK has a variety of sectoral plans dedicated to socio-economic sectors that are not included in the "Maritime 2050 – Navigating the Future". The "Fisheries Act 2020" regulates the sustainable management of fisheries, aquaculture, and marine conservation. The "Growing the bioeconomy: a national bioeconomy strategy to 2030" aims to transform the UK's economy using biological sciences and biotechnology. These two sectoral plans were not introduced in this study, since only the strategies indicated in the responses to the questionnaires were analyzed.

Ireland's Nation Ocean Strategy is, of all documents analyzed in the case studies, the oldest strategy. Despite being considered a Nation Ocean Strategy in the context of the IMP and contributing to the implementation of the IMP Action Areas, it is outdated when compared to the strategies of France and Portugal, not responding to some of the Focus Areas of the Blue Growth Strategy. The lack of measures for the 'Aquaculture' and 'Blue Biotechnology' Focus Areas can be justified by the date of publication of the 'Harnessing our Ocean Wealth'. This strategy was officially published on July 1, 2012, before the release date of the "Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Blue Growth - opportunities for marine and maritime sustainable growth". Therefore, the Irish strategy was written before the final publication of the Blue Growth Strategy, and for this reason, it may not exhibit measures and actions that fall within all the Focus Areas that contribute to the implementation of the Blue Growth Strategy. The lowest number of measures in some social-economic sectors of Ireland's strategy can also be justified by the existence of distinguished sectorial plans. It's the case of the "Marine Biotechnology Task Force Report", which is dedicated to enhancing the use of marine bioresources, the "National Strategic Plan for Sustainable Aquaculture Development" and the "Statement of Strategy 2018-2020. Enabling Sustainable Growth", both dedicated to fisheries and aquaculture, and the "Irish Maritime Directorate Strategy 2021-2015" which sets out the main objectives for the Irish maritime transportation sector. These sectoral plans weren't analyzed because, for this study, only the strategies presented in the answered questionnaires were considered.

Of all the case strategies studied, the National Ocean Strategies of France and Portugal are those that are truly in line with the EU IMP. The strategies of these two countries incorporate all the objectives and action fields of this policy, as well as the socio-economic sectors most relevant to it, complying with the EC's request for the development of integrated national maritime policies. These two maritime strategies also include all the Focus Areas of the Blue Growth Strategy, one of the main pillars of the IMP. In terms of legislation, these case studies incorporated the MSP and the MSFD at a national level, as requested by the EC. Both these countries have a historical relationship with the Sea, specifically with the south of the Atlantic. They are also the two EU MS with the highest EEZ (Guerreiro, 2021; Guerreiro et al., 2021; Santos, 2021). France has a long history of land spatial planning, particularly with coastal management. The French government has increasingly recognized the importance of maritime policies, which lead to the creation of the Ministry for the Sea, in 2020. The main objective of this ministry is to promote Blue Growth and develop policies related to the oceans and MSP (Guerreiro et al., 2017; Guerreiro, 2021). Portugal was one of the first EU countries to develop a national ocean strategy, in 2006. However, its relationship with ocean policies dates to the 90s with the World Ocean International exhibition in 1998 (EXPO98). In governmental terms, the importance of creating a ministry specialized in Sea affairs was recognized with the Ministry of Economy and the Sea. Two other institutions specializing in maritime policies were also introduced, the General Directorate for Maritime Policy and the General Directorate of Natural Resources, Security, and Maritime Services. The first is responsible for creating and managing national ocean strategies and issues related to Blue Growth. The second specializes in the implementation of MSP and MSFD, the environmental pillar of the IMP (Guerreiro, 2021; Guerreiro et al., 2021; Santos, 2021).

Sustainable development goals and United Nations decade of ocean science for sustainable development

Regarding the framework of the SDGs and Decade of Ocean Sciences for Sustainable Development in the National Ocean Strategies, Spain and Ireland were the only countries whose strategies did not fit all the selected SDGs. The National Ocean Strategies of the remaining countries are aligned with the SDGs, exhibiting measures exclusively dedicated to their achievement. In all case studies, it was clear that the Ocean Strategies display a greater number of measures for the goals of SDG 14 – Life Below Water. In general, all the National Ocean Strategies of the case studies contribute to the implementation of the Decade of Ocean Sciences for Sustainable Development, apart from Spain's strategy, which does not respond to half of the Decade's key challenges. Portugal's National Ocean Strategy was the only strategy that presented measures for all the targets of the selected SDGs, as well as for all the key challenges of the Decade of Ocean Sciences for Sustainable Development. For this reason, it can be considered the National Ocean Strategy that contributes most efficiently to the implementation of the 2030 Agenda. Nevertheless, considering additionally sectorial policies all the case studies have additional measures aligned with several SDGs of the 2030 Agenda.

European union strategy for the Atlantic Basin

The studied countries are part of the European Union Strategy for the Atlantic Area, sharing economic, social, and environmental characteristics[4]. Therefore, it would be expected common management of maritime activities and convergence of the socio-economic sectors of their National Ocean Strategies (EC, 2011). The importance of 'Combat and adaptation to Climate Change and Nature conservation' is one of the characteristics that all the analyzed national ocean strategies have in common. This feature is in line with one of the most important areas of action of the new EU's Atlantic Action Plan 2.0, the protection of the environment, with special emphasis on coastal areas (Aguiar Machado, 2019). The EC acknowledged that there was a data gap for a precise socio-economic analysis to be carried out, in the Atlantic region. For this reason, it requested the ME belonging to the EU Strategy for the Atlantic Area to collect the best accurate data. Except for Spain, all the strategies analyzed offered a reasonable number of measures for the 'I&D+i (Investigation and Development + Innovation)' sector, which meets the EC's request (Fernández-Macho et al., 2015). Spain is, of all the case studies, the country that is least integrated into the EU's Atlantic Arc, which is verified by the fact that it does not present a national maritime policy and a national ocean strategy in the context of the IMP framework (Fernández-Macho et al., 2015; Quero García et al., 2021). The Spanish strategy was the one that least incorporated the objectives of both Atlantic Action Plan 2013-2020 and Atlantic Action Plan 2.0. That can be justified by the fact that the 'Programa Operativo del FEMP 2014-2020' is mostly dedicated to the sectors of fisheries and aquaculture. The UK's 'Maritime 2050' is a strategy predominantly focused on maritime transportation. Although it contains measures and actions that contribute to the achievement of most of the objectives of the Atlantic Action Plan 2.0, it leaves out essential areas for the sustainable development of the region covered by this plan, such as aquaculture, fisheries, and marine renewable energy sectors (EC, 2011). The two action plans for the EU's Atlantic Area are amongst the most developed within all the EU Ocean Basins action plans. One of the main principles of both Atlantic action plans is the achievement of Blue Growth (Dalton et al., 2019). Yet, Ireland's national ocean strategy does not exhibit measures that contribute to the realization of two Focus Areas of the Blue Growth Strategy. Ireland is also the case study with the most outdated National Ocean Strategy, as it was published in 2012. For this reason, it would be expected that this strategy would better fit the objectives of the first version of the Atlantic Action Plan. However, four of the ten specific objectives of this plan are not addressed by the measures and actions of 'Harnessing our Ocean Wealth'. For the Atlantic 2.0 Action Plan, Ireland's maritime strategy misses two of this plan's seven key objectives. France and Portugal are the only members of the EU Strategy for the Atlantic Area that truly incorporate the objectives of both Atlantic Action Plans in their National Ocean Strategies. The national ocean strategies of these two countries display specific measures for the fulfillment of the EU Strategy for the Atlantic Area. There is also conformity in the socio-economic sectors of both maritime strategies. Both these countries have a historical interest in the Atlantic area, recognizing the importance of creating measures for the proper management of the Atlantic Ocean (Guerreiro, 2021).

Conclusion

The EU's Atlantic area possesses unique characteristics and acts as a development motor for its MS. For the maximization of the sustainable growth of this area, it is expected that its countries, develop policies and manage their maritime activities in a coordinated way (EC, 2011). This study shows that most of the countries analyzed have similar key priorities. The combat and adaptation to climate change and nature conservation was the main key priority for all the national

4 https://www.europarl.europa.eu/factsheets/en/sheet/121/integrated-maritime-policy-of-the-european-union

ocean strategies examined, together with the I&D+I (Investigation and Development + Innovation). On the other hand, in all strategies, there are few measures for the exploration and prospecting of oil and gas, in line with EU Green Deal (EC, 2019).

It also became clear that Spain is the country further behind the adoption of IMP's objectives and guidelines. Spain has not yet completed the development of its MSP plans and its national ocean strategy leaves out half of the Blue Growth Strategy Focus Areas. The Spanish maritime strategy cannot also be considered a national ocean strategy according to the IMP framework because it leaves out essential sectors for the implementation of the IMP, which can be found in distinctive sectoral plans. Thus, Spain does not comply with the EC recommendation for the creation of an integrated national maritime policy (Becker-Weinberg, 2015). The same applies to the UK's maritime strategy. Although several reasons can be pointed out for the inexistence of a real IMP in Spain it cannot be discarded that the autonomic nature of the Spanish state makes it harder to develop real national integrated policies (Tudela Aranda, 2013). Ireland's national ocean strategy is clearly outdated when compared to the strategies of France and Portugal. The modernization of this strategy would be favorable for a better implementation of the IMP and of one of its main pillars, the Blue Growth Strategy. On the contrary, France and Portugal lead the way in implementing IMP, and their national ocean strategies undoubtedly demonstrate this.

Regarding the SDGs, it is unequivocal that SDG 14 – Life Bellow Water is the one that stands out in all national ocean strategies. On the other hand, only the Spanish and Irish strategies were the ones that did not contribute to the implementation of all the selected SDGs in an integrated way. Furthermore, the Spanish strategy also is the one that that least follows the key challenges of the Decade of Ocean Sciences for Sustainable Development. By contrast, the Portuguese strategy is the one that contributes the most to the accomplishment of the selected SDGs, as well as the Decade of Ocean Sciences for Sustainable Development.

The selected countries approach the EU Strategy for the Atlantic Area and its Action Plan in different ways. Spain's strategy is dedicated to aquaculture and fisheries, being the strategy that least fits the Atlantic Action Plan 2.0. The focus of the UK maritime strategy is maritime transportation. Although the objectives of this strategy correspond to some of the objectives of the Atlantic Action Plan 2.0, it leaves behind essential areas for the sustainable development of this region, such as ocean renewable energy and marine biotechnology. France and Portugal are, once again, the countries that truthfully contribute to the realization of the EU's Strategy for the Atlantic Area. The maritime strategies of these two countries are aligned with the objectives of the old and new Atlantic Action Plan, incorporating specific measures for the fulfillment of this EU Basin Strategy.

The sustainable development of the EU's Atlantic Area is categorically dependent on the holistic and integrated management of the countries that comprise it. Therefore, the establishment of integrated national ocean strategies will be fundamental for the growth of this region. The national ocean strategies of France and Portugal can pave the way for a new generation of maritime strategies, serving as an example for other countries and are at the moment leading the maritime policies in this region which no doubt represents the political priority given by the French and Portuguese governments to ocean policies, also reflecting the relevance of their EEZ's at a global scale.

The results obtained with this study can also contribute as a starting point for the creation of a working group that could allow a better alignment between the national ocean strategies of the countries of the Atlantic basin of the EU. It could follow the example of the HELCOM-VASAB MSP, adopted for the Baltic Sea region. This working group's ambition is to facilitate the integration of EU Directives with national planning policies (Hassler et al., 2018). The creation of a structure like the HELCOM-VASAB MSP, for the EU Atlantic basin, could thus ensure that the countries belonging to it, could work together as a network, for a more prosperous and successful implementation of the EU IMP and the Atlantic Action Plan 2.0.

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.

Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

Author contributions

ISM: Initial research design, Data collection, Conceptualization, Methodology, Investigation, Writing - original draft. JG: Conceptualization, Validation, Formal analysis, Resources, Writing - review and editing, Supervision, Project administration. CS: Conceptualization, Validation, Formal

analysis, Resources, Writing - review and editing. All authors contributed to the article 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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Comparative analysis of marine-protected area effectiveness in the protection of marine mammals: Lessons learned and recommendations

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The aim of this study is to assess marine-protected areas' (MPAs) effectiveness in the protection of marine mammals. With this purpose, the study analyzed the long-term population trend of four different species of marine mammals, geographically placed in distant MPAs. In addition, matching biophysical and governance indicators were identified in order to relate the different management approaches to the biological effectiveness or ineffectiveness of the respective MPA. The results show population recovery trends, providing empirical evidence that suggests the effectiveness of area-based protection measures in marine mammals. Moreover, a parallelism between the governance indicators and the biophysical ones supports that biological and management effectiveness are interrelated. On this basis, the biophysical indicator of human impact was discussed to be deeply related to the precautionary principle, which appears less efficient than the adaptive management. Finally, this study highlights the necessity to better monitor the effectiveness of MPAs in order to avoid paper parks and suggest future recommendations.

KEYWORDS

marine protected areas, management effectiveness, marine mammals, adaptive management, paper parks, case studies

1 Introduction

1.1 Marine mammal species of the world

Nowadays, the updated list of marine mammals consists of 132 currently living species, placed in four different taxonomic groups including cetaceans (whales, dolphins, and porpoises), pinnipeds (seals, sea lions, and walruses), sirenians (manatees and dugongs), and marine fissipeds (polar bears and sea otters). Nonetheless, the proportion differs considerably from one taxonomic group to another; cetaceans

represent 70%, pinnipeds 25%, sirenians 3%, and marine fissipeds 2% (Committee on Taxonomy, 2021), (NOAA, 2019b).

Marine mammals are a very diverse group. First of all, the degree of adaptation to the aquatic environment of each taxonomic group depends on the proportion of time spent in water (Hoelzel, 2009). Therefore, Cetaceans, which spend their entire lives in water, have extreme aquatic adaptations and a great diversity of morphological forms, whereas the sea otter and the polar bear are less adapted to the aquatic lifestyle due to the fact that they spent most of their lifetime on ice or land along the shore (Würsig, 2019).

Marine mammals' ecosystems are also very diverse (marine, terrestrial, or both) as is the variety in their ecological roles (herbivores, filter feeders, and top predators).

Overall, there are considerable challenges in order to protect this heterogenous group of species. Hence, in most cases, the development and implementation of management approaches must be very dynamic due to the long list of threats marine mammals are exposed to, often requiring international collaborations and agreements.

1.2 Documented threats faced by marine mammals

Direct threats are the proximate human activities or processes that have impacted, are impacting, or may impact the status of the taxon being assessed (e.g., unsustainable fishing or logging, agriculture, and housing developments) (IUCN, 2021). Marine mammal species worldwide are known to be impacted by several anthropogenic activities, most of them being addressed as direct threats.Marine mammal threats can be classified into seven different categories: incidental catch and fishing gear interactions, direct harvesting, pollution, traffic, pathogens and introduced species, resource depletion, and ocean-physics alteration. All of them have direct human activity as a threat source aside from ocean-physics alteration, which is not directly due to human activity but to external drivers like, e.g.,climate change (Avila et al, 2018).

As can be seen in Figure 1, the relative impact of different threat types is variable across different taxa. However, overall, in terms of marine mammal threats, incidental catch is the most common threat category affecting 112 species followed by pollution (99 species), direct harvesting (89 species), and traffic (86 species).

Each of these four major threats is associated to several threat attributes; the ones having more impact in marine mammals are by-catch (associated to incidental catch) followed by wastes (associated to pollution) and direct harvesting (associated to commercial activity) (Avila et al, 2018).

1.3 Legal framework and place-based conservation

Numerous treaties and conventions all over the world have established the protection and preservation of the marine

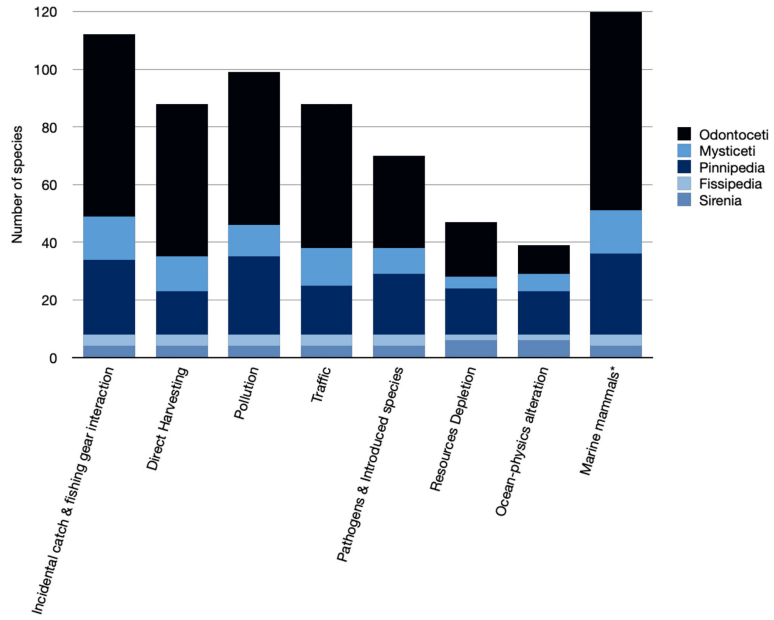

FIGURE 1
Number of species of each taxon documented to be affected (between 1991 and 2016) by different threat categories. Source: Adapted from Avila et al, 2018.

environment. Some of the aforementioned can be related to marine mammals even though their application and purpose are more general, while others have been specifically created for the protection of these animals.

For instance, the purpose of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES; Washington, 1973) entails the protection of marine mammals without them being the primary objective.

Moreover, other conventions have also provided broad marine protection, for example, the Convention on the Conservation of Migratory Species of Wild Animals placed in Bonn in 1979, recognizing the threats migratory species face during their travels (CMS; United Nations Convention on the Conservation of Migratory Species of Wild Animals (Bonn). Additional examples are the United Nations Convention on the Law of the Sea United Nations Convention on the Law of the Sea, (Montego Bay)) or the United Nations Convention on Biological Diversity (CBD; United Nations Convention on Biological Diversity, 1992).

The aforementioned conventions constitute a legal framework that enables the protection of marine mammals. However, more specific treaties provide these species with a higher level of protection. For instance, the International Convention for the Regulation of Whaling (ICRW, Washington, 1946) was created with the specific purpose of sustainably managing whale stocks. The convention emphasized the need to prevent the further overfishing of this species, aiming to ensure the natural increases of the whale stocks that will allow the future exploitation of the whales, once regulated, without endangering the natural resource. While the original signatories of the Whaling Convention were 15 whaling countries, the parties now number 89 states. Most of the countries that previously engaged in whaling have ceased this activity and actually oppose to whaling for commercial purposes (Scovazzi, 2016).

Each of these conventions and treaties mentioned above constitutes a legal framework that enables the protection of marine mammals. However, even the ones specifically created for the protection of these animals are lacking enforcement. For instance, from the perspective of international law, any country that has not signed the whaling convention can still hunt these animals in the same places where others (the ones who signed up the convention) are protecting them. Therefore, conventions represent a first step toward the protection of marine mammals; however, the global legal circumstances are significantly complex.

On the contrary, marine-protected areas (MPAs) are more likely to achieve the intended goals of protection toward marine mammals. Taking into account that most MPAs are placed in territorial waters, once they are proposed, they come with its own country legal framework and own placed-based objectives. Afterward, once the MPA is declared, its legal framework will be part of the national legislation. Hence, the government would be able to enforce these rules and protect the marine mammals under the national law. Once MPAs are declared, they are backed by national legislation, which allows governments to enforce the obligations at a more local scale.

Therefore, careful consideration should be given to whether MPAs are effective or not in the protection of marine mammals since MPAs are the most concrete and operative part of these international efforts. Contrary to conventions and treaties, these ones have already acquired a more legally binding nature. However, cetaceans are highly mobile animals, and the ranges of most populations are sometimes too large for this to be practicable. On the other hand, when only a portion of a cetacean population's range can be included within a protected area, there is obvious merit in selecting and designing MPAs in habitats that bear special importance for the species to be protected, such as key breeding and feeding areas (Sellheim, 2020). Consequently, the aims of this study are to

1. Assess the effectiveness of MPAs in the protection of marine mammals
2. Provide lessons learned and future recommendations, for instance, the necessity of MPA effectiveness evaluation or the benefits of having a more adaptive management

2 Methodology

According to the International Union for Conservation of Nature (IUCN) (IUCN-WCPA, 2008, as cited in Horigue et al, 2012) and Kelleher (1999), MPAs are the designated areas of intertidal or subtidal terrain, with a degree of protection and therefore where human activities are more regulated or even banned.

In the following sections, several existing MPAs around the world are going to be analyzed through a very extensive literature review to obtain information on cetacean habitat protection. In order to study the greatest variety of MPA approaches to marine mammal's protection, the selection of the case studies does not cover a specific region.

2.1 Selection of case studies

Extended research was carried out to choose several representative case studies of protection of marine mammals. This study has chosen the following criteria for the selection of case studies:

1. The presence of marine mammals and identification of key species of concern
2. Defined MPA goals in view of marine mammals
3. Previous threats to marine mammals in the area actually covered by the MPA
4. A minimum of 10 years since MPA establishment

5.The existence of qualitative data on marine mammal population trends within the area

The first and second criteria were developed to assure the importance of marine mammalians in the protection of the area. The third criterion was established to capture an eventual changing trend in the populations of marine animals after MPA designation.

The effects of an MPA are not immediate but become eventually apparent several years after its implementation (Selig and Bruno, 2010). The criterion of 10 years was not arbitrary, but Two interrelated aspects were considered: the MPA management plan established the frequency of revision and the required time to detect change in the trend of a population of marine mammals.

Concerning long-term population trends, it was established by the minimum required period under the IUCN criteria for assessing population decline. In cases where data do not cover three generations, 10 years were kept as the minimum required period (IUCN, 2010 as cited in Magera et al., 2013).

Regarding the response variable, according to the guideline of "Outline for Management Plan for National Nature Reserves," the management plan objective is usually specified for a period of 10 years and therefore, for each MPA, the management plan is rewritten after 10 years (North-East Asian Subregional Programme for Environmental Cooperation (NEASPEC), 2021). Both criteria were fulfilled with the same period of time; hence, the minimum since the MPA establishment was determined to be 10 years.

Lastly, the fifth criterion was developed to conduct a high-quality study of the MPA effectiveness for marine mammals based on long-term reliable data.

In order to decide which MPAs were suitable for this study, a selection procedure was developed applying the five criteria outlined above. Bibliographic research was carried out through the directory of worldwide MPAs that feature or include marine mammals' habitat (Cetaceanhabitat.org, 2022). Consequently, 20 MPAs were obtained constantly endeavoring the representativeness of different parts of the world as can be seen in Annex 1.

Subsequently, extensive research was carried out to ensure that the aforementioned criteria were fulfilled. For this purpose, the official IUCN website for protected areas was used as source of information to retrieve the status year of the MPA (Explore the World's Protected Areas, 2022). If one of the criteria was not fulfilled, the rest of them were not applied. Only four MPAs fulfilled all the criteria above stated and were therefore selected as case studies (Annex 1).

2.2 Established indicators for the effectiveness assessment

Goals related to the protection of marine mammals in each of the selected MPAs were grouped. Relevant indicators were chosen to address the overall value of these goals, following Pomeroy et al. (2004).

The basis of this study was to use variations in the population trend of target species to assess MPA effectiveness in the protection of marine mammals; hence, indicator number 1 (focal species abundance) was scored.

The evaluation of the governance goals was undertaken in order to assess management effectiveness and to draw lessons from those MPA experiences. Indicator number 2 (area under no or reduced human impact), indicator number 3 (existence of a decision-making management body), indicator number 4 (existence and adoption of a management plan), and indicator number 5 (existence and adequacy of enabling legislation) were evaluated.These indicators are illustrated in Table 1.

Furthermore, the results of the biophysical indicator 1 were used as evidence to demonstrate biological effectiveness (or ineffectiveness) depending on the variations of the population

TABLE 1 Matching indicators chosen in the view of the abovementioned goals.

Indicators	Type of indicator	Definition of the indicator, reasons to measure it, and form of assessment
1. Focal species abundance	Biophysical	Improved and sustained numbers of focal species in the MPA through times is widely seen to indicate MPA's effectiveness.
2. Area under no or reduced human impact	Biophysical	Reducing human impact levels increases the probability of focal species to replenish and maintain themselves through time. The levels of protection were characterized based on the allowed activities within the MPA, using as a guide (Grorud-Colvert et al., 2021).
3. Existence of a decision- making and management body	Governance	The existence of a legally mandated MPA decision-making management body will lead to a more effective and accountable management, becoming easier to have a successful MPA.
4. Existence and adoption of a management plan	Governance	The existence and adoption of a management plan the document where the MPA goals and objectives are specified, thereby allowing MPA evaluation.
5. Existence and adequacy of enabling legislation	Governance	The existence and adequacy of enabling legislation are a measure of the national and international legislation that provides the MPA with a sound legal foundation deserving enforcement.

Source: Pomeroy et al, 2004.

trends. Finally, once the effectiveness of each study case was analyzed, the overall effectiveness of MP:As in the protection of marine mammals was assessed through discussion.

Lastly, a comparison between the four case studies was held, in order to relate the effectiveness of the MPA (quantified by indicators 1 and 2) to MPA governance (indicators 3–5). The obtained results were placed in a broader perspective to learn lessons and provide future recommendations.

3 Results

Applying the methodology described above, four case studies from different parts of the world were selected. It can be noted that the unequal distribution of resources between developed and developing countries acts as a criterion itself. This can be clearly seen in Annex 1, where most of the cases from undeveloped countries do not fulfill the aforementioned criteria. Consequently, the four MPAs chosen belong to developed countries and are placed in different parts of the world.

Firstly, The Wadden Sea is placed along the coasts of Denmark, Germany, and the Netherlands. Secondly, The Banks Peninsula is on the East coast of the South Island of New Zealand. Humpback Whale National Marine Sanctuary is located in Hawaii, and Melville bay is in Greenland.

The MPAs were divided into two oceans; two MPAs were located on the North Atlantic, whereas the other two were placed on the Pacific Ocean. All of them were separated by enormous distances.

In the following sections, each case study is going to be characterized, the population trends of the focal species as shown, and the indicators values are assessed.

3.1 The Wadden Sea

The Trilateral Wadden Sea Cooperation (TWSC) between Denmark, Germany, and the Netherlands (see Figure 2) was established in 1978 (Common Wadden Sea Secretariat (CWSS), 2021). In 1990 (entered in force 1 year later), the Agreement on the Conservation of Seals in the Wadden Sea (WSSA) was concluded to promote close cooperation among the Parties (Denmark Germany, Netherlands). It aimed to achieve and maintain a favorable conservation status for the harbor seal population, which was a particularly critical issue in 1988

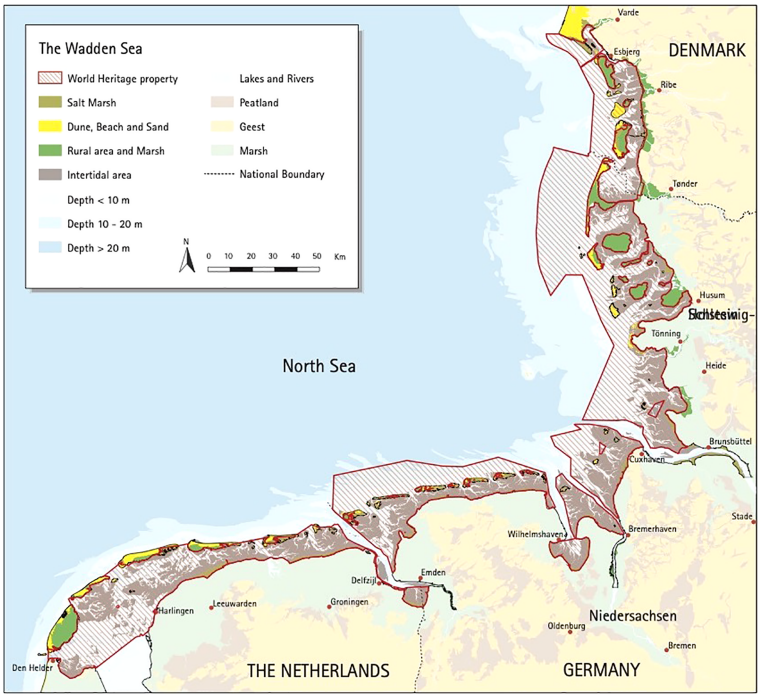

FIGURE 2
Map of the Wadden Sea. Source: UNESCO, World Heritage Center, 2014.

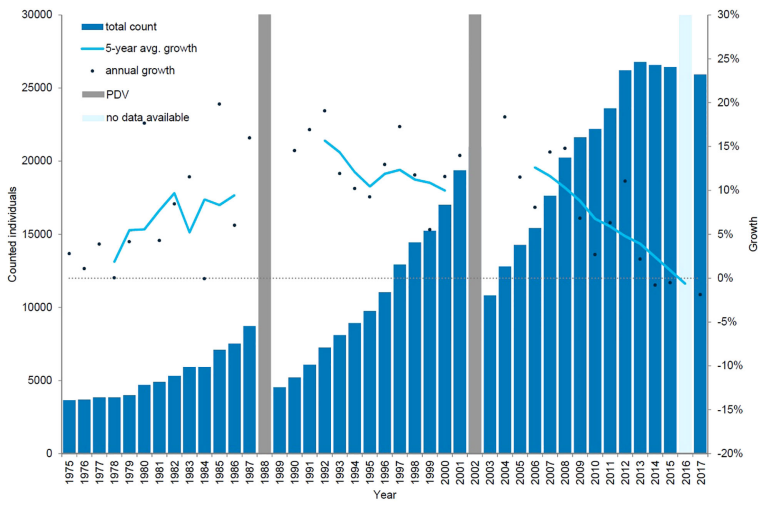

FIGURE 3
Harbor seal count in the Wadden Sea 1975–2017. No total number available for 1988, 2022, and 2016 due to Phocine Distemper Virus (PDV) or weather. Source: Jensen et al., 2017.

(Common Wadden Sea Secretariat, 2016). The state of declaration of the Wadden Sea Plan was adopted in 1997 (Common Wadden Sea Secretariat, 1997) and updated in 2010 (Common Wadden Sea Secretariat (CWSS), 2010). Therefore, the Wadden sea was designated as a conservation area in 2009, but conservation measures were taken since 1978 and the target species had been protected since 1991.

3.1.1 Population trends

Harbor seals were hunted in the Wadden Sea until 1977, critically decimating the population (Jensen et al., 2017). In 1974, the population counted only 3,551 animals. From 1979, the population presented a recovering trend until 1988 when the epizootic of Phocine Distemper Virus (PDV) reduced the population by 57% (Figure 3) (Reijnders et al., 2010). After the PDV epizootic, the harbor seal population recovered, reaching pre-epizootic levels by 1995 and more than doubling its levels by 2001 (Jensen et al., 2017). In 2002, a second PDV epidemic decimated the population, in this case by 50% (Reijnders et al., 2010). Afterward, the population grew again until 2014. Lastly, by 2017, the total population of harbor seals in the Wadden Sea numbered approximately 38,126 animals (Jensen et al., 2017).

3.1.2 Area under human impact

Some activities, such as mining and mineral oil prospecting, are considered to have such a high impact that they are incompatible with biodiversity conservation and should not occur on any MPA (Grorud-Colvert et al., 2021). No other human impact was evaluated since mining was allowed, and MPAs were already classified as incompatible with conservation.

There is currently no oil extraction in the Dutch Wadden Sea, and according to the Statutory Order on the Nature Reserve Wadden Sea, the exploitation of gas and oil in the Danish part of the conservation area is prohibited. However, Mittelplate 1, Germany's largest oil field, is situated within the core of the National Park. Since 1987, the field has been exploited. The infrastructure of the production island was also developed and located on the southern edge of the Wadden Sea (Baer and Nehls, 2017).

3.1.3 Existence of a decision-making management body

In the case of the Wadden Sea, there is a very well-defined decision-making management body. The Trilateral Wadden Sea Cooperation comprises of two levels of decision-making: the Trilateral Governmental Council and the Wadden Sea Board (WSB). They are supported by the Common Wadden Sea Secretariat (CWSS) as the coordinating body and first contact point, advisors from Non Governmental Organizations (NGOs), and task groups as well as expert networking groups (Waddensea-worldheritage.org, 2021a).

3.1.4 Existence and adoption of a management plan

An analysis of the existent management plan was carried out in order to determine the completeness of the plan. Since the *Wadden Sea Plan* (Common Wadden Sea Secretariat, 2010) is complete and, at the same time, enforceable, it can be concluded that the MPA is being guided by goals and objectives to achieve certain outcomes and that there is a basic strategy to achieve these goals and objectives (Pomeroy et al, 2004).

3.1.5 Existence and adequacy of enabling legislation

A legal overview was conducted to determine the existence of legislation, its compatibility, and appropriateness toward the MPA. As a result of the analysis, it was obtained that there are numerous laws of different levels supporting the MPA; International laws (Convention on the Conservation of Migratory Species of Wild Animals, Ramsar Convention, Agreement on the Conservation of Seals in the Wadden Sea…), EU legislation (Habitat Directive, Natura 2000…), and national protection (Statutory Order on the Wadden Sea Nature and Wildlife Reserve, Federal Nature Conservation Act…) (Waddensea-worldheritage.org, 2021b). Therefore, the existence of adequate legislation has been determined to support the management of the MPA.

3.2 Banks peninsula marine mammal sanctuary

The Banks Peninsula Marine Mammal Sanctuary is the first marine mammal sanctuary created in New Zealand. It was established in 1988 to order to protect the endangered Hector's dolphin (*Cephalorhynchus hectori*) from bycatch in set nets. When the sanctuary was first created, it covered an area of 1,140 km². Nowadays, the Banks Peninsula Marine Mammal Sanctuary encompasses a total area of approximately 14,310 km², which can be seen in Figure 4 (Doc.govt.nz, 2021).

3.2.1 Population trends

In the case of the Hector's dolphin population, the study found to assess the effectiveness of the MPA in the protection of marine mammals was focused in other demographic factors rather than direct estimates of abundance. However, since the number of reliably marked individuals photographically captured during 1986–2006 was reported in the study *First evidence that marine protected areas can work for marine mammals* (Gormley et al., 2012), Figure 5 was created based on that data. As it can be noticed in Figure 5, there is no clear pattern in the variation of demographic abundance over the years nor a very clear differentiation between pre- and post-sanctuary periods. However, the tendency appears to be positive.

In order to assess the effectiveness of the MPA in the protection of marine mammals, the mean annual survival and the population growth were calculated for the pre-sanctuary and post-sanctuary periods. As it can be seen in Figures 6, both values were improved in the post-sanctuary period. According to Gormley et al. (2012), there is a 90% probability that survival improved between the pre- and post-sanctuary periods with a mean annual survival increase of 5.4% since the establishment of the sanctuary. An increase of survival of this magnitude is biologically significant with a corresponding increase in the population growth of 6%. The mean estimated annual population growth rate also had a greater change to be positive in the post-sanctuary period (41%) then in the pre-sanctuary period (7%).

3.2.2 Area under human impact

Construction and other activities as mining and oil exploration are allowed in the MPA. However, the Department of Conservation (DOC) has established some non-mandatory guidelines for minimizing acoustic disturbance to marine mammals. Additionally, mussel farms are placed along the coastline of the MPA.

Regarding fisheries restrictions, the DOC has established some to mitigate the impacts of fishing on Hector's dolphin, for instance, banning set netting in the Marine Mammal sanctuary (Anderton, 2008). However, it should be taken into account that set netting is the main known threat to Hector's dolphins on that area, accounting 58% of dolphin mortalities withconfirmed cause since 1988 until it was banned in 2008 (DOC and MFish, 2007).

3.2.3 Existence of a decision-making management body

New Zealand's Department of Conservation is the agency of state responsible for the sanctuary management (Hughey, 2000). However, Hector's Dolphin Threat Management Plan is led by the DOC and the Ministry of Fisheries (MFish). The DOC is responsible for managing the dolphin populations, while Fisheries New Zealand is responsible for managing the impacts of fishing on the dolphins *(Threat Management Plan for Hector's and Māui dolphin, 2022)*. No other bodies holding decision-making and management authority have been found.

3.2.4 Existence and adoption of a management plan

There are five marine mammal sanctuaries along the coasts of New Zealand. All of them are placed relatively close together and were established to protect Hector's dolphin. The DOC decided to develop a threat management plan (TMP) for the species instead of having a management plan for each MPA. An analysis of the management plan (DOC and MFish, 2007) was undertaken, revealing some missing sections, mostly in the administration component, but the goals were also very vague, whereas specific objectives were inexistent.

3.2.5 Existence and adequacy of enabling legislation

The DOC administers the MPA under several acts and regulations that provide a legal foundation for its adequate

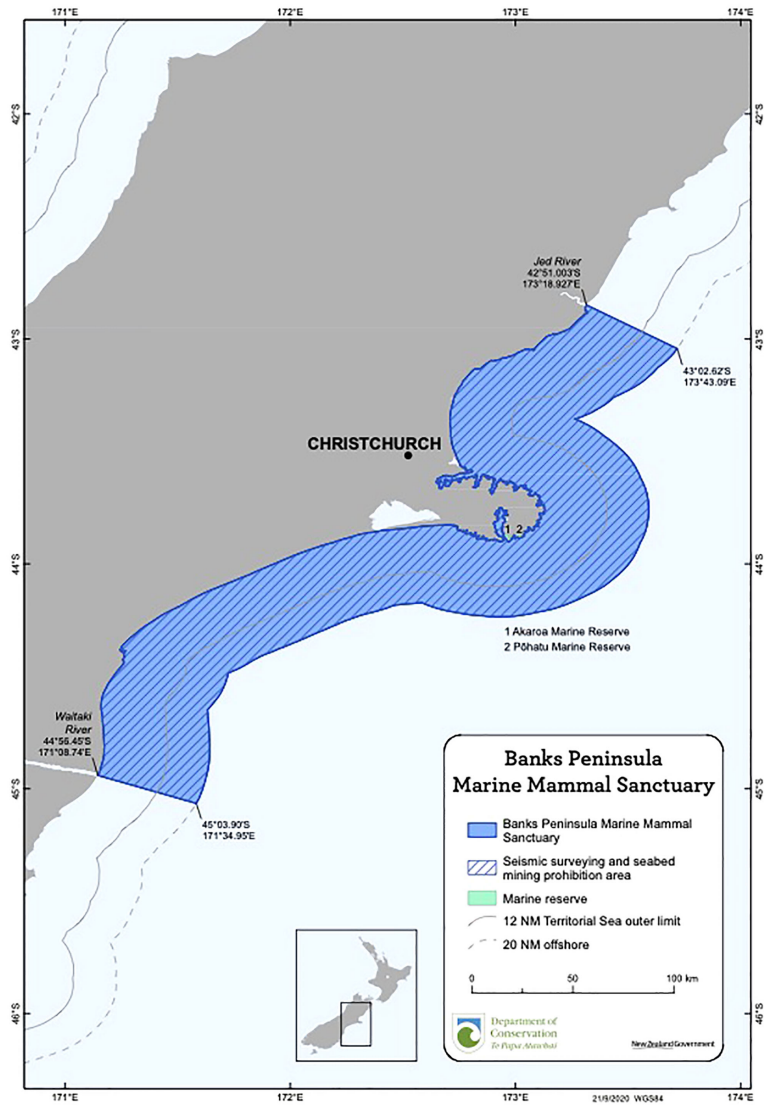

FIGURE 4
Map of the Banks Peninsula Marine Mammal Sanctuary. Source: Doc.govt.nz, 2021.

implementation. First of all, New Zealand is a founding member of the IWC. Moreover, the MPA is also supported by the Marine Mammals Protection Act 1978 and Marine Mammal Sanctuaries, Marine Mammal Protection Regulations 1992 (DOC and MFish, 2007).

3.3 Melville Bay

Melville Bay is located in Greenland, was designated a Nature Reserve in 1977, and covers an area of 7,957 km² (Figure 7, DOPA Explorer, 2021). All types of hunting are prohibited except for Narwhal traditional hunting. Narwhals are subject to a small-scale regulated hunting in Greenland. The yearly quotas are established by the Minister for Fisheries, Hunting and Agriculture after consultation with Kalaallit Nunaanni Aalisartut Piniartullu Katt (The Association of Fishers & Hunters in Greenland) (*Order No. 7 on conservation and hunting of beluga and narwhal*, 2011).

3.3.1 Population trends

Narwhal abundances were estimated from aerial surveys during summer in Melville Bay in 2007, 2012, 2014, and 2019. The abundance was 1,834 (CV = 0.92, 95% CI: 396–8,500) in 2007, 915 (CV = 0.44, 95% CI: 431–2,141) in 2012, 1,768 (CV = 0.39, 95% CI: 864–3,709) in 2014, and 4,755 (CV = 0.84, 95%

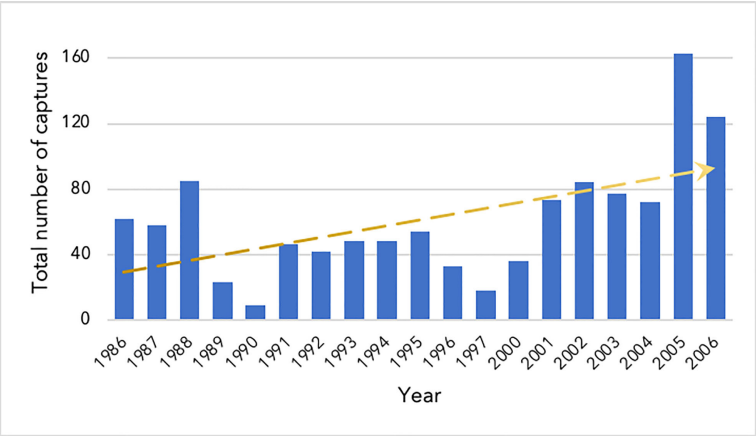

FIGURE 5
Hector's dolphin count in the Banks Peninsula Marine Mammal Sanctuary. Source: Own elaboration, data amended from Gormley et al. (2012).

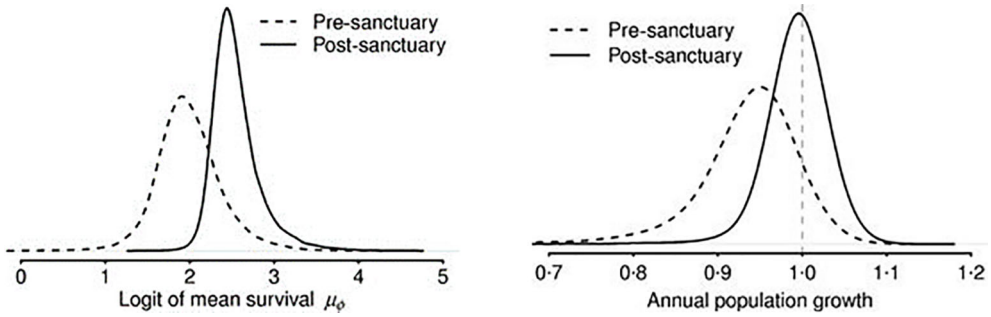

FIGURE 6
Hector's dolphin count in the Banks Peninsula Marine Mammal Sanctuary. Source: Own elaboration, data amended from Gormley et al. (2012).

CI: 1,158–20,066) in 2019. While available data suggest an increase in the abundance of narwhals in Melville Bay since 2012, it is subjected to high uncertainty in the 2019 estimate, and the observed trend is not significantly different from zero (NAMMCO-JCNB Joint Working Group, 2020). On the other hand, a posterior study on the narwhal stocks in Melville Bay highlights the difficulties on the analysis of the available data due to the highly aggregated distribution of the population, which determines high variability among random transects. A decline in the narwhals sighted in Melville Bay between 2007 and 2019 was noted, which may indicate a population decline (NAMMCO-North Atlantic Marine Mammal Commission, 2021).

The distribution of the sightings of narwhals was also studied, detecting a decrease in the area of usage of 84%, the area on a stratum level where the narwhals have been sighted has gone from 16,400 km² in 2007 to 2,610 km² in 2019. The monotonic decline in area usage may be an indicator of a population decline (NAMMCO-JCNB Joint Working Group, 2020).

3.3.2 Area under human impact

A hunting analysis was carried out in Melville Bay that highlighted the increase on the hunting level in the Nature Reserve during the period of 2005–2019 (NAMMCO-JCNB Joint Working Group, 2020), sometimes even exceeding the established quota. This hypothesis can be confirmed by the NAMMCO (North Atlantic Marine Mammal Commission) catch database, which can be seen in Figure 8.

Since hunting the target species is allowed in the aforementioned area, this study would designate Melville Bay as an MPA with a low or inexistent level of protection. However, it should be taken into account that fishing and hunting are inherent to the Inuit culture, being one of their most important

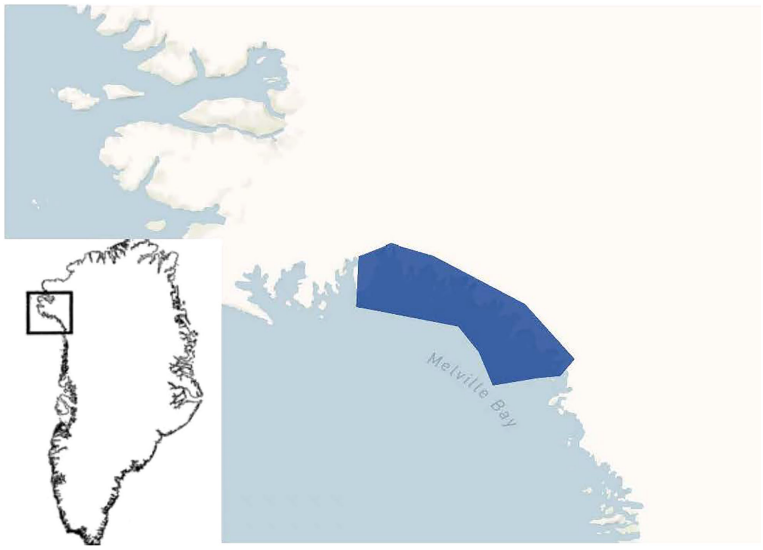

FIGURE 7
Map of Melville Bay. Source: UNEP-WCMC and IUCN, 2022.

food sources (Searles, 2002). Therefore, no marine protection of the area would ever be provided by Greenland without coexisting with the hunting of marine mammals. Perhaps, controlled hunting should already be considered as a form of protection to these species. Since the culture plays such an important role in this case, this study recommends a more in-depth assessment including the social component of the region.

3.3.3 Existence of a decision-making management body

Some West Greenland narwhals may travel to Canadian waters; therefore, narwhal management is a shared responsibility between Greenland and Canada. Greenland and Canada have established a bilateral management body, the Canada/Greenland Joint Commission on the Conservation and Management of

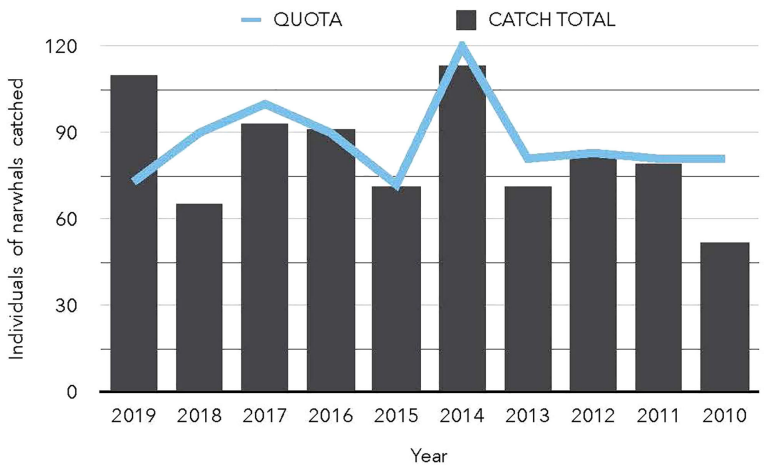

FIGURE 8
Total catches of narwhals in Melville Bay by year and its respective quota. Source: Own elaboration, data amended from Catch database—NAMMCO, 2021a.

Narwhal and Beluga (JCNB). The JCNB has a Joint Scientific Working Group (JWG) together with the NAMMCO Scientific Committee Working Group on the Population Status of Narwhal and Beluga in the North Atlantic. This NAMMCO-JCNB JWG provides advice at the request of the JCNB and NAMMCO, pertaining to such issues as stock delineation, total allowable catches, and threats to beluga and narwhal populations. The JCNB Commission meets periodically to receive this advice and provide management advice to Canada and Greenland (Searles, 2002).

However, concerning Melville Bay in particular, UNEP-WCMC and IUCN (2022) claim its management authority to be The Environmental Agency The Greenland Home Rule Government. Nevertheless, neither website nor official document has been found that supports this theory. Conversely, in the database of the European Commission, Melville Bay has not been reported with any management authority (Melville Bay | Dopa-explorer.jrc.ec.europa.eu, 2022).

Therefore, this study concludes that there is no clearly identifiable decision-making management body for the Melville Bay MPA. However, a designated management body does exist for the target species of the area, the narwhals.

3.3.4 Existence and adoption of a management plan

No management plan has been found. Nonetheless, several official documents have been written where the main goals and regulations appear.

Reports in 2001, 2004, 2005, 2009, 2012, 2017, and 2020 have been written by the Joint Working Group between JCNB and NAMMCO (Scientific Working Groups - Reports - NAMMCO, 2021a). These reports discuss the abundance and distribution of narwhal and beluga, in order to adjust harvesting, in the form of annual landed catch.

General goals can be found in some publications (Nuttall, 2005; Protection of the Artic Marine Environment (PAME), 2015); however, neither specific goals nor objectives were stated.3.3.5Existence and adequacy of enabling legislation

Greenland is bound by the International Whaling Convention through the participation of Denmark. It submitted its instrument of ratification in 1950. However, the regulation of the Narwhal hunting is outside the remit of the International Whaling Commission and is entirely regulated within the Greenland Home Rule Government. Since 2004, the catches of Narwhal have been regulated quotas. In 2004, the Home Rule adopted a new executive order quota for Narwhals; the *Greenland Home Rule Executive Order No. 2* of 12 February 2004 on the Protection and Hunting of Beluga and Narwhals (Fitzmaurice, 2009). The *Executive Order* states the annual narwhal quota.

Additionally, narwhal was added to CITES (International Convention on Trade in Endangered Species of Fauna and Flora) Appendix III, in 1977 by Greenland. Later on, in 1979, narwhals were uplisted to Annex II of the CITES. However, the regulation of the narwhal by the CITES is inconsistent and haphazard. There is neither an effective policy nor satisfactory legal measures.

3.4 Hawaiian Islands humpback whale national marine sanctuary

Hawaiian Islands constitute one of the world's most important humpback whale (*Megaptera novaeangliae*) habitats. Scientists estimate that more than 50% of the entire North Pacific humpback whale population migrates to Hawaiian waters each winter to mate, calve, and nurse their young (Calambokidis et al, 2008, as cited on Office of National Marine Sanctuaries, 2010).

On 4 November 1992, the Hawaiian Islands Humpback Whale National Marine Sanctuary (HIHWNMS) was designated by the Hawaiian Islands National Marine Sanctuary Act (Subtitle C of Public Law 102-587, the Oceans Act of 1992). Encompassing 3,548 km^2 of federal and state waters, the sanctuary extends from the shorelines of Hawai'i to the 100-fathom (equivalent to 183 m) isobath and is composed of five separate MPAs as illustrated in Figure 9.

3.4.1 Population trends

The SPLASH (Structure of Populations, Levels of Abundance and Status of Humpbacks) project was designed to determine the abundance, trends, movements, and population structure of humpback whales throughout the North Pacific. For Hawaii, three methods were used to compare estimates to determine trends. Despite the fact that absolute abundance in these estimates had certain biases, the annual rates of increase were very similar and ranged from 5.5% to 6.0% (Calambokidis et al, 2008). The primary basis for 1991–1993 estimates is from the NPAC study (Calambokidis et al., 1997, Calambokidis et al., 2001 as cited in Calambokidis et al, 2008,) with the recalculation of abundances to match samples described in Table 2.

Additionally, another study analyzed the Hawaiian distinct population segment (DPS) humpbackwhalepopulation. Thisstudyshoweda substantial population increase, where the Hawaiian DPS humpback whale population grew from 800 individuals in 1979 to more than 10,000 individuals in 2005 (Figure 10), with the population growth rate estimated to be approximately 6%. NMFS subsequently delisted it from the Endangered Species.

Act in 2016 (NMFS, 2015 as cited in Valdivia et al., 2019).

Consecutively, a study in humpback whale abundance in Hawaii was conducted from 2001 to 2019. However, abundance was estimated as number of whales per scan instead of absolute abundance (scan meaning each observation)(Frankel et al, 2021). Nonetheless, the population trend was also estimated and can be used in the present study.

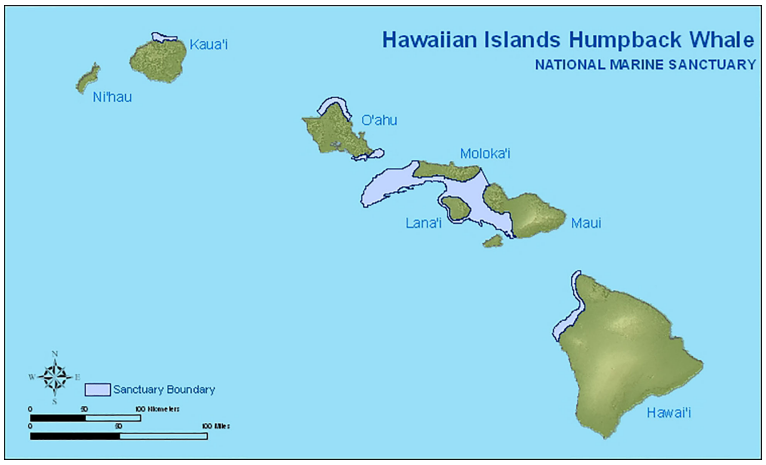

FIGURE 9
Map of Hawaiian Islands Humpback Whale National Sanctuary boundaries. Source: (MapsHawaiian Islands Humpback Whale National Marine Sanctuaries, 2021).

TABLE 2 Estimates of annual increases in humpback whale abundance based on comparison to previous estimates.

Hawaii estimates	Year	Estimate	Year	Estimate	Annual incr.
Adj. year Petersen NPAC to SPLASH	1991-93	3,556	2004-06	7,120	5.5%
Hilborn–Wint/Feed NPAC-SPLASH	1991-93	3,760	2004-06	8,034	6.0%
Peter using SEAK marks	1991-93	5,151	2004-06	10,425	5.6%

Source: Adapted from Calambokidis et al, 2008,).

From 2001 to 2009, there was a relatively consistent increasing trend. Whale numbers peaked in 2010, with a mean count of 34 whales per scan, followed by a period of increased interannual variability lasting through 2015. Whale numbers dropped in 2016 to the lowest value since 2001 and remained low through 2019 (Frankel et al, 2021).

3.4.2 Area under human impact

Extensive research on HIHWNMS regulations was undertaken in order to have a better understanding of the allowed activities within the Sanctuary.

First of all, it is forbidden to “take”, harass, harm, hunt, or shoot any humpback whale in the sanctuary (National Ocean Service, 2020). In addition, other activities are prohibited, such as dumping or dredging, together with any activity that might cause sea bed alteration, for instance, harbor expansion or nearshore construction. Moreover, sand mining and hydrocarbon exploration cannot be undertaken in the sanctuary. However, there are no restrictions on fishing activities, allowing recreational and commercial fishing in the sanctuary but always maintaining a 100-yd distance from humpback whales. Anchoring is also permitted in the sanctuary since is an activity exempted from the altering submerged land prohibition (NOS, 1997). Consequently, US HIHWNMS is minimally protected because it allows extensive fishing and anchoring (Grorud-Colvert et al., 2021).

3.4.3 Existence of a decision-making management body

Nowadays, the sanctuary is being managed through a cooperative federal-state partnership between NOAA's Office of National Marine Sanctuaries and the state of Hawaii through theDivision of Aquatic Resources. The decision-making body is constituted by a Sanctuary Advisory Council made up of different members that represent ocean user groups (e.g., scientists and communities). Its role is to provide advice and recommendations to the federal sanctuary superintendent. All members are appointed by the Office of National Marine Sanctuaries director in consultation with the state of Hawaii. Moreover, the council members name and role can be found on the official website of the Sanctuary.

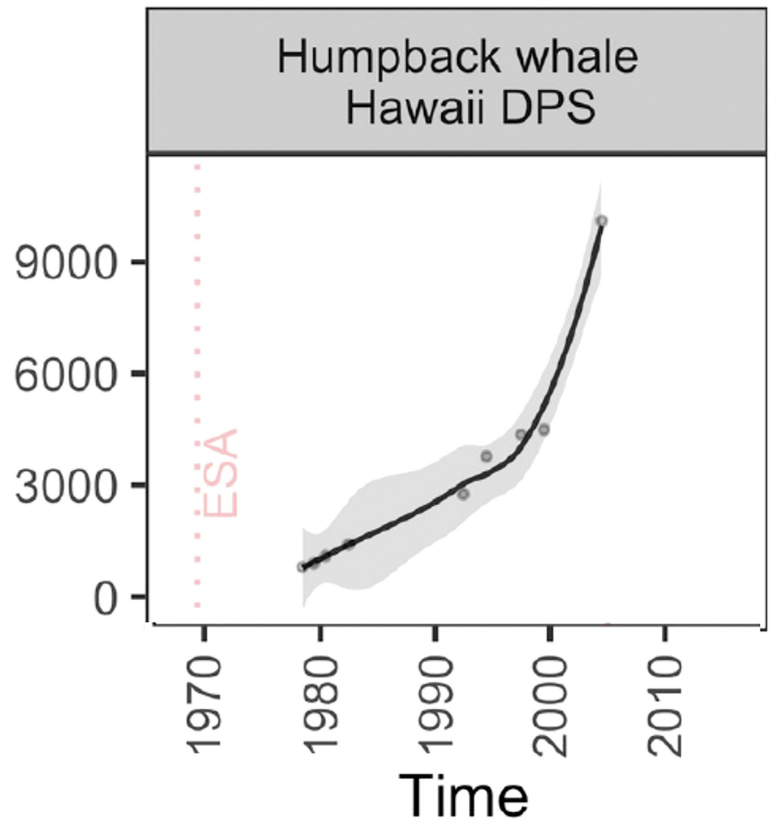

FIGURE 10
Population level trend on Humpback whale Hawaii DPS. Source: Valdivia et al. (2019).

3.4.4 Existence and adoption of a management plan

The current HIHWNMS management plan was completed in 2020 (National Ocean Service, 2020). However, in this study, the completeness of the previous management plans has also been analyzed since the humpback whale population trend was available before 2020. The management plans have undergone successful analysis proving that they contain adequate goals and objectives in conjunction with legislative support (National Ocean Service, 2002).

3.4.5 Existence and adequacy of enabling legislation

Since 1995, NOAA's National Marine Fisheries Service (NOAA Fisheries)—not the sanctuary—is responsible for the protection of whales under the U.S. Marine Mammal Protection Act (MMPA), the Endangered Species Act (ESA), the Hawaiian Islands National Marine Sanctuary Act, and the National Marine Sanctuaries Act (NMSA) (NOS, 1997). Therefore, the existence of adequate legislation has been determined to support the management of the MPA.

4 Discussion

4.1 Marine-protected areas are effective in the protection of marine mammals

In order to assess MPA effectiveness in the protection of marine mammals, this study has analyzed the population trends of several marine mammal species placed in four different MPAs. The results of the recovery trends will be discussed individually to provide accurate assessment.

First of all, regarding the Wadden Sea case study, the increase in the population growth after the establishment of The Trilateral Wadden Sea Cooperation (TWSC) in 1978 suggests that the population is recovering, as can be seen in Figure 3. Previously, harbor seals were hunted until they were critically decimated in 1974 counting a population of only 3,551 animals. Nowadays, the total population of harbor seals in the Wadden Sea numbers approximately 38,126 animals (Jensen et al., 2017). Results also show a decreasing growth rate in the last few years of the survey, which could indicate that the population growth is approaching an asymptotic limit (Jensen

et al., 2017). Therefore, the management and place-based conservation approach on harbor seals have resulted into a full recovery of this species in The Wadden Sea.

Concerning the second case study, the increase in annual survival after the establishment of the Banks Peninsula Marine Mammal Sanctuary suggest that the sanctuary restrictions have resulted into a reduction of Hector's dolphin bycatch. Furthermore, the increase of survival of Hector's dolphins, shown in Figure 6, is biologically significant, with a steady increase of their population. Therefore, this case of study shows an improvement in the demography of a marine mammal species following conservation actions (Gormley et al., 2012).

The present study does not consider Melville Bay in the effectiveness assessment on marine mammal's protection. The governance indicators results suggest inappropriate planning, the lack of governance and poor regulation. Consequently, Melville Bay does not present the basic requirements of an MPA, such as a management plan or a decision-making management body. Since it is legally established as a protected area but is being undermanaged, not ensuring sufficient protection on the ground, it meets the conditions to be defined as a "paper park" (Dudley and Stolton, 1999; Pieraccini et al, 2016). Hence, it must not be taken into account in the assessment of effectiveness because it should not be strictly considered as an MPA.

Lastly, related to the Hawaiian humpback whale population, there is some criticism on how suitable and/or appropriate are MPAs in conserving marine highly mobile species (MHMS) (Wilson, 2016). However, several studies have highlighted the effective contribution of MPAs protecting MHMS when these are placed in critical habitats for the species survival [e.g., Pérez-Jorge et al. (2015) as cited in Kersting and Gallon (2019)].

In addition, Hawaii is well known for being a critical breeding habitat for the humpback whale individuals of the Central North Pacific population (Cartwright et al., 2012). The results of this study show a substantial recovery of the Hawaiian humpback whale population by 2005 (Calambokidis et al, 2008). In fact, The Hawaiian humpback whales were delisted from the Endangered Species in 2016 based on its strong population growth and the mitigation of key threats (NMFS, 2015 cited in Valdivia et al., 2019). These findings underscore the capacity of MHMS such as whales to recover from population declines when conservation actions are implemented in a critical breeding habitat.

However, it is also noticeable that there has been a decrease in the abundance of these species since 2016 (Frankel et al, 2021). Several experts have been hypothesizing about the declines in humpback whale numbers, but no conclusive explanation has been found yet. Nonetheless, the potential hypothesis is related to animal behavior and external environmental factors, outside of the MPA management limitations (NOAA, 2019a).

These results provide an empirical evidence of population recovery on a variety of marine mammal species following area-based protection measures. This study suggests a capacity of marine mammals to recover from population declines when place-based approaches are implemented. This assumption can be addressed in these cases studies. However, further large-scale research is necessary to validate this theory.

4.2 Lessons learned

The indicator results were grouped into five categories depending on the evaluation outcomes; this can be seen in Table 3. This aforementioned table presents the essential data to analyze and compare the indicator results in order to justify biological effectiveness.

First and foremost, there appears to be a parallelism between the governance indicators and the biophysical ones, which can be seen in Table 3. In fact, The Wadden Sea is a good example that biological effectiveness comes with management effectiveness. Supporting the idea that these two elements must work together as part of the same management cycle (Barragán-Muñoz, 2014; Elliott et al., 2017; García-Sanabria et al., 2021). Therefore, far from disconnected, they are interrelated. In addition, Melville Bay is a living example of theopposite. This case study shows how MPAs' conservational goals can be jeopardized, when basic management tools as a management plan and a decision-making management body are missing.

On the other hand, in spite of the fact that HIHWNS (Hawaiian Islands Humpback Whale National Sanctuary) governance indicator results suggest effective management, the species abundance indicators do not have such a good outcome as other case studies, for instance, the Banks Peninsula Sanctuary, which has less favorable management results but a better biological outcome. This controversy supports the theory that despite management efforts, natural disturbances can radically alter ecosystems regardless of how well an area is being managed (Pomeroy et al, 2004).

Moreover, it should also be taken into account the amount of time the management measures were implemented on the different MPAs. For instance, the conservation measures on the Wadden Sea were taken since 1978 and the focal population experienced a full recovery. Future research could investigate the recovery differences on focal populations depending on time variables.

Contrarily to the governance indicators, the biophysical indicator of human impact does not suggest an association with the focal species abundance. How is possible that MPAs have good biological outcomes? Either the allowed activities do not produce an impact in the protection of the animals or the levels of protection are not well classified according to the conservational outcomes.

In the case of Melville Bay, extremely impactful activities such as hunting are being carried out. Hence, the effects of the ongoing overharvesting can be seen in the population composition (NAMMCO, 2019 as cited in Heide-Jørgensen et al., 2020) and in how the area of usage in Melville Bay has shrunk by 84% (NAMMCO-JCNB Joint Working Group, 2020). Therefore, allowed activities based on human impact can affect the biological outcomes.

Consequently, perhaps the levels of protection corresponding to the allowed activities are not being correctly evaluated. For example, The Wadden Sea was categorized as minimally protected because oil prospecting is considered incompatible with conservation and should not occur in any MPA (Grorud-Colvert et al., 2021). However, so far, high safety and environmental standards have paid off and no negative side effects to the surrounding areas have been reported (Baer and Nehls, 2017).

The precautionary principle is deeply rooted in the scientific field, being especially important in marine environment management, where scientific uncertainties abound. In its essence, the precautionary principle requires taking action in the form of protective conservation and management actions to reduce the risk of harm from an activity before negative consequences become apparent. The establishment of MPAs itself is thus a precautionary act (Antarctic Ocean Alliance, 2013). However, some respectable scientists in the marine spatial management field want to take it to a new level, recommending to focus on creating MPAs, or modifying existing MPAs, to make highly protected IUCN Category I reserves (Hoyt, 2021). In these areas, all extractive and potentially disturbing activities are prohibited. Even though these reserves provide many benefits to science, several reports show how reluctant politicians and policymakers are to them (Ballantine and Langlois, 2008).

The present study suggests that fully protected areas are not necessary to obtain noticeable biological benefits in marine mammals. Perhaps, a better approach to improve management effectiveness and meet governmental goals could be found through a more active strategy instead of implementing the precautionary principle, which might be more focused on preservation than conservation.

Alternatively, an adaptive management has a different approach when scientific uncertainty exists. Adaptive management incorporates research into conservation actions, focusing on an ongoing monitoring and evaluation of the MPA. Therefore, adaptive management enables a continuous improvement of the MPA, with its inherent uncertainty, based on a constant evaluation on the management actions.

Overall, whereas in the precautionary principle, everything is treated as threat, adaptive management approaches are context specific. Therefore, applying the adaptive management will allow us to address the exact issues and threats that affect the marine mammals leading to similar levels of protection than the fully protected areas because Category I Reserves would take everything as a threat, even what is not. Addressing issues that do not affect the species does not increase management effectiveness. On the contrary, it will lead to less financial benefits and more political resistance.

4.3 Recommendations

Aichi Target 11 of the Convention of Biological Diversity (CBD) promotes the expansion of the global protected area

TABLE 3 Assessment of the indicators values for each case study, categorization based on the evaluation undertaken in

Values: -> Very good -> Good -> Neutral -> Bad - > Very bad.

Case studies \ Indicators	Indicator 1	Indicator 2	Indicator 3	Indicator 4	Indicator 5
	Focal Species Abundance	Human Impact	Decision-Making management body	Management Plan	Enabling Legislation
The Wadden Sea					
Banks Peninsula Marine Mammal Sanctuary					
Melville Bay		?			
Hawaiian Islands Humpback Whale National Marine Sanctuary					

network to cover 17% of all terrestrial land and 10% of coastal and marine areas by 2020 (Convention on Biological Diversity, 2022). However, the accelerated increasing rate of protected area coverage, shown in Figure 11, could lead to have many protected areas that will be only "paper parks."

The effective management of protected and conserved areas is embedded in Aichi Target 11 "effectively and adequately managed." Consequently, the Global Database on Protected Area Management Effectiveness (PAME) was developed in order to assess how well the areas are being managed (UNEP-WCMC, 2017). However, in total, only 11% of the protected areas present in The World Database on Protected Areas (WDPA) have been assessed by 2020 (UNEP-WCMC and UNEP-WCMC and IUCN, 2022).

Moreover, PAME assessments are obtained from data providers, which are entities or individuals that manage the protected areas (UNEP-WCMC, 2017). Therefore, the process of assessing management once the MPA is already accounted in the Aichi Target 11 is not common, even if one of the targets set by Parties to the CBD is to assess 60% of the total protected areas effectiveness. The clear limitation of this indicator is that it does not reveal how effectively the world's protected areas are managed; it simply illustrates where assessments have been carried out (UNEP-WCMC and UNEP-WCMC and IUCN, 2021).

In this regard, the present study would like to highlight the necessity to better monitor the effectiveness of MPAs to avoid more cases like Melville Bay. With this purpose, future research could examine the possibility of developing a new chapter in The World Ocean Assessment (WOA) including MPAs or, even better, the first MPAs' world assessment. This global assessment could be written by a group of experts instead of the managers itself. All protected areas present in the WDPA may be considered in the evaluation. The assessment, although not a policy document, could provide the same benefits for countries than the PAME evaluations, such as determining which management aspects are more effective, prioritizing resources where they are needed the most, and officially reporting Aichi conservation target (UNEP-WCMC, 2017). Moreover, this "tool" could be used as double- edged sword, simultaneously pressuring the governments and providing them with the scientific guidance to enhance their MPA effectiveness.

5 Conclusion

As the amount of MPAs in the world is increasing at an accelerated pace, it is important to understand the effect of these management tools in the population of protected species. By investigating the effectiveness of MPAs in the protection of marine mammals, the present study provides ample empirical evidence that area-based protection measures can be effective for different types of marine mammals. In addition, the lessons learned obtained through the outcomes of an array of different and complementary indicators showed different approaches to enhance MPAs' overall effectiveness. On this basis, it became the need of an independent assessment for the global evaluation of MPAs' effectiveness. Furthermore, this study suggests that an adaptive management, being context-specific, is possibly more effective than the precautionary principle. Overall, these findings provide evidence for discussion and further research on the protection of marine mammals and spatial management effectiveness.

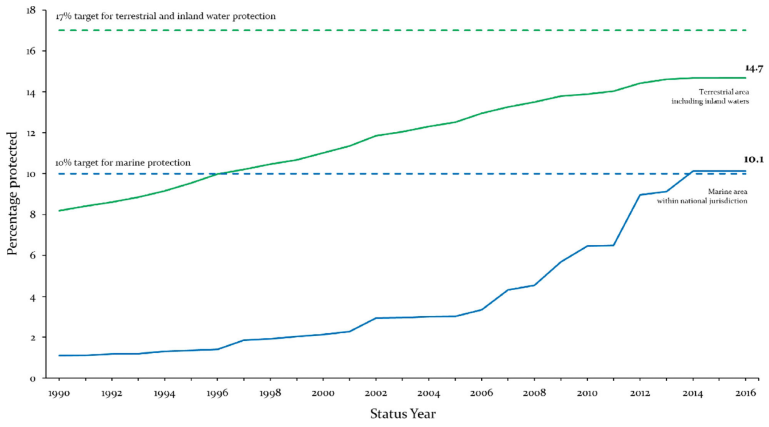

FIGURE 11
Growth of the global protected area network since 1990 [source: UNEP-WCMC and IUCN 2016 as cited in UNEP-WCMC (2017)].

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

The research was done for EGT guided and supervised by JGS. All authors contributed to the article and approved the submitted version.

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Conflict of interest

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

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmars.2022.940803/full#supplementary-material

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Glossary

MPA	marine-protected area
NOAA	National Oceanic and Atmospheric Administration
CITES	Convention on International Trade in Endangered Species CMS
IUCN	International Union for Conservation of Nature CITES
Species CMS	Convention on Migratory Species
UNCLOS	United Nations Convention on the Law of the Sea CBD
Sea CBD	Convention on biological Diversity
ICRW	International Convention for the Regulation of Whaling WCPA
Whaling WCPA	World Commission on Protected Areas
TWSC	Trilateral Wadden Sea Cooperation
CWSS	Common Wadden Sea Secretariat WSSA
WSSA	Conservation of Seals in the Wadden
Sea DOC	Department of Conservation
MFish	Ministry of Fisheries
NAMMCO	North Atlantic Marine Mammal Commission
JCNB	Joint Commission on the Conservation and Management of Narwhal and Beluga
JWG	Joint Working Group
UNEP	United Nations Environment Programme
WCMC	World Conservation Monitoring Center
PAME	Protected Area Management Effectiveness NMFS
Effectiveness NMFS	National Marine Fisheries Service
HIHWNMS	Hawaiian Islands Humpback Whale National Marine Sanctuary NOS
NOS	National Ocean Service
MMPA	Marine Mammal Protection Act ESA
ESA	Endangered Species Act
NMSA	National Marine Sanctuaries Act
MHMS	marine highly mobile species
WDPA	World Database on Protected Areas

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Challenging the new blue deal by embedding interactions with the non-humans in the offshore renewable energy development

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This paper is challenging the new blue deal outlining the need for a change in the expectative. Offshore wind farms (OWFs) are not only a climate-friendly way of producing electricity but also a shifting paradigm unique opportunity, acknowledging the increasing presence of anthropogenic infrastructure in the marine environment and seeing them as the place for recreating relations with non-humans and work with them. We give some ideas that could ground a research program pairing both positive and negative aspects of OWF and study the conditions of realization of mutual beneficial relationship coming from the "mosaic of open-ended assemblages of entangled ways of life."

KEYWORDS

OWF, MPA (marine protected area), reef effect, entangled mesh, world-making, interconnectedness, hybridity, assemblages

Introduction

Offshore wind farm (OWF) development is increasingly seen as a climate-friendly way for energy supply by contributing decarbonizing and reducing greenhouse gas emissions and achieving the United Nations Sustainable Development Goal 7 "Affordable and Clean Energy" (IEA, 2019; Galparsoro et al., 2022). In addition, technological advances and increasing demand for renewable energy (Glarou et al., 2020) added to the European goal of climate neutrality by 2050 and lead to the integration of this technology option into the future energy mix. Hence, the European Union (EU) forecasts that offshore wind must provide 30% of Member States' electricity demand by 2050, increasing from the current 12 Gigawatts (GW) capacity to 300 GW, hence multiplying by 15 the marine space allocated to wind energy (Lloret et al., 2022). The US Department of Energy (DOE) as well has set a goal of 54 GW installed by 2030 and is planning for 86 GW to be installed by 2050 (Goodale and Milman, 2019). This ocean sprawl (Duarte et al., 2013; Firth et al., 2016) will at least modify the occupation of the

marine space and consequently the status of marine ecosystems. One can imagine that introducing a deep technological artifact will alter the living conditions of the inhabitants and hence disturb the environment or users of this environment. This new potential source of alteration of marine spaces must be added to the list of disturbances and pressures already existing in the marine space and recorded through the 11 descriptors of good environmental status of the Marine Strategy Framework Directive (MSFD) adopted in 2008. What does this perspective imply for marine life and the present ocean users? Will the development of wind power be an additional pressure on ecosystems when we are struggling to reduce those that are actually harming the marine environment? What if this large-scale deployment initiates a new era of our development model looking for a symbiosis between energy production for human use and proliferation of marine life? How does this challenge open up new perspectives for approaches to conservation and economic development? To clarify these issues, we first review the literature identifying socio-ecological impacts of OWF development. Then, we explore the contemporary thoughts that pave the way for imagining a symbiotic relation between energy production and marine life. Then, we conclude by identifying grounds for future research.

OWF, a threat for marine life and users of the ocean but also an asset

OWFs are and will be increasingly established in marine areas to meet the rising global demand for renewable energy, hence experiencing the ocean sprawl. For Europe, however, this development must be consistent with the commitments to marine biodiversity protection and strategic planning. Those latter are contained respectively in the MSFD (Directive 2008/56/EC), which came into force in 2008 as the environmental pillar of European maritime policy, and the Maritime Spatial Planning Directive (MSPD; Directive 2014/89/EU). While the former aims to maintain or restore the functioning of marine ecosystems, the latter aims to promote the sustainable growth of maritime economies, the sustainable development of maritime spaces, and the sustainable use of marine resources. To achieve this, Member States must take into account economic, social, and environmental aspects by applying an ecosystem-based approach and promote the coexistence of relevant activities and uses. In this context, OWF as one pillar of the blue economy provides obvious benefits while producing renewable energy but may induce several ecological disruptions in marine environment and socioeconomic upheavals, known as negative externalities. They can provide some positive impacts as well. With few exceptions like Galparsoro et al. (2022), the scientific literature reviews separately negative and positive impacts. Hernandez et al. (2021) stress the importance of understanding the relationship between the activities associated with an OWF and their impacts, distinguishing effects from impacts (Taormina et al., 2018; Hernandez et al., 2021). They can be classified considering the ecological levels and the spatial and temporal scales (Hernandez et al., 2021). Whereas effects consider modifications of environmental parameters, such as the substrate type, hydrodynamics, water temperature, noise, or electromagnetic fields, the impacts are the changes observed at the receptor level, that is, the ecosystemic compartments (biotopes, biocenocis), ecological levels (populations or community), and some ecological processes within marine ecosystems (trophic interactions) (Hernandez et al., 2021). OWF effects and impacts might be present at the three stages of OWF development (installation, operation and maintenance, decommissioning) regardless of technologies used (Furness et al., 2013; Bailey et al., 2014; Bergström et al., 2014; Schuster et al., 2015).

Among the negative impacts are collision risks with avian and bat collision above the water and entanglement of marine vertebrates or marine mammals with underwater structures (Inger et al., 2009; Peschko et al., 2020; Peschko et al., 2021), underwater noise could generate stress (Wahlberg and Westerberg, 2005; Madsen et al., 2006; Cook et al., 2018; Glarou et al., 2020; Mooney et al., 2020; Tougaard et al., 2020; ; Maxwell et al., 2022), generation of electromagnetic fields that could be a concern for some fish species that are magneto-sensitive or that use geomagnetic field information for orientation purposes (Peters et al., 2007; Normandeau et al., 2011; Gill et al., 2014; Maxwell et al., 2022), and loss of soft bottom habitats with the introduction of hard bottom substrata (Glarou et al., 2020). Maxwell et al. (2022), acknowledging the abundance of literature about fixed offshore wind turbines, do it as well, focusing on floating wind turbines. They all mainly identify ecosystem degradation; habitat loss for marine mammals, fish, benthic communities (at the installation and operation stages); habitat disturbance for birds and bats (at the operation stage); changes on habitat at the seabed level for benthic communities (at the installation and decommissioning stage); and physical damage for marine mammals, birds, and bats (at the installation, operation stage). However, there are still gaps in scientific knowledge about the ecological impact of wind turbines (Dannheim et al., 2020; WWF, 2014); especially, uncertainties remain regarding the assessment of cumulative impacts (Galparsoro et al., 2022). Nevertheless, Gartman et al. (2016a); Gartman et al. 2016b) identify how to design turbines and operate their installation and operation to minimize impacts on marine species and habitats and reduce risks on marine life.

However, this discussion is site-specific. It depends greatly on location. The magnitude and the matter of concern are determined

case by case for each specific OWF project. The initial state and resilience of the area can vary and impact differently some ecosystem elements (Causon and Gill, 2018; Gill, 2005; Cook et al., 2018; Galparsoro et al., 2022). Lloret et al. (2022) demonstrate that importing the northern European sea OWF model development to the Mediterranean Sea is not straightforward. That is why each project, as a response to a call for tenders, is supposed to carry out an impact analysis showing in each specific case what the issues are. Indeed, OWF projects must be consistent with biodiversity protection and conservation objectives like Sustainable Development Goal (SDG) 14 or Convention on Biological Diversity at the international level or Marine Strategy Framework Directive (MSFD) at the European level.

Moreover, as this implementation occurs in a crowded ocean, not only marine life but also some human uses and activities could be disrupted as well (Inger et al., 2009; Glarou et al., 2020). Conflicting marine activities and competing uses of the littoral zone are likely to arise, as well as different societies' inherent values regarding legacy and "patrimonialization" in coastal regions (Bell et al., 2013; Bidwell, 2017; Lloret et al., 2022). Although OWF can be seen as visually appealing, representing a shift toward clean energy in the future, it could compete spatially with some other uses, mainly fishing, but also shipping, extraction of resources, tourism (Virtanen et al., 2022) that are responsible for current pressures and cumulated impacts on marine environments and their degradation while OWFs are not yet implemented. OWFs could also face societal opposition and disapproval especially from close by communities (Kermagoret et al., 2016; Virtanen et al., 2022). Therefore, the OWF is developed as part of marine spatial planning, especially in Europe, since the EU set a target in May 2020 to protect 30% of the EU's seas by 2030 when launching the EU Biodiversity Strategy 2030.

But wind farm implementation could also have positive effects by increasing the abundance and biodiversity of hard bottom species due to reef effects (provision of food, spawning, nursery, shelter opportunity) (Punt et al., 2009; Wilson and Elliott, 2009; Langhamer, 2012; Reubens et al., 2013; Ashley et al., 2014; Bray et al., 2016; van Hal et al., 2017; Glarou et al., 2020; Coolen et al., 2020; Degraer et al., 2020). Indirect impacts, such as the increase in prey species that results from the creation of a no-fishing zone for safety reasons in the OWF, may in some cases have positive impacts. The increase in prey species will increase the availability of food for higher trophic levels (Galparsoro et al., 2022) and outlines the need for an ecosystem-based approach when considering the suitability of wind farm implementation. Creating a no-take zone within the OWF can also favor possible spillover effects to neighboring areas (Ashley et al., 2014; Coates et al., 2016; Halaouani et al., 2020). As an example, Langhamer (2012) outlines how the artificial reef effect is important when constructing scour protections; it can generate an enhanced habitat, creating heterogeneity in the area that is important for species diversity and density. OWFs could also behave as marine protected areas (MPAs) by being exclusion zones to destructive fishing activities like trawling (Ashley et al., 2014; Halouani et al., 2020). Indeed, prohibiting trawling near OWFs eliminates fishing pressure and decreases disturbance of fish benthos and benthic habitats (Teilmann and Carstensen J 2012, Galparsoro et al., 2022). Here again, location matters and can differ among organisms (Langhamer, 2012). Benefits will only be realized with consideration of the layout, design of OWF arrays, location, and access rules. Illustrative evidence of the reef aspect and spillover effect is the discussion around the "rigs to reef" in the context of decommissioned offshore man-made installations that pave the way of "renewables to reefs" (Smyth et al., 2015). Fowler et al. (2018) conducted a global survey of environmental experts to guide the best decommissioning practices in the North Sea. Whereas partial removal options were considered to deliver better environmental outcomes than complete removal platforms, they were equally supported for wind turbines. The key elements under discussion here are biodiversity enhancement, provision of reef habitat, and protection from bottom trawling (Fowler et al., 2018). This reef effect is confirmed by Coolen et al. (2020); by conducting a multivariate analysis, they compared data from old oil and gas platforms with data of a young wind farm and a natural reef. They showed an overlap in communities on steel and rock and between the wind farm and platforms (Coolen et al., 2020). Callahan and Jackson (2014) explored the future of California's offshore oil and gas platforms and assessed the economic and ecological efficiency of a "rig-to-reef" program through a cost–benefit analysis and concluded that such a program would result in direct and indirect benefits that far exceed the costs. When displacement of fisheries occurs and is of particular concern, the artificial reef effects could be an argument for exploring the coexistence of OWF and fisheries (Hooper et al., 2015). Indeed, the co-location already exists off the coast of Louisiana in the Gulf of Mexico where oil and gas platforms are used by recreational fishermen and scuba divers (Stanley and Wilson, 1989; Gordon, 1993).

A discussion that remains within the minimizing risks perspective: The need for a change of paradigm seeking for hybridity

The literature review allows to consider OWF development projects' pros and cons and how much they are site-dependent. Major studies discuss separately wind farms' positive and negative effects related to the different projects' locations focusing on one side on disruptions and on the other side—however to a lesser extent—on reef and MPA benefiting effects. Literature neglects assessing systematically both sides jointly. At the very best, discussions about wind farm developments and their locations try to be the least invasive concerning other

existing activities and try to minimize the associated risks. From one specific project point of view, this approach allows to consider the necessary trade-offs to be made. But it remains within the paradigm of impact minimization and cost–benefit analysis. This approach is in line with the thinking that considers economic development on one hand and environmental preservation on the other. The very few studying both negative impacts and benefits conclude asking policymakers "whether installations should be designed to either minimize negative environmental impacts or as facilitators of ecosystem restoration" (in Inger et al., 2009). Is this enough for overcoming issues at stake that face climate change upheavals and loss of biodiversity in an ocean sprawl? In Europe, the existing institutional and political frameworks with the MSFD (Directive 2008/56/EC) and the MSPD (Directive 2014/89/EU) together with the blue growth challenge and the EU Biodiversity Strategy 2030 shape a context that calls for a new conception of marine space. This new conception could be based on recent philosophical proposals. Recent proposals allow us to consider the relationships between humans, their actions, and their non-human environment in a more integrated way and with a different ambition than that of minimizing impacts. In this perspective, what if the ocean sprawl becomes the opportunity of establishing a mutually beneficial relationship between biota, users of the sea, and man-made infrastructure (Glarou et al., 2020)? The OWF would not be considered only as disruptive or benefiting projects but rather as a disturbance occasioning fluctuating assemblages between humans and non-humans alike. Those assemblages would be multispecies "world-making projects" in line with a renewal ecology (Bowman et al., 2017), a symbiotic economy that would showcase a shifting development pathway groundbreaking with business-as-usual trends.

OWF as a disturbance occasioning fluctuating assemblages between humans and non-humans alike

OWFs could challenge the traditional dichotomy between conservation and exploitation because they could initiate new ways of inhabiting the world. Michel Serres and Philippe Descola put an end to the great division between nature and culture (Boemare, 2021). The former by calling for a natural contract to be negotiated between Earth and its inhabitants and granting nature the status of a legal subject (Serres, 1990). The latter by stressing on the existing different conceptions of relating human and non-human and shaping new ontology about nature–culture relations (Descola, 2005, 2013 for the English version). Hence, the idea of inhabiting the Earth within an interspecific co-habitation with non-human has emerged far away from the "modern" vision of the 17th century inherited from Descartes for whom the project was to become master and possessor of nature. This approach is enlarged to things and objects by Morton (2012); Haraway (2016), and Coccia (2019); Coccia (2020); Coccia (2022).

The landscape and the territory as a life artifact

We follow on the analysis proposed by Boemare (2021). The first step is to explore what life is, awakening awareness of the oneness of life that runs through all living things, leading to an understanding of culture and nature (Coccia, 2019). Coccia (2019) proposes in the sower a useful interpretation of the painting Sower at Sunset of Vincent Van Gogh. The starting idea, well known to biologists, is that at the base of life is the process of capturing light and solar energy and transforming it into organic matter. Growing up is a process of accumulating light in the body; it is still metabolized light that both and identically animals and humans seek to capture in the tissues of their prey. Van Gogh's painting shows the sower and a tree on the same foreground outlining no difference between sowing whether it will be a human's or vegetable's act. Hence, the landscape and therefore the territory are resulting from the various strategies of human, animal, or vegetable seeding, of each of the live beings that compose it. There is no more artificiality in the act of the sower than in the act of the plant, "every species cultivates and constructs the world differently"; they are both developers of space, the territory is co-constructed by the species that animate it. The landscape is thus a "random accumulation of disparate living individuals … each species is the agro-ecological territory of the other: each being is the gardener of other species but also the garden of other species, and what we call 'world' is finally only a relationship of reciprocal culture." His conclusion enlightens the notion of wild nature, "in this sense there is no wild space, because everything is cultivated and because being in the world means gardening other species, and at the same time and with the same gesture being the object of the seeding of others … Each landscape is thus an ephemeral, artificial installation provisionally constructed by the sowing of its inhabitants," which is the essence of living. Enlarging the analysis, he sees the earth as a non-natural space but a "life artefact, no less artificial than a chair or a smartphone" (Coccia, 2022).

A life artifact composed of living and non-living beings in an entangled mesh

The second step takes root in Morton (2012). Morton (2012) is opposed to the idea of a face-to-face confrontation between

man and nature. He pleads for a participative ecology that experiences the interweaving and coexistence of things and beings (Morton, 2012). He argues that all forms of life as well as all dead forms, just like the environment composed of living and non-living beings, are connected in a vast entangling mesh. But what are those things interconnected? The mesh is vast in Tim Morton's work and confronts us with encountering "strange strangers." Those are the ones, beings and things of all kinds, with which the things we look at are likely to enter into relation, to coexist. Hence, this interconnectedness penetrates all dimensions of the natural and the artificial: no being, construct, or object.

Less is more, the necessity of cooperation and symbiosis to inhabiting disorder

It allows him to account for the idea that thinking the mesh means that "less is more" like two married people pay less taxes than two single people because in a sense they are less than two (Morton, 2012). Because each one needs the other to exist, there are no two single parts interconnected but interdependent like bacteria in the human stomach. In Morton's theory, it leads to the very interesting necessity of cooperation and symbiosis to exist. In this, he joins and relies on Margulis (1981) for whom symbiosis is the driving force of evolution. He is not very far away from Haraway (2016) arguing for sympoiesis, the "making-with" idea that nothing is self-organizing. Since all things depend on each other, we have a good reason to pay attention to things. The destruction or creation of some things will affect others, since we cannot exist independently. Meeting with strange strangers, we have to accept "inhabiting disorder" (Haraway, 2016), which means "to risk getting back to earth, to follow the tangled threads of everything that makes up the complicated fabric of the world, the wefts that attach to each other, not only humans, the earth, other species, biological elements, but also artifacts, technologies, and objects mixed together…" (Caeymaex et al., 2019).

Renewing relationships: Assemblages as multispecies "world-making projects"

The detour we made through the analysis of the sower's chart, the entangling mesh, and inhabiting the disorder is useful because it renders obsolete the arbitrations between artificiality and naturalness, domestic and wildlife and allows for a shift that considers the actions of the species that inhabit a territory, and therefore their impacts, as powers to act. These powers of action are inscribed in time and space. As such, the landscape is an ephemeral and contextual temporal construction. For those who wish to intervene on the territory, the objective of prioritizing an ecological composition rather than another in reference to a known ideal state of the past is no longer necessarily appropriate and allows thinking about the territory, its composition, and the exploration of its possible futures with other criteria that can be debated by "ruminating" as proposed by Isabelle Stengers (Boemare, 2021).

The project of acting becomes that of defining "new and more attentive ways" of relating to other beings in order to make the world with them (Despret, 2019; Stengers, 2019; Morizot, 2020). The erosion of biodiversity and environmental upheavals can then be understood as a "crisis of relations" between live beings, things. The project becomes one of building, rebuilding, and renewing these relationships and "reviving the world" (Latour, 2021). For research, remedying the erosion of biodiversity and the living requires conducting a program that places the powers of action as the meshes of a web of entangled relationships to be constructed. We also need tools for its operationalization.

Discussion

How far this analysis helps us thinking to OWF development? What if one grabs this moment, seizes this window of opportunity of OWF development to change our way of being in the world operating a true metamorphosis challenging the new blue deal? The institutional and political context is favorable. Wind energy development projects are part of national energy transition strategies aligned with ambitious international climate and biodiversity protection objectives. They are also integrated for European states in a regulatory framework formed by a national planning imposed by the European directive on strategic planning establishing a framework for maritime spatial planning. The governance of the ocean is being reshaped (Guerreiro, 2021). A wind turbine is an artifact, it is also a portion of territory engaging economic activities and marine life on the ground and throughout the height of the water column on the whole territory of the farm but also on land. A contemporary and fruitful avenue for research would be to put at the core of research the idea of interconnectedness and to seek around offshore wind turbines the creation of interspecific assemblages that maximize the benefits for both humankind and biodiversity. This would allow us to take advantage of the advances in science and philosophy while being careful not to fall into unbridled optimism and remaining conscious of our cultural hubris. Indeed, we face here a moment of "wild renaissance" (Logé,

2019) where cross-cutting knowledge between ecology, economy, biosemiotics (Emmeche and Kull, 2011), and anthropology but also the opening to a new sensibility can lead to a metamorphosis of our way of being in the world (Coccia, 2020; Latour, 2021). Paradoxically, this new perspective should emerge thanks to an "enlarged anthropocentrism" allowing us to make a common world (Bimbenet, 2017) and operate the necessary decentering and multiplication of worlds (Viveiros de Castro, 2009). We first need rethinking habitats and worlds as environments in an Uexküll sense. In an operational way, it consists of translating and taking into account the "world" produced by each living being in its specific way of inhabiting it, that is, by considering that each living being accesses its surroundings through its physiological senses (Uexküll, 1934). This is a subjective "world view." These being different from one species to another, living beings of multiple species can at the same time inhabit a different and similar environment. The mesh obtained will represent the juxtaposition of "environments-worlds." These "environments-worlds" are made of more or less broad series of elements, "carriers of significance," and "marks" that are the only things that interest the animal. These new elements could be integrated in an ecosystemic framework and related to the OWF pros and cons reviewed. The MSFD and MSPD directives would shape their development and ensure consistency with the new governance of the ocean. We would then be up to locate, design, and define OWF access rules at each specific site in a way that fosters mutual beneficial relationships coming from the "mosaic of open-ended assemblages of entangled ways of life" (Morton, 2018).

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

The author confirms being the sole contributor of this work and has approved it for publication.

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Conflict of interest

The author declares 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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Diversity in marine protected area regulations: Protection approaches for locally appropriate marine management

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Globally, marine protected area (MPA) objectives have increasingly shifted from a primary focus on maintaining ecosystems through prohibiting extractive activities, to more equitable approaches that address the needs of both people and nature. This has led to MPAs with a diverse array of fisheries restrictions and recent debate on the type of restrictions that contribute to achieving biodiversity goals. Here we use a global dataset of 172 MPAs (representing 31 nations) alongside nine detailed case study MPAs (from Australia, Belize, Cambodia, Federated States of Micronesia, Fiji, Indonesia, Madagascar, Solomon Islands, and United States of America), including partially protected areas that allow regulated fishing, to illustrate the many diverse pathways that some MPAs have adopted to protect biodiversity and safeguard the rights and well-being of resource-dependent coastal communities. We group MPAs based on their restrictions and explore four key insights emerging from these groupings using our nine case studies: (i) MPAs use highly diverse approaches to regulate fisheries; (ii) partially protected areas can address gaps in regional fisheries management; (iii) devolving resource management rights to communities influences the chosen fisheries restrictions; and (iv) state-governed MPAs can use highly tailored fisheries restrictions to increase equity in access. We find that partially protected MPAs can offer effective and equitable pathways for biodiversity conservation if tailored to local context. Rather than focusing primarily on fully protected areas for achieving new

global MPA targets, we recommend countries use a blend of locally-appropriate protection levels – from fully protected areas to partially protected MPAs to achieve positive biodiversity outcomes.

KEYWORDS

marine protected area (MPA), partial protection, fisheries regulation, marine management, biodiversity targets, MPA

1 Introduction

Globally, area-based conservation has undergone an evolution from a historical focus on protecting ecosystems through access restrictions, to more equitable approaches for both people and nature (Sandbrook et al., 2011; Mace, 2014; Tallis and Lubchenco, 2014; Garnett et al., 2018; Dawson et al., 2021). With this shift comes an increasing need to recognize a diverse spectrum of approaches to achieve conservation outcomes. The design and implementation of Marine Protected Areas (MPAs), which are commonly used conservation interventions in response to declines in ocean health, have also followed this broader evolution (Pendleton et al., 2018; Campbell and Gray, 2019). For example, those establishing MPAs increasingly engage marine stakeholders in the design and implementation phases and include social considerations in their targets or outcomes (Campbell and Gray, 2019). As many coastal communities depend on coastal ecosystems, there is a need for approaches to marine protection that include and address the diverse needs of marine stakeholders while protecting biodiversity. Many MPAs increasingly have objectives to support building resilient social-ecological systems (Cinner et al., 2012; Mace, 2014).

MPA coverage has rapidly expanded in recent years, in part driven by countries' commitments under the Convention on Biological Diversity Aichi Target 11 to designate 10% of their marine areas as MPAs by 2020 (Grorud-Colvert et al., 2019). This global commitment to expand MPA area was further reinforced by Goal 14 ('Life Below Water') of the UN Sustainable Development Goals, which also adopted a target for nations to designate 10% of their marine areas under protection. MPA coverage increased from 0.5% of global marine area in 2004 (Toropova et al., 2010) to 7.7% in 2020 (UNEP-WCMC and IUCN, 2021)—and has been accelerated by the designation of some very large, isolated (i.e. remote) MPAs (>100,000 km^2) (Toonen et al., 2013). The recent adoption of the Kunming-Montreal Global Biodiversity Framework, of which Target 3 calls for nations to 'ensure and enable that by 2030 at least 30 percent of … coastal and marine areas … are effectively conserved and managed' seems likely to further accelerate and incentivize global growth in marine protection (CBD, 2022).

IUCN defines an MPA as: '*A clearly defined geographical space, recognised, dedicated, and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values*' (Dudley, 2008). While the IUCN definition is recognized globally, in reality, MPAs are often defined differently in each jurisdiction based on the priorities and legal systems of the country, the national or sub-national legal instruments used in designation, and the naming conventions for protected areas in the country (e.g. Amkieltiela et al., 2022). MPAs are required to set objectives based on achieving positive outcomes for nature to meet the global IUCN definition – such as increases in marine species abundance, biomass, and age-class (Dudley, 2008). MPAs must be implemented in areas where human activities currently or in the future would otherwise be damaging or unsustainable for the marine environment to deliver positive outcomes for nature. Protection levels within MPAs can vary, and the term MPA has always covered a wide range of levels of protection. These range from 'fully' protected areas (where all extractive and damaging activities are prohibited) and 'highly' protected areas (where only activities with low environmental impact are allowed), to 'lightly' protected (with moderate extractive activity, e.g. gear restrictions or periodic harvest), to only 'minimally' protected with fewer restrictions on fishing or other extractive activities (Day et al., 2012; Horta e Costa et al., 2016; Grorud-Colvert et al., 2021). A global synthesis suggests that 94% of MPAs allow some form of fishing (Costello and Ballantine, 2015).

There has been debate on the required minimum levels of protection for MPAs to count towards marine protection targets (Agardy et al., 2003; Agardy et al., 2016; Pendleton et al., 2018). On one end of the spectrum, it is argued that only fully or highly protected MPAs (i.e. MPAs that prohibit extractive activities or only allow those with minimal environmental impact) should count towards biodiversity targets (Davis, 2012; Pendleton et al., 2018; Sala and Giakoumi, 2018; Sala et al., 2018). This 'biodiversity first' focus, however, risks misalignment with current conservation thinking around inclusivity and equity in conservation and the need to support resilient social-ecological marine systems. While there is strong evidence that effectively managed, isolated, large, older, fully or highly protected MPAs provide the greatest biodiversity outcomes (Lester and Halpern, 2008; Sciberras et al., 2013; Edgar et al., 2014; Sala and Giakoumi, 2018), such strict protection is ill-suited to many areas. In addition, there is a paucity of empirical data to illustrate the efficacy of 'lightly' protected areas, many of which are critical to the integrity of social-ecological systems (Cinner et al., 2016; Crane et al., 2017a; Crane et al., 2017b). Some of the most biodiverse ocean areas—and those in most urgent need of protection—are located in places where marine resource use is deeply intertwined with culture (McClanahan et al., 2006; Crane et al., 2017a) and critical for livelihoods and food security (Loper et al., 2008; Cinner et al., 2016). Furthermore, greater returns on investment from MPA establishment for biodiversity can be expected in locations where

people are moderately extracting resources, rather than in places that are suitable for fully protected areas (i.e. isolated areas with low extraction rates) (Cinner et al., 2018).

In this paper we discuss how positive biodiversity outcomes can be achieved from MPAs with diverse fishing restrictions. We seek to identify how different and diverse regulations could be combined within MPAs to achieve different forms of partial protection. We refer to MPAs which do not prohibit all fishing as 'partially protected' areas (Lester and Halpern, 2008; Sciberras et al., 2013; Zupan et al., 2018) in contrast to MPAs that prohibit all fishing activity known as 'fully' protected areas or no-take areas (Grorud-Colvert et al., 2021). We then, through comparative analysis of case studies, evaluate how local context may have influenced MPA regulation choices. Specifically, we use global data and nine case study MPAs—including partially protected areas—to illustrate different MPA implementation strategies that could be used to protect biodiversity while also safeguarding the rights and well-being of resource dependent communities. We first develop and apply a classification framework to explore MPA restrictions across highly diverse contexts. We then focus on fisheries restrictions within MPAs, given these represent a major source of social conflict between local communities and management authorities in many MPAs. We identify common groupings of MPAs based on restrictions and evaluate the restriction choices and local context for the case study MPAs. Through this effort, we illustrate and evaluate potentially locally appropriate marine conservation measures and how they might support more positive and equitable biodiversity outcomes – especially for linked social-ecological systems.

2 Methods

2.1 Protection classifications and definitions

Several typologies have been developed for describing MPAs based on their objectives, regulations, or permitted activities. IUCN defines protected area categories based on the objective of an MPA or zone provided that biodiversity conservation is a primary goal (Day et al., 2012). Other MPA classifications have been proposed, for example, by broadly grouping MPAs into different categories based on fisheries gear restrictions, other human activities (e.g. aquaculture), and accessibility (Horta e Costa et al., 2016), or by level of protection and stage of MPA establishment (Grorud-Colvert et al., 2021). Fisheries restrictions are also often classified based on input rules (e.g. limited entry, time restrictions, gear restrictions), output rules (e.g. allowable catch limits), or technical measures (e.g. size limits, time or area closures) (Selig et al., 2017).

Many MPAs do not have a single set of static regulations that are applied in the long-term and across the entire MPA. Instead, many MPAs manage extractive use based on complex interwoven restrictions that we group into five broad restriction categories: *who*, *what*, *when*, *where*, and *how* (Tables 1 and 2). These restrictions can be implemented by governments, local communities, or other stakeholders within MPAs, and each of them can be used individually or in combination. For example, an MPA may incorporate zonation (restrictions on *where* people can fish) that creates fisheries areas subject to gear restrictions (restrictions on *how* fishing can occur). In addition to fisheries restrictions there can be restrictions on other activities occurring in MPAs, such as aquaculture, bottom exploitation (e.g. sand mining), and non-extractive uses (e.g. tourism) (Horta e Costa et al., 2016).

2.2 Case study MPAs and global dataset

To understand outcomes from a diversity of MPA management and restrictions, we considered nine illustrative case study MPAs (Figure 1; Table 1, S1). These MPAs were selected during a workshop held at the 5th International Marine Conservation Congress in Kuching, Sarawak in June 2018. Case studies were selected based on discussion balancing: (i) diverse governance types and geographical locations, (ii) where detailed knowledge of establishment, management, and regulations were available to the authors/workshop participants, and (iii) where documented assessments of biodiversity outcomes were available. Case study MPAs are: (1) Wakatobi National Park (NP), Indonesia, (2) Kubulau District Locally Managed Marine Area (LMMA), Fiji, (3) Velondriake LMMA, Madagascar, (4) Koh Rong Archipelago Marine Fisheries Management Area (MFMA), Cambodia, (5) Ulithi Atoll and associated islands, Outer Islands of Yap State, Federated States of Micronesia, (6) Cottesloe Reef Fish Habitat Protection Area (FHPA), Australia, (7) Kona Coast Fishery Management Area (FMA), Hawaii, USA, (8) Nusatupe Reef MPA, Solomon Islands, and (9) Half Moon Caye Natural Monument (NM), Belize (Figure 1). Case study MPAs included exclusively fully protected areas, zoned MPAs incorporating partial protection and fully protected areas, and exclusively partially protected MPAs (Table 1). While the majority of case study MPAs do have documented biodiversity benefits (Table 1), we acknowledge that most still face challenges (Table S1). Therefore, these case study MPAs should not be considered 'fully effective' and we recognize, as for most MPAs, there is scope for case study MPAs to improve their effectiveness.

To place our nine case study MPAs in a global context, we used a dataset of 167 MPAs under different forms of governance from 31 nations and tropical and temperate waters originally gathered by Gill et al. (2017). The dataset therefore illustrates variation in MPA restrictions that can be seen at the global scale (see Gill et al., 2017). For each MPA in the global dataset we searched for official management plans online, using the World Database of Protected Areas (www.protectedplanet.net) and also included government documents and non-governmental organization (NGO) reports. Four of our case study MPAs were already included in the global dataset, so in total we obtained information on 172 MPAs. We follow the IUCN MPA definition, which means that some of the MPAs we include in our analysis may not formally be called 'Marine Protected Areas' in their countries' legal system, but they meet the IUCN definition of an MPA.

2.3 MPA classification

For the 172 MPAs we identified the broad 'restrictions categories' used within each MPA—i.e. whether there were restrictions based on *where*, *when*, *what*, and *how* people can fish, *who* can fish, and other restrictions (Table 2). To better understand how fisheries were being managed, within these restriction categories we identified the specific

TABLE 1 Overview of case study MPAs.

MPA (establishment year) – extent	Context and Objectives[1]	Governance arrangements[2]	Regulations	Biodiversity outcomes
1. Wakatobi National Park, South East Sulawesi, Indonesia (1996) – 1,390,000 ha	IUCN Protected Area Category: II Wakatobi National Park (NP) is the second largest marine national park in Indonesia. It has multiple objectives, including biodiversity conservation, sustainable development of the regional economy, especially from the fisheries and tourism sectors, and the availability of sustainable livelihoods for local communities (Clifton, 2013; von Heland and Clifton, 2015).	IUCN Governance Type: A The Park is managed by the Wakatobi National Park Authority reporting to the Ministry of Environment and Forestry in Jakarta. While the park is under state governance, there is community involvement in management in parts of the NP, and also formal recognition of customary governance in specific geographic locations by the Wakatobi National Park Authority (Clifton, 2013; (Jack-Kadioglu et al., 2020).	The MPA is zoned including no-take areas and sustainable fisheries areas – including some areas under irregular closures controlled by communities (Jack-Kadioglu et al., 2020). Fishing vessels larger than 10 gross tons are excluded from the MPA (Muawanah et al., 2020). No MPA-specific restrictions on gear effort, size/weight, species, or permits – though national fisheries regulations apply. Aquaculture and non-extractive activities are allowed in specific MPA zones – with tourism development encouraged within the NP (Tam, 2019).	Ecological monitoring has found that biomass of some fish groups has increased in the MPA (Firmansyah et al., 2016).
2. Kubulau District Locally Managed Marine Area, Bua Province, Fiji (2004) – 12,000 ha	IUCN Protected Area Category: IV Kubulau District Locally Managed Marine Area (LMMA) is located in Bua Province, Fiji (Weeks and Jupiter, 2013). The LMMA spans the customary fishing ground (*qoliqoli*) and has objectives of maintaining or improving long-term sustainable yield and reproductive capacity of fisheries, maintaining or improving biodiversity and ecosystem function, and supporting reef resilience into the future (Weeks and Jupiter, 2013).	IUCN Governance Type: B The LMMA is governed using a co-management approach between Kubulau communities and Wildlife Conservation Society (WCS). Decisions are taken by the Kubulau Resource Management Committee – formed from representatives of each village – with scientific input, guidance, and monitoring and evaluation support from WCS.	Kubulau District LMMA consists of three district-wide permanent no-take areas, seventeen village-managed periodic harvest closures (tabu areas), and a larger surrounding fisheries area under local community governance. The LMMA incorporates seasonal closures, species-specific fisheries bans, and restrictions on how people can fish. While size limits on fish are enforced, these are defined by national law rather than the LMAA. Recreational activities are allowed with permission, and within the no-take areas require a formal marine reserve user tag to be issued.	No-take areas have greater fish abundance and biomass than surrounding fished areas (Jupiter and Egli, 2010), including some sites with exceptionally high biomass (Barrett et al., 2018). Period harvest closures on average support greater biomass of targeted fisheries species (Goetze et al., 2018). However, during harvests fishers remove much of this, therefore a network of closures of differing ages is required to provide long-term protection for biodiversity.
3. Velondriake, Madagascar (2006) – 64,000 ha	IUCN Protected Area Category: V Velondriake locally managed marine area (LMMA) is located in, southwest Madagascar (Harris, 2007). The LMMA evolved from successful temporary octopus closures by the village of Andavadoaka in November 2004 to a fully-fledged LMMA officially gazetted in 2015 (Gardner et al., 2018). The LMMA aims are: fisheries development; nature conservation; economic development; solidarity between local communities; education; sustainable biodiversity use and preservation for future generations; and ecotourism.	IUCN Governance Type: B The LMMA is governed by the Velondriake Association (VA), comprising regional sub-committees representing different villages. Velondriake is regulated by a dina—a locally developed set of laws (Andriamalala and Gardner, 2010). Madagascar lacks a legal framework for LMMAs, but Velondriake is gazetted as a protected area with Blue Ventures as the delegated management authority (Gardner et al., 2018). Blue Ventures sub delegates aspects of management to the VA. Thus, the LMMA is de jure co-managed by Blue Ventures and the Government of Madagascar, it is de facto co-managed by VA and Blue Ventures. (Gardner et al., 2020).	The LMMA is zoned and includes five permanent coral reef no-take areas, two permanent mangrove reserves, and numerous restricted use zones and aquaculture zones. Fishing is allowed in parts of the LMAA, and there are periodic irregular fisheries closures (particularly for octopus). Destructive fishing practices are banned. Fishing for selling catch is allowed, but uses small-scale fishing gears by community members. Non-extractive recreational uses are allowed in parts of the LMMA.	Community-managed no-take areas within Velondriake LMMA have higher fish biomass than control sites (Gilchrist et al., 2020). Fisheries catch data also shows that mean octopus size increases inside the periodic fisheries closure areas (Benbow et al., 2014).
4. Koh Rong Archipelago Marine Fisheries Management Area,	IUCN Protected Area Category: VI Koh Rong marine fisheries management area (MFMA), declared in 2016, is Cambodia's first large-scale	IUCN Governance Type: B Authority of the Marine National Park resides with the Ministry of Environment	The MPA incorporates no-take areas, periodic irregular closures, and sustainable fishing areas. as well as pre-determined annual fisheries seasons (in a fish refuge	Long-term monitoring surveys in Koh Rong MFMA indicate stability or slight recovery in coral reef health

(Continued)

TABLE 1 Continued

MPA (establishment year) – extent	Context and Objectives[1]	Governance arrangements[2]	Regulations	Biodiversity outcomes
Preah Sihanouk Province, Cambodia (2016) – 52,000 ha	and multiple-use MPA (West and Teoh, 2016). The area was also designated as a Marine National Park in 2018. The MFMA was declared with the intention of protecting biodiversity, supporting sustainable fishing and tourism, and contributing to poverty alleviation to address issues such as pollution, destructive fishing, and coastal development (Fisheries Administration, 2016).	and the management of the MFMA sits with the Ministry of Agriculture, Forestry and Fisheries (MAFF) and the three Community Fisheries (CF). CFs are legally recognized community groups representing their members. The MAFF management structure consists of a Provincial Management Committee and a multi-stakeholder Technical Working Group, which includes businesses and NGOs actively involved in MPA management, as well as CFs, government and authorities.	zone and for some key fisheries species such as mackerel). There are also fisheries species and size/weight restrictions, and also gear type (i.e. no trawl nets), effort, and habitat/depth restrictions for fishing in some of the zones. Medium-scale fishing (i.e. based on boat size) must be licensed *via* permit by the government. There are also fishing restrictions based on residency within the MPA. Commercial fishing is not allowed in the MPA. Aquaculture and non-extractive activities are allowed in certain areas of the MPA. Bottom exploitation is not allowed.	indicators since MPA management began (Thorne et al., 2015; Glue et al., 2020). Coral reef surveys in 2019 observed an increase in hard coral cover, an increase in biomass of grouper (Serranidae) and parrotfish (Scaridae) families, and stability in the abundance of fish classified as economically valuable to local fisheries. While positive change was observed, the total biomass of grouper and parrotfish families in the MPA remains low, indicative of a reef system previously overexploited (Glue and Teoh, 2020). Social surveys conducted in 2017 showed that the majority of households (92.4%, n=132) in the five main settlements perceived benefits of the MFMA to their villages, due to a perceived increase in fish stocks and also tourism (Roig-Boixeda et al., 2018).
5. Ulithi Atoll and associated islands, Outer Islands of Yap State, Federated States of Micronesia (centuries old) – approximately 55,000 ha	IUCN Protected Area Category: V Ulithi Atoll and associated islands is the largest atoll in the Yap outer islands, the fourth largest atoll in the world, and part of the Federated States of Micronesia (Crane et al., 2017a). The marine conservation goals for community-implemented marine protection around Ulithi Atoll and associated islands are healthy reefs, healthy populations of fish, and healthy people from sustainable harvesting.	IUCN Governance Type: D Reef management is provided in a decentralized way by local communities who also heavily depend on their reefs for food security and well-being (Crane et al., 2017a). Partial protection management approaches under the governance of local communities have been used in the outer islands for many centuries (Crane et al., 2017a). Local declines in fisheries resources in recent decades have caused food security concerns (Crane et al., 2017a; Crane et al., 2017b) and led to the reinstating of traditional management, establishing stronger enforcement, and seeking scientific support to assess the problems and the impacts of management (Crane et al., 2017a).	Management is heavily reliant on temporary reef closures. Some 'closed' reefs are closed for household fishing but opened for significant community events. Ulithi Atoll and associated islands therefore include spatial zonation but without permanent no-take areas. Temporal restrictions represent irregular closings (e.g. following death of a Chief), and changes in permitted activities during the year or on a pre-fixed date (e.g. a holiday). Communities also implement fishing gear restrictions and species-specific restrictions (e.g. bans on night spear-fishing parrotfish; bans on gill nets, etc. (Crane et al., 2017a). Subsistence fishing is allowed, but commercial fishing is not. Only those who are resident in Ulithi Atoll and associated islands or have cultural ties are permitted to fish. There are no restrictions on fish size or weight, nor habitat restrictions for fishing. Non-extractive recreational uses are permitted in parts of the atoll. Bottom exploitation is not allowed.	Communities have reported multiple positive biodiversity outcomes as a result of enhancing partial protection. For example, fish biomass has more than doubled in the managed area on the Island of Falalop, Ulithi Atoll (Crane et al., 2017a). Here, community members have reported the return of fish species absent for many years (e.g. *Kyphosus cinerascens* and *Kyphosus biggibus*) and that spill-over is occurring into adjacent areas which they fish (Crane et al., 2017a). Two new fisheries closures on Satawal Island led to community members reporting increased fish diversity, abundance, and body size after only nine months (N. Crane, personal communication).
6. Cottesloe Reef Fish Habitat Protection Area, Western Australia, Australia, (2001) – 341 ha	IUCN Protected Area Category: VI Cottesloe Reef, located in Perth's western suburbs. The Cottesloe Marine Protection Group proposed that the reef system should be a Fish Habitat Protection Area (FHPA) because of the reefs' popularity and vulnerability to human impacts. FHPA are locations declared as	IUCN Governance Type: A The FHPA is governed by the Department of Fisheries, Western Australia. Under the requirements for FHPA designation, the government is required to involve communities in the management of the area	Within the FHPA spearfishing, collection of aquarium fish, and commercial fishing are prohibited. Recreational fishing is allowed for certain species, but not net fishing. The take of abalone is prohibited to the south of Cottesloe Groyne—dividing the rules for abalone into two discrete spatial areas within the FHPA (Department of Fisheries, 2010).	There has been limited evaluation of the biodiversity outcomes of the FHPA. Monitoring by the Department of Fisheries, Western Australia has suggested that the FHPA is helping to maintain stable populations of molluscs

(Continued)

TABLE 1 Continued

MPA (establishment year) – extent	Context and Objectives[1]	Governance arrangements[2]	Regulations	Biodiversity outcomes
	having special ecological and community significance and thus deserving special management to ensure its long-term sustainability. The aim for Cottesloe Reef FHPA is to preserve valuable fish and marine environments for the future use and enjoyment of all people.	(Department of Fisheries, 2001). The Cottesloe Marine Protection Group (a local community group) has coordinated volunteer programs to support the FHPA and raise awareness locally of the importance of the FHPA (Department of Fisheries, 2001).	Snorkeling and SCUBA are allowed. Use of jet skis and anchoring of any craft are prohibited. Aquaculture is prohibited.	(including abalone) and echinoderms (Fairclough et al., 2008; Fairclough et al., 2011).
7. Kona Coast Fishery Management Area, Hawaii, USA (1999) – 1,070 ha	IUCN Protected Area Category: IV Kona Coast Fishery Management Area (FMA) comprises four distinct areas on the southwestern portion of the main island of Hawaii. Kona coastal waters are an important harvest area for the Hawaii marine aquarium fishery (particularly yellow tang *Zebrasoma flavescens*) (Rossiter and Levine, 2014). This coastline also supports significant reef-based tourism, with the tourism industry concerned that over-harvesting of aquarium fish was reducing the value of diving sites (Tissot and Hallacher, 2003; Capitini et al., 2004). To reduce conflict while avoiding prohibiting all aquarium fish collecting, a network of fish replenishment areas was established in 1999 (Rossiter and Levine, 2014). The FMA has narrow objectives, specifically to reduce the impacts of aquarium fishing in West Hawaii's waters (Rossiter and Levine, 2014).	IUCN Governance Type: A The MPA is managed by the Division of Aquatic Resources, Department of Land and Natural Resources, State of Hawaii Government.	There is no spatial allocation of restrictions within the FMA (i.e. all restrictions apply across the whole area). Collecting any aquarium fish or fish feeding is prohibited. Fish feeding as part of traditional 'ōpelu fishing gears is allowed. Fishing anywhere within the FMA with legal fishing gear for legal species for personal consumption is allowed. Legal gear/species refers to regional fisheries restrictions for the west Hawaii coast, so are not FMA level restrictions. There are no temporal restrictions, or restrictions on who can fish. Non-extractive recreational uses are allowed (e.g. snorkeling and SCUBA diving). Exceptionally, permits may be issued to engage in activities otherwise prohibited by law, but are not issued as standard.	Kona Coast FMA has led to increased populations of aquarium targeted fish (yellow tang), and there is evidence of fish spill-over from the FMA to surrounding areas for aquarium fish collection (Williams et al., 2009). Concerns have been raised that the FMA displaced aquarium fish harvesters, concentrating them at sites outside the protected area (Stevenson and Tissot, 2013; Stevenson et al., 2013).
8. Nusatupe, Western Province, Solomon Islands (1998) – 150 ha	IUCN Protected Area Category: Ib Nusatupe Island is located in the Western Province of the Solomon Islands. Nusatupe is surrounded by biodiverse fringing coral reef ecosystems. Nusatupe MPA is a permanent no-take MPA that is embedded within a larger network of MPAs that mix partial protection approaches across the Ghizo Islands (Liligeto, 2011). Nusatupe, has a permanent no-take MPA, created to promote the conservation of marine biodiversity and maintain the subsistence resource base on which local communities of the region depend. Small-scale aquaculture, mostly with a research focus (particularly giant clams), is a major function of the MPA.	IUCN Governance Type: C The MPA is managed by the World Fish Centre, but is located within a larger MPA network that is managed by GELCA. The World Fish Center runs an aquaculture research center on Nusatupe – which is the primary focus of their activities on Nusatupe.	The MPA is exclusively no-take. No resource extraction activities of any kind are permitted (Liligeto, 2011). Prohibitions on fishing within Nusatupe MPA are enforced by staff at the World Fish Center (Foale and Manele, 2003). Small-scale aquaculture, mostly is allowed, and indeed a major function of the MPA. Non-extractive recreational activities are allowed provided users follow rules established for the MPA (Liligeto, 2011).	Limited ecological monitoring data available for this MPA. Surveys have identified large seagrass beds foraged by dugongs and hawksbill turtles, with hawksbill turtles nesting adjacent to the MPA (Liligeto, 2011).
9. Half Moon Caye Natural Monument, Belize (1982) – 3925 ha	IUCN Protected Area Category: II Half Moon Caye Natural Monument (NM) is a protected area within Lighthouse Reef Atoll, and considered one of the highest priority areas for conservation in the Mesoamerican Barrier Reef system (Belize Audubon Society, 2007; Belize Audubon Society, 2016). There is a low population of temporary residents on Half Moon	IUCN Governance Type: B The NM is managed by the Belize Audubon Society under a co-management agreement with the Ministry of Natural Resources and the Environment.	The Half Moon Caye NM consists of six zones, with no extractive activities allowed in any of the zones— i.e. all zones are no-take areas (Belize Audubon Society, 2007; Belize Audubon Society, 2016). Three zones are open to recreational snorkeling, diving, and boating, and educational activities. Three of the zones are closed to visitors except for scientific research with authorization.	Fish abundance is generally higher inside the NM than at sites outside (Sedberry et al., 1999). Parrotfish biomass increased on reefs within the protected area between 2009 and 2013 (Cox et al., 2017). The island of Half Moon Caye is also highly protected

(Continued)

TABLE 1 Continued

MPA (establishment year) – extent	Context and Objectives[1]	Governance arrangements[2]	Regulations	Biodiversity outcomes
	Caye island, but it is regularly visited by fishers and tourists from elsewhere in Belize who travel to Lighthouse Reef Atoll. The management vision for Half Moon Cay is: 'To protect and preserve natural resources and nationally significant natural features of special interest or unique characteristics to provide opportunities for interpretation, education, research and public appreciation for the benefit of current and future generations, within a functional conservation area' (Belize Audubon Society, 2007; Belize Audubon Society, 2016).			as an important bird nesting site (Mitchell et al., 2017).

[1]IUCN Protected Area Categories follow Day et al. (2012).
[2]IUCN Protected Area Governance Types follow Borrini-Feyerabend et al. (2013).
[3]See Table S1 for an expanded version of this case study table.

TABLE 2 Restrictions categories and restriction types used in marine protected areas and definitions.

Restriction category	Definition	Restriction types	Number of MPAs
Fisheries Restriction categories			
Where	Spatial regulations on where fishing can occur	• Zonation • Habitat/depth restrictions	95
When	Temporal regulations on when fishing can occur	• Daily times for fishing activity • Irregular closures for periodic harvesting on a non-predetermined schedule • Changes in permitted activities many times during a single year at predetermined fixed dates • Annual fisheries seasons • Changes in permitted activities pre-determined at an >1 year cycle • Fisheries closures whenever spawning aggregations form	41
Who	Restrictions on who is allowed to fish—different access/activities allowed within the MPA based on people's identity	• Restrictions on who can fish based on cultural heritage • Restrictions on who can fish based on residency • Requires a permit • Requires membership of a fishing cooperative	62
What	Restrictions on what species or individuals (e.g., size, weight) can be caught	• Minimum size/weight restrictions • Target species restrictions	73
How	Restrictions on how fishing can occur (e.g. fishing gears, gear effort)	• Gear type restrictions • Gear effort restrictions	114
No-take area	Permanent closure of an area to all fisheries with the expectation that fisheries will not be allowed at any point in the future		102
Other restriction categories			
Aquaculture	Aquaculture activities allowed within the MPA		9
Bottom exploitation	Bottom exploitation allowed within the MPA (e.g. sand mining)		3
Non-extractive use	Non-extractive uses allowed within the MPA (e.g. scuba diving, tourism)		161

'Restriction categories' represent broad groupings, while 'restriction types' represent the specific restriction implemented within each MPA. Number of MPAs represents how many MPAs out of the 172 MPAs included in the analysis contained a restriction category. We considered no-take areas as a distinct restriction category, as they represent the strongest form of harvest restrictions, curbing where (spatially defined area), when (intended permanent closure), what (no species can be caught), who (no people can fish), and how (no fishing gears can be used) harvesting occurs.

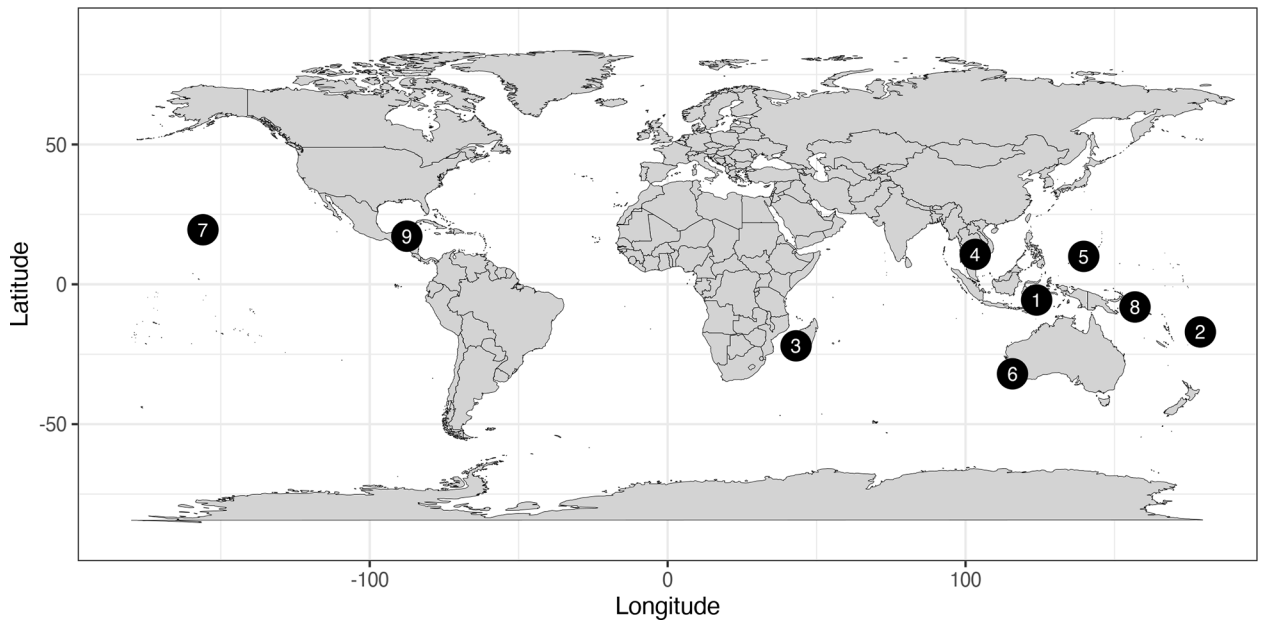

FIGURE 1
Location of case study MPAs. Case study MPAs are: (1) Wakatobi National Park, Indonesia, (2) Kubulau District Locally Managed Marine Area (LMMA), Fiji, (3) Velondriake LMMA, Madagascar, (4) Koh Rong Archipelago Marine Fisheries Management Area, Cambodia, (5) Ulithi Atoll, Federated States of Micronesia, (6) Cottesloe Reef Fish Habitat Protection Area, Australia, (7) Kona Coast Fishery Management Area, Hawaii, USA, (8) Nusatupe MPA, Solomon Islands, and (9) Half Moon Caye Natural Monument, Belize.

fisheries 'restriction types' that were being implemented in each of the 172 MPAs in the dataset (Tables 2, 3). Where a single management regulation combined multiple restriction categories or restriction types we separated them into their individual components. For example, MPAs that restrict lobster harvesting to a fixed annual season with a minimum size for landings incorporates multiple restriction types. This case includes a species restriction (*what*—restriction on the specific species allowed to be caught), a size restriction (*what*—restriction on what sizes of individuals are allowed to be caught), and a temporal restriction (*when*—annual

TABLE 3 Example 'restriction types' identified for each 'restriction category' for MPAs globally.

Restriction category	Restriction type	Number of MPAs with restriction	Example	
			MPA	Restriction
Where		*94*		
	Zonation – spatially defined area within an MPA boundary	79	Wadi El-Gemal National Park, Egypt	The MPA is separated into nine spatially designated zones, with distinct management guidelines provided for each zone (Government of Egypt, Ministry of State for Environmental Affairs, and Egyptian Environmental Affairs Agency; Egypt Environmental Policy Program, 2004).
	Habitat/depth restrictions[1]	29	Port Noarlunga Aquatic Reserve, Australia	The MPA prohibits fishing within 25 meters of any part of Horseshoe Reef, the northern Port Noarlunga Reef, or the southern Port Noarlunga Reef, or from the last 50 meters of the western end of the Port Noarlunga Jetty that becomes exposed at low water (Fisheries Management (Aquatic Reserves) Regulations, 2008).
When		*40*		
	Daily times fishing activity is allowed to occur	4	Contoy Island National Park, Mexico	The National Park has four established zones, one of which was established to minimize the impact of the Caribbean lobster fishery on seabirds during the mass migration of lobster known as "corrida". This zone allows fishing from 3:00pm to 7:00am the following day to avoid seabird feeding times to minimize seabird bycatch (Mexico National Commission of Natural Protected Areas, 2015).
	Irregular closures for periodic harvesting on a non-predetermined	12	Misool MPA, Raja Ampat MPA	Within the MPA many villages have revived 'Sasi' - a local management practice where areas of reef are closed to fishing of certain important fish and/or invertebrates for a period of time. The closures are often opened when important community events happen, but the exact future

(Continued)

TABLE 3 Continued

Restriction category	Restriction type	Number of MPAs with restriction	Example	
			MPA	Restriction
	schedule (closures may be from several months to several years, but opening date not set at point of closure)		Network, Indonesia	opening date is not defined at the point the reef area is closed (Technical Implementing Unit of the Raja Ampat Archipelago Waters Conservation Area (KKP), 2016).
	Changes in permitted activities many times during a single year at pre-determined fixed dates (e.g. fishing allowed on public holidays, weekends etc.)	5	Levante de Mallorca-Cala Ratjada Marine Reserve, Spain	This MPA does not permit commercial fishing on Saturdays, Sundays, or public holidays. Recreational fishing is allowed only on weekends (Saturday and Sunday) and two weekdays each week (Tuesday and Thursday) (Government of Spain, Ministry of Agriculture, Fisheries, and Food, 2017).
	Annual fisheries seasons (changes in permitted activities are pre-determined on a fixed annual cycle)	25	Abrolhos Islands' Fish Habitat Protection Area, Australia	This MPA implements a fisheries closure for baldchin groper (*Choerodon rubescens*) from 1 November to 31 January each year, and a rock lobster (*Panulirus cygnus*) fisheries closure from 30 June to 15 October each year for recreational fishers (Government of Western Australia Department of Fisheries, 2015).
	Changes in permitted activities are pre-determined at an >1 year cycle (e.g. fixed closure for fishing for 2 year period, with opening date set at time of closure)	1	Kubulau District LMMA, Fiji	This LMMA implements periodic harvest closures that prohibit all harvesting activities for a predetermined period of time. For example, one tabu (closure) area was established for five years from 2009-2014 in Cakau Vusoni village (WCS, 2009).
Who		*60*		
	Restrictions on who can fish based on cultural heritage (or similar) not associated with current residency location	6	Encounter Marine Park, Australia	This MPA allows Aboriginal peoples to practice traditional fishing in all zones of the Marine Park, while prohibiting all other users from fishing in some of these zones (South Australia Department of Environment, Water, and Natural Resources, 2012).
	Restrictions on who can fish based on residency in a settlement located within or adjacent to the MPA	24	Bacalar Chico Marine Reserve and National Park, Belize	This MPA has two zones open to residents of Bacalar Chico for substance fishing, while prohibiting non-residents from conducting subsistence fishing in these zones. (Belize Fisheries Department, 2015).
	Require permits issued by government or designated management body	43	Cayman Islands Protected Areas, Cayman Islands	This MPA requires fishers to get a license if they wish to use fish pots, spear guns, or seine nets. License holders must carry licenses when using fish pots, seine nets, or spear fishing and adhere to license conditions. Licenses are issued by the Cayman Islands Department of Environment (Cayman Islands Department of Environment, 2016).
	Require membership of fishing cooperative	4	Arrecife de Puerto Morelos National Park, Mexico	Membership of the Pescadores Fisheries Cooperative Society of Puerto Morelos provides additional fisheries access in this MPA that other fishers who are not a member of the cooperative are unable to access. For example, cooperative members are permitted to commercially fish in one zone where commercial fishing is prohibited for other park users, while another zone is directly under concession to the cooperative giving them exclusive commercial fisheries access. Within these two zones, subsistence fishers are prohibited from spearfishing, while cooperative members are allowed to spearfish (National Institute of Ecology, Mexico Secretary of Environment, Natural Resources and Fishing, 2000).
What		*73*		
	Minimum size/weight restrictions	6	West Hawaii Regional Fishery	This Regional Fisheries Management Area prohibits possession of more than five yellow tang larger than 4.5 inches total length, or more than five yellow tang smaller than 2 inches total length within the MPA (State of Hawai'i Division of Aquatic Resources, 2020).

(Continued)

TABLE 3 Continued

Restriction category	Restriction type	Number of MPAs with restriction	Example	
			MPA	Restriction
			Management Area, USA	
	Target species restrictions	71	Virgin Islands National Park, U.S. Virgin Islands	This MPA implements a series of MPA-level species-specific restrictions around minimum size/weight for capture and annual fisheries seasons for named high priority species. This includes specific MPA-level restrictions on catching Conch (*Aliger gigas*), Caribbean Spiny Lobster (*Panulirus argus*), and several species of snapper (Lutjanidae) and grouper (Epinephelinae) (U.S. National Park Service, 2017).
How		*114*		
	Gear type restrictions	113	Dry Tortugas National Park, U.S. Florida Keys	This MPA prohibits spear fishing, use of a hand-held hook or snare (except when a gaff is used to land a fish lawfully caught), taking fish by sling or any powered gun, and dragging or trawling a cast net or dip net when fishing within the MPA (National Park Service, U.S. Department of the Interior, 2014).
	Gear effort restrictions	36	Mnazi Bay Ruvuma Estuary Marine Park, Tanzania	This MPA prohibits the use of pull nets with stretched-mesh size of less than 2.5 inches within the boundaries of the MPA. (United Republic of Tanzania Ministry of Natural Resources and Tourism; Board of Trustees for Marine Parks and Reserves, Tanzania, 2005).
No-take area		*59*[2]		
No-take area	Complete long-term prohibition on all fisheries	*59*[2]	Jaragua National park, Dominican Republic	This MPA has nine zones with varying levels of protection, including fully protected/no-take areas (e.g., zona intangible, zona primitiva, zona de preservación) and other zones which allow fishing (e.g., zona de pesca, zona de reserve Pesquera) (United National Environment Program, 2014).

[1]Habitat and depth restrictions were not separated as they were often confounded in management plans. For example, in Port Noarlunga Reef Aquatic Reserve, Australia fishing is not allowed within 25 meters of any inter-tidal area that becomes exposed at low water (Fisheries Management (Aquatic Reserves) Regulations, 2008).
[2]Represents MPAs that include permanent no-take areas while allowing fishing in other areas of the MPA.

fishing season). We considered complete permanent bans on all extractive activities (fully protected areas) as a distinct restriction category, as they represent the strictest form of fishery regulation, curbing *where* (spatially defined area), *when* (intended permanent closure), *what* (no species can be caught), *who* (no people can fish), and *how* (no fishing gears can be used) fishing occurs. Most MPAs exist within a complex patchwork of fisheries management arrangements, coastal protection, or national management interventions. When classifying MPAs we specifically focused on restrictions implemented within the MPA that are different to surrounding waters. For example, Hawaii has implemented state-wide restrictions on fishing gears (including minimum mesh sizes, time of day restrictions for certain fishing gears, and species-specific protections) that apply to all fisheries in state waters (Department of Land and Natural Resources, 2005; Department of Land and Natural Resources, 2014). While these restrictions apply within all MPAs in the state and may be enforced by MPA management authorities, we did not include them in our MPA restriction analysis as they do not represent MPA-level restrictions. Our analysis of the presence/absence of restriction categories and restriction types is based on written management plans and reports for the MPAs available online. While we have local knowledge of case study MPAs, for some MPAs in our global dataset the restrictions in the management plan may not be fully implemented. This is a broader challenge for protected areas – i.e. 'paper parks'. This does not affect our analysis or interpretation, which is primarily driven by case studies, with the global dataset providing background context for the types of regulations frequently included in MPA management plans.

2.4 Data analysis

To identify whether there were common groupings of similar restrictions used in MPAs, and evaluate how our case study MPAs aligned with these groupings, we coded the presence or absence of each restriction category or type for all 172 MPAs. We then conducted principal components analysis (PCA), a multivariate statistical method to quantify similarities or differences between individual MPAs based on their restrictions. PCA generates a set of axes (principal components) that are combinations of the original input variables (in this case different MPA restrictions), maximizing the original data variance explained by each axis while minimizing correlations among axes. Each axis can be interpreted based on the strongest correlations to individual variables (restrictions). Correlations can be either positive or negative (between -1 and 1), depending on the direction and magnitude of the results. Here we consider all correlations >|0.3| as significant (following Hoshino et al., 2017). MPA restrictions with strong correlations to principal component axes that explain a large proportion of the data variation are the most important for distinguishing among MPAs. This approach allowed us to first evaluate which restrictions distinguished between MPAs in the global dataset, but then

contextualize these clusters identified in the PCA through drawing on qualitative information from the case study MPAs.

We ran two separate PCAs, the first based on all 172 MPAs using the presence or absence of the different broad 'restriction categories' in the MPA (i.e., presence/absence matrix of Table 2 restriction categories). This allowed us to explore the relative power to discriminate between MPAs based on broad differences in restrictions. Given the widespread use of partial protection approaches to manage fisheries within MPAs, we then subset the data to the 129 MPAs that allow some form of fishing—thus removing the exclusively no-take MPAs (n=43). We then conducted a PCA based on the individual fisheries 'restriction types' (i.e. presence/absence matrix of Table 3 restriction types). PCA analysis was conducted in the vegan package (Oksanen et al., 2020).

To distinguish groups of MPAs based on restrictions we used k-means clustering, which has previously been used to classify MPAs into groups (e.g. Bohorquez et al., 2019). K-means clustering allocates MPAs into a pre-specified number of groups based on the presence/absence of restrictions while minimizing the amount of variation within each group. We selected the number of clusters based on examining a scree plot of the within group sum of squares for 0-15 clusters – i.e. how much variation in MPA restrictions can be explained by the clusters. All analyses were conducted in R (R Core Team, 2020).

3 Results and discussion

3.1 Identified restriction clusters

The majority of MPAs reviewed were partially protected, with 75% (129) of the 172 MPAs allowing some fishing to occur within their boundaries. Fisheries restrictions provided the greatest explanatory power to discriminate among MPAs across the 'restriction categories' (Table 2). We found that certain restrictions on fisheries within MPAs were frequently implemented together. For example, *when* and *where* fishing can occur were often implemented simultaneously within the same MPA, as were restrictions on *who* could fish and *what* could be harvested (Figure 2A). Principal component (PC) 1 explained 37% of variation in MPA restrictions (Figure 2A), and was most strongly driven by *how* fishing can be conducted (0.52 correlation with PC1), *what* can be caught (0.48), *where* fishing can occur (0.47), and *who* can fish (0.37) (Table S2). PC2 explained 19% of variation (Figure 2A) and was most strongly driven by the presence of no-take areas (0.78 correlation with PC2), in addition to *where* (0.50) and *when* (0.33) people can fish (Table S2). Aquaculture, bottom exploitation, and non-extractive recreational uses provided little power to discriminate among MPAs based on their restrictions (Table S2). This was unsurprising given the majority

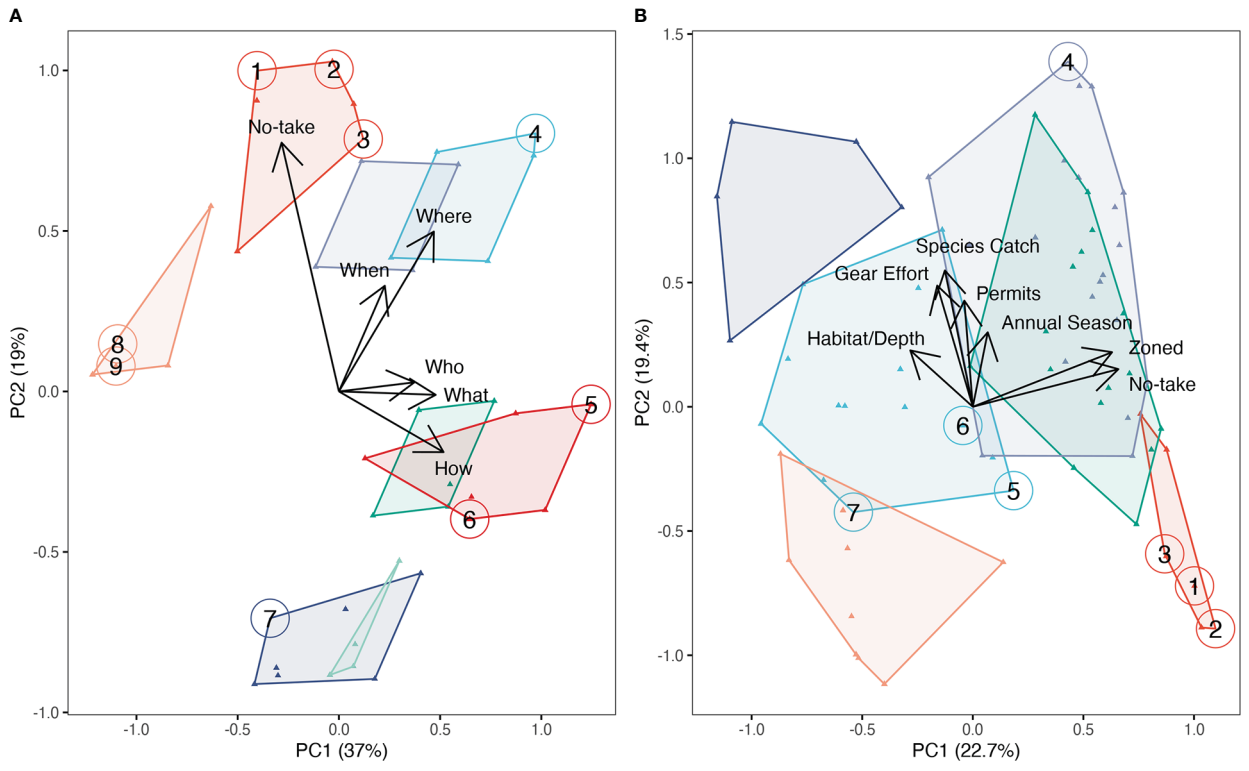

FIGURE 2
Principal Components Analysis of MPA regulations. **(A)** All 172 MPAs based on the restriction categories (Table 2), and **(B)** the 129 MPAs that allow fishing based on the specific fishing restrictions types (Table 3). K-means clustering is used to identify groups of similar MPAs based on **(A)** eight clusters and **(B)** six clusters. The nine case study MPAs are colored by cluster group and numbered: (1) Wakatobi National Park, Indonesia, (2) Kubulau District Locally Managed Marine Area (LMMA), Fiji, (3) Velondriake LMMA, Madagascar, (4) Koh Rong Archipelago Marine Fisheries Management Area, Cambodia, (5) Ulithi Atoll, Federated States of Micronesia, (6) Cottesloe Reef Fish Habitat Protection Area, Australia, (7) Kona Coast Fishery Management Area, Hawaii, USA, (8) Nusatupe MPA, Solomon Islands, and (9) Half Moon Caye Natural Monument, Belize. Part **(B)** shows only MPAs that allow fishing, therefore (8) Nusatupe MPA and (9) Half Moon Caye Natural Monument are not included as these are exclusively no-take MPAs. Of the 172 MPAs included in **(A)**, 43 unique combinations of restriction categories were recorded (43 unique data point locations), while from the 129 MPAs included in **(B)** 71 unique combinations of specific fishing restrictions from the MPAs were recorded (71 unique data point locations).

of our restriction categories were focused on fisheries, and fisheries management represents a major objective of most MPAs.

When we examined the more specific 'restrictions types' (i.e., the specific rules applied within the broader restriction categories; Table 3) for MPAs that allow fishing, we found frequently co-occurring restrictions. We found that the use of gear effort restrictions, species catch restrictions, permits, and annual fisheries seasons were commonly used together in MPAs (Figure 2B). We also found that the use of zonation and fully protected zones commonly co-occurred—because zonation is required for an MPA to both allow fishing and incorporate permanent fully protected zones. The presence of fully protected zones (0.66 correlation with PC1) and zonation (0.63) had the greatest power to discriminate between MPAs—strongly correlating with PC1 which explained 22% of the variance (Figure 2B and Table S3). We also found that the use of species-specific restrictions (0.55 correlation with PC2), gear effort restrictions (0.49), fisheries permits (0.43), and annual fisheries seasons (0.30) were important for distinguishing between MPAs that allow fishing (Table S3). These restriction types were strong correlates of PC2, which explained 19% of the variation (Figure 2B and Table S3).

We found eight groupings of MPAs based on our cluster analysis of restriction categories, of which five were mapped to our case studies (Figure 2A). To provide a more detailed investigation of how MPAs regulate fisheries, we conducted cluster analysis on the fishing 'restriction types' for MPAs that allow fishing. We identified six clusters, three of which were represented by case studies (Figure 2B). Clusters represent groups of MPAs that are implementing similar 'restriction categories' or 'restriction types'. For example, Kubulau District LMMA, Wakatobi NP, and Velondriake LMMA (clustered upper-center of Figure 2A and lower-right of Figure 2B) all use permanent fully protected zones and similar restrictions on *where* and *when* fishing can occur, while Nusatupe Reef and Halfmoon Caye NM (clustered center-left of Figure 2A) are exclusively fully/highly protected MPAs. By identifying co-occurring case studies within clusters we can investigate whether MPAs that are implementing similar restriction categories or types are aiming to achieve similar or highly divergent objectives.

3.2 Key insights from case studies

Our comparative analysis of the MPA restrictions and case studies revealed four key insights: (i) MPAs use highly diverse approaches to regulate fisheries; (ii) partially protected areas can address gaps in regional fisheries management; (iii) devolving resource management rights to communities influences the chosen fisheries restrictions; and (iv) state-governed MPAs can use highly tailored fisheries restrictions to increase equity in access. More broadly, across our case studies we found that partial protection approaches are providing an alternative pathway for marine conservation to achieve biodiversity outcomes that can complement fully protected MPAs.

3.2.1 MPAs use highly diverse approaches to regulate fisheries

We found MPAs implement many different restriction combinations to address similar management goals—with spatial zonation particularly important for facilitating diverse fisheries restriction combinations. We identified 16 fisheries 'restriction types' (Table 3), which occurred in 73 unique combinations across the 129 MPAs that allowed fishing. This suggests high diversity in how different restrictions can be combined given an MPA's management objectives and local context. For example, both Koh Rong Archipelago MFMA and Cottesloe Reef FHPA aim to conserve and protect fisheries species and habitats while still allowing sustainable harvesting (Table 1). Cottesloe Reef FHPA uses gear type, habitat and depth restrictions, while Koh Rong Archipelago MFMA uses annual fishing seasons, permits, target species restrictions, and gear effort restrictions (Table 1). Koh Rong Archipelago MFMA had 12 different restriction types—the greatest in our dataset.

Our results highlight the importance of spatial zonation in enabling partial protection approaches for MPAs—both for incorporating no-take areas, but also for spatially allocating other restrictions. Zonation and the use of no-take areas were highly correlated (Figure 2B and Table S3), which is not surprising because zonation is required for an MPA to both allow fishing and incorporate permanent no-take areas. These two variables are not perfectly correlated, however, as some zoned MPAs do not include no-take areas. Some MPAs may also use spatial restrictions without using formal zonation terminology or producing zonation plans. Cottesloe Reef FHPA, for example, does not include no-take areas and is not formally zoned, but has species-specific fisheries restrictions that spatially divide the MPA into two distinct areas based on a visual marker on the coastline (Table 1). Cottesloe Reef FHPA clusters with Ulithi Atoll and Kona Coast FMA in our restriction type analysis (Figure 2B). Similar to Cottesloe Reef FHPA, Ulithi Atoll does not incorporate strict no-take but does include spatial zonation. While Kona Coast FMA also does not incorporate no-take, it does not use spatial zonation. This is likely why Cottesloe Reef FHPA and Ulithi Atoll are located more closely together in our PC analysis (Figure 2B). Our case studies that allowed fishing, therefore, exemplified the diversity of approaches shown by partially protected MPAs to restrict harvesting (Figure 2B).

3.2.2 Partially protected areas can address gaps in regional fisheries management

MPAs exist in seascapes with highly variable national and sub-national fisheries management contexts which are reflected in their MPA-specific fisheries restrictions and management objectives (e.g. Table 1). National or sub-national fisheries management is generally concerned with how fisheries stocks are managed outside of MPAs or other spatially discrete management interventions (Hall and Mainprize, 2004). Fisheries management requires balancing political realities, livelihood needs, and ecological evidence to maintain harvest sustainability and the capacity to monitor and enforce any breaches of fisheries restrictions (Teh et al., 2017). Yet often fisheries management fails because of poor design or implementation, including failure to follow the precautionary principle (Selig et al., 2017). Area-based management approaches—such as MPAs—are amongst the most frequent and most successful tools for small-scale fisheries management (Selig et al., 2017). This is especially true for small-scale fisheries that define success based on ecological and human well-being outcomes, as opposed to profitability and

efficiency metrics that are often used to characterize large commercial fisheries (Selig et al., 2017).

Given the low capacity for national or sub-national fisheries management in many coastal areas with urgent conservation needs (Mora et al., 2009; Worm and Branch, 2012; Costello et al., 2016), MPAs often have dual aims of biodiversity conservation and supporting fisheries sustainability (e.g. White et al., 2014). For example, the Koh Rong Archipelago MFMA contains the most restrictions of any MPA in our dataset, in part because there is limited regional fisheries management, a history of open access to fisheries resources, and high community dependence on fisheries (Table 1). Therefore, the multi-use, zoned, Koh Rong Archipelago MFMA must balance supporting and building sustainable fisheries management alongside providing biodiversity outcomes. In a similar way, Wakatobi NP must balance dual objectives of sustainable fisheries with biodiversity conservation (Table 1; Amkieltiela et al., 2022). Indonesia has national fisheries management, however, this mostly excludes small-scale fisheries (vessels < 10 gross tons), which remain largely unmanaged despite representing the majority of fishing vessels (Halim et al., 2019; Tranter et al., 2022). The few national regulations that apply to small-scale fisheries, such as bans on destructive fishing gears and restrictions on some threatened species harvesting (e.g., humphead wrasse; *Cheilinus undulatus*), are poorly enforced (Amkieltiela et al., 2022; Tranter et al., 2022). To improve fisheries management, Wakatobi NP sustainable fishing zones focus on enforcing these national regulations and limiting fishing to small-scale fishers, but do not implement further gear restrictions.

Where there is greater national fisheries management capacity, MPAs can still be designated to support local-scale fisheries sustainability. Given that MPAs must fit within a complex patchwork of national fisheries management, MPAs established with similar objectives in different countries may use different restrictions based on the national fisheries management context. For example, both Cottesloe Reef FHPA and Kona Coast FMA were established based on the desire from local groups to provide enhanced conservation and protection to fisheries species and habitats above those provided by regional fisheries management in nations with high national fisheries management capacity (Table 1). Both of these MPAs still allow sustainable harvesting, with Kona Coast FMA potentially providing positive biodiversity outcomes (Table 1). Both MPAs grouped together based on 'restriction types'—including restrictions on *what* can be fished (Figure 2B). Kona Coast FMA has few fisheries restrictions specifically for the MPA (Table 1), allowing fishing using any 'legal gear' for personal consumption. 'Legal gear' does not relate to MPA rules, but regional fisheries rules. Cottesole Reef FHPA, in contrast, implements many specific gear restrictions and some species catch restrictions; these supplement regional species catch and temporal restrictions that also apply and are enforced in the FHPA (Table 1).

3.2.3 Devolving resource management rights to communities influences the chosen fisheries restrictions

Marine resource management rights can be devolved in multiple ways to the local level. Four of our case study MPAs (Velondriake LMMA, Wakatobi NP, Kubulau District LMMA, and Ulithi Atoll) that devolve management rights to communities incorporate periodic fisheries closures—and have demonstrated biodiversity benefits (Table 1). Despite different MPA governance characteristics (Table 1), these MPAs all combine spatial management and temporal management, with all except Ulithi Atoll containing permanent no-take areas. Devolved management rights can include a wide range of co-management approaches (Sen and Raakjaer Nielsen, 1996) or governance solely by Indigenous peoples or local communities (Sen and Raakjaer Nielsen, 1996; Borrini et al., 2013). These different approaches allow local groups to make decisions around the management of specific areas within an MPA, a whole MPA, or a larger MPA network.

LMMAs involve local communities in co-management or fully devolve governance to communities (Jupiter et al., 2014; Gardner et al., 2020). In Fiji, for example, there is a strong recognition of Indigenous rights—dividing coastal areas into customary fishing grounds known as *qoliqoli* (Sloan and Chand, 2016). Communities are required to give up their fishing rights to these areas when incorporated into state-governed MPAs. Hence Fiji has few state-governed MPAs, but instead has extensive LMMAs such as Kubulau District LMMA under co-management between customary owners and an NGO (Table 1; Aswani et al., 2017). Similarly, Velondriake LMMA in Madagascar uses shared governance by local stakeholders and NGOs to achieve biodiversity outcomes (Gardner et al., 2020). These LMMAs can include permanent fully protected areas, but also periodically harvested closures that open on cycles under the control of local village leaders in partnership with NGOs and national LMMA networks (Jupiter et al., 2014). These periodic harvest closures can provide conservation benefits, though they require careful management to avoid biodiversity gains being lost when the area is open to fishing (Goetze et al., 2018).

State-governed MPAs can also use co-management approaches to increase community involvement in marine resource governance. Wakatobi NP, for example, is a government managed MPA that uses formal spatial zonation to designate areas as fully protected, open to small-scale fishing with some restrictions, or for community management (Table 1). These community management areas—known as *Kaombo* ('fish banks')—are located near villages. Local customary institutions control access to *Kaombo* areas through long-term periodic harvest closures and harvest closure areas that are opened in periods of bad weather when normal fishing grounds are inaccessible (Jack-Kadioglu et al., 2020). While *Kaombo* areas can lose their conservation gains rapidly when opened to fishing if not well managed, their presence also helps support the implementation of the other fully protected MPA zones.

Exclusively fully protected MPAs that provide biodiversity benefits often owe some of their success to being relatively small, having devolved management rights, or having partial protection in the surrounding seascape. Therefore, positive biodiversity gains may not be scalable with simple expansion of fully protected area extent if this compromises equity. For example, Nusatupe Reef MPA is a small (0.49 km^2) exclusively no-take MPA, while Half Moon Caye NM is a larger (39.25 km^2) exclusively no-take MPA. While individually these MPAs are fully protected, they are integrated into a much larger network of partially protected MPAs. In the case of Nusatupe, this larger MPA network is governed by a committee comprised of key local stakeholders, NGOs, and local government, and actively

promotes both marine conservation and sustainable marine resource use given the high local community dependence (e.g. implementing seasonal closures, rotational closures, and gear restrictions) (Liligeto, 2011). Similarly, Half Moon Caye NM is a relatively small area of high tourism value surrounded by areas under partial protection or open to fisheries (Table 1; Belize Audubon Society, 2007; Belize Audubon Society, 2016). Therefore, successes associated with smaller, fully protected MPAs should be treated cautiously when considering scaling to designate larger, fully protected MPAs, as successes from smaller fully protected areas likely depend, in part, on fisheries access in surrounding areas.

3.2.4 State-governed MPAs can use highly fisheries tailored restrictions to increase equity in access

State-governed MPAs can be highly tailored to recognize diverse needs of local communities and increase the likelihood of positive biodiversity outcomes, although overcomplicated regulations risk hindering management effectiveness. Koh Rong Archipelago MFMA contains the most restrictions of all of the case study MPAs—including fully protected areas and restrictions on *where*, *when*, *who*, *what*, and *how* fishing can occur—which were defined through spatial prioritization tools and intensive consultation with marine resource users (Boon et al., 2014; Mulligan and Longhurst; Mizrahi et al., 2016; Table 1). This MPA incorporates co-management (Mizrahi et al., 2016), with decisions made by a locally elected committee and a multi-stakeholder group alongside government (Mulligan et al., 2014; Preah Sihanouk Provincial Hall, 2014). Therefore, despite intimate government involvement in Koh Rong Archipelago MFMA, the co-management governance structure and extensive consultation process has led to very different restriction structures to other government-implemented case study MPAs. When considering the 'restriction categories', Koh Rong Archipelago MFMA is more similar to community-implemented MPAs such as Ulithi Atoll than to our other MPAs involving government (Figure 2A). However, these similarities disappear when considering the specific 'restriction types' implemented (Figure 2B). The high level of tailoring restrictions in Koh Rong MFMA has resulted in an MPA with strong support and positive perceptions by local fishing communities while delivering conservation benefits (Roig-Boixeda et al., 2018). It also, however, has resulted in a complex zoning and regulation system that requires significant and well-communicated demarcation and awareness raising across sectors —especially with the rapidly growing tourism industry (i.e. new site users). The complexity of the regulation system results in an additional management burden that local authorities have been struggling to meet. Too much complexity in partially protected MPA regulations has previously been highlighted as a major challenge for MPA compliance, with the need to simplify restrictions for widespread user adoption (Iacarella et al., 2021).

3.3 Lessons for equitable marine conservation

3.3.1 Partial protection can offer equitable pathways for biodiversity conservation

Given ambitious targets, the diversity of local societal goals and needs, and limited capacity, the ability for the conservation community to deliver on global targets through fully protected MPAs alone is limited. Firstly, a focus on exclusively fully protected MPAs combined with area-based targets for protection will likely lead to prioritization of 'residual' sites for MPA establishment—i.e. protecting remote areas that are already at low risk from extractive activities (Devillers et al., 2015; Barnes et al., 2018; Devillers et al., 2020). While in some cases protection of remote sites may be important, given these could face greater risk in the future, their protection results in limited near-term biodiversity gains. Secondly, aligning equity, human well-being, and environmental protection goals is increasingly center stage in conservation (Mace, 2014). This calls into question the appropriateness of fully protected MPAs that have objectives of maintaining or restoring ecosystems to 'pristine' condition despite being located in coastal areas with dependent resource users. For MPAs to deliver equitable outcomes they must be well managed with appropriate and inclusive governance structures and regulations for the local context. Therefore, externally imposed, fully protected MPAs will likely be unethical. Thirdly, if implemented, top-down imposed fully protected MPAs are unlikely to generate positive biodiversity outcomes. This is especially in areas where communities are reliant on fisheries or other coastal ecosystem services for human well-being, including food security (Cinner et al., 2012; Klain et al., 2014; Chaigneau et al., 2019). In this context, fully protected MPAs will likely generate social conflict and negative effects on well-being (e.g. Pomeroy et al., 2007; Evans, 2009; Mahajan and Daw, 2016). They would also likely suffer from low compliance (e.g. Campbell et al., 2012), or require substantial resource investment in enforcement to generate any positive biodiversity outcome. Therefore, in addition to being unethical these areas are likely not a cost-effective use of conservation funds. It is therefore important to openly recognize the tradeoffs and tensions that exist between maximizing biodiversity gains while balancing financial realities, issues of equity and food security (e.g. fisheries access), and social cohesion when using MPAs as tools for biodiversity conservation (e.g. Krueck et al., 2019). Fundamentally, MPA protection decisions must be grounded in local context and equity, and decisions on what counts towards protection targets must consider that a sole focus on fully protected areas will devalue the contribution of partially protected areas and risk stalling ocean conservation (Campbell and Gray, 2019).

Partially protected MPAs offer more opportunities for locally relevant tailoring of MPA regulations than exclusively fully protected MPAs. This additional flexibility—especially not fully excluding communities from fishing—can in many cases be perceived as more equitable by stakeholders and generate greater local support (e.g. (Chuenpagdee and Jentoft, 2007; Purwanto et al., 2021). Economic and food security benefits from MPAs often provide tangible outcomes for local stakeholders subjected to MPA restrictions. Furthermore, successful conservation approaches that have community support can rapidly diffuse into adjacent communities (Ehrlich et al., 2012; Gardner et al., 2018; Mills et al., 2019). Therefore, the use of partial protection approaches that include resource users in decision-making may lower the costs of replicating and scaling—potentially leading to overall greater conservation gains. Aligning these considerations with conservation targets can drive progress towards more holistic conservation outcomes that can lead to more sustainable resource

governance (Halpern et al., 2013). Therefore, in many contexts, MPAs incorporating partial protection may be better positioned to provide greater return-on-investment benefits for both people and biodiversity than exclusively fully protected MPA approaches (Chuenpagdee and Jentoft, 2007).

More equitable approaches to MPAs are apparent in the increased global recognition of different governance models (Bennett and Dearden, 2014). Equity in protected areas can be thought of in three dimensions: recognition (acknowledged legitimacy of rights/values by stakeholders), procedure (inclusive/effective participation of stakeholders), and distribution (sharing of costs/benefits of management between stakeholders) (Schreckenberg et al., 2016; Zafra-Calvo et al., 2017). All three components must be integrated for equitable MPA establishment and management. By identifying and including different stakeholder groups in finding equitable solutions, it is possible to achieve biodiversity outcomes that minimize disproportionate impacts on particular groups (Gurney et al., 2015). Over the last few decades, momentum has been growing behind building institutional structures that facilitate the co-management of marine resources between government and local communities and/or direct governance by local communities, ensuring local voices can shape MPA management (Clifton, 2003; Schultz et al., 2011). Devolving rights and decision-making authority to resource users through different governance models does not necessarily lead to weaker biodiversity protection, and can lead to more equitable outcomes (Leisher et al., 2007; del Pilar Moreno-Sánchez and Maldonado, 2010; Bennett and Dearden, 2014; Stafford, 2018).

3.3.2 Partial protection approaches can generate biodiversity benefits

Defining fishing regulations within partially protected areas to lead to sustainable fisheries and biodiversity outcomes can be achieved through regulation choice—including fishing gears, appropriate zoning structure, and employing evidence-informed single-species and threshold-based management. Reducing the impact of fishing gears can improve fisheries sustainability and biodiversity outcomes within partially protected areas (Crane et al., 2017a). Different fishing gears have widely variable ecosystem impacts, resulting in variation in their sustainability and the recovery time of ecosystems following use (Horta e Costa et al., 2016; Mbaru et al., 2020). For gears used by small-scale fisheries, destructive fishing practices—such as blast and cyanide fishing—cause damage lasting many decades by destroying reef habitats and killing non-target benthic species (Fox et al., 2019). In contrast, hand line fisheries can have much lower impacts on reef habitat and non-target reef species (Campbell et al., 2018; Mbaru et al., 2020). Restricting fishing within partially protected MPAs to regulated hook-and-line can lead to increased fish biomass (Campbell et al., 2018). In theory, a focus on reducing, and diversifying—but not eradicating—fishing gears and pressure within existing MPAs can result in greater overall biodiversity gains than expanding no-take areas under some contexts (Hopf et al., 2016). Thus, careful planning around gear types allowed, followed by monitoring and evaluation for adaptive management of gear impacts, can be used to balance the trade-off between fisheries and biodiversity outcomes when using partial protection approaches.

Appropriately defined and recognized boundaries are key for partially protected areas to provide both biodiversity and sustainable fisheries benefits. Spatial zonation within MPAs allows the implementation of different regulations in different parts of the MPA. This could include smaller no-take areas as part of a suite of management over a larger area—such as a zoned mixed-use MPA that allows extractive resource use within some areas. Alternatively similar effects could be achieved through a network of MPAs that includes both partial protection and full protection. The effectiveness of partially protected areas can be enhanced by the presence of adjacent fully protected areas (Zupan et al., 2018), and many of the community-governed case study MPAs that reported biodiversity benefits did include permanent no-take areas (Table 1). In other cases, temporal protection approaches can allow some forms of rotational extractive use across the whole MPA improving fisheries sustainability (Carvalho et al., 2019). When combined with species-specific protections for vulnerable species, these temporal protections can also provide longer-term biodiversity protection (Goetze et al., 2016; Carvalho et al., 2019). In all these cases, having clearly defined and recognized internal boundaries is essential for the MPAs to function.

Intuitively, employing evidence-informed single-species and threshold based management can also help partially protected areas to function more effectively. It is important to clearly identify the specific biodiversity objectives of partially protected areas if continued fisheries access is desired. For example, MPAs can focus on protecting key vulnerable species, or rebuilding and maintaining ecological functions or habitats. Ecosystem function approaches can use tools such as biomass thresholds to identify MPA objectives based on maintaining or enhancing fish biomass to certain levels (McClanahan et al., 2011; Karr et al., 2015). These thresholds can be highly variable by species (Brown and Mumby, 2014). For example, maintaining herbivorous reef fish biomass at 50% of the level expected in the absence of fishing retains over 80% of many herbivory functions (MacNeil et al., 2015). Herbivore biomass can be maintained at this level by partial protection approaches—such as bans on specific gears or species catch restrictions (MacNeil et al., 2015). While this results in lower fish biomass than in the absence of fishing, it allows fisheries to continue while still maintaining ecosystem functions. Threshold-based management requires MPA managers to conduct monitoring, evaluation, and learning activities to track fish biomass levels within their MPAs—ideally comparing fully protected, partially protected, and control areas without protection. This information can then be used to adaptively manage MPA-specific fisheries regulations to ensure biomass is maintained above such thresholds.

3.3.3 Looking forward

Our case studies provide diverse examples demonstrating that partial protection approaches within MPAs also have the potential to deliver on biodiversity outcomes while supporting social-ecological resilience when they are well-designed and well-managed. Target 3 of the newly adopted Kunming-Montreal Global Biodiversity Framework calls for 30% of coastal and marine areas to be effectively conserved and managed by 2030 (CBD, 2022). As this global target is translated into new national targets and action plans we encourage countries to consider a blend of locally appropriate protection levels – from fully protected areas to partially protected

MPAs – to achieve positive biodiversity outcomes. Fully protected areas remain an important tool for biodiversity protection, and should be implemented where appropriate, either as exclusively fully protected MPAs or as zones within MPAs with differing protection levels. However, because partial protection provides more opportunities to incorporate local access and resource use, it often results in more equitable and effective conservation approaches compared to exclusively fully protected areas (Fidler et al., 2022). We recommend further research into the optimal proportion of fully verses partially protected areas and their appropriate governance models to generate biodiversity outcomes without compromising access to resources, equability, food security, and local rights. A push for exclusively fully protected MPAs as global protection targets are implemented could risk increasing marine resource conflict and undermine social-ecological systems (e.g. Schleicher et al., 2019). We therefore recommend consideration of the full spectrum of MPAs that deliver positive biodiversity outcomes moving forward.

Adoption and recognition of partial protection approaches increases the diversity of regulations available to MPA managers. This helps MPAs become more locally tailored, and thus provides more pathways to achieve equitable governance, effective implementation and therefore build more resilient social-ecological systems. Our regulation classification can help MPA managers consider and design locally relevant MPA regulations, support evaluation of existing MPA regulations, as well as future research efforts on MPA effectiveness. MPAs that embrace contributions from partial protection alongside fully protected zones are therefore a valuable complementary approach to fully protected MPAs. Or, partially protected MPAs may be an important complement to fully protected MPAs within an MPA network. Our in-depth review of partially protected MPA restrictions demonstrates that a diversity of approaches can lead to positive biodiversity outcomes.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

DA-B, E, HF, DG, NK, and GA contributed to conception and initiation of the study. DAB, LV, Am, NC, Es, HF, DG, JG, NC, SM, MT, and GA participated in the study design workshop. DA-B, LV, and DG analyzed the MPA regulations and organized the dataset. DA-B performed the statistical analysis and wrote the first draft of the manuscript. All authors contributed to the submitted article 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.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmars.2023.1099579/full#supplementary-material

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Designing transdisciplinarity for transformative ocean governance

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The 2030 Agenda for Sustainable Development sets out a transformative vision which has yet to be realised for SDG14 and oceans. Recognition of the "indivisibility" of the Goals and enhanced integration of ocean governance support this transformation, but require at least multidisciplinary, or probably transdisciplinary, approaches. For regions which are highly dependent on development finance, a powerful leverage point for a transdisciplinary transformation is in the design of development investments. The work presented here identifies design features of ocean development-financed projects involving substantial amounts of research in two Pacific Small Island Developing States (SIDS): Fiji and the Solomon Islands. Transdisciplinary approaches were closely aligned to what is established as Mode 2 research modalities which focus on participation and multi-knowledge systems, as opposed to Mode 1 which have a predominantly scientific basis. From the literature an analytical indicator framework was developed which scored projects on their Modes of research within four categories: Product, Process, Policy and People. This framework was applied to five development-financed projects, and permitted the balance of Mode 1 and Mode 2 to be assessed and significant differences between projects identified. The work surfaces project features which can be embedded in the design of ocean investments which promote transdisciplinarity. This tractable and practical recognition of transdisciplinarity has connotations to the UN Ocean Decade in its ability to deliver on its transformation rhetoric. With capacity weaknesses and constrained financial resources in developing countries, and urgent ocean-related challenges especially in SIDS, moving to designed-in transdisciplinary and transformational outcomes remains a priority.

KEYWORDS

ocean, policy, transdisciplinary, transdisciplinarity, Pacific, development, SIDS

1 Introduction

1.1 Transformation through integration

The UN 2030 Agenda for Sustainable Development sets out a transformative vision which has yet to be realized for SDG14 ("life below water"). In the 2030 Agenda, the 17 Sustainable Development Goals (SDGs) represent a set of interrelated and indivisible development Goals, although the strength of the connections between the Goals are uneven (McGowan et al., 2019). Recognition of this "indivisibility" of the goals, means

that more integrated approaches are required for this envisioned transformation to sustainable development. SDG14 is highly integrated to other SDGs, especially in SIDS (Small Island Developing States) which are reliant on the ocean (e.g. Singh et al., 2018; Singh et al., 2021). Thus, the global high-level policy frame demands enhanced integration of ocean knowledge, management and governance to support this transformation explicit in Agenda 2030.

Present formalized knowledge systems, derived from universities and research institutes, are "arguably failing humanity" when compared to global challenges (e.g. Fazey et al., 2020). For more integrated outcomes it is necessary to traverse traditional scientific discipline boundaries and combine or connect multiple disciplines. The necessity of working towards integrated approaches for more sustainable outcomes, has been embedded into some mechanisms of support, such as the UK Research and Innovation Global Interdisciplinary Research Hubs (UKRI, 2019) through which this work was undertaken, and the Belmont Forum which is a partnership of funding organizations, international science councils, and regional consortia which has a Vision to support international transdisciplinary research providing knowledge for understanding, mitigating and adapting to global environmental change.

A review of transdisciplinary funding mechanisms concluded that research funding agencies that have a critical role to play by directly supporting and incentivizing transdisciplinary research (OECD, 2020). In addition, the OECD review concluded with respect to developing transdisciplinary approaches that "*the UN and other international bodies…. can play an important role in building consensus and catalyzing action*" and that this "*requires changes not only within science systems but also support and engagement from other sectors of society*".

This United Nations Decade of Ocean Science for Sustainable Development (2021-2030) has a Vision for the "Science We Need for the Ocean We Want" and a Mission which includes "transformative ocean science solutions" (UNESCO, 2022a). The Decade requires financial resources in the region of US $5-7 billion over the first 5 years to fully meet the needs of implementation. The Decade has a process of endorsing existing initiatives and projects (UNESCO, 2021; UNESCO, 2022b). Resource mobilization has secured US $855 million, primarily through existing project endorsement, and a further US $15 million in new funds to support Decade action. A significant resource mobilization gap of >80% is apparent over the remaining 5 first years of the Decade; significant additional funds will be required to meet its objectives (UNESCO, 2022b).

With the UN sustainable development transformation being predicated on more integrated knowledge and outcomes, and consequently increasing levels of knowledge and understanding which traverse traditional discipline boundaries our research focuses on the research design of the financial resource gap of the Decade. In a perpetually resource limited environment, efficient and effective investments become a priority. In Decade terms, this translates to how best design future programmes, or design criteria to endorse relevant projects, which ensure this integration-dividend is captured and the transformation of Agenda 2030 advanced.

1.2 Transdisciplinarity for oceans

The Decade identifies that transdisciplinarity is the key to transformative knowledge; it states that one of the barriers to overcome to achieve SDG14 is that transdisciplinary approaches to ocean science require a systematic change to framing problems, identifying resources and disseminating results (UNESCO, 2022a). Transdisciplinary research has been defined as a comprehensive, multi-perspective, problem- and solution-oriented approach that transcends disciplinary boundaries and bridges science with practice (Pohl, 2011; Franke et al., 2022). The process of joint knowledge production between experts from different disciplines (Coghlan and Brydon-Miller, 2014), sectors, and decision levels, including joint problem formulation, knowledge generation, application in both scientific and societal practice, mutual quality control of scientific rigor, social robustness, and practical relevance leads to transdisciplinary co-production (Polk, 2015). This concept of 'transdisciplinarity' was developed in the 1970s (Jantsch, 1972; Piaget, 1972) before the principle of sustainable development (Brundtland, 1987) further encouraged integrative approaches.

Transdisciplinary research has been perceived to (1) tackle real life problems, (2) address the complexity of these problems by involving a variety of actors from science and practice and accounting for the diversity of their perspectives, and (3) create knowledge that is solution-oriented, socially robust, and transferable to both scientific and societal practice (Pohl and Hadorn, 2007; Lang et al., 2012; Berni, 2016). While there is still ongoing debate on definitions, transdisciplinarity can be differentiated from multidisciplinary, where knowledge stays within discipline boundaries, and interdisciplinarity, in which knowledge is a synthesis of disciplines in a coordinated and coherent whole. In many ways, transdisciplinarity transcends discipline boundaries by creating new integrated knowledge (e.g. Bammer, 2005 and Jahn et al., 2012); this is a fundamental essence of the transformation urged by Agenda 2030, and implicit in the UN Ocean Decade.

While the precise definition and role of transdisciplinary is becoming somewhat normalized but still debated within academia, approaches or tools to measure of assess transdisciplinary approaches are limited. Transdisciplinary studies are still relatively rare, making up <10% of coastal and marine published work (Riechers et al., 2022). Many of these studies articulate on transdisciplinarity and codeveloping solutions-oriented science (e.g. Arkema and Ruckelshaus, 2017, for the Caribbean ocean conservation; Syddall et al., 2021, for Pacific tuna fisheries), sometimes focusing on specific components of transdisciplinarity (such as knowledge integration in Swedish water research, Hoffmann et al., 2017). Whereas, other research discusses the form of projects that would promote transdisciplinarity (e.g. Brink et al, 2018 for ecosystem services and planning; Wolff et al., 2019, for management of river valleys; Franke et al., 2022; on marine real-work laboratories to support the UN Decade), but refrain from developing systematic analytical approaches or tools to assess and evaluate transdisciplinary progress.

1.3 Towards transdisciplinarity by design

Considerable time and effort were expended by the authors, and the broader team involved in the One Ocean Hub project, in framing and structuring transdisciplinarity in a practical and functional way to support development outcomes. A working definition emerged from this project through a collaborative deliberative analysis, involving

one of the authors; "*Transdisciplinarity is a collaborative research process between researchers and the individuals the research is supposed to engage, benefit, or consider, together developing a co-designed knowledge generation process*" (Strand et al., 2022).

However, progression towards an analytical framework which had the potential to identify and characterize the transdisciplinary nature of ocean development investments was frustratingly elusive (Maharaj and Hills, 2021). This maybe reflects the challenge of moving from a well-found theoretical and conceptual basis of transdisciplinarity formulated in the past, to practical application in contemporary sustainability settings. In our context, literature prior to the emergence of transdisciplinary research agendas, decades ago, provided an entry point in practical application of transdisciplinary.

One major approach to transdisciplinarity stems from a March 2000 congress in Zurich, Switzerland, attended by ~800 people from more than 42 countries, including industry, government, and academics from nearly 40 disciplines (Klein, 2004). The goal of the conference was to develop transdisciplinary practice, promote transdisciplinary research, and create favorable institutional structures and power incentives (du Plessis et al., 2013; Segalàs-Coral and Tejedor, 2012). An approach was developed, subsequently termed the Zurich approach, for which the Network for Transdisciplinary Research (td-net) is still maintained by the Swiss Academies of Arts and Sciences (SAAS, 2022).

In formulation the Zurich approach fundamentally drew on the Mode approach to knowledge generation (Gibbons, 1994; Gibbons et al., 1994). In summary, the Mode approach identifies two polarized styles or approaches. Mode 1 focuses on problems of academic interest, which are implemented in disciplinary ways and involve scientists doing science as the normative process and organizational fixed hierarchical institutional arrangements. Whereas Mode 2 involves problems located within the domain of the solution, change-orientation in knowledge and practice and more transient institutional arrangement, and transdisciplinary research methods (Gibbons, 1994; Gibbons et al., 1994). Differentiation between Mode 1 and 2 in projects and initiatives was tractable (e.g. Mitchell, 2020); this was our entry point into contemporary ocean development investments.

The Mode 2 approach to knowledge production was embedded in the Zurich definition of transdisciplinarity and deliberation and discourse around transdisciplinarity were mainly fueled by Mode 2 knowledge production (Jahn et al., 2012). Gibbons and his colleagues "generalized key features of transdisciplinarity – heterogeneity, social responsibility and contextuality – into a new way to produce scientific knowledge (Jahn et al., 2012). Consequently, the authors took the Mode approach as a practical bifurcation for knowledge generation; with the structure and process of Model 1 obviating transdisciplinarity, whereas the structure of Mode 2 being obligate to, or at least promulgator of, transdisciplinary approaches.

1.4 Research aim and approach

The primary aim of the research presented here was to elaborate a tractable and practicable approach for the UN Ocean Decade to identify transdisciplinary investments which could meet its stated transformative agenda. A secondary aim was to provide an approach which could be used by development partners and governments more widely in designing transformative ocean-related interventions for developing countries.

This study was targeted at two Pacific SIDS which were selected as they were the two target countries in the region of the One Ocean Hub project supporting this work: Fiji and the Solomons Islands (the latter classified as a Least Developed Country). SIDS tend to have a strong reliance on ocean resources and, the South Pacific/developing country focus constrains itself to tractable and practical approaches due to the "persistent disparities in ocean science capacity" (Harden-Davies et al., 2022) and urgency of action. The approach of the authors was to journey through the bewildering array of generic discourse of transdisciplinary to create tangible and practical ways forward, which could be appreciated by development partners and in government offices in the South Pacific and elsewhere.

The unit of analysis was recently completed Overseas Development Assistance (ODA) supported ocean-related projects which were interrogated to determine their blend of Modes. To achieve this a literature review identified design features necessary to promulgate transdisciplinary approaches in ocean development projects, and then recently completed ocean-related development projects were interrogated.

2 Methodology

2.1 Development of indicators

An extensive literature analysis of published journal papers and books was conducted in order to extract the characteristics or features of Mode 1 and Mode 2. Each publication was reviewed in order to identify constituent indicators. The analysis identified and extracted features or characteristics which the authors conferred to being indicative of either Mode 1 or 2. Consolidation of the list of Mode 1 and 2 candidate indicators removed overlapping or nested indicators through aggregation undertaken by the authors. Following this consolidation process, there remained 31 indicators for Mode 1 and 37 indicators for Mode 2; indicative source references for each indicator were retained (Table 1). Although the literature on which the indicators emerged was extensive, some possible indicators may have been missed in other un-read publications. However, it is a working assumption that the 30+ indicators for Mode 1 and 2 were adequate to characterise the project approach.

Subjective iterative shuffling of the indicators was undertaken by the authors to try to identify coherent higher-level groupings of indicators. This process concluded with identifying four groupings of indicators which applied to both the Modes: Product, Process, Policy and People. The authors termed this the 4P framework and it was used as the basis of interrogation of specific ocean development projects (Table 1).

2.2 Selection of ocean-related projects

Development projects which included an ocean component in the South Pacific region and which were supported by Overseas Development Assistance were selected for interrogation by the 4P framework.

TABLE 1 The groups, indicators and descriptions for Mode 1 and Mode 2 which make up the 4P framework.

MODE 1		
Group	Indicators	Summary description and indicative reference
Product	a. Stepwise research b. Conventional output c. Scientific knowledge d. Ascientific validity e. Bio-social separation f. Production led g. Research non-ultilitarian Academic problem-setting	a. One discovery may build upon another (Gibbons et al., 1994) b. Conventional and applied research outcomes (Kelemen and Bansal, 2002) c. Production of scientific knowledge (Gibbons et al., 1994, Osborne, P., 2015, Hessels and van Lente, 2008) d. Adding to the base of disciplinary knowledge with replicability and validity (Kelemen and Bansal, 2002) e. Permits for a more realistic description of material– biophysical and socio-cultural, epistemic structures, within separate disciplines (Ostrom, 2007, Scholz, 2011) f. With respect to usage, production precedes consumption (Kelemen and Bansal, 2002) g. Not intended to support practice and that potential use do not influence research design (Kelemen and Bansal, 2002) Problems are set and solved in a context governed by the largely academic, interests (Gibbons et al., 1994)
Process	a. Communication specialism b. Peer accessibility c. Consensus d. Knowledge specialisation e. Knowledge reliability f. Cognitive norms g. Pragmatic conformity h. Disciplinary challenges i. Discipline aligned j. Science application Technology transfer	a. Discrete areas of specialization communication wise (Gibbons et al., 2001) b. All research must be communicable in a form that can be understood by one's colleagues (Gibbons et al., 2001) c. Requires consensus, even if a limited one (Gibbons et al., 2001) d. Knowledge accumulated through the professionalization of specialisation largely institutionalized in universities (Gibbons et al., 1994) e. Notion of reliable knowledge which preserves and upholds the integrity of scientific findings (Gibbons et al., 2001) f. Follows cognitive and social norms in the production, legitimation and diffusion of knowledge of this kind (Gibbons et al., 1994; Huff, 2000) g. Impermeable and paradigmatic conformity mostly within the limits of single disciplinary boundary (Kelemen and Bansal, 2002) h. The source of the intellectually challenging problems, arises largely within disciplines (Gibbons et al., 2001) i. Traditional disciplinary structure of science and technology (Gibbons et al., 1994) j. Pure science, generated in theoretical/experimental environments, is applied (Etzkowitz and Leydesdorff, 1997, Knorr-Cetina, 1999) Technology is transferred (Etzkowitz and Leydesdorff, 1997, Knorr-Cetina, 1999)
Policy	a. Institutional hierarchy b. Fixed structure c. Institutional channels d. Analytical focus e. Weak accountability f. Separate science	a. Organisationally enforces hierarchy (Gibbons et al., 1994) b. Tends to preserve its form specifically during project implementation duration (Gibbons et al., 1994) c. Results are communicated through institutional channels following bureaucracy (Gibbons et al., 1994) d. Less reflexive (Gibbons et al., 2001) e. Socially less accountable (Gibbons et al., 2001) f. Socially less accountable (Gibbons et al., 2001)
People	a. Mainly academics b. Discipline based c. Professional level d. Individualistic e. Skill homogeneity Exclusive orientation	a. Research team composed of disciplinary experts and expatriates like scientists and academic leaders (Gibbons et al., 1994) b. Over-rigid and hierarchical disciplinary boundary work (Gibbons et al., 1994) c. Highly trained individuals (Huff, 2000) d. Supports individualism within disciplinary boundaries (Huff, 2000) e. Homogeneity of training (Gibbons et al., 1994) Homogeneity of training (Gibbons et al., 1994)
MODE 2		
Characteristics	Indicators	References
Product	a. Diverse range of intellectual products which are of interest to social, scientific, economic and political domains b. Transient knowledge c. High applicability d. Transdisciplinary knowledge e. New norms f. Highly integrateable g. Discoveries unconfined to disciplines h. Balanced creatively i. In-house expertise Sensitivity	a. More diverse set of intellectual and social demands where results are communicated to those who have participated in the course (Gibbons et al., 1994) b. Production of transient knowledge (Kelemen and Bansal, 2002) c. Applied and applicable research outcome (Kelemen and Bansal, 2002) d. Knowledge created is transdisciplinary and from a broader range of considerations (Gibbons et al., 1994) e. New norms emerge that are appropriate to transdisciplinary knowledge Gibbons et al., 1994) f. The determinants of a potential solution involve the integration of different skills in a framework of action (Gibbons et al., 1994) g. The discoveries lie outside the confines of any particular discipline and practitioners need not return to it for validation (Gibbons et al., 1994) h. The creative act lies just as much in the capacity to mobilize and manage these perspectives and methodologies, their 'external' orchestration, as in the development of new theories or conceptualisations, or the refinement of research methods, the 'internal' dynamics of scientific creativity (Knorr-Cetina, 1999) i. Knowledge is embodied in the expertise of individual researchers and research teams as well as conventional research products like journal articles or patents (Knorr-Cetina, 1999) Sensitivity to the impact of the research is built in from the start (Gibbons et al., 1994)
Process	a. Transdisciplinary b. Accountability and transparency c. Vital processing period	a. More diverse set of intellectual and social demands (Gibbons et al., 1994) b. Results are communicated to those who have participated in the course (Gibbons et al., 1994) c. The diffusion of the results is initially accomplished in the process of their production and subsequent

(Continued)

TABLE 1 Continued

MODE 1		
Group	Indicators	Summary description and indicative reference
	d. Composite and multidimensional e. Highly inclusive f. Contextual knowledge production g. Supports mutual learning h. Capacity and consensus building i. Heterogenous group j. Permeable research boundaries k. Best practices Collaborative	diffusion occurs primarily as original practitioners move to new problem contexts (Gibbons et al., 1994) d. Quality control process is composite and multidimensional (Gibbons et al., 1994) e. Socially extended process which accommodates many interests in a given application process (Gibbons et al., 1994) f. Knowledge is generated within a context of application (Etzkowitz and Leydesdorff, 1997; Knorr-Cetina, 1999) g. Mutual learning among scientists and practitioners about a complex, societally relevant problem may be seen as the kernel of transdisciplinary processes (Scholz, 2000; Scholz et al., 2000). h. Capacity building among all participants; consensus building about what the main problems are, including their genesis and transformation, strategies for mitigating emerging conflicts in a process (Scholz and Steiner, 2015) i. Heterogeneity of skills and expertise to the problem-solving process (Gibbons et al., 2001) j. Transdisciplinary and permeable research boundaries (Kelemen and Bansal, 2002) k. Theoretical perspectives and practical methodologies to solve problems (Knorr-Cetina, 1999) l. Policy-oriented collaborative research processes in a greater variety of contexts (Russell et al., 2008)
Policy	a. Feedback encouraged b. Permits more freedom c. Change valued d. Quality control e. Context of application	a. Both practitioners and social policy professionals facilitate the flow of feedback, learning and reflexivity (Gibbons et al., 1994; Tranfield and Starkey, 1998) b. Emergence of loose organizational structures, flat hierarchies, and open-ended chains of command (Gibbons et al., 2001) c. Research and situated learning are embedded with action or change processes (Eden and Huxham, 1996) d. Quality control is exercised as a socially extended process (Gibbons et al., 1994) Additional criteria are added through the context of application which now incorporates a diverse range of intellectual interests as well as other social, economic or political ones (Gibbons et al., 1994)
People	a. Socially accountable and reflexive b. Social scientists c. Cross, multi and transdisciplinary group d. Pluralist and participatory e. Team based f. Heterogeneous mixture g. Mutual learning h. Elements of relationality i. Creative and cooperative j. Quite flexible	a. Socially accountable and reflexive (Gibbons et al., 1994) b. Pluralist and participatory (Kelemen and Bansal, 2002) c. Creativity is manifested as a group phenomenon with the individual's contribution seemingly subsumed (Gibbons et al., 1994) d. Characterised by transdisciplinarity (Gibbons et al., 1994) e. Institutionalised in a more heterogeneous and flexible socially distributed system (Gibbons et al., 1994) f. Correlated to the socially distributed knowledge production system (Gibbons et al., 1994) g. Facilitated process of mutual learning between science and society that relates a targeted multidisciplinary or interdisciplinary research process (Jantsch, 1972; Scholz, 2000; Klein et al., 2001) h. Multi-stakeholder discourse for developing socially robust orientations about a specific real-world issue (Jantsch, 1972; Scholz, 2000; Klein et al., 2001) i. Creation of a more cooperative mode of knowledge production (Gibbons et al., 1994; Eden and Huxham, 1996; Tranfield and Starkey, 1998) j. Considerable flexibility in the approach (Gibbons et al., 1994)

The project selection criteria were:

a. The project was targeted at Fiji and Solomon Islands which were One Ocean Hub target countries.
b. The project had to be recently completed so that final documentation was accessible.
c. The project appeared to involve multiple ocean-relevant disciplines.
d. The project included a research-type component, in that creating new knowledge and understanding was an objective.

Extensive internet search and then targeted discussions with local contacts (usually Project Manager/Director or Technical Staff who were involved in implementation of the projects) by the authors through email or direct conversation to establish the correct documents to review, led to the selection of the following projects for which comprehensive reporting was available:

1) National Marine Ecosystem Service Valuation (MESV) for Fiji and Solomon Islands, a part of the Marine and Coastal Biodiversity Management in Pacific Island Countries (MACBIO) project.
2) National Ecosystem and Socio-Resilience Analysis and Mapping (ESRAM) for Fiji and Solomon Islands, a part of Pacific Ecosystems-based Adaptation to Climate Change (PEBACC) project.
3) Reweaving the Ecological Mat (REM) project for Fiji.

2.3 Application of the 4P framework

Each project output was reviewed in detail to identify the presence of each of the 68 indicators in the 4P framework. Differences between the exact wording of indicators and the reporting documents were

permitted for inclusion if the sense of use was similar. The presence of each indicator was verified by an extracted reference from the official project documents. To reduce possible bias, the initial findings obtained were sent to the other author for verification.

This process provides a dataset of the presence/absence of 68 indicators, across two Modes and four groupings, from five projects: MESV-Fiji, MESV-Solomon Islands, ESRAM-Fiji, ESRAM-Solomon Islands and REM-Fiji. Samples of text from project documents which helped to identify presence of indicators are provided (Table 2). All indicators were assumed to be independent and were equally weighted in the subsequent analysis, as there was no rational *a priori* basis for weighting.

2.4 Statistical analysis

Statistical analysis was undertaken to determine the difference between Mode 1 and Mode 2 indicators by project. $\chi 2$ analyses were undertaken between each project pair, with the null hypothesis that the expected distribution of indicators present for Mode 1 and for Mode 2 was equal between pairwise projects. A Bonferroni adaptation was applied to the significance level of the $\chi 2$ value to reduce the chance of obtaining false-positive results (type I errors) when multiple pairwise tests are performed on a single set of data (Sokal and Rohlf, 1995). The Bonferroni adaptation involved dividing the $\chi 2$ value by the total number of pairwise tests undertaken for each of the

TABLE 2 Example compilation of edited extracts from the reports on which indicator presence was determined, divided into the 4P groups for brevity.

CHARACTERISTICS	MODE 1 INDICATORS		
	MESV (Fiji)	ESRAM (Solomon Islands)	REM (Fiji)
Product	4.1. Fiji-MESV, pg 3: Under the MACBIO project, IUCN Oceania is primarily responsible for conducting national economic assessments of marine and coastal ecosystem services in all five MACBIO countries, including conducting a data gap analysis. National reports on the value of marine and coastal ecosystem services will be provided to countries to inform marine spatial planning and marine resource management in general. This is one of those reports.	3.10 ESRAM-SI, pg 16: Figure 1-1 shows the key components of the PEBACC project, which are: (1) ecosystem and socio-economic resilience analysis and mapping (ESRAM) study – baseline study for adaptation planning at national, provincial and community levels; (2) EbA options assessment – EbA options analysed, prioritised and plans developed; (3) implementation plans – EbA plans implemented with demonstrated benefits; and (4) communications and outreach products developed to promote integration of EbA options into climate change policies, plans and projects	4.1 REM-PS, pg 3: The primary purpose is to introduce and profile the project and garner support of the church and civil society leaders for the project through bilateral meetings, briefings and discussions. This is the primary purpose of these visits. The follow-up visits are for monitoring purposes and to conduct further awareness and training on the project. Regional and international conference. The purpose is to reflect, establish networks, advocate for development alternatives, and to profile the project and the work of the churches on development and ecology. These are also opportunities to learn and share experiences on development and ecology from the Pacific region.
Process	3.2. Fiji-MESV, pg 69: A range of activities address the three broad areas which are implemented in an integrated manner that combines scientific research to inform policy with communication as a means of disseminating research information.	3.1 ESRAM-SI, pg 16: communications and outreach products developed to promote integration of EbA options into climate change policies, plans and projects (SPREP 2016).	3.1 REM-PS, pg 3: Regional conference for advocacy training, including media advocacy, and advocacy strategising. This is crucial to enhancing the profile of the project and to raising questions in the region about development and ecology. Part of this advocacy strategy is to build a regional network on development and ecology among church and civil society leaders, and the dissemination of information and relevant media articles. Policy briefs on various aspects of development and the ecology. These policy briefs are mainly for churches and civil society.
Policy	2.1. Fiji-MESV, pg B: The MACBIO Project has undertaken economic assessments of Fiji's marine and coastal ecosystem services and	2.1 ESRAM-SI, pg 48: Effective institutional	2.1 REM-CN, pg 2: Since the 2006 political coup in Fiji, there have been a number of developments that have impacted upon structures and relationships in regional politics and implicitly on the leadership and

(Continued)

TABLE 2 Continued

CHARACTERISTICS	MODE 1 INDICATORS		
	MESV (Fiji)	ESRAM (Solomon Islands)	REM (Fiji)
	supports the integration of results into national policies and development. 2.7. Fiji-MESV, pg 10: There are three regional organisations that play a major role in use and management of marine and coastal resources, the Secretariat of the Pacific Community (SPC), the Pacific Islands Forum Fisheries Agency (FFA) and the Secretariat of the Pacific Regional Environment Program (SPREP). (Gillett and Tauati, 2018). The SPC has an active role in assisting member countries with marine and coastal fisheries development and management and also in developing scientific research and data collection on the state of marine resources. The FFA is more oriented to assisting member countries in management of tuna resources, including surveillance, economic and legal aspects. SPREP has been charged by the governments and administrations of the Pacific region to help with the protection and sustainable development of the region's environment. Other regional organisations, such as the University of the South Pacific (USP), have different levels of involvement in marine and coastal resources. planning.	administrations are imperative for environmental management and enforcement of environmental legislation and policies.	stewardship task of the faith-based Christian organisations in the Pacific. For example, the increasing influence of the Melanesian Spearhead Group (MSG) and the emergence of the Pacific Islands Development Forum (PIDF) have presented challenges to existing regional bodies such as the Pacific Islands Forum Secretariat (PIFS) and the reshaping and refocusing of political and developmental issues and interests on what are regarded as regional creations. In addition, the Forum's Pacific Plan, which acted as a guiding framework for governance, economic development, the environment and security in the region, came to an end in 2013. Gender based violence affects two out of every three women in the Pacific and is a major threat to peace and justice in the region. Gender based violence reflects systemic power inequities in social relations. These power inequities are further exacerbated by deteriorating social relations linked to poverty, economic exploitation, poor education and drug and alcohol abuse.
People	1.1. Fiji-MESV, pg 12: The responsibility of preparing the NBSAP was delegated to the DoE, which was guided by a steering committee that included representatives of a broad range of government departments, NGOs, academics and UNDP (DoE, 2007).	1.1 ESRAM-SI, pg 10: With assistance from SPREP, this and the subsequent volumes (Volumes 2 and 3) are the result of a collaboration between BMT WBM, our subconsultants, and the numerous communities, government and other stakeholder representatives who have been involved in the project to date. Key project team personnel involved in the ESRAM process	1.2 REM-PS, pg 2: This project argues the point that indigenous and Christian ecological frameworks (knowledge, ethics and practices), have much to contribute to addressing the 'ecological and developmental crises. Ecology as understood in most Pacific indigenous communities is both the relationship among the people in a community, and the relationship with their natural environment.
CHARACTERISTICS	MODE 2 INDICATORS		
	MESV (Fiji)	ESRAM (Solomon Islands)	REM (Fiji)
Product	Not available	4.1 ESRAM-SI, pg 16: communications and outreach products developed to promote integration of EbA options into climate change policies, plans and projects	3.7 REM-PS, pg 3: Activities: Networking, profiling and bilateral meetings • The primary purpose is to introduce and profile the project and garner support of the church and civil society leaders for the project through bilateral meetings, briefings and discussions. This is the primary purpose of these visits. The follow-up visits are for monitoring purposes and to conduct further awareness and training on the project. • Regional and international conference. The purpose is to reflect, establish networks, advocate for development alternatives, and to profile the project and the work of the churches on development and ecology. These are also opportunities to learn and share experiences on development and ecology from the Pacific region. Education, training, awareness • In-country conferences for churches and civil society organisations. These national conferences are essential, both to introduce the project to a wider audience in the countries mentioned,

(Continued)

TABLE 2 Continued

CHARACTERISTICS	MODE 1 INDICATORS		
	MESV (Fiji)	ESRAM (Solomon Islands)	REM (Fiji)
			and hence to foster interest and ownership, and also to strategically plan with the churches how such a project can be implemented at their local communities, why it is crucial and how it can shape internal policies relating to development and the ecology, and the health of their people. • Training workshops on developing 'ecological indicators'. The ecological indicators meant here relate to environmental and physical health of people and the health of relationship between people and their environment. • Public lectures on the broad theme 'development and the ecology' and related topics that will further the discussions and debates on a revised developmental mandate, content and strategies. Its aim is to raise awareness on the need to review how development is understood and the need for alternative thinking about development. Advocacy • Regional conference for advocacy training, including media advocacy, and advocacy strategising. environment and their people.
Process	1. Fiji-MESV, pg13: In 2002, the SPC proposed a community-based fisheries management programme for Fiji (King et al., 2002). The programme considered an integrated approach built on participative learning activities that are employed in Fiji by NGOs in dealing with communities.	3.2 ESRAM-SI, pg 11: communications and outreach products developed to promote integration of EbA options into climate change policies, plans and projects.	3.1 REM-CN, pg 3: However, what is peculiarly sad in the Pacific is the progressive abandonment of indigenous and faith-based ecological frameworks (knowledge, ethics and practices) as legitimate ways to deal with the fissures in the ecological framework of Pacific people. The social context in which this follow-up project is situated is basically a crisis of this ecological framework, understood here to mean the myriad human relationships, and the values and ethics that govern and define that relationship, and their relationship with the environment.
Policy	Not available	2.3 ESRAM-SI, pg 11: Task 1 Ecosystem baseline and threat assessment; Identify the current state of ecosystems, trends and drivers of change with root causes, scenarios, governance factors. Identify ecosystem types, ecosystem services and threats. Identify ecosystem services that are valued by the community.	2.1 REM-PS, pg 3: Advocacy: Regional conference for advocacy training, including media advocacy, and advocacy strategising. This is crucial to enhancing the profile of the project and to raising questions in the region about development and ecology. Part of this advocacy strategy is to build a regional network on development and ecology among church and civil society leaders, and the dissemination of information and relevant media articles. Policy briefs on various aspects of development and the ecology. These policy briefs are mainly for churches and civil society. The focuses will include but not limited to
People	1.1. Fiji-MESV, pg 21: To this end, the ecosystem service valuation included the participation of government staff and local resource managers at every opportunity to permanently augment the capacity of country nationals to use ecosystem data and economic valuation in development of policies and resource management decision-making.	1.1 ESRAM-SI, pg 28: Ecosystem valuations can assist resource managers to deal with the effects of market failures (i.e. inability of a market to reflect the full social costs or benefits of goods or services), by measuring their costs to society, in terms of lost economic benefits (King and Mazzotta, 2000). These costs to society can then be imposed on those who are responsible or can be used to establish the value of actions to reduce or eliminate environmental impacts.	1.2 REM-PS, pg 2: The well-being and wholeness of these myriad relationships are dependent on the ethics and values systems that govern them. So, if there is bad political and community governance, and lack of social justice, the consequences are likely to be seen in how the community treats their natural environment, and the stewardship of their land and sea resources. Conversely, if there is a lack of appreciation of the natural environment and its significant role and contribution to the well-being and wholeness in the lives of the community, then the consequences are reflected somehow in how the community governs itself, how it treats its people, the sharing of its resources and its dispense of justice. communities and their natural environments.

threshold significant levels (P<0.05 to P<0.001); this meant that higher $\chi 2$ values were required to be significant.

3 Results

3.1 Analysis of indicators

The presence of each of the 68 indicators in each of the 5 analysed projects is presented (Figure 1). The presence of multiple Mode 1 indicators can be seen in all of the projects, although REM has only two (Figure 1A). However, REM demonstrates presence of all Mode 2 indicators, with other projects demonstrating varying frequencies of Mode 2 indicators (Figure 1B).

3.2 Comparative analysis by Mode

The percentage of Mode 1 and 2 indicators present for were determined (Figure 2). All projects had a combination or mix of Mode 1 and Mode 2 indicators. In four of the five projects Mode 1 indicators were more prevalent than Mode 2. However, in the REM project all Mode 2 indicators were present.

MESV-FJ and REM were dominated by one research Mode (Mode 1 and Mode 2, respectively), whereas the three other projects had more of a mix of Modes; ESRAM-SI had a near equal balance of Mode 1 and Mode 2 indicators. In the analysed sample of projects, there seemed to be a trade-off between Mode I and Mode 2, with either one Mode dominating or a moderate balance between the two Modes.

The $\chi 2$ analysis showed highly significant (P<0.001) differences between REM and all other projects in terms of indicators (Table 3). There was also significant differences in the same programme (ESRAM and MESV) but implemented in Fiji and Solomon Islands suggesting that national-level design and implementation approaches are a significant factor in project delivery, even when they are under a common multi-country programme. ESRAM-SI, with its relatively similar balance of Mode 1 and Mode 2 indicators, was significantly different to MESV-FI, having notably more Mode 2 indicators, but also significantly different to REM partly through having more Mode 1 indicators. This suggested that ESRAM-SI holds a central point which is significantly different to projects dominated by Mode 1 and by Mode 2, and thus in a statistical sense the Mode model is not just bipolar but a continuum.

3.3 Analysis by 4P grouping

The percentage presence of indicators with each of the 4P groups for Mode 1 and Mode 2 was determined to indicate of the relative strength of that group in each project. The MESV project in Fiji and Solomon Islands demonstrated a balance towards Mode 1 with all the 4P groups in Mode 1 having a high percentage of indicators present (over 80%, except Product in Fiji) (Figure 3). In fact all possible Mode 1 indicators were present for Process (100%) and Policy (100%) in Fiji, and Process (100%) and People (100%) in Solomon Islands. Whereas, the presence of Mode 2 indicators in MESV was low being 0 to 40%, except for the People group in Solomon Islands (Figure 3B). Comparing MESV between the two countries, the Solomon Islands has a stronger presence of Mode 2 indicators compared to Fiji. The absence of Mode 2 Product and Policy groups in Fiji, and the People focus on Solomon Islands, again reflect differences in implementation between the countries.

4P analysis of the ESRAM project demonstrated a similar general trend to MESV, with differences between the project in the way it was implemented between the two countries and the Solomon Islands demonstrating stronger Mode 2 elements compared to Fiji (Figure 4).

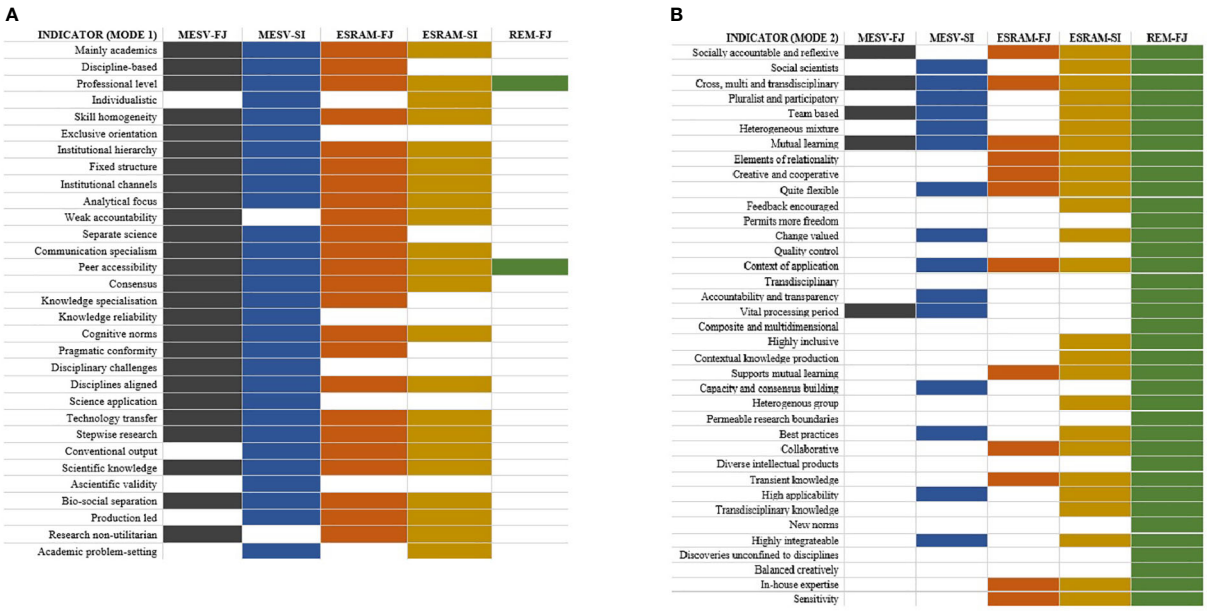

FIGURE 1
Presence of indicators derived from reports of each of the 5 analysed projects for Mode 1 **(A)** and Mode 2 **(B)** (FJ = Fiji, SI = Solomon Islands).

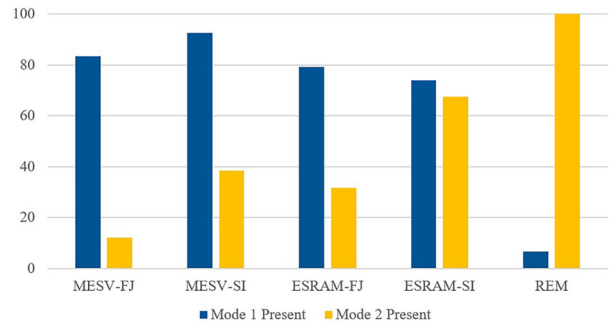

FIGURE 2
The percentage of indicators present in Mode 1 and Mode 2 for each of the 5 projects.

The REM project was focused on Fiji. The analysis indicates much stronger Mode 2 bias in its implementation compared to both MESV and ESRAM (Figure 5). The REM project demonstrates presence of all of the Mode 2 indicators in each of the 4P categories. There were some small elements of Mode I in REM, with <20% of Mode I indicators present in Process and People groups.

4 Discussion

4.1 A lens into transdisciplinarity

Literature analysis confirmed that there was a major distinction between Modes. Mode 1 indicators reflect a more scientifically based and academic led venture, while Mode 2 indicators emphasized diversity, mutualism and social aspects of research which had transdisciplinarity at the core. The analysis presented here was conducted using the 4P's Framework which captures these literature-derived differential characteristics between Mode 1 and 2. Projects like MESV-FJ proved to be mainly Mode 1 with a focus on scientific knowledge generation in this case in relation to ecosystem service economic valuation, while REM-FJ proved to be predominantly Mode 2 with strong elements of collaboration and mutual learning. The ESRAM-SI project had a relatively balanced blend between Mode 1 and Mode 2 drawing on both knowledge production and collaborative learning, and demonstrating that projects can reflect a mix of Mode and 2 approaches. In our project examples, we found a range from discipline-focused scientific knowledge production, to socialized holistic and transdisciplinary knowledge and understanding advancement.

It is envisaged that the 4P framework might provide a useful framework for assessing the blend of Mode 1 and Mode 2, with provision of designing-in further Mode 2 characteristics which promote transdisciplinary outcomes. The framework has relevance before, during (such as mid-term review) and after project completion and used to incrementally progress the transdisciplinary nature of ocean investments. The potential of the 4P's framework is that it represents a practical tool for advancing the design of ocean-related investment which promote transdisciplinary and thus the sustainable development transformation as per Agenda 2030. Implicit in this framework are some key requirements for development project design, such as multi-stakeholder involvement and participation, and inclusion of a diversity of ocean-based knowledge.

To achieve the Agenda 2030-style transformation, further investigation of practical implementation of multiple disciplinary approaches in development contexts need to be progressed. Present knowledge systems are not fit-for-purpose for the global challenges and need vast and rapid shift in focus (Fazey et al., 2020). The 4Ps framework captures many elements of disciplinarity drawn from the literature, yet further frameworks and tools in securing transformative design of ocean investments can further progress transdisciplinarity. For example, Norström et al. (2020) focus on principles of knowledge co-production to address complex sustainability problems, Cundill et al. (2015) focus on team composition and the social process of learning, and Rigolot (2020) places transdisciplinarity centrally in Mode 2, but as "a way of being" within a broader discipline of "integration and implementation sciences" (i2S).

Yet, to promote transdisciplinarity further as a practical instrument for transformative outcomes, there is a need for empirical and experiential studies on transdisciplinarity. Complementary to sematic and conceptual progression, future work needs to clarify the roles and responsibilities of involved actors (Hoffmann et al., 2017), and include personal values and ethics (Wolff et al., 2019). To move towards transdisciplinary, substantive epistemological shifts will be required which traverse sustainability- and development-based knowledge generation, and involve a collaboration of scientists, funders, governments and international organizations (OECD, 2020). The holistic but practical nature of the 4P framework has the potential to be an instrument with multiple entry points for promoting transformative approaches for sustainable development. With further research the 4P framework could be used to reflect on the design and implementation of past initiatives, or for setting guidelines or guardrails for the design of new initiatives which aim to inculcate transdisciplinarity as a mechanism for promoting transformative outcomes.

TABLE 3 The significance of pairwise $\chi 2$ tests between projects for Mode 1 and Mode 2 indicators: with NSD = not significantly different; * = P<0.05; ** = P<0.001; and *** = P<0.0001", ($\chi 2$ with 3 degrees of freedom, P values with Bonferroni adaptation).

	MESV-FJ	MESV-SI	ESRAM-FJ	ESRAM-SI
MESV-SI	*	–	–	–
ESRAM-FJ	NSD	NSD	–	–
ESRAM-SI	***	NSD	*	–
REM	***	***	***	***

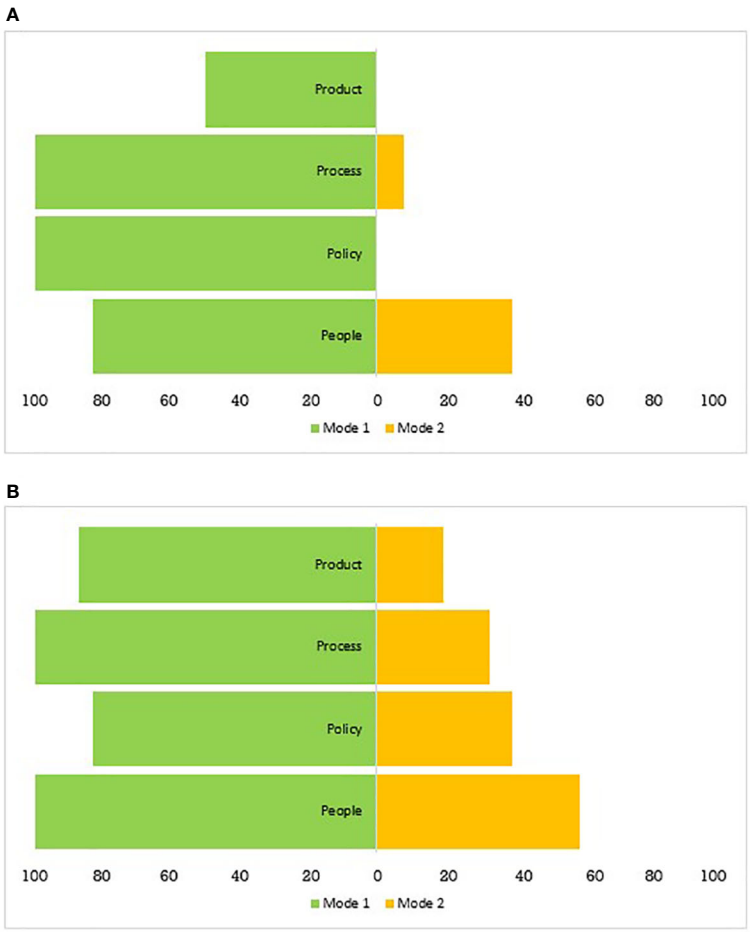

FIGURE 3
National Marine Ecosystem Service Valuation (MESV) analysis using showing percentage presence of indicators Mode 1 and Mode 2 in the 4P groups: **(A)** Fiji, **(B)** Solomon Islands.

4.2 Transdisciplinarity and the UN ocean decade

The UN Decade notes the need to move beyond "business as usual" and towards "transformative ocean science" with the UN 2030 Agenda being positioned as the "central framework" (UNESCO, 2022a). As most of the financial resources are based on external initiatives which are endorsed by the Decade, the procedure for endorsement of initiatives is paramount in shaping the Decade and its outcomes. Agenda 2030 emphasizes the need for transformational endeavors, and transdisciplinarity is seen as one way to progress such transformation, yet this is weakly reflected in the endorsement criteria. It should also be noted that endorsement calls revolve around the 10 challenges stated by the UN Decade, which include reducing pollution, protecting biodiversity, developing equitable ocean economies and expanding Global Ocean Observing, but the criteria are tacit on the epistemological revolution required in knowledge-systems and transdisciplinarity for transformative outcomes (in the sense of e.g. Fazey et al., 2020).

General terminology in the UN Decade endorsement criteria, state, for example, that initiatives will "contribute to the achievement of the SDGs", and that initiatives should lead to "uptake of science and ocean knowledge for policy, decision making, management and/or innovation" (UNESCO, 2020). This is alongside more specific criteria related to other features, including co-design, data access, partnerships and overcome barriers to diversity and equity. The need for integrated, multiple-discipline or transdisciplinary approaches for transformative action is not explicitly mentioned in the endorsement criteria. The Decade rhetoric on ocean knowledge for transformation does not seem to be fully balanced with the constituent project endorsement criteria.

Furthermore, contrary to the need for strong leadership in securing the future of the oceans, the endorsement procedure represents passive absorbance of existing funded initiatives. Only in the case of "Potential Decade Actions" are initiatives at the design stage and have not secured financial resources. The work presented here has demonstrated tractable ways of analyzing project design to determine if it prevents, or promotes, transdisciplinary, or for revising project design such that transdisciplinarity is promoted. The opportunity for driving forward transdisciplinary approaches with transformational outcomes is apparent within the Decade. However, mass endorsement of projects based on generalist guidelines may help to reduce the significant Decade financing gap, but will passively track "business-as-usual" and fail to meet the high-level rhetoric and ambition of the Decade and Agenda 2030.

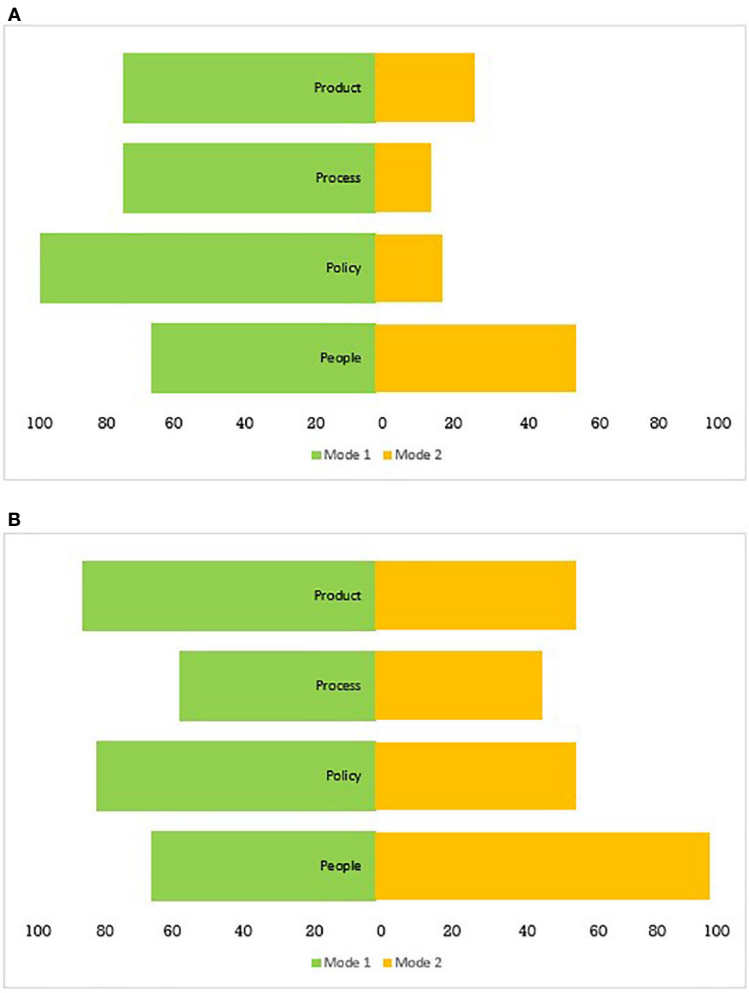

FIGURE 4
National Ecosystem and Socio-Resilience Analysis and Mapping (ESRAM) analysis using showing percentage presence of indicators Mode 1 and Mode 2 in the 4P groups: **(A)** Fiji, **(B)** Solomon Islands.

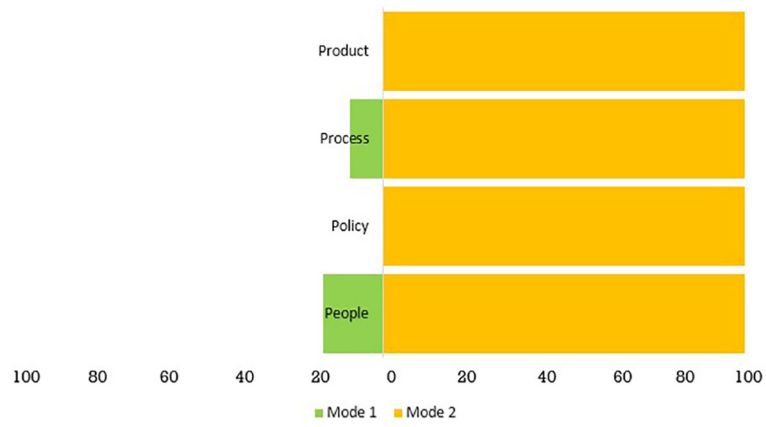

FIGURE 5
Reweaving the Ecological Mat (REM) analysis showing percentage presence of indicators Mode 1 and Mode 2 in the 4P groups.

5 Conclusions

Defining tractable ways forward from dialogues around transdisciplinarity to meet the Agenda 2030 challenge for integrated outcomes remains a challenge. The work presented here attempts to provide a practical process contributing to the design and assessment of transdisciplinary ocean-investments. With limited capacity and constrained financial resources in developing countries, and urgent ocean-related challenges especially in SIDS, moving from "business-as-usual" approaches to transdisciplinary and transformational outcomes is a priority. Expanding further ocean-based knowledge, may not be a sufficient path to transdisciplinary and transformational outcomes; this has connotations to filling the financing gap in the UN Ocean Decade, as well as shaping significant investments by development partners into oceans.

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

JH initially conceived the study and it was further developed by PM. The 4P's framework was developed under the guidance of JH by PM. Data analysis and visualisation was carried out by JH and PM. All authors contributed to the article 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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Ecotourism in Marine Protected Areas as a tool to valuate natural capital and enhance good marine governance: A review

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Marine Protected Areas (MPAs) are essential to reach the UN Ocean's Decade challenges and the Sustainable Development Goal 14 (life bellow water – conserve coastal and marine areas), and their crucial role for the health of the planet was highlighted in the United Nations Ocean Conference. However, often these MPA's are no more than Paper Parks, with poor financial and human resources, thus lacking effectiveness. Moreover, they frequently trigger conflicts with local communities, by imposing restrictions to their activities with no alternative or compensations, causing serious governance inefficiencies. Thus, within the UN Oceans Decade, MPA's must face simultaneously three of the challenges: Protect and restore ecosystems and biodiversity (Challenge 2); Develop a sustainable and equitable ocean economy (Challenge 4) and Change humanity's relationship with the ocean (Challenge 10). To address those challenges, it becomes clear that management models of MPA's had to find ways to value natural capital and, at the same time, involve local communities and stakeholders in the governance processes. The conservation of biodiversity has both direct and indirect economic benefits for many sectors of the economy, namely tourism, being ecotourism considered one of the segments particularly adequate to value natural capital. Ecotourism, defined as "environmentally responsible travel and visitation to relatively undisturbed natural areas", to enjoy and appreciate nature, is often used to enhance the natural capital, while protecting and promoting protected areas. Several studies have been carried out about ecotourism in MPA's all over the world, particularly in the 21st century. In this article, we analyzed several case studies focusing ecotourism in MPAs, to better understand the connection between the development of this industry, the development of sustainable blue economy, and the efforts for ocean

conservation. From the analysis conducted, we conclude that ecotourism development and community participation are of paramount importance in achieving sustainable development in MPAs, although there is still room to new advances improving good marine governance.

KEYWORDS

Marine Protected Areas, blue economy, ecotourism, conservation, sustainability, governance

1 Introduction

Marine Protected Areas (MPAs) are vital for biodiversity (Agardy et al., 2003). The UN Ocean's Decade challenges, the Sustainable Development Goal 14, and several other global and European agendas, policies and agreements, identify as a major goal for the protection of the marine environment and biodiversity the establishment of MPAs (European Commission, 2019; European Commission, 2020). The EU Biodiversity strategy for 2030 sets the goal for 30% of the seas to be under protection by 2030 (European Commission, 2020; UNOC, 2022).

There are many types of MPAs, and they can vary in several aspects such as size, conservation goals, governance, level of protection, among other factors (Pham, 2020). MPAs are favorable areas for the development of environmental education actions, scientific research, and tourism activities (Abbad et al., 2022).

MPAs and other diverse coastal ecosystems all have a great potential for nature-based ecotourism, due to their natural and cultural heritage, landscape, seascape, and recreational opportunities. Coastal and marine protected areas have natural capital stocks that provide several ecosystem services vital to humans. The delivery of these benefits depends on the protection and sustainable management of natural capital through effective nature conservation strategies (Gollier, 2019; Hooper et al., 2019). Since the United Nations General Assembly has designated 2002 as the International Year of Ecotourism (IYE), this type of tourism has been seen as a sustainable way to value natural capital (Eagles et al., 2002). Furthermore, the IUCN considers Ecotourism as a key tool for the financing of protected areas while contributing to improve incomes of local communities and the involvement of stakeholders. Since than ecotourism, particularly in protected areas, has greatly evolved all over the world and MPA's have shown to have great potential. Effective management of MPAs involves high costs and human resources, with the financial funds usually coming from national public funds devoted to the creation and management of MPAs, but also from International or European projects, private funds (foundations), and revenues generated on-site for some MPAs (entrance fees, development of ecotourism activities - example: in the Galapagos Marine Reserve tourism is a major economic activity) (Drumm, 2003; Balmford et al., 2004; Gabrié et al., 2012; BlueSeeds, 2020).

Tourism is a major economic activity in the European Union, and the EU Blue Economy Report (2022), establishes tourism as the EU "*third-largest economic sector with a wide-ranging impact on economic growth, employment, and social development*", and coastal areas and islands tend to be major tourism hotspots (European Commission, 2022). The increasing number of tourists rises some concerns regarding the environmental impacts that tourism has on marine ecosystems, and the sustainable development of coastal areas, since the more attractive a place is the more tourists it will attract, which may diminish the quality of the experience (Hillery et al., 2001; Queiroz et al., 2014; Kurniawan et al., 2022).

However, tourism is an important economic asset for many countries, especially in small islands' states (Seetanah, 2011), with a wide-ranging impact on economic growth, employment, and social development (Scheyvens and Momsen, 2008; Queiroz et al., 2014; Bhuiyan et al., 2016). Increased environmental awareness of the public, who is increasingly looking for more sustainable and responsible options, both for the environment and local communities, has provided the rise of ecotourism. Ecotourism is often considered a potential approach to strengthen conservation of natural ecosystems while, at the same time, enhancing a more sustainable local development (Ross and Wall, 1999; Chen et al., 2020). Therefore, ecotourism is an alternative solution that aims to protect natural resources, especially biodiversity, to promote the sustainable use of those resources, to create an ecological experience and environmental awareness for tourists and, at the same time, protect and respect the natural heritage of destinations and benefit the local communities (Mosammam et al., 2016; Chen et al., 2020).

Ecotourism rapidly expanded across the world and can be a key component to ensure a more sustainable and equitable Blue Economy (Cisneros-Montemayor et al., 2019; Stronza et al., 2019).

Around the world, the number of tourists seeking destinations where they can enjoy natural spaces and biodiversity is increasing (Moniz et al., 2009; Drumm et al., 2016; Noll et al., 2019). An example of the increased valuation of biodiversity is the observation of whales and dolphins in their natural habitat, the so-called "whale watching", which has become a relevant and growing marine ecotourist activity worldwide (Hoyt, 2005; Silva, 2015; Vieira et al., 2018). There is thus a need to align the goals of conservation and protection of nature with the enhancement of its natural capital, through Ecotourism and Nature-based Tourism, safeguarding nature, but making the protection and enhancement become an asset to the surrounding communities (Laulhe et al., 2012). The valorization of natural capital through ecotourism and nature tourism will actively contribute to achieve the goals established in the EU strategy for Biodiversity and the UN Ocean's Decade challenges.

In this article, we reviewed several studies focusing on ecotourism in MPAs, to understand the governance models that best enhance the relationship between ecotourism and the good management/effectiveness of MPAs, based on the valuation of natural capital.

2 Methods

In May 2022 we used the database Web of Science to identify studies about ecotourism in MPA's all over the world, from 2011 to 2022, in all languages and published as articles. The systematic literature review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guide (Moher et al., 2009). The search query looked for studies with titles, abstracts, and/or keywords that included the words: "ecotourism" and "marine governance" and "natural capital" and "MPA" or "marine protected area*" and "nature tourism" or "conservation "marine area*". The asterisk (*) symbol was used for the truncation and its effect is to retrieve all the words that contain the part of the word preceding the asterisk. The selection of words is representative of the focus of this research: ecotourism targeting MPAs, as a way to value the potential natural capital of those areas, and search for models of good governance that can make compatible ecotourism and conservation. This query generated a list of 404 publications with these criteria, and no publication was discarded due to the language. The PRISMA model was used to filter documents obtained from the databases according to the eligibility criteria. We discarded 33 of the publications before the screening process since they were not available (free access was not available). During the screening process, through peer review to minimize bias risk, 273 of the publications were excluded, since they did not include a clear reference to marine protected areas (MPAs) governance models, a reference to ecotourism in MPAs, or a reference to the economy or financing of MPAs (see Figure 1). In the end, 98 publications were included in the analysis.

We will analyze the spatial distribution by region/continent of the selected articles, whenever possible (since there must be some articles that are more global), to infer about representativity regarding the input for the research from different areas and continents.

Four main criteria of research were defined: Governance, Ecotourism, Stakeholders involvement, and Economy, to code the studies regarding the inclusion of these criteria.

2.1 Governance (C1)

Governance consists of the interactions between structures, processes, and traditions, which determine how responsibilities are exercised, how decisions are taken, and how the views of citizens and interest groups (stakeholders) are integrated into the decision-making process.

The concept of marine governance, mostly began to be elaborated during the second half of the 90's of the last century, particularly during the UN 1998 International Year of the Oceans, where the issues of ocean governance and sustainability were a key stone of the report "The Ocean Our future" of the Independent World Commission on the Oceans (Independent World Commission on the Oceans, 1998). Following, Paquet developed one of the first theoretical concepts defining marine governance: *"The governance of marine spaces is the management of stakeholder activities in these spaces. To optimize this management and to address stakeholder issues requires that effective governance frameworks be in place. Collaborative, cooperative, and integrative governance are improved frameworks for dealing with stakeholder issues. Traditional governance models have been based on a management science approach where the premise is that leadership of organizations (public, private or civic) is strong, and have good understanding of their environment (future trends, rules of the game, and the organization's goals)"* (Paquet, 1999).

Governance can also be defined as "the structural, institutional, ideological, and procedural umbrella under which development programs and management practices operate" (Bennett and Dearden, 2014), and it also determines "how and if the interaction between structures, processes, and institutions merges to solve social and environmental problems" (Plummer and Fennell, 2009).

Thus, the governance of MPAs is a determining factor for their success. Governance applies a systems' perspective on MPAs, both as a "governing system" and as a "system-to be-

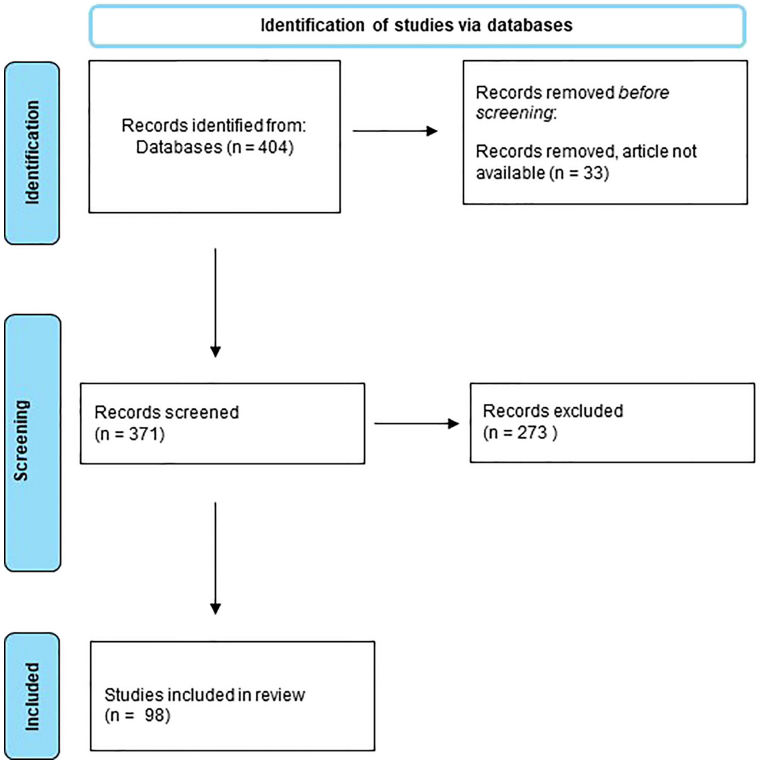

FIGURE 1
Screening process of the literature sample. Diagram of selection and eligibility criteria, including sample sizes, using the PRISMA model.

governed". In this studied we searched for information regarding the institutional and legal framework for the governance and management of MPA's in the sample of articles.

2.2 Ecotourism in MPAs (C2)

Marine ecotourism is an important sector for the development of sustainable tourism, that considers environmental conservation efforts, by reducing environmental impacts and promoting the local communities' needs and involvement (Eagles et al., 2002; Spenceley, 2017; Wiltshier et al., 2022). It is considered a growing and profitable sector. In the analyzed studies, we searched for the reference and examples of ecotourism in marine protected areas.

2.3 Stakeholder involvement in MPAs (C3)

Stakeholder engagement is vital for the success of MPAs. Stakeholder is essentially "*any group or individual with a direct or indirect interest, or stake, in the resources of that the MPA has authority to manage. Stakeholders may include government agencies, non-governmental agencies (NGOs), local community groups, local communities, and other resource management agencies*" (Walton et al., 2013). Stakeholder involvement is an ongoing process that intends to include the interested parties in the assessing, planning, and implementation of the MPA, and is widely known as an indicator of success for MPAs and marine conservation (Pomeroy and Douvere, 2008; Hoelting et al., 2013; Cárcamo et al., 2014). The concept of integrated frameworks involving stakeholders in a collaborative and cooperative approach of management made its path and reached the governance and management of protected areas. In the analyzed studies we searched for references or indications of active engagement of stakeholders in every stage of the development of MPAs.

2.4 Economy of MPAs (C4)

Ecological benefits can translate into economic benefits, and this includes market benefits (goods or services observed through a market transaction; example: the increase in tourism) and non-market benefits (not achieved by a market transaction; example: the benefit to people from knowing that a threatened species is protected). We searched for references or indications to the funding and economic benefits of MPAs.

The publications were coded to identify the defined criteria. The content of each publication was further analyzed to establish the clear presence of the defined criteria.

3 Results

Using the PRISMA model to filter documents obtained from the databases according to the eligibility criteria, we obtained 98 publications to analyze. Of these publications, 393 were in English, 8 were available in Spanish and 3 in Brazilian Portuguese, and no article was discarded based on the language.

Table 1 summarizes the characteristics identified for each of the 98 studies reviewed in terms of criteria compliance of particular interest in this review.

The distribution of the articles sample by Region (geographic continent) is shown in Figure 2, revealing that 19% of the analyzed studies were from Europe, 17% from South America, 12% from Asia,11% from Oceania, 11% from Africa, 10% from North America, 3% from Central America and

TABLE 1 Description of the literature sample based on the criteria (n= 98).

Author(s) and Year	C1	C2	C3	C4
Afonso et al., 2019	–	+	–	–
Amengual and Alvarez-Berastegui, 2018	+/-	–	–	+/-
Aswani et al., 2017	+	–	–	–
Barragan-Paladines and Chuenpagdee, 2017	+	–	+	–
Batel et al., 2014	–	+/-	–	+/-
Bax et al., 2016	+/-	–	–	–
Biggs et al., 2016	–	+	–	+/-
Bond, 2019	–	–	–	+/-
Brouwer et al., 2016	–	–	–	+/-
Buonocore et al., 2020	+/-	–	–	+/-
Calado et al., 2012	+/-	–	+	–
Carvache-Franco et al., 2019	–	+	–	–
Cerveny et al., 2020	+/-	+/-	–	–
Cheng et al., 2018	–	+/-	–	–
Cheung et al., 2022	–	+	–	–
Chimienti et al., 2017	–	+/-	–	+/-
Cini and Saayman, 2013	–	+/-	–	–
Cisneros-Montemayor et al., 2020	–	+	–	+/-
da Silva, 2019	+	–	+/-	–
Davis et al., 2019	–	–	–	+/-
Dube and Nhamo, 2021	–	+/-	–	–
Estradivar et al., 2022	+/-	–	–	–
Estradivar et al., 2022	+	–	+/-	–
Fache and Breckwoldt, 2018	+/-	–	+/-	–
Fernandez-Llamazares et al., 2020	–	+	–	–
Figueiroa et al., 2016	+/-	–	–	–
Gairin and Andrefouet, 2020	+/-	–	–	–

(Continued)

TABLE 1 Continued

Author(s) and Year	C1	C2	C3	C4
Gallacher et al., 2016	+/-	–	–	–
Galparsoro and Borja, 2021	+/-	–	–	–
Gardner et al., 2020	+	–	–	–
Gelcich et al., 2013	–	+	–	+
Giraldo et al., 2014	+/-	–	–	–
Gladun, 2015	+/-	–	–	–
Gonzalez-Bernat and Clifton, 2017	+	–	+/-	–
Gownaris et al. 2019	+/-	–	–	–
Harris et al., 2022	+/-	–	–	–
Hiriart-Bertrand et al., 2020	+/-	–	–	–
Huang et al., 2015	+/-	–	–	–
Hughes et al., 2021	+/-	–	–	–
Hunt and Vargas, 2018	–	+	+/-	–
Ison et al., 2018	–	–	+/-	+
Johnson et al., 2019	+/-	–	–	–
Katikiro et al., 2015	+/-	–	+/-	–
Kawaka et al., 2017	+/-	–	+/-	–
Kessel et al., 2017	–	+	–	+
Kirkman et al., 2019	+/-	–	–	–
Kusumawati and Visser, 2014	+	–	+/-	–
Kyvelou and Ierapetritis, 2021	+/-	+/-	–	–
Lai and Leone, 2020	+	–	–	–
Lemelin and Dawson, 2014	–	+/-	–	–
Li and Fluharty, 2017	+	–	–	+/-
Lima et al., 2021	+	–	+	–
Llausas et al., 2019	+/-	+/-	+/-	–
Lucrezi et al., 2019	+	+	+	–
Mackelworth et al., 2013	+	+	+	+
Mackelworth et al., 2013	+/-	–	–	–
MacKinnon et al., 2015	+/-	–	–	–
Maretti et al., 2019	+	–	+/-	+
McKinley et al., 2019	–	+	–	+/-
Mills et al., 2011	+/-	–	–	–
Morzaria-Luna et al., 2020	+/-	–	+/-	–
Murphy et al., 2018	–	+	–	+/-
Navarro-Martinez et al., 2020	–	+	–	–
Nicoll et al., 2016	–	+/-	+/-	–

(Continued)

TABLE 1 Continued

Author(s) and Year	C1	C2	C3	C4
Noble et al., 2019	+/-	+/-	+/-	–
Padash et al., 2016	–	+/-	–	–
Patrizzi and Dobrovolski, 2018	+/-	–	–	–
Perera-Valderrama et al., 2020	+/-	–	–	–
Qiu, 2013	+	+	–	+
Quintana et al., 2021	–	–	+/-	–
Ratsimbazafy et al., 2019	+/-	–	+	–
Rees et al., 2018	+/-	–	–	–
Robb et al., 2015	+	–	+/-	–
Rodriguez-Rodriguez et al., 2015	–	–	+	+
Rodriguez-Rodriguez et al., 2016a	+/-	–	–	–
Rodriguez-Rodriguez et al., 2016b	+/-	–	–	–
Santos et al., 2021	+/-	–	+/-	–
Scheske et al., 2019	+/-	+/-	–	–
Schiavetti et al., 2013	+/-	+/-	–	–
Schoning, 2021	+	–	–	–
Schram et al., 2019	+/-	–	+/-	–
Sciberras et al., 2015	+/-	–	–	–
Scully-Engelmeyer et al., 2021	+/-	–	–	+/-
Smallhorn-West et al., 2020	+/-	–	–	–
Spenceley, 2017	–	+/-	–	+/-
Steinfurth et al., 2020	+/-	–	–	–
Strickland-Munro et al., 2016	+/-	+/-	–	–
Syakur et al., 2012	–	–	+	–
Nur Syamsi and Lee, 2021	–	+	+/-	–
Teh et al., 2012	+/-	–	+/-	–
Turner et al., 2016	+/-	+/-	–	–
Tyllianakis et al., 2019	–	+	–	–
Ullah et al., 2022	+/-	–	+	–
Vilar et al., 2020	+/-	–	–	–
Virtanen et al., 2018	+/-	–	–	–
Watson and Hewson, 2018	+/-	–	–	–
Zoppi, 2018	+/-	–	–	–
Zorondo-Rodriguez et al., 2019	+/-	–	–	–

The table is organized by author(s) and year. Complete references are in Supplementary Table 1. Columns C1 to C4 correspond to the criteria used to analyze the literature sample. C1 – Governance in MPAs; C2 – Ecotourism in MPAs; C3- Stakeholder involvement in MPAs; and C4 – Economy or finances of MPAs. + indicates that the study satisfies the column category; - indicates that it does not; and +/- indicates that partially meets the criteria (some references about the topic, but not enough related to the main objectives of the criteria).

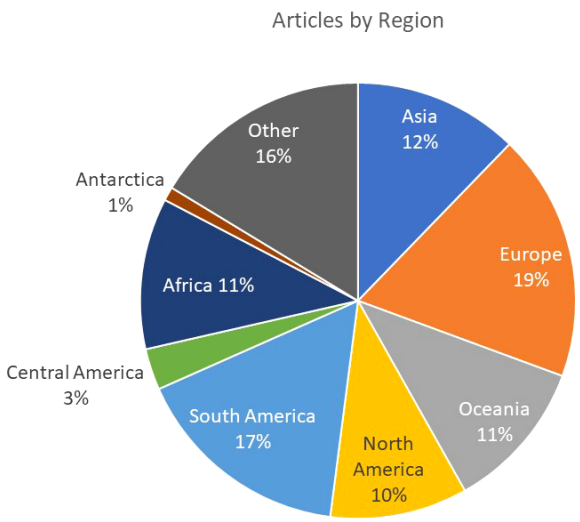

FIGURE 2
Distribution by region/continent of the articles sample.

1% from Antarctica. There's a 16% of studies labeled with "others" meaning that those articles were not confined to a specific continent, mostly being worldwide examples. The results show that there is a significant balance between the number of analyzed articles by region, only with Antarctica with a low representation, which was expected, given the fact that it is a continent with no permanent human inhabitants.

The broader spectrum of our literature analysis is available in Figure 3, demonstrating that only a small percentage of studies fully includes the topics of the defined criteria in spite of governance being essential for MPA effectiveness. Criteria C1 (governance) is completely included in only 16 studies of the universe among the 98 analyzed.

Regarding governance, most studies identify as a major challenge the complexity of governance structures, demanding institutional cooperation and collaboration to avoid overlaps, and most of them identified a top-bottom approach to governance in most MPAs, governed primarily by the state under a clear legal framework (Mackelworth et al., 2013; Qiu, 2013; Lucrezi et al., 2019; Pereira da Silva, 2019). Multilevel governance is also referred in some studies that support that a multilevel governance is necessary for good governance practice in MPAs (Zoppi, 2018). As an interpretive framework concerning intertwined relationships between different governmental levels (international, national, regional, local), non-governmental organizations and private enterprises and stakeholders, multilevel governance stands for the need of interactions at various levels and the need for cooperation and participation (Bache, 2010). Multilevel governance processes are particularly important, regarding policies concerning economic and social cohesion and nature conservation, since they are intrinsically connected to mutual relationships between municipalities, provinces, regions and national states (Bache, 2010; Zoppi, 2018). For example, in Brazil, the governance of large scale marine protected areas is a challenge, since it requires good institutional collaboration and involves a wide range of agencies and shared accountability, which often lead to overlaps of roles (Pereira da Silva, 2019). In Croatia, in the Cres-Lošinj special marine reserve, it is possible to have an example of how governance made without the cooperation and involvement of local communities and local authorities, leads to unsuccess and unbalanced governance. A legal change made by the government

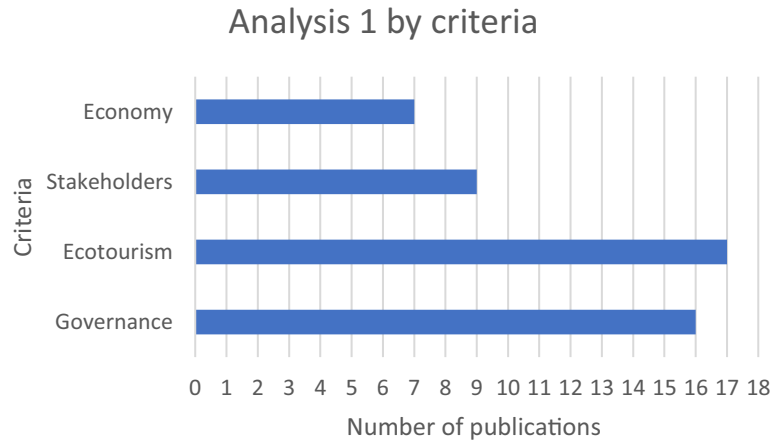

FIGURE 3
Number of publications in which the articles fully meet the criteria.

in 2006, led to a discrepancy between the objectives of local development and the international commitments, which led to a proposed downgrading of the MPA (Mackelworth et al., 2013).

The analysis of the literature sample identified 17 studies that completely include the criteria C2 (ecotourism), with clear examples of ecotourism development in MPAs. Tourism is broadly known as a major economic driver for MPAs and their communities (Hunt and Vargas, 2018; Tyllianakis et al., 2019; Cisneros-Montemayor et al., 2020). Some of the activities developed in marine protected areas mentioned in the studies are diving, marine mammal observation and tours (whales, dolphins, turtles, sharks, etc.), recreational fishing, surfing, and beach based tourism (Kessel et al., 2017; Cisneros-Montemayor et al., 2020; Fernández-Llamazares et al., 2020). Some MPAs plans include cooperative management for the conservation and protection of their natural values, including the endorsement of activities that are aligned with objectives of the MPA, such as well-managed ecotourism (Lucrezi et al., 2019). The management plan of Ponta do Ouro Partial Marine Reserve, in Mozambique, endorses activities that are aligned with the objectives of the plan, such as ecotourism activities of scuba diving, shark diving, whale watching and others (Lucrezi et al., 2019).

Stakeholders' involvement (criteria C3) is mostly recognized as an indicator of effectiveness and success of MPAs, but only nine of the analyzed studies openly indicated the direct involvement of stakeholders in the development, implementation, and management phases of MPAs. Some MPAs management plans detail stakeholder involvement in their governance schemes and in all phases of the implementation of a MPA (Lucrezi et al., 2019; Ullah et al., 2022). Most studies recognize that usually stakeholders are NGOs, local communities, local authorities, governmental agencies, tourism operators, fisheries operators, and scientists (Calado et al., 2012; Mackelworth et al., 2013; Ratsimbazafy et al., 2019).

Regarding the criteria C4, economy and finance of MPAs, only seven of the literature sample had some reference to economic values and finance of MPAs. Some studies identified that the most important 'economic' variables in MPAs are linked to fishing, shipping and aquaculture activities (Rodríguez-Rodríguez et al., 2015), and other studies clearly indicate that the development of tourism, mainly ecotourism, has in general changed and improved the livelihoods of the communities that live in the MPA, providing job opportunities and a significant increase in the annual income of local residents, as for example in the Sanya Coral Reef National Marine Reserve in China (Qiu, 2013; Kessel et al., 2017; Wiltshier et al., 2022). The application of tourist fees to MPAs is also generally mentioned as a way to finance MPAs (Gelcich et al., 2013; Batel et al., 2014).

Most studies ended up being assessed as "partially meet the defined criteria, since they have some references about the topic, but not enough related to the main objectives of the defined criteria" (Figure 4), since they were lacking essential information to fulfil the criteria; e.g. some might refer that governance is important, but they do not present the governance structures or frameworks (institutional and/or legal), not including ecotourism examples or products, stakeholder engagement was just briefly mentioned and not indicating specifically economic or financing information about MPAs.

4 Discussion

The increased interest in oceans as vectors for strategic development, within the framework of the Ocean Science for Sustainable Development decade and in view of the global

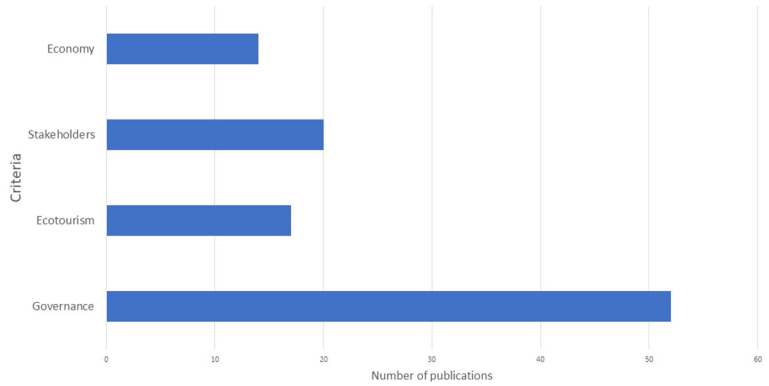

FIGURE 4
Number of publications in which the articles partially meet the defined criteria.

goals established by the Sustainable Development Goals (SDGs), particularly SDG 14 "*Conserve and sustainably use the oceans, seas and marine resources for sustainable development*", makes it essential to value marine natural resources to achieve a sustainable future. The conservation of Biodiversity has potential direct economic benefits for many sectors of the economy, including tourism, which is why it is necessary to slow down the biodiversity loss of the recent decades, through valuing natural capital. In this context, ecotourism arises as an opportunity to reconcile nature conservation policies with the economic and social needs of the population. The marine protected areas are generally established with a firm understanding that their management will involve balancing the relationship between people and marine ecosystems (Pomeroy and Douvere, 2008; Lucrezi et al., 2019). Due to their elevated management costs, some MPAs are appealing to ecotourism to achieve some economical sustainability and to bring benefits for their local communities (Drumm, 2003; Balmford et al., 2004; Gabrié et al., 2012; BlueSeeds, 2020). Tourism is a major contributor for the economy of MPAs and their gateway communities, with a wide range of benefits (Spenceley, 2017; Wiltshier et al., 2022).

First, we find that ecotourism products in protected areas can help to integrate local communities and stakeholders (e.g. local guides, restaurants, NGOs, travel agencies, etc.), and when this integration is successful, it creates strong incentives for local communities for nature conservation, by linking economic benefits to healthy and well-managed protected areas (Drumm et al., 2016; Pham, 2020). Several of the studies analyzed identified ecotourism as an economic driver for MPAs and their communities. A practical example of valuing nature through ecotourism was the creation of the organization MEET, an EU organization (founded by IUCN-Med), which works as a consultant for the Protected Areas of the Mediterranean in the area of ecotourism ideals (Figueiredo, 2020). This network is constantly developing, continually including new protected areas in its program, and currently has 44 Protected Areas from 10 different Mediterranean countries. MEET ecotourism products rely on the creation of a local cluster, which includes at least one protected area, a tour operator and several local providers of tourist services (eg accommodation, recreation, transport, food, etc.). In addition, the purchase of a MEET product contributes to a conservation fund for the protected area involved and to the distribution of capital fairly to the surrounding communities (Drumm et al., 2016; Noll et al., 2019). MEET is a good example of how MPAs and ecotourism can benefit local communities and try to achieve an effective connection between tourism and conservation.

Second, we recognized that despite all the benefits, tourism can also have impacts on biodiversity and that's why it is important that MPAs managers and tourist operators work together regarding ecotourism (Qiu, 2013; Silva, 2015; Spenceley, 2017; Hampton and Jeyacheya, 2020). There are also some negative impacts for the gateway communities such as the increased of the living cost in these major tourist areas (Wolf et al., 2019; Wiltshier et al., 2022). For example, in Fernando de Noronha, the application of high taxes to access the Island has increased and impacted the prices of goods and services (Wiltshier et al., 2022) and in Croatia, the increased of tourism boosted issues related to housing affordability since the prizes of rentals and real estate became too high for the residents (Mikulić et al., 2021).

Third, we find that MPA governance faces many challenges partially related to a complex institutional and legal framework, difficulties to adapt to changes, a wide range of stakeholders involved, and social-natural relations. Several studies identified that a fair and effective collaborative governance model can enhance positive socio-economic benefits to the community through ecotourism (Keyim, 2018; Forje and Tchamba, 2022). From the articles analyzed, most governance models when defined, do not consider the component of natural capital appreciation, and it makes it look as if governance and management models of MPA might not be in line with the product of ecotourism. Moreover, even though there was a global movement towards a new approach to the governance and management of protected areas, shifting from a centralized/state model to a model involving stakeholders and local communities, more adapted to the needs of the XXIst century (Phillips, 2003), most of the analyzed studies still identify a top-bottom, governed centered approach to governance models in MPAs (Qiu, 2013; Lucrezi et al., 2019). Ineffective governance leads to failure to deliver the estimated socioeconomical and environmental outcomes expected from MPAs (Hughes, 2011; Turner et al., 2016). More research into understanding the interconnection between MPA governance models and the ecotourism product is needed to better enhance the natural capital of these protected areas.

Fourth, we conclude that stakeholders' involvement in the MPAs processes of planning and management is very important (Lucrezi et al., 2019), and usually referred in several of the studies, from all the regions. Stakeholders' involvement creates an environment for exchange and interaction between different stakeholder groups, allowing early identification of potential conflicts and enabling collaborative problem solving. MPAs with active stakeholders tend to be more effective (Walton et al., 2013; Rodríguez-Rodríguez et al., 2015). The financial sustainability of MPAs is a challenge worldwide and a cornerstone to achieve effective management (Reid-Grant and Bhat, 2009; Thur, 2010).

Regarding the analysis by geographical region, we concluded that there was representativity regarding the input for the research from different areas and continents.

The concepts of participatory governance and management models are being subsequently adopted by IUCN as a way to make more effective the management of protected areas (Borrini-Feyerabend et al., 2013) but, at the same time, to help sustainable financing of protected areas, particularly by favoring economic activities compatible with nature conservation, such as ecotourism (Eagles et al., 2002; Emerton, 2006; Shiiba et al., 2022). These trends were particularly important in marine protected areas where marine ecotourism revealed to be critical, not only for economical revenue based on the natural assets, but also by involving local communities in the management process. Furthermore, marine ecotourism showed to be a keystone economic activity, particularly in small island development states (SIDS). For example, in Seychelles, a stakeholder driven process involving dive and boat operators, conservation organizations and governmental agencies instigated and enabled the sustainable use of whale sharks as an ecotourism resource (Rowat and Engelhardt, 2007).

This literature review aimed to understand the governance models that best enhance the relationship between ecotourism and a good management/effectiveness of MPAs, based on the enhancement of natural capital through ecotourism. A combination of good governance model, that brings stakeholders into the decision making process, can help ecotourism to boost the value of the natural capital of MPAs, without compromising their conservation values and priorities (Eagles et al., 2002; Borrini-Feyerabend et al., 2013; Long et al., 2021; Shiiba et al., 2022). The concept of sustainability stated in the sustainable development goal 14 (SDG 14) – Life Below Water, highlights the need to balance the three essential dimensions of sustainability – economic, social and environmental (Recuero Virto, 2018), with the first two pillars being somehow dependent on the environmental priorities (Scott Cato, 2009).There is no successful conservation without the involvement and support of local communities (Eagles et al., 2002), and to attain that goal, communities need to develop sources of income to compensate for economic restrictions that arise from the conservation goals of the MPAs. In this context, ecotourism appears as an excellent opportunity to improve the livelihoods of the communities whose income comes from these MPAs, through the creation of job opportunities (Qiu, 2013; Kessel et al., 2017; Wiltshier et al., 2022). We conclude that there is a knowledge gap regarding the enhancement of natural capital though ecotourism, and that governance models of MPAs might not be ready to fully support ecotourism has a booster of the sustainability of MPAs so, there is an opportunity for further development of research in this area.

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

DC wrote the manuscript. MV, JG, and AB provided guidance and feedback on data analysis, peer review and revised the manuscript. All authors contributed to the article 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.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmars.2022.1002677/full#supplementary-material

SUPPLEMENTARY TABLE 1
Description of the literature sample based on the criteria (n=98).

SUPPLEMENTARY TABLE 2
References of literature sample (n=98).

SUPPLEMENTARY TABLE 3
Search criteria for the databases.

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Transitioning from blue growth to the sustainable blue economy: A review of Ireland's new marine governance in the aquaculture sector

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This paper reviews the evolution of marine governance in Ireland in response to EU policy requirements in relation to the development of a sustainable blue economy in coherence with the United Nations Ocean Decade (2021-2030). In response to these EU requirements, Ireland has introduced the National Marine Planning Framework (NMPF) and Maritime Area Planning Act, 2021 (MAPA) in 2021 to deliver this sustainable blue economy. This new marine and coastal governance framework in Ireland reforms the consenting regime for key blue economy sectors such as Offshore Renewable Energy (ORE) and sets new policy requirements for the integration of aquaculture within the MSP framework. However, the exclusion of aquaculture from the new consenting regime may hinder the full integration of the sector into MSP and impede compliance with environmental goals established by EU Directives (e.g., WFD, MSFD, MSPD). This review identifies policy and legal gaps which may impede the integration of aquaculture into the new Irish marine governance and national MSP process. Furthermore, this paper analyses aquaculture licensing cases to assess the integration of environmental criteria into planning decisions to gather insight into the readiness of the sector's transition towards a sustainable model. The analysis from this paper indicates that the legal framework underpinning MSP in Ireland may have a limited impact on the integration of aquaculture and hinder the delivery of sustainability across all marine sectors.

KEYWORDS

marine spatial planning (MSP), UN ocean decade, new blue deal, aquaculture governance, Ireland marine management

Introduction

The 1982 *United Nations Convention on the Law of the Sea* (UNCLOS) established the first international legal framework underpinning contemporary marine policy and has guided the development of national and international ocean governance regimes. Such regimes were initially developed on sector-by-sector basis, (e.g., fisheries management, aquaculture development, conservation, marine pollution, transport) limiting sustainable and equitable use of marine space. The United Nations and the European Union have recognised the need for implementing new policies and instruments such as *Integrated Marine Management* (IMP) and *Maritime Spatial Planning* (MSP), to support sustainable development of the ocean economy. To advance these efforts, the UN declared 2021 to 2030 as the *UN Decade of Ocean Science for Sustainable Development* to encourage States to advance the sustainable blue economy.

The European Union (EU) has been at the forefront of the development of marine policy and legislation to advance sustainability in the marine environment (Boyes and Elliott, 2014; Garland et al., 2019). For example, the *Marine Strategy Framework Directive (MSFD) (2008)* and *Maritime Spatial Planning Directive (MSPD) (2014)* mandate the implementation of an Ecosystem-based Approach to support the sustainable use of marine resources (European Commission, 2008; European Commission, 2014). Governance tools such as MSP have been advocated to enable the coordinated use of marine space to reduce spatial conflict between sectors and facilitate the integration of socio-economic and ecological criteria into management decisions (Ehler, 2021; (UNESCO-IOC, 2021). Most recently having recognised the need for a governance model which prioritises sustainability, the EU issued a policy statement "*on a new approach for a sustainable blue economy in the EU*" (COM/2021/240). However, delivering a sustainable blue economy in the EU through MSP at an operational level across various sectors is proving to be challenging (Frazão Santos et al., 2021; Haapasaari and van Tatenhove, 2022).

For example, Ireland has developed an MSP (e.g., NMPF) framework in which aquaculture is integrated into the process from a strategic policy standpoint, but the operationalisation of these provisions will be limited by the omission of the sector in the legal framework established by the Maritime Area Planning Act (Government of Ireland, 2021). In the case of ORE, the policy strategies established in the NMPF will be made operational through the MAPA. This differentiated treatment in the legal framework underpinning MSP could be arguably considered sectoral. Through the development of the *National Marine Planning Framework (NMPF)* and *Maritime Area Planning Act (MAPA)* in 2021 Ireland has met the EU requirements of the MSPD. The NMPF and the new legal framework for marine development established through the MAPA aim to promote the development of a sustainable blue economy with the support of MSP. This new marine and coastal governance framework in Ireland reforms the consenting regime for key blue economy sectors such as Offshore Renewable Energy (ORE) and sets new policy requirements for the integration of aquaculture within the MSP framework. However, the exclusion of aquaculture from the new consenting regime of MAPA may hinder the full integration of the sector into MSP and impede compliance with environmental goals required by various EU Directives (e.g., WFD, MSFD, MSPD) (Government of Ireland, 2021).

Aquaculture has been recognised as a key sector for the blue economy through various EU regulatory and policy frameworks (e.g., *Common Fisheries Policy, Blue Growth Agenda, MSP Directive, MSFD Directive).* With the aim of advancing the understanding of how the EU's sustainable blue economy can be implemented with the support of MSP, this paper focuses on Ireland's aquaculture licensing system and the level of integration of EU environmental and marine governance policy and legislation in the sector. Through an analysis of the policy and legislation underpinning aquaculture licensing in Ireland, this paper demonstrates how the sector operates in a fragmented and complex regulatory environment that has not been integrated into the statutory basis of MSP in Ireland.

The paper starts by discussing (1) how EU marine governance has evolved; (2) how it has been integrated into Ireland's national governance landscape; (3) how Irish aquaculture licensing operates; (4) and analyses the consistency through which environmental compliance is manifested in licensing decisions. The analysis and policy recommendations presented offers perspectives into how EU member states can strengthen the delivery of sustainable blue economy aspirations into aquaculture management through MSP and supporting regulation.

EU marine governance

The foundations of the EU's sustainable blue economy policy were first established in the 2007 Blue Book which introduced Integrated Maritime Policy (IMP) to implement a cross-sectoral approach to marine and maritime affairs in the EU (European Commission, 2007). The Blue Book defined a new governance framework which identified MSP as a key instrument for adopting an integrated policy approach to maximise the economic growth of the coastal and maritime sectors in the EU, whilst complying with sustainability requirements (European Commission, 2007; European Commission, 2012a).

This new governance model was later endorsed as the Blue Growth strategy by the EU in its communication: 'Opportunities for marine and maritime sustainable growth' (COM/2012/494) (European Commission, 2012a). The Blue Growth Communication policy actions were centred around five focus areas: blue energy; aquaculture; maritime, coastal and cruise tourism; marine mineral resources and blue biotechnology. Sectors such as fisheries, environment and maritime transport were not included with the justification that they are covered under specific ongoing EU initiatives already in place such as the Common Fisheries Policy (CFP) and the Marine Strategy Framework Directive (MSFD). This created a policy framework in which marine environmental protection and fisheries were excluded from broader marine governance frameworks such as MSP. Arguably, this has led to the continued development of a

fragmented sectoral approach to marine governance. Research has therefore critiqued the blue growth ambitions by the European Commission as mainly focused on sectoral development and failure to integrate the environmental goals (Jones et al., 2016; Ertör and Hadjimichael, 2020; Leposa, 2020).

In the context of MSP, it was noted that the blue growth agenda was a dominant priority and often aligned with strategic sectoral planning priorities (Schultz-Zehden et al., 2019; Trouillet, 2020). In contrast, the target for good environmental status (GES)[1] through the MSFD, social and cultural priorities were relatively undermined and unachieved (Jones et al., 2016; Flannery et al., 2019). This exacerbates concerns about tensions and fragmentation between the MSPD and the MSFD, with some viewing them as having contrasting goals of advancing development and conserving biodiversity. Due to the dominance of the Blue Growth discourse in the EU, the problems to be addressed by MSP no longer related to good environmental governance, but rather, are concerned with creating the appropriate conditions for the rapid expansion of target industries including offshore renewable energy and aquaculture (Guerreiro, 2021; Ansong et al., 2022).

This is evidenced in the aquaculture sector by the use of financial mechanisms to support growth, rather than prioritising and developing policy that would advance a sustainable aquaculture model and progress environmental compliance in the sector (European Commission, 2013). More specifically, the 2013 Strategic Guidelines for the sustainable development of EU aquaculture directly linked the sector with the EU's blue growth strategy. These guidelines fail to define sustainable aquaculture and rather focus policy interventions on the promotion of the growth of EU aquaculture (European Commission, 2013). An overview of relevant EU marine policy and its alignment with aquaculture development are provided in Table 1 below based on objectives and implementation mechanisms defined for the sector.

Following policy developments requiring the implementation of environmental sustainability across marine industries, the EU aligned its policy with the United Nations Ocean Decade sustainable blue economy model. The definition of a sustainable blue economy, as stated in the *Declaration of the* Sustainable Blue Economy Finance Principles, is 'projects and activities that contribute directly to the achievement of UN Sustainable Development Goal (SDG) 14, to conserve and sustainably use the Ocean's *resources, and other SDGs, especially those that contribute to the good governance of the Ocean*' (UNEP, 2018). The fulfilment of the UN Ocean Decade has listed several desired outcomes for the sustainable use of the ocean of which the most relevant ones for aquaculture development are cited below (Ryabinin et al., 2019). These are:

These policy goals have been introduced through the European Green Deal, guiding the shift towards a sustainable blue economy (European Commission, 2019a). The Green Deal calls for a transformation of the EU economy to a modern, resource-efficient and competitive economy where net emissions of greenhouse gases are phased out and the EU's natural capital is protected. Critically, the Green Deal highlights that the sustainable blue economy is essential to achieving its objectives. This is evidenced by the 2020 Farm to Fork Strategy and Blue Farming in the European Green Deal developed in support of the Green Deal, further strengthening the role of sustainable aquaculture as a key enabler for sustainable food systems (European Commission, 2012b).

In contrast to the Blue Growth Strategy, the new approach for a sustainable blue economy in the EU communication: Transforming the EU's Blue Economy for a Sustainable Future (COM/2021/240) seeks to merge environmental protection with economic goals (European Commission, 2021a). It further covers a wide range of sectors including fisheries, aquaculture, maritime transport, offshore renewable energy and decommissioning offshore platforms. Hence, it proposes a paradigm shift from blue growth to a sustainable blue economy. For this shift to happen, the Blue Deal advocated in this Communication has the following initiatives: economic activities at sea and in coastal areas need to reduce their cumulative impacts on the marine environment and value chains need to transform themselves to contribute to climate neutrality and zero pollution, circular economy and waste prevention, preserve biodiversity and invest in nature, climate adaptation and coastal resilience, sustainable food production system and improvement in the management of space at sea. MSP is identified as a priority to achieve these goals.

Maritime Spatial Planning is advocated as a key enabler for the sustainable blue economy, as identified in the EU's Blue Economy Communication. The MSP process is a key process to implementing sustainable blue economy vision and objectives through iterative stages of pre-planning, assessment, planning, stakeholder engagement implementation, monitoring, evaluation and review/adaptation. In the case of aquaculture, MSP is identified as an essential governance mechanism to enable the growth of a sustainable aquaculture sector by ensuring access to ocean space and compliance with environmental conservation requirements (Puszkarski and Śniadach, 2022).

The shift towards a sustainable blue economy in the EU (as stated in COM (2021) 240) requires the systemic integration of ocean policy into the economic policy of the European Green Deal through the New Blue Deal (European Commission, 2019b). The EU's New Blue Deal establishes a series of actions through the agenda presented in this Communication. This includes developing and expanding sustainable aquaculture and ORE, underpinned by sustainable governance models such as MSP. These actions, therefore, need to be fully and comprehensively embedded into Ireland's current and future marine policy, legislation, and blue economy sectoral strategies.

These policy goals have been introduced through the European Green Deal, guiding the shift towards a sustainable blue economy. The Green Deal calls for a transformation of the EU economy to a modern, resource-efficient and competitive economy where net emissions of greenhouse gases are phased out and the EU's natural capital is protected. Critically, the Green Deal highlights that the sustainable blue economy is essential to achieving its

1 The Good Environmental Status (GES) means that the different use of marine resources is conducted at a sustainable level, ensuring their continuity for future generations (MSFD 2008/56/EC)

TABLE 1 Key EU policy and law relevant to aquaculture.

Policy	Objectives	Implementation
1983 Common Fisheries Policy	Ensure aquaculture is managed in an environmentally sustainable way	Promote development of sustainable aquaculture activities through Financial Mechanisms
IMP Blue Book 2007	Promote the development of an environmentally safe aquaculture industry in Europe	Regulatory framework
Blue Growth Agenda 2012	Promote aquaculture through an 'open method of coordination' based on non-binding strategic guidelines, multiannual national strategic plans and the exchange of best practices.	Strategic EU funding
Sustainable Blue Economy Communication 2021	Support best practice to ensure good environmental performance	EMAF Funding

objectives. This is evidenced by the 2020 Farm to Fork Strategy and Blue Farming in the European Green Deal developed, further strengthening the role of sustainable aquaculture as a key enabler for sustainable food systems.

The new EU strategic guidelines for a more sustainable and competitive aquaculture sector are introduced in the "Blue Farming in the European Green Deal" document (European Commission, 2021b). The Blue Farming guidelines establish policy objectives and actions to boost organic aquaculture production in the EU. This sustainable aquaculture model proposed by the EU presents an important economic opportunity for Ireland. Ireland is the leading producer of organic aquaculture products in the EU, having an output of 18.5m tonnes out of the EU's annual output of 74m tonnes in 2020 (European Market Observatory for Fisheries and Aquaculture Products, 2022). Additionally, Ireland is the only producer of organic salmon in the EU, giving it a strong competitive advantage and opportunity for expansion (Irish Farmer's Association, 2023). Ireland aims to implement these EU policy aspirations through its National Strategic Plan for Sustainable Aquaculture Development 2030. In order to implement these policy aspirations, it is necessary to have a licensing system that provides legal certainty and adaptability. In the following section, the definition of EU sustainable aquaculture policy is identified. This is followed by an overview of the Irish aquaculture licensing process is presented and its weaknesses highlighting where there are challenges to achieving the implementation of a more sustainable aquaculture sector.

Marine governance in Ireland

Ireland's marine governance trajectory has followed the broad objectives contained in the wider EU policy and legislation. The Government of Ireland has shifted its marine policy and legislation to address recognised weaknesses in previous governance regimes and deliver on wider policy objectives, such as the implementation of Maritime Spatial Planning (MSP), in line with EU requirements.

In recognition of the EU's Integrated Maritime Policy, the Government published its Integrated Marine Plan (IMP) in 2012, "Harnessing Our Ocean Wealth (HOOW)." HOOW set out three high level goals and a roadmap to realise the government's vision of doubling the contribution to GDP of the maritime sector to 2.4% per year, by 2020. These three goals based on sustainable development were; 1. A thriving maritime economy, 2. Achieving healthy ecosystems, 3. Increasing engagement.

Previously, HOOW (GoI, 212) set the policy context for the enabling conditions necessary to deliver on blue economy goals, whilst ensuring both environmental protection and sectoral growth. Those original goals have informed the high-level objectives contained in Ireland's Marine Planning Policy Statement and are implemented through the National Marine Planning Framework (NMPF) adopted in 2021 and the Maritime Area Planning Act, 2021 (MAPA).

HOOW set out eight enablers essential to creating the conditions for growth and investment, and these were further broken down into 39 actions linked to one or more of the over-arching goals (1-3, above) with specified timelines and allocated responsibility. One of these eight enablers was 'Governance' explicitly recognising the need to deliver greater efficiency in public services; removing barriers where possible, providing robust planning and licensing frameworks to support sustainable development and create more certainty for industry (Table 2). The last review of progress of HOOW, covers the year 2018 and recognises progress made under the two key Governance actions: these include the Review of Aquaculture Licensing under action 2 and the Certified Aquaculture Programme.

As is evident from Table 2 the items to be progressed under the second Governance action, relate primarily to planning and consenting systems. Noting that HOOW preceded the adoption of the EU MSP Directive, work had already commenced on reforming the extant foreshore consenting regime by the responsible government department, however, this work had to adapt in line with the requirements of the new Directive and other policy matters.

Aquaculture was positioned as a key sector for development and expansion in HOOW. Under this plan, €2.59 million in public aid supported the development of aquaculture through a sustainable aquaculture scheme, delivering 38 aquaculture capital development projects. These projects focused on improving environmental outcomes in the industry, for example addressing veterinary health issues in salmon, multi-trophic aquaculture, environmental management monitoring in connection to the Water Framework Directive, and improvements in mussel and oyster production, amongst other intervention areas (Government of Ireland, 2018).

TABLE 2 Government actions contained in HOOW.

No.	Key Action	Supports Goal
1	Develop and implement clear and forward-looking policies and strategies that support an increased contribution from our ocean economy to national GDP.	1
	-Implement existing (e.g. Food Harvest 2020) and planned (e.g. Ports Policy, OREDP) sectoral strategies/plans through effective coordination of actions across a range of government departments and agencies.	1
	-Develop an integrated enterprise strategy to generate momentum in specific emerging market opportunities prepared across development agencies (e.g. offshore renewables, offshore services, ICT and sensors, biotechnology).	1
	-Continue to develop new policies/strategies that address gap areas through an integrated approach.	1
2	Develop an integrated approach to marine and coastal planning and licensing to maximise the potential for Ireland's ocean economy; assist with managing our resources effectively and sustainably; manage potential conflicts; and ensure harmonisation with coastal/terrestrial planning	1
	-Address the deficiencies in the current planning and licensing system by continuing make business process improvements; e.g. administrative efficiencies and licensing decisions to address the current caseload.	1
	-Update/improve legislation to streamline planning and consent processes	1
	-Develop an appropriate Maritime Spatial Planning Framework for Ireland within which the scope and objectives of an overarching national Marine Spatial Plan will be defined	1,2,3

HOOW emphasised the need to update and improve legislation to streamline planning and consenting processes in marine and coastal planning and presented policy conditions to do so. Following on this policy work, the Irish government developed the Maritime Area Planning Act, 2021 (MAPA) and the National Marine Planning Framework (NMPF). The MAPA reforms the licencing and consenting system for the majority of marine activities and developments. Aquaculture was excluded from the new licencing and consenting regime despite various recommendations emphasizing the need to update the legislation for aquaculture, and multiple high-level aquaculture policy reviews (Independent Aquaculture Licensing Review Group, 2017). The differentiated governance regime between ORE and aquaculture fails to address issues of institutional and intersectoral fragmentation, posing a barrier to the development of MSP and the delivery of a sustainable blue economy.

Ireland transposed the MSP Directive in 2016 through Regulations, but this was strengthened in 2018 through primary legislation to give full effect to the Directive's requirements. A National Stakeholder Advisory Group on MSP was established in 2017 with representatives from social, economic and environmental pillars and continues to meet regularly. A Baseline Report on MSP was subject to a period of publication in late 2018 with associated public consultation events nationwide, and finalised in 2019 (DHPLG, 2018). Following that, a Marine Planning Policy Statement was launched for public consultation in June 2019 and approved by Government in November 2019, coinciding with the publication of the first draft of the National Marine Planning Framework, Ireland's first maritime spatial plan. The latter was approved by Government and formally established in May 2021 (DHPLG, 2021).

The NMPF contains Overarching Marine Planning Policies (OMPPs) that reflect social, economic and environmental aspects that need to be taken into account by all marine users and activities. The NMPF also comprises Activity specific or Sectoral Marine Planning Policies (SMPPs) policies that contain a more detailed basis for decision-making within 16 specific marine sectors/activities (DHPLG, 2021). These policies cover the types of activity to be supported, how these interact with other users, and approaches to mitigating or avoiding impacts. Public bodies are legally obliged to "secure the objectives" of NMPF policies. Despite this, the key mechanism for implementing NMPF objectives is the consenting or licensing processes that apply to each activity, which may change with the commencement of specific parts of the Maritime Area Planning Act, 2021 (MAPA) depending on the activity concerned. This could represent a policy and regulatory risk with different sectors subject to different regimes that may not totally align in terms of sustainability outcomes. The regulatory risk presented by the exclusion of aquaculture in the new marine licensing system is highlighted in the Pre-Legislative Scrutiny report for the MAPA (Joint Committee on Housing, Local Government and Heritage, 2021)

The purpose of MAPA is to regulate the maritime area, from the mean low water mark to the outer limits of the continental shelf (usually 200 nautical miles). This is to be achieved through the National Marine Planning Framework and the Act provides a strengthened legal basis for MSP in Ireland. MAPA also contains provisions on Maritime Area Consents (MACs), necessary for the occupation of the maritime area for the purposes of carrying out certain maritime uses (long term) and licenses for a shorter term or more minor uses. To administer these specific responsibilities, the Act provides for the establishment of a dedicated body, the Maritime Area Regulatory Authority (MARA), which will be responsible for granting, revoking and suspending consents, administrative responsibility for foreshore consents and general enforcement of the Act. MARA is expected to become operational in 2023.

Some of the 16 sectors included in the NMPF operate under very different regulatory frameworks and policies, which represents a challenge for integrated planning and management. Specifically, this refers to fisheries and aquaculture or developments, which will remain subject to their existing regulatory regime (e.g., Fisheries

1997, Foreshore Acts 1933-2014). Despite a different consenting regime, they are still subject to the high-level objectives of the NMPF. In addition, under s.31 of MAPA, the Minister has the power to compel public bodies to comply with the NMPF and EU MSP Directive.

Under the new Act the remaining, and majority, of other marine activities will require a single State consent, known as a Maritime Area Consent (MAC), which effectively relates to due diligence checks and regulates the terms for the occupation of sea space. If granted, it is also necessary to allow a project proponent to advance to the next stage of the planning process: an application for Development Consent, which involves a project-level assessment, including environmental impacts and public consultation. The MAC effectively streamlines the marine consent process by aligning the foreshore planning system with the planning system, facilitating integration between marine and terrestrial planning systems (Ritchie et al., 2022). Arguably, the new marine planning regime applicable to the relevant sectors (e.g., ORE) will progress integrated marine planning and harmonise land-sea interactions. In addition to the NMPF, Designated Marine Area Plans (DMAP) are provided for in the Act, enabling local authorities to propose spatial management plans for specific marine areas (Government of Ireland, 2021). Given the exclusion of aquaculture in the Act, it remains unclear how aquaculture will be provided for in this marine zoning system, potentially posing a barrier to achieving integrated marine planning and development of a sustainable blue economy.

The shift towards a sustainable blue economy in the EU (as stated in COM (2021) 240) requires the systemic integration of ocean policy into the economic policy of the European Green Deal through the New Blue Deal. The EU's New Blue Deal establishes a series of actions through the agenda presented in this Communication (European Commission, 2019b). This includes the development and expansion of sustainable aquaculture and ORE, underpinned by sustainable governance models such as MSP. These actions will need to be reflected in Ireland's current and future marine policy, legislation, and blue economy sectoral strategies.

The European Commission establishes an agenda for the adoption of sustainable value chains, including aquaculture. This agenda promotes the development of responsible food systems from marine resources and positions sustainable aquaculture as a valuable and low-impact source of food. The EU green deal through the "Blue Farming in the European Green Deal" document establishes policy objectives and actions to increase organic aquaculture production in the EU.

In the following section, EU policy relating to sustainable aquaculture is identified and is followed by an overview of the Irish aquaculture licensing process to identify how sustainability operates in the sector through environmental compliance with EU environmental protection legislation (e.g., Birds and Habitats Directives).

Sustainable aquaculture

The definition of sustainable aquaculture by EU policy has developed on a sectoral basis, having developed most of its strategies and policies from the Common Fisheries Policy, focusing on economic growth (Long, 2016). One of the first attempts by the EU to integrate sustainability into the aquaculture sector was through the Blue Growth Strategy. The Strategic Guidelines for the sustainable development of EU aquaculture COM/2013/229 established the importance of aquaculture development in blue growth policy strategies (European Commission, 2013; European Parliament, Council of the European Union, 2013).

The aim of these guidelines was to increase aquaculture production across Member States by improving administrative procedures and coordinated spatial planning. This Communication did not provide a clear definition of sustainable aquaculture. Instead, it defines sustainable development of aquaculture as compliance with EU environmental legislation (e.g., CFP, MSFD, WFD, Habitats and Birds Directives), coordinated spatial planning and integration of aquaculture into Natura2000 sites (ibid, 6-7). Biodiversity and nature conservation was relegated to favour economic growth as evidenced by the 2012 Guidance document on aquaculture activities in the Natura 2000 Network. This guidance offered guidelines to support Member States in the development of aquaculture in Natura 2000 sites.

Following wider EU policy development such as the MSP Directive and the New Blue Deal, aquaculture policy has progressed efforts in implementing sustainability in the aquaculture sector. The Strategic guidelines for a more sustainable and competitive EU aquaculture for 2021 to 2030 integrated the sector into the EU sustainable economy ambitions under the auspice of the Green Deal, maintaining a sectoral approach (European Commission, 2021). These guidelines advance the importance of environmental quality in aquaculture production by citing the need to ensure "the mitigation of the impact that aquaculture activities may have on the environment (be it in terms of carbon footprint, effluents, waste or other impacts on marine and freshwater ecosystems), and that aquaculture activities do not significantly harm ecosystems or biodiversity" (ibid, 9-10). Environmental performance should be measured by states as; "(i) ensuring that environmental legislation is applied and its objectives are met; (ii) further mitigating the impact of aquaculture; and (iii) promoting aquaculture with lower environmental impact and aquaculture that provides ecosystem services" (ibid). The policy cited indicates that the EU has made some progress in defining sustainable aquaculture, however it continues to favour a sectoral approach in the wider marine governance landscape. The following section gives an overview of the Irish aquaculture licensing system and demonstrates the complexity of the regulatory framework.

Aquaculture licensing system in Ireland

Ireland's aquaculture licensing system operates in a complex and fragmented regulatory environment, subject to various national legislative instruments and EU regulations, and consequently under the remit of various Government institutions. The licensing system is subject to numerous regulations from

different sectors such as; agri-food, animal welfare, environmental conservation, and marine management, further contributing to its fragmentary nature. Figure 1 provides an overview of this complex governance landscape.

At a national level, aquaculture is regulated under various legislative codes which account for the different spatial scales in which the industry operates (e.g., land-based facilities, inter-tidal and marine). This has resulted in a complex system in which the sector must operate under different planning systems, accounting for use of the foreshore, in-land facilities, coastal zones, and marine zone. Figure 2 provides an overview of this complex system of legislation under which licences and permits for aquaculture operations are processed.

The general framework for processing aquaculture licensing and licence appeals are set out in Section 61 of the *Fisheries (Amendment) Act, 1997* and *Aquaculture (Licence Application) Regulations 2018*. The Minister for Agriculture, Food, and the Marine, (MAFM) is the licensing authority and the Aquaculture and Foreshore Management Division (AFMD) of the Department manages aquaculture licence processing on behalf of the Minister, and in the case of land-based development, responsibility is shared with the relevant local authority.

The general considerations for the processing of licence applications are detailed in *Section 61 of the Fisheries (Amendment) Act 1997* (Irish Government, 1997). Figure 3 provides an overview of the steps of the licensing process and indicative processing time based on the Independent Aquaculture Licensing Review Group, 2017 report. The licensing process can be further extended in the case an appeal is presented.

Section 22 of the Fisheries Act, 1997 - *Appeals against licensing decisions* establishes an appeals mechanism for licensing decisions (Irish Government, 1997). One month after the publication of a licensing decision, aggrieved parties (e.g., licensee, public consultation participants, statutory consultees) may present objections towards the licensing conditions. The Fisheries Act does not provide detailed guidance on grounds for appeals which has led to criticism of the transparency of the licensing system (Independent Aquaculture Licensing Review Group, 2017). The general considerations of focus during the appeals process can be based on licensing considerations (see Table 3). Through a review of selected appeals licensing decisions detailed in the following section, it has been identified that appeals focus on findings from Appropriate Assessment reports submitted with applications. These findings can determine an aquaculture site to be deemed unsuitable or have a potentially significant adverse impact, or a potential negative impact and be expected to have an adverse impact.

Furthermore, appeals focusing on the licensing considerations issued in the Act (see Table 3), and the Aquaculture Licence Appeals Board (ALAB) will request more information from the licence applicant to make a determination. This can take the form of a supplementary Environmental Impact Statement (EIA), Appropriate Assessment (AA) screening matrix, water modelling reports, sea lice dispersal models etc. More information can be requested outside of the cited scope but this is not specified in legislation or policy which can impede consistency in the appeals process.

These conditions establish the baseline ecological considerations that must be met in aquaculture production. The ecological considerations are implemented through environmental indicators and management plans in the conditions set out in licences. For example, in the case of marine-based finfish aquaculture, one of the key environmental indicators is sea-lice occurrence and is implemented through the requirement of integrated pest management plans in licences and the establishment of the *National Sea Lice Monitoring Programme* (Department of Agriculture, Fisheries and Food, 2000). In the case of shellfish aquaculture, water quality monitoring and proximity to designated Shellfish Waters must be accounted for in licensing conditions. The numerous requirements derived from this dispersed regulatory framework have contributed to the number of appeals carried forward (e.g., 14 in 2014, 11 in 2017, 37 in 2018, 69 in 2019), which can be attributed to an inconsistency in licensing decisions which will be explained in the following sections (ALAB, 2020a). For context, in 2017 there were 324 licence determinations made in 2019 (DAFM, 2020).

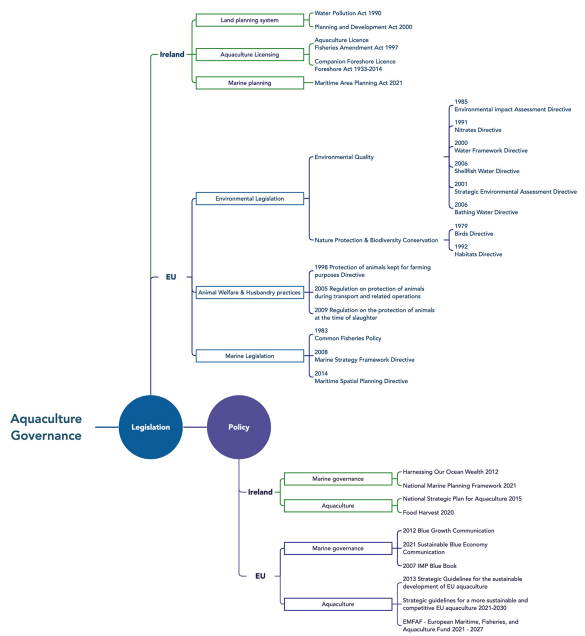

FIGURE 1
Aquaculture Governance.

EU requirements

In addition to the criteria and conditions referenced above, further complexity is added by EU regulations applicable to the sector. At the EU level, there is no specific harmonised legislation for regulating aquaculture activities. The regulatory framework for the sector is fragmented and is set out by the *Common Fisheries Policy 1380/2013* and EU environmental legislation such as the *Habitats Directive (92/43/EEC), EU Birds Directive (2009/147/EC), Environmental Impact Assessment Directive (2014/92/EU)* and

Aquaculture Licensing in Ireland				
Legislation	**Consent/authorisation type**			**Relevant Institution**
Fisheries Act 1959 - 2003 S.I. No. 240/2018 Licence Application Regulations (Under Fisheries Act 1997)	i. Aquaculture Licence ii. Trial Licence iii. Renewal of Aquaculture Licence iv. Review of Aquaculture Licence	Marine based: • Finfish • Shellfish • Intertidal • Subtidal • Seaweed, aquatic plants • Aquatic fish food	Land-based: • Finfish • Shellfish • Intertidal • Subtidal • Seaweed, aquatic plants • Aquatic fish food	Aquaculture and Foreshore Management Division of the Department for Agriculture, Food, and the Marine
Foreshore Acts 1933 - 2011	Companion Foreshore Licence			Department of Housing, Planning and Local Government
Planning and Development Act 2000 (as amended)	Planning Permission			Local Planning Authority or An Bord Pleanála
Local Government (Water Pollution) (Amendment) Act, 1990	Licence to Discharge Trade Effluent			Environmental Protection Agency

FIGURE 2
Aquaculture Licensing in Ireland.

public consultation requirements of the *Public Participation Directive (2003/35/EC)*.

As the transposition of these Directives follows the principle of subsidiarity, national implementation has been complicated (Long, 2016). Implementation of environmental compliance requirements derived from the Nature conservation Directives has been inadequate in Ireland as evidenced by ECJ judgements. (i.e., the Birds Directive and Habitats Directive). This is evidenced by the 2007 European Court of Justice (ECJ) ruling against Ireland in *Commission of the European Communities v Ireland [C-418/04]* for not complying with Article 6 (3) and (4) of the Habitats Directive requirements for Appropriate Assessments (AA) for aquaculture activities in or adjacent to Natura 2000 areas (European Commission, 2004). As a result of this ruling, Ireland was required to conduct several Appropriate Assessments for aquaculture activities in 20 Natura 2000 sites (e.g., SPA and SAC sites).

This ruling had strong implications for the aquaculture industry, as most aquaculture sites had been licensed in the 1980s and 1990s, and were in or near Natura2000 sites, making the licences of these sites in breach of AA requirements (Independent Aquaculture Licensing Review Group, 2017). Aquaculture farms were unable to renew their licences until the government developed the AA for Natura 2000 sites. This also resulted in exclusion from EU grant funding eligibility, hindering access to financial support mechanisms aimed at supporting the sustainable development of the sector. The following section demonstrates through selected case studies the complexity of the licensing system through licence applications that went through the appeals process.

Case studies

Salmon aquaculture in Bantry Bay, Co. Cork

Salmon farming in Ireland developed in the 1980s and has been the subject of environmental and social criticism (Phyne, 2009). Poor environmental performance in salmon aquaculture operations has been assessed by the occurrence of sea-lice infestation on wild salmon and harmful algal blooms episodes (HABs). For example, such is the importance of negative environmental outcomes at a statutory level in salmon aquaculture, that Norway has embedded salmon lice incidence into its management system (Bailey and Eggereide, 2020). In this case, the government deems salmon aquaculture operations as sustainable when sea lice levels are kept at a minimum level. In the case of HAB episodes, the loss of US$ 800M for Chilean salmon aquaculture companies in 2016 demonstrated how inadequate contingency plans can adversely affect the industry (Mardones et al., 2021). These two

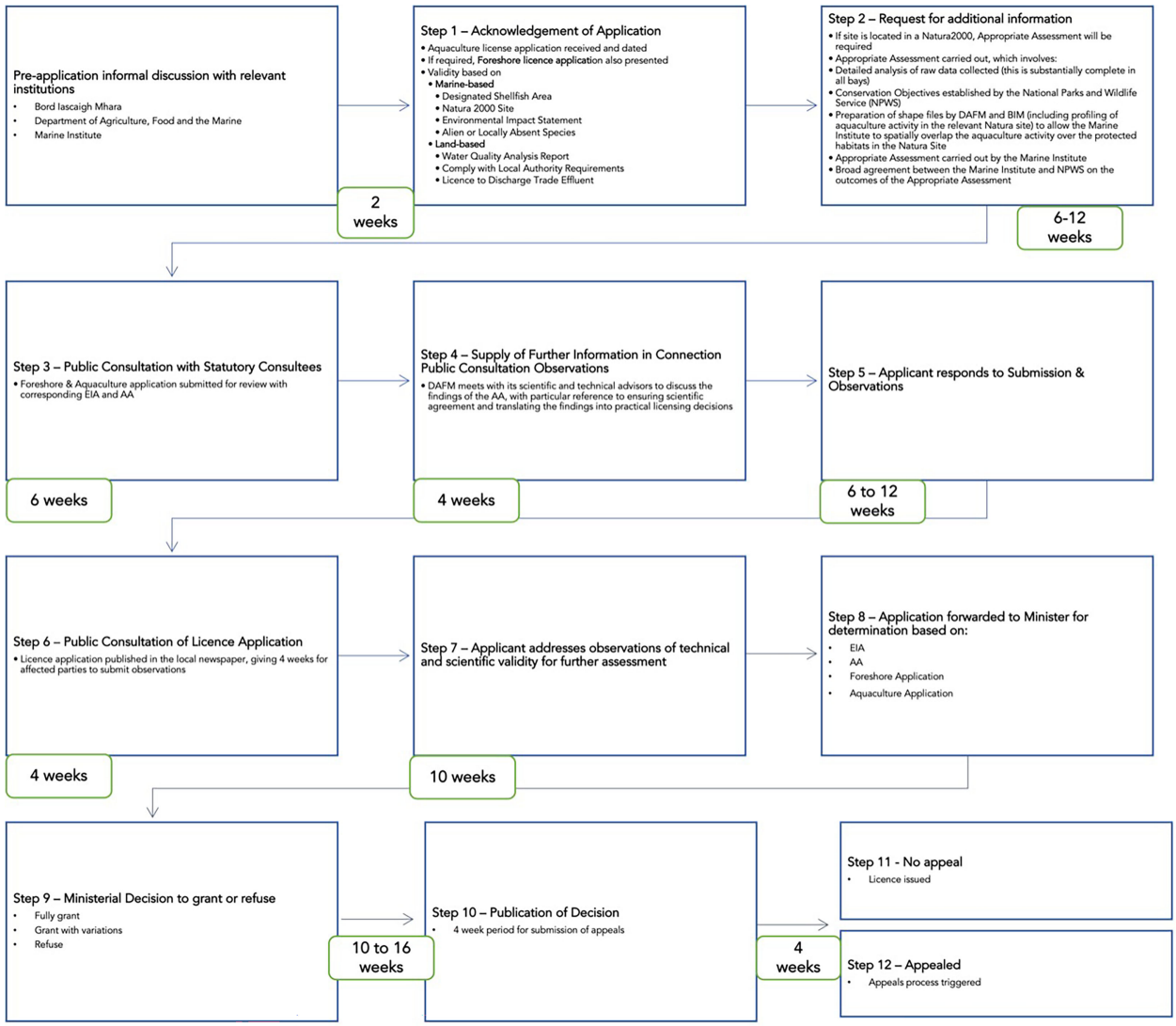

FIGURE 3
Overview of licensing process.

environmental impact indicators are associated with poor governance and inadequate aquaculture licensing and monitoring systems (McMahon, 2000; Davidson et al., 2020; Osmundsen et al., 2022). They also affect social acceptance of salmon aquaculture in Ireland, leading to the opposition of the development of the industry as demonstrated by the numerous appeals against salmon farm applications.

Given the importance of salmon aquaculture in Ireland and its promotion by policy and sectoral strategies, the licensing application for a salmon farm at Shot Head in Bantry Bay is analysed. In 2015, the Minister for Agriculture, Food and the Marine granted aquaculture and foreshore licenses for the licence application presented in 2011 for this site. This decision was appealed under the provisions of Section 47 of the Fisheries Act 1997. Thirteen appeals were presented against the licence approval, and one appeal from the Licensee was submitted, requesting the amendment of licence conditions (ALAB, 2017).

This resulted in the licensing process for the site spanning a 7-year determination period (2015 to 2022) (ALAB, 2020; ALAB, 2022). This case study focuses on the appeals process in which a number of environmental considerations were presented by the appellants to oppose the development of salmon aquaculture in Bantry Bay. This case study provides an example of how environmental criteria are integrated into the licensing process through the grounds for appeals.

Here we focus on the issues of significant environmental concern brought forward by appellants and how these were integrated into the appeals process and subsequent licensing decision. Appellants argued that the original EIA presented with the application did not adequately address the impact of in-shore fishing activity and the “footprint of the proposed farm” on benthic conditions (ALAB, 2017). The environmental concerns cited based on this EIA which was characterised as flawed by the appellants were the following (ALAB, 2017; ALAB, 2022):

10.3389/fmars.2023.1075803

TABLE 3 Licence processing and monitoring under the Fisheries Act 1997.

Licensing considerations	the suitability of the place or waters at or in which the aquaculture is or is proposed to be carried on for the activity in question
	other beneficial uses, existing or potential, of the place or waters concerned
	the particular statutory status, if any, (including the provisions of any development plan, within the meaning of the Local Government (Planning and Development) Act, 1963 as amended) of the place or waters
	the likely effects of the proposed aquaculture, revocation or amendment on the economy of the area in which the aquaculture is or is proposed to be carried on
	the likely ecological effects of the aquaculture or proposed aquaculture on wild fisheries, natural habitats and flora and fauna
	the effect or likely effect on the environment generally in the vicinity of the place or water on or in which that aquaculture is or is proposed to be carried on; (i) on the foreshore, or (ii) at any other place, if there is or would be no discharge of trade or sewage effluent within the meaning of, and requiring a licence under section 4 of the Local Government (Water Pollution) Act, 1977
	the effect or likely effect on the man-made environment of heritage value in the vicinity of the place or waters
Licence operation conditions	a specification, by means of a map or otherwise, of the boundaries or limits of the place or waters in relation to which the licence is granted
	the amount of feed inputs
	annual or seasonal limits on stock inputs, outputs and standing stock on site
	operational practices, including the fallowing of sites
	the reporting of incidences of disease and the presence of parasites
	the disposal of dead fish
	measures for preventing escapes of fish, and arrangements for the reporting of escapes
	monitoring and inspection of the aquaculture carried on pursuant to the licence
	the keeping of records by the licensee
	the protection of the environment (including the man-made environment of heritage value) and the control of discharges
	appropriate environmental, water quality and biological monitoring
Environmental Monitoring requirements (only applicable to marine finfish)	Benthic monitoring
	Water Column Monitoring
	Strategy for improved pest control
	Sea lice monitoring and control
	Audit of operations
	Fallowing
	Structural design protocol
	Proposed site layout

1. Increased threat to wild salmon and sea trout from sea lice Atlantic salmon is a protected species under the Habitats Directive and under the EU Freshwater Fish Directive (78/659/EEC)
2. Threat to wild salmon from escaped farm fish/disease control
3. Insufficient carrying capacity to support additional aquaculture – that the Bay has reached the limit of its ability to support multiple aquaculture activities
4. Site suitability: weather vulnerability
5. Toxic chemical discharges/pollution
6. Nutrient and settleable solid discharges
7. Impacts on farmed shellfish
8. Impacts on benthic/pelagic and local freshwater habitats, including marine mammals, birds and benthic impacts (European Commission, 2000)
9. Impact on tourism, including salmon angling
10. Impact on commercial in-shore fishing
11. Impact on on-shore angling
12. License conditions (e.g., cage dimensions and type, cage number and configuration and production and farm management strategies, including fallowing)
13. Cumulative impacts
14. Noise impacts
15. Absence of local aquaculture management scheme

16. Dissatisfaction with the licence approval process
17. Matters relating to the environmental impacts of fish farming, including: sustainability of the salmon farming industry in relation to the preparation of farm feed; contribution of fish farming to climate change; impact of license on global protection of wild salmonoid stocks
18. Applicant's supposed record of inadequate compliance, enforcement and monitoring

In consideration of the afore-mentioned environmental concerns presented, the Appeals Board determined that the Licensee's Environmental Impact Assessment (EIA) and Environmental Impact Statement (EIS) (ALAB, 2017) did not adequately address the environmental requirements, and requested the submission of a Supplementary EIS. Furthermore, no AA screening was presented with the initial application. This demonstrates that the initial licensing decision did not adequately account for sustainability criteria, therefore requiring further data and science to guide the decision-making process.

The Supplementary EIS required that the following be addressed; risk of sea-lice infestation on wild salmonoids migrating from the surrounding rivers (Dromagowlane and Trafrask) and impact on freshwater pearl mussel populations. The second issue was the impact of waste discharge from the farm on the maintenance of good water status as required by the Water Framework Directive (European Commission, 2000). This request by the Appeals Board is consistent with best practices and research which argue that the effectiveness of the integration of environmental criteria into aquaculture licensing can be measured through the environmental quality management measures and monitoring conditions of a license.

The Supplementary EIS addressed these two issues through detailed scientific assessments. For the first issue concerning sea-lice infestation risks, the farm developer, Marine Harvest Ireland, commissioned the preparation of a hydrodynamic (HD) model to investigate the dispersal of sea lice from all sites in Bantry Bay and assess the risk posed to wild salmonoid populations (Marine Harvest Ireland, 2018). The results of the model determined that there was zero probability of sea lice entering the Dromagowlane and Trafrask Rivers. The Appeals Board accepted the results from the HD model assessment and determined that the proposed aquaculture activity in the site will not have significant effects on the receiving environment, ensuring compliance with Article 6(3) of the Habitats Directive (ALAB, 2022).

The specific management actions resulting from this decision required the Licensee to comply with Sea Lice Monitoring and Control Protocol No.3 for Offshore Finfish Farms and Pest Management Plan (Department of the Marine and Natural Resources, 2000). In regards to concerns about impact on 'Good Water Status' of the receiving environment, the Board determined that no general environmental effects will result from the operations of Marine Harvest Ireland; "the modelling results in the Water Modelling Report indicate that the impacts of the finfish farm operation at the Site will not have an adverse environmental impact on Outer Bantry Bay's and Berehaven's current classification under the WFD Directive (ALAB, 2022).

The potential for cumulative impacts of existing salmon aquaculture operations in Bantry Bay in combination with the proposed site, addressed in the Water Modelling Report, resulted in the Board determining that the proposed farm at Shot Head would not contribute significant cumulative environmental impact (RPS, 2015; ALAB, 2022). This was further supported by the AA screening exercise conducted by the Marine Institute in 2020 which screened out the surrounding SPA and SAC sites (ALAB, 2022; Marine Institute, 2022). In conclusion, the Board found that the carrying capacity of Bantry Bay is not expected to be exceeded by the operation of the Licensee's proposed aquaculture activities. The before mentioned conclusions demonstrate the level of environmental regulatory scrutiny through which licensing applications undergo in Ireland is inconsistent. For example, the initial EIA, EIS and AA presented with the application were inadequate and confirms the need for better science and data in support of the development of a sustainable blue economy. The use of cumulative impact assessments and carrying capacity assessments for aquaculture sites could be used to better inform licensing decisions.

Oyster cultivation in Spike Island, Cork Harbour, Co. Cork

A 2009 licence application for oyster cultivation in Cork Harbour was refused in April 2022, after an 11.5-year processing period. The applicant then appealed the decision unsuccessfully (ALAB, 2021a). In the first instance, the Minister refused the application based on the Visual Impact Assessment carried out for the site and its proximity to tourism amenities in Spike Island (ALAB, 2022). The basis of the determination was the potential adverse effects on other users and economic activities (e.g., tourism) and there were no environmental concerns presented in the determination (Department of Agriculture, Food and the Marine, F. and the M, 2019c). This licensing decision reflects the failure to integrate environmental criteria into the determination process.

On the presentation of the appeal, the main reason for confirming the refusal of the application was on environmental grounds. In an AA carried out during the appeals process, the ALAB identified environmentally significant (see Table 4) effects that could arise from the proposed aquaculture site which had not been identified when the licence was first presented (ALAB, 2022).

This reflects inconsistencies in the use of environmental information during the licensing process, as the initial recommendation and conclusion statements by the Marine Institute determined that the licence would not have adverse significant impacts on the marine environment and that the qualifying features of the area would not be adversely impacted (ALAB, 2021b). But in the appeals process, it was determined that the potential impacts on the SAC and SPA sites could not be ruled out, therefore refusal of the licence was recommended. The

TABLE 4 Licence and appeal for an oyster cultivation site in spike island.

Observation	Licensing Determination	Appeals Determination
Inconsistent	Suitability of the place or waters – scientific advice determined the waters are suitable for oyster cultivation	Site deemed unsuitable because of potential disturbance or displacement impact on SCI species in Cork Harbour SPA
Consistent	Other beneficial uses of the waters covered – may have negative effects on public access to recreational and other activities	Site would have a potential significant adverse impact on other uses or users Expected to have an adverse effect on the economy of the area due to effect on tourism
Inconsistent	Statutory status of waters – site is located near Great Island SAC and Cork Harbour SPA. According to both AA for aquaculture of these two sites, the sites are not located within shellfish designated waters	Potential negative impact on the statutory status of the area
Inconsistent	No significant ecological effects on wild fisheries, natural habitats flora and fauna	Expected to have a negative ecological impact
Inconsistent	No significant impacts on the marine environment and that the quality status of the area will not be adversely impacted.	Expected to have a negative ecological impact

extended processing time and changes to the final determination suggest that a robust framework for aquaculture policy through MSP could result in more time-efficient licensing.

Oyster cultivation in Trawbreaga, Co. Donegal

In 2021, the ALAB recommended the refusal for an organic Pacific oyster cultivation licence at a site in Trawbreaga Bay, Co. Donegal be upheld (ALAB, 2020). The licence determination was based on the potential impact on pre-existing aquaculture activities and aquaculture development policy in the Bay (see Table 5 for specificities).

This decision was based on the AA carried out for the SPA of Trawbreaga Bay in 2019, in compliance with Article 6 provisions of the Habitats Directive (Marine Institute, 2021). In its final report, the ALAB cited cumulative impacts and spatial conflicts with pre-existing aquaculture activities in Trawbreaga Bay as grounds for refusal (ALAB, 2021a). For example, it cited that the proposed Site would impact on "the orderly aquaculture development in the bay" and have "negative impacts on the operations of existing oyster farms and have a hydrodynamic impact with a potential for sedimentation pattern change and rerouting of currents in the area" (ALAB, 2021a; ALAB, 2021b). This case demonstrates how spatial planning policy has been developed for aquaculture activities in specific Bays in Ireland and how this policy can inform licencing decisions.

These three case studies demonstrate how the Irish aquaculture licensing process integrates environmental criteria, primarily through the Appropriate Assessment process required by Article 6 of the Habitats Directive. The appeals cases analysed above demonstrate that there are inconsistencies in the interpretation and rigour of environmental data provided to licensing authorities. In the first instance, determinations are based on best available data and limited staff time. The appeals process provides more time and data needed for a final determination.

The rigour of environmental data was inconsistent as demonstrated by outlining the inconsistencies between the original AA presented and the AA presented during the appeal. It is essential that applicants and licensing authorities refer to existing AA for aquaculture zones when preparing and determining applications to ensure consistency with past determinations in the adjacent area. Overall, the opaque determination process could be improved to ensure more efficient and robust determinations. In the following section, the limitations of the licensing system are discussed and how this may pose a barrier to the integration of the sector into the MSP process.

Discussion

The complex institutional and regulatory framework of the aquaculture licensing process has been widely critiqued and identified as a barrier to the sustainability of the sector (Independent Aquaculture Licensing Review Group, 2017;

TABLE 5 Licence and appeal determination for oyster cultivation in trawbreaga bay.

Observation	Licence Determination	Appeals Determination
Consistent	Potential negative impact on existing oyster farms through reduced growth and hydrodynamic impact with a potential for sedimentation pattern change, and rerouting of currents in the area	Satellite imagery and visit to the proposed site confirmed the potential negative impacts on adjacent licensed sites
Consistent	Negative impact on passage of migratory fish passages and boats	Migratory fish would not use the channel in the site area
Consistent	Excessive in size in respect to past licensing policy and would not be in accordance to orderly development policy in the bay	Site is over 1.3 hectares in size, licensing policy for the Bay dictates 0.9 hectares maximum

Renwick, 2018). This is in line with barriers identified for the development of EU aquaculture more generally, which include strict environmental regulation, high bureaucratic burden, and overreliance on command-and-control instruments to manage negative environmental externalities, which hinders economic development (Abate et al., 2016; Bostock et al., 2016). As far back as 2012, numerous submissions on the Consultation for HOOW emphasised the need for a "better planning system to provide for sustainable aquaculture development" and identified foreshore and aquaculture licensing systems as barriers (Department of Agriculture, Food, and the Marine, 2012).

Furthermore, the Independent Aquaculture Licensing Review Group (2017) recommended that "a root-and-branch reform of the aquaculture license application processes is necessary", and aquaculture operators have emphasized the need to address the dysfunctional nature of the licensing system (Rendwick, 2018). However, these concerns remain largely unaddressed as evidenced by the continuing operation of the existing licensing system (with no obvious changes/improvements) and the exclusion of the sector from the scope of the Maritime Area Planning Act, 2021. There has been great concern over the need to reform the aquaculture licensing system and ensure the sector's integration within the enabling legislation (e.g., MAPA) of the national MSP framework. During the Pre-legislative Scrutiny of the MAPA, concern about the omission of aquaculture was presented in various instances, and the Committee recommended that regulation and management of aquaculture should be provided for in the forthcoming act (Joint Committee on Housing, Local Government and Heritage, 2021). Furthermore, the Committee was informed by the Department of Housing, Local Government and Heritage which is the relevant MSP authority in Ireland that "aquaculture would feature in the regime at a later date, noting this was a matter for the Minister for Agriculture, Food and the Marine." In spite of this aquaculture licensing was not included in the final version, it is envisioned that through the NMPF (MSP statement), spatial planning for aquaculture should be provided to ensure compatibility and compliance within the broader marine licensing system.

The integration of aquaculture within the new marine governance framework of Ireland underpinned by the MAPA and the NMPF is limited to a policy level as shown detailed in Table 6. The lack of an updated statutory basis underpinning the implementation of MSP in the aquaculture licensing process will limit the fulfilment of these policy objectives.

NMPF and aquaculture

These policy aspirations require a modern licensing system with fast processing times which can accommodate newer sustainable aquaculture practices such as multi-trophic approaches and the introduction of new species (Independent Aquaculture Licensing Review Group, 2017). Effectively, the current aquaculture licensing system can be considered extant within the context of the new marine planning system introduced by the MAPA. This in turn limits the effectiveness of the implementation of MSP across all sectors for the delivery of a sustainable blue economy.

Various policy documents, public consultations and government reports indicated the need to update the legislation regulating aquaculture and the need to reform the licensing system. For example, the National Strategic Plan for Sustainable Aquaculture Development 2015-2020 established four actions aimed at improving the licensing process, with one of these actions focusing on the "review and revision of the aquaculture licensing process, including the applicable legal framework" (Department of Agriculture Food and the Marine, 2015).

However little progress has been made and the government has favoured sectoral strategies and policies to support the development of the sector. Sustainable aquaculture tools have been developed by the government, based on an ecosystem approach to aquaculture with limited integration of ICZM and MSP principles. Table 7 provides an overview of one of the management tools – Co-

TABLE 6 Aquaculture policy in the NMPF.

No.	Policy
1	Proposals for sustainable development of aquaculture that:
	-demonstrate use of innovative approaches, and/or
	-contribute to diversification of species being grown in a given locality, particularly proposals applying a multi-trophic approach, and/or
	-enhances resilience to the effects of climate change should be supported
2	Non-aquaculture proposals in aquaculture production areas must demonstrate consideration of, and compatibility with, aquaculture production. Where compatibility is not possible, proposals must demonstrate that they will, in order of preference:
	a) avoid
	b) minimise
	c) mitigate significant adverse impacts on aquaculture
	d) If it is not possible to mitigate significant adverse impacts upon aquaculture, proposals should set out the reasons for proceeding.
3	Land-based coastal infrastructure that is critical to and supports development of aquaculture should be supported, in accordance with any legal requirements and provided environmental safeguards contained within authorisation processes are fully met.

TABLE 7 Sustainable aquaculture tools.

FAO EEA Principles	CLAMS
The scoping and definition of ecosystem boundaries and stakeholder identification.	**Plans developed for each water body through Single Bay Management practices** Bannow Bay, Co. Waterford; Carlingford Lough, Co. Louth and Co. Down (NI); Roaringwater Bay, Co. Cork; Castlemaine Harbour, Co. Kerry; Lough Swilly, Co. Donegal; Clew Bay, Co. Mayo; Killary Harbour, Co. Galway; the North Shannon Estuary, Co. Clare; Dungarvan Harbour, Co. Waterford; Kilkerrin Bay, Co. Galway; and Mulroy Bay, Co. Donegal **Stakeholder identification** CLAMS Group for each management area with members from fish and shellfish aquaculture operators, regulators, consultation group representing interest groups such as tourism bodies, local recreation groups.
Identification of main issues	Responsible Government departments consulted to determine relevant policy and licensing issues and CLAMS representatives are then asked to review these issues and provide feedback.
Prioritization of the issues	Identification and prioritization of issues that may impact the sustainable growth of aquaculture within each region and engage proactively.
Definition of operational objectives	•Supporting a thriving maritime economy •Maintaining good environmental status •Sustaining local jobs and supporting communities •Producing high quality products sought by international markets
	Outcomes of the implementation of these objectives •Development of navigation plans (Special Unified Marking Schemes (SUMS) •Deployment and maintenance of IALA navigation markers •Preparation of bay scale aquaculture profiles to inform Appropriate assessments •Water quality projects •Beach and pier clean-ups •Re-alignment and rationalisation of mussel lines •Oyster farm realignment and trestle recycling programs •Oyster farming shore litter surveys and programs
Elaboration of an implementation plan	CLAMS National Framework sets out the structure for each Regional CLAMS Group
Corresponding implementation process, reinforcing, monitoring and evaluation	Periodic monitoring of actions implemented by CLAM Groups representatives
Long-term policy review	CLAMS National Review in 2020 and update of 5 CLAMS regional plans

ordinated Local Aquaculture Management Systems (CLAMS) that have been developed within this context, in coherence with the FAO ecosystem approach to aquaculture (FAO, 2010).

Co-ordinated Local Aquaculture Management Systems (CLAMS) have been in operation since 1998 to facilitate the organised growth and sustainable development of aquaculture inshore and in bays, and implementation has been carried out by fish and shellfish farmers. This participatory policy framework established a governance mechanism for the identification of spatial conflicts, environmental impacts of aquaculture and overall operationalisation of an ecosystem approach to aquaculture (Carr, 2019; Pendleton and Carr, 2022). Even though CLAMS attempt to coordinate and integrate the different users of Bays in which aquaculture develops, it maintains a sectoral focus. For example, data-gathering and analysis activities have been limited to evaluating the environmental quality impact of aquaculture (Bottom Grown Mussel Review Group, 2008).

In 2003, BIM, Ireland's Seafood Development Agency introduced Ecopact, an environmental quality certification (ECQ) for fish farms to support the implementation of CLAMS. Ecopact was designed to support aquaculture operators to adhere to the EU's Eco-Management and Audit Schemes (BIM, 2003). Ecopact certification requires operators to implement measures such as monitoring environmental impacts, compliance with nature conservation, management of noise, odours, waste management and stock health management. This is in line with the EEA principles and supports the delivery of a sustainable aquaculture model in Ireland in line with the EU's new sustainable blue economy model.

The environmental quality support tools provide a foundation for the implementation of a sustainable aquaculture model, in line with the EEA. But these tools are seldom cited in licensing decisions and in support of aquaculture policy. Additionally, these tools favour a sectoral approach to aquaculture management and have a limited impact in progressing efforts towards the integration of aquaculture into a wider marine planning framework.

Marine zoning and MSP can mitigate the environmental impact of aquaculture as demonstrated by the experience of the salmon aquaculture sector in Chile, Norway and the United Kingdom (Craig, 2019). In the case of Ireland, this could be achieved through the development of Designated Maritime Area Plans (DMAP) for aquaculture and the integration of existing Single Bay Management Plans. In a similar vein, Spain has identified zones for high aquaculture potential within its national MSP and provided policy guidelines on how spatial conflicts with other marine activities can be resolved. The integration of aquaculture into the MSP process in Spain is strong as reflected by the "Marine Spatial Planning of Aquaculture in Spain" plan which was integrated into the National MSP plan (Gobierno de España, 2020). This work is further supported by an ecosystem approach to the spatial planning

of aquaculture which reflects the integration of ecological boundaries as evidenced by the strategic plans created for the three eco-regions of Spain (e.g., North-Atlantic, Mediterranean and Canary Islands) (Stelzenmüller, 2016).

In Scotland, aquaculture has been integrated into the marine licensing process through the Marine Scotland Act 2010 through the requirement of a marine licence for the installation of marine farming equipment (Scottish Government, 2010). This effectively streamlines the marine planning system with the aquaculture licensing process and provides a statutory basis for the policy objectives defined for the aquaculture sector by Scotland's MSP. Overall, the Spanish and Scottish experiences demonstrate how aquaculture can be integrated within MSP national processes to ensure the sustainable development of the sector and the attainment of broader sustainable blue economy ambitions.

In order to further align the aquaculture sector with MSP, a carrying capacity approach can be applied through licensing. This could be achieved through the integration of carrying capacity assessments into DMPAs developed for aquaculture. This approach has seen particular success in the salmon aquaculture licensing system in Norway (Bailey and Eggereide, 2020). In Norway, salmon aquaculture licensing shares several elements with steps in the MSP process, providing for wider coherence in marine planning and the attainment of sustainable development;

- Establish institutional framework;
- Assess baseline and identify issues;
- Establish vision and objectives;
- Produce plan;
- Establish public consultation;
- Implementation;
- Monitoring and review.

(Stelzenmüller, 2016). Given the importance of the salmon aquaculture sector in Ireland, it will be essential for the NMPF to identify approaches to better accommodate the sector.

Conclusion

This paper outlines the fragmented regulatory framework in which aquaculture operates in Ireland and how the failure to integrate it into the legislation underpinning MSP presents a missed opportunity to develop a truly inter-sectoral marine governance approach. The development of marine and environmental governance in Ireland has developed in a fragmented manner which has led to the limited integration of the sector into the evolving marine governance landscape. This is in part a broader governance issue as Ireland has been slow at adopting statutory environmental requirements derived from EU environmental conservation law (OECD, 2021). MSP can help resolve these issues and enable the development of sustainable aquaculture. Below, recommendations based on best practices from other European jurisdictions are presented to demonstrate how aquaculture can be better integrated into MSP.

In conclusion, the differentiated management regime of aquaculture and its exclusion from the new marine planning regime demonstrates that Ireland faces barriers in the full implementation of MSP by omitting a key sector from legal reform. Furthermore, the legal uncertainty of the sector limits the development of innovative aquaculture models outlined in the NMPF such as integrated multi-trophic aquaculture and the introduction of new species with lower trophic impact (Alexander et al., 2015; Craig, 2019). The current framework poses a challenge to meeting over-arching law and policy objectives established by NMPF as aquaculture continues to operate in an extant system. To summarise it is essential that the Irish licensing system is updated to facilitate the development of sustainable aquaculture, and integrate it into the sustainable blue economy being promoted through MSP.

Author contributions

MT was the main author of the manuscript. JA wrote the following section: EU Marine Governance. AO'H assisted in the writing of the section on Marine Governance in Ireland. All authors contributed to the article 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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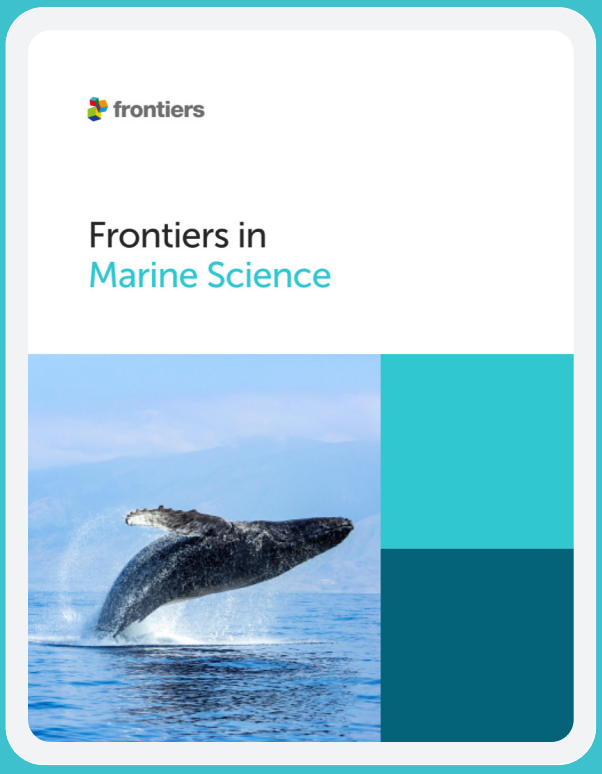

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