AMPLIFYING THE POTENTIAL OF MARINE SPATIAL PLANNING FOR CONSERVATION AND SUSTAINABILITY

By © Julie M. Reimer

A thesis submitted to the School of Graduate Studies in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

Department of Geography

Memorial University of Newfoundland and Labrador

October 2022

St. John’s, Newfoundland and Labrador

Abstract

The ocean is ubiquitously impacted by humans as our activities expand at an increasing rate. Marine spatial planning (MSP) is a process for analyzing and allocating space to specific human activities, while accounting for ecosystems, to inform ocean management and the use of ocean management tools. MSP has proliferated as an approach that seeks balance between social, economic, and ecological objectives to use the ocean sustainably. Despite its rapid uptake, the process continues to face critical challenges in operationalizing theoretical best practices and struggles to deliver sustainability, as socioeconomic development often takes precedence over conservation. Though MSP promises an ecosystem-based, integrated, place-based, adaptive, strategic, and participatory process, these principles have not fully come to fruition. The goal of this thesis is to explore these challenges and develop guidance to amplify the potential of MSP for biodiversity conservation and ocean sustainability, filling a void in the academic discourse that is often descriptive and disjointed from the complex reality of MSP practice.

Using mixed methods, including systematic review, expert opinion survey, case study analysis, and qualitative scoring, this thesis aims to identify how management tools might deliver sustainability targets, how conservation might be embedded in MSP, and how MSP principles might be translated into practice. Results highlight the importance of multi-sector management tools for achieving ocean sustainability targets, and gaps in evidence for social and economic outcomes from common spatial management tools. This research identifies potential strategies for recognizing biodiversity as fundamental to sustainable resource use, proposing the need for conservation ready MSP. Finally, this research produces the MSP Index, a tool for gauging MSP progress based on principles. The application of this tool to case studies revealed possibly persistent challenges in implementing adaptive and participatory MSP. MSP holds the potential to support ambitious goals for a healthy ocean; however, as processes adopt best practices, they become increasingly complex, requiring significant and ongoing investments that may be underestimated by the academic discourse. For MSP to meet its full potential, science must engage deeply with practitioners to understand the realities of MSP and co-produce sustainable solutions for a sustainable ocean.

General summary

Globally, there is no part of the ocean that is unimpacted by human activities. Now more than ever, a coordinated approach to planning for when, where, and how we use the ocean is needed. Marine spatial planning (MSP) has been widely accepted by scientists and decision-makers as an approach that can help to balance social, economic, and environmental objectives for the ocean. MSP is guided by the following principles: sustainable use needs healthy ecosystems; linking across ocean users and regulators, like government; adapting to change; purposefully planning over the long-term; and including all people with an interest in the ocean. Despite nearly 20 years of practice in MSP, the process still faces major challenges in using these principles and delivering the promise of a sustainable and healthy ocean. The goal of this research is to explore these challenges and develop guidance to help MSP achieve its full potential, filling a gap in the scientific discussion that is disconnected from the complicated reality of MSP.

This research uses a combination of methods from the social sciences to identify how common ocean management tools, like fisheries closures, might deliver goals for ocean sustainability; how protecting nature might be better included in MSP; and how MSP principles might be better used in practice. Research findings highlight the importance of management tools that regulate more than one human activity for achieving sustainability and show a gap in our knowledge of social and economic outcomes from these tools. This research identifies potential strategies for showing how protecting nature is central to ocean sustainability and describes the need for MSP that can enable these strategies. Finally, this research produces a useful tool for understanding how well MSP practice has used guiding principles. MSP has the potential to help achieve global goals for a healthy ocean, but as MSP gets closer to best practices, it also gets more complex and needs more investments. These issues might be underestimated by scientists. For MSP to reach its potential, scientists need to work together with ocean planners and decision-makers to create solutions that will deliver a healthy ocean.

Acknowledgements

Like marine spatial planning, this has been a lengthy process needing collaboration and adaptation. I'm thankful to have had the support of many through the course of this research. First, to Rodolphe Devillers, my co-supervisor: thank you for teaching me to confidently express my ideas, for the spirited debates, and for appreciating my dry humour. To Joachim Claudet, my other co-supervisor, thank you for encouraging me to try things imperfectly and for showing me that science can be a pathway to change-making. And thanks to you both for getting me to France! This experience changed me, as a scientist and as a person, for the better. It has been an absolute honour and a genuine pleasure to learn from you both – your mentorship means the world to me.

To Charlie Mather, my late-to-the-party co-supervisor, who has graciously tethered me to the Department of Geography since 2020: your kindness, thoughtfulness, and support getting to the finish line made all the difference. Plus, you taught me the value of coloured paper and kokis, without which this thesis wouldn't be complete. To Natalie Ban, my supervisory committee member: this thesis has been improved by your wisdom and attention to quality research. I am grateful to have been a part of the most incredible department, full of clever students, interdisciplinary scientists, and cook-off-enthusiasts. To Carissa Brown, thank you for your willingness to always lend a listening ear – you are a bright spot in grad school. To the former Marine Geomatics Lab, Emilie, Mairi, Bea, Simone, Callum, Brandon, Tash, and Aaron: thank you for the inspiration, your friendship, and the ongoing "is a hot-dog a sandwich" debate that lives rent free in my brain.

While completing this PhD, I've journeyed into the world of activism, and I am thankful to the many who have mentored me on this path. To Kelsey Wierdsma: thank you for showing me the power of young voices and living the mantra "empowered women empower women". To Kyle Empringham of The Starfish Canada: thank you for showing me a new, empathy-based way to lead – shantay you stay. To Andi White of Fisheries and Oceans Canada: thank you for guiding me and inviting me into collaborations that have opened new doors. To Gretchen Fitzgerald and Kristina Jackson of the Sierra Club

Canada Foundation: thank you for trusting in my leadership and for sharing your vision of the environmental movement. My activism would not be the same without you.

To my family and friends: thank you for your unwavering support and for listening to my ocean musings. Being a first-generation student is a wild ride, and I'm thankful to the many who have tried to understand my world over these last four years. Finally, to my husband, Peter: thank you for tolerating my too-busy schedule, for enduring years of long-distance marriage, and for teaching me to write during undergrad. You always see my brilliance, and you never once doubted that I could do this.

I am grateful to the organizations that provided funding for my research: the Natural Sciences and Engineering Research Council of Canada (NSERC), the Mitacs Globalink Award, the School of Graduate Studies of Memorial University, and the Queen's Alumni Association. During my studies, I have been honoured to receive the New Brunswick Environmental Network's Phoenix Award and recognition from the Corporate Knights as a Top 30 Under 30 Sustainability Leader in Canada.

Table of contents

List of tables

List of figures

List of abbreviations

ABMT	Area-based management tool
EU	European Union
FC	Fishery closure
FPA	Fully protected area
GRA	Gear restriction area
IOC	Intergovernmental Oceanographic Commission
LMMA	Locally managed marine area
MPA	Marine protected area
MSP	Marine spatial planning
OECM	Other effective area-based conservation measure
PIPA	Phoenix Island Protected Area
PPA	Partially protected area
PSSA	Particularly sensitive sea area
SDG	Sustainable Development Goal
TURF	Territorial user right fishery

List of appendices

Positionality statement

When you close your eyes and think of the ocean, what do you see? What do you hear? What do you feel? I see a vast blue horizon, peppered by the evergreen trees and rocky shores of the Fundy Isles, the open Atlantic beyond. I hear the deep exhale of a nearby whale and the joy of those experiencing it for the first time. I feel a salty layer of mist across my face, the gentle rock of waves lulling the boat and its passengers into a shared sense of wonder. I feel an immense curiosity and a call to action to protect this special place that gives life to our planet.

For some, the path to becoming an ocean scientist is sparked by a clear moment: an impactful childhood experience, an inspiring explorer, a particular charismatic ocean species. For me, it is marked by many small moments, wrong turns, chance encounters, and opportunities at the right time. A turn from human anatomy to animal physiology, a pivot from ecology to marine management, a full transformation from natural to social scientist, and a certainty that I can be both a scientist and an activist. This thesis is as much an academic pursuit as it is my love letter (a very long one) to the ocean and all those who feel pulled by the tide.

I approached this research under a lens of problem solving and solution building, particularly to create something useful for ocean managers, planners, and decision-makers. My early days in whale watching tourism taught me that the ocean is deceptively quiet. This is a place that is teeming with life – from benthic organisms on the seafloor, to migrating fish, to people building their lives in cadence with the ocean – and its existence is more threatened today than ever before in history. I approached this research with a view that ocean ecosystems cannot be disentangled from humans and intertwining protection with prosperity is necessary if the ocean is to thrive. With this lens and, like many students, a deep desire to be a part of change, I set off to explore, understand, and amplify the potential of marine spatial planning for ocean conservation and sustainability.

1. Introduction

1.1 Background

1.1.1 Geography and ocean planning

Geography is inherently interdisciplinary, recognizing the inextricable links between social and natural systems (Baerwald, 2010). By contributing this interdisciplinary understanding of the natural world, geography is often well-positioned to build knowledge of natural resource management, sustainability, and biodiversity conservation (Harden, 2012; Skole, 2004). At the interface of natural and social sciences, geography can build a more holistic understanding of ocean ecosystems, social systems, and economies, and how these systems are interconnected. While geographers have been analyzing the ocean for decades (Marmer & Vallaux, 1934; Smith, 2005), a particular subdiscipline has emerged that explores marine resource management and can inform how ocean spaces and resources are used, perceived, and managed (Levine, 2015). Approaches to managing marine resources range from simple fishery regulations to multi-sector management tools, accompanied by complex planning processes that account for multiple uses of ocean resources in time and space (Day et al., 2019; Reimer et al., 2020). This research applies the geographical lens to persistent challenges in planning for a healthy and sustainable ocean, contributing to a deeper understanding of marine spatial planning practice (MSP). As the ocean experiences rapid change (Halpern et al., 2019), this research aims to amplify the potential of MSP for achieving global goals for marine conservation and ocean sustainability.

1.1.2 State of the ocean

The ocean is the world's great unifier, profoundly connecting our ecosystems, economies, and communities. By 2030, ocean resources and industries are projected to contribute over USD $3 trillion and provide over 40 million full-time equivalent jobs (OECD, 2016). In the same period, 55% of the ocean will be susceptible to multiple climate change-drivers (Henson et al., 2017). A healthy ocean is critical to the survival of humanity (Laffoley et al., 2020). Despite its importance, year after year the ocean becomes warmer (Cheng et al., 2019), more acidic (Doney et al., 2020), and loses life-sustaining oxygen

(Breitburg et al., 2018), affecting its ability to recover and support biodiversity (Duarte et al., 2020). On a global scale, the benefits people receive from ocean ecosystem services are declining (IPBES, 2019). Cumulative impacts in over half of the ocean are increasing significantly, as nearly all ocean nations experience these impacts in coastal waters, particularly due to climate change, fishing, and pollution (Halpern et al., 2019). Scientists broadly agree on these critical threats, though they also identify societal failures, including poor governance, as major threats to ocean ecosystems (Boonstra et al., 2015). Yet, the ocean is often described by competing narratives: one where the ocean is vulnerable and needing protection, and another where the ocean is an area of opportunity and development (Voyer et al., 2018).

As economic interest in developing ocean industries continue to grow, management must embrace this opportunity to drive efforts toward sustainable practices and measures that reduce threats to the ocean and its resources (Lee et al., 2020). People around the world perceive the ocean to be threatened by human activities, and support protection efforts, though substantially fewer people believe that the ocean is currently in poor health (Lotze et al., 2018). This disconnect, between current actions and consequences, may plague the ocean with a lack of political will, inaction, and ineffective management solutions. The ocean is in a state of crisis, simultaneously experiencing rapid ecosystem deterioration and intense expansion of ocean industries (Jouffray et al., 2020). Still, hope remains. Marine life can be rebuilt with urgent and significant effort to reduce pressures on the ocean by mitigating climate change, protecting areas where biodiversity is abundant, and recovering populations, habitats, and ecosystems (Duarte et al., 2020). The time for sustainability solutions that ensure a healthy, productive, and equitable ocean for all has come.

1.2.3 Ocean science and sustainability

Scientific attention to the ocean, its conservation, management, and sustainability, has steadily increased since the early 2000s (Figure 1.1). As our understanding of the ocean has advanced, so too have global commitments to managing and protecting the ocean. Over the last decade, international conservation and sustainability agendas have come to include specific ocean goals, recognizing its societal importance. In 2015, the United Nations released the *2030 Agenda for Sustainable Development*, which included 17 Sustainable Development Goals (SDGs). Among these is the first development goal dedicated to ocean health, *SDG 14: Life Below Water*. SDG 14 comprises 10 targets that collectively aim to "conserve and sustainably use the oceans, seas, and marine resources for sustainable development" (United Nations General Assembly, 2015). Despite these good intentions, fragmented governance systems have largely failed at achieving ambitious conservation and sustainability goals, crediting this ineffective governance with the deteriorating state of the marine environment (Young et al., 2007; Ntona & Morgera, 2018). If the goal is 100% sustainable ocean management, a commitment 15 nations have made under the Ocean Panel (https://oceanpanel.org), management tools from across ocean sectors must be used to address multiple, interacting, and accumulating threats and impacts (Ban et al., 2014; Reimer et al., 2020; Spalding et al., 2016).

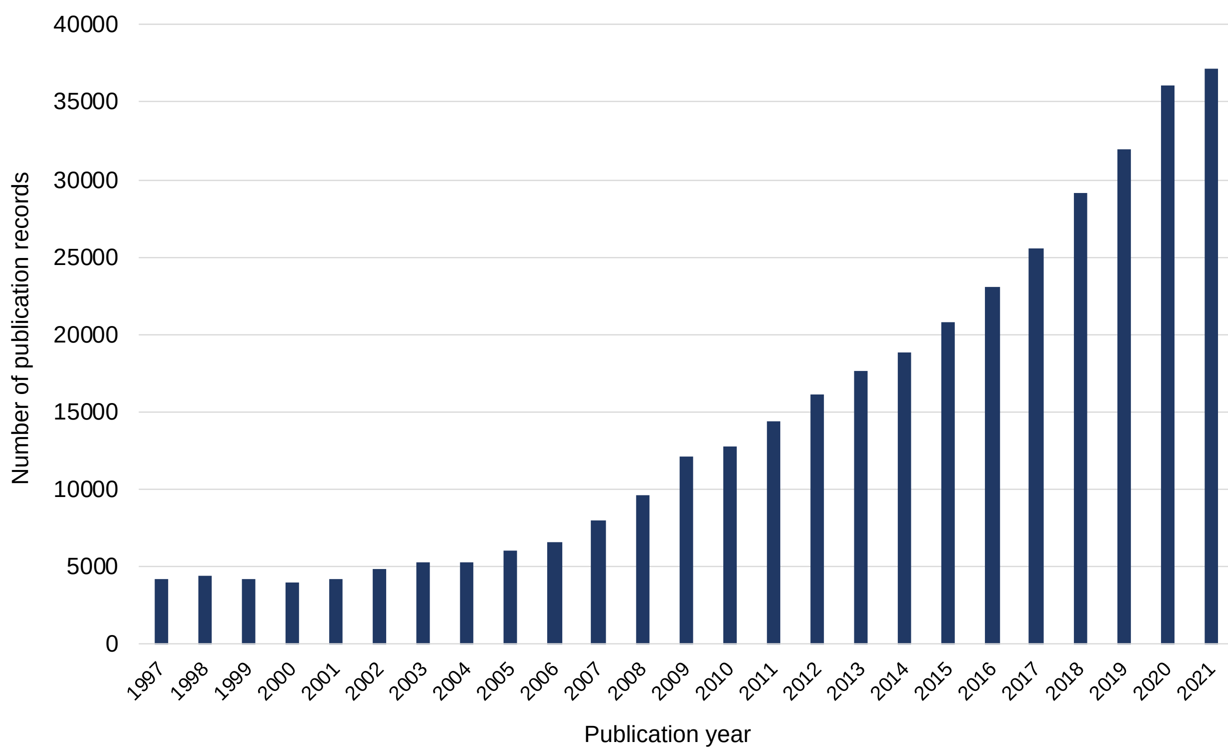


Figure 1.1. Increasing trend in publications related to the ocean, conservation, and sustainability between 1997 and 2021. Data collected from Web of Science on January 15, 2022, using search string ("ocean*" OR "marine" OR "sea") AND ("conserv*" OR "sustain*" OR "health*" OR "protect*" OR "manage*").

As nations commit to national and international goals for a healthy and sustainable ocean, balancing these goals with ambitions for ocean development will be critical. While SDG 14 targets generally aim to regulate activities, minimize impacts, and protect or restore ocean ecosystems, the goal itself seeks to enable continued use and development of ocean industries (United Nations, 2015). SDG 14 might be regarded as an enabling condition for the "blue economy", a concept emerging from the 2012 United Nations Conference on Sustainable Development. The blue economy attempts to reconcile economic growth with improved livelihoods, social equity, and the safeguarding of ocean resources and ecosystems (FAO, 2015). Still, the blue economy narrative has often emphasized production growth, rather than advancing social equity and human well-being (Cisneros-Montemayor et al., 2021; Farmery et al., 2021). A sustainable and equitable blue economy requires commitments to local communities, including inclusive governance, considering impacts to human well-being, and sharing wealth derived from the blue economy (Bennett et al., 2019). Both SDG 14 and the blue economy point to a need for governance that seek balance across ecological, economic, and social objectives for the ocean.

Achieving SDG 14 will be important for overall global sustainable development, as SDG 14 targets are related to all other SDGs (Singh et al., 2018); however, these ambitious targets for restoring marine ecosystems, enabling sustainable fisheries, and reducing systemic challenges of pollution and acidification have been described as largely aspirational rather than operational and measurable (Cormier & Elliott, 2017). To achieve this goal, management-level guidance is critically needed (Diz et al., 2018; Haas et al., 2019; United Nations Environment Programme, 2017). While science has a central role in providing this guidance (Claudet et al., 2020), science that aims to inform decision-making may be disconnected from the complex realities of planning and management and therefore less useful to practitioners.

In a survey of 181 protected area managers, Lemieux et al. (2021) found that many do not see the academic literature as relevant to their needs. As practitioners rely more on professional knowledge and experience (Cook et al., 2010; Lemieux et al., 2021), scientific research may lack relevance because it underestimates the complexities of governance and management practice or practitioners may also simply lack the interest or capacity to synthesize, contextualize, and follow scientific recommendations, being already busy dealing with day-to-day challenges. The relevance gap between the science being produced and the science needed and used by practitioners is growing, necessitating research that has a specific and demonstrable effect on management activities and increased interactions between researchers and decision-makers (Lemieux et al., 2021). This gap is not new, McNie (2007) describes how the supply of scientific information may be mismatched from the actual needs of decision-makers. In 2010, Cook et al. found that few conservation practitioners managing over 1000 protected areas in Australia used scientific evidence to support management. In Canada, policy and management had substantially diverged from ocean science and, at the time, government decision-making appeared to undermine its own legislated mandates for sustainable ocean management and protection (Bailey et al., 2016).

Even when scientific knowledge is relevant to marine management, barriers that prevent exchange of knowledge between scientists and decision-makers affect its utility (Cvitanovic et al., 2016). Fully overcoming these barriers likely necessitates transdisciplinary approaches to problematization of ocean issues and solution-making, requiring scientists, practitioners, and stakeholders to work collaboratively to understand the many sides of issues, to broaden perspectives, and to generate ideas, possibilities, and innovations for solving problems that would otherwise not emerge working in isolation (Chuenpagdee, 2018). As a starting point, where the resources, capacity, or infrastructure for transdisciplinary approaches are limited, researchers may examine ocean planning processes and management tools in effort to bridge the gap between science and practice, providing operational guidance that may better support the delivery of ocean conservation and sustainability goals. A sustainable future for the ocean depends on integration across ocean science and observation, technology, literacy, and effective governance (Visbeck, 2018).

1.2.4 Ocean planning and management

Traditionally, ocean governance has been highly divided, with different ocean uses managed individually, and spatially fragmented, with governance spread across multiple agencies (Flannery et al., 2019); however, it has long been understood that this siloed approach to management, focusing on single species, sectors, or issues, is ineffective for achieving conservation and sustainability goals (Curtin & Prellezo, 2010; Grumbine, 1994; Long et al., 2015). Ecosystem-based management (EBM), an alternative to the dominant single-sector approach, has been widely accepted as the preferred approach to managing marine resources and human activities (Long et al., 2015). This approach is rooted in ecology, aiming to preserve ecosystem structure, function, and essential processes (Leslie & McLeod, 2007), while considering the role of human activities in altering ecosystems (Agardy et al., 2017; CBD, 2007). EBM has taken many forms and different names with subtle differences, but the approach generally captures the entire ecosystem, including humans, to sustain ecosystem health, integrity, and resilience (Alexander & Haward, 2019). The scale of EBM ought to reflect ecological boundaries more than political, sectoral, or jurisdictional boundaries (Wondolleck & Yaffee, 2017). Given this, EBM warrants collaboration across governments, organizations, industries, and ocean users (Pirot et al., 2000; Wondolleck & Yaffee, 2017).

While much of the science required for EBM exists (Trenkel, 2018), it remains stifled in its implementation by persistently fragmented management agencies (Charles, 2018). Other approaches, including integrated coastal zone management, marine protected areas (MPAs), and integrated ocean management have been promoted to support EBM to varying extents. In its early development, integrated coastal zone management (ICZM) centred around resolving conflicts between coastal zone stakeholders, though the approach evolved in parallel with EBM, aiming to overcome single-species or single-sector management (Domínguez-Tejo et al., 2016; Forst, 2009). Through the protection of multiple species, connected habitats, and ecosystem services over the long-term, MPAs are considered an important management tool for achieving EBM goals (Fraschetti et al., 2011). Though MPAs are an important component of EBM, they along are not sufficient for delivering the full vision of EBM (Halpern et al., 2010) and should fit into the wider context of ocean planning (Agardy et al., 2011). More recently, integrated ocean management has been identified as an approach that is, at its core, ecosystem-based, encompassing several other approaches and tools, including ICZM, MPAs, and marine spatial planning (MSP) (Winther et al., 2020). Despite these advances, operationalizing EBM continues to face challenges that prevent the whole-of-government approach necessary for overcoming sectoral silos, including insufficient governance structures, communication, and participation (Alexander & Haward, 2019).

MSP is frequently heralded as a process that facilitates the implementation of EBM (Domínguez-Tejo et al., 2016; Douvere, 2008; Olsen et al., 2014), allowing for planning at an ecosystem scale, while requiring integration across sectors and governments (Ehler & Douvere, 2009). For example, the EU's Integrated Maritime Policy identifies MSP as an essential planning tool and provides the Maritime Strategic Framework Directive, which requires Member States to implement EBM (Frazão Santos et al., 2014). MSP is fundamentally defined as "a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that are usually specified through a political process" (Ehler & Douvere, 2009).

Over its history, MSP has evolved and continues to evolve in both theory and practice (Portman, 2016). The Intergovernmental Oceanographic Commission's influential guide to MSP indicates that it should reflect six key characteristics: (1) ecosystem-based, (2) integrated, (3) place-based or area-based; (4) adaptive, (5) strategic, and (6) participatory (Ehler & Douvere, 2009). The MSP process identifies conflicting uses and ecosystem threats, resulting in a marine spatial plan that identifies areas where management interventions may be most prudent, while also facilitating coordinated decision-making (Collie et al., 2013; Jay et al., 2012). The output of MSP is a spatial management plan, a comprehensive and strategic document that identifies when, where, and how the goals and objectives will be met using spatial management measures (Ehler & Douvere, 2009). Spatial management measures, also called spatial or area-based management tools (ABMTs), are geographically defined areas where human activities are regulated to deliver one or more social and ecological outcomes to achieve objectives for biodiversity conservation, sustainable resource use, or both (Johnson et al., 2018; Molenaar, 2013). With proper use, MSP may be the most pragmatic approach to recognizing synergy between biodiversity and sustainable development objectives (Rees et al., 2018), and between SDG 14 and other SDGs (Ntona et al., 2017); however, it has been selectively used for strategic sectoral planning or conservation planning (Jones et al., 2016), often failing to integrate across objectives (Trouillet, 2020), and tends to exclude, disenfranchise, and disempower stakeholders (Flannery et al., 2018). Today, MSP is clearly linked to the development of a sustainable blue economy that seeks to enhance both ocean health and economic growth, while employing principles of social equity and inclusion (UNESCO-IOC/European Commission, 2020, 2021).

Previous case study analyses revealed a gap between the idealized version of MSP described in the literature, that seeks balance between conservation and sustainable use objectives, and the reality of MSP that is driven by a political process, and often blue economy objectives (Clarke & Flannery, 2020; Jones et al., 2016; Zuercher et al., 2022). This gap raises the question of whether MSP is fully realizing its key characteristics. By following administrative and geopolitical boundaries, MSP may not effectively employ the ecosystem-based characteristic (Le Tissier, 2020), though some marine spatial plans account for ecological considerations within administrative boundaries (Domínguez-Tejo et al., 2016). While MSP initiatives often engage stakeholders, they may not participate at all stages of the process (Collie et al., 2013), and a failure to acknowledge power and inequality in MSP may reduce inclusivity and the participatory characteristic (Flannery et al., 2018). MSP initiatives also often reference monitoring intentions (Collie et al., 2013), though comprehensive evaluations of plans are rare and often under-prioritized and poorly funded (Zuercher et al., 2022). Without proper monitoring and evaluation, MSP lacks the capacity to be a properly adaptive process based on learning from experience (Ehler & Douvere, 2009). MSP holds the potential to simultaneously support goals for a healthy ocean and sustainable use of ocean resources (Kirkfeldt & Frazão Santos, 2021), but over its nearly 20-year evolution, it continues to face critical challenges in bringing theoretical best practices to fruition.

Today, MSP lacks sufficient regulatory policy and institutional frameworks, leading to poor implementation, and often fails to balance economic development with biodiversity conservation for environmental sustainability, in addition to struggling with monitoring, evaluation, and adaptation, stakeholder engagement, inclusion of social data, transboundary issues, and climate change (Frazão Santos et al., 2021). At the same time, a largely academic literature that shows little awareness of the complex socio-political and planning dimensions of MSP continues to evolve (Ehler et al., 2019; Flannery et al., 2020; Le Tissier, 2020). This literature provides high-level and general goals for MSP that appear to be mirrored in the, often vague, objectives of marine spatial plans (Zuercher et al., 2022). Though this literature frequently intends to inform decision-making and practice (for example Fernandes et al., 2017; Foley et al., 2010; Said & Trouillet, 2020; Wright et al., 2019), mismatches between MSP research and implemented plans may indicate that an idealized version of MSP is diverging from, and potentially incompatible with, the realities of ocean governance (Zuercher et al., 2022).With more than 75 countries in the pre-planning, planning, or implementation phases of MSP (Ehler, 2020), relying on this process to deliver its promises for the blue economy (Voyer et al., 2018), it is a critical time for science to provide evidence-based guidance, informed by the realities of MSP, that might amplify the potential of MSP from theory to practice.

1.2 Research objectives

Well-summarized scientific evidence that is timely and appropriately packaged to meet the needs of practitioners can direct management choices away from ineffective management interventions (Walsh et al., 2015). This thesis aims to contribute knowledge to the academic literature that bridges the idealized version of MSP with MSP in practice, while developing useful guidance for practitioners. Its goal was to explore MSP and spatial management to identify potential pathways for MSP to support both ocean conservation and sustainability goals. Specifically, the objectives of this thesis are aimed at developing evidence-based guidance to support practitioners in overcoming critical challenges in MSP, including selecting management tools that are fit-for-purpose to sustainability objectives; incorporating biodiversity conservation in MSP; and translating

MSP principles to practice. In response to these objectives, I asked the following research questions:

1. How might ABMTs support the achievement of SDG 14 targets? (Chapter 2)
2. How has conservation been included in MSP practice? (Chapter 3)
3. How might MSP initiatives be described by their use of key principles? (Chapter 4)

Individually, these questions are addressed through careful analysis, providing management-level guidance on how to better incorporate the idealized, and more theoretical, principles of MSP into MSP processes and ocean management. Together, these questions strive to unlock the potential of MSP for conservation and sustainability by developing guidance based on existing marine spatial plans and documented evidence. While providing this guidance, this research contributes to knowledge by improving the connection between the academic discourse on MSP and MSP practice.

1.3 Methodology

This research employs mixed methodology, combining qualitative and quantitative methods to respond to the presented research questions. Mixed methods research considers multiple perspectives and positions, recognizing the strength of both qualitative and quantitative approaches to knowledge generation (Johnson et al., 2007). Mixed methods approaches are common across disciplines of ocean science, particularly as science seeks to inform management. Bennett and Dearden (2014) use mixed methods, including exploratory interviews and household surveys, to examine perceptions of MPA impacts, governance, and management processes. Brown et al. (2017) assess the validity of mixed methods approaches through a comparison of qualitative and quantitative approaches to participatory mapping. The authors conclude that validity for mixed methods in this context requires a reasonable degree of spatial overlap between results, though understanding whose values are represented is critical for informing decision-making. In MSP research, Galparsoro et al. (2021) pair literature review with expert opinion survey based on case studies, and a qualitative classification system, to explore the current use, and prospects for use, of ecosystem services in MSP. Reflecting the diversity of approaches under mixed methodology, research in this paradigm employs and combines a variety of qualitative and quantitative methods (Johnson et al., 2007).

This research uses mixed methods to synthesize information and evidence to inform how MSP and related management tools can be better used to achieve its full potential as a process that supports both biodiversity conservation and sustainable ocean use, bridging the gap between idealized MSP and MSP in practice. This includes the use of multiple research methods, such as systematic literature review, expert opinion survey, confidence assessment, document analysis, themes analysis, case study analysis, and qualitative scoring rubrics. Through a blend of inductive and deductive approaches, this thesis addresses research questions by allowing results to emerge from the data in some chapters, while in other chapters applying a predetermined framework to the data (Skjott Linneberg & Korsgaard, 2019). Specific methods and data sources used in response to each research question are detailed in the subsequent chapters.

1.4 Dissertation organization

This dissertation is organized into an introductory chapter, three research chapters, and a conclusion chapter. This thesis adopts a manuscript-style form, thus the three research chapters that follow stand as independent manuscripts written specifically for publication in peer-reviewed journals. The manuscripts are presented as they appear or will appear in the scientific literature with minor changes to formatting and content where appropriate to fit the organization of this thesis. Each manuscript contains an introduction, including a literature review, methods, results, discussion, and conclusions. Some overlap in introductory content can be expected between manuscripts. Each manuscript explores a different component of MSP to inform pathways that may amplify the potential of MSP in practice as a process that serves both conservation and sustainable use of the ocean and ocean resources.

Chapter 2 assesses the potential of common area-based marine management tools (ABMTs) for achieving SDG 14. In this chapter, I use mixed qualitative methods, including rapid systematic literature review, expert opinion survey, confidence assessment, and a qualitative scoring system to link seven ABMTs to the delivery of 17 social, economic, and ecological outcomes that hold potential to contribute to SDG 14 targets. This chapter highlights evidence gaps and demonstrates the relative importance of ABMTs for ocean sustainability. This research provides management-level guidance for selecting ABMTs to achieve SDG 14, contributing to the body of science exploring this goal by moving SDG 14 away from the aspirational and toward the operational. which may allow MSP to be strategic in its use of ABMTs to better support progress toward ocean conservation and sustainability targets.

Chapter 3 explores how biodiversity conservation has permeated MSP practice. In this chapter, I use qualitative document and themes analysis to assess the inclusion of conservation principles and priorities in five international MSP case studies to identify a potential pathway toward more integrated MSP that balances conservation and blue growth. This chapter proposes the concept of conservation-ready MSP, where plans are designed to support and enact conservation. This research goes beyond the current literature, which largely explores the relationship between MSP and marine protected areas, by assessing the inclusion of conservation at large in MSP. This research identifies potential strategies for embedding conservation in MSP, from recognizing biodiversity as fundamental to sustainable resource use to making specific conservation commitments in MSP.

Chapter 4 develops an index for gauging progress in MSP processes based on MSP principles, many of which have been challenging to implement. In this chapter, I use qualitative document analysis of fundamental MSP guides and literature review to identify key features of principles. Key features are developed into the MSP Index, a scoring guide that allows for high-level comparison across diverse types of marine spatial plans. I randomly selected six case studies to test the Index. This chapter produces a new tool that links MSP principles to practice, providing guidance to practitioners on areas for improvement that may lead to more effective MSP for achieving social, economic, and ecological objectives. Academically, this research contributes to the MSP discourse by synthesizing MSP guides and key literature to summarize best practices, deepening the understanding of MSP principles and how they might be realized in practice.

1.5 Co-authorship statement

This dissertation contains a series of manuscripts that have either been published, are under peer review for publication, or are in preparation to be submitted for publication with two or more co-authors. I am the principal researcher and lead author for each of the presented manuscripts.

Chapter 2 was published in volume 4, issue 4 of *Nature Sustainability* with co-supervisors Dr. Rodolphe Devillers and Dr. Joachim Claudet (https://doi.org/10.1038/s41893-020-00659-2). All co-authors were involved in the conception of this research, study design, and editing the published manuscript. As lead researcher, I collected the data, performed all analyses, synthesized conclusions, and independently drafted the initial manuscript. Dr. Natalie Ban supported design of the survey questionnaire used in this research and additionally provided comments on an early version of this manuscript.

At the time of writing this, Chapter 3 is in preparation for publication with co-authors Dr. Rodolphe Devillers, Dr. Joachim Claudet, Dr. Natalie Ban, Dr. Brice Trouillet, and Dr. Tundi Agardy. As lead researcher, I designed this study, conducted the qualitative analysis, synthesized conclusions, and independently drafted the initial manuscript. All co-authors were involved in final preparations of the manuscript, while Dr. Devillers and Dr. Claudet were also involved in the conception of this research. Dr. Ban, Dr. Trouillet, and Dr. Agardy provided expertise on MSP and critical input on the manuscript and interpretations of the analysis.

At the time of writing this, Chapter 4 is in preparation for publication with co-authors Dr. Rodolphe Devillers, Dr. Joachim Claudet, Dr. Rachel Zuercher, and Pascale Groulx. Dr. Devillers and Dr. Claudet were involved in the conception of this research. As lead researcher, I designed this study, collected and reviewed literature to inform the Marine Spatial Planning Index, developed the initial Index, applied the index to case studies, and authored the initial manuscript. Dr. Zuercher provided input on the methods of this study and reviewed preliminary results. Groulx provided critical insight as an MSP leader and practitioner for this study. All co-authors supported development of the final Index and are involved in preparation of the manuscript for publication.

1.6 References

Agardy, T., Davis, J., Sherwood, K., & Vestergaard, O. (2017). *Taking Steps toward Marine and Coastal Ecosystem-Based Management: An Introductory Guide* [Preprint]. MarXiv. https://doi.org/10.31230/osf.io/akh93

Agardy, T., di Sciara, G. N., & Christie, P. (2011). Mind the gap: Addressing the shortcomings of marine protected areas through large scale marine spatial planning. *Marine Policy*, *35*(2), 226–232. https://doi.org/10.1016/j.marpol.2010.10.006

Alexander, K. A., & Haward, M. (2019). The human side of marine ecosystem-based management (EBM): ‘Sectoral interplay’ as a challenge to implementing EBM. *Marine Policy*, *101*, 33–38. https://doi.org/10.1016/j.marpol.2018.12.019

Baerwald, T. J. (2010). Prospects for Geography as an Interdisciplinary Discipline. *Annals of the Association of American Geographers*, *100*(3), 493–501.

Bailey, M., Favaro, B., Otto, S. P., Charles, A., Devillers, R., Metaxas, A., Tyedmers, P., Ban, N. C., Mason, T., Hoover, C., Duck, T. J., Fanning, L., Milley, C., Cisneros-Montemayor, A. M., Pauly, D., Cheung, W. W. L., Cullis-Suzuki, S., Teh, L., & Sumaila, U. R. (2016). Canada at a crossroad: The imperative for realigning ocean policy with ocean science. *Marine Policy*, *63*, 53–60. https://doi.org/10.1016/j.marpol.2015.10.002

Ban, N. C., Maxwell, S. M., Dunn, D. C., Hobday, A. J., Bax, N. J., Ardron, J., Gjerde, K. M., Game, E. T., Devillers, R., Kaplan, D. M., Dunstan, P. K., Halpin, P. N., & Pressey, R. L. (2014). Better integration of sectoral planning and management approaches for the interlinked ecology of the open oceans. *Marine Policy*, *49*, 127–136. https://doi.org/10.1016/j.marpol.2013.11.024

Bennett, N. J., Cisneros-Montemayor, A. M., Blythe, J., Silver, J. J., Singh, G., Andrews, N., Calò, A., Christie, P., Di Franco, A., Finkbeiner, E. M., Gelcich, S., Guidetti, P., Harper, S., Hotte, N., Kittinger, J. N., Le Billon, P., Lister, J., López de la Lama, R., McKinley, E., … Sumaila, U. R. (2019). Towards a sustainable and equitable blue economy. *Nature Sustainability*, *2*(11), 991–993. https://doi.org/10.1038/s41893-019-0404-1

Bennett, N. J., & Dearden, P. (2014). Why local people do not support conservation: Community perceptions of marine protected area livelihood impacts, governance and management in Thailand. *Marine Policy*, *44*, 107–116. https://doi.org/10.1016/j.marpol.2013.08.017

Boonstra, W. J., Ottosen, K. M., Ferreira, A. S. A., Richter, A., Rogers, L. A., Pedersen, M. W., Kokkalis, A., Bardarson, H., Bonanomi, S., Butler, W., Diekert, F. K., Fouzai, N., Holma, M., Holt, R. E., Kvile, K., Malanski, E., Macdonald, J. I., Nieminen, E., Romagnoni, G., … Whittington, J. D. (2015). What are the major global threats and impacts in marine environments? Investigating the contours of a shared perception among marine scientists from the bottom-up. *Marine Policy*, *60*, 197–201. https://doi.org/10.1016/j.marpol.2015.06.007

Breitburg, D., Levin, L. A., Oschlies, A., Grégoire, M., Chavez, F. P., Conley, D. J., Garçon, V., Gilbert, D., Gutiérrez, D., Isensee, K., Jacinto, G. S., Limburg, K. E., Montes, I., Naqvi, S. W. A., Pitcher, G. C., Rabalais, N. N., Roman, M. R., Rose, K. A., Seibel, B. A., … Zhang, J. (2018). Declining oxygen in the global ocean and coastal waters. *Science*, *359*(6371), eaam7240. https://doi.org/10.1126/science.aam7240

Brown, G., Strickland-Munro, J., Kobryn, H., & Moore, S. A. (2017). Mixed methods participatory GIS: An evaluation of the validity of qualitative and quantitative mapping methods. *Applied Geography*, *79*, 153–166. https://doi.org/10.1016/j.apgeog.2016.12.015

CBD. (2007, February 7). *Ecosystem approach principles*. Secretariat of the Convention on Biological Diversity. https://www.cbd.int/ecosystem/principles.shtml

Charles, A. (2018). What is ecosystem-based management? *Ecology*, *99*(5), 1246–1247. https://doi.org/10.1002/ecy.2149

Cheng, L., Zhu, J., Abraham, J., Trenberth, K. E., Fasullo, J. T., Zhang, B., Yu, F., Wan, L., Chen, X., & Song, X. (2019). 2018 Continues Record Global Ocean Warming.

Advances in Atmospheric Sciences, *36*(3), 249–252. https://doi.org/10.1007/s00376-019-8276-x

Chuenpagdee, R. (2018). Transdisciplinary Perspectives on Ocean Governance. In International Ocean Institute-Canada (Ed.), *The Future of Ocean Governance and Capacity Development* (pp. 23–27). Brill Nijhoff.

Cisneros-Montemayor, A. M., Moreno-Báez, M., Reygondeau, G., Cheung, W. W. L., Crosman, K. M., González-Espinosa, P. C., Lam, V. W. Y., Oyinlola, M. A., Singh, G. G., Swartz, W., Zheng, C., & Ota, Y. (2021). Enabling conditions for an equitable and sustainable blue economy. *Nature*, *591*(7850), 396–401. https://doi.org/10.1038/s41586-021-03327-3

Clarke, J., & Flannery, W. (2020). The post-political nature of marine spatial planning and modalities for its re-politicisation. *Journal of Environmental Policy & Planning*, *22*(2), 170–183. https://doi.org/10.1080/1523908X.2019.1680276

Claudet, J., Bopp, L., Cheung, W. W. L., Devillers, R., Escobar-Briones, E., Haugan, P., Heymans, J. J., Masson-Delmotte, V., Matz-Lück, N., Miloslavich, P., Mullineaux, L., Visbeck, M., Watson, R., Zivian, A. M., Ansorge, I., Araujo, M., Aricò, S., Bailly, D., Barbière, J., … Gaill, F. (2020). A Roadmap for Using the UN Decade of Ocean Science for Sustainable Development in Support of Science, Policy, and Action. *One Earth*, *2*(1), 34–42. https://doi.org/10.1016/j.oneear.2019.10.012

Collie, J. S., Vic Adamowicz, W. L., Beck, M. W., Craig, B., Essington, T. E., Fluharty, D., Rice, J., & Sanchirico, J. N. (2013). Marine spatial planning in practice. *Estuarine, Coastal and Shelf Science*, *117*, 1–11. https://doi.org/10.1016/j.ecss.2012.11.010

Cook, C. N., Hockings, M., & Carter, R. (Bill). (2010). Conservation in the dark? The information used to support management decisions. *Frontiers in Ecology and the Environment*, *8*(4), 181–186. https://doi.org/10.1890/090020

Cormier, R., & Elliott, M. (2017). SMART marine goals, targets and management – Is SDG 14 operational or aspirational, is ‘Life Below Water’ sinking or swimming? *Marine Pollution Bulletin*, *123*(1–2), 28–33. https://doi.org/10.1016/j.marpolbul.2017.07.060

Curtin, R., & Prellezo, R. (2010). Understanding marine ecosystem based management: A literature review. *Marine Policy*, *34*(5), 821–830. https://doi.org/10.1016/j.marpol.2010.01.003

Cvitanovic, C., McDonald, J., & Hobday, A. J. (2016). From science to action: Principles for undertaking environmental research that enables knowledge exchange and evidence-based decision-making. *Journal of Environmental Management*, *183*, 864–874. https://doi.org/10.1016/j.jenvman.2016.09.038

Day, J. C., Kenchington, R. A., Tanzer, J. M., & Cameron, D. S. (2019). Marine zoning revisited: How decades of zoning the Great Barrier Reef has evolved as an effective spatial planning approach for marine ecosystem-based management. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *29*(S2), 9–32. https://doi.org/10.1002/aqc.3115

Diz, D., Johnson, D., Riddell, M., Rees, S., Battle, J., Gjerde, K., Hennige, S., & Roberts, J. M. (2018). Mainstreaming marine biodiversity into the SDGs: The role of other effective area-based conservation measures (SDG 14.5). *Marine Policy*, *93*(April 2017), 251–261. https://doi.org/10.1016/j.marpol.2017.08.019

Domínguez-Tejo, E., Metternicht, G., Johnston, E., & Hedge, L. (2016). Marine Spatial Planning advancing the Ecosystem-Based Approach to coastal zone management: A review. *Marine Policy*, *72*, 115–130. https://doi.org/10.1016/j.marpol.2016.06.023

Doney, S. C., Busch, D. S., Cooley, S. R., & Kroeker, K. J. (2020). The Impacts of Ocean Acidification on Marine Ecosystems and Reliant Human Communities. *Annual Review of Environment and Resources*, *45*(1), 83–112. https://doi.org/10.1146/annurev-environ-012320-083019

Douvere, F. (2008). The importance of marine spatial planning in advancing ecosystem-based sea use management. *Marine Policy*, *32*(5), 762–771. https://doi.org/10.1016/j.marpol.2008.03.021

Duarte, C. M., Agusti, S., Barbier, E., Britten, G. L., Castilla, J. C., Gattuso, J.-P., Fulweiler, R. W., Hughes, T. P., Knowlton, N., Lovelock, C. E., Lotze, H. K., Predragovic, M., Poloczanska, E., Roberts, C., & Worm, B. (2020). Rebuilding marine life. *Nature*, *580*(7801), 39–51. https://doi.org/10.1038/s41586-020-2146-7

Ehler, C., & Douvere, F. (2009). Marine Spatial Planning: A step-by-step approach toward ecosystem-based management. *Intergovernmental Oceanographic Commission and Man and the Biosphere Programme*, *IOC Manual*(6), 1–98.

Ehler, C. N. (2020). Two decades of progress in Marine Spatial Planning. *Marine Policy*. https://doi.org/10.1016/j.marpol.2020.104134

Ehler, C., Zaucha, J., & Gee, K. (2019). Maritime/Marine Spatial Planning at the Interface of Research and Practice. In J. Zaucha & K. Gee (Eds.), *Maritime Spatial Planning: Past, present, future* (pp. 1–21). Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-319-98696-8

FAO. (2015). *Achieving Blue Growth through implementation of the Code of Conduct for Responsible Fisheries* (p. 23). Food and Agricultural Organization of the United Nations. https://www.fao.org/3/i4999e/i4999e.pdf

Farmery, A. K., Allison, E. H., Andrew, N. L., Troell, M., Voyer, M., Campbell, B., Eriksson, H., Fabinyi, M., Song, A. M., & Steenbergen, D. (2021). Blind spots in visions of a “blue economy” could undermine the ocean’s contribution to eliminating hunger and malnutrition. *One Earth*, *4*(1), 28–38. https://doi.org/10.1016/j.oneear.2020.12.002

Fernandes, M. da L., Esteves, T. C., Oliveira, E. R., & Alves, F. L. (2017). How does the cumulative impacts approach support Maritime Spatial Planning? *Ecological Indicators*, *73*, 189–202. https://doi.org/10.1016/j.ecolind.2016.09.014

Flannery, W., Clarke, J., & McAteer, B. (2019). Politics and Power in Marine Spatial Planning. In J. Zaucha & K. Gee (Eds.), *Maritime Spatial Planning* (pp. 201–217). Springer International Publishing. https://doi.org/10.1007/978-3-319-98696-8_9

Flannery, W., Healy, N., & Luna, M. (2018). Exclusion and non-participation in Marine Spatial Planning. *Marine Policy*, *88*(October 2017), 32–40. https://doi.org/10.1016/j.marpol.2017.11.001

Flannery, W., Toonen, H., Jay, S., & Vince, J. (2020). A critical turn in marine spatial planning. *Maritime Studies*, *19*(3), 223–228. https://doi.org/10.1007/s40152-020-00198-8

Foley, M. M., Halpern, B. S., Micheli, F., Armsby, M. H., Caldwell, M. R., Crain, C. M., Prahler, E., Rohr, N., Sivas, D., Beck, M. W., Carr, M. H., Crowder, L. B., Emmett Duffy, J., Hacker, S. D., McLeod, K. L., Palumbi, S. R., Peterson, C. H., Regan, H. M., Ruckelshaus, M. H., … Steneck, R. S. (2010). Guiding ecological principles for marine spatial planning. *Marine Policy*, *34*(5), 955–966. https://doi.org/10.1016/j.marpol.2010.02.001

Forst, M. F. (2009). The convergence of Integrated Coastal Zone Management and the ecosystems approach. *Ocean & Coastal Management*, *52*(6), 294–306. https://doi.org/10.1016/j.ocecoaman.2009.03.007

Fraschetti, S., Claudet, J., & Grorud-Colvert, K. (2011). Transition from single-sector management to ecosystem-based management: What can marine protected areas offer? In J. Claudet (Ed.), *Marine Protected Areas: A Multidisciplinary Approach*. Cambridge University Press.

Frazão Santos, C., Agardy, T., Andrade, F., Crowder, L. B., Ehler, C. N., & Orbach, M. K. (2021). Major challenges in developing marine spatial planning. *Marine Policy*, *132*, 103248. https://doi.org/10.1016/j.marpol.2018.08.032

Frazão Santos, C., Domingos, T., Ferreira, M. A., Orbach, M., & Andrade, F. (2014). How sustainable is sustainable marine spatial planning? Part I-Linking the concepts. *Marine Policy*, *49*, 59–65. https://doi.org/10.1016/j.marpol.2014.04.004

Galparsoro, I., Pınarbaşı, K., Gissi, E., Culhane, F., Gacutan, J., Kotta, J., Cabana, D., Wanke, S., Aps, R., Bazzucchi, D., Cozzolino, G., Custodio, M., Fetissov, M., Inácio, M., Jernberg, S., Piazzi, A., Paudel, K. P., Ziemba, A., & Depellegrin, D. (2021). Operationalisation of ecosystem services in support of ecosystem-based marine spatial planning: Insights into needs and recommendations. *Marine Policy*, *131*, 104609. https://doi.org/10.1016/j.marpol.2021.104609

Grumbine, R. E. (1994). What Is Ecosystem Management? *Conservation Biology*, *8*(1), 27–38.

Haas, B., Fleming, A., Haward, M., & McGee, J. (2019). Big fishing: The role of the large-scale commercial fishing industry in achieving Sustainable Development Goal 14. *Reviews in Fish Biology and Fisheries*, *8*(1), 161–175. https://doi.org/10.1007/s11160-018-09546-8

Halpern, B. S., Frazier, M., Afflerbach, J., Lowndes, J. S., Micheli, F., O'Hara, C., Scarborough, C., & Selkoe, K. A. (2019). Recent pace of change in human impact on the world's ocean. *Scientific Reports*, *9*(1), 11609. https://doi.org/10.1038/s41598-019-47201-9

Halpern, B. S., Lester, S. E., & McLeod, K. L. (2010). Placing marine protected areas onto the ecosystem-based management seascape. *Proceedings of the National Academy of Sciences*, *107*(43), 18312–18317. https://doi.org/10.1073/pnas.0908503107

Harden, C. P. (2012). Framing and Reframing Questions of Human–Environment Interactions. *Annals of the Association of American Geographers*, *102*(4), 737–747. https://doi.org/10.1080/00045608.2012.678035

Henson, S. A., Beaulieu, C., Ilyina, T., John, J. G., Long, M., Séférian, R., Tjiputra, J., & Sarmiento, J. L. (2017). Rapid emergence of climate change in environmental drivers of marine ecosystems. *Nature Communications*, *8*(5020), 1–9. https://doi.org/10.1038/ncomms14682

IPBES. (2019). *Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (Version 1)*. Zenodo. https://doi.org/10.5281/zenodo.5657041

Jay, S., Ellis, G., & Kidd, S. (2012). Marine Spatial Planning: A New Frontier? *Journal of Environmental Policy & Planning*, *14*(1), 1–5. https://doi.org/10.1080/1523908X.2012.664327

Johnson, D., Adelaide Ferreira, M., & Kenchington, E. (2018). Climate change is likely to severely limit the effectiveness of deep-sea ABMTs in the North Atlantic. *Marine Policy*, *87*(September 2017), 111–122. https://doi.org/10.1016/j.marpol.2017.09.034

Johnson, R. B., Onwuegbuzie, A. J., & Turner, L. A. (2007). Toward a Definition of Mixed Methods Research. *Journal of Mixed Methods Research*, *1*(2), 112–133. https://doi.org/10.1177/1558689806298224

Jones, P. J. S., Lieberknecht, L. M., & Qiu, W. (2016). Marine spatial planning in reality: Introduction to case studies and discussion of findings. *Marine Policy*, *71*, 256–264. https://doi.org/10.1016/j.marpol.2016.04.026

Jouffray, J.-B., Blasiak, R., Norström, A. V., Österblom, H., & Nyström, M. (2020). The Blue Acceleration: The Trajectory of Human Expansion into the Ocean. *One Earth*, *2*(1), 43–54. https://doi.org/10.1016/j.oneear.2019.12.016

Kirkfeldt, T. S., & Frazão Santos, C. (2021). A Review of Sustainability Concepts in Marine Spatial Planning and the Potential to Supporting the UN Sustainable Development Goal 14. *Frontiers in Marine Science*, *8*, 713980. https://doi.org/10.3389/fmars.2021.713980

Laffoley, D., Baxter, J. M., Amon, D. J., Currie, D. E. J., Downs, C. A., Hall-Spencer, J. M., Harden-Davies, H., Page, R., Reid, C. P., Roberts, C. M., Rogers, A., Thiele, T., Sheppard, C. R. C., Sumaila, R. U., & Woodall, L. C. (2020). Eight urgent, fundamental and simultaneous steps needed to restore ocean health, and the consequences for humanity and the planet of inaction or delay. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *30*(1), 194–208. https://doi.org/10.1002/aqc.3182

Le Tissier, M. (2020). Unravelling the Relationship between Ecosystem-Based Management, Integrated Coastal Zone Management and Marine Spatial Planning. In T. G. O'Higgins, M. Lago, & T. H. DeWitt (Eds.), *Ecosystem-Based Management, Ecosystem Services and Aquatic Biodiversity: Theory, Tools and Applications*.

Lee, K.-H., Noh, J., & Khim, J. S. (2020). The Blue Economy and the United Nations' sustainable development goals: Challenges and opportunities. *Environment International*, *137*, 105528. https://doi.org/10.1016/j.envint.2020.105528

Lemieux, C. J., Halpenny, E. A., Swerdfager, T., He, M., Gould, A. J., Carruthers Den Hoed, D., Bueddefeld, J., Hvenegaard, G. T., Joubert, B., & Rollins, R. (2021). Free Fallin'? The decline in evidence-based decision-making by Canada's protected areas managers. *FACETS*, *6*, 640–664. https://doi.org/10.1139/facets-2020-0085

Leslie, H. M., & McLeod, K. L. (2007). Confronting the challenges of implementing marine ecosystem-based management. *Frontiers in Ecology and the Environment*, *5*(10), 540–548. https://doi.org/10.1890/060093

Levine, A. S. (2015). Marine resource management: Culture, livelihoods, and governance. *Applied Geography*, 4.

Long, R. D., Charles, A., & Stephenson, R. L. (2015). Key principles of marine ecosystem-based management. *Marine Policy*, *57*, 53–60. https://doi.org/10.1016/j.marpol.2015.01.013

Lotze, H. K., Guest, H., O'Leary, J., Tuda, A., & Wallace, D. (2018). Public perceptions of marine threats and protection from around the world. *Ocean and Coastal Management*, *152*, 14–22. https://doi.org/10.1016/j.ocecoaman.2017.11.004

Marmer, H. A., & Vallaux, C. (1934). The Physical and Human Geography of the Sea. *Geographical Review*, *24*(1), 168. https://doi.org/10.2307/209516

Molenaar, E. J. (2013). *Area-based management tools* (Issue May).

Ntona, M., Morgera, E., & Ntona, M. (2017). Connecting SDG 14 with the other Sustainable Development Goals through marine spatial planning. *Marine Policy*, *January*, 1–9. https://doi.org/10.1016/j.marpol.2017.06.020

OECD. (2016). *The Ocean Economy in 2030*. https://doi.org/10.1787/9789264251724-en

Olsen, E., Fluharty, D., Hoel, A. H., Hostens, K., Maes, F., & Pecceu, E. (2014). Integration at the round table: Marine spatial planning in multi-stakeholder settings. *PLoS ONE*, *9*(10). https://doi.org/10.1371/journal.pone.0109964

Pirot, J.-Y., Meynell, P.-J., & Elder, D. (2000). *Ecosystem Management: Lessons from around the world* (p. x + 132). http://www.iucn.org

Portman, M. E. (2016). Marine spatial planning. In *Environmental Planning for Oceans and Coasts*. https://doi.org/10.1007/978-3-319-26971-9

Rees, S. E., Foster, N. L., Langmead, O., Pittman, S., & Johnson, D. E. (2018). Defining the qualitative elements of Aichi Biodiversity Target 11 with regard to the marine and coastal environment in order to strengthen global efforts for marine biodiversity conservation outlined in the United Nations Sustainable Development Goal 14. *Marine Policy*, *93*(June 2017), 241–250. https://doi.org/10.1016/j.marpol.2017.05.016

Reimer, J. M., Devillers, R., & Claudet, J. (2020). Benefits and gaps in area-based management tools for the ocean Sustainable Development Goal. *Nature Sustainability*. https://doi.org/10.1038/s41893-020-00659-2

Said, A., & Trouillet, B. (2020). Bringing 'Deep Knowledge' of Fisheries into Marine Spatial Planning. *Maritime Studies*, *19*(3), 347–357. https://doi.org/10.1007/s40152-020-00178-y

Singh, G. G., Cisneros-Montemayor, A. M., Swartz, W., Cheung, W., Guy, J. A., Kenny, T. A., McOwen, C. J., Asch, R., Geffert, J. L., Wabnitz, C. C. C., Sumaila, R., Hanich, Q., & Ota, Y. (2018). A rapid assessment of co-benefits and trade-offs among Sustainable Development Goals. *Marine Policy*, *93*(March 2017), 223–231. https://doi.org/10.1016/j.marpol.2017.05.030

Skjott Linneberg, M., & Korsgaard, S. (2019). Coding qualitative data: A synthesis guiding the novice. *Qualitative Research Journal*, *19*(3), 259–270. https://doi.org/10.1108/QRJ-12-2018-0012

Skole, D. L. (2004). Geography as a Great Intellectual Melting Pot and the Preeminent Interdisciplinary Environmental Discipline. *Annals of the Association of American Geographers*, *94*(Nrc 2002), 739–743. https://doi.org/10.1111/j.1467-8306.2004.00429.x

Smith, H. D. (2005). *The Geography of the sea*. *LX*(2), 719–755. https://doi.org/10.1080/00221341508983951

Spalding, M. D., Meliane, I., J. Bennett, N., Dearden, P., G. Patil, P., D. Brumbaugh, R., D. Spalding, M., Meliane, I., J. Bennett, N., Dearden, P., G. Patil, P., & D. Brumbaugh, R. (2016). Building towards the marine conservation end-game: Consolidating the role of MPAs in a future ocean. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *26*(May), 185–199. https://doi.org/10.1002/aqc.2686

Trenkel, V. M. (2018). How to provide scientific advice for ecosystem-based management now. *Fish and Fisheries*, *19*(2), 390–398. https://doi.org/10.1111/faf.12263

Trouillet, B. (2020). Reinventing marine spatial planning: A critical review of initiatives worldwide. *Journal of Environmental Policy and Planning*, *22*(4), 441–459. https://doi.org/10.1080/1523908X.2020.1751605

UNESCO-IOC/European Commission. (2020). *Sustainable Blue Economy*. Intergovernmental Oceanographic Commission. https://unesdoc.unesco.org/ark:/48223/pf0000374788

UNESCO-IOC/European Commission. (2021). *MSPglobal International Guide on Marine/Maritime Spatial Planning* (IOC Manuals and Guides No 89, p. 152). UNESCO.

United Nations. (2015). Transforming our world: The 2030 Agenda for Sustainable Development. *General Assembley 70 Session*, *16301*(October), 1–35. https://doi.org/10.1007/s13398-014-0173-7.2

United Nations Environment Programme. (2017). *Preliminary analysis of area-based management measures to support SDG implementation*.

Visbeck, M. (2018). Ocean science research is key for a sustainable future. *Nature Communications*, *9*(1), 690. https://doi.org/10.1038/s41467-018-03158-3

Voyer, M., Quirk, G., McIlgorm, A., & Azmi, K. (2018). Shades of blue: What do competing interpretations of the Blue Economy mean for oceans governance? *Journal of Environmental Policy and Planning*, *20*(5), 595–616. https://doi.org/10.1080/1523908X.2018.1473153

Walsh, J. C., Dicks, L. V., & Sutherland, W. J. (2015). The effect of scientific evidence on conservation practitioners' management decisions. *Conservation Biology*, *29*(1), 88–98. https://doi.org/10.1111/cobi.12370

Winther, J.-G., Dai, M., Rist, T., Hoel, A. H., Li, Y., Trice, A., Morrissey, K., Juinio-Meñez, M. A., Fernandes, L., Unger, S., Scarano, F. R., Halpin, P., & Whitehouse, S. (2020). Integrated ocean management for a sustainable ocean economy. *Nature Ecology & Evolution*, *4*(11), 1451–1458. https://doi.org/10.1038/s41559-020-1259-6

Wondolleck, J. M., & Yaffee, S. L. (2017). Drawing Lessons from Experience in Marine Ecosystem-Based Management. In J. M. Wondolleck & S. L. Yaffee (Eds.), *Marine Ecosystem-Based Management in Practice: Different Pathways,* *Common Lessons* (pp. 1–12). Island Press/Center for Resource Economics. https://doi.org/10.5822/978-1-61091-800-8_1

Wright, G., Gjerde, K. M., Johnson, D. E., Finkelstein, A., Ferreira, M. A., Dunn, D. C., Chaves, M. R., & Grehan, A. (2019). Marine spatial planning in areas beyond national jurisdiction. *Marine Policy*, S0308597X18304408. https://doi.org/10.1016/j.marpol.2018.12.003

Zuercher, R., Motzer, N., Magris, R. A., & Flannery, W. (2022). Narrowing the gap between marine spatial planning aspirations and realities. *ICES Journal of Marine Science*, fsac009. https://doi.org/10.1093/icesjms/fsac009

2. Benefits and gaps in area-based management tools for the ocean Sustainable Development Goal

Abstract

Sustainable Development Goal (SDG) 14 provides a vision for the world's oceans; however, management interventions needed to achieve SDG 14 remain less clear. We assessed the potential contributions of seven key area-based management tools (such as fisheries closures) to SDG 14 targets. We conducted a rapid systematic review of 177 studies and an expert opinion survey to identify evidence of the ecological, social and economic outcomes from each tool. We used these data to assess the level of confidence in the outcomes delivered by each tool and qualitatively scored how each tool contributes to each target. We demonstrate that a combination of tools with diverse objectives and management approaches will be necessary for achieving all SDG 14 targets. We highlight that some tools, including fully and partially protected areas and locally managed marine areas, may make stronger contributions to SDG 14 than others. We identify gaps in the suitability of these tools to some targets, particularly targets related to pollution and acidification, and identify evidence gaps for social and economic outcomes. Our findings provide operational guidance to support progress toward SDG 14.

2.1 Introduction

The United Nations Sustainable Development Goals (SDGs) provide a transformational vision of sustainable development across the environmental, social, and economic dimensions. Sustainable Development Goal 14: Life Below Water (SDG 14) aims to "conserve and sustainably use oceans, seas, and marine resources for sustainable development" (United Nations, 2015). Through its seven primary targets, SDG 14 addresses ocean challenges: reducing marine pollution (SDG 14.1), restoring marine ecosystems (SDG 14.2), reducing ocean acidification (SDG 14.3), enabling sustainable fisheries (SDG 14.4), conserving marine areas (SDG 14.5), ending harmful fishery subsidies (SDG 14.6), and increasing economic benefits to Small Island Developing States and least developed countries (SDG 14.7). Achieving SDG 14 was shown to benefit other SDGs, most notably SDG 1: No Poverty and SDG 2: Zero Hunger (Claudet et al., 2020; Singh et al., 2018). A focus on sustaining marine ecosystem services may foster fair and equitable benefit-sharing that contributes to multiple interconnected SDGs (Ntona et al., 2017); however, SDG 14 was criticized for being largely aspirational rather than operational and measurable (Cormier & Elliott, 2017), and management-level guidance is critically needed to support progress toward SDG 14 targets (Diz et al., 2018; Haas et al., 2019; United Nations Environment Programme, 2017).

Management of human activities and natural resources often has a spatial dimension, reflecting various social, sectoral, or geopolitical boundaries. This spatial lens extends to planning and management of oceans and their natural resources (Claudet et al., 2006; Ehler & Douvere, 2009; Jupiter et al., 2014; Sterling et al., 2017). Planning and management can address single-sector needs, like achieving specific fisheries objectives (Palmer & Demarest, 2018), or multiple objectives in the wider seascape, as with comprehensive ocean zoning or marine spatial planning (Agardy et al., 2011; Frazão Santos et al., 2020). Both single- and multi-sector spatial plans tend to rely on the implementation of spatial or area-based management tools (ABMTs).

ABMTs are geographically defined areas where human activities are regulated for one or more purposes, delivering one or more social and ecological outcomes to achieve objectives for biodiversity conservation, sustainable resource use, or both (Johnson et al., 2018; Molenaar, 2013). Since ABMTs are common across ocean sectors, management objectives, and social-ecological contexts (Ehler & Douvere, 2009), and given their recommended use for achieving conservation and sustainability goals (De Santo, 2018; Secretariat of the Convention on Biological Diversity et al., 2016), a clearer understanding of the contributions of ABMTs to SDG 14 targets may enable strategic planning toward achieving this goal. Here, we assess evidence of ecological, social, and economic ABMT outcomes, ranging from increasing organism size to maintaining ecosystem resilience to preserving access to resources and cultural traditions. We use this evidence to determine the potential contributions of prominent ABMTs to SDG 14 targets, guiding countries and practitioners in selecting the best interventions to deliver SDG 14.

2.2 Methods

2.2.1 Selecting ABMTs and outcomes

The ABMTs assessed in this study were identified from a list of spatial management tools provided by Ehler and Douvere (Ehler & Douvere, 2009), which included marine protected areas (MPAs), fishery closures (FCs), gear restriction areas (GRAs), and particularly sensitive sea areas (PSSAs). Here, we separated the broad category of MPAs into two distinct tools: fully protected areas (FPAs) and partially protected areas (PPAs) due to their documented differences in outcomes (Zupan et al., 2018). Locally managed marine areas (LMMAs) and territorial user right fisheries (TURFs) were added, as they have emerged prominently in the literature in recent years (Lester et al., 2017; Rocliffe et al., 2014). In total, we identified seven ABMTs with objectives in biodiversity conservation, sustainable resource use, particularly fisheries, or both (Figure 2.1, Table A2). ABMTs regulate the activities of single sectors, as is typical of FCs, GRAs, TURFs, and PSSAs, or multiple sectors, as is typical of FPAs, PPAs, and LMMAs. Some ABMTs may overlay tools, for example an ABMT regulating multiple sectors, like an FPA, may make use of multiple single-sector tools, like FCs, GRAs, or PSSAs. Many of these tools may be considered ‘other effective area-based conservation measures’ (OECMs) in some contexts and these tools may overlap in their application or the types of regulations they use.

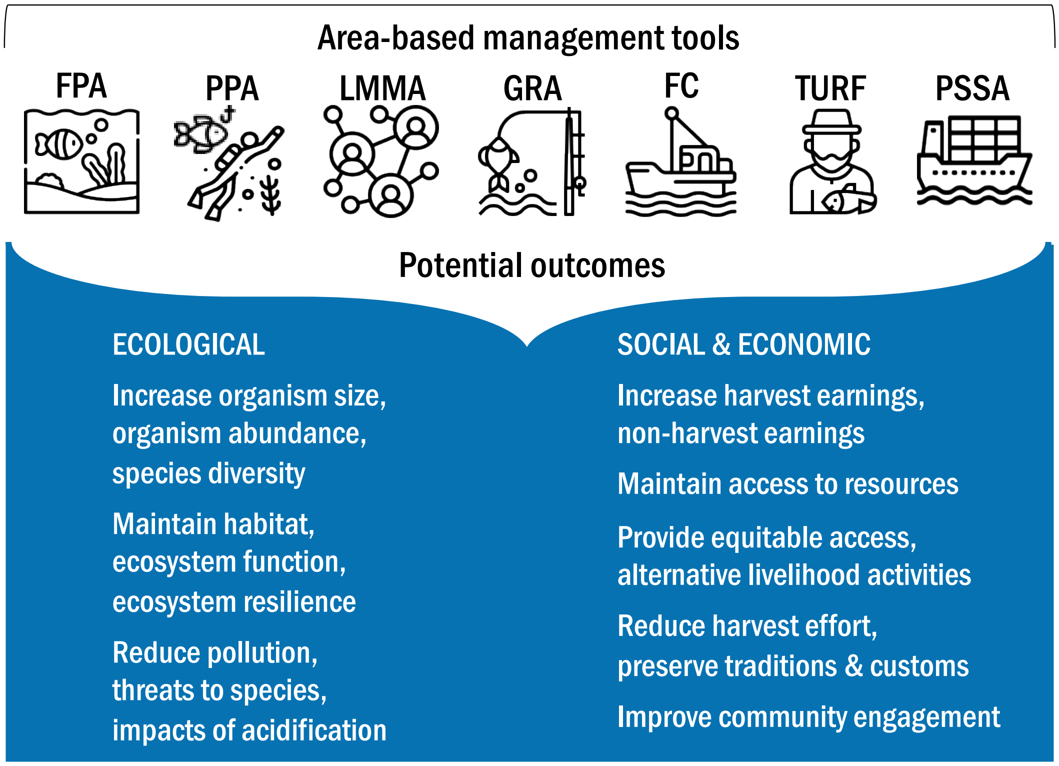


Figure 2.1. Area-based management tools and their potential ecological, social, and economic outcomes assessed in this study. The selected tools have objectives for biodiversity conservation, sustainable resource use, or both and regulate activities of single or multiple sectors. Complete definitions of tools and outcomes are provided in Supplementary Tables 1 and 2. This figure presents positive effects on outcomes given their potential contributions to SDG 14, though positive, negative, and neutral effects were collected as evidence in this study. FPA, fully protected area; PPA, partially protected area; LMMA, locally managed marine area; GRA, gear restriction area; FC, fishery closure; TURF, territorial user right fishery; PSSA, particularly sensitive sea area. Icons are attributed to Becris (LMMA), Freepik (FPA, PPA), Mavadee (PSSA), Smashicons (FC), Surang (GRA), Wichai.wi (TURF) from www.flaticon.com.

We assessed 17 ecological, social, and economic outcomes identified from previous reviews reporting observed and expected ABMT outcomes, particularly in the context of MPAs (Bennett & Dearden, 2014a) and LMMAs (Jupiter et al., 2014) (Figure 2.1). Outcomes were assigned distinct definitions (Table A1), and evidence of outcomes reported in literature needed to fit these definitions to be included in review. Some of these outcomes have direct links to SDG 14 targets (e.g., maintaining ecosystem resilience and SDG 14.2 on ecosystem restoration), while others are indirect (e.g., maintaining equitable access to resources and SDG 14.4 on sustainable fisheries). Since the primary aim of this research is to provide guidance on the use of ABMTs to achieve

SDG 14 targets, outcomes not previously identified from existing reviews but with direct links to targets, such as reducing pollution and SDG 14.1, were added. Many of the assessed outcomes may be considered as indicators for monitoring and evaluation of ABMTs (Biedenweg et al., 2016; Kincaid et al., 2017; Pomeroy et al., 2004), which may inform or align with SDG 14 indicators.

2.2.2 Rapid systematic review

Rapid systematic reviews identify all studies meeting specific criteria, such as publication year, article type, geographic region, language, database, data type, or data extraction method (Ganann et al., 2010). We used a rapid review method to overcome challenges introduced by the number of ABMTs and outcomes assessed and the vastness of literature in this field of study. The review was conducted using the Web of Science between July and October 2019, and was limited to primary literature, including only articles and reviews published in English in 2002 or later. While the grey literature could have provided additional information relevant to this study, including this information would not have permitted a systematic review due to the diversity of access restriction and languages that can be found in the grey literature. Since this method excludes publications from governments, non-governmental organizations, and other research organizations, we also conducted an expert opinion survey to compensate for evidence not found in the primary literature. The constraint on publication year was used to identify studies listing author email addresses, which were later used as contact information to invite participants for this survey (Sinclair et al., 2018). We conducted two phases of rapid systematic review.

The first phase of rapid review was intended to capture synthesis-based evidence, including meta-analyses, systematic reviews, and standard literature reviews, and thus it was assumed that publications earlier than 2002 would have been included in these studies. Where synthesis-based evidence was identified, further review of individual studies in the second phase was not required, reducing the risk of double counting outcomes from individual studies that may have been captured by reviews. In addition to these limitations, search terms were designed to return the most relevant literature from titles, abstracts, and keywords (Table A3, Table A4). The efficacy of search terms was tested using pilot searches to ensure that 10 pre-determined studies were returned by the selected search terms in Web of Science (Table A5).

Search terms were designed for the seven ABMTs, for ABMT outcomes in general, for meta-analyses and reviews, and for the 17 outcomes assessed in this study. All returned literature was screened first by reviewing titles and abstracts and then by reviewing full articles where an inclusion decision could not be made confidently from the title and abstract. Literature was screened based on the following criteria:

- Population: studies must observe the marine environment
- Intervention: studies must observe at least one of the seven ABMTs, aligning with the assigned definitions (Table A2), though evidence of any assessed ABMT was recorded
- Time and place: studies must be published after 2001 in any geographic location
- Outcomes: studies must report evidence of positive, negative, or no effect on at least one of the 17 selected outcomes (Table A1), excluding studies using strictly theoretical methods or theoretical modelling

In the second phase of the review, additional searches were conducted to identify studies reporting evidence of individual ABMT outcomes for any case where synthesis-based evidence was not identified in the first phase of review. Returned literature for each outcome per ABMT was sorted using the "Relevance" feature on Web of Science, which ranks studies based on search term frequency in titles, abstracts, and keywords. Then, the first 25 records were screened using the same method and inclusion criteria as the first review phase. In cases where fewer than 10 records met all inclusion criteria, the next 25 records available in Web of Science were screened. We used this method to ensure that the most relevant literature and best available evidence was captured.

In the first phase, when studies met all inclusion criteria, the following data were extracted: study type (i.e., meta-analysis, systematic review, or standard literature review), number of studies reviewed or included in the meta-analysis, geographical scope, ABMT type, outcome type (i.e., ecological, social, economic, or multiple), evidence of outcomes, and effect directions (e.g., positive effect on organism size). Additional information related to study quality, including the reporting and rigour of methods, was recorded and informed distinctions made between study type where necessary. Systematic literature reviews were distinguished from standard literature reviews such that the former reported a search strategy, including search terms, and inclusion/exclusion criteria. For each study included, the reported ABMT was classified according to the definitions used in this study (Table A2), which in some cases differed from the ABMT that was searched in Web of Science. For example, if a study was returned by a search for FC outcomes, but the described ABMT fit this study's definition of a GRA, the ABMT was classified as a GRA. Where it was unclear whether an MPA was fully or partially protected, MPAtlas (http://www.mpatlas.org/) was used to determine the appropriate ABMT type. If an MPA was reported as being entirely no-take on MPAtlas, it was classified as an FPA. All other MPAs, including those with some no-take zones according to MPAtlas, were classified as PPAs. In the second phase, data on study location, ABMT type, evidence of outcomes, and effect direction were extracted and qualitative information that clarified the nature of reported outcomes was recorded.

2.2.3 Expert opinion survey

An expert opinion survey was designed to capture knowledge of ABMT outcomes that could fill gaps from the rapid systematic review. Using Qualtrics® software, the online survey asked participants to identify their familiarity with the assessed ABMTs, the expected effect of ABMTs on each outcome, and to provide demographic information relating to their professional experience. When identifying the expected effects of ABMTs on outcomes, participants were asked to assume that ABMTs were appropriately designed, actively managed, and well-enforced. We identified potential participants using two methods: (1) authors of studies included in the first phase of review and (2) known experts in the ABMTs identified from our collective professional networks, including representatives of academia, governments, non-governmental organizations, and independent experts. Invitations to participate were extended to these individuals via direct email with an anonymous link to the survey. In addition, we invited participants to share the survey with colleagues or to provide contact information of colleagues to receive an individual invitation. To conduct the confidence assessment, responses on the expected effects of ABMTs were grouped into positive effects from “Strong Positive” and “Positive” responses, negative effects from “Strong Negative” and “Negative” responses, and uncertain effects from “Do Not Know” and “Prefer Not to Answer” responses.

This research was approved by the Interdisciplinary Committee on Ethics in Human Research (ICEHR) at the Memorial University of Newfoundland, ICEHR No. 20200294-AR.

2.2.4 Confidence assessment

To determine the level of confidence in the delivery of ABMT outcomes, we used an assessment method modified from the IPBES assessment process (Intergovernmental Panel on Biodiversity and Ecosystem Services, 2016) (Figure 2.2, Table A6, Figure A3). We defined five confidence categories based on the quantity and quality of evidence and level of agreement among evidence collected via rapid systematic review and expert opinion survey. These categories are:

- Well-established: comprehensive evidence exists, and conclusions agree
- Established but incomplete: general agreement among evidence, although limited evidence exists
- Established but unresolved: moderate evidence exists, although conclusions do not consistently agree or disagree
- Unresolved: comprehensive evidence exists, and conclusions do not agree
- Incomplete: limited evidence exists, recognizing major knowledge gaps

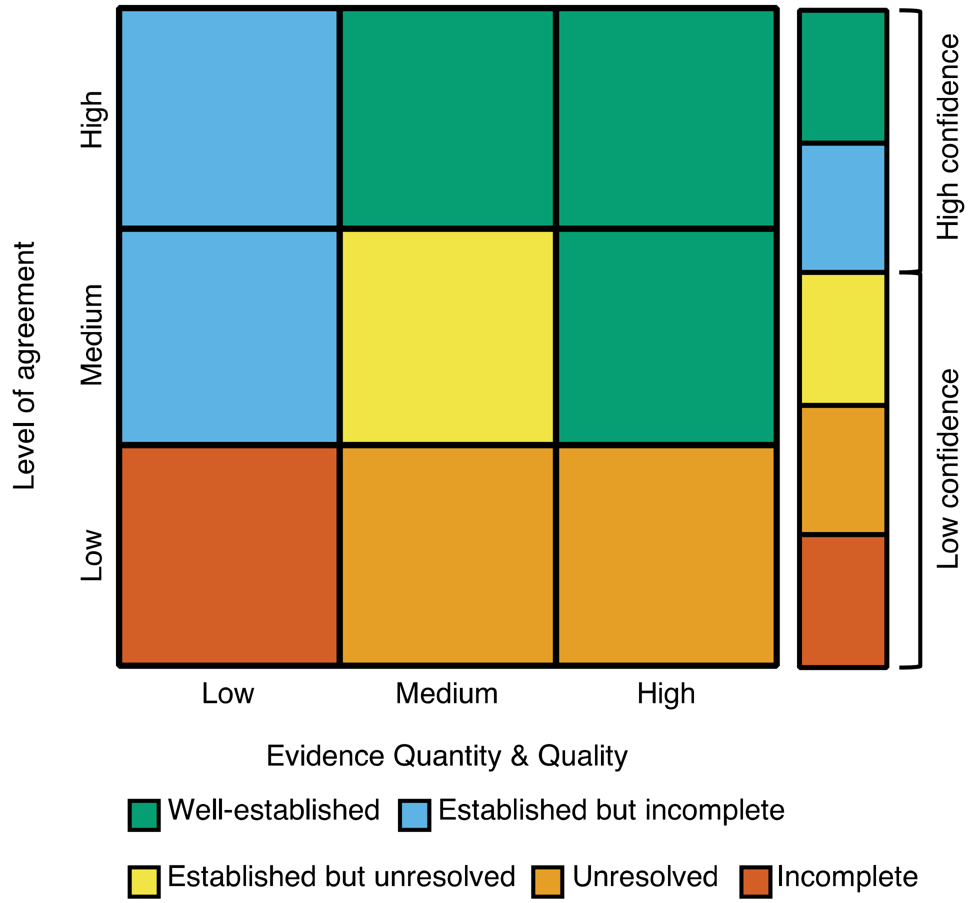


Figure 2.2. Confidence assessment framework, adapted from IPBES (Intergovernmental Panel on Biodiversity and Ecosystem Services, 2016), used to determine confidence in the delivery of area-based management tool (ABMT) outcomes based on evidence from rapid systematic review and expert opinions. Criteria for determining quantity and quality of evidence and level of agreement among evidence are defined in Supplementary Table 6 and detailed in Supplementary Figure 3. "Well-established" and "established but incomplete" categories were considered to be high confidence categories, while remaining categories were considered to be low confidence, for the purpose of linking ABMTs to Sustainable Development Goal 14 targets (see Methods).

We used a qualitative ranking system to determine the quantity and quality of evidence and the level of agreement to be either "high", "medium", or "low" based on the criteria presented in Table A6, applied in a decision tree presented in Figure A3. High quantity and quality evidence included one or more meta-analysis or systematic review or more than one standard literature review or five or more individual studies and more than 75% of experts reporting one expected effect. High agreement required the majority of studies to agree on an ABMT outcome, the majority of experts to agree on an outcome, and for the studies and experts to agree on that same outcome. Each ABMT outcome was assessed according to these criteria and assigned a confidence category (Figure A3). Well-established and established but incomplete categories were considered to be of high confidence, reflecting high certainty that a particular ABMT would deliver a particular outcome, and were assigned confidence scores of 2 and 1, respectively. All other confidence categories were not assigned a confidence score, as these categories were considered to be of low confidence.

2.2.5 Linking ABMTs to SDG 14 targets

ABMT outcomes assessed in this study do not all make equivalent contributions to SDG 14 targets. To account for this, each outcome was assigned a contribution score per target. Scores ranged from one to three, depending on the type of contribution. A direct contribution (score= 3) has a central role in meeting the objectives of the target; a supporting contribution (score= 2) aids the delivery of a direct contribution; and an indirect contribution (score= 1) enables the delivery of supporting or direct contributions to a lesser extent. We considered contributions to the targets broadly based on their description and, where feasible, their indicators. While some indicators were used to inform contribution scores for ABMT outcomes, others were not relevant to the outcomes assessed. For example, a study reporting an ABMT outcome of healthy ocean acidity (pH), the indicator for SDG 14.3, would be considered as evidence of a direct contribution to this target. Similarly, a study reporting improved ecosystem resilience as an ABMT outcome would be considered as evidence of an indirect contribution to this target. In contrast, the indicator for SDG 14.5, protected area coverage, is not an outcome of ABMTs and is therefore not relevant to this study. To link ABMTs to SDG 14 targets, an ABMT score was calculated according to the following equation:

$$\textit{ABMT score} = \Sigma\ (\textit{Confidence score} \times \textit{Contribution score}) \qquad \text{(Eq. 1)}$$

Possible ABMT scores ranged between 0 and 102, depending on the assigned confidence and contribution scores for the 17 assessed outcomes. ABMT scores were qualitatively compared to determine the relative contributions of ABMTs to SDG 14 targets (Figure A4).

2.3 Results

2.3.1 Evidence of ABMT outcomes

We identified 276 records of ABMT outcomes from 177 studies (Table 2.1). Of these studies, 31 reported evidence through synthesis-based literature, including meta-analyses, systematic reviews, or literature reviews. Although we found evidence of fully protected areas (FPAs), partially protected areas (PPAs), gear restriction areas (GRAs), fishery closures (FCs), and territorial user right fisheries (TURFs) in these 31 studies, most reported only ecological outcomes. The majority of records from both synthesis-based evidence and evidence from individual studies reported on outcomes from FPAs and PPAs (25% and 29%, respectively). The proportion of all literature-based evidence records across outcomes was comparable for locally managed marine areas (LMMAs), GRAs, FCs, and TURFs (8%, 14%, 12%, 12%, respectively); however, no synthesis-based evidence was identified for outcomes of LMMAs. Individual studies reported 204 records of evidence for ABMT outcomes, including 95 records of positive effects, 68 records of negative effects, and 41 records documenting no effect of ABMTs on outcomes. No literature-based evidence was identified for outcomes of particularly sensitive sea areas (PSSAs).

Table 2.1. Summary of literature-based evidence of area-based management tool (ABMT) outcomes collected via rapid systematic review. Blue cells indicate outcomes from synthesis-based evidence, including meta-analyses, systematic reviews, or literature reviews, and show the number of studies reporting evidence. White cells indicate the number of individual studies reporting evidence, for any outcome that was not reported in synthesis-based evidence (see Methods). Values represent one study per evidence record relating to an ABMT outcome, though some studies reported evidence of more than one outcome or evidence from more than one ABMT and are therefore counted in multiple cells where relevant. Evidence may report positive (+), negative (-), or neutral effects (○) on the ABMT outcome. FPA, fully protected area; PPA, partially protected area; LMMA, locally managed marine area; GRA, gear restriction area; FC, fishery closure; TURF, territorial user right fishery; PSSA, particularly sensitive sea area. Icons are attributed to Becris (LMMA), Freepik (FPA, PPA), Mavadee (PSSA), Smashicons (FC), Surang (GRA), Wichai.wi (TURF) from www.flaticon.com.

	Outcomes	Area-based management tools																				
		FPA			PPA			LMMA			GRA			FC			TURF			PSSA		
		+	-	○	+	-	○	+	-	○	+	-	○	+	-	○	+	-	○	+	-	○
Ecological	Organism size	11	0	0	5	0	1	3	0	0	2	0	0	2	0	0	1	0	0	0	0	0
	Organism abundance	16	0	0	8	0	0	2	0	0	3	0	0	3	0	0	3	0	0	0	0	0
	Species diversity	6	0	0	0	0	1	3	0	1	1	0	0	0	0	2	2	0	0	0	0	0
	Habitat	1	0	0	2	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0
	Ecosystem function	3	0	0	2	0	1	1	0	0	1	0	0	2	0	1	1	0	0	0	0	0
	Ecosystem resilience	0	0	2	2	0	0	0	0	0	2	1	0	0	0	0	0	1	0	0	0	0
	Reduce pollution	3	2	2	1	5	12	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0
	Threats to species	1	0	1	1	0	0	2	0	0	5	0	1	2	1	0	1	0	0	0	0	0
	Ocean acidification	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Social & Economic	Harvest earnings	1	0	0	2	0	0	2	0	0	2	0	0	1	0	0	3	0	0	0	0	0
	Non-harvest earnings	3	1	0	10	1	1	0	0	0	0	1	0	0	0	0	1	1	0	0	0	0
	Alternative livelihoods	0	0	0	2	2	0	1	0	0	0	0	0	0	2	0	1	0	0	0	0	0
	Access to resources	0	3	0	0	0	1	0	0	0	1	0	0	1	1	0	4	4	0	0	0	0
	Equitable access	0	2	0	0	1	0	1	0	0	1	1	0	0	0	0	3	0	0	0	0	0
	Reduce harvest effort	0	1	0	3	3	5	2	0	0	0	5	4	2	3	6	0	1	0	0	0	0
	Preserve traditions	1	1	0	1	3	0	2	0	0	3	0	0	0	0	0	0	2	0	0	0	0
	Community engagement	4	6	0	2	0	0	3	0	0	0	1	0	1	1	0	2	0	0	0	0	0

Expert opinions collected using survey questionnaires (n=75) exhibited greater agreement on the ecological outcomes of most ABMTs than social and economic outcomes (Figure 2.3). Experts agreed that for most ABMTs, positive effects would occur for the majority of ecological outcomes. More than 60% of experts agreed that FPAs, PPAs, LMMAs, and FCs would have positive effects on organism size (96%, 87%, 60%, and 87%, respectively), organism abundance (89%, 91%, 67%, and 89%, respectively), maintaining habitat (96%, 92%, 67%, and 65%, respectively), ecosystem function (93%, 84%, 63%, and 61%, respectively), ecosystem resilience (92%, 81%, 61%, and 63%, respectively), and on reducing threats to species (93%, 84%, 72%, and 87%, respectively). More than 60% of experts also agreed that GRAs would have positive effects on organism size (68%), organism abundance (73%), maintaining habitat (76%), and reducing threats to species (79%).

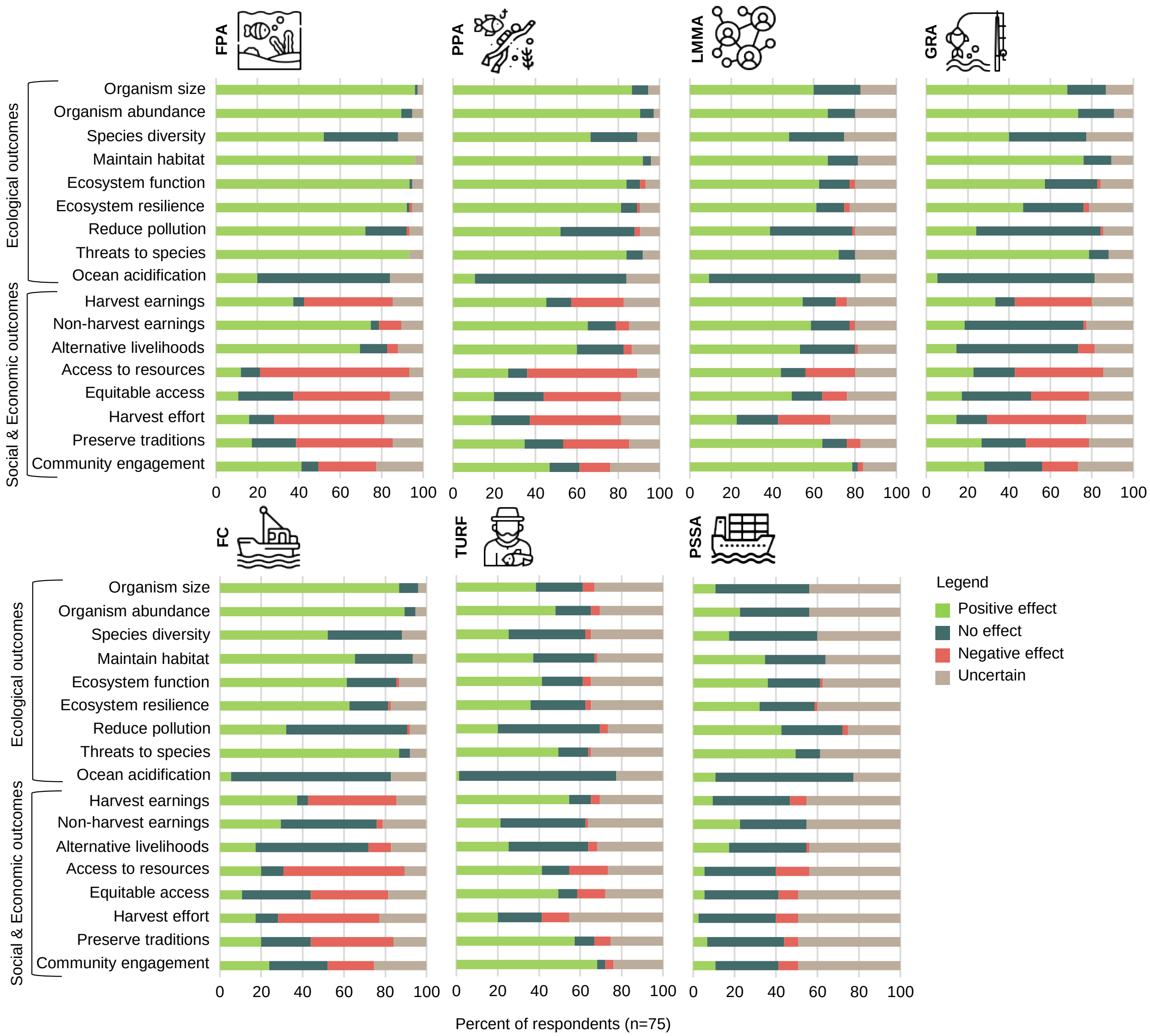


Figure 2.3. Expert opinions (n= 75) on the expected effects of area-based management tools (ABMTs) on ecological, social, and economic outcomes. See Supplementary Tables 1 and 2 for definitions of ABMTs and outcomes. FPA, fully protected area; PPA, partially protected area; LMMA, locally managed marine area; GRA, gear restriction area; FC, fishery closure; TURF, territorial user right fishery; PSSA, particularly sensitive sea area. Icons are attributed to Becris (LMMA), Freepik (FPA, PPA), Mavadee (PSSA), Smashicons (FC), Surang (GRA), Wichai.wi (TURF) from www.flaticon.com.

In contrast, at least 25% of experts agreed that FPAs, PPAs, LMMAs, GRAs, and FCs would have negative effects on harvest earnings (43%, 25%, 37%, and 43%, respectively), maintaining access to resources (72%, 53%, 43%, and 59%, respectively), equitable access to resources (47%, 37%, 28%, and 37%, respectively), and preserving traditions and customs (47%, 32%, 31%, and 40%, respectively). Experts were less certain about outcomes of TURFs and PSSAs, as more than 20% of experts indicated either “do not know” or “prefer not to answer” for all outcomes of these tools (see Methods). Several experts commented on the difficulty of providing general information on expected effects of ABMTs, especially those pertaining to social and economic outcomes, given the context-dependency of these outcomes relative to local ABMT objectives, monitoring capacity, and social groups.

2.3.2 Confidence assessment

Based on evidence provided by the literature and by experts, we found generally greater confidence in the delivery of ecological outcomes than social and economic outcomes from the assessed ABMTs (Figure 2.4). We found high confidence, assigned to “well-established” and “established but incomplete” categories (Figure 2.2), that multi-sector ABMTs, including FPAs, PPAs, and LMMAs, would have positive effects on organism size and abundance, species diversity, habitat, ecosystem function and resilience, and reducing threats to species. Most single sector ABMTs, including GRAs, FCs, and TURFs, were found to have positive effects on fewer ecological outcomes, including organism size and abundance, ecosystem function, and reducing threats to species, with high confidence. We also found high confidence that the seven ABMTs would have no effect on reducing impacts of acidification. While we found no literature-based evidence (Table 2.1), there was medium or high agreement among experts that ABMTs would have no effect on this outcome (Figure 2.3). Similarly, though to a lesser extent, there was agreement that none of the ABMTs studied are likely to reduce pollution, though confidence assessment was “incomplete” for LMMAs and PSSAs. Further, we found that FPAs may have the potential to reduce pollution, though evidence of this outcome was “established but unresolved”. Low confidence persisted for all outcomes of PSSAs, except the shared result of no effect of ABMTs on reducing impacts of acidification.

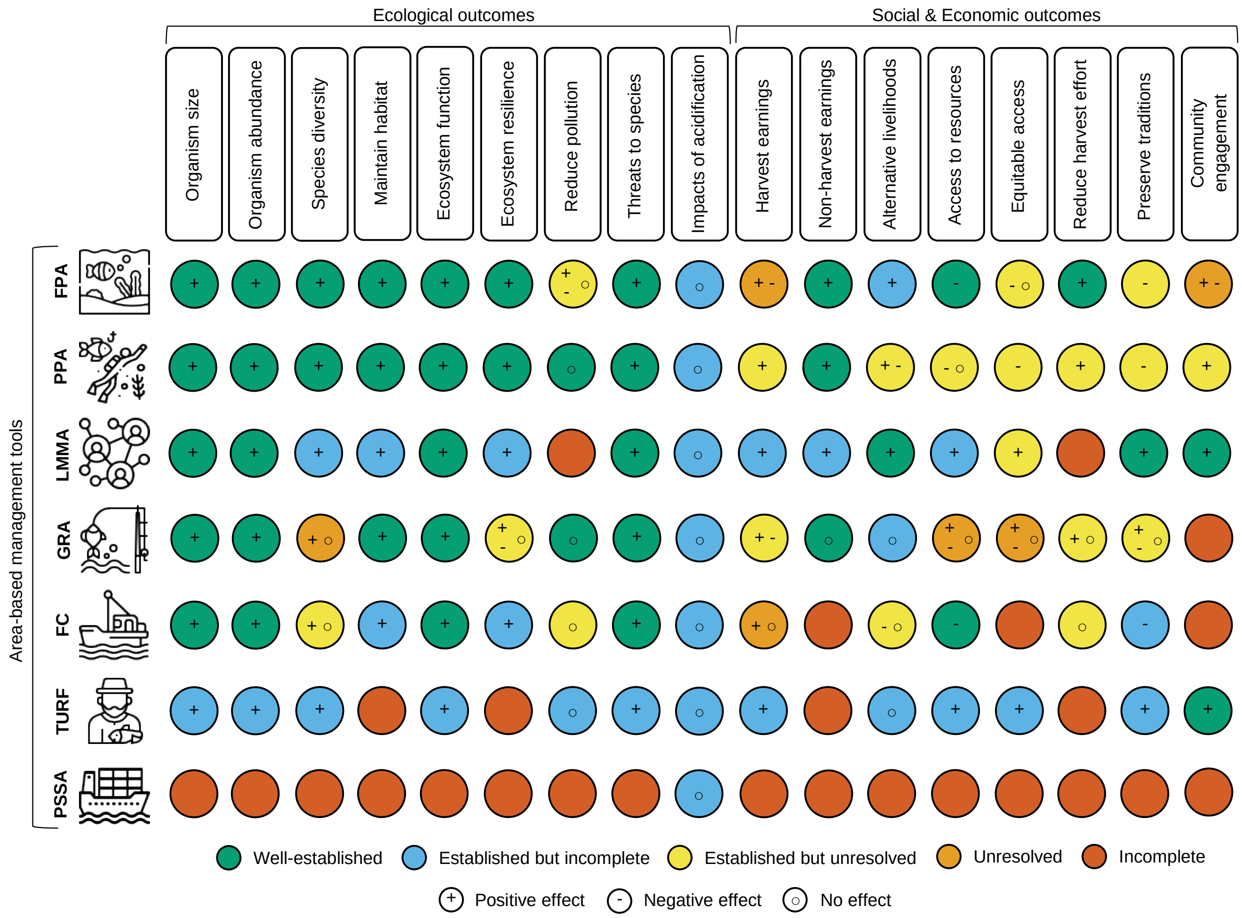


Figure 2.4. Confidence assessment of literature-based and expert opinion evidence for the delivery of ecological, social, and economic outcomes from area-based management tools (ABMTs). There is highest confidence in the delivery of "well-established" outcomes (green) and lowest confidence in the delivery of "incomplete" outcomes (dark orange). The effect direction for each outcome is indicated within each circle. For some "established but unresolved" and "unresolved" outcomes, more than one effect direction is indicated due to a lack of agreement among evidence. "Incomplete" outcomes do not indicate an effect direction. FPA, fully protected area; PPA, partially protected area; LMMA, locally managed marine area; GRA, gear restriction area; FC, fishery closure; TURF, territorial user right fishery; PSSA, particularly sensitive sea area. Icons are attributed to Becris (LMMA), Freepik (FPA, PPA), Mavadee (PSSA), Smashicons (FC), Surang (GRA), Wichai.wi (TURF) from www.flaticon.com.

Across ABMTs, low confidence, assigned to "established but unresolved", "unresolved", and "incomplete" categories (Figure 2.2), was found for 43% of all assessed outcomes; however, these were assigned to only 25% of ecological outcomes compared to 63% of social and economic outcomes. There is an apparent lack of evidence of social and economic outcomes and, where evidence does exist, it agrees less often than that for ecological outcomes, resulting in low confidence (Figure 2.4). For ecological outcomes, 25% exhibited high quantity and quality evidence and 44% showed a high level of agreement among evidence. In contrast, no social or economic outcome exhibited high quantity and quality evidence and only 21% showed a high level of agreement among evidence. Further, where high confidence was determined for social and economic outcomes, the effect direction on outcomes across ABMTs was not always consistent. While we found high confidence that some ABMTs have positive effects on increasing non-harvest earnings, alternative livelihood activities, maintaining access to resources, and preserving traditions, others were found to have no effect or negative effects on the same outcome. The direction of effects on social and economic outcomes were generally less consistent across tools than was found for ecological outcomes.

2.2.3 Linking ABMTs to SDG 14 targets

We found that the assessed ABMTs could potentially contribute to five of the seven SDG 14 targets (Figure 2.5): SDG 14.2 (marine ecosystems), SDG 14.4 (sustainable fisheries), SDG 14.5 (conservation), SDG 14.6 (harmful subsidies), and SDG 14.7 (Small Island Developing States) based on qualitatively determined ABMT scores (see Methods). Since we determined with high confidence that most or all of the assessed ABMTs have no effect on reducing pollution or the impacts of ocean acidification (Figure 2.4), we found no strong evidence that these tools contribute to SDG 14.1 (marine pollution) or SDG 14.3 (ocean acidification). Based on the confidence assessments presented here, there is currently no evidence that PSSAs on their own contribute to SDG 14 targets. We found that multi-sector ABMTs (i.e., FPAs, PPAs, and LMMAs) make greater potential contributions to targets that focus on ecological objectives, including SDG 14.2, 14.4, and 14.5, than single-sector ABMTs (i.e., GRAs, FCs, and TURFs). This reflects the high confidence identified for positive effects of multi-sector ABMTs on more ecological outcomes than single-sector ABMTs (Figure 2.4). For all ABMTs, except PSSAs, the potential contributions made to these targets were greater than potential contributions to targets with social and economic objectives, including SDG 14.6 and 14.7.

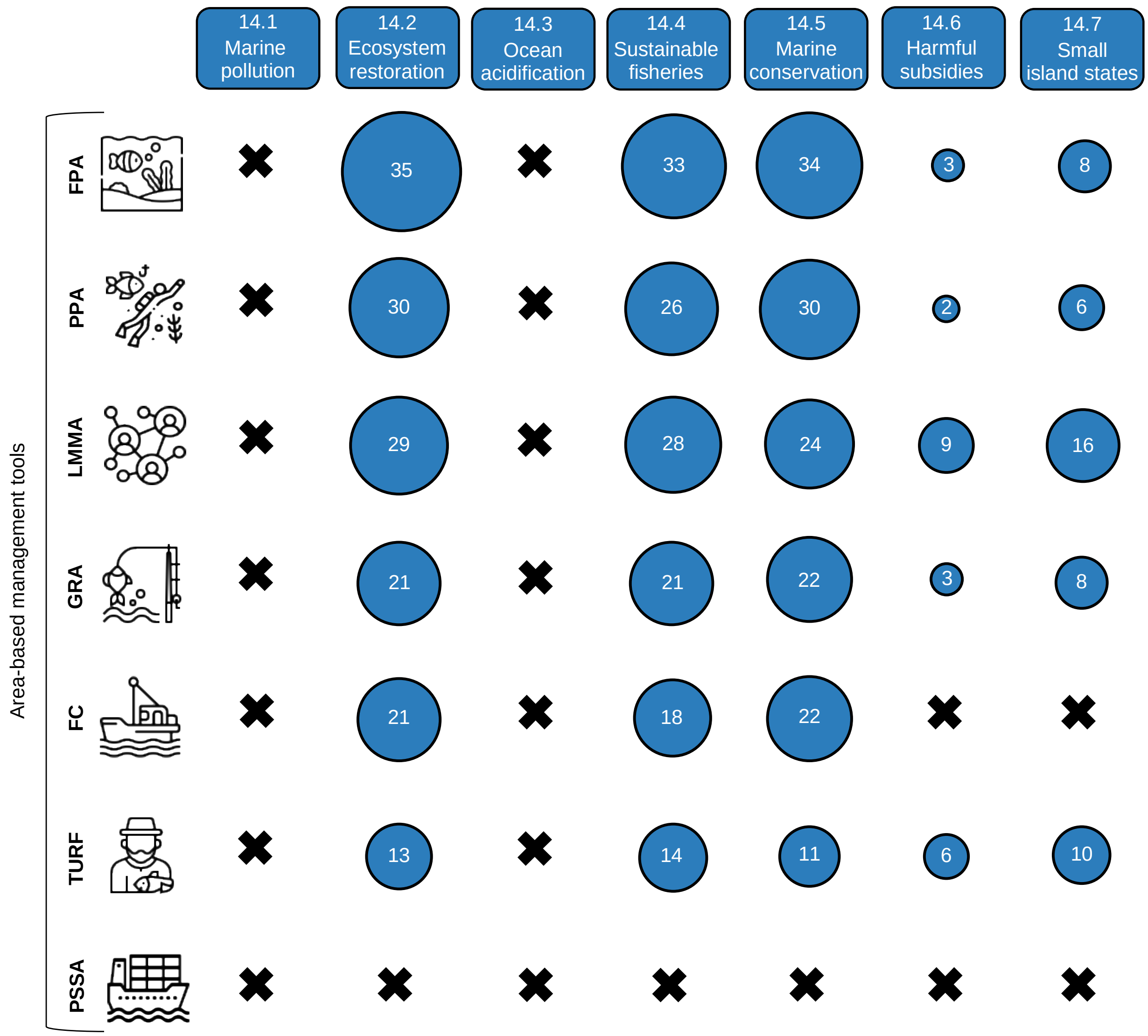


Figure 2.5. Potential contributions of area-based management tools (ABMTs) to Sustainable Development Goal 14 (SDG 14) targets based on confidence assessments of ABMT outcomes and the potential contributions of outcomes to SDG 14 targets (see data supplied with Supplementary Information). Circle size is proportional to ABMT scores indicated in each circle (scores range from 0 to 102, see Equation 1 in Methods). Crosses indicate an ABMT score of zero, meaning no potential contribution of a tool to a target, based on current evidence and the relative contribution of an outcome to a target. FPA, fully protected area; PPA, partially protected area; LMMA, locally managed marine area; GRA, gear restriction area; FC, fishery closure; TURF, territorial user right fishery; PSSA, particularly sensitive sea area. Icons are attributed to Becris (LMMA), Freepik (FPA, PPA), Mavadee (PSSA), Smashicons (FC), Surang (GRA), Wichai.wi (TURF) from www.flaticon.com.

While multi-sector ABMTs might make similar contributions to ecologically focused SDG 14 targets, they differ in their potential to contribute to socially and economically focused targets (Figure 2.5). FPAs emerged as the tool with the greatest potential to contribute to

SDGs 14.2, 14.4, and 14.5; however, this tool had lower ABMT scores than LMMAs for contributing to SDG 14.6 and 14.7. PPAs had the lowest ABMT scores for contributing to SDG 14.6 and 14.7 of all assessed ABMTs, with the exception of FCs and PSSAs, which were not found to make contributions to these targets based on current evidence. We identified LMMAs as the ABMT with the greatest potential to contribute to SDG 14.6 and 14.7. Second to LMMAs, TURFS presented higher ABMT scores for these targets than other tools. Both LMMAs and TURFs were the only tools found to increase harvest earnings and maintain access to resources with high confidence (Figure 2.4), thus supporting their greater potential to contribute to these targets. FCs were the only single-sector ABMT found to make no contribution to SDG 14.6 and 14.7. This is likely due to the negative effect of FCs on maintaining access to resources (Figure 2.4), an outcome that supports these targets.

2.4 Discussion

We found that, based on current evidence, FPAs hold the greatest potential to contribute to ecologically focused SDG 14 targets (i.e., SDG 14.2, 14.4, and 14.5), aiming to preserve or restore ocean ecosystems and biodiversity, followed by PPAs and LMMAs (Figure 2.5). Those three tools typically regulate multiple sectors and activities, while the remaining tools target activities of single sectors, particularly fisheries via GRAs, FCs, and TURFS and shipping activities via PSSAs. Our results indicate that these multi-sector ABMTs, which may involve the use of multiple single-sector ABMTs, will be important for achieving SDG 14, given their strong potential to contribute to multiple targets. Since no single ABMT assessed was found to potentially contribute to all targets, nor was a single ABMT identified as holding the greatest potential to contribute to both ecologically and socially and economically focused targets, our findings highlight the need for a combination of tools to meet SDG 14. This resonates with a preliminary analysis by the United Nations of spatial management strategies, including marine spatial planning and integrated coastal zone management, for achieving ocean-related SDGs (United Nations Environment Programme, 2017). Our results also highlight the potential role of these ABMTs in contributing to conservation targets as OECMs. While we determined similar ABMT scores for multi-sector tools, an important distinction between FPAs, PPAs, and

LMMAs lies in their overarching objectives: biodiversity conservation is the key goal of FPAs and PPAs (Sciberras et al., 2015), while LMMAs prioritize sustainable resource use over conservation *per se* (Burke et al., 2011).

LMMAs, a tool that has been favoured in Small Island Developing States (Island Voices Global Choices, 2018), are unique in their application of a suite of ABMTs under a shared management strategy that is collaborative across communities, partner organizations, and governments at the local level (Govan, 2009). These characteristics are likely reflected in the ABMT scores we present here (Figure 2.5), particularly due to their ability to deliver ecological, social, and economic outcomes with high confidence (Figure 2.4). Despite the relatively limited evidence of LMMA outcomes in the primary literature (Table 2.1), this ABMT scored similarly to FPAs and PPAs that are well-documented. It is clear from our results that experts agree on generally positive expected effects of LMMAs on outcomes (Figure 2.3). Given these findings, LMMAs represent an opportunity for management as a potential pathway and a research priority to support the achievement of SDG 14. As a tool for ensuring a healthy and resilient ocean for sustainability (Giakoumi et al., 2017; Organization for Economic Co-operation and Development, 2017), FPAs undoubtedly have a central role in achieving SDG 14.2, 14.4, and 14.5; however, the overarching aim of LMMAs may enable greater delivery of outcomes contributing to SDG 14 targets that seek to sustain the social and economic systems affecting oceans and ocean resources.

While our results show how the assessed ABMTs can potentially contribute SDG 14 targets, they also highlight limitations of ABMTs. We found “incomplete” evidence for all assessed outcomes of PSSAs (Figure 2.4), hence, no potential for PSSAs to contribute to SDG 14 (Figure 2.5). PSSAs may make other important contributions to conservation and sustainability by reducing impacts from international shipping activities. This tool has been suggested for use in areas beyond national jurisdiction for conservation (Roberts et al., 2010; Rochette et al., 2014), where threats to biodiversity are growing (Gjerde et al., 2016; Warner, 2014). We highlight a need for more research on PSSA outcomes to support this tool as a potential pathway to SDG 14 in the high seas and suggest that

ABMTs contributing to conservation outcomes should be used until the role of PSSAs can be clarified, such as FPAs. Our results also demonstrate the inability of the assessed ABMTs to effectively reduce marine pollution (SDG 14.1) and impacts of ocean acidification (SDG 14.3) (Figure 2.5). Other ABMTs not assessed here, such Special Areas designed under the MARPOL Convention (International Maritime Organization, 2020), may better support these targets. Our results may reflect the broader and more systemic changes required for addressing these issues; for example, regulating the consumption and disposal of plastic or large-scale actions for reducing carbon emissions and decarbonizing economies (Blythe et al., 2018; Geels et al., 2017; Stafford & Jones, 2019). Such systemic transformations may be necessary precursors to effectively achieving SDG 14.1 and 14.3, for which little progress has been made (United Nations, 2019). It will be important to consider both non-spatial and spatial management tools, including and beyond the ABMTs assessed here, to achieve all SDG 14 targets. Holistic approaches to planning and management across the land-sea interface, like integrated coastal zone management (Pittman & Armitage, 2016) and ridge-to-reef management (Delevaux et al., 2018), will likely be important for incorporating land-based regulations with ABMTs to achieve SDGs, including SDG 14 (United Nations Environment Programme, 2017).

Through this work, we have identified several evidence gaps pertaining to ABMTs and their outcomes. We highlight low confidence and a lack of evidence pertaining to the social and economic outcomes of ABMTs (Table 2.1, Figure 2.3, Figure 2.4). Low confidence was found for 61% of social and economic outcomes assessed, compared to only 25% of ecological outcomes. These findings indicate a need for research to better assess social and economic outcomes of ABMTs at varying scales and for diverse stakeholders, which may first require the development of measurable indicators for targets that are presently without (Recuero Virto, 2018). This evidence gap is again highlighted by the ABMT scores presented here, which indicate the low potential of these tools to contribute to SDG 14.6 and 14.7 that are socially and economically focused. While recent work helped to identify social and economic outcomes of marine protected areas

(Ban et al., 2019), an apparent evidence gap persists in identifying these outcomes for single-sector ABMTs, including FCs, GRAs, TURFs, and PSSAs.

We recognize the inherent limitations of our study imposed by the rapid systematic review method. While efforts were made to ensure that this method captured all relevant information, it cannot be truly comprehensive as would a full systematic review capturing both primary and grey literature. Our focus on primary, peer-reviewed literature provided a common filter, ensuring a consistent rigour across the collected evidence. This method was used to conduct a high-level confidence assessment that relied on a qualitative ranking system to assess the quantity and quality of evidence (Table A6). To compensate for differences in the availability of literature-based evidence, we surveyed experts to identify the expected effects of ABMTs. Through the selection of survey participants in primarily research institutions and government, expertise from industry, Indigenous Peoples, and communities are not present in our confidence assessments. As with any scientific synthesis, our work may be affected by publication bias with some ABMTs more represented in the literature than others, as well as a tendency for literature to report positive outcomes. As more evidence becomes available, the confidence assessments and potential contributions of tools to SDG 14 targets presented here may be refined.

Our results demonstrate the qualitative potential of ABMTs to contribute to SDG 14 and their use in practice should appropriately reflect this. Further, while we did select prominent ABMTs for assessment, other tools are available to practitioners and may also prove useful for achieving SDG 14. Our study does not assess the efficacy of ABMTs, nor does it quantify the extent of outcomes. While ABMTs may deliver similar outcomes, one tool may have a stronger effect than others and our study does not account for this. Delivery of these outcomes is dependent on local social-ecological systems and may vary by target species, ecosystems, and management regimes. To reach their fullest potential, ABMTs must be appropriately designed with attention given to local needs, actively managed, and well-enforced to consistently deliver outcomes contributing to SDG 14 (Bennett & Dearden, 2014b; Devillers et al., 2015; Gill et al., 2017).

2.5 Conclusion

ABMTs are one type of management tool in a suite of tools and approaches available to decision-makers for achieving conservation and sustainability objectives. Our results confirm that no single ABMT can be used to reach all SDG 14 targets, but that a combination of tools, especially those regulating multiple sectors, will likely be necessary for achieving this goal. When multiple ABMTs are used synergistically, multiple and more diverse outcomes may occur, potentially making stronger contributions to SDG 14. Placing ABMTs into the wider picture of integrated land-sea management, including both spatial and non-spatial approaches, will be important for achieving ocean conservation and sustainability goals (Álvarez-Romero et al., 2015; Reuter et al., 2016). This is especially true for SDG 14 targets that may not be met using ABMTs, including SDG 14.1 to reduce marine pollution and SDG 14.3 to reduce ocean acidification as our results indicate. Our findings highlight important evidence gaps related to social and economic outcomes of ABMTs, especially single-sector ABMTs, providing a research agenda for future work. Through our assessment, we demonstrate which ABMTs may be most useful for achieving specific SDG 14 targets, allowing ocean planners and practitioners to make strategic decisions when selecting management tools. By linking ABMTs to SDG 14 targets, our work may support future research to assess potential contributions of existing or planned ABMTs to SDG 14 at a regional, national, and international scale.

2.6 References

Agardy, T., di Sciara, G. N., & Christie, P. (2011). Mind the gap: Addressing the shortcomings of marine protected areas through large scale marine spatial planning. *Marine Policy*, *35*(2), 226–232. https://doi.org/10.1016/j.marpol.2010.10.006

Álvarez-Romero, J. G., Adams, V. M., Pressey, R. L., Douglas, M., Dale, A. P., Augé, A. A., Ball, D., Childs, J., Digby, M., Dobbs, R., Gobius, N., Hinchley, D., Lancaster, I., Maughan, M., & Perdrisat, I. (2015). Integrated cross-realm planning: A decision-makers' perspective. *Biological Conservation*, *191*, 799–808. https://doi.org/10.1016/j.biocon.2015.07.003

Ban, N. C., Gurney, G. G., Marshall, N. A., Whitney, C. K., Mills, M., Gelcich, S., Bennett, N. J., Meehan, M. C., Butler, C., Ban, S., Tran, T. C., Cox, M. E., & Breslow, S. J. (2019). Well-being outcomes of marine protected areas. *Nature Sustainability*, *2*(6), 524–532. https://doi.org/10.1038/s41893-019-0306-2

Bennett, N. J., & Dearden, P. (2014a). From measuring outcomes to providing inputs: Governance, management, and local development for more effective marine protected areas. *Marine Policy*, *50*(PA), 96–110. https://doi.org/10.1016/j.marpol.2014.05.005

Bennett, N. J., & Dearden, P. (2014b). Why local people do not support conservation: Community perceptions of marine protected area livelihood impacts, governance and management in Thailand. *Marine Policy*, *44*, 107–116. https://doi.org/10.1016/j.marpol.2013.08.017

Biedenweg, K., Stiles, K., & Wellman, K. (2016). A holistic framework for identifying human wellbeing indicators for marine policy. *Marine Policy*, *64*, 31–37. https://doi.org/10.1016/j.marpol.2015.11.002

Blythe, J., Silver, J., Evans, L., Armitage, D., Bennett, N. J., Moore, M.-L., Morrison, T. H., & Brown, K. (2018). The Dark Side of Transformation: Latent Risks in Contemporary Sustainability Discourse. *Antipode*, *0*(0), 1–18. https://doi.org/10.1111/anti.12405

Burke, L., Reytar, K., Spalding, M., & Perry, A. (2011). *Reefs at Risk Revisited*. World Resources Institute.

Claudet, J., Bopp, L., Cheung, W. W. L., Devillers, R., Escobar-briones, E., Haugan, P., Matz-l, N., Heymans, J. J., Barnerias, C., Bowler, C., Brun, V., Cazenave, A., Diver, C., Bailly, D., Barbie, J., Pierre, I., Laplace, S., & Me, L. De. (2020). Perspective A Roadmap for Using the UN Decade of Ocean Science for Sustainable Development in Support of Science , Policy , and Action. *One Earth*, *2*. https://doi.org/10.1016/j.oneear.2019.10.012

Claudet, J., Roussel, S., & Pelletier, D. (2006). Spatial management of near shore coastal areas: The use of Marine Protected Areas (MPAS) in a fisheries management context. *Vie et Milieu- Life and Environment*, *56*(4), 301–305.

Cormier, R., & Elliott, M. (2017). SMART marine goals, targets and management – Is SDG 14 operational or aspirational, is ‘Life Below Water’ sinking or swimming? *Marine Pollution Bulletin*, *123*(1–2), 28–33. https://doi.org/10.1016/j.marpolbul.2017.07.060

De Santo, E. M. (2018). Implementation challenges of area-based management tools (ABMTs) for biodiversity beyond national jurisdiction (BBNJ). *Marine Policy*, *97*(April), 34–43. https://doi.org/10.1016/j.marpol.2018.08.034

Delevaux, J. M. S., Whittier, R., Stamoulis, K. A., Bremer, L. L., Jupiter, S., Friedlander, A. M., Poti, M., Guannel, G., Kurashima, N., Winter, K. B., Toonen, R., Conklin, E., Wiggins, C., Knudby, A., Goodell, W., Burnett, K., Yee, S., Htun, H., Oleson, K. L. L., … Ticktin, T. (2018). A linked land-sea modeling framework to inform ridge-to-reef management in high oceanic islands. In *PLoS ONE* (Vol. 13, Issue 3). https://doi.org/10.1371/journal.pone.0193230

Devillers, R., Pressey, R. L., Grech, A., Kittinger, J. N., Edgar, G. J., Ward, T., & Watson, R. (2015). Reinventing residual reserves in the sea: Are we favouring ease of establishment over need for protection? *Aquatic Conservation: Marine and Freshwater Ecosystems*, *25*(4), 480–504. https://doi.org/10.1002/aqc.2445

Diz, D., Johnson, D., Riddell, M., Rees, S., Battle, J., Gjerde, K., Hennige, S., & Roberts, J. M. (2018). Mainstreaming marine biodiversity into the SDGs: The role of other effective area-based conservation measures (SDG 14.5). *Marine Policy*, *93*(April 2017), 251–261. https://doi.org/10.1016/j.marpol.2017.08.019

Ehler, C., & Douvere, F. (2009). Marine Spatial Planning: A step-by-step approach toward ecosystem-based management. *Intergovernmental Oceanographic Commission and Man and the Biosphere Programme*, *IOC Manual*(6), 1–98. https://doi.org/Intergovernmental Oceanographic Commission and Man and the Biosphere Programme

Frazão Santos, C., Agardy, T., Andrade, F., Calado, H., Crowder, L. B., Ehler, C. N., García-Morales, S., Gissi, E., Halpern, B. S., Orbach, M. K., Pörtner, H.-O., & Rosa, R. (2020). Integrating climate change in ocean planning. *Nature Sustainability*. https://doi.org/10.1038/s41893-020-0513-x

Ganann, R., Ciliska, D., & Thomas, H. (2010). Expediting systematic reviews: Methods and implications of rapid reviews. *Implementation Science*, *5*(1), 1–10. https://doi.org/10.1186/1748-5908-5-56

Geels, F. W., Sovacool, B., Schwanen, T., & Sorrell, S. (2017). Sociotechnical transitions for deep decarbonization: Accelerating innovation is as important as climate policy. *Science*, *357*(6357), 1242–1244. https://doi.org/10.1126/science.aao3760

Giakoumi, S., Scianna, C., Plass-Johnson, J., Micheli, F., Grorud-Colvert, K., Thiriet, P., Claudet, J., Di Carlo, G., Di Franco, A., Gaines, S. D., Garcia-Charton, J. A., Lubchenco, J., Reimer, J., Sala, E., & Guidetti, P. (2017). Ecological effects of full and partial protection in the crowded Mediterranean Sea: A regional meta-analysis. *Scientific Reports*, *7*, 8940. https://doi.org/10.1038/s41598-017-08850-w

Gill, D. A., Mascia, M. B., Ahmadia, G. N., Glew, L., Lester, S. E., Barnes, M., Craigie, I., Darling, E. S., Free, C. M., Geldmann, J., Holst, S., Jensen, O. P., White, A. T., Basurto, X., Coad, L., Gates, R. D., Guannel, G., Mumby, P. J., Thomas, H., … Fox, H. E. (2017). Capacity shortfalls hinder the performance of marine protected areas globally. *Nature*, *543*(7647), 665–669. https://doi.org/10.1038/nature21708

Gjerde, K. M., Reeve, L. L. N., Harden-Davies, H., Ardron, J., Dolan, R., Durussel, C., Earle, S., Jimenez, J. A., Kalas, P., Laffoley, D., Oral, N., Page, R., Ribeiro, M. C., Rochette, J., Spadone, A., Thiele, T., Thomas, H. L., Wagner, D., Warner, R., … Wright, G. (2016). Protecting Earth's last conservation frontier: Scientific, management and legal priorities for MPAs beyond national boundaries. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *26*(September), 45–60. https://doi.org/10.1002/aqc.2646

Govan, H. (2009). *Status and potential of locally-managed marine areas in the Pacific Island Region: Meeting nature conservation and sustainable livelihood targets through wide-spread implementation of LMMAs*. https://doi.org/SPREP/WWF/WorldFish-Reefbase/CRISP

Haas, B., Fleming, A., Haward, M., & McGee, J. (2019). Big fishing: The role of the large-scale commercial fishing industry in achieving Sustainable Development Goal 14. *Reviews in Fish Biology and Fisheries*, *8*(1), 161–175. https://doi.org/10.1007/s11160-018-09546-8

Intergovernmental Panel on Biodiversity and Ecosystem Services. (2016). *The IPBES Assessment Process*.

International Maritime Organization. (2020). *Special Areas Under MARPOL*.

Island Voices Global Choices. (2018). *In-depth analysis of partnerships for Small Island Developing States*.

Johnson, D., Adelaide Ferreira, M., & Kenchington, E. (2018). Climate change is likely to severely limit the effectiveness of deep-sea ABMTs in the North Atlantic. *Marine Policy*, *87*(September 2017), 111–122. https://doi.org/10.1016/j.marpol.2017.09.034

Jupiter, S. D., Cohen, P. J., Weeks, R., Tawake, A., & Govan, H. (2014). Locally-managed marine areas: Multiple objectives and diverse strategies. *Pacific Conservation Biology*, *20*(2), 165–179. https://doi.org/10.1071/PC140165

Kincaid, K., Rose, G., & Devillers, R. (2017). How fisher-influenced marine closed areas contribute to ecosystem-based management: A review and performance indicator scorecard. *Fish and Fisheries*, *18*(5), 860–876. https://doi.org/10.1111/faf.12211

Lester, S. E., McDonald, G., Clemence, M., Dougherty, D. T., & Szuwalski, C. S. (2017). Impacts of TURFs and marine reserves on fisheries and conservation goals: Theory, empirical evidence, and modeling. *Bulletin of Marine Science*, *93*(1), 173–198. https://doi.org/10.5343/bms.2015.1083

Molenaar, E. J. (2013). *Area-based management tools* (Issue May).

Ntona, M., Morgera, E., & Ntona, M. (2017). Connecting SDG 14 with the other Sustainable Development Goals through marine spatial planning. *Marine Policy*, *January*, 1–9. https://doi.org/10.1016/j.marpol.2017.06.020

Organization for Economic Co-operation and Development. (2017). *Marine Protected Areas: Economics, Management and Effective Policy Mixese*. OECD Publishing. https://doi.org/10.1787/9789264276208-en.

Palmer, M. C., & Demarest, C. (2018). Getting to good enough: Performance of a suite of methods for spatially allocating fishing effort to management areas. *Fisheries Research*, *204*(February), 26–32. https://doi.org/10.1016/j.fishres.2018.02.003

Pittman, J., & Armitage, D. (2016). Governance across the land-sea interface: A systematic review. *Environmental Science and Policy*, *64*, 9–17. https://doi.org/10.1016/j.envsci.2016.05.022

Pomeroy, R. S., Parks, J. E., & Watson, L. M. (2004). *How Is Your MPA Doing? A Guidebook of Natural and Social i=Indicators for Evaluating Marine Protected Area Management Effectiveness*. https://doi.org/10.1016/j.ocecoaman.2005.05.004

Recuero Virto, L. (2018). A preliminary assessment of the indicators for Sustainable Development Goal (SDG) 14 “Conserve and sustainably use the oceans, seas and marine resources for sustainable development.” *Marine Policy*, *98*(February), 47–57. https://doi.org/10.1016/j.marpol.2018.08.036

Reuter, K. E., Juhn, D., & Grantham, H. S. (2016). Integrated land-sea management: Recommendations for planning, implementation and management. *Environmental Conservation*, *43*(2), 181–198. https://doi.org/10.1017/S0376892916000023

Roberts, J., Chircop, A., & Prior, S. (2010). Area-based Management on the High Seas: Possible Application of the IMO’s Particularly Sensitive Sea Area Concept. *International Journal of Marine and Coastal Law*, *25*(4), 483–522. https://doi.org/10.1163/157180810X525403

Rochette, J., Gjerde, K., Druel, E., Ardron, J. A., Craw, A., Halpin, P., Pendleton, L., Teleki, K., & Cleary, J. (2014). Delivering the Aichi target 11: Challenges and opportunities for marine areas beyond national jurisdiction. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *24*(S2), 31–43. https://doi.org/10.1002/aqc.2507

Rocliffe, S., Peabody, S., Samoilys, M., & Hawkins, J. P. (2014). Towards a network of locally managed marine areas (LMMAs) in the Western Indian Ocean. *PLoS ONE*, *9*(7), e103000–e103000. https://doi.org/10.1371/journal.pone.0103000

Sciberras, M., Jenkins, S. R., Mant, R., Kaiser, M. J., Hawkins, S. J., & Pullin, A. S. (2015). Evaluating the relative conservation value of fully and partially protected marine areas. *Fish and Fisheries*, *16*(1), 58–77. https://doi.org/10.1111/faf.12044

Secretariat of the Convention on Biological Diversity, Food and Agriculture Organisation of the United Nations, The World Bank, United Nations Environment Programme, & United Nations Development Programme. (2016). *Biodiversity and the 2030 Agenda for Sustainable Development Biodiversity Is Essential for Sustainable Development*.

Sinclair, S. P., Milner-Gulland, E. J. J., Smith, R. J., McIntosh, E. J., Possingham, H. P., Vercammen, A., & Knight, A. T. (2018). The use, and usefulness, of spatial conservation prioritizations. *Conservation Letters*, *11*(6), 1–7. https://doi.org/10.1111/conl.12459

Singh, G. G., Cisneros-Montemayor, A. M., Swartz, W., Cheung, W., Guy, J. A., Kenny, T. A., McOwen, C. J., Asch, R., Geffert, J. L., Wabnitz, C. C. C., Sumaila, R., Hanich, Q., & Ota, Y. (2018). A rapid assessment of co-benefits and trade-offs among Sustainable Development Goals. *Marine Policy*, *93*(March 2017), 223–231. https://doi.org/10.1016/j.marpol.2017.05.030

Stafford, R., & Jones, P. J. S. (2019). Viewpoint – Ocean plastic pollution: A convenient but distracting truth? *Marine Policy*, *103*(September 2018), 187–191. https://doi.org/10.1016/j.marpol.2019.02.003

Sterling, E., Ticktin, T., Kipa Kepa Morgan, T., Cullman, G., Alvira, D., Andrade, P., Bergamini, N., Betley, E., Burrows, K., Caillon, S., Claudet, J., Dacks, R., Eyzaguirre, P., Filardi, C., Gazit, N., Giardina, C., Jupiter, S., Kinney, K., McCarter, J., … Wali, A. (2017). Culturally Grounded Indicators of Resilience in Social-Ecological Systems. *Environment and Society*, *8*(1), 63–95. https://doi.org/10.3167/ares.2017.080104

United Nations. (2015). Transforming our world: The 2030 Agenda for Sustainable Development. *General Assembley 70 Session*, *16301*(October), 1–35. https://doi.org/10.1007/s13398-014-0173-7.2

United Nations. (2019). The sustainable development goals report 2019. In *United Nations publication issued by the Department of Economic and Social Affairs*.

United Nations Environment Programme. (2017). *Preliminary analysis of area-based management measures to support SDG implementation*.

Warner, R. M. (2014). Conserving marine biodiversity in areas beyond national jurisdiction: Co-evolution and interaction with the law of the sea. *Frontiers in Marine Science*, *1*(MAY), 1–11. https://doi.org/10.3389/fmars.2014.00006

Zupan, M., Fragkopoulou, E., Claudet, J., Erzini, K., Horta e Costa, B., & Gonçalves, E. (2018). Marine partially protected areas: Drivers of ecological effectiveness. *Frontiers in Ecology and the Environment*, *16*(7), 381–387. https://doi.org/10.1002/fee.1934

3. Conservation ready marine spatial planning

Abstract

Marine spatial planning (MSP) often favors blue growth objectives over biodiversity conservation, diminishing its role in promoting sustainability. We used document analysis to assess how conservation principles and priorities are included in five case studies to identify a path for better integrating conservation with MSP. Five themes emerged, reflecting conservation in MSP from weak to strong inclusion: (1) prioritizing economy; (2) ecosystems as limits; (3) social-ecological systems; (4) ecosystems as functional; and (5) ecosystems as fundamental. Our analysis suggests MSP priorities for managing or mitigating impacts and conservation was less apparent, though some plans appear more prepared to integrate conservation. We propose the concept of conservation ready MSP, where plans are designed to integrate conservation in MSP as a way to support sustained ocean use. MSP may be more conservation ready when specific commitments are made and conservation underpins ocean use, reflecting the fundamental role of biodiversity conservation in sustainability.

3.1 Introduction

Ensuring a healthy ocean is a global priority for sustainable development (Claudet et al., 2020; United Nations, 2015), but our footprint on the ocean is growing like never before (Jouffray et al., 2020). A new narrative is needed to recognize that humans, the ocean, biodiversity, and climate are inextricably linked, and that by protecting the ocean we protect ourselves (Laffoley et al., 2020).

Single-sector approaches historically dominated ocean management, though multi-sector approaches are now widely regarded as necessary to achieve conservation and sustainability goals (Reimer et al., 2020; Schupp et al., 2019). Marine spatial planning (MSP) has emerged prominently over the past two decades as an approach that accounts for multiple uses and objectives, supported by policymakers, practitioners, and academics

(Flannery et al., 2020). Today, more than 75 countries are undertaking MSP across all ocean basins (Ehler, 2020; Frazão Santos et al., 2020).

In practice, MSP is often used for strategic sectoral planning or blue growth, diluting the supporting role of ecosystems and the need for their protection (Frazão Santos et al., 2014; Jones et al., 2016; Trouillet, 2020). Balancing socioeconomic activities and conservation remains a key challenge in MSP (Frazão Santos et al., 2018). For many years, MSP and conservation planning, especially marine protected area (MPA) planning, have evolved in parallel with little integration (Vaughan & Agardy, 2020). Without efforts to integrate conservation with MSP, it may fail to achieve its potential as a holistic, multi-objective process that can support conservation and sustainable use goals.

Here, we explore (i) which conservation principles and priorities have permeated MSP and (ii) how this might inform integration of conservation in MSP. Using a broad definition of conservation – *the protection, management, and maintenance of ecosystems, species, and populations to safeguard the conditions that ensure their long-term survival* (IUCN, 2021) – we analyzed its inclusion in formal MSP using an in-depth document analysis of five case studies. We propose that conservation ready MSP – where plans are designed to support and enact conservation by embedding these principles and priorities, recognizes and secures the foundational role of conservation in sustainable resource use.

3.2 Methods

3.2.1 Selection of case studies

We selected case studies following a screening process of the Intergovernmental Oceanographic Commission (IOC)'s online database (http://msp.ioc-unesco.org, see Appendix B Methods and Figure B1). Answering our research questions required case studies that were sufficiently detailed and readily available in English. We screened case studies from Europe, the UK, and the USA due to the availability of documents from these regions and for their long history and experience with formal MSP as it is considered in this study (Ehler et al., 2019).

While our analysis focuses on a wide range of conservation principles and priorities (see below), we used MPA listing as an indicator for conservation to ensure case studies captured diverse approaches. We selected case studies based on whether and how they included MPAs as listed by the IOC database or by preliminary scan of the MSP document (Appendix B Methods). We selected newer and older plans reflecting different types (advisory or regulatory), spatial and temporal scales, ocean sectors, and phases of MSP from pre-implementation to adaptation (Table B1). We analyzed MSP documents from Belgium, Norway, Scotland, Wales, and Washington State (USA).

3.2.2 Document and themes analysis

We used a hybrid approach of inductive and deductive qualitative coding, the process of labelling and organizing passages of text, in QSR International's NVivo-12 software (Fereday & Muir-Cochrane, 2006; Skjott Linneberg & Korsgaard, 2019) to identify conservation principles and priorities used in MSP (see Appendix B Methods, Table B2). Conservation principles reflect key concepts in biodiversity conservation, such as ecological resilience (Folke et al., 1996) and biological connectivity (Margules & Pressey, 2000). Conservation priorities reflect action areas, such as protecting habitat or endangered species. We also recorded analytical memos, ongoing reflections on the data, to track emerging themes and extract meaning (Birks et al., 2008).

We conducted a themes analysis based on coding data and memos (Skjott Linneberg & Korsgaard, 2019) to describe how conservation has been included in MSP and identify a path toward integration. Themes were identified inductively from the qualitative data, following document analysis. We condensed analytical memos and arranged them into basic themes: coherent topics on how conservation, or more generally ecosystems, were conceptualized, emerging from at least two case studies (Attride-Stirling, 2001). We quantitized codes and memos into frequency counts (Sandelowski et al., 2009) to estimate prominence and compare across case studies, which informed basic themes. We then defined and clustered basic themes into organizing themes that shared similar topics or approaches to conservation from four or more case studies (Attride-Stirling, 2001). Since themes were derived from codes and memos, we lastly qualitatively assessed the extent to which case studies reflected each theme to allow for comparison.

3.3 Results

3.3.1 Conservation principles and priorities in MSP

The case studies varied in their guiding principles, policies, sectors addressed, and use of conservation tools (Table 3.1, see Appendix B for case study overview). These differences alone do not necessarily imply stronger or weaker integration of conservation but reflect diverse approaches to conservation and, potentially, enabling conditions for integration.

Table 3.1. Differences across case studies in their inclusion of conservation in MSP, from mention of conservation-centric guiding principles to references to specific conservation management tools. Documents analyzed were *(1) Royal Decree establishing the marine spatial planning for the period 2020 to 2026 in the Belgian sea-areas* and a public-facing brochure; (2) *Update of the Integrated Management Plan for the Norwegian Sea*; (3) *Scotland's National Marine Plan*; (4) *Welsh National Marine Plan*; and (5) *Marine Spatial Plan for Washington's Pacific Coast*.

MSP case study	**Conservation included in MSP as . . .**					
	Guiding principles	Overarching policy	Specific goals	Dedicated section	Specific commitments	Specific tools
Belgium	✓		✓	✓	✓	✓
Norway			✓	✓	✓	✓
Scotland	✓	✓	✓*			✓
Wales	✓	✓	✓*			✓
Washington	✓					✓

*Scotland relies on strategic objectives from the European Marine Strategy Framework Directive and both Scotland and Wales refer to the UK's High-Level Marine Objectives, though neither provide independent conservation specific goals.

The analyzed plans rarely referred to principles and priorities as conservation *per se*, particularly for references to "resilience" and "reduce/manage impacts". Across case studies, sustainability-related codes were used most often (23% of all references), while codes for "general conservation", "conservation measure/tool", "ecosystem services", "habitat protection", "specific species", and "resilience" collectively accounted for less than half of all references (40%, Figure 3.1). The Welsh case relied more on sustainability and resilience concepts than other plans, with references to these codes being 17- and 7-percentage points higher than average, respectively (Figure 3.2).

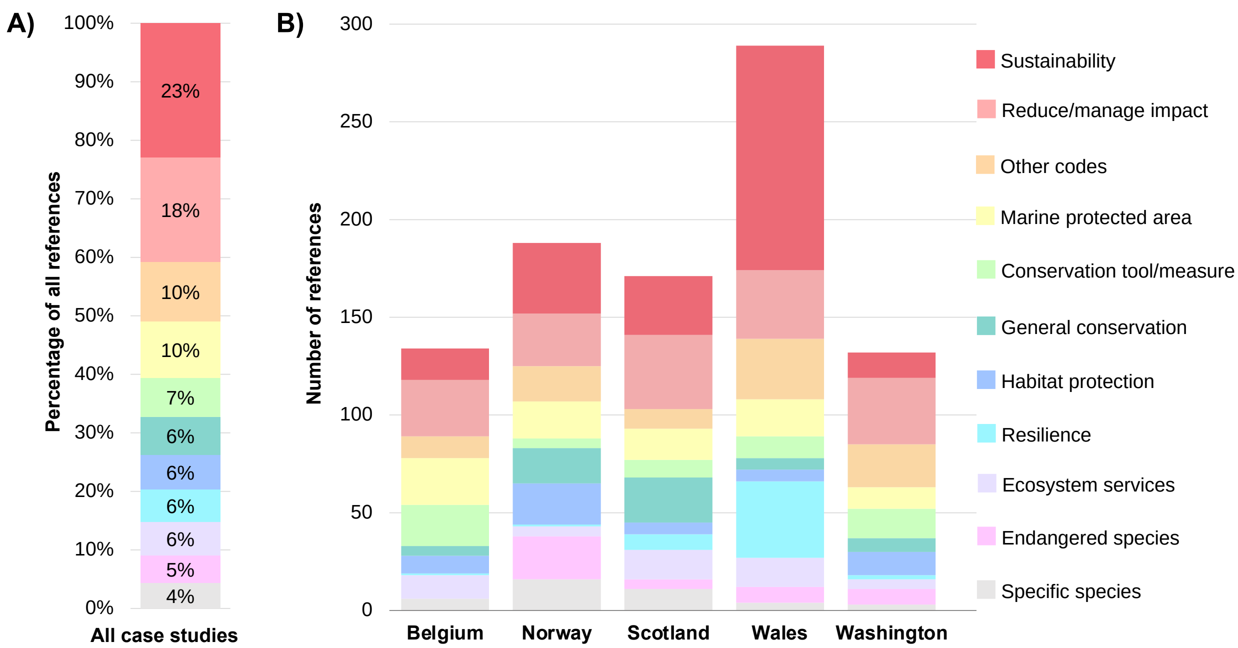


Figure 3.1. Occurrences of conservation principles and priorities referenced in MSP case studies. References to codes related to conservation principles and priorities (A) as percentages across all case studies and (B) as frequencies within individual case study documents. Other codes include those with fewer than 15 references across all case studies: “connectivity & coherence”, “ecosystem function”, “invasive species”, “long-term”, and “restoration”. Sustainability-related codes include “sustainability”, “blue economy”, “sustainable development”, “Sustainable Development Goal 14”, and “sustainable resource use”. MPA related codes include “marine protected area”, “MPA network”, and “specific MPA”.

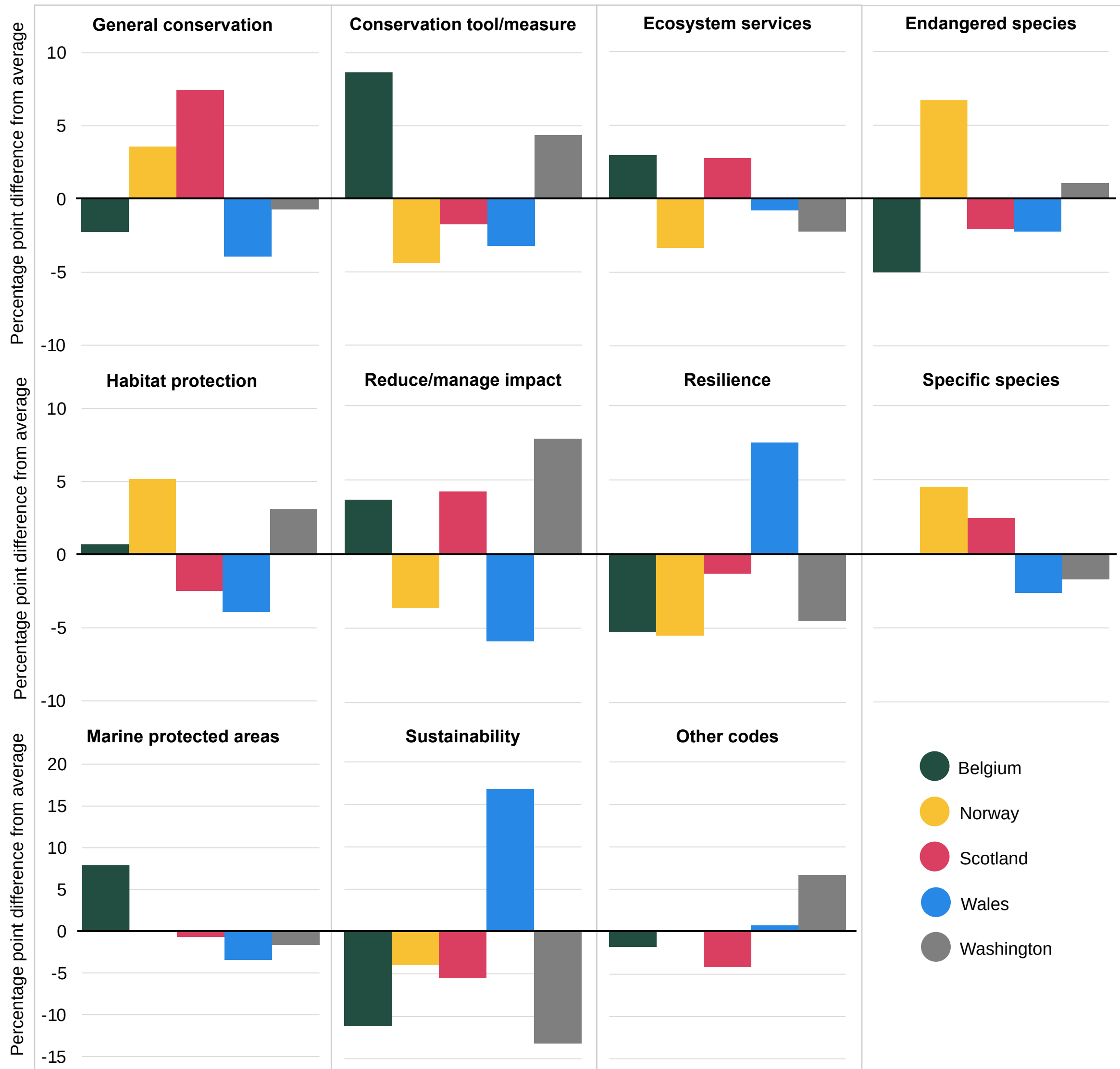


Figure 3.2. Comparisons of conservation principles and priorities across MSP case studies, showing percentage point deviation within each case study from the average percentage of references per code across all case studies.

3.3.2 Themes on conservation in MSP

Our analysis revealed five organizing themes, developed from coding and analytical memos, reflecting how MSP includes conservation (Table 3.2, Figure B2), on a spectrum of strong to weak inclusion: (1) *ecosystems as fundamental*, (2) *ecosystems as functional*, (3) *social-ecological systems* (4) *ecosystems as limits,* and (5) *prioritizing economy* (Table B3, see Annex B for detailed themes descriptions).

Ecosystems as fundamental emerged from all but the Welsh case, demonstrates the value of ecosystems beyond the services provided, and represents the strongest inclusion of conservation (Table 3.2). The Norwegian, Scottish, and Washington cases recognize connectivity between species, habitats, and ecosystem function, and point to a need for reducing threats to these. The Belgian, Norwegian, and Scottish cases present commitments to biodiversity management and reducing risk of impacts to MPAs to ensure high quality MPAs to meet conservation objectives. The Belgian plan emphasizes "working with nature" and defines MPA boundaries, reflecting the higher-than-average references to this code (Figure 3.2). This theme also reflects that these cases showed more frequent references to conservation principles and priorities, cumulatively, compared to sustainability and reducing impacts (Figure 3.1).

Table 3.2. Definitions of organizing and basic themes and the number of analytical memos sorted into each basic theme per case study.

Organizing theme (number of memos per theme)	**Basic theme**	**BELGIUM**	**NORWAY**	**SCOTLAND**	**WALES**	**WASHINGTON**
Ecosystems as fundamental: Healthy ecosystems underpin the ocean economy and have intrinsic value beyond the services they provide. (15)	Ecosystems, species, and habitats are interconnected and impacts to ecosystems should be avoided to maintain ecosystem function.		✓✓	✓		✓✓
	Prioritizing biodiversity conservation via effective conservation measures, including marine protected areas.	✓✓✓ ✓✓✓ ✓	✓✓	✓		
Ecosystems as functional: Ecosystems serve functions that benefit society through the delivery of ecosystem services. (13)	Ecosystems and the services they provide hold economic value.		✓✓✓	✓		
	Reducing threats and impacts to ecosystem services supports long-term sustainability.		✓✓	✓	✓	✓
	Co-locating conservation measures with other activities delivers ecosystem service benefits from protected areas.			✓	✓✓	✓
Social-ecological systems: Interdependencies between the socio-economic and ecological systems are recognized. (7)	Contributions of ecosystems to well-being are recognized as important for sustainability.	✓			✓✓	✓✓
	Space is created for local needs and priorities to be reflected in planning and management.			✓		✓

Ecosystems as limits: Ecosystems can be sustainably developed, and resources extracted, at a maximum within environmental limits. (10)	Sustainable development and maximum sustainable use occur within ecological limits of the marine environment.		✓	✓✓✓	✓✓	
	Environmental limits and risks are identified but guidance for managing within limits is not provided.			✓✓	✓	✓
Prioritizing economy: Continuation and/or development of ocean industries are clear priorities of marine spatial plans. (15)	Current and, to a lesser extent, new activities are maintained and impacts of activities on each other are minimized.	✓✓			✓✓✓	✓✓✓
	Activities with economic value are permitted within protected areas to limit the impact of conservation on industry.	✓	✓	✓✓✓✓		✓

Ecosystems as functional focuses on ecosystem services that benefit society and a more utilitarian view of conservation, emerging clearly from most cases (Table 3.2) and only somewhat from the Belgian case via coding (Figure 3.2). This theme acknowledges that reducing threats and impacts to ecosystems is necessary to ensure the long-term delivery of services, particularly economically valuable services in the Norwegian and Scottish cases. While “ecosystem services” was not coded particularly often (Figure 3.1), it guided most the analyzed plans, exemplified by the Norwegian case stating, “there is a clear relationship between biodiversity conservation and ecosystem functioning and the provision of ecosystem services”.

Social-ecological systems was the least evident among themes, recognizing the contributions of ecosystems to well-being and a need for local engagement with MSP (Table 3.2). In the Scottish case, the national plan is intended to guide regional planners doing more localized MSP. This theme also reflects the recognized role of Tribal governments in the Washington case. The Welsh case was the only plan with cultural objectives, including preserving language, contributing to well-being, ensuring access to the marine environment, and an overarching policy for a “strong, healthy, and just society”. In the Belgian case, the connection between the social and ecological systems was clear from the onset, stating that “striving for the desired level of naturalness will result in healthy ecosystem services, at the service of social well-being.”

Ecosystems as limits emerged from all but the Belgian case, indicating that ecosystems can be exploited to a sustainable maximum capacity (Table 3.2). This theme suggests that sustainable development and use occur within ecological limits, though plans often acknowledged limits without defining them or providing guidance to manage within them. The Scottish, Welsh, and Washington cases in particular omit responsibility for managing within limits or defer this to other policies, plans, or agencies. Both the Scottish and Welsh cases follow the UK guidance of “living within environmental limits” as an overarching policy for users of the plan (Table 3.1). This theme also reflects the higher-than-average references to “resilience” in the Welsh case (Figure 3.2), as resilient ecosystems may better withstand maximal sustainable use.

Prioritizing economy emerged prominently across cases as plans aimed to coordinate continued use and development of existing and future activities (Table 3.2). This theme reflects frequent references to sustainability and “reduce/manage impact” (Figure 3.1), a priority for maintaining activities and minimizing their impacts on each other, and allowing activities within MPAs (Table 3.2). The Belgian and Scottish cases in particular allow economically important activities within MPAs where there is, in the Scottish case, “social or economic benefits of national importance”. This theme is less apparent in the Norwegian case but is masked by a pattern of requiring longer-term assessments to warrant conservation action, thereby ensuring continuance of economic activities and limiting conservation’s impact on other uses.

3.3.3 Conservation ready MSP

Our analysis reveals that some plans appear more prepared to integrate conservation than others. We argue that some plans are more conservation ready – better prepared to support and enact conservation given their use of conservation principles and priorities and inclusion of conservation through policies, goals, commitments, specific tools, or as a use of marine space. We suggest that the themes presented here reflect a spectrum of conservation readiness (Figure 3.3). Plans favouring *ecosystems as fundamental* and *ecosystems as functional*, like the Belgian and Norwegian cases, may be more conservation ready than plans favouring *ecosystems as limits* and *prioritizing economy*, like the Scottish, Welsh, and Washington cases (Figure 3.4).

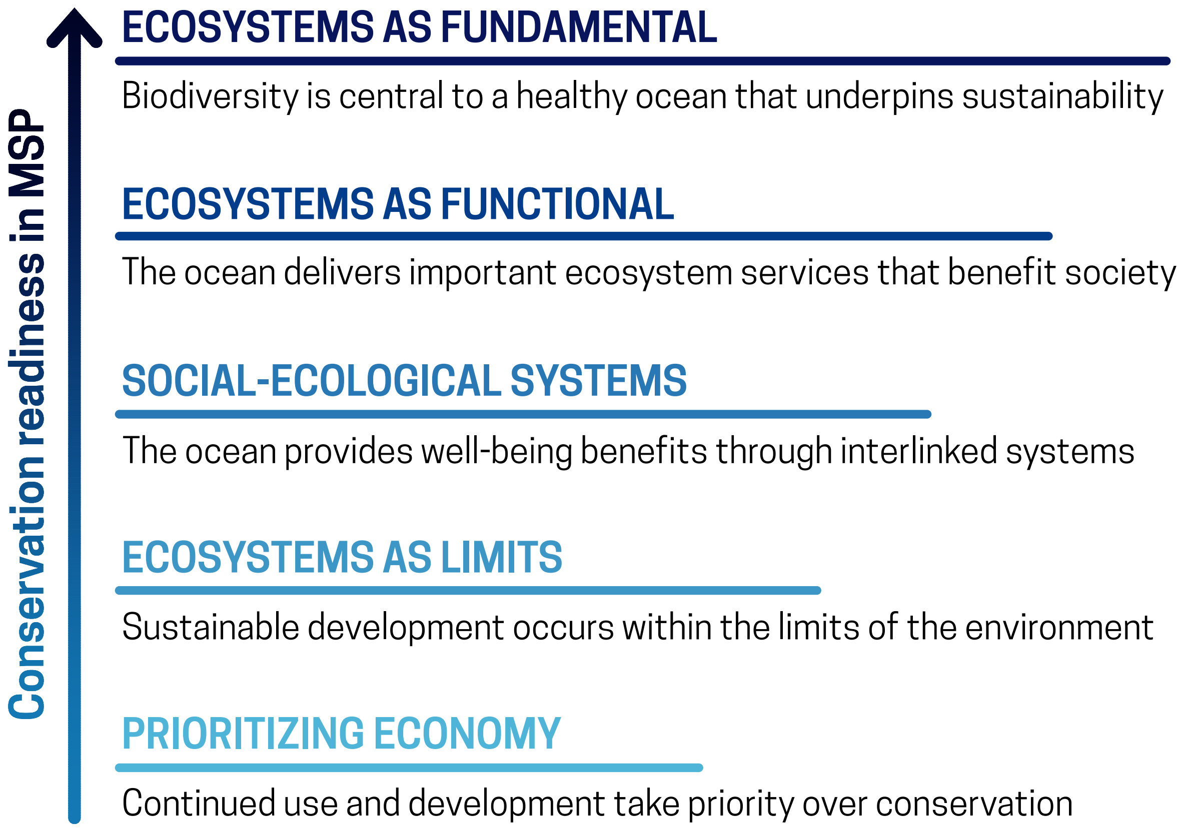


Figure 3.3. Conservation readiness in MSP based on organizing themes derived from case studies, where readiness is highest in plans that incorporate conservation using an *ecosystems as fundamental* theme and lowest in plans that incorporate conservation using a *prioritizing economy* theme.

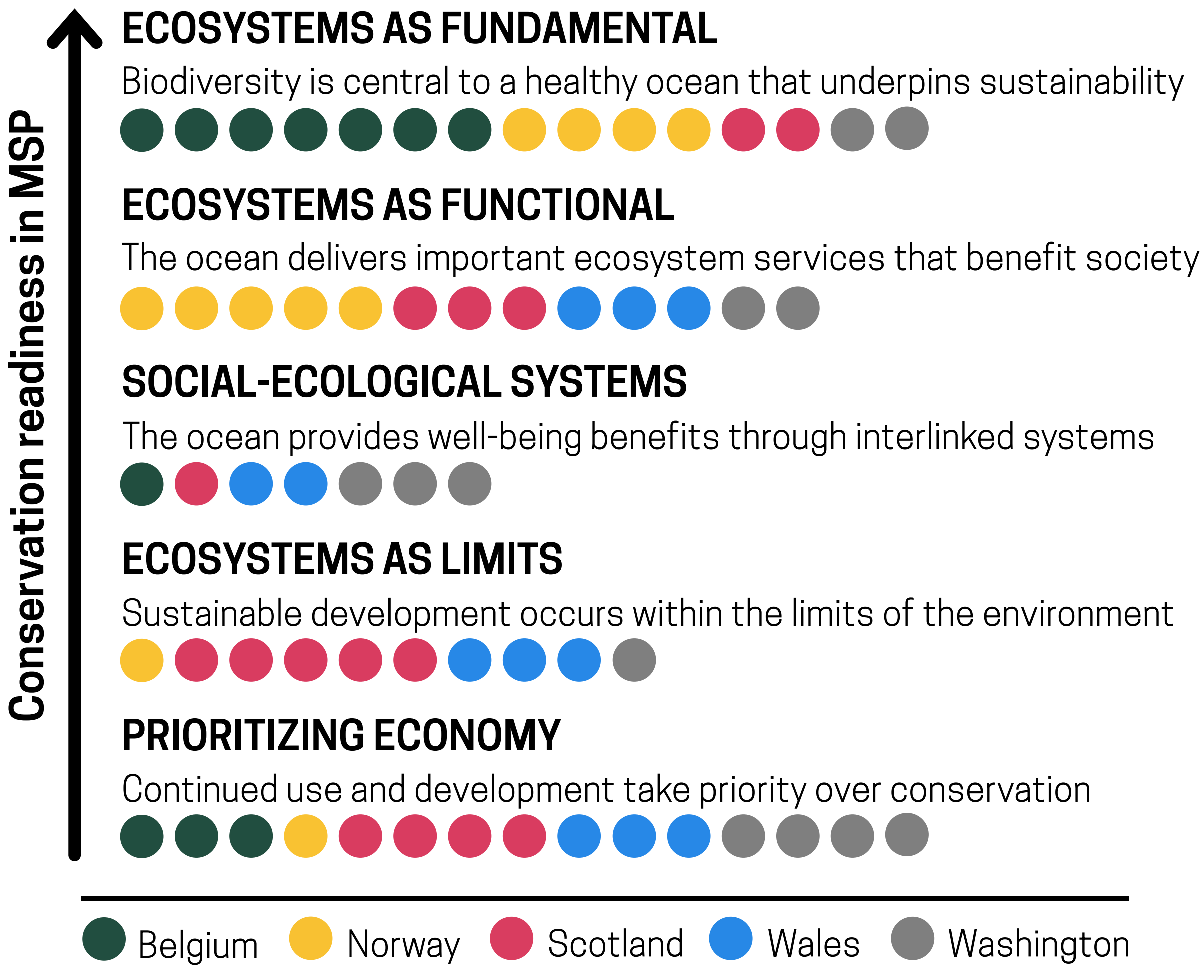


Figure 3.4. Conservation readiness across MSP case studies. The relative importance of organizing themes per case study is depicted with coloured circles for analytical memos sorted into each theme (see Table 3.2). Case studies can reflect multiple themes to varying extents, affecting their level of conservation readiness.

Plans that frame *ecosystems as fundamental* may be the most conservation ready, recognizing that biodiversity conservation serves as a foundation for sustainable resource use (Frazão Santos et al., 2018, Figure 3.3). The Belgian and Norwegian plans most strongly reflect this theme (Figure 3.4), making specific conservation commitments (Table 3.1) and higher-than-average coding frequencies for conservation priorities (Figure 3.2). For these plans, conservation principles and priorities are more apparent, ecosystems are seen as interconnected, and biodiversity is prioritized in conservation measures (Figure 3.1, Table 3.2).

Plans that frame *ecosystems as functional* may still be conservation ready, reflecting the role of healthy ecosystems in sustaining economically important services (Table 3.2); however, prioritizing only target species would limit the role of wider "biodiversity services" (Cavanagh et al., 2016; Seddon et al., 2016), potentially dampening conservation readiness. This theme is apparent in the Norwegian case, where conservation appears to serve as an enabling factor for sustainable use. This and the Belgian case also favour *ecosystems as fundamental*, improving conservation readiness relative to the Scottish case that leans more toward *ecosystems as limits* (Figure 3.4).

Plans that reflect *social-ecological systems* recognize the importance of ecosystems to well-being, and thus their importance to sustainability, and may be somewhat conservation ready (Table 3.2, Figure 3.3). Favouring *social-ecological systems* may improve the inclusion of local needs and well-being objectives, as exemplified by the Washington and Welsh cases. Positive well-being outcomes can enhance MPA effectiveness by being more socially acceptable (Ban et al., 2019). Thus, favouring *social-ecological systems* may similarly support well-being outcomes in MSP, thereby improving social acceptability and potentially conservation readiness.

While *ecosystems as limits* acknowledges the ecosystem, *prioritizing economy* favours development and minimizing the impact of conservation on continued use. Plans favouring these themes, including the Scottish, Washington, and Welsh cases, may be less conservation ready (Figure 3.4), as their focus lies in sustainability, reducing or managing impacts, and resilience (Figure 3.2). The Welsh case notably relied on resilience concepts, which were tied to future ocean benefits rather than explicitly ecological resilience. The Scottish and Welsh plans also refer to "maximizing sustainable development" without defining the "maximum". This language may stem from fisheries maximum sustainable yield, which similarly relies on environmental limits and has been criticized for its simplistic view of ecosystems (Legović et al., 2010). These plans may be less ready to integrate conservation, focusing instead on sustaining extractive activities.

3.4 Discussion

Our analysis demonstrates that a layering of themes is likely required to achieve diverse MSP objectives (Figure 3.4), but that conservation readiness may be bolstered through certain themes, particularly by framing ecosystems as fundamental to sustainable use and development. Conservation may be embedded in MSP via *ecosystems as functional* and *social-ecological systems*; enacted through conservation measures via *ecosystems as fundamental*; and address impacts from multiple uses via *ecosystems as limits*. Sectors depending on healthy ecosystems, like fisheries, may benefit more from conservation ready MSP in the short-term than less dependent sectors, like mining, where *prioritizing economy* may take precedent. In the long term, conservation ready MSP may safeguard healthy ecosystems by avoiding trade-offs between immediate profit and the long-term delivery of multiple benefits.

We suggest that planners consider how each of these themes are reflected in MSP, and how the use of conservation principles and priorities can ensure that healthy ecosystems support full spectrum sustainability (Foley et al., 2020). Conservation readiness might be improved via a dedicated conservation component in MSP, as in the Belgian and Norwegian cases; however, we also recommend that conservation be viewed as underpinning other ocean uses, reflecting the need for protection and restoration to deliver sustainability (Claudet, 2021). These cases were both in the adaptation phase of MSP (Table B1) and may be more conservation ready than earlier iterations. Conservation readiness may require time and adaptation as plans are evaluated and new information becomes available. MSP that incorporates well-being considerations, reflecting the social-ecological systems theme, and that goes further to prioritize participation, equity, and inclusion, may bolster conservation readiness via social acceptance. Further, since marine spatial plans often prioritize economic development (Trouillet, 2020), the historical context of conservation and political motivations will likely influence conservation readiness.

Conservation ready MSP does not negate the need for conservation planning. We found that the analyzed plans rarely focused on finer principles and priorities, such as connectivity, ecosystem function, restoration, and long-term conservation, which may be difficult to include in MSP. For instance, connectivity is essential for ecosystem functioning and can support ecosystem-based MSP (Foley et al., 2010), but achieving connectivity remains a challenge in conservation planning (Balbar & Metaxas, 2019), potentially hindering its uptake in MSP. Our results highlight how some conservation concepts can be co-opted by MSP to promote use in perpetuity. In our analysis, resilience seems disconnected from the ability of ecosystems to recover from disturbances without slowly degrading, and therefore did not consider the need for conservation measures to promote resilience (Darling & Côté, 2018; Hughes et al., 2005). Comprehensive MSP that uses conservation planning as a tool may improve conservation readiness (Trouillet & Jay, 2021).

MSP research and practice are diverse (Trouillet, 2020). The plans assessed in this study do not reflect the full spectrum of MSP and our results may be less relevant to non-European or European influenced nations. While our qualitative analysis was comprehensive, it was limited to five marine spatial plans available in English. We propose the concept of conservation ready MSP as potentially beneficial, but the concept may not be generalizable for all MSP initiatives. The plans analyzed here take different approaches to conservation, but there are many more approaches that could further inform conservation ready MSP. This analysis was conducted on the most recent iteration of MSP and does not reflect accompanying documents that could add to our interpretations. Future work may consider these accompanying documents and additional plans, programs, or policies that MSP may rely on to bolster conservation readiness. Further, it is possible that highly integrated governance frameworks confer conservation readiness, which may also be explored in future research. Our analysis does not assess conservation outcomes, but future studies may continue this work by analyzing outcomes to further develop this concept.

3.5 Conclusion

Our results suggest that MSP is driven by ocean management and impact mitigation to foster sustainable use and development. With cumulative impacts from climate change and human activities increasing in intensity across the ocean (Halpern et al., 2019), mainstreaming biodiversity in strategy, policy, and planning is critical for sustainable development (OECD, 2018). As others have identified a need for climate ready MSP (Frazão Santos et al., 2020), we suggest a need for conservation ready MSP to support progress toward global ocean goals (Secretariat of the Convention on Biological Diversity et al., 2016; Secretariat of the Convention on Biological Diversity & Technical Advisory Panel-GEF, 2012). MSP may be more conservation ready when ecosystems are viewed as fundamental to sustainable use, rather than limits to resource use or prioritizing economy. Conservation readiness is not intended to bias MSP, but rather to integrate the objectives of marine protection, sustainable use, and sustainable development. We propose conservation ready MSP as a concept and a call to action to centralize biodiversity in planning if we are to achieve a truly sustainable blue economy.

3.6 References

Attride-Stirling, J. (2001). Thematic networks: An analytic tool for qualitative research. *Qualitative Research*, *1*(3), 385–405. https://doi.org/10.1177/146879410100100307

Balbar, A. C., & Metaxas, A. (2019). The current application of ecological connectivity in the design of marine protected areas. *Global Ecology and Conservation*, *17*, e00569. https://doi.org/10.1016/j.gecco.2019.e00569

Ban, N. C., Gurney, G. G., Marshall, N. A., Whitney, C. K., Mills, M., Gelcich, S., Bennett, N. J., Meehan, M. C., Butler, C., Ban, S., Tran, T. C., Cox, M. E., & Breslow, S. J. (2019). Well-being outcomes of marine protected areas. *Nature Sustainability*, *2*(6), 524–532. https://doi.org/10.1038/s41893-019-0306-2

Birks, M., Chapman, Y., & Francis, K. (2008). Memoing in qualitative research: Probing data and processes. *Journal of Research in Nursing*, *13*(1), 68–75. https://doi.org/10.1177/1744987107081254

Cavanagh, R. D., Broszeit, S., Pilling, G. M., Grant, S. M., Murphy, E. J., & Austen, M. C. (2016). Valuing biodiversity and ecosystem services: A useful way to manage and conserve marine resources? *Proceedings of the Royal Society B: Biological Sciences*, *283*(1844), 20161635. https://doi.org/10.1098/rspb.2016.1635

Claudet, J. (2021). The seven domains of action for a sustainable ocean. *Cell*, *184*(6), 1426–1429. https://doi.org/10.1016/j.cell.2021.01.055

Claudet, J., Bopp, L., Cheung, W. W. L., Devillers, R., Escobar-Briones, E., Haugan, P., Heymans, J. J., Masson-Delmotte, V., Matz-Lück, N., Miloslavich, P., Mullineaux, L., Visbeck, M., Watson, R., Zivian, A. M., Ansorge, I., Araujo, M., Aricò, S., Bailly, D., Barbière, J., … Gaill, F. (2020). A Roadmap for Using the UN Decade of Ocean Science for Sustainable Development in Support of Science, Policy, and Action. *One Earth*, *2*(1), 34–42. https://doi.org/10.1016/j.oneear.2019.10.012

Darling, E. S., & Côté, I. M. (2018). Seeking resilience in marine ecosystems. *Science*, *359*(6379), 986–987. https://doi.org/10.1126/science.aas9852

Ehler, C. N. (2020). Two decades of progress in Marine Spatial Planning. *Marine Policy*. https://doi.org/10.1016/j.marpol.2020.104134

Ehler, C., Zaucha, J., & Gee, K. (2019). Maritime/Marine Spatial Planning at the Interface of Research and Practice. In J. Zaucha & K. Gee (Eds.), *Maritime Spatial Planning: Past, present, future* (pp. 1–21). Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-319-98696-8

Fereday, J., & Muir-Cochrane, E. (2006). Demonstrating Rigor Using Thematic Analysis: A Hybrid Approach of Inductive and Deductive Coding and Theme Development. *International Journal of Qualitative Methods*, *5*(1), 80–92. https://doi.org/10.1177/160940690600500107

Flannery, W., Toonen, H., Jay, S., & Vince, J. (2020). A critical turn in marine spatial planning. *Maritime Studies*, *19*(3), 223–228. https://doi.org/10.1007/s40152-020-00198-8

Foley, M. M., Halpern, B. S., Micheli, F., Armsby, M. H., Caldwell, M. R., Crain, C. M., Prahler, E., Rohr, N., Sivas, D., Beck, M. W., Carr, M. H., Crowder, L. B., Emmett Duffy, J., Hacker, S. D., McLeod, K. L., Palumbi, S. R., Peterson, C. H., Regan, H. M., Ruckelshaus, M. H., … Steneck, R. S. (2010). Guiding ecological principles for marine spatial planning. *Marine Policy*, *34*(5), 955–966. https://doi.org/10.1016/j.marpol.2010.02.001

Foley, P., Pinkerton, E., Wiber, M., & Stephenson, R. (2020). Full-spectrum sustainability: An alternative to fisheries management panaceas. *Ecology and Society*, *25*(2). https://doi.org/10.5751/ES-11509-250201

Folke, C., Holling, C. S., & Perrings, C. (1996). Biological Diversity, Ecosystems, and the Human Scale. *Ecological Applications*, *6*(4), 1018–1024. https://doi.org/10.2307/2269584

Frazão Santos, C., Agardy, T., Andrade, F., Calado, H., Crowder, L. B., Ehler, C. N., García-Morales, S., Gissi, E., Halpern, B. S., Orbach, M. K., Pörtner, H.-O., & Rosa, R. (2020). Integrating climate change in ocean planning. *Nature Sustainability*. https://doi.org/10.1038/s41893-020-0513-x

Frazão Santos, C., Agardy, T., Andrade, F., Crowder, L. B., Ehler, C. N., & Orbach, M. K. (2018). Major challenges in developing marine spatial planning. *Marine Policy*, *August*, 1–3. https://doi.org/10.1016/j.marpol.2018.08.032

Frazão Santos, C., Domingos, T., Ferreira, M. A., Orbach, M., & Andrade, F. (2014). How sustainable is sustainable marine spatial planning? Part I-Linking the concepts. *Marine Policy*, *49*, 59–65. https://doi.org/10.1016/j.marpol.2014.04.004

Halpern, B. S., Frazier, M., Afflerbach, J., Lowndes, J. S., Micheli, F., O'Hara, C., Scarborough, C., & Selkoe, K. A. (2019). Recent pace of change in human impact on the world's ocean. *Scientific Reports*, *9*(1), 11609. https://doi.org/10.1038/s41598-019-47201-9

Hughes, T., Bellwood, D., Folke, C., Steneck, R., & Wilson, J. (2005). New paradigms for supporting the resilience of marine ecosystems. *Trends in Ecology & Evolution*, *20*(7), 380–386. https://doi.org/10.1016/j.tree.2005.03.022

IUCN. (2021). *IUCN Definitions—English*. International Union for the Conservation of Nature. https://www.iucn.org/sites/dev/files/iucn-glossary-of-definitions_en.pdf

Jones, P. J. S., Lieberknecht, L. M., & Qiu, W. (2016). Marine spatial planning in reality: Introduction to case studies and discussion of findings. *Marine Policy*, *71*, 256–264. https://doi.org/10.1016/j.marpol.2016.04.026

Jouffray, J.-B., Blasiak, R., Norström, A. V., Österblom, H., & Nyström, M. (2020). The Blue Acceleration: The Trajectory of Human Expansion into the Ocean. *One Earth*, *2*(1), 43–54. https://doi.org/10.1016/j.oneear.2019.12.016

Laffoley, D., Baxter, J. M., Amon, D. J., Claudet, J., Hall-Spencer, J. M., Grorud-Colvert, K., Levin, L. A., Reid, P. C., Rogers, A. D., Taylor, M. L., Woodall, L. C., & Andersen, N. F. (2020). Evolving the narrative for protecting a rapidly changing ocean, post-COVID-19. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *n/a*(n/a), 1–23. https://doi.org/10.1002/aqc.3512

Legović, T., Klanjšček, J., & Geček, S. (2010). Maximum sustainable yield and species extinction in ecosystems. *Ecological Modelling*, *221*(12), 1569–1574. https://doi.org/10.1016/j.ecolmodel.2010.03.024

Margules, C. R., & Pressey, R. (2000). Systematic conservation planning. *Nature*, *405*(6783), 243–253. https://doi.org/10.1038/35012251

OECD. (2018). *Mainstreaming Biodiversity for Sustainable Development*. OECD Publishing. https://doi.org/10.1787/9789264303201-en

Reimer, J. M., Devillers, R., & Claudet, J. (2020). Benefits and gaps in area-based management tools for the ocean Sustainable Development Goal. *Nature Sustainability*. https://doi.org/10.1038/s41893-020-00659-2

Sandelowski, M., Voils, C. I., & Knafl, G. (2009). On Quantitizing. *Journal of Mixed Methods Research*, *3*(3), 208–222. https://doi.org/10.1177/1558689809334210

Schupp, M. F., Bocci, M., Depellegrin, D., Kafas, A., Kyriazi, Z., Lukic, I., Schultz-Zehden, A., Krause, G., Onyango, V., & Buck, B. H. (2019). Toward a Common Understanding of Ocean Multi-Use. *Frontiers in Marine Science*, *6*, 165. https://doi.org/10.3389/fmars.2019.00165

Secretariat of the Convention on Biological Diversity, Food and Agriculture Organisation of the United Nations, The World Bank, United Nations Environment Programme, & United Nations Development Programme. (2016). *Biodiversity and the 2030 Agenda for Sustainable Development Biodiversity Is Essential for Sustainable Development*. https://www.cbd.int/development/doc/biodiversity-2030-agenda-technical-note-en.pdf

Secretariat of the Convention on Biological Diversity & Technical Advisory Panel-GEF. (2012). *Marine spatial planning in the context of the convention on biological diversity: A study carried out in response to CBD COP 10 decision X/29.* (No. 68; Technical Series, p. 44). http://www.deslibris.ca/ID/242835

Seddon, N., Mace, G. M., Naeem, S., Tobias, J. A., Pigot, A. L., Cavanagh, R., Mouillot, D., Vause, J., & Walpole, M. (2016). Biodiversity in the Anthropocene: Prospects and policy. *Proceedings of the Royal Society B: Biological Sciences*, *283*(1844), 20162094. https://doi.org/10.1098/rspb.2016.2094

Skjott Linneberg, M., & Korsgaard, S. (2019). Coding qualitative data: A synthesis guiding the novice. *Qualitative Research Journal*, *19*(3), 259–270. https://doi.org/10.1108/QRJ-12-2018-0012

Trouillet, B. (2020). Reinventing marine spatial planning: A critical review of initiatives worldwide. *Journal of Environmental Policy and Planning*, *22*(4), 441–459. https://doi.org/10.1080/1523908X.2020.1751605

Trouillet, B., & Jay, S. (2021). The complex relationships between marine protected areas and marine spatial planning: Towards an analytical framework. *Marine Policy*, *127*, 104441. https://doi.org/10.1016/j.marpol.2021.104441

United Nations. (2015). Transforming our world: The 2030 Agenda for Sustainable Development. *General Assembley 70 Session*, *16301*(October), 1–35. https://doi.org/10.1007/s13398-014-0173-7.2

Vaughan, D., & Agardy, T. (2020). Marine protected areas and marine spatial planning – allocation of resource use and environmental protection. In *Marine Protected Areas* (p. 35). Elsevier Ltd. https://doi.org/10.1016/b978-0-08-102698-4.00002-2

4. The MSP Index: A tool to guide and assess marine spatial planning

Abstract

Marine spatial planning has the potential to balance multiple demands for ocean space with environmental protection and is increasingly considered crucial for achieving global ocean goals. In theory, MSP should adhere to six principles: (1) ecosystem-based, (2) integrated, (3) place-based, (4) adaptive, (5) strategic, and (6) participatory. Despite nearly two decades of practice, MSP continues to face critical challenges with fully realizing these principles, hindering its ability to achieve the promise of balance. Here, we develop the MSP Index, a principle-based tool for assessing progress in MSP that can guide practitioners in actualizing principles in practice. We used qualitative analysis of fundamental MSP guides, complemented with literature review, to identify key features of MSP principles. We developed these features into a scoring guide that gauges progress relative to principles, then tested the Index on six case studies available in English from distinct regions. We found that the Index allows for high-level comparison across diverse types of marine spatial plans, highlighting the extent to which MSP principles have permeated practice. Our results reveal successes and gaps in MSP initiatives, particularly related to gaps in the adaptive and participatory principles. The Index does not assess MSP outcomes but serves as a guidance tool that would be best employed by practitioners. It is the first tool of its kind to link MSP principles to practice, allowing for assessment of individual initiatives and comparison of diverse initiatives across ocean regions and nations.

4.1 Introduction

Over the last 50 years, ocean industries have expanded at an increasing rate, representing a global acceleration in ocean development that is changing the ocean as it unfolds (Jouffray et al., 2020). Such rapid change may represent a loss to humanity of natural resources, ecosystems and the services they provide, life sustaining oxygen, and critical species (Laffoley et al., 2020). As nations develop aspirations for the blue economy – a pathway for bridging economic development with ocean stewardship, protection, and restoration (Mulazzani & Malorgio, 2017; Voyer et al., 2018) – the need for coordinated, collaborative, and comprehensive ocean planning becomes increasingly urgent.

Marine spatial planning (MSP) is a process for analyzing the spatial and temporal distributions of ocean uses to achieve ecological, economic, and social objectives (Ehler & Douvere, 2009). It offers a more holistic approach than traditional single-sector planning by accounting for multiple uses and objectives, while adopting some concepts from terrestrial planning (Jay, 2010; Jay et al., 2013). MSP can help to coordinate and regulate the blue economy by identifying sites for new ocean uses, mitigating conflicts, fostering collaboration, and promoting capacity building (UNESCO-IOC/European Commission, 2021), while still ensuring that efforts to realize the economic potential of the ocean does not damage already fragile ecosystems. At its core, MSP strives to achieve balance, holding the potential to deliver both ocean conservation and sustainable use or development objectives (Frazão Santos et al., 2018; Secretariat of the Convention on Biological Diversity & Technical Advisory Panel-GEF, 2012). There is a strong and growing body of academic research and theory behind MSP (Ehler et al., 2019; Flannery et al., 2020), but if this theory cannot be translated into practice (Trouillet, 2020), MSP will not fulfill its potential for supporting global goals for a healthy and productive ocean.

In their influential step-by-step guide to MSP, Ehler & Douvere (2009) identified characteristics of effective MSP: (1) ecosystem-based, (2) integrated, (3) place-based or area-based (hereafter, place-based), (4) adaptive, (5) strategic and anticipatory (hereafter, strategic), and (6) participatory. Here, we consider these characteristics to be foundational principles of MSP, aligning with those guiding MSP in the European Union (EU). For instance, the EU principal for "using MSP according to the area and type of activity" mirrors the place-based principle; "incorporating monitoring and evaluation" reflects the adaptive principle; and "coordination with Member States" aligns the integrated principle (Commission of the European Communities, 2008). The application of these principles in practice has proven challenging, as MSP continues to grapple with adaptation, engagement, institutions, and balancing economic development with conservation (Frazão Santos et al., 2018). MSP initiatives are diverse (Trouillet, 2020), and often driven by political interests and investments (Flannery et al., 2019), resulting in plans that unevenly employ best practices and may or may not support a sustainable blue economy.

As many initiatives worldwide are in pre-planning and plan preparation phases of MSP (Ehler, 2020), and given the growing prominence of blue economy discourses and policies (Golden et al., 2017; Silver et al., 2015), now is a critical time for providing guidance that ensures MSP theory informs practice. We aim to identify the key features of principles to develop the MSP Index, a tool that gauges progress on the use of principles within diverse MSP initiatives that can inform process improvement and MSP advancement toward best practices.

4.2 Methods

4.2.1. Identifying MSP features

We used a three-step process to identify and describe MSP features. We define features as prominent attributes of MSP principles that comprise a set of requirements – elements that describe a given feature. This three-step process involved (1) literature review and qualitative document analysis to identify potential features; (2) qualitative sorting to identify preliminary features; and (3) qualitative sorting to amalgamate and describe key features (Figure C1). First, potential features were derived from a review of fundamental MSP guides, including Ehler & Douvere's (2009) step-by-step guide and Ehler's (2014) guide to evaluating marine spatial plans. At the time of review, the recent international MSP guide (UNESCO-IOC/European Commission, 2021) had not yet been published. This review was supplemented with select papers that are widely accepted as leading publications in the subject area based on the number of citations or publications authored by subject matter experts (expertise determined by the number of articles on a topic by the author(s)) (Long et al. 2015, Table C1). Our intention was not to develop a comprehensive index, but an index that could be flexible enough to be adapted with alternative features as needed by MSP practitioners. Given this, it was deemed unnecessary to conduct an exhaustive literature review to identify all possible features under MSP principles, though we are confident that MSP best practices have been captured.

For document analysis, we used a blended approach to qualitative coding to identify features from the MSP guides and selected supplementary literature (Skjott Linneberg & Korsgaard, 2019). Passages of text were deductively assigned a code for the potential principle they reflected (e.g., adaptive or participatory) and inductively assigned a code for a potential feature (e.g., uncertainty or stakeholder dialogue) as they emerged from the text. Analysis of the selected literature resulted in 194 potential features. Potential features overlapped in their intention or, in some cases, better reflected potential requirements (i.e., descriptive elements or specific actions to be taken to fulfill a feature). We used cutting and sorting of the coded passages of text to group similar items together (Ryan & Bernard, 2003), establishing a set of 43 preliminary features. For each of these, we described an intention and retained potential requirements of features identified from the coded passages of text. Following this, we used a second round of cutting and sorting to amalgamate preliminary features where there were redundancies and to ensure best fit of the features to their respective MSP principles (Figures C1 & C2). This process resulted in a set of 36 key features, six per MSP principle, each with distinct intentions and requirements.

4.2.2. Developing & testing the MSP Index

Using the identified features, we developed the MSP index – a qualitative scoring guide that can be used to assess progress in MSP processes as it relates to MSP principles. In this guide, we used a four-point scale, from zero to three points. A zero measure indicated the absence of a feature, while one to three points captured the varying extents to which MSP meets feature criteria. For each possible score, we developed a concise criteria statement from feature intentions and requirements. In our index, a feature can be absent (score = 0); minimal, where a feature is generally present, but few requirements are present (score = 1); good, where commitments to a feature are made, but not all requirements are present (score = 2); or excellent, where all requirements are clearly present in an MSP initiative (score = 3).

To test the functionality of the MSP index, we applied the scoring guide to six international case studies. We selected case studies from an online database of MSP initiatives developed by the Intergovernmental Oceanographic Commission (IOC) (http://msp.ioc-unesco.org) in June 2021. It should be noted that, as of January 2022, this website is not active. We provide the MSP initiatives previously listed on this website in the data provided with Supplementary Information. To capture a diversity of MSP processes, we used stratified random sampling to identify one case study for each of the six regions identified by this website: Africa (n=10 MSP initiatives), Asia (n=8), Europe (n=38), Middle East (n=2), Oceania (n=10), and the Americas (n=38). Each of the 106 MSP initiatives was assigned an identifier number and all initiatives within a given region were arranged in numerical order. We used R Version 3.6.1 to randomly sample case studies by identifier number from each ocean region, then screened the associated case study using the following criteria:

- Language: the case study documentation must be in English
- Plan: the case study must have a final draft or final approved plan available
- Supporting content: the case study must have sufficient content publicly available

If a randomly selected case study did not meet these criteria, then we continued random sampling without replacement until a case study was selected that did meet the criteria. For most regions, the first or second case study screened met the inclusion criteria, except for Africa where the sixth case study screened met the criteria. The six selected case studies capture MSP initiatives of different times, at different scales, and with different intentions (Table 4.1).

Table 4.1. Characteristics of case studies selected to test functionality of the MSP index. Intention reflects the high-level purpose of each case study, where coastal zone planning focuses on integrated planning in that zone, conservation planning focuses on the protection of biodiversity and ecosystems, and marine planning encompasses a broader form of MSP.

Case study	**Year**	**Scale**	**Intention**
Ireland	2021	490,000 km^2	Marine planning
Israel	2015	26,000 km^2	Marine planning
Kiribati – PIPA*	2015	408,250 km^2	Conservation planning
Philippines – Bataan	2007	Up to 15 km municipal limit	Coastal zone planning
South Africa	2017	472,280 km^2	Marine planning
USA – Rhode Island	2010**	3,800 km^2	Marine planning

*PIPA – Phoenix Islands Protected Area

**Revisions of general policies and regulatory standards adopted January 10, 2012

We applied the MSP index to these case studies using qualitative coding of primarily the final marine spatial plan. Where it was unclear how to score a feature based on the final marine spatial plan, we reviewed grey literature for additional information, including webpages, legislation, guiding documents and frameworks, participation documents, and government documents where relevant. Passages of text within these documents were coded to features under the MSP principles. Once all documents had been coded, we reviewed the related passages of text to score each feature from using the scoring guide. Feature scores were then summed within each principle to determine a principle score (out of 18), and all six principle scores were summed to determine the overall MSP score (out of 108).

4.3 Results

4.3.1. The MSP Index

The MSP index comprises 36 features, ranging from establishing a common framework for integration in MSP to monitoring to setting goals and objectives (Figure 4.1). Of the 36 features, 33 were identified, in some part, from Ehler & Douvere (2009) and Ehler (2014). Only climate change (adaptive), multi-level integration (integrated), and scale (place-based) emerged from the supplementary literature alone. Most features emerged from more than one source, though resource allocation, climate change, upstream and downstream, and spatial information emerged from single sources (i.e., one reviewed document). The features broadly reflect best practices and core elements of MSP to assess the planning process as it relates to foundational principles, rather than MSP outcomes that relate to particular objectives (e.g., sustainable fishing practices, suitable areas for renewable energy development). Criteria statements for features ranged from a lack of recognition or intention to achieve a feature to implementation of a feature, where requirements have been met (Figure 4.2).

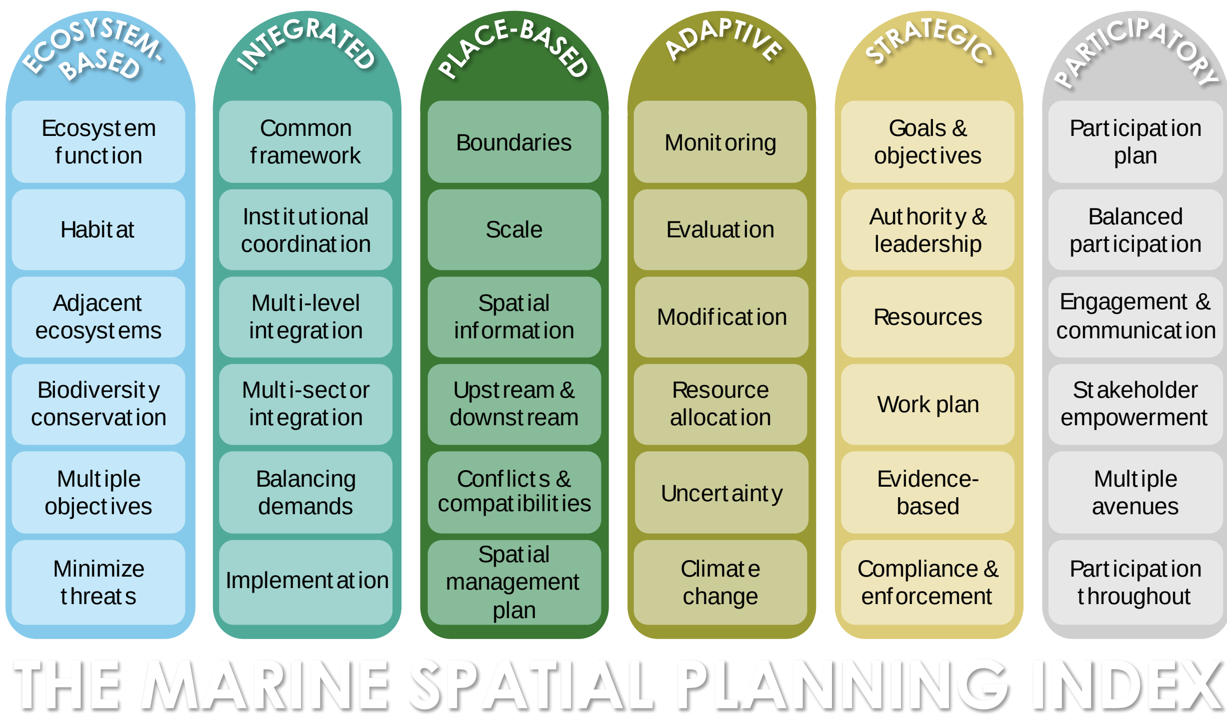


Figure 4.1. Features of the MSP index under foundational principles ecosystem-based, integrated, place-based, adaptive, strategic, and participatory. To assess MSP progress, each feature can score between zero and three points based on feature criteria statements defined in the MSP index scoring guide (Table C2).

	Absent (0)	Minimal (1)	Good (2)	Excellent (3)
ECOSYSTEM FUNCTION	No recognized need for policies and/or measures to maintain or restore ecological structure and function.	Recognized need for policies and/or measures to maintain or restore ecological structure and function, possibly including biotic and abiotic ecosystem components, disturbance regimes, trophic interactions, and/or population and/or community dynamics.	Policies and/or measures identified to maintain or restore ecological structure and function, including biotic and abiotic ecosystem components, disturbance regimes, trophic interactions, and/or population and community dynamics.	Policies and/or measures exist to maintain or restore ecological structure and function, including biotic and abiotic ecosystem components, disturbance regimes, trophic interactions, and population and community dynamics.
BOUNDARIES	No clear intention to establish boundaries.	Clear intention to establish boundaries for the planning area, possibly prior to initiating MSP, including geographical, administrative, and/or analytical boundaries at local, national, and transnational scales as needed.	Clear commitment to establishing boundaries for the planning area prior to initiating MSP, including geographical, administrative, and/or analytical boundaries at local, national, and transnational scales as needed.	Boundaries are established for the planning area prior to initiating MSP, including geographical, administrative, and analytical boundaries at local, national, and transnational scales as needed.
PARTICIPATION PLAN	No clear intention to establish a participation plan.	Intention to establish a plan that may indicate who, when, and how to involve stakeholders and rightsholders, may be developed at MSP onset, and/or may defines the participation objectives and/or entitlement to participate.	Commitment to establishing a plan indicating who, when, and how to involve stakeholders and rightsholders, developed at MSP onset, and/or defines participation objectives and entitlement to participate.	A plan exists, indicating who, when, and how to involve stakeholders and rightsholders; developed at MSP onset; defines participation objectives and entitlement to participate, which may evolve over time.

Ecosystem-based Place-based Participatory

THE MARINE SPATIAL PLANNING INDEX

Figure 4.2. Example scoring guide for three features from the MSP index under ecosystem-based, place-based, and participatory principles. Case studies were scored according to this guide (Table C2).

4.3.2. Testing the MSP Index

The analyzed case studies differed in their goals, processes, and capacity to affect and implement policy and regulations. Most case studies had goals related to sustainability, including sustainable use of resources, sustainable ecosystems, and sustainable development of new ocean uses; however, the Kiribati case, while listed by the IOC as an MSP initiative, appeared as a marine protected area planning in a remote and isolated region. Because this case study was listed as an MSP initiative by the IOC, we did not exclude it from analysis. All case studies were led or adopted by government authorities, except for the Israel plan that was primarily developed outside the government by a team of researchers, planners, and consultants. In this case, governments were stakeholders who participated in the MSP process.

While some plans established an MSP policy framework, others focused on regulations and zoning. The Bataan initiative was the only case study to establish zones for all uses and objectives (e.g., Aquaculture zone, municipal fishing zone, sanctuaries). The Rhode Island case established zones for only renewable energy development. The Rhode Island case was also the only initiative analyzed that established regulations, though these regulations were also specific to minimizing the impact of renewable energy developments on existing uses and the ecosystem. This plan occurred at the state-level with linkages to national-level policy and legislation. In contrast, the Ireland and South Africa case studies are national-level initiatives that established frameworks for decision-making concerning marine uses and planning.

We found that the MSP index was flexible enough to be applied to the diverse case studies selected (Table 4.1), providing a high-level snapshot of progress made toward realizing MSP principles in these initiatives (Figure 4.3). Of a possible 108 points, the initiatives scored between 84 (*Rhode Island Ocean Special Area Management Plan*) and 44 points (*Coastal Land- and Sea-use Zoning Plan of the Province of Bataan).* On average, the place-based principle scored highest across plans (13.5 out of 18 possible points). The lowest average scores were found for the adaptive (6.5 out of 18 possible points) and participatory principles (7.7 out of 18 possible points). For the remaining principles, average scores were 11.5, 11.5, and 12.2 out of 18 possible points for ecosystem-based, integrated, and strategic principles, respectively. The highest score for any principle was 16, achieved by the Rhode Island case for the place-based principle and the Kiribati case for the strategic principle. For all case studies, only nine of 36 principles (six per case study) scored 14 or higher, and four of these instances belonged to the Rhode Island initiative.

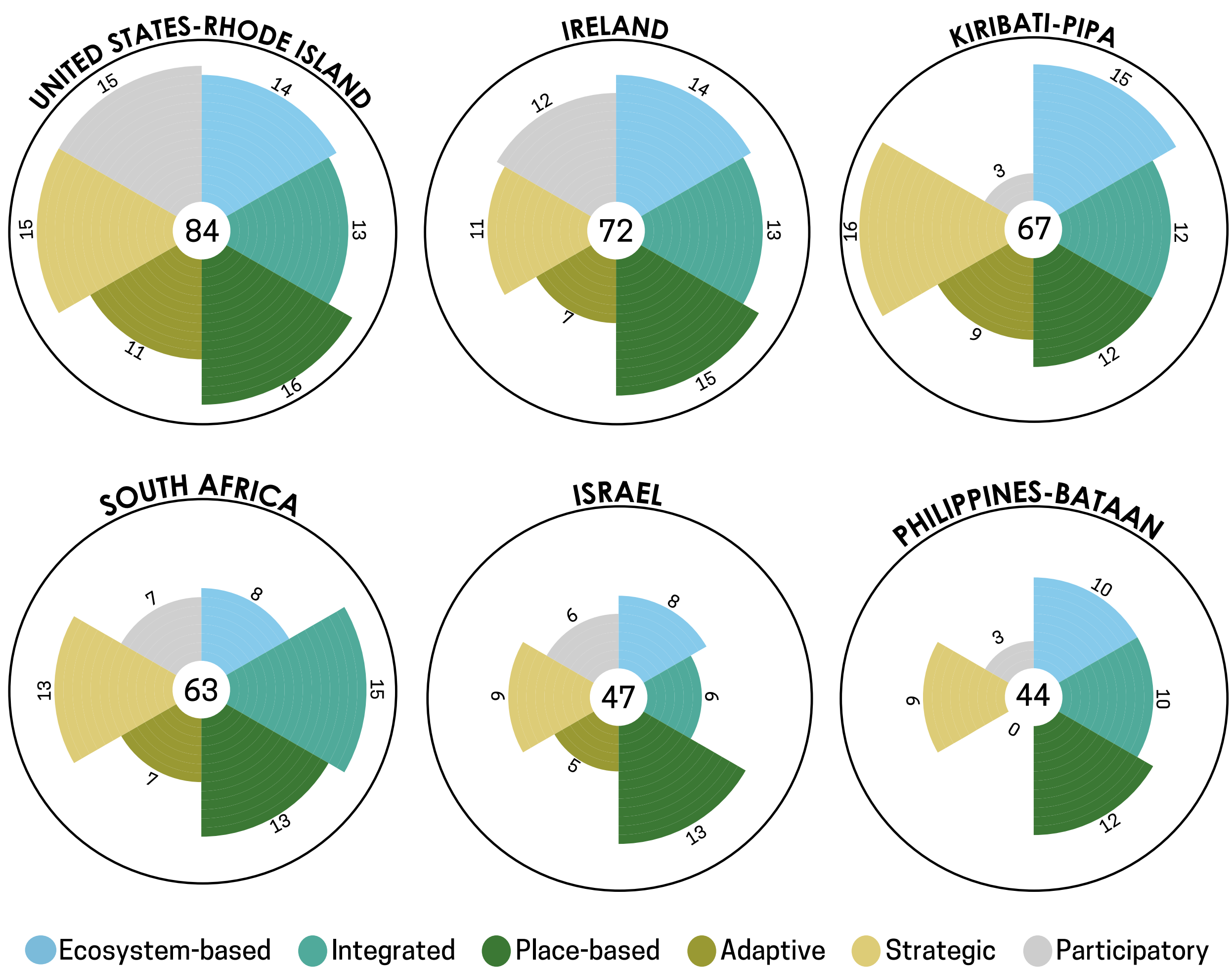


Figure 4.3. MSP index scores for assessed case studies, where each petal represents the score per MSP principle (ecosystem-based, integrated, place-based, adaptive, strategic, and participatory). The maximum score per principle is 18, depicted by the number at the outer edge of each petal. The maximum possible MSP index score is 108, depicted by the number in the centre of each flower plot.

Within principles, features were most often scored as good (score = 2; 43% of scores), followed by minimal (score = 1; 23% of scores), excellent (score = 3; 22% of scores), and absent (score = 0; 13% of scores). Resource allocation (adaptive) scored as absent for all case studies, while compliance and enforcement (strategic) and balancing demands (integrated) scored as minimal for all but Rhode Island and Kiribati cases. Uncertainty (adaptive) also scored as minimal for all but the Rhode Island case study. Under the participatory principle, stakeholder empowerment and participation plan both scored as absent for half of the case studies. In contrast, boundaries (place-based) scored as excellent for all cases except Israel, and spatial information (place-based) scored as excellent for all but the Kiribati and Bataan case studies (see data provided in Supplementary Information).

Within case studies, the Rhode Island case scored above average for all MSP principles, while the Israel and Bataan cases scored below average for all principles. The Israel case scored 50% of the maximum possible principle score (18) or less for all principles except place-based. The Bataan initiative was the only case study to score zero on a principle (adaptive). The Kiribati case (*Phoenix Islands Protected Area Management Plan 2015-2020*), scored below average for the participatory principle.

4.4 Discussion

We developed and tested the MSP Index, demonstrating how this new tool can facilitate high-level assessment of MSP documents, and ultimately MSP processes. The MSP Index gives a snapshot of the extent to which theoretical principles have permeated MSP practice. We found that the Index can be used to compare different types of MSP initiatives, from local to national-scale plans, recent and older plans, and plans with diverse objectives in sustainable resource use and biodiversity conservation. The case studies analyzed to test functionality of the Index revealed that while some principles are clearly intrinsic to the MSP process, like place-based which consistently scored high among analyzed initiatives, others appear more challenging to implement. We found that only 25% of MSP principles scored 14 or higher across case studies (maximum score = 18), resonating with persistent challenges facing MSP development, including deficiencies in political and institutional frameworks; stakeholder engagement; balancing economic development with conservation, and incorporating global environmental change (Frazão Santos et al., 2018). These challenges hinder the use of MSP principles in practice, reflected here under the integrated, participatory, ecosystem-based, and adaptive principles, respectively. Our case study analysis generally shows how MSP principles have been unevenly applied in practice.

MSP is not intended to lead to a one-time plan, but should be approached like other planning exercise as an iterative process that ensures the plan remains relevant (Ehler & Douvere, 2009). We found that the adaptive principle scored lowest across analyzed case studies (Figure 4.3). Once plans are complete, the incentive for governments to continue investment in MSP likely diminishes. There are few clear examples of MSP initiatives that embrace change, dynamic systems, and adaptation (Collie et al., 2013; Gissi et al., 2019), and initiatives seldom dedicate sufficient resources to monitoring, evaluation, and adaption (Frazão Santos et al., 2018). Further, it is difficult to disentangle the actual outcomes of MSP from all other elements affecting ocean activities and ecosystems (Varjopuro, 2019). At a global scale, evaluation in MSP has shifted away from evaluation of outcomes to evaluation of the MSP process itself (Stelzenmüller et al., 2021). A similar trend has been observed in conservation, where political and institutional barriers to assessing conservation impacts can be pervasive and difficult to overcome (Pressey et al., 2021). These challenges in evaluation were apparent in our analysis, as four case studies scored minimal or absent for the evaluation feature and no case study met the criteria for resource allocation under the adaptative principle, though it is possible that these features exist in practice and have not been publicly documented. The latter feature requires mechanisms for resources to be reallocated away from ineffective management actions to alternatives based on monitoring and evaluation (Table C2). Our application of the MSP Index reveals that the analyzed plans may be poorly prepared to undertake iterative planning and adaptation. Similarly, though to a lesser extent, our MSP Index scores show that many initiatives lack key features of a participatory process.

Recent MSP initiatives appear devoid of politics (Flannery et al., 2019), despite MSP being an intrinsically political process (Ehler & Douvere, 2009). This unpolitical version of MSP sanitizes the process toward consensus, likely disempowering stakeholders with diverse and contrasting views (Flannery et al., 2019). Through the MSP Index, our analysis may confirm this, as the stakeholder empowerment feature scored consistently low. To achieve an excellent score for this feature, an initiative must demonstrate that mechanisms exist to ensure stakeholders have the means, skills, and knowledge to participate in MSP, among other criteria (Table C2). Others have found a perception among MSP participants that the process is deliberately exclusionary, plagued by poor communication, fragmented governance, and vagueness surrounding winners and losers in MSP (Flannery et al., 2018). To be properly participatory, MSP initiatives must distinguish between inviting stakeholders to the table and empowering them to influence MSP outcomes, including policy (Said & Trouillet, 2020).

The MSP Index is intended to give a high-level overview of MSP initiatives, whether they are in development or implemented, but it does not evaluate the efficacy of MSP, nor MSP outcomes. The Index is limited in its capacity to reflect all aspects of MSP. One cannot discern the intention or context of MSP from Index scores alone. For example, the Kiribati case study presented here scored low on the participatory principle; however, the Phoenix Island Protected Area (PIPA) region lacks permanent human settlement and, at the time of this plan, was inhabited by fewer than 40 people employed as government caretakers for the protected area (Ministry of Environment, Lands and Agriculture Development, 2015). Given this, the participatory principle may not be as applicable to this case study as for others assessed here due to a lack of local users. In such cases, this principle might be omitted, or the Index might be adapted to employ other principles that suits local needs and MSP objectives. Over time, principles may become more or less relevant to an MSP initiative. In the case of PIPA, as the area is opened to commercial fishing for the first time since 2015 (Guterman, 2021), a participatory and inclusive process may be necessary for future iterations of MSP. With flexibility in use of the MSP Index and varied contexts, we recommend that Index scores be accompanied by a description of the analyzed plans to reflect local realities and challenges faced in MSP.

Despite recent growing recognition of the importance of culture for ocean planning and management (Christie et al., 2017; Kikiloi et al., 2017; McKinley et al., 2019), cultural values have not been widely embraced in MSP (Gee, 2017). As presented here, the MSP Index lacks a direct cultural component, which may reflect the relative importance of culture when fundamental MSP guides were published. Still, culture may be captured, in part, by some features. For example, criteria for the evidence-based feature includes use of the different types of information, such as Indigenous and local knowledge, and criteria for the stakeholder empowerment feature includes decentralizing management or enabling participation in governance (Table C2). These criteria may be extracted from existing features and added to a future iteration of the Index that more directly incorporates culture. A culture-related MSP principle may include features such as dedicated funds for collecting sociocultural data, investment in reliable partnership building and knowledge co-production, or co-management (Pennino, 2021).

The case study analyses we present are limited by the implications of external review, including access to only publicly available documents, which likely do not capture the MSP initiatives in their entirety. Our application of the MSP Index focused on final marine spatial plan documents, and was supplemented with relevant webpages, legislation, and relevant documents as necessary. Still, this method is limited to documents that are freely available, and it is likely that files in progress or sensitive in nature, including those pertaining to the adaptive and participatory principles, are not made available to the general public. Given this, it was difficult to discern some features. For example, if an initiative is farther along in the MSP process, a work plan may exist but may not be reported in the current iteration of the plan. For a feature to score ‘excellent’ (3), all requirements of said feature must be clearly present in the analyzed documents. This resulted in nearly twice as many features scoring ‘good’ (2), rather than ‘excellent’ across case studies. The Rhode Island case develops a strong spatial management plan, but it is not clear from the plan alone whether a preferred scenario was selected from alternatives. Since the plan did not meet all requirements of this feature, it was scored as ‘good’. Future applications of the Index by external reviewers may couple document analysis with practitioner interviews. Secondly, future iterations of the Index may be more flexible if an excellent score required the majority of requirements to be present, rather than all. In general, the MSP Index would be best used by case study experts and MSP practitioners who are aware of the complete context of assessed initiatives beyond what is published in publicly available documents.

4.5 Conclusion

The MSP Index developed and tested in this study proved to be a flexible tool for assessing MSP processes based on foundational principles, including being ecosystem-based, integrated, place-based, adaptive, strategic, and participatory. The Index uses a qualitative scoring guide to assess key features under these principles, highlighting successes and gaps in processes that can inform MSP advancement. The MSP Index is not an evaluation tool, *per se*, because it does not assess outcomes of the plans, rather it assesses key features that reflect MSP best practices. By using the Index, successes and gaps in MSP processes can be identified to inform a path forward. Our application of the Index to six case studies reveals that MSP principles are unevenly applied in practice, which may reflect the diversity of approaches to, objectives for, and localized needs of MSP. While the Index is based on best practices derived from fundamental MSP guides (Ehler, 2014; Ehler & Douvere, 2009), the framework of the Index is flexible and customizable. Future iterations might incorporate new principles or features that are locally relevant. This may include a cultural component, given the need to incorporate cultural considerations in governance for effective and equitable ocean management and sustainability (Bennett et al., 2021; Christie et al., 2017; Claudet, 2021). The MSP Index is the first tool of its kind to gauge progress based on MSP principles, allowing for assessment of individual MSP processes and comparison of diverse initiatives around the world.

4.6 References

Bennett, N. J., Blythe, J., White, C. S., & Campero, C. (2021). Blue growth and blue justice: Ten risks and solutions for the ocean economy. *Marine Policy*, *125*, 104387. https://doi.org/10.1016/j.marpol.2020.104387

Christie, P., Bennett, N. J., Gray, N. J., ‘Aulani Wilhelm, T., Lewis, N., Parks, J., Ban, N. C., Gruby, R. L., Gordon, L., Day, J., Taei, S., & Friedlander, A. M. (2017). Why people matter in ocean governance: Incorporating human dimensions into large-scale marine protected areas. *Marine Policy*, *84*(January), 273–284. https://doi.org/10.1016/j.marpol.2017.08.002

Claudet, J. (2021). The seven domains of action for a sustainable ocean. *Cell*, *184*(6), 1426–1429. https://doi.org/10.1016/j.cell.2021.01.055

Collie, J. S., Vic Adamowicz, W. L., Beck, M. W., Craig, B., Essington, T. E., Fluharty, D., Rice, J., & Sanchirico, J. N. (2013). Marine spatial planning in practice. *Estuarine, Coastal and Shelf Science*, *117*, 1–11. https://doi.org/10.1016/j.ecss.2012.11.010

Commission of the European Communities. (2008). *Roadmap for Maritime Spatial Planning: Achieving Common principles in the EU* (Communication from the Commission, p. 12). European Commission. https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2008:0791:FIN:EN:PDF

Ehler, C. (2014). A Guide To Evaluating Marine Spatial Plans. *IOC Manuals and Guides*, 70–70. https://doi.org/10.17605/OSF.IO/HY9RS

Ehler, C., & Douvere, F. (2009). Marine Spatial Planning: A step-by-step approach toward ecosystem-based management. *Intergovernmental Oceanographic Commission and Man and the Biosphere Programme*, *IOC Manual*(6), 1–98.

Ehler, C. N. (2020). Two decades of progress in Marine Spatial Planning. *Marine Policy*. https://doi.org/10.1016/j.marpol.2020.104134

Ehler, C., Zaucha, J., & Gee, K. (2019). Maritime/Marine Spatial Planning at the Interface of Research and Practice. In J. Zaucha & K. Gee (Eds.), *Maritime Spatial Planning: Past, present, future* (pp. 1–21). Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-319-98696-8

Flannery, W., Clarke, J., & McAteer, B. (2019). Politics and Power in Marine Spatial Planning. In J. Zaucha & K. Gee (Eds.), *Maritime Spatial Planning* (pp. 201–217). Springer International Publishing. https://doi.org/10.1007/978-3-319-98696-8_9

Flannery, W., Healy, N., & Luna, M. (2018). Exclusion and non-participation in Marine Spatial Planning. *Marine Policy*, *88*(October 2017), 32–40. https://doi.org/10.1016/j.marpol.2017.11.001

Flannery, W., Toonen, H., Jay, S., & Vince, J. (2020). A critical turn in marine spatial planning. *Maritime Studies*, *19*(3), 223–228. https://doi.org/10.1007/s40152-020-00198-8

Frazão Santos, C., Agardy, T., Andrade, F., Crowder, L. B., Ehler, C. N., & Orbach, M. K. (2018). Major challenges in developing marine spatial planning. *Marine Policy*, S0308597X18306213. https://doi.org/10.1016/j.marpol.2018.08.032

Gee, K. (2017). Identifying culturally significant areas for marine spatial planning. *Coastal Management*, 9.

Gissi, E., Fraschetti, S., & Micheli, F. (2019). Incorporating change in marine spatial planning: A review. *Environmental Science and Policy*, *92*(August 2018), 191–200. https://doi.org/10.1016/j.envsci.2018.12.002

Golden, J. S., Virdin, J., Nowacek, D., Halpin, P., Bennear, L., & Patil, P. G. (2017). Making sure the blue economy is green. *Nature Ecology & Evolution*, *1*(2), 0017. https://doi.org/10.1038/s41559-016-0017

Guterman, L. (Ed.). (2021). Huge marine reserve to be revoked. *Science News*, *374*(6570), 918–919. https://doi.org/10.1126/science.acx9653

Jay, S. (2010). Built at sea: Marine management and the construction of marine spatial planning. *The Town Planning Review*, *81*(2), 173–191.

Jay, S., Flannery, W., Vince, J., Liu, W.-H., Xue, J. G., Matczak, M., Zaucha, J., Janssen, H., van Tatenhove, J., Toonen, H., Morf, A., Olsen, E., de Vivero, J. L. S., Rodríguez Mateos, J. C., Calado, H., Duff, J., & Dean, H. (2013). International Progress in Marine Spatial Planning. *Ocean Yearbook*, *27*(1), 171–212. https://doi.org/10.1163/22116001-90000159

Jouffray, J.-B., Blasiak, R., Norström, A. V., Österblom, H., & Nyström, M. (2020). The Blue Acceleration: The Trajectory of Human Expansion into the Ocean. *One Earth*, *2*(1), 43–54. https://doi.org/10.1016/j.oneear.2019.12.016

Kikiloi, K., Friedlander, A. M., Wilhelm, ’Aulani, Lewis, N., Quiocho, K., ’Āila, W., & Kaho’ohalahala, S. (2017). Papahānaumokuākea: Integrating Culture in the

Design and Management of one of the World's Largest Marine Protected Areas. *Coastal Management*, *45*(6), 436–451. https://doi.org/10.1080/08920753.2017.1373450

Laffoley, D., Baxter, J. M., Amon, D. J., Claudet, J., Hall-Spencer, J. M., Grorud-Colvert, K., Levin, L. A., Reid, P. C., Rogers, A. D., Taylor, M. L., Woodall, L. C., & Andersen, N. F. (2020). Evolving the narrative for protecting a rapidly changing ocean, post-COVID-19. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *n/a*(n/a), 1–23. https://doi.org/10.1002/aqc.3512

McKinley, E., Acott, T., & Stojanovic, T. (2019). Socio-cultural Dimensions of Marine Spatial Planning. In J. Zaucha & K. Gee (Eds.), *Marine Spatial Planning: Past, Present, Future* (p. 496). Springer Nature Switzerland AG. https://doi.org/10.1007/978-3-319-98696-8

Ministry of Environment, Lands and Agriculture Development. (2015). *PIPA Management Plan 2015-2020* (p. 136).

Mulazzani, L., & Malorgio, G. (2017). Blue growth and ecosystem services. *Marine Policy*, *85*(August), 17–24. https://doi.org/10.1016/j.marpol.2017.08.006

Pennino, M. G. (2021). The Missing Layers: Integrating Sociocultural Values Into Marine Spatial Planning. *Frontiers in Marine Science*, *8*, 8.

Pressey, R. L., Visconti, P., McKinnon, M. C., Gurney, G. G., Barnes, M. D., Glew, L., & Maron, M. (2021). The mismeasure of conservation. *Trends in Ecology & Evolution*, *36*(9), 808–821. https://doi.org/10.1016/j.tree.2021.06.008

Ryan, G. W., & Bernard, H. R. (2003). Techniques to Identify Themes. *Field Methods*, *15*(1), 85–109. https://doi.org/10.1177/1525822X02239569

Said, A., & Trouillet, B. (2020). Bringing 'Deep Knowledge' of Fisheries into Marine Spatial Planning. *Maritime Studies*, *19*(3), 347–357. https://doi.org/10.1007/s40152-020-00178-y

Secretariat of the Convention on Biological Diversity & Technical Advisory Panel-GEF. (2012). *Marine spatial planning in the context of the convention on biological diversity: A study carried out in response to CBD COP 10 decision X/29.* (No. 68; Technical Series, p. 44). http://www.deslibris.ca/ID/242835

Silver, J. J., Gray, N. J., Campbell, L. M., Fairbanks, L. W., & Gruby, R. L. (2015). Blue Economy and Competing Discourses in International Oceans Governance. *Journal of Environment & Development*. https://doi.org/10.1177/1070496515580797

Skjott Linneberg, M., & Korsgaard, S. (2019). Coding qualitative data: A synthesis guiding the novice. *Qualitative Research Journal*, *19*(3), 259–270. https://doi.org/10.1108/QRJ-12-2018-0012

Stelzenmüller, V., Cormier, R., Gee, K., Shucksmith, R., Gubbins, M., Yates, K. L., Morf, A., Nic Aonghusa, C., Mikkelsen, E., Tweddle, J. F., Pecceu, E., Kannen, A., & Clarke, S. A. (2021). Evaluation of marine spatial planning requires fit for purpose monitoring strategies. *Journal of Environmental Management*, *278*, 111545. https://doi.org/10.1016/j.jenvman.2020.111545

Trouillet, B. (2020). Reinventing marine spatial planning: A critical review of initiatives worldwide. *Journal of Environmental Policy and Planning*, *22*(4), 441–459. https://doi.org/10.1080/1523908X.2020.1751605

UNESCO-IOC/European Commission. (2021). *MSPglobal International Guide on Marine/Maritime Spatial Planning* (IOC Manuals and Guides No 89, p. 152). UNESCO.

Varjopuro, R. (2019). Evaluation of Marine Spatial Planning: Valuing the Process, Knowing the Impacts. In J. Zaucha & K. Gee (Eds.), *Maritime Spatial Planning* (pp. 417–440). Springer International Publishing. https://doi.org/10.1007/978-3-319-98696-8_18

Voyer, M., Quirk, G., McIlgorm, A., & Azmi, K. (2018). Shades of blue: What do competing interpretations of the Blue Economy mean for oceans governance? *Journal of Environmental Policy and Planning*, *20*(5), 595–616. https://doi.org/10.1080/1523908X.2018.1473153

5. Conclusions

5.1 Research contributions

MSP holds the potential to support goals for healthy ocean ecosystems and sustainable uses of ocean resources (Kirkfeldt & Frazão Santos, 2021). Despite its prominence worldwide and a growing body of scientific literature (Ehler, 2020; Flannery et al., 2020), MSP continues to face challenges with insufficient regulatory policy and institutional frameworks, often leading to poor implementation, and balancing economic development with biodiversity conservation for environmental sustainability (Frazão Santos et al., 2021). MSP also continues to struggle with adaptation, stakeholder engagement, inclusion of social data, transboundary issues, and climate change (Frazão Santos et al., 2021). Mismatches between the academic research and MSP practice may be producing recommendations that are incompatible with the complex realities of ocean governance (Zuercher et al., 2022). In this thesis, I explored these challenges in MSP to bridge the gap between the idealized version of MSP presented in the literature and MSP practice. Specifically, the objectives of this research were aimed at developing guidance based on evidence and existing marine spatial plans that might amplify the theoretical potential of MSP toward best practices for planning and management, supporting the delivery of ocean conservation and sustainability goals. This research contributes to knowledge by establishing bridges between the academic literature and practical planning and management.

As the gap between the science being produced and the science needed and used by managers and decision-makers grows (Lemieux et al., 2021), this research synthesized evidence and analyzed MSP practice to contribute knowledge specifically aimed at improving planning and management. The research questions addressed in this thesis provide guidance to practitioners on how to unlock the potential of MSP for conservation and sustainability by optimizing existing planning processes and management tools. Chapter 2 demonstrates the importance of multi-sector conservation tools (i.e., fully and partially protected areas) for achieving SDG 14 targets, highlighting the fundamental role of biodiversity in sustainable ocean use and development. MSP that is conservation-ready, embedding conservation principles and priorities as discussed in Chapter 3, may be more likely to implement these management tools as a means for achieving long-term sustainability. To deliver ecological, economic, and social objectives, MSP must recognize the synergy between biodiversity and sustainable development. The MSP Index developed in Chapter 4 provides a mechanism for assessing the key features of MSP that may capture this synergy, guiding practitioners toward best practices to realize, and amplify, the full potential of MSP.

While the three research chapters of this thesis represent standalone interventions into MSP and spatial management, together they provide a blueprint for how MSP practitioners may overcome critical challenges (i.e., those identified by Frazão Santos et al., 2021). In particular, this thesis demonstrates the potential for MSP to realize, through the planning process, spatial management plans, and the tools implemented as a result of MSP, the interdependencies between biodiversity conservation and sustainable resource use, enabling MSP to better balance economic development with conservation for environmental sustainability. Chapter 4 identifies the key features to include in MSP to unlock its full potential as an ecosystem-based process, including enacting biodiversity conservation, balancing multiple objectives, and minimizing threats to species and ecosystems, among other features and principles. Chapter 3 shows that spatial management plans, the primary output of the MSP process, can better realize the fundamental role of biodiversity in sustainable resource use and development by making specific conservation commitments and recognizing that conservation underpins ocean use. Chapter 2 identifies the tools with the most potential to achieve sustainability goals – primarily those with conservation objectives that affect multiple ocean sectors, indicating to practitioners which tools ought to be included in spatial management plans aiming to achieve sustainable resource use. Implementing the recommendations of this thesis, following its blueprint, may allow MSP to achieve its full potential as the foremost approach to coordinated, collaborative, and comprehensive ocean planning.

Chapter 2 deepens our understanding of the utility of common management tools available to MSP for supporting ambitious ocean goals and uncovers important knowledge gaps related to social and economic outcomes from these tools. Since SDG 14 can be described as largely aspirational (Cormier & Elliott, 2017), this chapter provides critical knowledge on how SDG 14 might be achieved at the management-level. Chapter 3 considers science-based conservation priorities and principles, beyond the relationship between MPAs and MSP (Agardy et al., 2011; Trouillet & Jay, 2021; Vaughan & Agardy, 2020), adding new knowledge of how conservation more broadly has been captured in MSP practice. Chapter 4 expands on Chapters 2 and 3 to explicitly link the theoretical principles of MSP, informed by fundamental MSP guides and the academic literature, to operational best practices on a spectrum from minimal to excellent use of key MSP features. This thesis adds to our understanding of how science can be synthesized and leveraged to operationalize science-based guidance into formats that are possibly more accessible and more useful to practitioners. Together, these chapters make academic and practical contributions that highlight the importance of multi-sector management tools, the need for conservation ready MSP, and the growing demand for local perspectives in MSP.

MSP is a place-based process, focusing on a specific ecosystem and the human activities occurring within those geographical boundaries (Ehler & Douvere, 2009). In Chapter 4, the place-based principle scored highest among analyzed case studies, reflecting the spatiality that is intrinsic to MSP. This process should produce a spatial management plan that makes use of spatial management measures, or area-based management tools (ABMTs), to achieve desired goals and objectives (Ehler & Douvere, 2009). Depending on these objectives, management tools, both spatial and non-spatial, might be layered to manage multiple overlapping uses and impacts. In Chapter 2, I found that multi-sector ABMTs, those managing more than one ocean use, hold the greatest potential for supporting *Sustainable Development Goal 14: Life Below Water* (SDG 14). Through the strategic selection of ABMTs, based on the ecological, social, and economic outcomes they deliver, MSP may become more effective and better able to contribute to global ocean goals. In particular, Chapter 2 demonstrates the importance of conservation tools for ocean sustainability, including fully and partially protected areas. As an ecosystem-based process, MSP can, and based on these findings should, integrate biodiversity objectives with sustainable use objectives. Conservation ready MSP encourages such integration.

Plans that are conservation ready are designed to support and enact conservation using relevant principles and priorities, and policies, goals, commitments, and management tools that enable conservation. In Chapter 3, I proposed that MSP may be more conservation ready when ecosystems are viewed as fundamental to sustainable use, rather than limits to resource use or prioritizing the economy over the ecosystem. This theme clearly relates to the ecosystem-based MSP principle assessed in Chapter 4. Beyond the thematic framing of biodiversity in MSP discussed in Chapter 3, key features of this principle discussed in Chapter 4, including ecosystem function, habitat, adjacent ecosystems, biodiversity conservation, multiple objectives, and minimizing threats, may also reflect conservation readiness. Plans that score higher under this principle, including the Kiribati, Ireland, and Rhode Island case studies, may be more conservation ready than plans with limited progress on ecosystem-based features. The use of multi-sector conservation ABMTs (Chapter 2), recognizing the fundamental role of biodiversity in MSP (Chapter 3), and fulfilling key features of ecosystem-based MSP (Chapter 4) may better realize the fundamental role of biodiversity in sustainable ocean development (OECD, 2018).

Broadly, MSP initiatives often take two general approaches to sustainability, a soft form – where the ecosystem is considered a use among other uses, and a hard form – where a healthy ecosystem is a precondition for sustainability (Trouillet, 2020). This research aimed to develop guidance for planning and management that ultimately attempts to lead MSP toward hard sustainability. Chapter 2 provides operational guidance that informs the strategic selection and use of ABMTs to achieve sustainable ocean targets, especially targets for healthy ocean ecosystems (SDG 14.2), sustainable fisheries (SDG 14.4), and ocean conservation (SDG 14.5). While Chapter 3 results indicate that including conservation as a dedicated section or use in MSP is important, aligning with a soft sustainability approach, a hard sustainability approach aligns with framing ecosystems as fundamental, and thus may produce more conservation ready plans. Further, Chapter 3 shows how conservation concepts, like resilience, can be appropriated in MSP, giving the impression of hard sustainability, without making specific commitments to biodiversity or enacting conservation measures that can enable ecological resilience. As many MSP initiatives lean toward soft sustainability, the reality of integrating marine conservation and economic development objectives in MSP appears more challenging than theory has suggested (Trouillet, 2020).

MSP is intended to serve as a democratic and participatory process that brings together diverse values and interests from ocean users (Flannery et al., 2018). To at least some extent, MSP relies on ocean users to implement and comply with regulations stemming from MSP (Pomeroy & Douvere, 2008). Case studies analyzed in Chapter 3 reflect this reality through the social-ecological systems theme, indicating a need for local engagement in MSP and, for some case studies, the inclusion of cultural and well-being objectives. Further, Chapter 2 shows the potential of locally managed marine areas to contribute to SDG 14 targets, despite a lack of literature-based evidence for outcomes of this ABMT. This unexpected result highlights the importance of local, bottom-up approaches to ocean management and MSP (Olsen et al., 2014). There is a clear imperative to incorporate sociocultural values in MSP to improve uptake and acceptance of plans among ocean users (Pennino, 2021); yet, results of Chapter 4 indicate an ongoing challenge with realizing the participatory principle of MSP. The case studies analyzed in Chapter 4 scored poorly on this principle, particularly the participation plan and stakeholder empowerment features. Without these features, MSP lacks important enabling conditions for effective participation. This research echoes calls for improved participation and engagement in MSP (Frazão Santos et al., 2021; Said & Trouillet, 2020), and reflects the need for inclusive and equitable governance to achieve a sustainable ocean (Claudet, 2021).

5.2 Amplifying the potential of marine spatial planning

MSP offers a holistic alternative to traditionally siloed and single-sector approaches to ocean planning and management, holding the potential to support both ocean conservation and sustainable use or development goals (Agardy et al., 2011). In theory, MSP aims to be ecosystem-based, balancing ecological, economic, and social interests; integrated across sectors, agencies, and levels of government; place-based, intrinsically tied to a geographic location and the implications of boundaries; adaptive, able to learn and change based on experience; strategic, anticipating future challenges over the long-term; and participatory, actively involving rightsholders and stakeholders (Ehler & Douvere, 2009). For MSP to reach the potential promised by these principles, theory must deeply permeate practice; yet, case study analyses reveal that marine spatial plans vary considerably in their objectives and their use of the MSP process (Collie et al., 2013; Jones et al., 2016). MSP theory is likely haphazardly applied in practice to support particular, often political and development-oriented (Trouillet, 2020), objectives. The irregular application of MSP principles, a result echoed in Chapter 4, likely diminishes the ability for MSP to support goals for a healthy ocean. To fully realize its theoretical potential, MSP must make investments that bring foundational principles to fruition and bridge the gap between scientists and practitioners.

With the decision to undertake MSP comes important opportunities for governments to invest in capacity building, leadership development, and mechanisms to overcome governance challenges, reduce institutional overlaps and gaps, and address ocean conflicts (Secretariat of the Convention on Biological Diversity & Technical Advisory Panel-GEF, 2012). As MSP initiatives unfold, governments will be faced with determining the best use of resources and where investments might be wisest to enable an efficient and effective MSP process (UNESCO-IOC/European Commission, 2021). The MSP Index is a principle-based tool that can gauge progress in MSP at various stages of development, providing an indication of gaps where investments might be needed. The MSP Index can also be used to guide investments at the onset of MSP through prioritization of key features, based MSP on objectives. Conservation ready MSP might prioritize ecosystem-based key features, ensuring that biodiversity and habitats underpin economic uses and development. MSP in a complex regulatory system might prioritize the integrated principle, ensuring that institutions are coordinated and using a common framework to employ multi-use management tools that deliver outcomes supporting sustainability. MSP in a busy area that captures interests of many rightsholders and stakeholders might prioritize the participatory principle, ensuring that participation occurs throughout MSP and that participants have multiple avenues for engaging with MSP.

MSP is commonly described firstly as a “public process” that seeks to achieve objectives “usually specified through a political process” (Ehler & Douvere, 2009), though it may be more apt to describe it firstly as political. As a political process, MSP may intrinsically disadvantage some communities, especially those often neglected in ocean planning processes, such as Indigenous communities, small-scale fisheries, and coastal communities (Gilek et al., 2021; Smith & Basurto, 2019; Yet et al., 2022). Despite this, MSP processes often appear to be devoid of politics, diluting the complexity of the process and the diversity of perspectives that ought to be captured through inclusive MSP (Flannery et al., 2019). Each research chapter in this thesis highlights the importance of local perspectives for MSP and ocean management, which requires effective participation. Theoretically, rightsholders and stakeholders should be empowered to participate fully in MSP (Ehler & Douvere, 2009); however, Chapter 4 indicates that participation plans and stakeholder empowerment may be insufficient MSP practice. Capacity building initiatives for MSP stakeholders remain rare, resulting in incongruent expectations among stakeholders that can lead to disappointment that affects the legitimacy of the process and its outcomes (Morf et al., 2019). Participatory approaches are time consuming and expensive (Zaucha & Kreiner, 2021), thus it is critical that investments made in participation are purposeful and appropriate. Participation might be optimized when criteria of stakeholder empowerment are met, investing in mechanisms to empower rightsholders and stakeholders to participate fully in MSP, ensuring participants have the means, skills, and knowledge to engage with a shared sense of purpose, values, rules, and trust among participants (Stephenson et al., 2019), and, wherever possible, enabling participation in governance.

Early MSP research was self-promotional, an important step in supporting the widespread uptake of MSP, though it was often naïve, showing little awareness of the complex socio-political, governance, and planning dimensions of its own practice (Flannery et al., 2020). It is apparent through this research that the closer MSP comes to theoretical best practices, the more complex the process and the more challenging resulting plans are to implement. Chapter 2 recommends the use of multi-sector management tools to support delivery of ocean sustainability targets. Chapter 3 recommends conservation ready MSP, where biodiversity underpins sustainable resource use and development. Chapter 4 recommends the MSP Index, whose application can inform best practices toward realizing foundational principles in MSP. These recommendations collectively indicate a need for highly integrated, participatory, and evidence-based planning.

MSP requires integration across multiple natural and human systems (Kidd et al., 2020), including across spatial and temporal scales, geopolitical boundaries, sectors, rightsholders and stakeholders, knowledge systems, and governance mechanisms (Gee et al., 2019), though few have empirically explored the approaches taken by practitioners to achieve such integration (Smythe & Mccann, 2019). A trade-off may exist between comprehensively following best practices to develop highly ambitious plans that may be difficult to implement, monitor, and evaluate, and selectively following best practices to develop less ambitious plans that may be more feasibly implemented, but may not deliver comprehensive sustainability objectives. This trade-off is exemplified by spatial management plans developed in New South Wales. While plans were highly ambitious in management objectives, they suffered from ambiguous language, unclear planning hierarchies, and a lack of clear timelines that rendered plans effectively immeasurable (Domínguez-Tejo & Metternicht, 2018). For evidence and evidence-based best practices to inform MSP, both researchers and institutions must advance knowledge exchange between scientists and decision-makers. This will require two-way investments to develop individual, institutional, and financial capacities for accessing, interpreting, and integrating scientific knowledge into decision-making processes (Cvitanovic et al., 2015, 2016). Ideally, transdisciplinary approaches characterized by collaboration between scientists, practitioners, and stakeholders, a slow and intentional process, and co-creation of knowledge, co-learning, and co-production of solutions will inform future MSP (Chuenpagdee, 2018). For MSP to achieve its full potential, the gap between theory and practice, between scientists and practitioners, must be bridged.

5.3 Limitations and future research

This thesis highlights important evidence gaps, areas for future research, and methodological challenges, particularly related to understanding MSP in practice and outcomes from ocean management. Chapters 2, 3, and 4 each present opportunities to build on the results of this research and expand our understanding of ABMTs and their contributions to ocean sustainability; how conservation ready MSP might be operationalized; and how theoretical principles of MSP have permeated practice. Across chapters, it was clear that further research is needed to explore linkages between local ocean management, MSP as it is currently conceptualized and practiced, and ocean sustainability. Using mixed methods, including systematic literature review, expert opinion survey, confidence assessment, document analysis, and case study analysis, this research synthesized existing information into guidance that can support MSP in achieving its full potential. With such methods come limitations that should be considered alongside these research findings. In general, approaches that combine multiple methods with multiple sources of information are useful for understanding MSP and developing management-level guidance.

While recent work has identified social and economic outcomes from marine protected areas (Ban et al., 2019; Rees et al., 2021) and fishery closures (Islam et al., 2021), Chapter 2 demonstrates a clear lack of evidence of social and economic outcomes from ABMTs in general, though social outcomes may be difficult to assess and may not be clearly linked to measurable indicators, possibly contributing to this observed lack of evidence. Further, this survey asked experts to assume that "ABMTs were appropriately designed, actively managed, and well-enforced", which may not be a fair assumption given the diversity within and among ABMTs in practice. Future work is needed to understand how common ABMTs are affecting socio-cultural and economic systems at various scales, and how differences in design, management, and enforcement might affect outcomes. In contrast to ecological outcomes, social and economic outcomes from management tools are not observed on the ocean, nor are they necessarily spatial. Chapter 2 recommends a combination of spatial and non-spatial management tools for achieving SDG 14 targets, particularly targets addressing issues from land-based or systemic sources (e.g., SDG 14.1 – Marine pollution, SDG 14.3 – Ocean acidification); however, the reality of combining spatial and non-spatial management may pose considerable challenges to existing regulatory frameworks. Future research might investigate these challenges and develop strategies for combined approaches to ocean management that delivers ecological, social, and economic outcomes to achieve full-spectrum sustainability (Foley et al., 2020).

While Chapter 2 assessed outcomes from common ABMTs, it was apparent through this research that assessing outcomes from MSP initiatives was not feasible. Between Chapter 3 and 4 case study selection, 55 MSP initiatives were screened for inclusion and, anecdotally, few, if any, of these initiatives clearly reported outcomes. We propose conservation ready MSP as an approach to embedding biodiversity conservation more meaningfully, but we did not assess conservation outcomes from the analyzed case studies. For these cases, such information was not available, and we were thus unable to assess whether plans favouring the *ecosystems as fundamental* theme were delivering conservation benefits. As marine spatial plans are increasingly implemented and evaluated, future research might attempt to link conservation readiness to outcomes. Similarly, future research may explore the relationship between MSP Index scores and ecological, social, and economic outcomes linked to MSP objectives. Recent research identified a need for monitoring strategies that are fit-for-purpose to MSP objectives, enabling evaluation and reporting of outcomes (Stelzenmüller et al., 2021). Importantly, this research highlights a missing element of accountability in MSP as plans seldom appear to plan for and implement evaluation strategies.

MSP research may not be grounded in the complex realities of ocean governance, planning, and management (Flannery et al., 2020). The MSP Index may help to bridge the gap between theory and practice, as it links MSP principles to key features and the operational requirements needed to achieve them. The Index provides a mechanism for gauging the use MSP principles in practice. Future research might expand our case study analysis globally, identifying trends in MSP practice and the broad permeation of MSP principles. Such a global analysis could reveal important gaps in MSP practice, inform guidance toward best practices, and support MSP in achieving its full potential. Based on Chapter 4 results, I predict there to be global shortcomings in the adaptive principle and suggest that some MSP principles may conflict with one another. MSP, as a place-based process, leads to spatial management plans that inform the use of spatial management tools. These tools tend to be static and may fail to reflect the dynamism of the socio-ecological, economic, and cultural systems they are trying to manage. MSP that attempts to manage under this high degree of dynamism, exacerbated by rapidly changing systems due to climate change and biodiversity loss, may give up key features of some principles to be more adaptive. Future work may explore the compatibility of MSP principles and comment on how principles can be optimized to achieve specific MSP objectives.

Academic MSP research has grown exponentially since the late 2000s, occurring in tandem with a growing practice of MSP by ocean nations (Ehler et al., 2019). As these two sources of information continue to evolve simultaneously, knowledge exchange between MSP scientists and practitioners will be imperative to ensure that an idealized version of MSP does not diverge from MSP in reality (Zuercher et al., 2022). While this research explored a diversity of ABMTs and marine spatial plans, with various scales, objectives, and approaches to planning, Chapters 3 and 4 would benefit from significantly expanded case study analyses that capture more, and more diverse, MSP initiatives. The number of case studies analyzed for these chapters limited the ability of this research to make broader claims about MSP practice. Additional case studies might add new detail, nuance, and practical recommendations for conservation ready MSP. For the MSP Index, additional case studies would allow for more comprehensive testing of its relevance, in addition to an assessment of trends in MSP. Further, Chapters 2 and 4 used alternatives to systematic literature review to compile evidence and MSP key features. These methods may not comprehensively capture all relevant information as would a truly systematic approach, which may have implications for the results presented here. In Chapter 2, a full systematic review may have provided further clarity on knowledge gaps or may have refined the potential contributions of ABMTs to SDG 14. In Chapter 4, a systematic review may have yielded additional key features or subtle differences in the key features identified.

This research relied heavily on secondary analyses of existing evidence and case studies conducted by external researchers, rather than experts involved with the analyzed ABMTs or MSP initiatives. This is an important limitation of this research that aimed to bridge idealized MSP with MSP in practice. By use of document analysis in Chapters 3 and 4, these case studies were limited to publicly available MSP documents that likely do not reflect the entirety of a region's experience with, and body of work for, MSP. The results of this research would have benefited from the qualitative richness of interviews conducted with MSP practitioners in each case study, and future research should consider approach. Further, this research did not directly seek to understand the realities of MSP in practice and how, from the practitioners' perspective, this may or may not align with MSP in theory. Future research should consider this as an important knowledge gap to remedy, ensuring that MSP research continues to be able to inform practice. While it is clear from this thesis that one size does not fit all for MSP, the results of this research might still lead toward a theory-informed approach that is potentially incompatible with the realities of complex planning which may not fit the mould of recommendations made here. Research on regulatory policy, institutional frameworks, governance operations, and the day-to-day duties of MSP practitioners may better ground research in these realities, ensuring that research findings are appropriately contextualized to inform practice.

5.4 Conclusion

Marine spatial planning holds the potential to support progress toward global goals for a healthy, productive, and sustainable ocean. This thesis explores critical challenges that continue to hinder the ability of MSP to achieve its potential, including balancing biodiversity conservation with socioeconomic development to achieve environmental sustainability and implementing the foundational principles of MSP. This research contributes operational guidance for strategically selecting management tools to achieve ocean sustainability targets; a pathway toward embedding biodiversity conservation in MSP; and culminates with the MSP Index, a principle-based tool for gauging progress in MSP that can guide decision-makers toward best practices. Future research may expand on the analyses presented here by linking conservation ready MSP and MSP Index scores to ecological, social, and economic outcomes from MSP initiatives. Further, the

MSP Index, if applied widely, may be used to identify global successes and gaps in MSP practice that can set an agenda for research that is purposefully linked to the needs to practitioners. It is apparent that the closer MSP moves toward theoretical best practices, the more complicated MSP practice becomes, likely requiring significant and ongoing investments of time, resources, and political will. The academic discourse may underestimate these challenges, potentially widening the gap between science and practice. For MSP to meet its full potential, science must engage deeply with practitioners to understand their realities and co-produce sustainable solutions for a sustainable ocean.

5.5 References

Agardy, T., di Sciara, G. N., & Christie, P. (2011). Mind the gap: Addressing the shortcomings of marine protected areas through large scale marine spatial planning. *Marine Policy*, *35*(2), 226–232. https://doi.org/10.1016/j.marpol.2010.10.006

Ban, N. C., Gurney, G. G., Marshall, N. A., Whitney, C. K., Mills, M., Gelcich, S., Bennett, N. J., Meehan, M. C., Butler, C., Ban, S., Tran, T. C., Cox, M. E., & Breslow, S. J. (2019). Well-being outcomes of marine protected areas. *Nature Sustainability*, *2*(6), 524–532. https://doi.org/10.1038/s41893-019-0306-2

Chuenpagdee, R. (2018). Transdisciplinary Perspectives on Ocean Governance. In International Ocean Institute-Canada (Ed.), *The Future of Ocean Governance and Capacity Development* (pp. 23–27). Brill Nijhoff.

Claudet, J. (2021). The seven domains of action for a sustainable ocean. *Cell*, *184*(6), 1426–1429. https://doi.org/10.1016/j.cell.2021.01.055

Collie, J. S., Vic Adamowicz, W. L., Beck, M. W., Craig, B., Essington, T. E., Fluharty, D., Rice, J., & Sanchirico, J. N. (2013). Marine spatial planning in practice. *Estuarine, Coastal and Shelf Science*, *117*, 1–11. https://doi.org/10.1016/j.ecss.2012.11.010

Cormier, R., & Elliott, M. (2017). SMART marine goals, targets and management – Is SDG 14 operational or aspirational, is ‘Life Below Water’ sinking or swimming? *Marine Pollution Bulletin*, *123*(1–2), 28–33. https://doi.org/10.1016/j.marpolbul.2017.07.060

Cvitanovic, C., Hobday, A. J., van Kerkhoff, L., Wilson, S. K., Dobbs, K., & Marshall, N. A. (2015). Improving knowledge exchange among scientists and decision-makers to facilitate the adaptive governance of marine resources: A review of knowledge and research needs. *Ocean and Coastal Management*, *112*, 25–35. https://doi.org/10.1016/j.ocecoaman.2015.05.002

Cvitanovic, C., McDonald, J., & Hobday, A. J. (2016). From science to action: Principles for undertaking environmental research that enables knowledge exchange and evidence-based decision-making. *Journal of Environmental Management*, *183*, 864–874. https://doi.org/10.1016/j.jenvman.2016.09.038

Domínguez-Tejo, E., & Metternicht, G. (2018). Poorly-designed goals and objectives in resource management plans: Assessing their impact for an Ecosystem-Based Approach to Marine Spatial Planning. *Marine Policy*, *88*, 122–131. https://doi.org/10.1016/j.marpol.2017.11.013

Ehler, C., & Douvere, F. (2009). Marine Spatial Planning: A step-by-step approach toward ecosystem-based management. *Intergovernmental Oceanographic Commission and Man and the Biosphere Programme*, *IOC Manual*(6), 1–98.

Ehler, C. N. (2020). Two decades of progress in Marine Spatial Planning. *Marine Policy*. https://doi.org/10.1016/j.marpol.2020.104134

Ehler, C., Zaucha, J., & Gee, K. (2019). Maritime/Marine Spatial Planning at the Interface of Research and Practice. In J. Zaucha & K. Gee (Eds.), *Maritime Spatial Planning: Past, present, future* (pp. 1–21). Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-319-98696-8

Flannery, W., Clarke, J., & McAteer, B. (2019). Politics and Power in Marine Spatial Planning. In J. Zaucha & K. Gee (Eds.), *Maritime Spatial Planning* (pp. 201–217). Springer International Publishing. https://doi.org/10.1007/978-3-319-98696-8_9

Flannery, W., Healy, N., & Luna, M. (2018). Exclusion and non-participation in Marine Spatial Planning. *Marine Policy*, *88*(October 2017), 32–40. https://doi.org/10.1016/j.marpol.2017.11.001

Flannery, W., Toonen, H., Jay, S., & Vince, J. (2020). A critical turn in marine spatial planning. *Maritime Studies*, *19*(3), 223–228. https://doi.org/10.1007/s40152-020-00198-8

Foley, P., Pinkerton, E., Wiber, M., & Stephenson, R. (2020). Full-spectrum sustainability: An alternative to fisheries management panaceas. *Ecology and Society*, *25*(2). https://doi.org/10.5751/ES-11509-250201

Frazão Santos, C., Agardy, T., Andrade, F., Crowder, L. B., Ehler, C. N., & Orbach, M. K. (2021). Major challenges in developing marine spatial planning. *Marine Policy*, *132*, 103248. https://doi.org/10.1016/j.marpol.2018.08.032

Gee, K., Blazauskas, N., Dahl, K., Göke, C., Hassler, B., Kannen, A., Leposa, N., Morf, A., Strand, H., Weig, B., & Zaucha, J. (2019). Can tools contribute to integration in MSP? A comparative review of selected tools and approaches. *Ocean & Coastal Management*, *179*. https://doi.org/10.1016/j.ocecoaman.2019.104834

Gilek, M., Armoskaite, A., Gee, K., Saunders, F., Tafon, R., & Zaucha, J. (2021). In search of social sustainability in marine spatial planning: A review of scientific literature published 2005–2020. *Ocean & Coastal Management*, *208*, 105618. https://doi.org/10.1016/j.ocecoaman.2021.105618

Islam, M. M., Begum, A., Rahman, S. M. A., & Ullah, H. (2021). Seasonal Fishery Closure in the Northern Bay of Bengal Causes Immediate but Contrasting Ecological and Socioeconomic Impacts. *Frontiers in Marine Science*, *8*, 704056. https://doi.org/10.3389/fmars.2021.704056

Jones, P. J. S., Lieberknecht, L. M., & Qiu, W. (2016). Marine spatial planning in reality: Introduction to case studies and discussion of findings. *Marine Policy*, *71*, 256–264. https://doi.org/10.1016/j.marpol.2016.04.026

Kidd, S., Calado, H., Gee, K., Gilek, M., & Saunders, F. (2020). Marine Spatial Planning and sustainability: Examining the roles of integration - Scale, policies, stakeholders and knowledge. *Ocean & Coastal Management*, *191*, 105182. https://doi.org/10.1016/j.ocecoaman.2020.105182

Kirkfeldt, T. S., & Frazão Santos, C. (2021). A Review of Sustainability Concepts in Marine Spatial Planning and the Potential to Supporting the UN Sustainable Development Goal 14. *Frontiers in Marine Science*, *8*, 713980. https://doi.org/10.3389/fmars.2021.713980

Lemieux, C. J., Halpenny, E. A., Swerdfager, T., He, M., Gould, A. J., Carruthers Den Hoed, D., Bueddefeld, J., Hvenegaard, G. T., Joubert, B., & Rollins, R. (2021).

Free Fallin'? The decline in evidence-based decision-making by Canada's protected areas managers. *FACETS*, *6*, 640–664. https://doi.org/10.1139/facets-2020-0085

Morf, A., Kull, M., Piwowarczyk, J., & Gee, K. (2019). Towards a Ladder of Marine/Maritime Spatial Planning Participation. In J. Zaucha & K. Gee (Eds.), *Maritime Spatial Planning* (pp. 219–243). Springer International Publishing. https://doi.org/10.1007/978-3-319-98696-8_10

OECD. (2018). *Mainstreaming Biodiversity for Sustainable Development*. Paris. OECD Publishing. https://doi.org/10.1787/9789264303201-en

Olsen, E., Fluharty, D., Hoel, A. H., Hostens, K., Maes, F., & Pecceu, E. (2014). Integration at the round table: Marine spatial planning in multi-stakeholder settings. *PLoS ONE*, *9*(10). https://doi.org/10.1371/journal.pone.0109964

Pennino, M. G. (2021). The Missing Layers: Integrating Sociocultural Values Into Marine Spatial Planning. *Frontiers in Marine Science*, *8*, 8.

Pomeroy, R., & Douvere, F. (2008). The engagement of stakeholders in the marine spatial planning process. *Marine Policy*, *32*(5), 816–822. https://doi.org/10.1016/j.marpol.2008.03.017

Rees, S. E., Ashley, M., Evans, L., Mangi, S., Sheehan, E. V., Mullier, T., Rees, A., & Attrill, M. J. (2021). An evaluation of the social and economic impact of a Marine Protected Area on commercial fisheries. *Fisheries Research*, *235*, 105819. https://doi.org/10.1016/j.fishres.2020.105819

Said, A., & Trouillet, B. (2020). Bringing 'Deep Knowledge' of Fisheries into Marine Spatial Planning. *Maritime Studies*, *19*(3), 347–357. https://doi.org/10.1007/s40152-020-00178-y

Secretariat of the Convention on Biological Diversity & Technical Advisory Panel-GEF. (2012). *Marine spatial planning in the context of the convention on biological diversity: A study carried out in response to CBD COP 10 decision X/29.* (No. 68; Technical Series, p. 44). http://www.deslibris.ca/ID/242835

Smith, H., & Basurto, X. (2019). Defining Small-Scale Fisheries and Examining the Role of Science in Shaping Perceptions of Who and What Counts: A Systematic

Review. *Frontiers in Marine Science*, *6*, 236. https://doi.org/10.3389/fmars.2019.00236

Smythe, C., & Mccann, J. (2019). *Achieving integration in marine governance through marine spatial planning: Findings from practice in the United States*. *167*(September 2018), 197–207. https://doi.org/10.1016/j.ocecoaman.2018.10.006

Stelzenmüller, V., Cormier, R., Gee, K., Shucksmith, R., Gubbins, M., Yates, K. L., Morf, A., Nic Aonghusa, C., Mikkelsen, E., Tweddle, J. F., Pecceu, E., Kannen, A., & Clarke, S. A. (2021). Evaluation of marine spatial planning requires fit for purpose monitoring strategies. *Journal of Environmental Management*, *278*, 111545. https://doi.org/10.1016/j.jenvman.2020.111545

Stephenson, R. L., Hobday, A. J., Cvitanovic, C., Alexander, K. A., Begg, G. A., Bustamante, R. H., Dunstan, P. K., Frusher, S., Fudge, M., Fulton, E. A., Haward, M., Macleod, C., McDonald, J., Nash, K. L., Ogier, E., Pecl, G., Plagányi, É. E., van Putten, I., Smith, T., & Ward, T. M. (2019). A practical framework for implementing and evaluating integrated management of marine activities. *Ocean & Coastal Management*, *177*, 127–138. https://doi.org/10.1016/j.ocecoaman.2019.04.008

Trouillet, B. (2020). Reinventing marine spatial planning: A critical review of initiatives worldwide. *Journal of Environmental Policy & Planning*, *22*(4), 441–459. https://doi.org/10.1080/1523908X.2020.1751605

Trouillet, B., & Jay, S. (2021). The complex relationships between marine protected areas and marine spatial planning: Towards an analytical framework. *Marine Policy*, *127*, 104441. https://doi.org/10.1016/j.marpol.2021.104441

UNESCO-IOC/European Commission. (2021). *MSPglobal International Guide on Marine/Maritime Spatial Planning* (IOC Manuals and Guides No 89, p. 152). UNESCO.

Vaughan, D., & Agardy, T. (2020). Marine protected areas and marine spatial planning – allocation of resource use and environmental protection. In *Marine Protected Areas* (pp. 13–35). Elsevier. https://doi.org/10.1016/B978-0-08-102698-4.00002-2

Yet, M., Manuel, P., DeVidi, M., & MacDonald, B. H. (2022). Learning from Experience: Lessons from Community-based Engagement for Improving Participatory Marine Spatial Planning. *Planning Practice & Research*, *37*(2), 189–212. https://doi.org/10.1080/02697459.2021.2017101

Zaucha, J., & Kreiner, A. (2021). Engagement of stakeholders in the marine/maritime spatial planning process. *Marine Policy*, *132*, 103394. https://doi.org/10.1016/j.marpol.2018.12.013

Zuercher, R., Motzer, N., Magris, R. A., & Flannery, W. (2022). Narrowing the gap between marine spatial planning aspirations and realities. *ICES Journal of Marine Science*, fsac009. https://doi.org/10.1093/icesjms/fsac009

Appendices

Appendix A. Chapter 2

A1. Supplementary tables

Table A1. Definitions of ecological, social, and economic outcomes of area-based management tools.

Outcome	Definition	References
Increased organism size	The mass of individual organisms increases. For example, individual fish are larger inside the management area than outside.	
Increased species abundance	The number of individuals per species increases. For example, there are more individual fish within the management area.	
Increased species diversity	The number of species and relative abundance of each species increases. For example, there are more types of species that are equally abundant within the management area.	
Maintained or restored habitat	The number of habitat types and/or heterogeneity of a habitat type is maintained at an existing level or naturally restored to a previous state.	Foley et al. (2010)
Maintained or restored ecosystem functions	The "interactions between ecosystem structure and processes underpinning the capacity of an ecosystem to provide goods and services" are maintained at an existing level or naturally restored to a previous state.	TEEB (2019)
Maintained or restored ecosystem resilience	The "capacity of [an ecosystem] to resist and recover from disturbance, and undergo change while still retaining essentially the same function, structure and integrity" is maintained at an existing level or naturally restored to a previous state.	IOC (2019)
Reduced pollution (physical, chemical, noise)	The amount of pollution of any kind is reduced. For example, floating plastic debris and the volume of noise from human activities are reduced.	
Reduced threats to species	Direct threats, "the proximate human activities or processes that have impacted, are impacting, or may impact the status of [species]" are reduced.	IUCN (2019)
Reduced impacts of ocean acidification	The impacts of declining pH (increased acidity) to species and ecosystems are reduced. For example, calcifying organisms are less affected by acidification within the management area.	The Nature Conservancy (2018)
Increased earnings from harvest activities	Financial gains from harvest activities within or in proximity to the management area increases due to increased catch efficiency. For example, fishers are earning more per catch because fish are larger and more abundant.	Jupiter et al. (2014)
Increased earnings from non-harvest activities	Income from non-harvest activities within or in proximity to the management area increase, for example from participation in management, access fees, or ecotourism activities.	Jupiter et al. (2014)
Provided alternative livelihood activities	Opportunities for alternative income earning activities external to the management area are	Jupiter et al. (2014)

	generated, for example in sewing cooperatives, handicraft production, or community health and education services.	
Maintained access to resources	The “ability to use and benefit from a resource or an area” is maintained at a similar level or minimally reduced level compared to access prior to the implementation of the ABMT.	Bennett et al. (2018)
Provided equitable access to resources	The “ability to use and benefit from a resource or an area” is allocated fairly across resource users.	Bennett et al. (2018); TEEB (2019)
Reduced harvest effort	The amount of time and fishing power used to harvest natural resources is reduced, for example by altering gear size, boat size, horsepower, etc.	IOC (2019)
Maintained traditional practices	Traditional practices, including traditional management systems and customary practices aligned with spiritual beliefs, are maintained or re-established within the management area.	Jupiter et al. (2014); LMMA Network (2019)
Community engagement with management	Communities are meaningfully involved in ABMT planning and management, demonstrating community organization, cohesiveness, and empowerment.	Jupiter et al. (2014)

Table A2. Definitions of area-based management tools included in survey questionnaire.

Tool	**Alternative names**	**Definition**	**Reference**
Fully protected area	Marine reserve, no-take area, no-go area, etc.	A non-temporary ABMT that prohibits all extractive activities and may or may not regulate access to the area to achieve biodiversity conservation objectives.	Horta e Costa et al. (2016)
Partially protected area	Marine park, multi-use MPA, buffer zones, etc.	An ABMT that regulates “some extractive uses but permits others” to achieve biodiversity conservation objectives.	Sciberras et al. (2015)
Fishery closure	Area and time restrictions, periodically harvested closures, fishery restricted areas, dynamic closure areas, etc.	An ABMT that regulates access to “[...] an entire fishing ground, or a part of it, for the protection of a section of the population (e.g. spawners, juveniles), the whole population or several populations [to achieve resource management objectives]. The closure is usually seasonal, but it could be permanent."	IOC (2019)
Gear restriction area	No-trawl areas/ zones, bottom-contact gear closures, species-specific gear restriction areas, etc.	An ABMT "prohibits or otherwise restricts the use of particular fishing equipment in a specified area" to achieve resource management objectives.	IOC (2019)
Territorial user right fishery	Area-based catch share programs, customary marine tenure, spatial property rights fisheries, etc.	An ABMT that “assigns rights to individuals and/or groups to fish in certain locations, generally, although not necessarily, based on long-standing tradition (‘customary usage’)” to achieve resource management objectives.	FAO (2002)
Locally managed	N/A	An ABMT in “an area of nearshore waters and coastal resources that is largely or wholly	Govan (2009)

marine area		managed at a local level by the coastal communities, land-owning groups, partner organizations, and/or collaborative government representatives who reside or are based in the immediate area."	
Particularly sensitive sea area	N/A	An ABMT designated by the International Maritime Organization (IMO) in "an area that needs special protection through action by IMO because of its significance for recognized ecological, socio-economic, or scientific attributes where such attributes may be vulnerable to damage by international shipping activities."	IMO (2006)

Table A3. Search terms used in the first phase of review in Web of Science (last search date: October 2019). Each ABMT was coupled with terms for general outcomes and reviews.

Topic	**Search terms**
Fishery closure	("fish* closure*" OR "fish* restrict*" OR "fish* ban" OR "fish* restr* area*" OR "fish* restr* zone*" OR "periodically harvested closure")
Gear restriction area	("gear restrict*")
Locally managed marine area	("locally managed marine area*" OR "LMMA")
Fully protected area	("marine reserve" OR "no-take" OR "no take" OR "fully protected area*" OR "integral reserve")
Partially protected area	("marine protected area" OR "marine park" OR "part* protected area")
Particularly sensitive sea area	("particularly sensitive sea area" OR ("PSSA" AND ("marine" OR "ocean" OR "sea")))
Territorial user right fishery	("territorial use* right*") OR ("TURF" AND "fish*" AND "right")
General outcomes	("effect*" OR "outcome*" OR "impact*" OR "assessment*" OR "evaluation*" OR "benefit*")
Reviews	("systematic review" OR "comprehensive review" OR "literature review" OR "meta-analys*" OR "review" OR "synthesis")

Table A4. Search terms used in the second phase of review in Web of Science (last search date: October 2019). Each outcome was coupled with search terms for ABMTs and general outcomes listed in Table A1.

Outcome	Search terms
Increased organism size	(“organism* size” OR “size of organism” OR “fish* size” OR “size of fish” OR “fish weight” OR “fish mass” OR “biomass”)
Increased abundance	(“species abundance” OR “organism* abundance” OR “fish* abundance” OR “abundance”)
Increased species richness	(“species richness” OR (“richness” AND “species”) OR “species diversity” OR “fish* diversity” OR (“diversity” AND “species”) OR “biodiversity”)
Maintained or restored habitat	((“habitat” AND “quality”) OR “habitat quality” (“habitat” AND “restor*”) OR “habitat restoration”)
Maintained or restored ecosystem function	(“ecosystem* function*” OR “ecosystem* process*” OR (“ecosystem*” AND “function*”) OR “ecosystem* health”)
Maintained or restored ecosystem resilience	(“ecosystem* resilienc*” OR (“ecosystem*” AND “resilienc*”) OR “ecosystem recover*” OR (“ecosystem*” AND “recovery”))
Reduced pollution (physical, chemical, noise)	(“pollut*” OR “marine debris” OR “debris” OR “plastic” OR “ghost fish*” OR “noise” OR “eutrophication” OR “nutrient loading” OR “nutrient pollut*”)
Reduced threats to species	((“threat*” OR “impact*” OR “effect*” OR “risk”) AND (“species” OR “biodiversity”) AND “conservation”)
Reduced impacts of ocean acidification	((“acidification” OR “acid*” OR “calcif*”) AND (“ocean” OR “marine” OR “sea”))
Increased earnings from harvest activities	((“income*” OR “earn*” OR “econom*” OR “job*” OR “employ*” OR “work*”) AND (“harvest” OR “fish*” OR “extract*”))
Increased earnings from non-harvest activities	((“income*” OR “earn*” OR “econom*” OR “job*” OR “employ*” OR “work*”) AND (“non-harvest” OR “non harvest” OR “tourism” OR “ecotourism” OR “management” OR “non-fish*” OR “non fish*”))
Provided alternative livelihood opportunities	(“alternative livelihood*” OR ((“alternative” OR “other” OR “new”) AND (“job*” OR “livelihood*” OR “opportunit*” OR “income*” OR “work*” OR “employ*”)))
Maintained access to resources	(“fish* access” OR “access to resource*” OR ((“access*”) AND (“fish*” OR “resource*” OR “harvest*”)))
Provided equitable access to resources	(“fish* access” OR “access to resource*” OR ((“access*”) AND (“fish*” OR “resource*” OR “harvest*”))) AND (“equit*” OR “fair*”)
Reduced harvest effort	(“fish* effort” OR “harvest effort” OR ((“fish*” OR “harvest” OR “extract*”) AND “effort”))
Maintained traditional practices	((“custom* practice*” OR “custom* fish*” OR “custom* activit*” OR “traditional practice*” OR “traditional fish*” OR “traditional activit*”) OR ((“custom*” OR “tradition*”) AND (“practice*” OR “activit*” OR “fish*”)))
Community engagement with management	((“public engagement” OR “communit* engagement” OR “communit* participat*” OR “public participat*” OR “communit* involv*” OR “public involv*” OR ((“communit*” OR “public” OR “stakeholder*” OR “user” OR “fisher”) AND (“engag*” OR “consult*” OR “participat*”)) AND (“manage*” OR “plan*” OR “policy”)))

Table 5A. Studies selected for pilot searches in Web of Science, testing efficacy of search terms in returning relevant literature.

Reference	Relevance
Ban et al. (2019)	Systematic literature review on positive and negative well-being outcomes of marine protected areas.
Claudet et al. (2008)	Meta-analysis on the effects of marine reserves, including ecological outcomes for fish density and species richness.
Giakoumi et al. (2017)	Meta-analysis on the effects of fully and partially protected areas, including ecological outcomes for biomass and density of fish assemblages, commercially important fishes, and sea urchins.
Goetz et al. (2018)	Meta-analysis on fisheries benefits of periodically harvested fisheries closures.
Halpern et al. (2009)	Meta-analysis on spillover effects of marine reserves, including ecological outcomes for abundance and biomass of fished species.
Lester et al. (2009)	Meta-analysis on the effects of no-take marine reserves at a global scale, including ecological outcomes for biomass, density, organism size, and species richness.
Lester et al. (2016)	Standard literature review of empirical evidence of territorial user right fishery performance.
Molloy et al. (2009)	Meta-analysis on the effects of marine reserves on fish populations, including ecological outcomes for fish density.
Sciberras et al. (2015)	Meta-analysis on the benefits of partially protected areas compared to fully protected areas, including ecological outcomes for fish density and biomass.
Zupan et al. (2018)	Meta-analysis on the effectiveness of partially protected areas, including ecological outcomes for biomass and abundance of commercial fish species.

Table A6. Qualitative ranking system used to determine quantity and quality of evidence and level of agreement among evidence, applied in confidence assessment.

	High	Medium	Low
Evidence	≥ 1 meta-analysis/systematic review OR > 1 standard literature review OR ≥ 5 independent studies AND > 75% of experts report one expected effect	Any circumstance where evidence only partially meets the criteria of high or low evidence	1 standard literature review OR < 5 independent studies AND >25% of experts report uncertainty OR any outcome for which no literature was identified
Agreement	Majority of studies agree on outcome AND majority of experts agree AND studies and experts agree	Any circumstance where agreement only partially meets the criteria of high or low agreement	Majority of studies disagree on outcome AND majority of experts disagree AND studies and experts disagree

A2. Supplementary figures

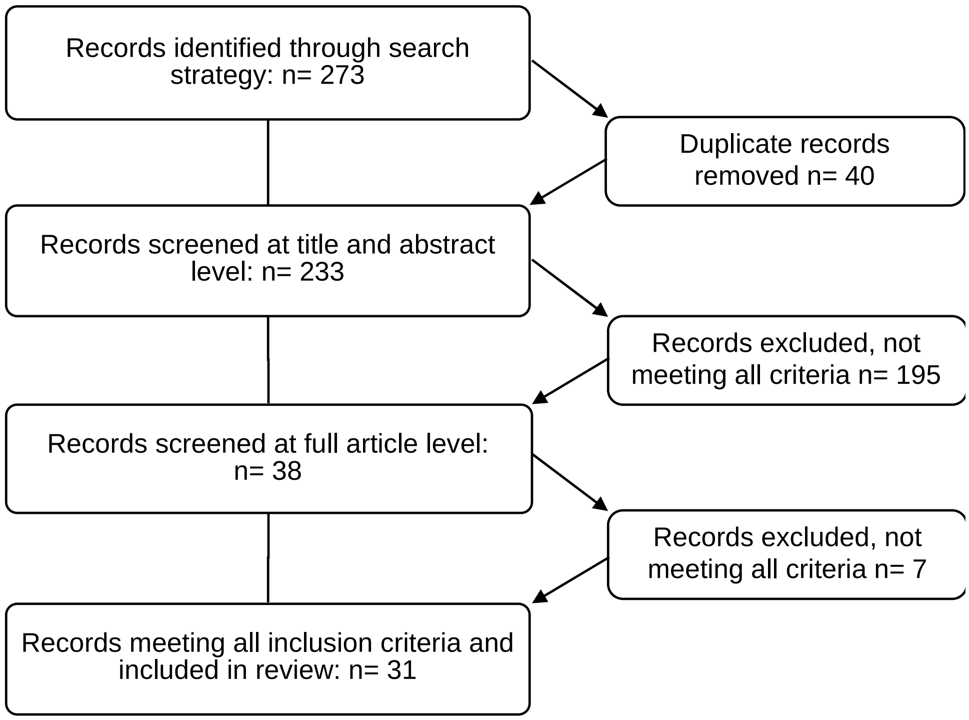


Figure A1. Phase one rapid review strategy from initial search to included literature.

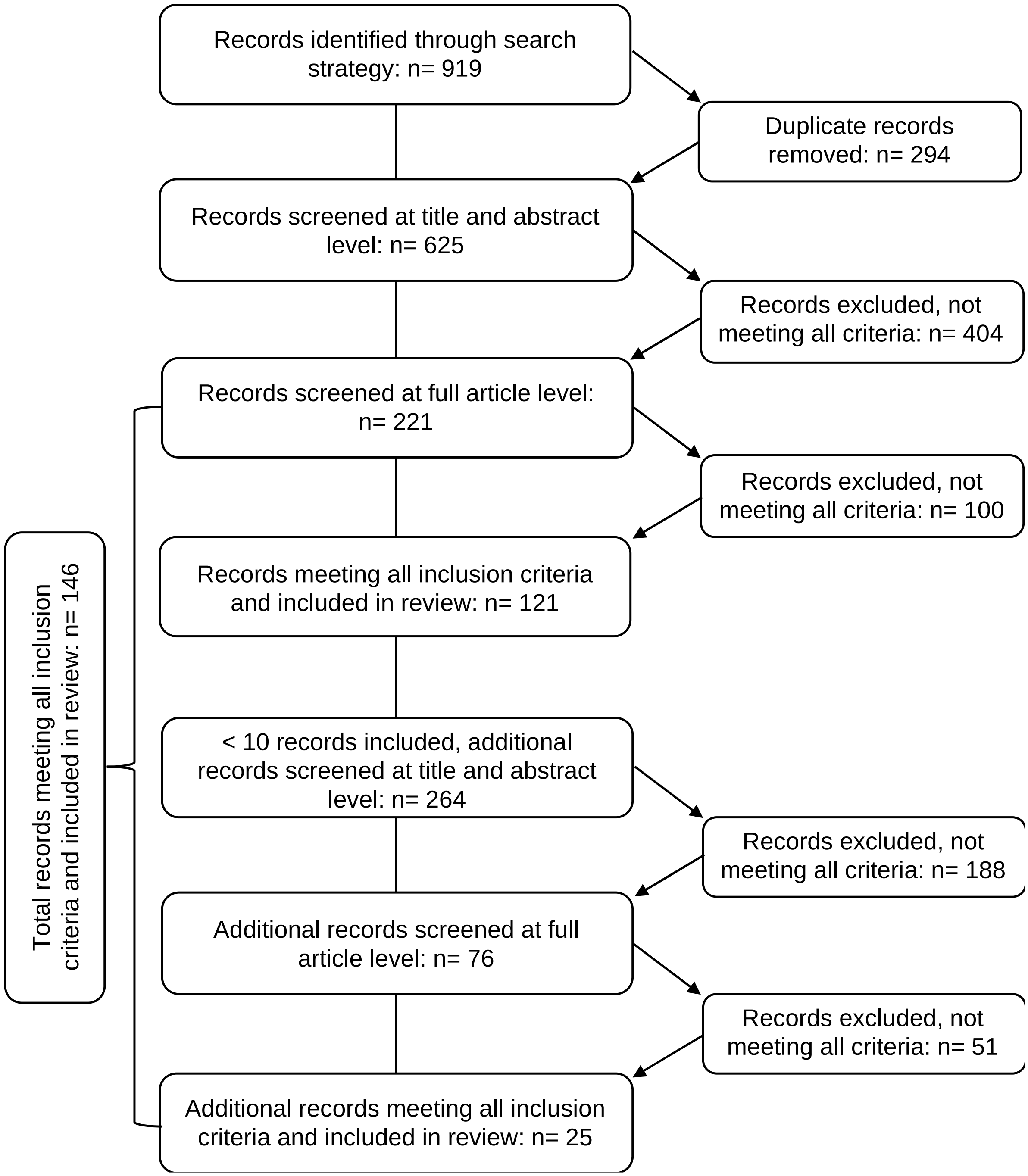


Figure A2. Phase two rapid review strategy from initial search to included literature.

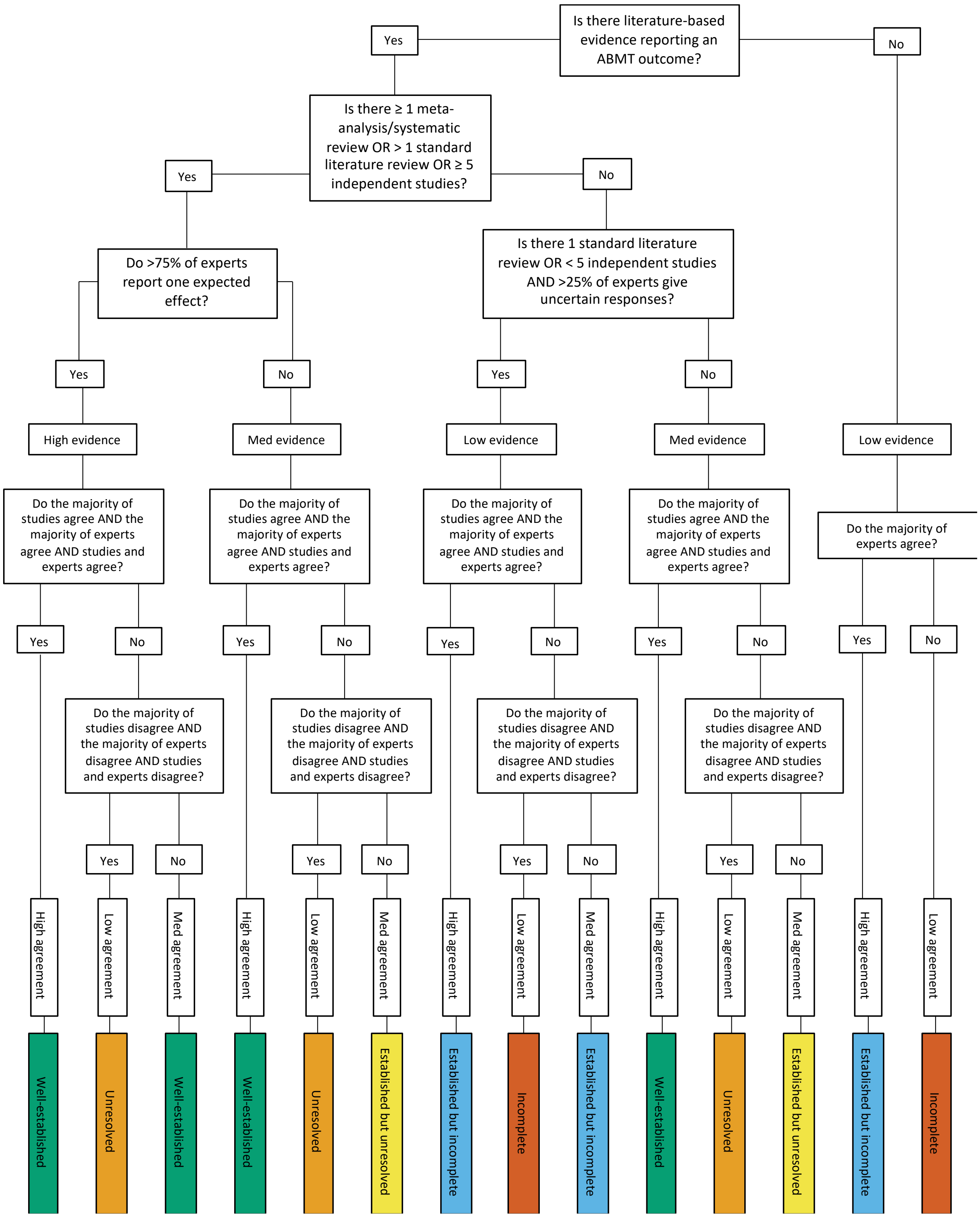


Figure A3. Decision tree used to determine confidence categories assigned to ABMT outcomes, combining literature-based and expert opinion evidence to assess the quantity/quality of evidence and the level of agreement among evidence.

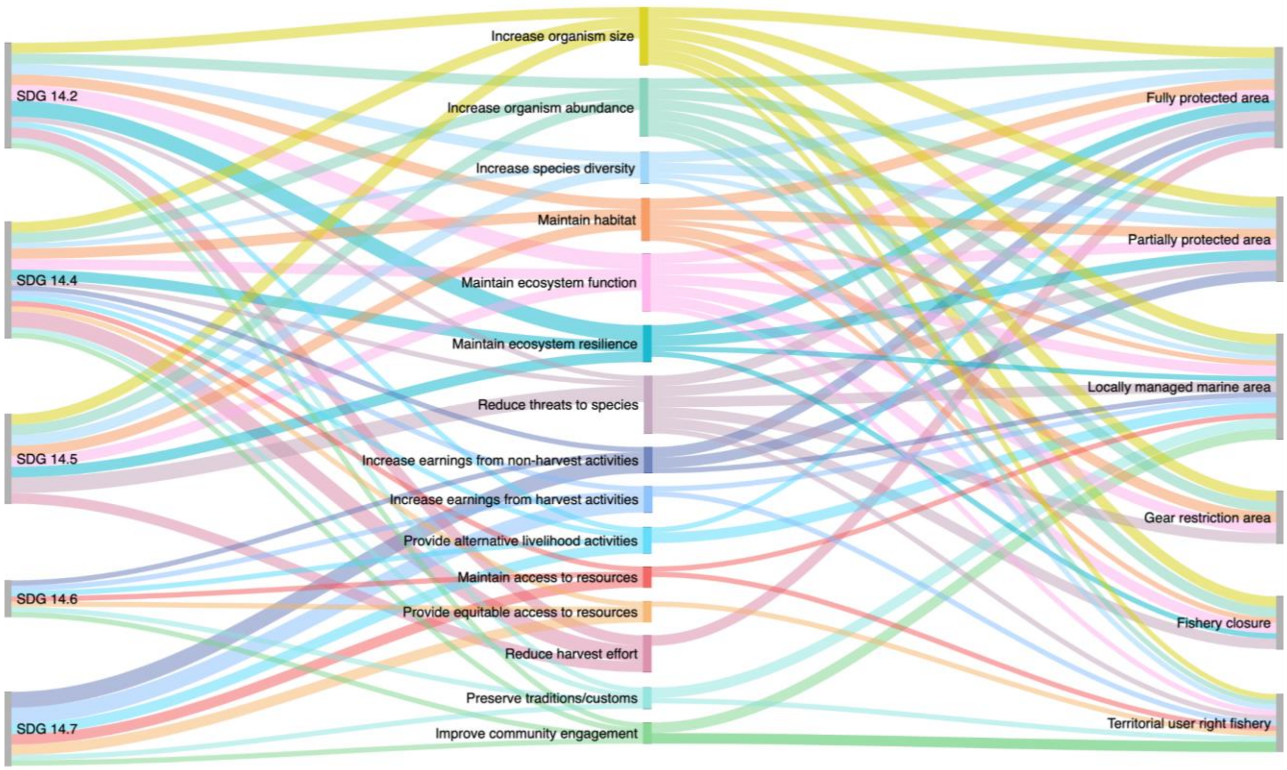


Figure A4. Visualization of contributions of ABMTs to SDG 14 targets based on ABMT outcomes. Thickness of lines indicate contribution scores (outcomes to SDG 14 targets) and confidence scores (ABMTs to outcomes). Confidence scores are based on quantity and quality of literature-based and expert opinion evidence and agreement among evidence (see Table B6).

Appendix B. Chapter 3

B1. Supplementary methods

Case studies were selected following a screening protocol using the database of marine spatial plans provided by the Intergovernmental Oceanographic Commission (IOC) Marine Spatial Planning Programme (http://msp.ioc-unesco.org) in March 2020. This screening protocol focused on MSP initiatives in Europe, the United Kingdom (UK), and the United States of America (USA) given their longer history and relevant experience in the use of formal MSP (Ehler, 2017; Ehler et al., 2019; Stelzenmüller et al., 2021). In many cases, plans in these regions have been formally approved, implemented, and, in some areas, adapted. Given this, screening focused on case studies from these regions to capture plans that are informed by current best practices. A total of 40 European, UK, and USA case studies listed in this database were screened for potential inclusion based on the availability of a final approved marine spatial plan (pre-implementation, implemented, or adapted) and language (plan available in English or English translation anticipated imminently at time of screening) (Figure B1).

Case studies were reviewed using a hybrid approach of inductive and deductive coding in QSR International's NVivo-12 software (Fereday & Muir-Cochrane, 2006; Skjott Linneberg & Korsgaard, 2019). An initial codebook containing three high-level codes and 10 sub-codes was designed based on common conservation-related principles and priorities and other concepts related to sustainability (Table B2). High-level codes were "general conservation", "marine protected areas", and "sustainability". Under "general conservation", sub-codes were a mix of conservation principles and priorities, specifically "connectivity & coherence", "ecosystem function", "ecosystem services", "endangered species", "habitat protection", "long-term", "reduce/manage impact", "resilience", and "restoration". "MPA network" was included as an initial sub-code under "marine protected area". Throughout document analysis, additional sub-codes were added *a posteriori* to this codebook as salient topics arose from the text (Attride-Stirling, 2001).

B2. Case study overview

The Belgian marine spatial plan was established through Royal Decree for the period of 2020-2026, extending throughout Belgian waters in the North Sea, a relatively small area compared to the other case studies analyzed here (Table S1). This plan includes sections dedicated to nature conservation, science and research, with a notable focus on quality conservation efforts over quantity. A core principle of this plan is "naturalness", which is considered a "basic precondition for the development of the Belgian North Sea". The plan also makes a connection between ecosystems and well-being. As a regulatory plan, this case establishes a clear definition for mitigation and sets boundaries for zones of commercial and industrial activities, as well as marine protected area (MPA) boundaries.

The Norwegian case study provides an update to a marine spatial plan first released for the Norwegian Sea in 2008-2009 and is one of three plans for the country's exclusive economic zone. Other plans exist for the Barents Sea and North Sea. This plan emphasizes “valuable and vulnerable” areas and sets goals for protection and sustainable use of the Norwegian Sea and for MPAs, though MPAs are planned and legislated under a separate process. These goals make reference to biodiversity and species management, especially within valuable and vulnerable areas. The plan identifies 12 of these areas that include, for example, habitat areas for commercially important species and areas containing cold-water corals. No new particularly valuable and vulnerable areas have been added to the plan since 2009. This plan culminates with government commitments to actions that will support the listed goals, for example by assessing new particularly valuable and vulnerable areas and “taking necessary steps to […] improve the conservation status of endangered and vulnerable species”. These commitments lack details on who, when, or how they are to be achieved. In this case, conservation often appears to be framed relative to sustainable resource use, as an enabling factor for continued use and development.

Scotland’s National Marine Plan uses overarching general policies to incorporate environmental protection and nature conservation in the plan, relying on other national or regional policies to provide strategies specific to conservation. The plan sets out to ensure a “clean, healthy, safe, productive, and biologically diverse” marine environment that is managed to meet the long-term needs of both nature and people, a shared vision for spatial plans in the UK. The intention of this plan is to provide guidance that regional planners can then apply to smaller-scale marine spatial plans that will meet local needs. Compared to Norway and Belgium’s marine spatial plans, the connection between conservation and “living within environmental limits” is less apparent. For each sector-specific section of the plan, there is general recognition of the potential impacts of sectoral activities to biodiversity and ecosystems, especially as those that may limit sustainable growth, though it is less clear that environmental standards must be met through specific management and regulations.

The Welsh National Marine Plan uses overarching policies to guide environmental protection and “living within environmental limits” and shares the UK vision for the marine environment. This plan sets four broad objectives that highlight sustainability, resilience, blue growth, and carbon emission targets. A clear priority in this plan is reducing intersectoral conflict, as established by the safeguarding policies applied to all new proposals with potential impacts to existing activities. While the overarching policies are intended to apply to the entire marine plan, only some sectors make specific reference to the environmental general policy (e.g., the Fisheries sectoral policy), which reflects the priorities and objectives of this plan in supporting existing activities and development. This plan, as well as Scotland's National Marine Plan, makes reference to "maximizing sustainable development", establishing that development occurs within some environmental limit without defining those thresholds or management actions to avoid crossing them. Where this case study differs from others is in its clear recognition of the contributions of the marine environment to well-being, also linking sustainable development to well-being.

The Washington State case was established as non-regulatory, lacking the authority to approve and prohibit developments or activities. The catalyst for this plan was clearly renewable energy development, as it was required to identify potential locations for such developments. It is the only marine spatial plan analyzed at the state-level; however, the planning area is comparable to that of the Welsh National Marine Plan. While this plan goes further than others to establish frameworks for reviewing risks and impacts from proposed developments, it too lacks clear management guidance on minimizing impacts to resources and ecosystems; yet, it is the only plan that provides a clear definition of adverse effects concerning ecologically important, sensitive, and unique areas. Most often this plan prioritizes reducing impacts to existing uses and users, similar to the Welsh case study, without clearly establishing a link between sustainable uses and the ecosystem. As a state-level plan, it is limited in its capacity to implement conservation measures, many of which are federally planned and regulated. A notable feature of this plan is the recognized role of Tribal governments in governance and the need to minimize impacts to Tribes.

B3. Extended themes description

Prioritizing economy was a prominent theme across case studies, as the documents analyzed established a clear need for plans to allow continued use and development of existing activities, as well as the development of new industries (Figure B2). This is unsurprising, given that each of these plans aims, in some capacity, to unite planning across ocean uses and users. This organizing theme reflects the frequent references to sustainability codes across case studies (Figure 3.1). This theme comprises two basic themes, including a priority for maintaining activities and minimizing the impacts of activities on each other, emerging from the Belgian, Welsh, and Washington case studies, and a common thread of permitting activities within protected areas to limit the impact of conservation on industry (Table B3). The latter stems from Scotland's National Marine Plan and the Belgian case study, both of which allow for development and industrial activities within existing protected areas where there is economic value or "social or economic benefits of national importance", in the case of Scotland. This theme is less apparent in the Norwegian case (Figure B2) and reflects a pattern of requiring more information and longer-term assessments to warrant conservation action, thereby ensuring continuance of industrial activities and limiting conservation's impact on these activities. This theme also reflects the frequent references to "reduce/manage impact" across case studies, and its particularly frequent use in the Belgium, Scotland, and Washington cases (Figure 3.1).

Ecosystems as fundamental demonstrates the value of ecosystems beyond the services they provide and captures the importance of healthy ocean ecosystems, especially for underpinning industries that are operating sustainably. This organizing theme emerged from all case studies except the Welsh National Marine Plan and comprises two basic themes: that ecosystems are interconnected, and their function should be maintained by reducing impacts, and that effective conservation measures prioritize conservation action and ecological value (Table B3). The Norwegian, Scottish, and Washington case studies all recognize the connectivity between species, habitats, and ecosystem function, and point to a need for reducing threats to these ecological units, especially those of ecological importance. This basic theme reflects the frequent references to “reduce/manage impact” within the spatial plans. The Belgian Norwegian, and Scottish cases also present commitments to biodiversity management, reducing risk of impacts to MPAs, and ensuring that MPAs are of high quality and able to meet conservation objectives (Table 3.3). In particular, Belgium’s spatial plan focuses on “working with nature”, where developments “take the natural processes as a starting point and/or envisage opportunities for nature development at the start of the design plans”. This is further reflected by the higher proportion of references to MPA-related codes in this case study (Figure 3.1). Overall, this organizing theme reflects the generally more frequent references to conservation principles and priorities, compared to codes for sustainability and reducing impacts, in all case studies except the Welsh case, which has a stronger focus on sustainability and resilience (Figure 3.2).

Ecosystems as functional takes a more anthropocentric view than *ecosystems as fundamental* by focusing on services provided by ecosystems that benefit society. This organizing theme was found in analytical memos for all but the Belgian case (Figure B2) and comprises three basic themes (Table B3). First, that ecosystem services hold economic value, stemming from a recognition in the Norwegian and Scottish cases that healthy ecosystems are necessary for continued delivery of ecosystem services to create benefits. Second, that reducing threats and impacts to ecosystems is necessary to ensure the long-term delivery of ecosystem services, a basic theme emerging from all but the Belgian case (Table B3). This basic theme also reflects the frequent references to “reduce/manage impact”. The third basic theme here emerged less prominently from Scottish, Welsh, and Washington case studies, and signalled the benefits of co-locating conservation measures with other activities through the delivery of ecosystem services. In particular, these cases identified potential benefits of co-locating MPAs with tourism and recreation activities or, in the Washington case, more generally identifying potentially compatible uses with MPAs. While “ecosystem services” was not coded with particularly high frequency (Figure 3.1), the concept of ecosystem services clearly guided the analyzed plans, going so far in the Norwegian case to state that “there is a clear relationship between biodiversity conservation and ecosystem functioning and the provision of ecosystem services".

Ecosystems as limits differs from *ecosystems as fundamental* and *functional* through its framing. For this theme, ecosystems can be exploited to some sustainable maximum capacity that falls within the limits of the environment. This theme emerged from all case studies, though to a lesser extent than previous themes, with the exception of Belgium's spatial plan and comprises two basic themes: that sustainable development and use occur within ecological limits and that plans can acknowledge that limits exist without defining limits or providing management guidance to stay within limits (Table B3, Figure B2). The latter basic theme is reflected in the Scotland, Wales, and Washington case studies, where responsibility for managing within limits is either omitted or deferred to other policies, plans, or agencies. As nations in the UK, both Scotland's and the Welsh National Marine Plans set "living within environmental limits" as an overarching policy that should be followed by users of the plan. The higher-than-average references to "resilience" in the Welsh National Marine Plan is reflected in this basic theme, as resilient ecosystems can presumably withstand maximal sustainable development and continued use (Figure 3.2).

Lastly, *social-ecological systems* emerged as an organizing theme, though was the least evident from analytical memos across case studies (Figure B2). This included two basic themes of recognizing the contributions of ecosystems to well-being and creating opportunities for local engagement with MSP (Table B3). In the Scottish case study, the national plan is intended to provide guidance to regional planners who can take a more localized approach to MSP. In the Washington case study, this is reflected by recognizing the roles of Tribal governments in MSP. Of the marine spatial plans analyzed, only this case study explicitly considered Indigenous Peoples and their role in governance. While other plans may not require inclusion of Indigenous Peoples, they did not similarly reference the role of affected communities in governance. The Welsh National Marine Plan was also unique in having some cultural objectives through preserving language, contributing to the well-being of coastal communities, and ensuring access to the marine environment, and an overarching policy to ensure a “strong, healthy, and just society”. These objectives go deeper than other case studies where economic and social benefits are encouraged, but less oriented toward well-being. In Belgium’s plan, the connection between the social and ecological systems is clear from the onset, as the plan states that “striving for the desired level of naturalness will result in healthy ecosystem services, at the service of social well-being.”

B4. Supplementary tables

Table B1. Overview of five case studies selected for document analysis, encompassing a diversity of scales, planning areas, types, phases, relations to MPAs, and included sectors. Potential future sectors are denoted with an asterisk (*). Where the IOC online database did not identify the relationship to MPAs, a preliminary scan of the MSP document was used to identify the appropriate category. Regulatory plans define legally enforceable mechanisms or measures for managing ocean uses. Advisory plans provide higher-level guidance for managing ocean uses that may be legally required in secondary regulatory planning.

Location	Scale	Planning area/size (km^2)	Year	Type	Phase	Relation to MPAs as listed by IOC	Sectors included
Belgium	National	North Sea/3,454	2020	Regulatory	Adaptation	Existing MPAs only	1. Nature conservation 2. Energy, cables, pipelines 3. Shipping, port development, dredging deposits 4. Fishing and aquaculture 5. Sand and gravel extraction 6. Coastal defences 7. Scientific research, radars, & measuring posts 8. Military use 9. Tourism & recreation 10. Cultural heritage & seascapes 11. Commercial and industrial activities
Norway	Sub-national	Norwegian Sea/ 1,120,000	2017	Advisory	Adaptation	MPAs under a separate process	1. Fisheries & aquaculture 2. Shipping & shipbuilding 3. Petroleum 4. Tourism 5. Mesopelagic fisheries* 6. Low trophic level fishing* 7. New aquaculture & kelp cultivation* 8. Residual raw materials (fishery by-products)* 9. Wind power & offshore renewables* 10. Seabed mining* 11. Bioprospecting*

Scotland	National	Scotland EEZ, Northeast Atlantic/ 69,002	2015	Advisory	Implementation	Existing and future MPAs	1. Sea fisheries 2. Aquaculture 3. Wild salmon & diadromous fish 4. Oil and gas 5. Carbon capture & storage 6. Offshore wind & marine renewable energy 7. Recreation and tourism 8. Shipping, ports, harbours, & ferries 9. Submarine cables 10. Defence 11. Aggregates
Wales	National	Bristol Channel, St. George's Channel, Irish Sea/32,000	2019	Advisory	Pre-implementation	Existing and future MPAs	1. Aggregates 2. Aquaculture* 3. Defence 4. Dredging & disposal 5. Energy- low carbon 6. Energy- oil and gas 7. Fisheries 8. Ports and shipping* 9. Subsea cabling 10. Surface water & wastewater treatment & disposal 11. Tourism & recreation* 12. Renewable energy* 13. Science and innovation*
Washington	Sub-national	Washington Pacific Coast/20,411	2018	Advisory	Implementation	MPAs under a separate process	1. Fisheries 2. Aquaculture 3. Recreation & tourism 4. Marine transportation, navigation, & infrastructure 5. Military uses 6. Research & monitoring 7. Renewable energy* 8. Offshore aquaculture* 9. Dredging & dredged material disposal* 10. Marine product extraction 11. Mining, including sand, gravel, and gas hydrate mining*

Table B2. Codes and their definitions used in document and themes analysis. Asterisks (*) identify codes included in the initial deductive codebook. Codes without an asterisk were added inductively as they emerged during analysis.

Code			Definition
Conservation-related codes	Principles	Connectivity & coherence*	Protecting marine species or biodiversity in general via ecologically connected and coherent marine protected area networks.
		Ecosystem function*	Recognizing the ecological processes, ecosystem structures, and species that comprise healthy, productive ecosystems that are resilient and continue to function.
		Long-term*	Referring to the temporal scope of planning and management, being long or longer term, to meet conservation and/or sustainability objectives, such as the long-term delivery of ecosystem services, avoiding long-term adverse effects, being resilient to change in the long-term.
		Resilience*	Referring to the capacity of species, habitats, and ecosystems to withstand human (e.g., development, fisheries activity) and natural (e.g., climate change) disturbances, continuing to function as healthy ecosystems delivering a range of ecosystem services at present and into the future.
		Restoration*	Referring to actions or a need to return specific species, biodiversity, habitats, or ecosystems to a former condition in which ecosystems are healthy, resilient, and able to deliver ecosystem services, either before or after a human activity or use.
	Priorities	Conservation tool/measure*	Referring to any management tool or measure that is not explicitly a Marine Protected Area and that delivers direct or ancillary conservation benefits, in general or specific to habitats or species, in the short- or long-term. They may also be specific to reducing the impacts of certain activities.
		Ecosystem services*	Referring to the goods and/or services that are either directly or indirectly delivered by ecosystems to humans or referring to the benefits to human well-being or economies derived from these services.
		Endangered species*	Referring to particular species or species more broadly that are rare, vulnerable, sensitive, threatened, declining, or endangered. Does not necessarily require legal status to be reflected here.
		General conservation*	Referring generally to the conservation or promotion of healthy nature/ecosystems/habitats/flora and fauna.
		Habitat protection*	Referring to the protection of specific habitat types (e.g., salt marshes), habitat-forming species (e.g., coral reefs), or habitats supporting ecological processes (e.g., spawning, foraging) or to the protection of habitat in general from specific or general activities.
		Invasive species	Referring to non-native, alien, introduced, or invasive species, either specific species or invasive species more generally.
		Marine protected area*	Any reference to marine protected areas (MPAs)or marine reserves.
		MPA network*	Any reference to a particular network or series of MPAs or an MPA network in general.
		Reduce/manage impact*	Referring to any action, commitment, or general statement on the need to either reduce, manage, or prevent negative impacts from specific activities or from human uses of oceans and ocean resources in general.
		Specific MPA	Any reference to a specific MPA within the planning area, either existing or proposed.

		Specific species	Referring to the conservation, protection, or reduction of harm to specific species in the case study region. Species may or may not be of commercial or conservation value.
Sustainability-related codes		Blue economy	Any reference to the “blue economy”, “ocean economy”, and “blue growth”, generally defined as ocean-based industries and activities that contribute economic value and may support wider social objectives.
		Sustainability*	Any general reference to sustainability, sustainable oceans management, or sustainable industries/activities/economies.
		Sustainable development	Any reference to the “sustainable development”, sustainable value creation, sustainable economic development, or sustainable growth of marine resources, industries, or activities.
		Sustainable Development Goal 14	Any specific reference to the United Nation’s Sustainable Development Goal 14 (SDG 14): Life Below Water.
		Sustainable resource use	Any reference to “sustainable use”, maintenance, or management of natural resources or ecosystems and/or their services or references to sustainable extractive activities (e.g., fishing, mining) or sustainable stock.

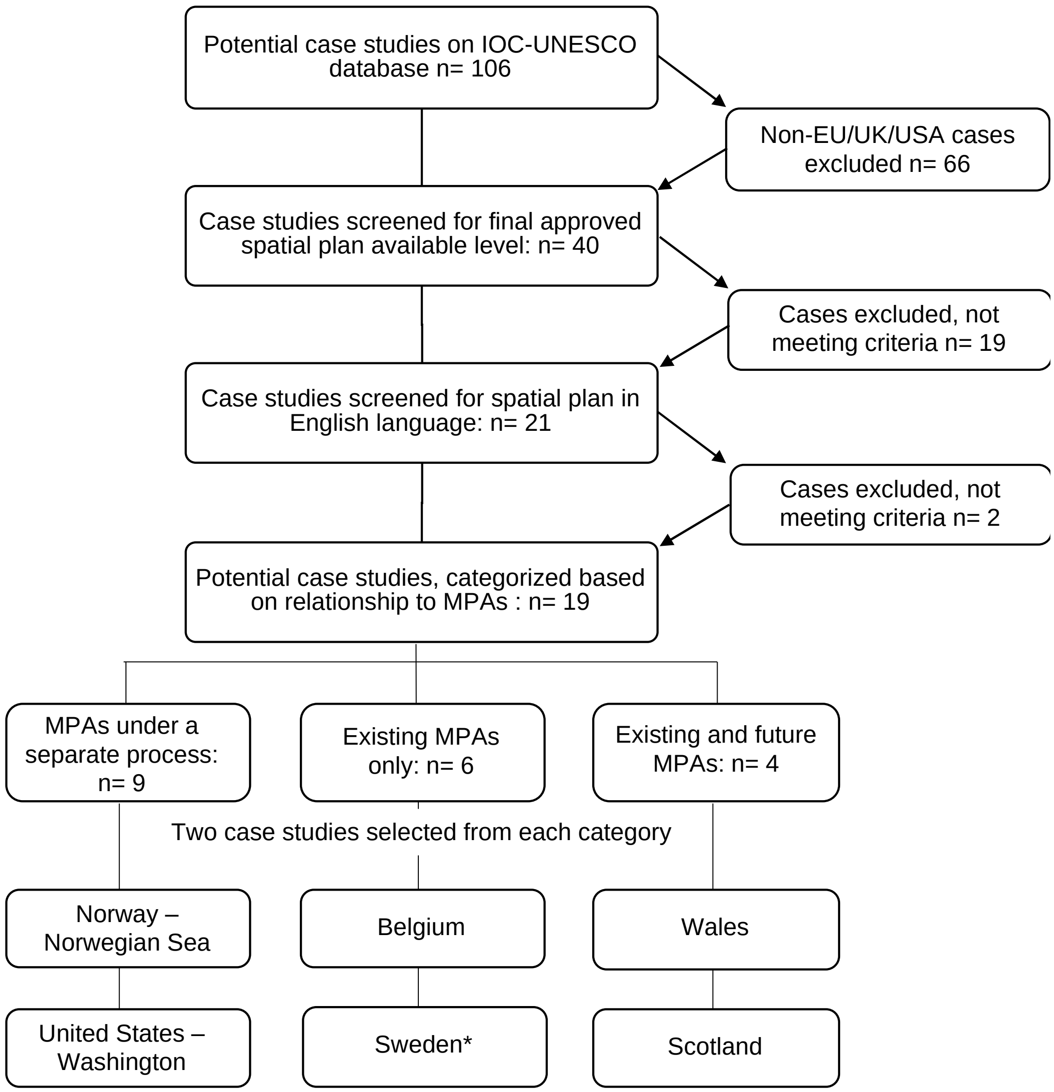
Table B3. Definitions of organizing and basic themes as they emerged from condensed analytical memos recorded per case study.

Organizing theme	**Definition**	**Basic themes**	**Emerged from...**	**Condensed analytical memos**
Ecosystems as fundamental (15 annotations)	Healthy ecosystems underpin the ocean economy and have value beyond the services they provide.	Ecosystems, species, and habitats are interconnected, and impacts to ecosystems should be avoided to maintain ecosystem function.	Norway	- Acknowledging ecological connectivity between species, habitats, ecosystem structure and function. - Reducing threats to ecological function and biodiversity
			Scotland	- Interconnectedness of ecosystems (role of species and habitats in delivering ecosystem services)
			Washington	- Avoid impacts to ecosystem function and integrity - Avoid adverse effects to ecologically importance, sensitive, and unique areas
		Prioritizing biodiversity conservation via effective conservation measures, including marine protected areas.	Belgium	- Giving priority to nature in nature conservation measures - Quality/effective MPAs over quantity - Enhancing naturalness via nature management measures - Implementing new marine protected areas - Ecosystems are fundamental, underlying development (relates to organizing theme) -Nature as foundational, "working with nature" (relates to organizing theme) - Value of nature beyond ecosystem services (relates to organizing theme)
			Norway	- Goal specific to management of biodiversity - Commitments to conservation action/developing new actions
			Scotland	- Reducing risk of impacts to MPAs, improving ability to meet conservation objectives
Ecosystems as functional (13 annotations)	Ecosystems serve functions that benefit society through the delivery of ecosystem services.	Ecosystems and the services they provide hold economic value.	Norway	- Biodiversity as natural resources with economic value - Value creation and blue growth orientation - Valuable and vulnerable habitats and species
			Scotland	- Ecosystem health for continued delivery of ecosystem services
		Reducing threats and impacts to ecosystem services supports long-term sustainability.	Norway	- Reducing threats to ensure opportunities for value creation - Reducing pressures and impacts on the environment
			Scotland	- Protecting biodiversity and increasing economic prosperity
			Wales	- Avoid impacts to habitats for commercial and protected species
			Washington	- Long-term sustainable ecosystem services via protection and restoration

		Co-locating conservation measures with other activities delivers benefits from protected ecosystem services.	Scotland;	- Sector benefiting from protection/conservation (especially tourism)
			Wales	- Co-locating sectors compatible with MPAs (e.g., tourism and recreation) - Diversifying sectors (e.g., alterative use of fishing vessels at certain times of year)
			Washington	- Identifying potential uses compatible with MPAs
Ecosystems as limits (10 annotations)	Ecosystems can be sustainably developed, and resources extracted, at a maximum within environmental limits.	Sustainable development and maximum sustainable use occur within ecological limits of the marine environment.	Norway	- Measures for protection are linked to sustainability
			Scotland	- Sustainable growth is limited by the environment - Maximizing sustainable activity - Sustainable development "within environmental limits"
			Wales	- Sustainably managing non-renewable resources - Maximizing oil and gas development sustainably
		Environmental limits and risks are identified though guidance for management within limits is not provided.	Scotland	- Deferring responsibility for managing within environmental limits - Acknowledging environmental risks and limits without giving guidance for management
			Wales	- Development giving "due regard" for environmental and cumulative impacts
			Washington	- Recognizing risks and impacts without addressing management
Prioritizing industry (15 annotations)	Continuation and/or development of ocean industries are clear priorities of marine spatial plans.	Current and, to a lesser extent, new activities are maintained and impacts of activities on each other are minimized.	Belgium	- Limiting impacts of one industry on another - Maintaining sectoral viability (e.g., no new closures)
			Wales	- Policies for safeguarding current activities - Safeguarding policy for each sector clear, general policy for the environment not specific per sector - Second to current activities, safeguarding potential new activities
			Washington	- Priority given to reducing impacts to existing uses over ecosystem - Minimize impacts to existing uses and adjacent tribes - Identify sites for potential new use/minimize conflict
		Activities with economic value are permitted within protected areas to limit the impact of conservation on industry.	Belgium	- Permitting potentially harmful activities in protected areas
			Norway	- Falling back on a need for more knowledge/longer term assessments to warrant conservation action
			Scotland	- Development in protected areas where there are social or economic benefits of "national importance"

				- Potential for projects with adverse effects to go ahead in Natura 2000 sites with permitting - Conservation measures impacting activities (e.g., fisheries) - Cumulative impacts only considered when they outweigh economic benefit
			Washington	- Permit certain activities in a specific MPA
Social-ecological systems (7 annotations)	Interdependencies between the socio-economic and ecological systems are recognized.	Contributions of ecosystems to well-being are recognized as important for sustainability.	Belgium	- Linked social and ecological wellbeing, ecosystem services focused
			Wales	- Optimize contributions of marine environment to well-being goals - Sustainable development linked to well-being
			Washington	- Recognize the ecosystem as a linked, social-economic-ecological system - Minimize adverse social and economic impacts
		Space is created for local needs and priorities to be reflected in planning and management.	Scotland	- Considering local priorities/other local plans
			Washington	- Recognizing Tribal governments as co-managers

B5. Supplementary figures



*Note: Sweden's national marine plans were not available in English at the time of analysis as anticipated due to the COVID-19 pandemic and did not undergo document analysis

Figure B1. Selection of case studies through systematic screening protocol of MSP initiatives listed on the Intergovernmental Oceanographic Commission online database (http://msp.ioc-unesco.org).

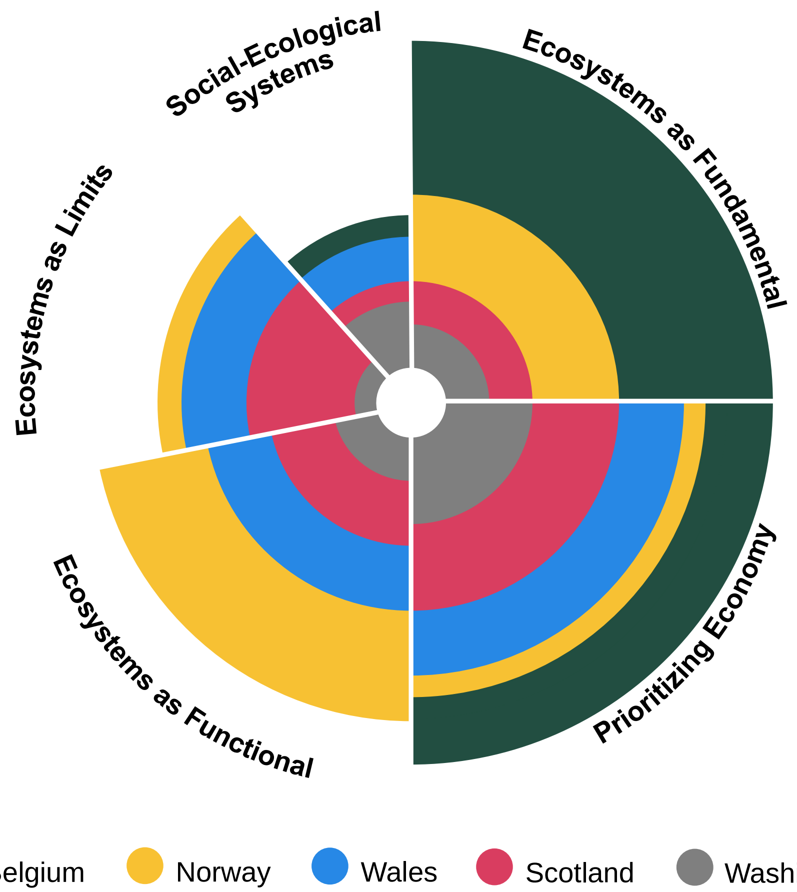


Figure B2. Relative importance of organizing themes within and across case studies based on the number of analytical memos sorted into each theme per case study (see Table 2). Size of each wedge depicts the total number of analytical memos per theme, while the coloured slices within each wedge depicts the number of memos per case study.

Appendix C. Chapter 4

C1. Supplementary tables

Table C1. Key literature used to identify features under each MSP characteristic. "Type" refers to either MSP-focused literature ("MSP") or other relevant literature ("Other"). The MSP principle listed for each item is not necessarily exclusive, as many of these resulted in the identification of features for other principles following qualitative cutting and sorting.

MSP Principle(s)	Citation	Type
All	Ehler, C. & F. Douvere. (2009). Marine Spatial Planning: a step-by-step approach toward ecosystem-based management. Intergovernmental Oceanographic Commission and Man and the Biosphere Programme, http://msp.ioc-unesco.org/msp-guides/msp-step-by-step-approach/	MSP

All	Ehler C. (2014). A Guide To Evaluating Marine Spatial Plans. IOC Manuals and Guides, http://msp.ioc-unesco.org/msp-guides/evaluating-marine-spatial-plans/	MSP
Adaptive	Frazão Santos, C., Agardy, T., Andrade, F., Calado, H., Crowder, L.B., Ehler, C.N., García-Morales, S., . . . & R. Rosa. (2020). Integrating climate change in ocean planning. Nature Sustainability, http://doi.org/10.1038/s41893-020-0513-x	MSP
Ecosystem-based	Borgström, S., Bodin, O., Sandström, A. & B. Crona. (2015). Developing an analytical framework for assessing progress toward ecosystem-based management. *AMBIO, 44,* http://link.springer.com/10.1007/s13280-015-0655-7	Other
Ecosystem-based	Convention on Biological Diversity. (2010). Ecosystem approach principles, https://www.cbd.int/ecosystem/principles.shtml	Other
Ecosystem-based	Foley, M.M., Halpern, B.S., Micheli, F., Armsby, M.H. & M.R. Caldwell. (2010). Guiding ecological principles for marine spatial planning. *Marine Policy, 34,* http://dx.doi.org/10.1016/j.marpol.2010.02.001	MSP
Ecosystem-based	Leslie, H.M. & K.L McLeod. (2007). Confronting the challenges of implementing marine ecosystem-based management. Frontiers in *Ecology and the Environment, 5,* http://doi.org/10.1890/060093	Other
Ecosystem-based	UNEP. (2011). Taking Steps toward Marine and Coastal Ecosystem-Based Management - An Introductory Guide. UNEP Regional Seas Reports and Studies No. 189, https://wedocs.unep.org/handle/20.500.11822/8445	Other
Integrated	Asif, M., Zutshi, A. & N. Ahmad. (2011). An integrated management systems approach to corporate sustainability. *European Business Review, 23,* https://doi.org/10.1108/09555341111145744	Other
Integrated	Stephenson, R.L., Hobday, A.J., Cvitanovic, C., Alexander, K.A., Begg, G.A., Bustamante, R.H., Dunstan, P.K., . . . T.M. Ward. (2019). A practical framework for implementing and evaluating integrated management of marine activities. *Ocean & Coastal Management, 177,* http://doi.org/10.1016/j.ocecoaman.2019.04.008	Other
Participatory	Kidd, S. & L. McGowan. (2013). Constructing a ladder of transnational partnership working in support of marine spatial planning: Thoughts from the Irish Sea. *Journal of Environmental Management, 126,* http://doi.org/10.1016/j.jenvman.2013.03.025	MSP
Participatory	Morf, A., Kull, M., Piwowarczyk, J. & K. Gee. (2019). Towards a Ladder of Marine/Maritime Spatial Planning Participation. In Zaucha, J. & K. Gee (Eds.) *Maritime Spatial Planning,* http://link.springer.com/10.1007/978-3-319-98696-8_10	MSP
Participatory	Twomey, S. & C. O'Mahony. (2019). Stakeholder Processes in Marine Spatial Planning: Ambitions and Realities from the European Atlantic Experience. In Zaucha, J. & K. Gee (Eds.) *Maritime Spatial Planning,* http://link.springer.com/10.1007/978-3-319-98696-8_13	MSP

Table C2. The MSP index scoring guide, using a four-point scale from zero to three, maximum possible points is 108. Absent means there is no intention or recognition of a feature; minimal means there is an intention or recognition of a feature; good means there is a commitment to and identification of a feature, and more requirements of a feature are present, and excellent means the feature fully exists with all requirements.

Feature		Absent (0 pts)	Minimal (1 pt)	Good (2 pts)	Excellent (3pts)
Adaptive	Monitoring	No clear intention to monitor for management outcomes.	Clear intention to monitor, possibly through routine or systematic processes, for management outcomes. A baseline description of the initial state of the system may not exist and performance indicators may not be identified.	Clear commitments and/or one-time investments are made to allow routine and/or systematic monitoring for management outcomes, compared against a baseline description of the initial state of the system using qualitative and/or quantitative performance indicators.	Reliable investments are made to allow routine and systematic monitoring for management outcomes, compared against a baseline description of the initial state of the system using qualitative and/or quantitative performance indicators.
	Resource allocation	No recognized need for resource reallocation to enable adaptation.	Recognized need for resource reallocation to enable adaptation.	Mechanisms identified to enable resource reallocation away from ineffective management actions, possibly based on monitoring and evaluation, to alternatives and/or to assess lower cost management alternatives for adaptation.	Mechanisms exist to enable resource reallocation away from ineffective management actions, based on monitoring and evaluation, to alternatives and to assess lower cost management alternatives for adaptation.

	Evaluation	No clear intention to establish an evaluation plan.	Clear intention to establish an evaluation plan for assessing efficacy and/or ability to achieve MSP objectives, possibly including procedures for regular analysis and interpretation of monitoring data to inform adaptation needs and/or for open and accessible reporting of evaluation findings.	Clear commitment to establishing an evaluation plan for assessing efficacy and ability to achieve MSP objectives, possibly measured against predetermined criteria, including procedures for regular analysis and interpretation of monitoring data to inform adaptation needs and/or for open and accessible reporting of evaluation findings.	An evaluation plan exists to assess efficacy and ability to achieve MSP objectives, measured against predetermined criteria, including procedures for regular analysis and interpretation of monitoring data to inform adaptation needs and for open and accessible reporting of evaluation findings.
	Modification	No recognized need for mechanisms for modifying MSP goals, objectives, and/or management measures.	Recognized need for mechanisms for modifying MSP goals, objectives, and/or management measures based on monitoring and evaluation, MSP may be flexible enough to be modified in response to a changing ecosystem and/or governance conditions in the short- and/or long-term.	Mechanisms identified for modifying MSP goals, objectives, and/or management measures based on monitoring and evaluation. MSP and/or the spatial management plan are flexible enough to be modified in response to changing ecosystems and/or governance conditions in the short- and long-term.	Mechanisms exist for modifying MSP goals, objectives, and/or management measures based on monitoring and evaluation. MSP and the spatial management plan are flexible enough to be modified in response to changing ecosystems and governance conditions in the short- and long-term.
	Uncertainty	No recognized need for mechanisms to make decisions under uncertainty.	Recognized need for mechanisms to make decisions under uncertainty related to the environmental and/or socio-economic contexts of MSP, possibly including use of the precautionary approach and/or identifying missing information and/or applied research needs to reduce uncertainty for future MSP.	Mechanisms identified to make decisions under uncertainty related to the environmental and socio-economic contexts of MSP, possibly including use of the precautionary approach to overcome uncertainty and/or identifying missing information and applied research needs to reduce uncertainty for future MSP.	Mechanisms exist to make decisions under uncertainty related to the environmental and socio-economic contexts of MSP, including use of the precautionary approach to overcome uncertainty and identifying missing information and applied research needs to reduce uncertainty for future MSP.

	Climate change	No recognized need for mechanisms to incorporate climate change in MSP.	Recognized need for mechanisms for incorporating climate change in MSP, possibly including recognition of climate change in MSP objectives, plans, and/or policies, climate-related risks, use of climate change scenarios to anticipate changes over time and space, and/or use of dynamic management.	Mechanisms identified for incorporating climate change in MSP, including recognition of climate change in MSP objectives, plans, and/or policies, climate-related risks, use of climate change scenarios to anticipate conflicts and changes in ecosystems, ecosystem services, and human activities over time and space, and/or use of dynamic management.	Mechanisms exist for incorporating climate change in MSP, including recognition of climate change in MSP objectives, plans, and policies, analysis of climate-related risks, use of climate change scenarios to anticipate conflicts and changes in ecosystems, ecosystem services, and human activities over time and space, and possibly use of dynamic management.
	Biodiversity conservation	No recognized need for policies and/or management measures to maintain or restore biodiversity.	Recognized need for policies and/or management measures to maintain or restore biodiversity, including native, threatened or endangered, and/or key species, their habitats, and/or ecological processes essential to biodiversity.	Policies and/or management measures identified to maintain or restore biodiversity, including native, threatened or endangered, and/or key species, their habitats, and/or ecological processes essential to biodiversity.	Policies and/or management measures exist to maintain or restore biodiversity, including native, threatened or endangered, and key species, their habitats, and ecological processes essential to biodiversity.
	Habitat	No recognized need for policies and/or management measures to maintain or restore habitat.	Recognized need for policies and/or management measures to maintain or restore habitat quantity, quality, and/or diversity, possibly including habitat important for ecological processes, ecologically valuable species, and/or life history stages, habitat spatial arrangement, and/or relationships between habitat	Policies and/or management measures identified to maintain or restore habitat quantity, quality, and/or diversity, including habitat important for ecological processes, ecologically valuable species, and/or life history stages, habitat spatial arrangement, and/or relationships between habitats.	Policies and/or management measures exist to maintain or restore habitat quantity, quality, and diversity, including habitat important for ecological processes, ecologically valuable species, and life history stages, habitat spatial arrangement, and relationships between habitats.

Ecosystem-based	Ecosystem function	No recognized need for policies and/or management measures to maintain or restore ecological structure and function.	Recognized need for policies and/or management measures to maintain or restore ecological structure and function, possibly including biotic and abiotic ecosystem components, disturbance regimes, trophic interactions, and/or meta-population and/or community dynamics.	Policies and/or management measures identified to maintain or restore ecological structure and function, including biotic and abiotic ecosystem components, disturbance regimes, trophic interactions, and/or meta-population and community dynamics.	Policies and/or management measures exist to maintain or restore ecological structure and function, including biotic and abiotic ecosystem components, disturbance regimes, trophic interactions, and meta-population and community dynamics.
	Adjacent ecosystems	No recognized need for policies and/or management measures to improve connections between ecosystems within the planning area and to the wider land-sea environments.	Recognized need for policies and/or management measures to maintain or improve connections between ecosystems within the planning area and to the wider land-sea environments, considering geomorphology, biogeography, and/or oceanography affecting the planning area.	Policies and/or management measures identified to maintain or improve connections between ecosystems within the planning area and to the wider land-sea environments, considering geomorphology, biogeography, and/or oceanography affecting the planning area.	Policies and/or management measures exist to maintain or improve connections between ecosystems within the planning area and to the wider land-sea environments, considering geomorphology, biogeography, and/or oceanography affecting the planning area.
	Multiple objectives	No recognized need for policies and/or management measures to balance conservation and sustainable use of biodiversity.	Recognized need for policies and/or management measures to secure the delivery of multiple ecosystem services, including tangible and/or intangible services, to balance conservation and sustainable use of biodiversity.	Policies and/or management measures identified to secure the long-term delivery of multiple ecosystem services, possibly including tangible and intangible services, to balance conservation and sustainable use of biodiversity. Ecosystem services within the marine area will be identified and will inform management priorities.	Policies and/or management measures exist to secure the long-term delivery of multiple ecosystem services, including tangible and intangible services, to balance conservation and sustainable use of biodiversity. Ecosystem services within the marine area are identified and inform management priorities.

	Minimize threats	No recognized need for policies and/or management measures to eliminate or minimize threats to species and ecosystems from human activities.	Recognized need for policies and/or management measures to eliminate or minimize threats to species and ecosystems from human activities, including identifying threats, managing ecosystems within their limits, spreading risk across the planning area, and/or addressing cumulative impacts.	Policies and/or management measures identified to eliminate or minimize threats to species and ecosystems from human activities, including identifying threats, managing ecosystems within their limits and defining those limits, spreading risk across the planning area, and/or addressing cumulative impacts.	Policies and/or management measures exist to eliminate or minimize threats to species and ecosystems from human activities, including identifying threats, managing ecosystems within their limits, spreading risk across the planning area, and addressing cumulative impacts.
Integrated	Common framework	No clear intention to establish a common framework for integration.	Clear intention to establish a common framework that integrates within and between stakeholders, governance, policy, legislation, and/or management.	Clear commitment to establishing a common framework that integrates within and between stakeholders, governance, policy, legislation, and management. The framework may clarify how integration addresses gaps in management.	A common framework that integrates within and between stakeholders, governance, policy, legislation, and existing management exists. The framework clarifies how integration addresses gaps in management.
	Balancing demands	No recognized need for mechanisms to ensure demands for development and protection are balanced within the planning area.	Recognized need for mechanisms to balance demands for development and protection within the planning area, possibly including evaluating trade-offs among ecological, social, and economic objectives and activities, considering cumulative impacts of multiple activities, and/or fostering economic diversification in marine sectors.	Mechanisms identified to balance demands for development and protection within the planning area, including evaluating trade-offs among ecological, social, and economic objectives and activities at temporal, spatial, and/or governance scales, considering cumulative impacts of multiple activities, and/or fostering economic diversification in marine sectors.	Mechanisms exist to balance demands for development and protection within the planning area, including evaluating trade-offs among ecological, social, and economic objectives and activities at temporal, spatial, and governance scales, considering cumulative impacts of multiple activities, and fostering economic diversification in marine sectors.

	Multi-sector integration	No clear intention to establish an integrated management plan across sectors.	Clear intention to establish an integrated management plan across sectors within and/or affecting the planning area that may include management measures, plans, and policies and/or communicate the expectation for integration.	Clear commitment to establishing an integrated management plan across sectors within and affecting the planning area that will include management measures, plans, and policies and communicate the expectation for integration.	An integrated management plan across sectors within and affecting the planning area exists and includes their management measures, plans, and policies and communicates the expectation for integration.
	Multi-level integration	No recognized need for mechanisms for implementing vertical and horizontal integration of new or existing governance and/or management systems.	Recognized need for mechanisms for implementing vertical and/or horizontal integration of new and/or existing governance and/or management systems, possibly including integration of different knowledges.	Mechanisms identified for vertical and horizontal integration of new and existing governance and/or management systems, possibly including integration of different knowledges, toward whole system management in addition to individual sub-systems.	Mechanisms exist for vertical and horizontal integration of new and existing governance and/or management systems, including integration of different knowledges, supporting whole system management in addition to individual sub-systems.
	Institutional coordination	No recognized need for mechanisms to support institutional coordination.	Recognized need for mechanisms to support institutional coordination, possibly including defining and assigning responsibility for MSP tasks and their integration, coordination of institutional programs and/or policies within and affecting the planning area, and/or commitments across institutions for implementing integrated management plans.	Mechanisms identified to support institutional coordination, including defining and assigning responsibility for MSP tasks and their integration, coordination of institutional programs and/or policies within and affecting the planning area, and/or commitments across institutions for implementing integrated management plans.	Mechanisms exist to support institutional coordination, including defining and assigning responsibility for MSP tasks and their integration, coordination of institutional programs and policies within and affecting the planning area, and commitments across institutions for implementing integrated management plans.
	Implementation	No recognized need for mechanisms for adopting and implementing integrated management plans.	Recognized need for mechanisms for adopting and implementing integrated management plans and/or resources to support implementation of integrated management plans.	Mechanisms are identified for adopting and implementing integrated management plans and/or resources are identified to support the increased costs (e.g., time, money, skills) of capacity, leadership, and tools for integration.	Mechanisms exist for adopting and implementing integrated management plans and resources are available to support the increased costs (e.g., time, money, skills) of capacity, leadership, and tools for integration.

Participatory	Participation plan	No clear intention to establish a participation plan.	Clear intention to establish a participation plan that may indicate who, when, and how to involve stakeholders and rightsholders, that may be developed prior to beginning MSP, and/or may define the functions and objectives of participation, MSP authorities and participants, and/or the entitlement to participate.	Clear commitment to establishing a participation plan indicating who, when, and how to involve stakeholders and rightsholders, developed prior to beginning MSP, and/or will define the functions and objectives of participation, MSP authorities and participants, and the entitlement to participate.	A participation plan indicating who, when, and how to involve stakeholders and rightsholders exists, was developed prior to beginning MSP, and defines the functions and objectives of participation, MSP authorities and participants, and the entitlement to participate, which may evolve over time as needed.
	Balanced participation	No recognition of a need for mechanisms to ensure that a final group of stakeholders and rightsholders is balanced and/or to anticipate and resolve conflicts.	Recognized need for mechanisms to ensure that the group of stakeholders and rightsholders is balanced, representing diverse interests, possibly with equal powers in advising and decision-making, and/or to anticipate and/or resolve conflicts, possibly in a transparent and equitable manner.	Mechanisms identified to ensure that the group of stakeholders and rightsholders is balanced, representing diverse interests, possibly with equal powers in advising and decision-making, and to anticipate and/or resolve conflicts in a transparent and equitable manner.	Mechanisms exist to ensure that the group stakeholders and rightsholders is balanced, representing diverse interests, with equal powers in advising and decision-making, and to anticipate and resolve conflicts in a transparent and equitable manner.
	Multiple avenues	No recognized need for mechanisms ensuring stakeholders have multiple avenues for both vertical and horizontal participation.	Recognized need for mechanisms ensuring stakeholders have multiple avenues for both vertical (e.g., formal communications, consultation) and horizontal (e.g., dialogue, negotiation) participation.	Mechanisms identified to ensure stakeholders have multiple avenues for both vertical (e.g., formal communications, consultation) and horizontal (e.g., dialogue, negotiation) participation, possibly simultaneously.	Mechanisms exist to ensure stakeholders have multiple avenues for both vertical (e.g., formal communications, consultation) and horizontal (e.g., dialogue, negotiation) participation simultaneously.

	Stakeholder empowerment	No recognized need for ensuring stakeholders have the means, skills, and knowledge to participate in MSP.	Recognized need for mechanisms to ensure stakeholders have the means, skills, and knowledge to participate with a shared sense of purpose, values, and/or rules, including policies and/or protocols for promoting trust among stakeholders and in the process.	Mechanisms identified to ensure stakeholders have the means, skills, and knowledge to participate with a shared sense of purpose, values, and/or rules, including policies and/or protocols for promoting trust among stakeholders and in the process, and/or decentralizing management to the lowest level and/or enabling participation in governance.	Mechanisms exist to ensure stakeholders have the means, skills, and knowledge to participate with a shared sense of purpose, values, and rules, including policies and/or protocols for promoting trust among stakeholders and in the process, and/or decentralizing management to the lowest level and/or enabling participation in governance.
	Participation throughout	No recognized need for mechanisms to ensure participation occurs throughout MSP.	Recognized need for mechanisms to ensure participation occurs throughout MSP, including regular meetings defined for stakeholder involvement and/or opportunity to engage in aspects of decision-making, setting objectives, developing alternatives, and/or identifying the preferred spatial management plan.	Mechanisms identified to ensure participation occurs throughout MSP, including regular meetings defined for stakeholder involvement at each MSP stage and opportunity to engage in aspects of decision-making, setting objectives, developing alternatives, and/or identifying the preferred spatial management plan.	Mechanisms exist to ensure participation occurs throughout MSP, including regular meetings defined for stakeholder involvement at each MSP stage and opportunity to engage in each aspect of decision-making, setting objectives, developing alternatives, and identifying the preferred spatial management plan.
	Engagement & communication	No recognized need for mechanisms to effectively engage and communicate with participants.	Recognized need for mechanisms to effectively engage and communicate with participants, including timely reporting and frequent contact, targeted and/or accessible communication, communication of evaluation and adaptation, designation of a lead communicator, and/or identification of resources.	Mechanisms identified to effectively engage and communicate with participants, including timely reporting and frequent contact, targeted and accessible communication, communication of evaluation and adaptation processes, designation of a lead communicator, and/or identification of resources.	Mechanisms exist to effectively engage and communicate with participants, including timely reporting and frequent contact, targeted and accessible communication in multiple formats, communication of evaluation and adaptation processes, designation of a lead communicator, and identification of resources.

Place-based	Spatial management plan	No clear intention to develop a preferred spatial management plan.	Clear intention to develop a spatial management plan, identifying when, where, and how the goals and objectives of MSP will be met, that may be formally adopted. The plan may identify boundaries, funding, institutional arrangements, rules, incentives and disincentives, and/or management measures.	Clear commitment to developing a preferred spatial management plan, possibly from alternative scenarios, identifying when, where, and how the goals and objectives of MSP will be met, and possibly adopted through a formal process. The plan will identify boundaries, funding, institutional arrangements, rules, incentives and disincentives, and/or management measures.	A preferred spatial management plan exists, developed from alternative scenarios, identifying when, where, and how the goals and objectives of MSP will be met, and is adopted through a formal process. The plan identifies boundaries, funding, institutional arrangements, rules, incentives and disincentives, and management measures.
	Boundaries	No clear intention to establish boundaries.	Clear intention to establish boundaries for the planning area, possibly prior to initiating MSP, including geographical, administrative, and/or analytical boundaries at local, national, and transnational scales as needed.	Clear commitment to establishing boundaries for the planning area prior to initiating MSP, including geographical, administrative, and/or analytical boundaries at local, national, and transnational scales as needed.	Boundaries are established for the planning area prior to initiating MSP, including geographical, administrative, and analytical, boundaries at local, national, and transnational scales as needed.
	Upstream & downstream	No recognition of upstream (i.e., affecting the planning area) and/or downstream (i.e., affected by the planning area) human activities and pressures.	MSP generally recognizes upstream (i.e., affecting the planning area) and/or downstream (i.e., affected by the planning area) human activities and pressures.	MSP identifies specific upstream (i.e., affecting the planning area) and/or downstream (i.e., affected by the planning area) human activities and pressures.	MSP incorporates specific upstream (i.e., affecting the planning area) and downstream (i.e., affected by the planning area) human activities and pressures in the spatial management plan.
	Spatial information	No clear intention to develop an inventory of spatial data.	Clear intention to develop an inventory of spatial data, including current and/or future trends in ecological, oceanographic, and human use data derived from multiple sources.	Clear commitment to developing an inventory of spatial data, including current and future trends in ecological, oceanographic, and human use data derived from scientific literature, expert opinion, government sources, local and/or traditional knowledge, and/or direct measurements.	An inventory of spatial data exists, including current and future trends in ecological, oceanographic, and human use data derived from scientific literature, expert opinion, government sources, local and traditional knowledge, and/or direct measurements.

	Scale	No clear intention to ensure MSP occurs at sufficient temporal and spatial scales.	Clear intention to ensure that MSP occurs at temporal and spatial scales sufficient to capture interactions between social, ecological, and/or oceanographic components of the planning area to support long-term objectives and/or goals.	Clear commitment to ensuring that MSP occurs at temporal and spatial scales sufficient to capture interactions between social, ecological, and oceanographic components of the planning area to support long-term objectives and/or goals.	MSP occurs at temporal and spatial scales sufficient to capture interactions between social, ecological, and oceanographic components of the planning area to support long-term objectives and goals.
	Conflicts & compatibilities	No clear intention to analyze spatial and temporal distributions and density of human activities to assess conflicts and compatibilities.	Clear intention to analyze spatial and temporal distributions and density of human activities to assess conflicts and compatibilities among existing uses, existing uses and the environment, and/or existing and future uses to inform the spatial management plan.	Clear commitment to analyzing spatial and temporal distributions and density of human activities to assess conflicts and compatibilities among existing uses, existing uses and the environment, and existing and future uses, possibly including a priori allocation of areas to future uses, to inform the spatial management plan.	Spatial and temporal distributions and density of human activities are analyzed to assess conflicts and compatibilities among existing uses, existing uses and the environment, and existing and future uses, possibly including a priori allocation of areas to future uses, to inform the spatial management plan.
Strategic	Resources	No recognized need for mechanisms to ensure sustainable human, technical, and/or financial resources are available to develop and implement the current and/or future iterations of MSP.	Recognized need for mechanisms to ensure sustainable human, technical, and/or financial resources are available to develop and implement the current and/or future iterations of MSP.	Mechanisms identified to ensure sustainable human, technical, and/or financial resources are available to develop and implement the current and/or future iterations of MSP over the long-term, possibly including a financial plan for MSP costs, means to multiple and alternative financial resources, and/or identification of appropriately skilled staff.	Mechanisms exist to ensure sustainable human, technical, and financial resources are available to develop and implement the current and future iterations of MSP over the long-term, including a financial plan for MSP costs, means to multiple and alternative financial resources, and identification of appropriately skilled staff.

	Goals & objectives	No clear intention to establish goals, objectives, and guiding principles at the onset of MSP.	A clear intention to establish goals, SMART objectives, and guiding principles at the onset of MSP that are supported by decision-makers and stakeholders.	A clear commitment to establishing goals, SMART objectives, and guiding principles at the onset of MSP that are supported by decision-makers and stakeholders.	Goals, SMART objectives, and enforceable guiding principles exist, established at the onset of MSP and supported by decision-makers and stakeholders. This may include a list of specific problems to be solved by MSP.
	Authority & leadership	No clear intention to establish authorities or MSP team to lead MSP.	Clear intention to establish authorities, political champions, a coordinating agency, and/or MSP team to lead MSP and/or the implementation of the spatial management plan.	Clear commitment to establishing authorities, political champions, a coordinating agency, and/or MSP team to lead MSP and the implementation of the spatial management plan, possibly prior to beginning MSP.	Authorities, political champions, a coordinating agency, and MSP team are established to lead MSP and the implementation of the spatial management plan, possibly prior to beginning MSP.
	Work plan	No clear intention to establish a work plan.	Clear intention to establish a work plan that identifies key work products and their interdependencies, assigns responsibility for outputs, identifies resources required to deliver outputs, sets a timeframe for initiating, completing, and revising MSP, and/or identifies potential risks in MSP and contingency measures.	Clear commitment to establishing a work plan that identifies key work products and their interdependencies, assigns responsibility for outputs, identifies resources for outputs, sets a timeframe for initiating, completing, and revising MSP, and/or identifies potential risks and contingency measures or a work plan exists containing some requirements.	A work plan exists that identifies key work products and their interdependencies, assigns responsibility for outputs, identifies resources required to deliver outputs, sets a timeframe for initiating, completing, and revising MSP, and identifies potential risks in MSP and contingency measures.

	Evidence-based	No clear intention to be evidence-based.	Clear intention to be evidence-based, using the best available natural and/or social science and/or different types of information relevant to the planning area.	Clear commitment to being evidence-based, possibly informed by a science advisory body or similar, using the best available natural and social science and/or different types of information relevant to the planning area and/or external environment.	MSP is evidence-based, informed by a science advisory body or similar, using the best available natural and social science and different types of information (e.g., scientific, Indigenous and local knowledge, and knowledge innovations and practices) relevant to the planning area and external environment.
	Compliance & enforcement	No clear intention to establish a plan and/or strategies for enforcement and compliance.	Clear intention to establish a plan and/or strategies that define authority and measures for enforcing the spatial management plan and achieving high compliance. Compliance may be defined, including which activities are subject to requirements of the spatial management plan and/or responses to non-compliance.	Clear commitment to establishing a plan and/or strategies that define authority and measures for enforcing the spatial management plan and achieving high compliance. Compliance is clearly defined, including which activities are subject to requirements of the spatial management plan and responses to non-compliance.	A plan and/or strategies exist that define authority and measures for enforcing the spatial management plan and achieving high compliance. Compliance is clearly defined, including which activities are subject to requirements of the spatial management plan and responses to non-compliance.

C2. Supplementary figures

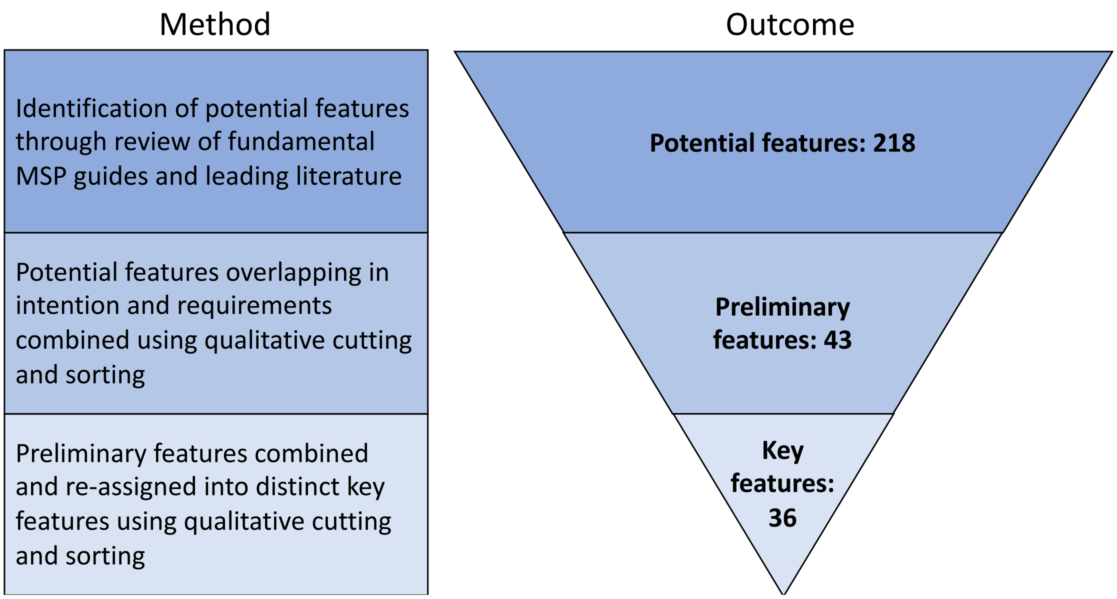
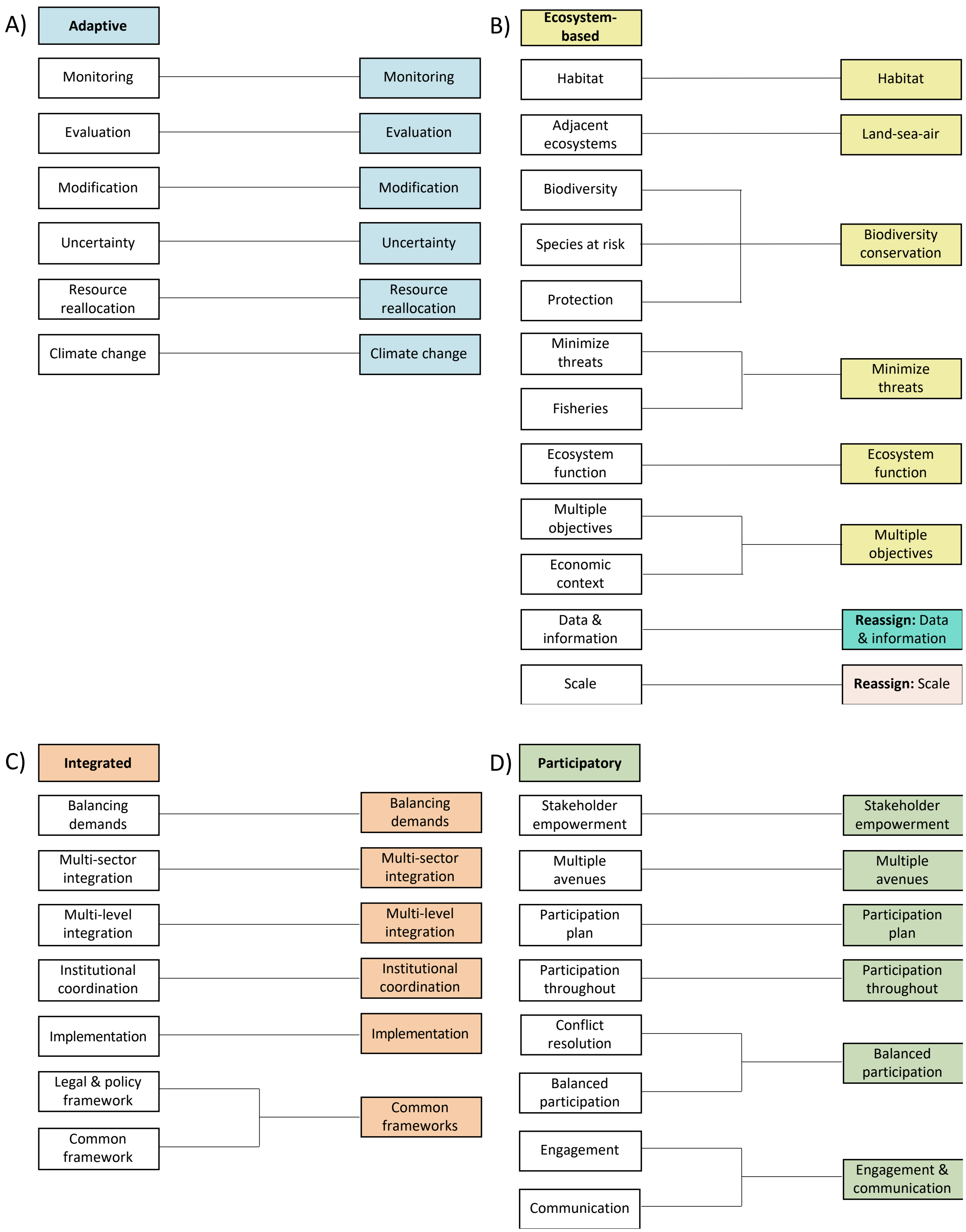


Figure C1. Three-step method and outcomes of each step for identifying features of the MSP Index. The initial 218 potential features identified through review of key literature underwent two rounds of qualitative cutting and sorting to establish the final 36 key features.


A)
Adaptive
Monitoring
Evaluation
Modification
Uncertainty
Resource reallocation
Climate change
Monitoring
Evaluation
Modification
Uncertainty
Resource reallocation
Climate change
B)
Ecosystem-based
Habitat
Adjacent ecosystems
Biodiversity
Species at risk
Protection
Minimize threats
Fisheries
Ecosystem function
Multiple objectives
Economic context
Data & information
Scale
Habitat
Land-sea-air
Biodiversity conservation
Minimize threats
Ecosystem function
Multiple objectives
Reassign: Data & information
Reassign: Scale
C)
Integrated
Balancing demands
Multi-sector integration
Multi-level integration
Institutional coordination
Implementation
Legal & policy framework
Common framework
Balancing demands
Multi-sector integration
Multi-level integration
Institutional coordination
Implementation
Common frameworks
D)
Participatory
Stakeholder empowerment
Multiple avenues
Participation plan
Participation throughout
Conflict resolution
Balanced participation
Engagement
Communication
Stakeholder empowerment
Multiple avenues
Participation plan
Participation throughout
Balanced participation
Engagement & communication

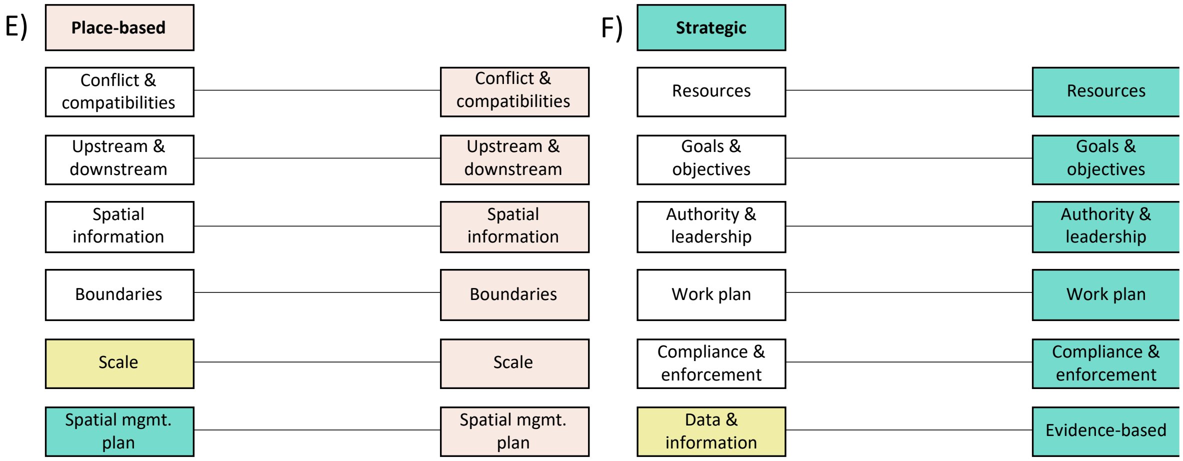


Figure S2. Detailed identification of the final 36 key features in the MSP index, established through qualitative cutting and sorting of 43 preliminary features, for each MSP principle: (A) adaptive, (B) ecosystem-based, (C) integrated, (D) participatory, (E) place-based, and (F) strategic.