Twenty years of marine systematic conservation planning: a global scoping review for good practices

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ABSTRACT

Background. Human activities are exerting increasing pressure on the ocean, threatening marine biodiversity and the many benefits it provides to people. Allocating adequate space to enable the sustainable and equitable use of the ocean resources, while ensuring cost-effective conservation and restoration of marine ecosystem is particularly challenging in light of ambitious global, regional, and national commitments, such as those established by the Global Biodiversity Framework. In this context, Systematic Conservation Planning (SCP) offers a robust framework to prioritize conservation actions that safeguard biodiversity while minimizing costs and facilitating dialogue among maritime sectors.

Methodology. The scoping review here assesses the challenges in SCP implementation and the obstacles preventing its adoption in guiding decision-making for the achievement of conservation objectives in harmony with human uses of marine resources. The 149 studies analysed, spanning from 2002 to early 2023, are distributed across all continents and encompass nine biogeographic realms.

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Results. Our analysis shows that only a limited number of SCP-based spatial plans have been implemented and just one study explicitly demonstrated the attainment of conservation targets defined through the SCP process. Inadequate criteria for assessing plan effectiveness and weak linkages between academic research and management practice were identified as significant impediments to the effective implementation of SCP outcomes.

Conclusions. The review synthetizes context-specific recommendations, emphasizing that good practices vary across countries according to their geopolitical and economic settings, from small island developing states to middle- and high-income countries. Our study highlights that aligning SCP objectives with international policy frameworks is essential for addressing gaps in conservation and restoration planning and for embedding SCP within global governance processes.

Subjects Conservation Biology, Ecology, Ecosystem Science, Marine Biology, Natural Resource Management

Keywords Marine conservation planning, Ecosystem-based management, Conservation targets, Restoration targets, Tradeoffs, Map of evidence

INTRODUCTION

The ocean is progressively occupied by human activities, posing threats to marine biodiversity and the many goods and benefits it provides to people (*O'Hara, Frazier & Halpern, 2021*). Notably, the growing demand for marine space by several socio-economic sectors, such as fishing, shipping, aquaculture, offshore oil exploration, and renewable energy, is increasingly leading to conflicts with achieving global conservation and restoration targets (*Galparsoro & Borja, 2021*). Regulating human activities is central to protecting and maintaining marine biodiversity and natural resources while delivering their benefits to humans (*Douvere, 2008*; *Elliott, Borja & Cormier, 2020*). Addressing this conflict is especially timely given the potential escalation in conflict arising from ambitious area-based conservation goals outlined in the Global Biodiversity Framework (*Gurney et al., 2023*), together with corresponding regional and national commitments, such as the recently established targets within the European Nature Restoration Regulation (*European Commission, 2024*).

Systematic Conservation Planning (SCP) offers an objective strategic process with clear principles and criteria to identify cost-effective biodiversity conservation measures and achieve biodiversity goals (*Margules & Pressey, 2000*; *Giakoumi et al., 2025*). *Pressey & Bottrill (2009)* in their seminal work, defined eleven SCP steps to allocate and implement conservation areas, including the identification of conservation objectives, priority habitats and species to be protected and monitored, selecting relevant ecological features, collecting spatially-explicit data on the distribution of these features as well as of socio-economic activities, setting quantitative identification of conservation targets, incorporating stakeholders in participatory design and adaptive management. As explained later in the Survey methodology section, SCP allows managers to anticipate potential conflicts between multiple socio-economic sectors and ecosystem components (*Leslie & McLeod,* 2007; Kukkala & Moilanen, 2012), also accounting for the complex interactions that can occur among them in a particular sea area (*e.g.*, Brown et al., 2014; Whitehead, Kujala & Wintle, 2016; Elliott, Borja & Cormier, 2020; Borja et al., 2024). Most importantly, SCP core principles (*e.g.*, comprehensiveness, connectivity, adequacy, representativeness, and efficiency) can guide to the establishment of ecologically coherent networks of Marine Protected Areas (MPAs) and Other Effective area-based Conservation Measures (OECMs), including accounting for transboundary considerations (Margules & Pressey, 2000; Elliott, Borja & Cormier, 2023; Mackelworth et al., 2024). Its value for transboundary coordination lies in its potential to align objectives, data processing, prioritization methods, and management strategies across jurisdictions, while allowing for differences in national or subnational policies (*e.g.*, Kirkman et al., 2019). Building on such a complex context, Gilby et al. (2021) developed the SCP approach further, by incorporating steps for the designation of ecosystem restoration measures. Finally, SCP supports the implementation of ecosystem-based management practices, aiming for a good ecological status while allowing other socio-economic interests to be sustainably achieved (Margules & Pressey, 2000; Galparsoro & Borja, 2021).

Despite its well-accepted theoretical framework, there are many implementation challenges that may require increased accessibility and engagement with stakeholders particularly where capacity is low, for example, providing practitioners with guidance on the most important components to be considered (*e.g.*, identifying conservation targets, desired level of connectivity across conservation areas and management alternatives) to make SCP a success (Janßen, Göke & Luttmann, 2019). Álvarez Romero et al. (2018) produced a global database from 1998 to 2016 to monitor advances and emerging trends in marine SCP and its rate of implementation. They concluded that most studies did not specifically inform conservation interventions but rather advanced the methodological aspects. The study also showed that several knowledge gaps, including inconsistent documentation, lack of transparency around decision-making throughout the planning process and poorly defined goals, still hamper the integration of SCP principles into spatial planning processes (but see Jung et al., 2025). Experience in several coastal regions of the world has demonstrated that adopting a systematic approach to conservation planning and management can enhance ecosystem health and productivity (Ban et al., 2013), and hence, documenting practical applications of SCP processes is important to enable the identification of opportunities to improve conservation outcomes.

Here, we conducted a scoping review (ScR) to reveal the extent to which current SCP practices worldwide are implemented on the ground. We evaluated successful applications of SCP to provide good practices and recommendations for academics, practitioners, managers and decision-makers, that can eventually favour the integration of SCP strategies in spatial management processes. Implemented practices across the SCP case studies in our analysis was assessed by highlighting context-dependent strengths and weaknesses across all stages of the process. While most scientific publications focus on the SCP steps related to spatial prioritization (*i.e.,* the allocation of effort and funds in space and time to achieve conservation objectives), we also investigated grey literature that provides more information about how the entire SCP process was implemented.

As a key output of our study, we provide the first open-access systematic map (as a summary of existing evidence) in which the whole dataset can be interactively visualized through the spatially explicit representation of collated information. The map can be easily interrogated by planners and decision-makers promoting the exchange of data regarding SCP practices, which includes determining the progress of their implementation stage.

SURVEY METHODOLOGY

Systematic conservation planning stages and terminology

The SCP framework proposed by *Pressey & Bottrill (2009)* is composed of an 11-stage structure for the optimal implementation of conservation resources. Briefly, these stages involve: (1) delineating the planning scope and available budget; (2) identifying relevant stakeholders to be engaged; (3) framing the social, economic and political setting around conservation areas; (4) defining conservation objectives; (5) collecting socio-economic information and relevant variables to the achievement of conservation objectives; (6) collecting biodiversity data; (7) setting quantitative objectives based on the available data; (8) assessing the achievement of the objectives within current conservation settings; (9) selecting additional conservation areas; (10) implementing conservation actions to the selected areas; (11) monitoring the effectiveness of undertaken decisions and adapting them accordingly. These stages are presented as a linear sequence, but some can be pursued simultaneously with possible revisions and reiterations. Stages 8 and 9 are usually fulfilled through *spatial prioritization* analyses, where information derived from the other stages converges to select *conservation areas* and/or *actions*, which minimize *conservation costs* and/or maximize biodiversity assets within a set budget or area. *Spatial prioritizations* are typically supported by *optimization tools*, software designed to help find the best possible solution to a problem within given constraints (*Giakoumi et al., 2025*). *Conservation areas* refer to MPAs, networks of MPAs and OECMs and are defined as places where any spatially explicit direct or indirect *action* for conserving biodiversity is implemented (*e.g.*, restricting fishing activities, shipping or anchoring). *Costs* represent social, economic and political constraints typically associated with the implementation of *actions* to be pursued. These elements are taken into account when assessing the feasibility of achieving conservation objectives (*i.e., conservation targets*), generally expressed as a quantity or minimum portion of relevant *ecological features* (*i.e.,* priority habitat, species or ecosystem services) to be protected, restored or managed within *conservation areas*. The achievement of these objectives strongly depends on the active involvement and participation of *stakeholders* (*i.e., stakeholder engagement*), defined as private, public, academic, governmental and non-governmental, individuals, organizations, or entities (local, national, regional) into the planning-to-implementation process. These stakeholders influence or are impacted by the *conservation actions* under consideration, planned or implemented. The inclusion of *stakeholders* can lead the planning process towards a *multiple-objective zoning* approach that considers and balances several goals (*e.g.*, conservation objectives and economic development) dividing an area into zones for specific uses.

Scoping review

Scoping studies are particularly relevant when the research questions behind them are very broad. Determining the breadth of a research question, its relevance and limits is also a specific trait of scoping reviews (ScRs). A ScR typically enables a systematic study by analyzing existing literature to determine whether significant gaps or opportunities for meaningful research exist; furthermore, it can clarify complex concepts and refine subsequent research inquiries (*Arksey & O'Malley, 2005*; *Levac, Colquhoun & O'Brien, 2010*). All these aspects fit the purposes of the current study which aims to map and synthesize evidence and processes in SCP practices, exploring their extent, state, and advancement in implementation. The study is intended to produce outcomes for a wide-ranging audience including academics, practitioners, managers, and decision-makers.

Scoping review protocol

The key question that guided the structure of the review approach was "What is the current knowledge regarding marine SCP approaches at a global scale?". To interrogate this further, a set of sub-questions was addressed (Table 1).

The whole ScR process was *a priori* specified in a study protocol published on the open-access platform Open Research Europe (*Fabbrizzi et al., 2023b*) and followed the SUMARI Protocol Template for Scoping Reviews (*JBI SUMARI, 2021*). It comprised the following steps: (i) definition of inclusion/exclusion criteria; (ii) definition of the search strategy; (iii) study/source evidence selection; (iv) data extraction, and (v) data analysis. The inclusion/exclusion criteria were formulated in alignment with the "Participants, Concept, and Context (PCC)" approach, which supports the identification of topics to be addressed to answer the review question (*Peters et al., 2020*). The ScR identified studies applying SCP, documenting prioritization approaches/criteria/tools, or offering guidelines for SCP implementation. All studies in the scientific literature that assessed the SCP contribution to the design of protected areas were considered. No restrictions were imposed on publication year, while language restrictions were based on the authors' proficiency (*i.e.,* English, French, Greek, German, Italian, and Spanish). The complete list of the inclusion/exclusion criteria is provided in Table S1. The literature search was conducted on January 26th, 2023 through the web-based databases Web of Science, Scopus, and Google Scholar. Details of the search strategy per database, including the date of search, search query, and number of documents returned by the search, are reported in Table S2. The selection of relevant studies and the subsequent data extraction were carried out within the online software platform Covidence (https://www.covidence.org/), involving a team of 14 reviewers among the authors. The software, designed to support the "team approach" recommended by *Levac, Colquhoun & O'Brien (2010)*, ensures robustness to the entire process, from the screening of the documents (abstracts and full-text screening) to the data extraction, by requiring the agreement between two independent reviewers at every stage. Table S3 gives the data extraction tool along with the complete list of fields to extract relevant information.

The ScR followed the methodology defined by *Peters et al. (2020)*, first outlined by *Arksey & O'Malley (2005)*, further developed by *Levac, Colquhoun & O'Brien (2010)*, and finally

Table 1 Review sub-questions.

1	What is the geographical distribution of the case studies adopting SCPs?
2	What are the criteria for implementing SCP, in particular, to address climatic resistance and resilience, functional connectivity, integrated land-freshwater-sea planning, cumulative impacts by multiple human uses, the contribution of OECMs, restoration site prioritization and actions, biological invasions, and ecological-socioeconomic tradeoffs?
3	What is the spatial contribution by case studies implementing SCP?
4	What are the successes and failures in implementing SCP as shown by the literature?
5	What are the barriers in the adoption of good practices enabling SCP implementation success?
6	What are the gaps of knowledge and policy recommendations provided by case studies implementing SCP?
7	What is the actual stage of implementation of SCPs?

enhanced by the Joanna Briggs Institute (https://jbi.global/) (JBI). The Preferred Reporting for Systematic Reviews and Meta-Analyses extension for scoping reviews (PRISMA-ScR; *Tricco et al., 2018*) supported the definition of the ScR protocol. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist was used for a better understanding of relevant terminology, core concepts, and key items for this scoping review, and is reported in the Supplemental PRISMA-Checklist. Only minor deviations from the published protocol were required during the review process, mainly pertaining to the data extraction tool, data analysis and presentation (Table S4).

Search strategy for grey literature

To avoid publication bias in the results and ensure the inclusion of practitioner-generated research (*Haddaway & Bayliss, 2015*), 25 organisational websites were queried, using a simplified and tailored search string (Table S5). The list of websites consulted was provided by *McIntosh et al. (2018)*, updated to the present and expanded following the authors' expertise. Studies were also identified opportunistically, through suggestions from authors and topic experts. The selection of eligible documents and data extraction were carried out according to the published ScR protocol.

Data analysis and presentation

Data collected within the present ScR were combined with those already available in the Marine Conservation Planning Database (https://marinescp.jcu.io/#/) produced by *Álvarez Romero et al. (2018)*, which included peer-reviewed publications published before 2016. Compared to the dataset produced by *Álvarez Romero et al. (2018)*, the current literature review was more restrictive: the present review is limited to studies primarily focusing on marine components, while *Álvarez Romero et al. (2018)* included terrestrial and/or freshwater conservation areas with potential downstream benefits for marine ecosystems. In addition, this study accounted for social, economic and political aspects of the SCP process, building upon the SCP framework as defined by *Pressey & Bottrill (2009)*, making it more likely to locate examples where stakeholder engagement was conducted. Many studies that refer to SCP do not meet the strict definition of SCP required for inclusion in this study. We define SCP as going beyond the identification of priority areas for conservation (*i.e.,* SCP stages 8 and 9), to engaging with stakeholders and revising planning scenarios to optimize outcomes for multiple objectives. In contrast, *Álvarez Romero et al. (2018)* also included studies that did not necessarily address socio-economic components. Therefore, studies from the Conservation Planning Database were filtered to meet the inclusion criteria of the present ScR. The analyses were subsequently discussed with the database authors through collaboration to develop shared insights into SCP implementation.

The combined dataset was analysed to illustrate: (i) the spatial and temporal distribution of SCP studies across continents and marine biogeographical realms as defined by *Spalding et al. (2007)* under the Marine Ecoregions of the World (MEOW) classification; (ii) the relationship between the stage of implementation of SCP studies, their rationale and considerations involved (*i.e.,* the typology of data collected and used throughout the planning process) (see Table 2 for details about the three fields); (iii) the relationship between the stage of implementation of SCP studies and the spatial and temporal scale of their application (Table 2); (iv) context-specific recommendations for good practices. Good practices were derived from case studies documenting plans implemented on the ground and outcomes were classified as reported by authors in the original study. We included all levels of implementation, with the exclusion of articles that did not go beyond theoretical or academic discussion.

The spatially explicit representation of all collected data was published through the open-source software tool EviAtlas (*Haddaway et al., 2019*) to provide planners and decision-makers with an interactive map where data can be easily interrogated. The map is accessible *via* a GitHub repository (https://eviatlasmapscp.github.io/) (GitHub, Inc. ©2024), providing a valuable resource since 42% of the case studies were identified as non-open-access documents.

RESULTS

Scoping review results

The search in all the sources queried resulted in 634 documents. After removing duplicates, 546 studies remained eligible for screening based on their titles and abstracts. Of these, following the inclusion and exclusion criteria listed in Table S1, 126 documents qualified for a full-text screening. Following the full-text screening, 82 documents were excluded, primarily because they did not report any practical SCP application in a specific geographic region (other exclusion reasons are listed in Fig. S1). Overall, 44 documents (corresponding to 44 case studies) met the criteria for inclusion in the ScR (Fig. S1). The list of all documents screened (both included and excluded) is given per screening stage in Data S1 and S2. Combining the selected case studies with those filtered from the Conservation Planning Database ($n = 105$, corresponding to 103 documents) led to a dataset consisting of 149 records (corresponding to the same number of case studies) and 54 columns (corresponding to the data extraction tool fields, Table S3). Eleven documents included in

Table 2 Descriptions for classes attributed to the three fields of the Systematic Conservation Planning (SCP) implementation stage, rationale and consideration. For the field number refer to the data extraction tool in Table S3. Classification for the SCP implementation stage (F53 of the data extraction tool) was adapted from *Grorud-Colvert et al. (2021)*. Classification for the SCP rationale (F18 of the data extraction tool was adapted from *Álvarez Romero et al. (2018)*. SCP considerations included the following fields of the data extraction tool: climate change (F27), connectivity (F29), human threats (F31), land-sea planning (F35), inter-realm connectivity (F36), cumulative impacts (F37), OECMs (F39), restoration (F42), invasive/alien species (F44), socioeconomic/cultural objectives (F47), tradeoffs (F49).

Field	Class	Description
Implementation stage	Only academic	No link to application/implementation of the produced plans.
	Unknown	Not specified.
	Proposed	The plan is made public in some formal manner by means of a statement by governing or other organizing body.
	Designated	The plan was recognized through legal means or other authoritative rulemaking but it is not yet implemented (*e.g.*, paper park).
	Implemented	The plan passed from existence on paper to being operationalized in the water.
	Monitored	The implemented plan is monitored to assess the effectiveness and be adjusted to achieve targets.
	Target achieved	Targets set in the plan are actually achieved.
SCP Rationale	Arbitrary	No reason provided.
	Ecological requirement	Ensure persistence of populations.
	Expert advice	Without further explanation of the rationale behind their recommendations.
	Legal mandate	Legislation.
	Socioeconomic	Fair distribution of costs.
	Previous plan/study	Adjustment of already existing plans.
	National/international goals	Commitments by the Maritime Spatial Planning. Directive, Nature Restoration Law, *etc.*
SCP consideration	Climate change	Data representing climate change are accounted for in the planning process.
	Connectivity	Data representing connectivity across/within habitats are accounted for in the planning process.
	Human threats	Data representing human threats (*e.g.*, fishing, transport, agriculture) are accounted for in the planning process.
	Land-sea planning	Data representing freshwater and/or terrestrial components are accounted for in addition to the marine ones, in the planning process.
	Cumulative impacts	Data representing cumulative impacts are accounted for in the planning process.
	OECMs	Data representing the distribution of existing or potential OECMs are accounted for in the planning process.
	Restoration	Data representing the distribution of existing or potential priority areas for restoration are accounted for in the planning process.
	Invasive/alien species	Data representing the occurrence of invasive/alien species are accounted for in the planning process.
	Socioeconomic/cultural objectives	Data representing socioeconomic/cultural objectives are accounted for in the planning process.
	Tradeoffs	Data representing tradeoffs between socioeconomic/cultural and conservation objectives in terms of cost are accounted for in the planning process.

(*continued on next page*)

Table 2 (*continued*)

Field	Class	Description
SCP spatial scale	Sub-national	SCP conducted for regions, provinces, states, or local areas within a country. It focuses on governance processes or activities that operate below the national level.
	National	SCP conducted for an entire country. It focuses on governance processes or activities that operate at the national level.
	Multi-national	SCP conducted involving multiple countries, involving interactions between two or more nations.
	Global	SCP encompassing the entire world, considering trends and issues that transcend national borders.

this ScR, were grey literature studies. All the included documents were in English, except for two that were in French and one in Greek. Data S3 lists all documents, both retained and not retained, from the Conservation Planning Database. Excluded documents did not meet the ScR criteria, primarily due to the absence of socio-economic data and stakeholder representation.

Spatio-temporal distribution and scale of case studies

The case studies assembled in the final dataset exhibit a broad global geographical distribution across all continents (Fig. 1). Most SCP case studies were conducted for Oceania/Australia ($n = 40$; 27%), Europe ($n = 37$; 25%), Asia ($n = 28$; 18%), and North America ($n = 24$; 16%). Africa ($n = 14$; 9%), South America ($n = 14$; 9%), and Antarctica ($n = 1$; 1%) showed notably fewer SCP case studies.

Regarding spatial scale, most case studies related to SCP applications at the sub-national level ($n = 102$; 68%) with fewer at the multi-national level ($n = 22$; 15%), followed by those at the national ($n = 21$; 14%) and global ($n = 4$; 3%) level. Overall, case studies covered nine marine biogeographic realms, as classified by *Spalding et al. (2007)*. Most were situated in the Temperate Northern Atlantic ($n = 60$; 40%), with slightly fewer from the Central Indo-Pacific ($n = 48$; 32%). The remaining case studies were distributed across the other marine biogeographic realms, with the fewest studies being conducted for the Southern Ocean ($n = 1$) (Fig. 1).

The database covers the period from 2002 to early 2023. Figure 2 shows the trend in the SCP practice, expressed as the cumulative number of case studies per year.

Implementation stage, considerations and rationale of case studies

Based on the available information, 97 SCP case studies fall into the implementation stage ‘only academic’ (65%). Few SCP case studies were actually ‘proposed’ ($n = 16$; 11%), ‘designated’ ($n = 5$; 3%) or ‘implemented’ ($n = 2$; 1%). Four case studies (3%) documented the monitoring of already implemented plans (‘monitored’) and only one study the complete achievement (*i.e.*, ‘target achieved’) of the targets set in the plan (*i.e.*, to protect the 30% of their waters; *Metcalfe et al., 2022*). For the remaining 24 case studies, information about the implementation stage was not provided by the documents and thus was reported as “unknown” (16%).

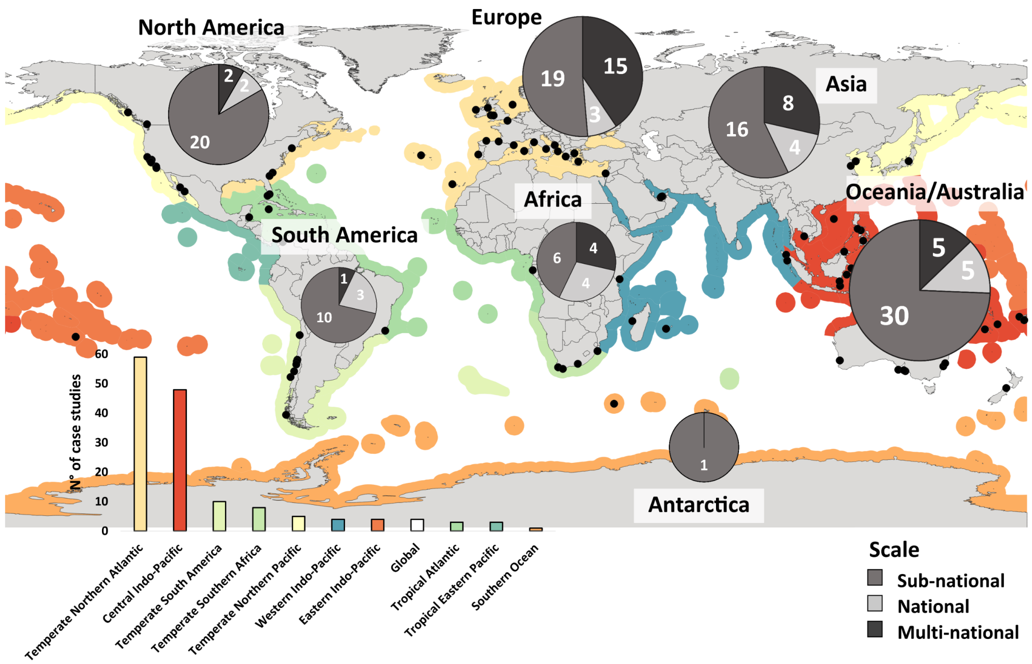

Figure 1 Global summary of Systematic Conservation Planning case studies distribution (black dots) across continents (pie charts) and marine biogeographical realms (bar plot). The size of the pie charts reflects the number of studies for each continent. The colours of pie charts indicate the three scales of application (sub-national, national and multi-national) with their respective number of studies. The bar plot indicates the number of case studies across marine biogeographical realms with colours reflecting their distribution in the map. The map was produced with QGIS1 3.28.6 (QGIS.org 2023. QGIS Geographic Information System. Open-Source Geospatial Foundation Project).

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The most common considerations used to constrain the SCP process across case studies over time (Fig. 3), were: 'human threats' ($n = 129$; 87%), 'tradeoffs' ($n = 127$; 85%), and 'socio-economic/cultural objectives' ($n = 117$; 79%). This applies especially to 'only academic', 'designated' and 'monitored' case studies (Fig. 4). 'Connectivity' ($n = 48$; 32%), integrated 'land-sea planning' ($n = 35$; 23%) and 'climate change' ($n = 21$; 14%) considerations appear to be moderately central across implementation stages with fewer instances of inclusion in academic studies (Fig. 4). 'OECMs' ($n = 11$; 7%), 'restoration needs' ($n = 11$; 7%), 'cumulative impacts' on marine biodiversity ($n = 9$; 6%) and invasive/alien species' ($n = 8$; 5%) are still rarely considered regardless the stage of implementation. Yet, we found that the two implemented studies did include 'land-sea planning' and 'human threats' considerations because these were likely important for decision-makers (Fig. 4).

Most case studies were driven by 'ecological requirements' ($n = 49$; 33%) or did not provide any specific rationale for the SCP implementation ('arbitrary', $n = 43$; 29%) (Fig. S2). Many of them included 'national/international goals' ($n = 42$; 28%), 'socio-economic considerations' ($n = 31$; 21%), and 'expert advice' ($n = 26$; 17%). Only a few studies included the occurrence of 'previous plans' ($n = 12$; 8%) and 'legal mandates' ($n = 7$; 5%) as reasons for SCP implementation. Interestingly, 'legal mandates' and 'expert advice'

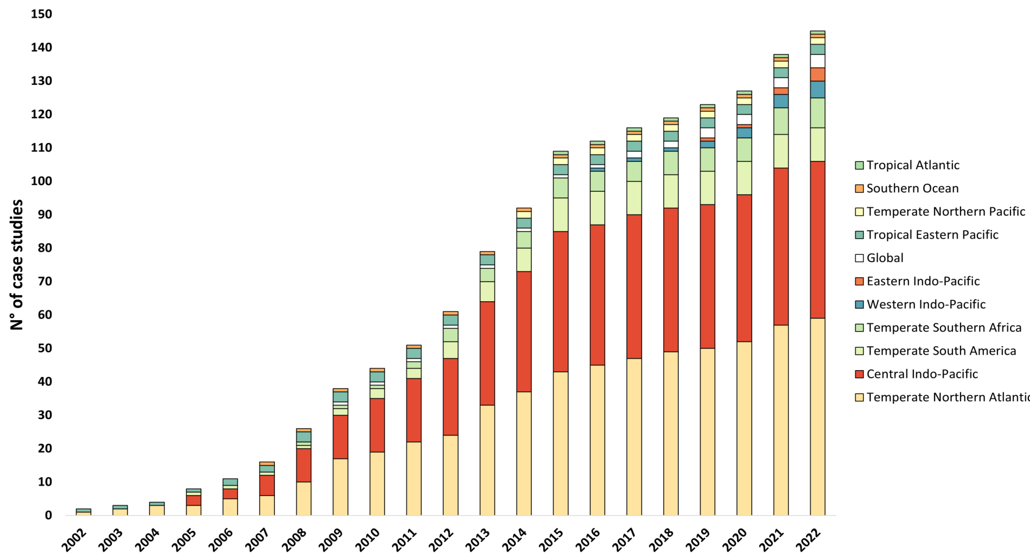

Figure 2 Cumulative number of case studies publications per year. Stacked bars show the temporal growing trend in each biogeographical realm. Each case study identifies an SCP exercise as presented in the corresponding document included in the scoping review. As the collection of literature was conducted in January 2023, we did not include this year.

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Figure 3 Trends over time in the number of case studies per stage of implementation, grouped by consideration applied. Lines and points represent the number of studies per year, coloured by implementation stage. Each panel refers to a specific rationale. The implementation stages "Unknown" and "Target achieved" are not represented: the former due to lack of informative value, and the latter because it includes only one case study.

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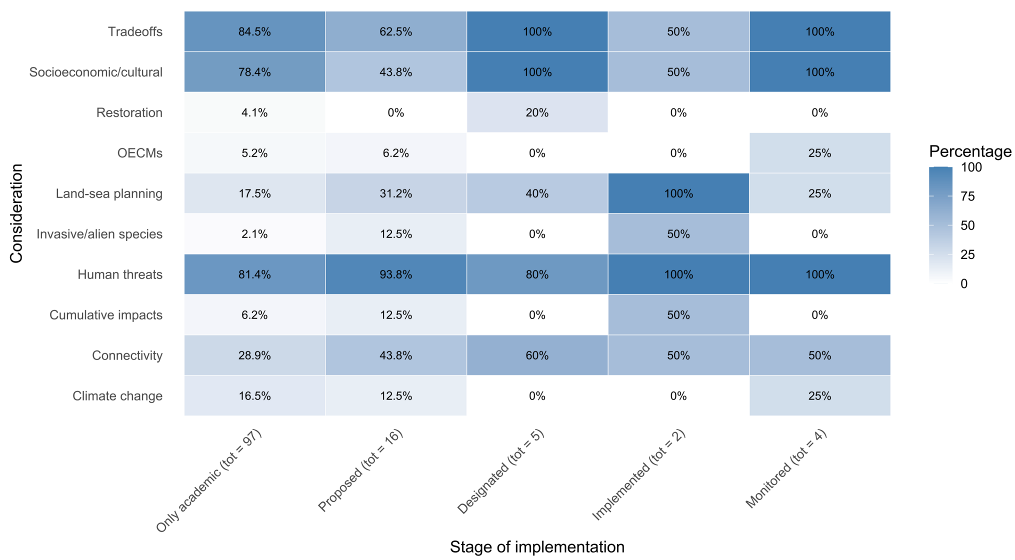

Figure 4 The percentage of case studies associated with each consideration (rows) per stage of implementation (columns). Darker shades indicate higher proportions. The implementation stages "Unknown" and "Target achieved" are not represented: the former due to lack of informative value, and the latter because it includes only one case study.

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were found to be irrelevant in implemented case studies, while all other rationales were considered in at least one out of the two studies (Fig. S3). However, this conclusion may be biased by the level of information given in the documents presenting the 'implemented' case studies.

Implementation stage of case studies across spatial scales

The case studies in the implementation category 'only academic' ($n = 97$) existed for all spatial scales, with the sub-national one (62%) prevailing over the others (multi-national 21%; national 13%; and global 4%). All other case studies, *i.e.*, excluding the purely academic ones, encompassed a reduced range of spatial scales. 'Proposed' plans ($n = 16$) were mostly applied at the sub-national level (75%), with only four case studies being applied nationally. Plans classified as 'designated', 'implemented' and 'monitored' were only found at the sub-national level ($n = 5$, $n = 2$, and $n = 4$, respectively). The only case study documenting the achievement of targets set in their plan (*i.e.*, 'target achieved') was applied at the national level (Fig. 5, Table S6). Figure S4 shows the distribution of case studies across continents grouped by their implementation stages. Oceania/Australia stands out both in terms of the total number of case studies and the breadth of implementation stages, with cases spanning from 'only academic' and 'proposed' to 'implemented' and 'monitored'. North America follows, showing a wide range of implementation stages but fewer cases overall, while Europe, although it has a high number of documented cases, is more strongly concentrated in earlier stages. Asia and South America show moderate representation with limited progression to advanced stages, while Africa remains sparsely

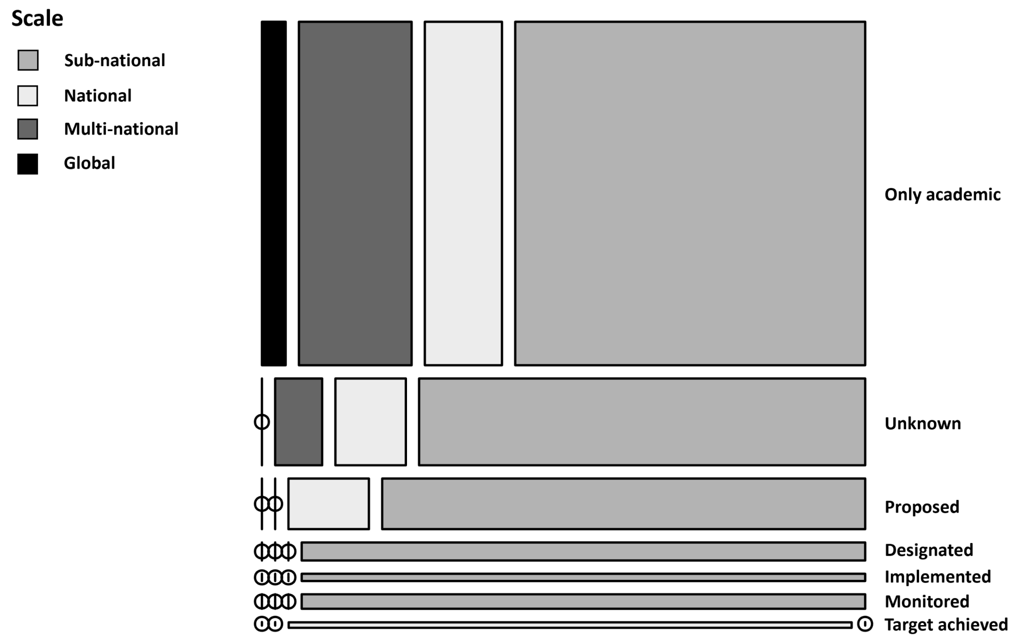

Figure 5 The proportional areas of the contingency table representing the Systematic Conservation Planning implementation stages across spatial scale levels of application. The different shades of grey in the figure represents the four spatial scales: sub-national, national, multi-national, global. The symbol "Θ" refers to 0 case studies. The plot was produced in the R environment (R version 4.3.1) with the 'vcd' package (*Meyer et al., 2023*).

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represented but includes some more advanced efforts. Antarctica is represented by a single academic example.

Context-specific recommendations for good practices

Implemented case studies were used to identify context-specific recommendations for good practices. These SCP case studies ($n = 28$) were classified into three categories according to the International Monetary Fund's World Economic Outlook Database (April) 2024 and the World Bank country classifications by income level for 2024–2025: small island developing states, middle-income countries and high-income countries, thereby covering both the Global North and the Global South. Although no examples from low-income and lower-middle income countries were found, this global representation ensures the lessons learned are widely relevant. Eight of the eleven grey literature documents included in the review contributed to this collection of success stories (Table S6).

Nine case studies were conducted in small island developing states, including plans distributed across central/eastern Indo-Pacific islands (*i.e.*, Fiji, French Polynesia, Papua New Guinea and the Solomon Islands). Shared recommendations include the importance of multi-objective zoning, land-sea planning, and adopting a participatory expert mapping approach based on co-management with local stakeholders and communities. Plans developed by these states were commissioned or supported by local authorities.

Seven case studies were conducted by middle-income countries, including SCP from Africa and South America (*i.e.,* Gabon, Indonesia, Mexico and South Africa). Approaches and recommendations from these case studies, indicated the importance of adopting multi-scale spatial planning methods, to be implemented simultaneously at both local and national levels. Broader groups of stakeholders at different levels are involved and plans are developed to respond to the legally mandated national spatial planning processes.

Finally, 12 case studies were conducted in high-income countries including Australia, China, Greece, Spain, Saint Kitts and Nevis, the United Arab Emirates and the United States of America. At the forefront, the need to increase the extent of protection to meet national and international commitments and create ecologically meaningful and efficient MPA networks emerged among the primary objectives to be pursued by these countries. The successes found across the case studies were mainly attributed to political and societal willingness, high-level and top-down legislative support, and the availability of large private-public investments.

DISCUSSION

Where and why SCP has been effectively implemented: context-specific lessons learned

The reviewed marine SCP case studies represented many global ecoregions and covered a wide temporal distribution from 2002 to early 2023. When planning is practice-oriented (rather than purely theoretical), a discernible trend across continents is that the spatial scale of case studies is mainly confined to the sub-national level with few cases of national or multi-national applications. This pattern may be driven by the existence of numerous local initiatives that often lack alignment, with implications for effective coordination among SCP projects. We found that national-scale SCP examples concern countries with relatively small Exclusive Economic Zones (EEZs), such as Gabon and Saint Kitts and Nevis (see *Metcalfe et al., 2022* and *Agostini et al., 2010*, respectively), but can also include countries with bigger EEZs where national-scale planning is achieved through a hierarchical approach based on coordinated planning at sub-national scales. For instance, in the case of Papua New Guinea, SCP is implemented within regional contexts that follow the marine bioregions identified within the EEZ (approximately 2.5 million square kilometres) thereby allowing regional plans to be scaled up to the national level (see *Tulloch et al., 2021*).

Lessons learned from the implemented case studies are mainly context-dependent. This means that the very distinct biological, socio-economic and geo-political settings characterizing different country groups result in systematic conservation plans that emphasize different aspects of the process. It is noteworthy that the inclusion of grey literature substantially expanded the body of documented successful SCP case studies. This highlights the importance of considering such sources when evaluating the application and practical implications of SCP, a process that is often driven by institutions (*e.g.*, environmental, governmental or non-governmental organizations) whose work and outcomes are not systematically published in the scientific literature.

Small island developing states tend to embrace a "think globally, act locally" approach (*André, 2021*) where local communities become leading actors in determining the relative importance of biodiversity conservation and human demands. In places where regional indigenous traditions remain strong and the need for speed in MPA design occurs in relatively data-poor contexts (*Nuno et al., 2024*), local knowledge is largely used to increase the accuracy of mapping the distribution of natural resources and human activities. Such knowledge can therefore constitute a key input layer within SCP processes, supporting spatial prioritization and improving the representativeness and feasibility in conservation area selection (*i.e.,* SCP stage 5, 6 and 9). Fishers and fish traders are particularly involved, as their role in these countries is viewed as primary in both influencing and being affected by management decisions: their participation helps shape realistic quantitative conservation targets and operational constraints (*i.e.,* SCP stage 7). In this context, a key strength lies in the ability to explicitly account for the fact that fishing behaviour is not solely market-driven, but is also strongly influenced by factors such as time preferences, risk aversion, and cultural identity, as shown in the case of the Fiji Islands (see *Adams et al., 2011*). In French Polynesia, coupling traditional fisheries management, grounded in social cohesion and highly localized rules, with scientific approaches based on SCP, has been shown to yield positive effects in terms of the resource representation–cost ratio (see *André et al., 2022*). The use of systematic planning ensured objectivity and data-driven solutions. When a multi-objective zoning approach is used (*i.e.,* assigning different activities and regulations to specific zones), SCP supports the development of efficient and socially acceptable solutions which are believed to be more likely implemented, as demonstrated in the case of Solomon Islands (see *Game et al., 2011*). The increased accessibility of decision support tools (such as Marxan or Marxan with Zones) was essential in these island states since it provided decision-makers with user-friendly instruments to work transparently toward conservation and other objectives simultaneously (*Watts et al., 2009*; *Tulloch et al., 2021*). The possibility of clearly visualizing all the information, provided validation that all parties' interests were well represented, thereby strengthening their confidence in the overall process. Beyond data visualization, the value of the process lies in the possibility of identifying trade-offs among multiple objectives in decision-making. These trade-offs reveal the extent to which different parties' interests are represented, which is particularly important given that it is far more common for interests to be only partially accommodated than fully aligned. Finally, adopting an integrated land-sea planning approach that explicitly accounts for cross-realm connectivity provides a concrete mechanism for systematic conservation planning, enabling actions that support ecosystem processes operating at the interface between terrestrial, freshwater, and marine systems. This approach build on the recognition that actions undertaken on land can have substantial effects on the marine environment and facilitates scaling up from regional to national processes (*Klein et al., 2014*; *Tulloch et al., 2021*).

In case studies from middle-income countries, implemented SCP initiatives recognise the importance of adopting multi-scale approaches to more realistically reflect the multi-scale nature of marine social-ecological systems. For instance, in the province of KwaZulu-Natal on the east coast of South Africa, this approach led to the selection of a smaller conservation area while still achieving the same targets of scale-unlinked plans (*i.e.,* plans developed independently at different spatial scales without explicit coordination or methodological integration across levels). At the same time, it promoted the integration of fine-scale and large-scale spatial management policies (*e.g.*, aligning inshore conservation planning with offshore strategic priorities) (see *Lagabrielle et al., 2018*). Along the same lines, another element that proved effective was the development of national frameworks, such as national projects or research foundations. In the case of Gabon, for instance, this approach played a key role in supporting the alignment of numerous regional projects, establishing a broader legislative framework and preventing funding and efforts from being dispersed (see *Metcalfe et al., 2022*). However, the broader the scope of the SCP, the larger the stakeholder groups that need to be involved, often leading to decisions that generate conflicts (*Boyes & Elliott, 2014*; *Boyes & Elliott, 2015*). For this reason, SCPs in middle- to high- income countries place greater emphasis on the *a priori* identification of key stakeholders to be involved, selecting those who can secure long-term support, build trust and enhance communication across sectors from local communities to decision-makers and politicians.

Implemented SCP efforts in high-income countries have sought to pursue more the alignment with national and international commitments, with the aim of achieving broader conservation targets and create ecologically meaningful and efficient MPA networks. The strong collaboration of private sectors with nongovernmental and governmental organizations had a significant role in this direction. In the case of California, as an example, co-management between fishers, local and federal authorities and The Nature Conservancy led to the protection of large areas of the seafloor while addressing economic impacts of trawl closure. The success of this approach entails several fundamental enabling conditions: fishing privileges linked to the achievement of project goals, the removal of barriers that inhibit innovation and adaptive strategies, and willingness of community and government leaders (see *Gleason et al., 2013*). Two additional topics that emerged as crucial elements for successful SCP are the development of zonation plans within MPA boundaries and the adoption of the precautionary principle, particularly when spatially explicit information on biodiversity distribution is incomplete. In the Great Barrier Reef, Australia, precautionary rezoning that evenly distributed no-take areas across the planning region enhanced the representation of previously unknown conservation features while minimizing opportunity costs by assigning less restrictive protection to higher-cost areas, such as those important for trawling (see *Bridge, Grech & Pressey, 2016*).

Table 3 provides a summary highlighting the specific objectives, criteria, spatial scales and stakeholder involvement for each geopolitical context. It also illustrates the main similarities and differences across these context.

Challenges and key constraints to SCP implementation

Despite its recognized potential to enhance conservation effectiveness (*Adams et al., 2019*), SCP research remains largely disconnected from real-world implementation. Most SCP case studies primarily pursue academic objectives or lack clearly defined goals, with few translating into concrete conservation outcomes. This gap reflects both the time lag between scientific publication and practical application, and the complexity of marine governance, which involves multiple administrative bodies and legal frameworks. For instance, the SCP study conducted by *Giakoumi et al. (2012)* for enhancing biodiversity conservation in the

Table 3 Summary of the specific objectives, adopted criteria, spatial scales and stakeholder involvement applied in each geopolitical context. The table also shows the main similarities and differences across them.

Country type	Specific objectives	Adopted criteria	Spatial scales	Stakeholder involvement
Small island developing states	– Balance biodiversity conservation with local human needs – Reduce conflicts prioritizing vulnerable groups – Enhance local legitimacy	– High integration of local and Indigenous knowledge – Multi-objective zoning – Cross-realm (land-sea) connections – Adaptive co-management accounting for socio-economic and environmental changes	**Local to Regional**, with potential for national scaling	**High**: – Strong bottom-up processes – Fishers and fish traders as key actors – Inclusive of marginalized groups – Local authorities play a central role
Middle-income countries	– Support legally mandated national MSP – Align regional projects with national goals – Prevent funding dispersion	– Multi-scale planning – Creation of national frameworks and coordination platforms – Legislative alignment	**Local to National**, with regional consideration	**Moderate to High**: – Top-down processes – Multiple stakeholder groups identified a priori – Emphasis on trust-building and cross-sector communication – Challenges due to scale and diversity of actors
High-income countries	– Achieve international biodiversity targets – Build ecologically coherent MPA networks – Ensure long-term conservation impact	– National frameworks – Top-down legislative support – Precautionary principle – Zonation within MPAs – Best available science	**Regional to National**, with international commitments	**High but Complex**: – Strong top-down processes – Multiple stakeholder groups involved (local to political level) – Public–private partnerships and education programs support acceptance

Ionian Sea and the ecosystem-based marine spatial plan in the Aegean Sea developed by *Markantonatou et al. (2021)* were only recently (in 2024) taken into account by the Greek competent authorities for the identification of areas aiming to achieve the 30% conservation target in the Greek seas by 2030. Additional factors, such as the underrepresentation of locally led planning processes in the scientific literature, language barriers limiting the global visibility of non-English work (*Amano et al., 2021*; *Khelifa, Amano & Nuñez, 2022*), and the prevalence of grey literature documents that do not fully adhere to SCP principles (such as representativeness, connectivity and efficiency), further obscure on the ground SCP applications.

In spite of the growing importance of socio-economic context in SCP, we found that inclusion of inappropriate cost data can compromise biodiversity and social outcomes (*Adams, 2024*), leading to a simplistic shift of conservation areas towards areas under no or little negative pressure, which may not be always the best solution to achieve impactful biodiversity/ecosystem conservation outcomes (*Cockerell et al., 2020*; *Sacre et al., 2020*). Although for high-risk habitats (*e.g.*, deep-water ecosystems) that have yet to be exploited, this approach can still serve as an important safeguard against disturbance and biodiversity loss, this largely adopted strategy underscores the ongoing imperative to pinpoint regions facing elevated risks due to human activities, encompassing existing and emerging industries (*O'Hara, Frazier & Halpern, 2021*). Care is needed to ensure that prioritizing low-cost options does not bias conservation planning outcomes toward particular ecosystem types (*e.g.*, by disproportionately favoring deep-water closures at the expense of measures in shallower areas, which host distinct ecosystems and typically sustain higher levels of human use). Moreover, prioritizing low-previous-impact areas may yield muted conservation benefits when measured by traditional indicators, potentially creating a mismatch between expectations and achievable outcomes. Hence, it is very important that the spatial prioritization approach aligns with the objectives set in the SCP process and that the variables in the decision-support tools are carefully chosen based on the desired outcomes. The same planning tool, *e.g.*, Marxan, can be used to avoid or favour the inclusion of high-risk areas in networks of MPAs.

Limited basic scientific knowledge severely affects the seamless integration of relevant ecosystem processes into SCP (*Holness et al., 2022*; *Papazekou, 2022*; *André et al., 2022*). Despite advance in methodological guidance (*Tittensor et al., 2019*), uncertainties linked to climate change and its potential effects on biodiversity distribution continue to challenge the development of robust plans for future climate change scenarios (*Jefferson, Palomares & Lundquist, 2022*). Another crucial aspect is the still scarce ability to account for and achieve functional, three-dimensional and cross-realm connectivity measures that match the complexity of the marine system (*Venegas-Li et al., 2018*; *Balbar & Metaxas, 2019*; *Podda & Porporato, 2023*). SCP case studies that made this effort typically used data about ecological corridors (*Lagabrielle et al., 2011*), larval dispersal, animal migrations, genetic flows, habitat models and ocean currents (*Beger et al., 2014*; *Schill et al., 2015*; *Wilcox et al., 2023*) to inform the prioritization process (SCP stages 7 and 8), often with the support of software specifically designed to incorporate connectivity considerations (*e.g.*, Marxan with Connectivity; *Tulloch et al., 2021*). Transboundary aspects of connectivity also need to be incorporated into SCP to allow similar outcomes across regional seas irrespective of national borders (*Elliott, Borja & Cormier, 2023*). Biodiversity conservation and ecosystem processes often require consideration of broader spatial scales, including transboundary connectivity, as ecological dynamics frequently extend beyond individual planning regions and jurisdictions. A lack of harmonisation between adjacent areas and across national boundaries will prevent coherence and equivalence in marine management practices (*Elliott, Borja & Cormier, 2023*; *Sink et al., 2019*; *Galparsoro et al., 2025*). Other relevant ecological features, such as invasive/alien species dynamics, are still scarcely considered in marine SCP (see also *Giakoumi et al., 2016*). Despite recent efforts (*Holness et al., 2022*), a high level of uncertainty, data limitation, and the lack of scientific or political interest may hinder the actual integration of these factors into the SCP process. The predominance of sub-national implemented SCPs, as noted earlier in the Discussion, also prevents the integration of both transboundary considerations and invasive/alien species dynamics into the SCP process, with national- and multinational- level implementations, required to address such considerations, remaining under-implemented.

Finally, even when conservation and restoration objectives are clearly defined, the criteria guiding planning decisions are often poorly specified: while a wide range of ecological and socio-economic factors can influence the process, standardized and transparent frameworks for their selection remain limited, particularly for large-scale, coordinated restoration planning (*Gilby et al., 2021*). Despite growing policy emphasis on marine restoration and recent technical advances, the lack of consolidated guidance for integrating restoration objectives into SCP continues to hinder effective implementation (*Bergseth, Russ & Cinner, 2015*; *McIntosh et al., 2018*; *Fabbrizzi et al., 2023a*). Without explicitly incorporating restoration into the planning process, expected MPA outcomes, such as measurable improvements in ecosystem conditions (*e.g.*, higher species abundance), may not occur, potentially leading to unmet expectations and limiting the wider implementation of spatial conservation measures.

Recommendations for SCP implementation

Several recommendations can be drawn from our scoping review to bridge the gap between the theoretical framework and the real-world implementation of SCP.

Country-specific characteristics, such as geo-political and social contexts, are key determinants of how an SCP process should be developed, requiring a clear understanding of appropriate timelines and political procedures (SCP stages 1 and 3). Local-scale processes (*i.e.,* sub-national case studies), based on high quality data, are often better suited to guide plans in small countries, thereby increasing the reliability and robustness of planning outputs. Instead, implementation at the national and transboundary level is more appropriate for large-scale planning processes where such approaches can strengthen coherence in planning procedures (*Hering et al., 2023*; *European Commission, 2024*; *Klein et al., 2025*) and common targets must be achieved (*e.g.*, EU countries meeting the 30% protection and 10% strict protection targets under the EU biodiversity framework) (*Botts et al., 2019*; *Buschke, Botts & Sinclair, 2019*).

Beyond the increasing emphasis on quantified targets for high levels of protection (*e.g.*, 10% strict protection), greater attention is also needed on how such targets are operationalized in practice, particularly where conservation priorities benefit from stronger protections. From an SCP perspective, we found that implementation choices are primarily guided by considerations linked to human uses, socio-economic and cultural objectives, and tradeoffs between ecological and economic needs (*Giakoumi et al., 2011*; *Yates, Schoeman & Klein, 2015*; *Galparsoro & Borja, 2021*). Approaches that explicitly account for both conservation and socio-economic objectives (*e.g.*, achieving equity alongside economic and environmental benefits) are especially important for generating cost-effective plans, improving the potential for resolving conflicts between the conservation of marine environments and human uses, and quantifying and balancing their tradeoffs (*Klein et al., 2008*; *Halpern et al., 2013*; *Levin et al., 2013*; *Harris et al., 2014*; *Neubert et al., 2025*).

Evidence-based approaches supported by continuous and systematic data collection are essential for transparent and robust decision-making in SCP (*Giakoumi et al., 2012*; *Galparsoro & Borja, 2021*). By aligning data collection with planning, evaluation, and scenario development, these approaches improve understanding of ecological processes, human impacts and climate change effects, while enabling the incorporation of uncertainty and adaptive target setting (SCP stages 5, 6 and 7). Good practices to mainstream climate considerations within the SCP process also encompass identifying and protecting climate refugia as well as avoiding the prioritization of areas projected to be highly affected by climate change (SCP stages 8 and 9; *Green et al., 2009*; *Arafeh-Dalmau et al.,* 2023). A counterpoint is to embrace change as part of the planning process, ensuring that representativity of change (or risk) is itself considered (Keen et al., 2024). Flexible legislation and policy structures are therefore imperative to accommodate climate change adaptation measures (Wilson et al., 2020). The concept of flexibility has been embedded into conservation planning since the early 1990s (Kukkala & Moilanen, 2012) and is crucial for adaptive planning considering changes both in biodiversity and human activities within and beyond the planning region (Shabtay et al., 2025).

A temporal pattern emerging from the studies collected in our review indicates that global policy frameworks can become a driver for increased SCP implementation. Supporting evidence lies in the fact that many on-the-ground SCP exercises were conducted after 2011, which coincides with the adoption of the Aichi Biodiversity Targets under the Convention on Biological Diversity (CBD). This momentum in SCP studies likely reflects a positive acceleration driven by the formal international commitment to halt and reverse biodiversity loss. Recent global policy commitments, such as those outlined in the Kunming–Montreal Global Biodiversity Framework (GBF), further emphasize the need for robust and well-defined SCP processes (Giakoumi et al., 2025). In particular, GBF Target 1 calls for biodiversity-inclusive spatial planning, Target 3 establishes a quantitative objective to conserve at least 30% of representative and connected ecosystems, and Targets 14 and 21 highlight the importance of data and knowledge to inform decision-making (Convention on Biological Diversity, 2022). Along similar lines, the newly signed Agreement under the United Nations Convention on the Law of the Sea on the Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction (BBNJ) aims to strengthen cooperation among relevant legal instruments and frameworks to establish MPAs and other area-based management tools in the high seas (United Nations, 2023), facilitating transboundary conservation. Linking SCP objectives to these global commitments through tailored policies is central to addressing current gaps in conservation and restoration planning, situating SCP within the broader global policy agenda (Ban et al., 2013). High-income countries, under the strong obligation to increase financial support to lower-income nations, can largely contribute to a wide achievement of this objective (Convention on Biological Diversity, 2025). Such funding should reflect historical responsibility for biodiversity loss, capacity to pay, and population size, while also embodying ethical responsibility, solidarity, and trust in multilateral governance (Metabolic, 2024).

The effective implementation of SCP ultimately depends on strong political and societal willingness, supported by high-level legislation and sustained public–private investment. These conditions enable: (i) the establishment of national frameworks to guide regional processes, (ii) the definition of clear targets to be reached and policies that link SPC to global commitments, (iii) the formation of coordinated institutional structures fulfilling different and well-specified functions, (iv) enduring stakeholder collaboration, (v) and increased public awareness. Bridging the gap between SCP theory and practice further requires making academic evidence more accessible to decision-makers, improving standardized reporting of SCP impacts and the communication between researchers and practitioners. Public education programmes are likewise pivotal as they foster better understanding and appreciation of SCP benefits, particularly over the long term. Training courses tailored for administrators, politicians, and industry representatives can assist in bridging the gap between SCP science and practice (*Giakoumi et al., 2025*).

Placing these findings in a broader SCP context shows that the challenges and enabling conditions identified in marine systems largely mirror those observed in terrestrial and freshwater applications. While realm-specific ecological processes and pressures require tailored planning solutions, SCP implementation across realms is similarly influenced by political and legislative support, data availability, socio-economic integration, and the extent to which planning outputs are embedded in policy and governance structures (*Hermoso et al., 2018*; *McIntosh et al., 2018*; *Adams et al., 2019*). Although terrestrial and freshwater contexts often benefit from longer planning traditions, higher data availability and stronger governance foundations (*Baker et al., 2025*), the core drivers of SCP success and failure appear to be shared across realms, underscoring the need for cross-realm knowledge exchange and integrated policy frameworks.

CONCLUSIONS

The analysis of marine SCP case studies highlights the diverse strategies in which the process is applied globally, shaped by regional socio-economic, political, and ecological contexts. While scalable best practices have emerged, their broader adoption is often hindered by gaps in the academic literature, including limited evaluation of implementation outcomes and inconsistent reporting of methods. Our synthesis highlights the need to strengthen the interaction between academic research and practical management, essential for achieving more equitable and representative conservation planning on a global scale. The flexibility of SCP allows it to accommodate different sectoral considerations. Systematic conservation planning can integrate not only different sectoral priorities but also conservation objectives across multiple spatial scales. The hierarchical alignment of global, national, and regional objectives through SCP will be a key factor determining the effectiveness of efforts to conserve biodiversity and maintain ecosystem functioning. Yet, the process requires detailed knowledge of local systems and a strong ability to promote dialogue across sectors and spatial scales. Aligning SCP objectives with existing international policy frameworks is central to addressing current gaps in conservation and restoration planning and situating SCP within the broader global governance agenda. Moving forward, leveraging successful regional approaches and adapting them to specific contexts will be crucial to fostering effective and future-oriented marine conservation strategies.

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Author Contributions

- Erika Fabbrizzi conceived and designed the experiments, performed the experiments, analyzed the data, prepared figures and/or tables, authored or reviewed drafts of the article, and approved the final draft.
- Sylvaine Giakoumi conceived and designed the experiments, performed the experiments, authored or reviewed drafts of the article, and approved the final draft.
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REFERENCES

Adams VM. 2024. Costs in conservation: common costly mistakes and how to avoid them. *PLOS Biology* **22(6)**:e3002676 DOI 10.1371/journal.pbio.3002676.

Adams VM, Mills M, Jupiter SD, Pressey RL. 2011. Improving social acceptability of marine protected area networks: a method for estimating opportunity costs to multiple gear types in both fished and currently unfished areas. *Biological Conservation* **144(1)**:350–361 DOI 10.1016/j.biocon.2010.09.012.

Adams VM, Mills M, Weeks R, Segan DB, Pressey RL, Gurney GG, Groves C, Davis FW, Álvarez Romero JG. 2019. Implementation strategies for systematic conservation planning. *Ambio* **48(2)**:139–152 DOI 10.1007/s13280-018-1067-2.

Agostini VN, Margles SM, Schill SR, Knowles JE, Blyther RJ. 2010. Marine zoning in Saint Kitts and Nevis: a path towards sustainable management of marine resources. *The Nature Conservancy*.

Álvarez Romero JG, Mills M, Adams VM, Gurney GG, Pressey RL, Weeks R, Ban NC, Cheok J, Davies TE, Day JC, Hamel MA, Leslie HM, Magris RA, Storlie CJ. 2018. Research advances and gaps in marine planning: towards a global database in systematic conservation planning. *Biological Conservation* **227**:369–382 DOI 10.1016/j.biocon.2018.06.027.

Amano T, Berdejo-Espinola V, Christie AP, Willott K, Akasaka M, Báldi A, Berthinussen A, Bertolino S, Bladon AJ, Chen M, Choi C-Y, Bou Dagher Kharrat M, De Oliveira LG, Farhat P, Golivets M, Hidalgo Aranzamendi N, Jantke K, Kajzer-Bonk J, KemahlıAytekin MÇ, Khorozyan I, Kito K, Konno K, Lin D-L, Littlewood N, Liu Y, Liu Y, Loretto M-C, Marconi V, Martin PA, Morgan WH, Narváez-Gómez JP, Negret PJ, Nourani E, Ochoa Quintero JM, Ockendon N, Oh RRY, Petrovan SO, Piovezan-Borges AC, Pollet IL, Ramos DL, Reboredo Segovia AL, Rivera-Villanueva AN, Rocha R, Rouyer M-M, Sainsbury KA, Schuster R, Schwab D, Şekercioğlu ÇH, Seo H-M, Shackelford G, Shinoda Y, Smith RK, Tao S-d, Tsai M-s, Tyler EHM, Vajna F, Valdebenito JO, Vozykova S, Waryszak P, Zamora-Gutierrez V, Zenni RD, Zhou W, Sutherland WJ. 2021. Tapping into non-English-language science for the conservation of global biodiversity. *PLOS Biology* **19(10)**:e3001296 DOI 10.1371/journal.pbio.3001296.

André LV. 2021. Systematic spatial planning for the management of black pearl farming islands in the Pacific with a multi-criteria approach (biodiversity resources uses ciguatera). PhD thesis, Sorbonne Université.

André LV, Van Wynsberge S, Chinain M, Andréfouët S. 2022. Benefits of collaboration between indigenous fishery management and data-driven spatial planning approaches: the case of a Polynesian traditional design (rāhui). *Fisheries Research* **256**:106475 DOI 10.1016/j.fishres.2022.106475.

Arafeh-Dalmau N, Munguia-Vega A, Micheli F, Vilalta-Navas A, Villaseñor Derbez JC, Mora MPrécoma-deLa, Schoeman DS, Medellín-Ortíz A, Cavanaugh KC, Sosa-Nishizaki O, Burnham TLU, Knight CJ, Woodson CB, Abas M, Abadía-Cardoso A, Aburto-Oropeza O, Esgro MW, Espinosa-Andrade N, Beas-Luna R, Cardenas N, Carr MH, Dale KE, Cisneros-Soberanis F, Flores-Morales AL, Fulton S, García-Rodríguez E, Giron-Nava A, Gleason MG, Green AL, Hernández-Velasco A, Ibarra-Macías B, Johnson AF, Lorda J, Malpica-Cruz L, Montaño Moctezuma G, Olguín-Jacobson C, Parés-Sierra A, Raimondi PT, Ramírez-Ortiz G, Ramírez-Valdez A, Reyes-Bonilla H, Saarman E, Saldaña Ruiz LE, Smith A, Soldatini C, Suárez A, Torres-Moye G, Walther M, Watson EB, Worden S, Possingham HP. 2023. Integrating climate adaptation and transboundary management: guidelines for designing climate-smart marine protected areas. *One Earth* **6(11)**:1523–1541 DOI 10.1016/j.oneear.2023.10.002.

Arksey H, O'Malley L. 2005. Scoping studies: towards a methodological framework. *International Journal of Social Research Methodology* **8**:19–32 DOI 10.1080/1364557032000119616.

Baker DJ, Gaston KJ, Metcalfe K, Maclean IM. 2025. Systematic conservation planning for nature recovery. *BioScience* biaf030 DOI 10.1093/biosci/biaf030.

Balbar AC, Metaxas A. 2019. The current application of ecological connectivity in the design of marine protected areas. *Global Ecology and Conservation* **17**:e00569 DOI 10.1016/j.gecco.2019.e00569.

Ban NC, Bax NJ, Gjerde KM, Devillers R, Dunn DC, Dunstan PK, Hobday AJ, Maxwell SM, Kaplan DM, Pressey RL, Ardron JA, Game ET, Halpin PN. 2013. Systematic conservation planning: a better recipe for managing the high seas for biodiversity conservation and sustainable use: managing the high seas. *Conservation Letters* **7**:41–54 DOI 10.1111/conl.12010.

Beger M, Selkoe KA, Treml E, Barber PH, Von der Heyden S, Crandall ED, Toonen R, Riginos C. 2014. Evolving coral reef conservation with genetic information. *Bulletin of Marine Science* **90(1)**:159–185 DOI 10.5343/bms.2012.1106.

Bergseth BJ, Russ GR, Cinner JE. 2015. Measuring and monitoring compliance in no-take marine reserves. *Fish and Fisheries* **16**:240–258 DOI 10.1111/faf.12051.

Convention on Biological Diversity. 2022. Kunming-Montreal global biodiversity framework. In: *Adopted at the Fifteenth meeting of the conference of the parties to the convention on biological diversity (COP15), Montreal, Canada, December 2022. Available at https://www.cbd.int/gbf* .

Convention on Biological Diversity. 2025. In: *COP 16 final decisions: advancing the implementation of the Kunming-Montreal global biodiversity framework*. Secretariat of the CBD. *Available at https://www.cbd.int/meetings/COP-16*.

Borja A, Elliott M, Teixeira H, Stelzenmüller V, Katsanevakis S, Coll M, Galparsoro I, Fraschetti S, Papadopoulou N, Lynam C, Berg T, Andersen JH, Carstensen J, Leal MC, Uyarra MC. 2024. Addressing the cumulative impacts of multiple human pressures in marine systems, for the sustainable use of the seas. *Frontiers in Ocean Sustainability* **1**:1308125 DOI 10.3389/focsu.2023.1308125.

Botts EA, Pence G, Holness S, Sink K, Skowno A, Driver A, Harris LR, Desmet P, Escott B, Lötter M, Nel J, Smith T, Daniels F, Sinclair S, Stewart W, Manuel J. 2019. Practical actions for applied systematic conservation planning. *Conservation Biology* **33**:1235–1246 DOI 10.1111/cobi.13321.

Boyes SJ, Elliott M. 2014. Marine legislation—the ultimate 'horrendogram': international law, European directives & national implementation. *Marine Pollution Bulletin* **86(1–2)**:39–47 DOI 10.1016/j.marpolbul.2014.06.055.

Boyes SJ, Elliott M. 2015. The excessive complexity of national marine governance systems—has this decreased in England since the introduction of the Marine and Coastal Access Act 2009? *Marine Policy* **51**:57–65 DOI 10.1016/j.marpol.2014.07.019.

Bridge TC, Grech AM, Pressey RL. 2016. Factors influencing incidental representation of previously unknown conservation features in marine protected areas. *Conservation Biology* **30(1)**:154–165 DOI 10.1111/cobi.12557.

Brown CJ, Saunders MI, Possingham HP, Richardson AJ. 2014. Interactions between global and local stressors of ecosystems determine management effectiveness in cumulative impact mapping. *Diversity and Distributions* **20(5)**:538–546 DOI 10.1111/ddi.12159.

Buschke FT, Botts EA, Sinclair SP. 2019. Post-normal conservation science fills the space between research, policy, and implementation. *Conservation Science and Practice* **1**:e73 DOI 10.1111/csp2.73.

Cockerell B, Pressey RL, Grech A, Álvarez Romero JG, Ward T, Devillers R. 2020. Representation does not necessarily reduce threats to biodiversity: Australia's Commonwealth marine protected area system, 2012–2018. *Biological Conservation* **252**:108813 DOI 10.1016/j.biocon.2020.108813.

Douvere F. 2008. The importance of marine spatial planning in advancing ecosystem-based sea use management. *Marine Policy* **32**:762–771 DOI 10.1016/j.marpol.2008.03.021.

Elliott M, Borja A, Cormier R. 2020. Activity-footprints, pressures-footprints and effects-footprints—walking the pathway to determining and managing human impacts in the sea. *Marine Pollution Bulletin* **155**:111201 DOI 10.1016/j.marpolbul.2020.111201.

Elliott M, Borja Á, Cormier R. 2023. Managing marine resources sustainably—ecological, societal and governance connectivity, coherence and equivalence in complex marine transboundary regions. *Ocean & Coastal Management* **245**:106875 DOI 10.1016/j.ocecoaman.2023.106875.

European Commission. 2024. Regulation of the European Parliament and of the Council on nature restoration and amending Regulation (EU) 2022/869. *Official Journal of the European Union* 2024/1991.

Fabbrizzi E, Giakoumi S, De Leo F, Tamburello L, Chiarore A, Colletti A, Coppola M, Munari M, Musco L, Rindi F, Rizzo L, Savinelli B, Franzitta G, Grech D, Cebrian E, Verdura J, Bianchelli S, Mangialajo L, Nasto I, Sota D, Orfanidis S, Papadopoulou NK, Danovaro R, Fraschetti S. 2023a. The challenge of setting restoration targets for macroalgal forests under climate changes. *Journal of Environmental Management* **326**:116834 DOI 10.1016/j.jenvman.2022.116834.

Fabbrizzi E, Giakoumi S, Petza D, Katsanevakis S, Domínguez Crisóstomo E, Colloca F, Elliott M, Flannery W, Galparsoro I, Kruse M, Ben Lamine E, McAteer B, Stelzenmüller V, Fraschetti S. 2023b. Current practices in marine systematic conservation planning: protocol for a global scoping review. *Open Research Europe* **3**:136 DOI 10.12688/openreseurope.16300.1.

Galparsoro I, Borja Á. 2021. Defining cost-effective solutions in designing marine protected areas, using systematic conservation planning. *Frontiers in Marine Science* **8**:683271 DOI 10.3389/fmars.2021.683271.

Galparsoro I, Montero N, Mandiola G, Menchaca I, Borja Á, Flannery W, Katsanevakis S, Fraschetti S, Fabbrizzi E, Elliott M, Bas M, Barnard S, Piet G, Giakoumi S, Kruse

M, McAteer B, Runya RM, Lukyanova O, Morato T, Van Gerven A, Degraer S, Neuenfeldt S, Stelzenmüller V. 2025. Assessment tool addresses implementation challenges of ecosystem-based management principles in marine spatial planning processes. *Communications Earth & Environment* **6(1)**:55 DOI 10.1038/s43247-024-01975-7.

Game ET, Lipsett-Moore G, Hamilton R, Peterson N, Kereseka J, Atu W, Watts M, Possingham H. 2011. Informed opportunism for conservation planning in the Solomon Islands. *Conservation Letters* **4(1)**:38–46 DOI 10.1111/j.1755-263X.2010.00140.x.

Giakoumi S, Grantham HS, Kokkoris GD, Possingham HP. 2011. Designing a network of marine reserves in the Mediterranean Sea with limited socio-economic data. *Biological Conservation* **144**:753–763 DOI 10.1016/j.biocon.2010.11.006.

Giakoumi S, Guilhaumon F, Kark S, Terlizzi A, Claudet J, Felline S, Cerrano C, Coll M, Danovaro R, Fraschetti S, Koutsoubas D, Ledoux J-B, Mazor T, Mérigot B, Micheli F, Katsanevakis S. 2016. Space invaders; biological invasions in marine conservation planning. *Diversity and Distributions* **22(12)**:1220–1231 DOI 10.1111/ddi.12491.

Giakoumi S, Katsanevakis S, Vassilopoulou V, Panayotidis P, Kavadas S, Issaris Y, Kokkali A, Frantzis A, Panou A, Mavrommati G. 2012. Could European marine conservation policy benefit from systematic conservation planning? *Aquatic Conservation: Marine and Freshwater Ecosystems* **22(6)**:762–775 DOI 10.1002/aqc.2273.

Giakoumi S, Richardson AJ, Doxa A, Moro S, Andrello M, Hanson JO, Mazor T, McGowan J, Kujala H, Law E, Álvarez Romero JG, Magris RA, Gissi E, Arafeh-Dalmau N, Metaxas A, Virtanen EA, Ban NC, Runya RM, Dunn DC, Fraschetti S, Galparsoro I, Smith RJ, Bastardie F, Stelzenmüller V, Possingham HP, Katsanevakis S. 2025. Advances in systematic conservation planning to meet global biodiversity goals. *Trends in Ecology & Evolution* **40(4)**:395–410 DOI 10.1016/j.tree.2024.12.002.

Gilby BL, Olds AD, Brown CJ, Connolly RM, Henderson CJ, Maxwell PS, Schlacher TA. 2021. Applying systematic conservation planning to improve the allocation of restoration actions at multiple spatial scales. *Restoration Ecology* **29**:e13403 DOI 10.1111/rec.13403.

Gleason M, Feller EM, Merrifield M, Copps S, Fujita ROD, Bell M, Rienecke S, Cook C. 2013. A transactional and collaborative approach to reducing effects of bottom trawling. *Conservation Biology* **27(3)**:470–479 DOI 10.1111/cobi.12041.

Green A, Smith SE, Lipsett-Moore G, Groves C, Peterson N, Sheppard S, Lokani P, Hamilton R, Almany J, Bualia L. 2009. Designing a resilient network of marine protected areas for Kimbe Bay, Papua New Guinea. *Oryx* **43(4)**:488–498 DOI 10.1017/S0030605309990342.

**Grorud-Colvert K, Sullivan-Stack J, Roberts C, Constant V, Horta E, Costa B, Pike EP, Kingston N, Laffoley D, Sala E, Claudet J, Friedlander AM, Gill DA, Lester SE, Day JC, Gonçalves EJ, Ahmadia GN, Rand M, Villagomez A, Ban NC, Gurney GG, Spalding AK, Bennett NJ, Briggs J, Morgan LE, Moffitt R, Deguignet M, Pikitch EK, Darling ES, Jessen S, Hameed SO, Di Carlo G, Guidetti P, Harris JM, Torre J, Kizilkaya Z, Agardy T, Cury P, Shah NJ, Sack K, Cao L, Fernandez M, Lubchenco

J. 2021. The MPA guide: a framework to achieve global goals for the ocean. *Science* **373**:eabf0861 DOI 10.1126/science.abf0861.

Gurney GG, Adams VM, Álvarez Romero JG, Claudet J. 2023. Area-based conservation: taking stock and looking ahead. *One Earth* **6(2)**:98–104 DOI 10.1016/j.oneear.2023.01.012.

Haddaway NR, Bayliss HR. 2015. Shades of grey: two forms of grey literature important for reviews in conservation. *Biological Conservation* **191**:827–829 DOI 10.1016/j.biocon.2015.08.018.

Haddaway NR, Feierman A, Grainger MJ, Gray CT, Tanriver-Ayder E, Dhaubanjar S, Westgate MJ. 2019. EviAtlas: a tool for visualising evidence synthesis databases. *Environmental Evidence* **8**:22 DOI 10.1186/s13750-019-0167-1.

Halpern BS, Klein CJ, Brown CJ, Beger M, Grantham HS, Mangubhai S, Ruckelshaus M, Tulloch VJ, Watts M, White C, Possingham HP. 2013. Achieving the triple bottom line in the face of inherent trade-offs among social equity, economic return, and conservation. *Proceedings of the National Academy of Sciences of the United States of America* **110(15)**:6229–6234 DOI 10.1073/pnas.1217689110.

Harris LR, Watts ME, Nel R, Schoeman DS, Possingham HP. 2014. Using multivariate statistics to explore trade-offs among spatial planning scenarios. *Journal of Applied Ecology* **51(6)**:1504–1514 DOI 10.1111/1365-2664.12345.

Hering D, Schürings C, Wenskus F, Blackstock K, Borja A, Birk S, Bullock C, Carvalho L, Dagher-Kharrat MB, Lakner S, Lovrić N, McGuinness S, Nabuurs G-J, Sánchez-Arcilla A, Settele J, Pe'er G. 2023. Securing success for the nature restoration laws. *Science* **382**:1248–1250 DOI 10.1126/science.adk1658.

Hermoso V, Filipe AF, Segurado P, Beja P. 2018. Freshwater conservation in a fragmented world: dealing with barriers in a systematic planning framework. *Aquatic Conservation: Marine and Freshwater Ecosystems* **28(1)**:17–25 DOI 10.1002/aqc.2826.

Holness SD, Harris LR, Chalmers R, De Vos D, Goodall V, Truter H, Oosthuizen A, Bernard ATF, Cowley PD, Da Silva C, Dicken M, Edwards L, Marchand G, Martin P, Murray TS, Parkinson MC, Pattrick P, Pichegru L, Pistorius P, Sauer WHH, Smale M, Thiebault A, Lombard AT. 2022. Using systematic conservation planning to align priority areas for biodiversity and nature-based activities in marine spatial planning: a real-world application in contested marine space. *Biological Conservation* **271**:109574 DOI 10.1016/j.biocon.2022.109574.

Janßen H, Göke C, Luttmann A. 2019. Knowledge integration in marine spatial planning: a practitioners' view on decision support tools with special focus on Marxan. *Ocean & Coastal Management* **168**:130–138 DOI 10.1016/j.ocecoaman.2018.11.006.

JBI SUMARI. 2021. JBI SUMARI scoping reviews protocol template. (accessed on 25 April 2023).

Jefferson T, Palomares MLD, Lundquist CJ. 2022. Safeguarding seafood security, marine biodiversity and threatened species: can we have our fish and eat it too? *Frontiers in Marine Science* **9**:826587 DOI 10.3389/fmars.2022.826587.

Jung M, Adams VM, Alagador D, Álvarez Romero JG, Araujo MB, Arponen A, Beger M, Beher J, Carvalho SB, Giakoumi S, Hanson JO, Hermoso V, Jantke K, Kujala

H, McGowan J, Metaxas A, O'Connor L, Salgado-Rojas J, Schuster R, Smith B, Visconti P. 2025. An interoperable and standardized protocol for reporting systematic conservation planning projects. *Conservation Science and Practice* **7(7)**:e70097 DOI 10.1111/csp2.70097.

Keen LH, Stortini CH, Boyce DG, Stanley RR. 2024. Assessing climate change vulnerability in Canadian marine conservation networks: implications for conservation planning and resilience. *FACETS* **9(1)**:1–15 DOI 10.1139/facets-2023-0124.

Khelifa R, Amano T, Nuñez MA. 2022. A solution for breaking the language barrier. *Trends in Ecology & Evolution* **37(2)**:109–112 DOI 10.1016/j.tree.2021.11.003.

Kirkman SP, Holness S, Harris LR, Sink KJ, Lombard AT, Kainge P, Majiedt P, Nsiangango SE, Nsingi KK, Samaai T. 2019. Using systematic conservation planning to support marine spatial planning and achieve marine protection targets in the transboundary Benguela ecosystem. *Ocean & Coastal Management* **168**:117–129 DOI 10.1016/j.ocecoaman.2018.10.038.

Klein C, Becker K, Rivera DEC, Davey M, Dominguez-Martinez RM, Grantham H, Lucas B, Possingham H, Roberson L, Wakwella A, Wenger A, Watson JE. 2025. Marine conservation leadership: does Australia walk the talk? *Conservation Letters* **18(5)**:e13147 DOI 10.1111/conl.13147.

Klein CJ, Chan A, Kircher L, Cundiff AJ, Gardner N, Hrovat Y, Scholz A, Kendall BE, Airamé S. 2008. Striking a balance between biodiversity conservation and socioeconomic viability in the design of marine protected areas. *Conservation Biology* **22**:691–700 DOI 10.1111/j.1523-1739.2008.00896.x.

Klein CJ, Jupiter SD, Watts M, Possingham HP. 2014. Evaluating the influence of candidate terrestrial protected areas on coral reef condition in Fiji. *Marine Policy* **44**:360–365 DOI 10.1016/j.marpol.2013.10.001.

Kukkala AS, Moilanen A. 2012. Core concepts of spatial prioritisation in systematic conservation planning. *Biological Reviews* **88**:443–464 DOI 10.1111/brv.12008.

Lagabrielle E, Lombard AT, Harris JM, Livingstone TC. 2018. Multi-scale multi-level marine spatial planning: a novel methodological approach applied in South Africa. *PLOS ONE* **13(7)**:e0192582 DOI 10.1371/journal.pone.0192582.

Lagabrielle E, Rouget M, Le Bourgeois T, Payet K, Durieux L, Baret S, Dupont J, Strasberg D. 2011. Integrating conservation, restoration and land-use planning in islands—an illustrative case study in Réunion Island (Western Indian Ocean). *Landscape and Urban Planning* **101(2)**:120–130 DOI 10.1016/j.landurbplan.2011.02.004.

Leslie HM, McLeod KL. 2007. Confronting the challenges of implementing marine ecosystem-based management. *Frontiers in Ecology and the Environment* **5**:540–548 DOI 10.1890/060093.

Levac D, Colquhoun H, O'Brien KK. 2010. Scoping studies: advancing the methodology. *Implementation Science* **5**:69 DOI 10.1186/1748-5908-5-69.

Levin N, Tulloch AI, Gordon A, Mazor T, Bunnefeld N, Kark S. 2013. Incorporating socioeconomic and political drivers of international collaboration into marine conservation planning. *BioScience* **63(7)**:547–563 DOI 10.1525/bio.2013.63.7.8.

Mackelworth P, Fortuna CM, Antoninić M, Holcer D, Malak DA, Attia K, Bricelj M, Guerquin F, Marković M, Nunes E, Perez-Valverde C, Ramieri E, Stojanović I, Tunesi L, McGowan J. 2024. Ecologically and biologically significant areas (EBSAs) as an enabling mechanism for transboundary marine spatial planning. *Marine Policy* **166**:106231 DOI 10.1016/j.marpol.2024.106231.

Margules CR, Pressey RL. 2000. Systematic conservation planning. *Nature* **405**:243–253 DOI 10.1038/35012251.

Markantonatou V, Giakoumi S, Koukourouvli N, Maina I, Gonzalez-Mirelis G, Sini M, Maistrelis K, Stithou M, Gadolou E, Petza D, Kavadas S, Vassilopoulou V, Buhl-Mortensen L, Katsanevakis S. 2021. Marine spatial plans focusing on biodiversity conservation: the case of the Aegean Sea. *Aquatic Conservation: Marine and Freshwater Ecosystems* **31(8)**:2278–2292 DOI 10.1002/aqc.3610.

McIntosh EJ, Chapman S, Kearney SG, Williams B, Althor G, Thorn JPR, Pressey RL, McKinnon MC, Grenyer R. 2018. Absence of evidence for the conservation outcomes of systematic conservation planning around the globe: a systematic map. *Environmental Evidence* **7**:22 DOI 10.1186/s13750-018-0134-2.

Metabolic. 2024. On track or off course?—assessing progress toward the 30x30 target for the ocean. *Available at https://assets.bbhub.io/dotorg/sites/64/2024/10/On-track-or-off-course.pdf*.

Metcalfe K, White L, Lee ME, Fay JM, Abitsi G, Parnell RJ, Smith RJ, Agamboue PD, Bayet JP, Mve Beh JH, Bongo S, Boussamba F, De Bruyne G, Cardiec F, Chartrain E, Collins T, Doherty PD, Formia A, Gately M, Gnandji MS, Ikoubou I, Kema Kema JR, Kombila K, Kongo PE, Manfoumbi JC, Maxwell SM, Mba Asseko GH, McClellan CM, Minton G, Ndjimbou SO, koane Ndoutoume GN, Bibang Bi Nguema JN, Nkizogho T, Nzegoue J, Kouerey Oliwina CK, Otsagha FM, Savarit D, Pikesley SK, Du Plessis P, Rainey H, Kingbell Rockombeny LAD, Rosenbaum HC, Segan D, Sounguet G, Stokes EJ, Tilley D, Vilela R, Viljoen W, Weber SB, Witt MJ, Godley BJ. 2022. Fulfilling global marine commitments; lessons learned from Gabon. *Conservation Letters* **15**:e12872 DOI 10.1111/conl.12872.

Meyer D, Zeileis A, Hornik K, Friendly M. 2023. vcd: visualizing categorical data. R package version 1.4-12. *Available at https://CRAN.R-project.org/package=vcd*.

Neubert S, McGowan J, Metcalfe K, Hanson JO, Buenafe KCV, Dabalà A, Dunn DC, Everett JD, Possingham HP, Stelzenmüller V, Estep A, Ervin J, Richardson AJ. 2025. Multiple-use spatial planning for sustainable development and conservation. *Trends in Ecology & Evolution* **40(11)**:1126–1142 DOI 10.1016/j.tree.2025.09.007.

Nuno A, Madruga L, Cameron A, Airaud F, Andrade C, Nazaré L, Santos A, Graça M, Guedes M, Da Rocha N, Puig P, Walker K, Murray K, Rosendo S, Mulligan B. 2024. Establishing a marine protected area network using a marine spatial planning approach: a reflection on practical challenges and opportunities for social–ecological integration. *Conservation Science and Practice* e13196 DOI 10.1111/csp2.13196.

O'Hara CC, Frazier M, Halpern BS. 2021. At-risk marine biodiversity faces extensive, expanding, and intensifying human impacts. *Science* **372(6537)**:84–87 DOI 10.1126/science.abe6731.

Papazekou M. 2022. Prioritization of management options and activity zone planning through the implementation of systematic conservation planning: a case study on the national marine park of alonissos. Master Thesis, Aristotle University of Thessaloniki, Thessaloniki, Greece.

Peters MDJ, Marnie C, Tricco AC, Pollock D, Munn Z, Alexander L, McInerney P, Godfrey CM, Khalil H. 2020. Updated methodological guidance for the conduct of scoping reviews. *JBI Evidence Synthesis* **18**:2119–2126 DOI 10.11124/JBIES-20-00167.

Podda C, Porporato EMD. 2023. Marine spatial planning for connectivity and conservation through ecological corridors between marine protected areas and other effective area-based conservation measures. *Frontiers in Marine Science* **10**:1271397 DOI 10.3389/fmars.2023.1271397.

Pressey RL, Bottrill MC. 2009. Approaches to landscape- and seascape-scale conservation planning: convergence, contrasts and challenges. *Oryx* **43**:464 DOI 10.1017/S0030605309990500.

Sacre E, Weeks R, Bode M, Pressey RL. 2020. The relative conservation impact of strategies that prioritize biodiversity representation, threats, and protection costs. *Conservation Science and Practice* **2(8)**:e221 DOI 10.1111/csp2.221.

Schill SR, Raber GT, Roberts JJ, Treml EA, Brenner J, Halpin PN. 2015. No reef is an island: integrating coral reef connectivity data into the design of regional-scale marine protected area networks. *PLOS ONE* **10(12)**:e0144199 DOI 10.1371/journal.pone.0144199.

Shabtay A, Rothschild A, Makovsky Y, Neuman A, Bialik O, Goren L, Idan T, Slavenko A, Salingré S, Buba Y, Guy-Haim T, Herut B, Stern N, Gertman I, Gilboa M, Gal G, Ofir E, Rubin Blum M, Berenshtein I, Amir D, Karniel T, Belmaker J, Ben Lamine E, Giakoumi S. 2025. Lessons learned by addressing challenges to deep-sea conservation planning in the Southeastern Mediterranean Sea: linking science to practice, Ocean Coast. *Manage* **267**:107700 DOI 10.1016/j.ocecoaman.2025.107700.

Sink KJ, Harris LR, Van der Bank MG, Franken M, Skowno A, Driver A, Atkinson LJ, Fairweather TP, Kerwath S, Majiedt PA, Robinson T, Pfaff M, Rikhotso W, Smith C, Van Niekerk L. 2019. Chapter 11: key findings, priority actions and knowledge gaps. South African National Biodiversity assessment 2018 technical report volume 4: marine realm. Pretoria: South African National Biodiversity Institute.

Spalding MD, Fox HE, Allen GR, Davidson N, Ferdaña ZA, Finlayson M, Halpern BS, Jorge MA, Lombana A, Lourie SA, Martin KD, McManus E, Molnar J, Recchia CA, Robertson J. 2007. Marine ecoregions of the world: a bioregionalization of coastal and shelf areas. *BioScience* **57**:573–583 DOI 10.1641/B570707.

Tittensor DP, Beger M, Boerder K, Boyce DG, Cavanagh RD, Cosandey-Godin A, Ortuño Crespo G, Dunn DC, Ghiffary W, Grant SM, Hannah L, Halpin PN, Harfoot M, Heaslip SG, Jeffery NW, Kingston N, Lotze HK, McGowan J, McLeod E, McOwen CJ, O'Leary BC, Schiller L, Stanley RRE, Westhead M, Wilson KL, Worm B. 2019. Integrating climate adaptation and biodiversity conservation in the global ocean. *Science Advances* **5(11)**:eaay9969 DOI 10.1126/sciadv.aay9969.

Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, Moher D, Peters MDJ, Horsley T, Weeks L, Hempel S, Akl EA, Chang C, McGowan J, Stewart L, Hartling L, Aldcroft A, Wilson MG, Garritty C, Lewin S, Godfrey CM, Macdonald MT, Langlois EV, Soares-Weiser K, Moriarty J, Clifford T, Tunçalp Ö, Straus SE. 2018. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. *Annals of Internal Medicine* **169**:467–473 DOI 10.7326/M18-0850.

Tulloch VJ, Atkinson S, Possingham HP, Peterson N, Linke S, Allan JR, Kaiye A, Keako M, Sabi J, Suruman B, Adams VM. 2021. Minimizing cross-realm threats from land-use change: a national-scale conservation framework connecting land, freshwater and marine systems. *Biological Conservation* **254**:108954 DOI 10.1016/j.biocon.2021.108954.

United Nations. 2023. Agreement under the United Nations Convention on the law of the sea on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction. U.N. Doc. A/CONF.232/2023/4. United Nations.

Venegas-Li R, Levin N, Possingham H, Kark S. 2018. 3D spatial conservation prioritisation: accounting for depth in marine environments. *Methods in Ecology and Evolution* **9**:773–784 DOI 10.1111/2041-210X.12896.

Watts ME, Ball IR, Stewart RS, Klein CJ, Wilson K, Steinback C, Lourival R, Kircher L, Possingham HP. 2009. Marxan with zones: software for optimal conservation based land-and sea-use zoning. *Environmental Modelling & Software* **24(12)**:1513–1521 DOI 10.1016/j.envsoft.2009.06.005.

Whitehead AL, Kujala H, Wintle BA. 2016. Dealing with cumulative biodiversity impacts in strategic environmental assessment: a new frontier for conservation planning. *Conservation Letters* **10(2)**:195–204 DOI 10.1111/conl.12260.

Wilcox MA, Jeffery NW, Di Bacco C, Bradbury IR, Lowen B, Wang Z, Beiko RG, Stanley RR. 2023. Integrating seascape resistances and gene flow to produce area-based metrics of functional connectivity for marine conservation planning. *Landscape Ecology* **38(9)**:2189–2205 DOI 10.1007/s10980-023-01690-2.

Wilson KL, Tittensor DP, Worm B, Lotze HK. 2020. Incorporating climate change adaptation into marine protected area planning. *Global Change Biology* **26(6)**:3251–3267 DOI 10.1111/gcb.15094.

Yates KL, Schoeman DS, Klein CJ. 2015. Ocean zoning for conservation, fisheries and marine renewable energy: assessing trade-offs and co-location opportunities. *Journal of Environmental Management* **152**:201–209 DOI 10.1016/j.jenvman.2015.01.045.