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REVIEWS

Contribution of area-based fisheries management measures to fisheries sustainability and marine conservation: a global scoping review

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Abstract Area-based fisheries management measures (ABFMs) are commonly related to the sustainable use of resources but are increasingly considered broader conservation measures. This Scoping Review (ScR) identified and mapped the evidence base regarding the contribution of ABFMs to fisheries sustainability and marine conservation. The ScR was conducted following the JBI methodology and the PRISMA statement. A total of 2,391 documents were identified, and following a two-stage screening process, 151 documents were eventually included in the ScR for full review and data extraction. Most of the documents were published during the last 12 years. Studies had a wide geographical distribution (mainly located in Europe and North America), were primarily conducted at the subnational level, concerned fishing restrictions of towed gears,

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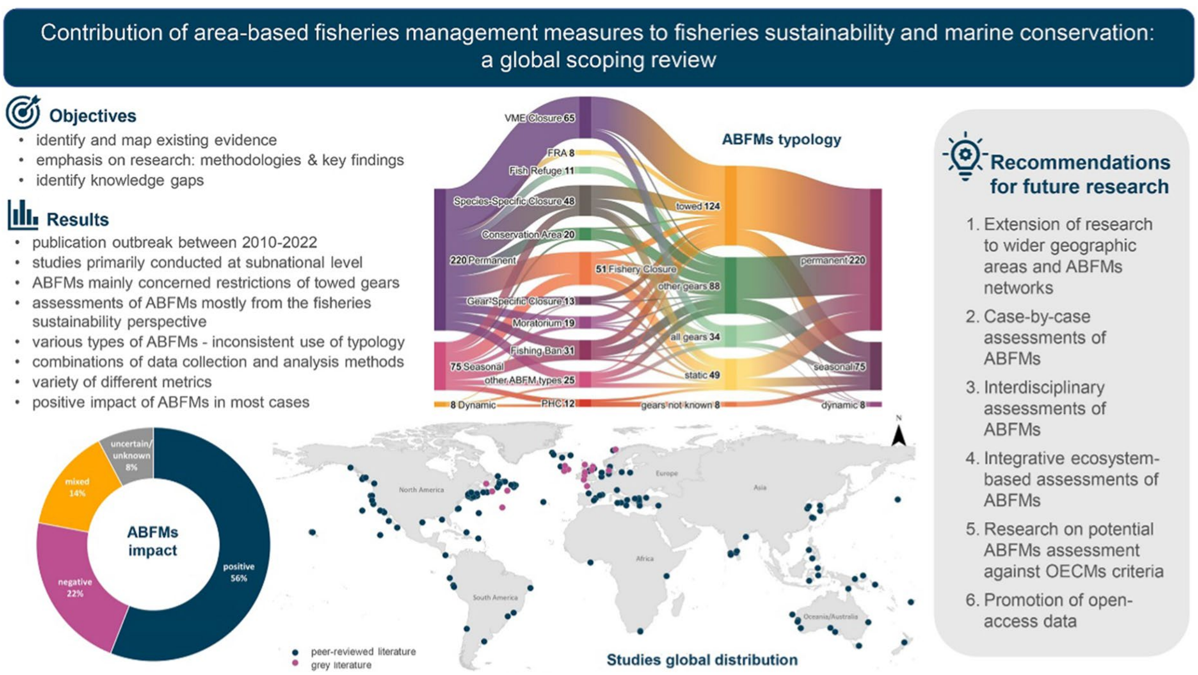
and assessed ABFMs from a single stock's perspective. ABFMs identified were of various types, and the use of terminology was not consistent in the literature. Multiple combinations of data collection (primarily experimental surveys/sampling and open data sources) and analysis methods (most commonly, fisheries and ecological analyses and modelling) were applied (often in combination), using a variety of different metrics. Various knowledge gaps emerged, mainly related to the study of ABFMs networks and the application of an interdisciplinary and ecosystem-based approach for assessing ABFMs. The social, economic, and environmental impact of ABFMs was positive in most cases (56%) and in less cases negative (22%) or mixed (14%). This ScR is a valuable source of information for the contribution of ABFMs to rebuilding marine ecosystems and attaining CBD conservation targets through the lens of the OECM concept.

Graphical abstract



Keywords Area-based marine conservation · Fisheries closures · Fisheries restricted areas · Other effective area-based conservation measures (OECMs) · Global biodiversity framework · Evidence synthesis

Introduction

Globally, many marine fisheries have collapsed due to overfishing caused by the uncontrolled expansion of the fishing sector, both in terms of fishing capacity and effort. The problem was systematically highlighted by FAO in its recurrent reviews of the state of world resources since 1968 (FAO 1968) but remained masked by the continuous opening of new fishing areas and progressive replacement of target species (serial overfishing) (Garcia and Newton 1994, 1997; Garcia and Grainger 1997) as well as inaccuracies in official statistics. The attention given to the problem intensified in the 1980s and 1990s (Garcia and Grainger 1997; Garcia and Newton 1997; Jackson et al. 2001; Myers and Worm 2003; Pauly et al. 1998; Pauly 2008). As a response to a century of rampant overfishing, the concept of sustainable fisheries, advocated since the 1930s, got increased traction. A suite of fisheries measures controlling both total fishing capacity and removals and introducing fishing rights, co-management, and the Ecosystem Approach to Fisheries (FAO 2003) were implemented in advanced nations with some success (Worm et al. 2009), as a means to control exploitation rates and for the recovery of fishery stocks (Caddy and Agnew 2005; Garcia and Ye 2018; Garcia et al. 2018).

Area-based management approaches have been widely recognised as a beneficial means for sustainably exploiting coastal and marine resources. Area-based management tools are geographically defined areas, where human activities are regulated to deliver one or more social and ecological outcomes (Molenaar 2013; Reimer et al. 2020; Gissi et al. 2022). A variety of area-based management tools exists worldwide under various jurisdictions, ranging from tools for the regulation of specific human activities (e.g., fisheries, shipping, or mining) to multi-sectoral or cross-sectoral tools, such as marine protected areas (MPAs) and marine spatial plans (Gissi et al. 2022). Many international processes have reiterated the commitment to use area-based management approaches (UN Environment 2018), e.g., the United Nations 2030 Agenda for Sustainable Development, the Convention on Biological Diversity (CBD) Strategic Plan 2010–2020 (CBD 2010), the Kunming-Montreal Global Biodiversity Framework (CBD 2022), and the EU Biodiversity Strategy for 2030 (EU 2021).

Area-based fisheries management measures (ABFMs) are formally established, spatially defined fishery management and/or conservation measures, implemented to achieve one or more intended fishery outcomes (CBD 2018). Applied currently in most contemporary fisheries management plans and regulations (Garcia et al. 2021), their outcomes are commonly related to the sustainable use of resources (Rice et al. 2018). According to the FAO Code of Conduct for Responsible Fisheries (Article 6.3; FAO 1995), states should implement management measures to prevent overfishing and secure that fishing effort matches the productive capacity of the ecosystems and their sustainable utilisation. Such objectives can be achieved through the use of ABFMs among other measures, by limiting the harvest of specific life stages, safeguarding genetic reservoirs, supporting the rebuilding phase of fisheries by protecting depleted stocks and their habitats, protecting essential fish habitats, such as spawning and nursery habitats, and limiting fleet capacity (Hall 2009).

ABFMs have been traditionally linked to the sustainable exploitation of commercially important species. However, they are increasingly considered broader conservation measures, especially when their implementation protects ecological features or mitigates fisheries' impacts on biodiversity or ecosystem structure and functioning (Rice et al. 2018; CBD 2018; Petza et al. 2019; FAO 2019; Garcia et al. 2021, 2022; ICES 2021; Himes-Cornell et al. 2022). ABFMs' promotion of primary, secondary, or ancillary forms of conservation is contingent on their objectives (IUCN-WCPA 2019). ABFMs promote primary or secondary conservation outcomes when the conservation benefits produced mirror their intended and explicit primary or secondary objectives respectively. Ancillary conservation is promoted by ABFMs when the management measures are explicitly intended to contribute to the sustainable harvest of the target species but, at the same time, de facto reduce pressure on biodiversity and ecosystem functioning.

ABFMs promoting ancillary forms of conservation may be considered Other Effective Area-Based Conservation Measures (OECMs) according to the definition of the CBD Decision 14/8 (CBD 2018), i.e., non-protected areas, which achieve positive long-term outcomes for the protection of biodiversity and associated ecosystem services, functions, and other locally relevant social or economic values. OECMs can contribute to the attainment of Target 14.5 of the 2030 Agenda for Sustainable Development (UN 2015) and Target 3 of the Kunming-Montreal Global Biodiversity Framework (CBD 2022). According to the latter, actions should be taken by 2030 to ensure that at least 30 per cent of land and sea areas globally are conserved through ecologically representative, effectively and equitably managed, and well-connected networks of protected areas and OECMs (CBD 2022).

One of the crucial components of a potential OECM is achieving a "sustained and effective contribution to in situ conservation of biodiversity" (Criterion C of the CBD Decision 14/8; CBD (2018)). However, assessing the overall efficacy of ABFMs as candidate OECMs is challenging since it is often confounded by other management measures in and beyond the ABFM area. Broader environmental and socio-economic factors constantly in flux may complicate the identification of individual cause-effect relationships. In general, as Rice et al. (2018) argue, the performance of an ABFM depends on (a) the overall environmental status and its intrinsic oscillations, including the effects of climate change; (b) the adequacy of its characteristics (e.g. space, time, and fishing activities restricted); (c) its intended purpose(s) and the issues it is envisioned to address; (d) fisheries governance, particularly community involvement, additional management measures inside and beyond the ABFM, access rules, and enforcement; and (e) total fishing pressure.

During a preliminary search of Scopus and Web of Science, no systematic reviews on fisheries sustainability and the conservation aspect of marine ABFMs (applied only for fisheries management) were identified. Rice et al. (2018) have identified the different types of ABFMs and evaluated their effectiveness from a conservation perspective, by applying an illustrative approach to synthesise the available evidence, instead of performing a systematic review. Recently, Himes-Cornell et al. (2022) evaluated ABFMs against OECMs criteria and sustainable use principles, broader ecosystem management objectives, and more general biodiversity conservation goals. This was accomplished by reviewing case studies across a broad range of spatial management approaches, highlighting how fisheries measures can help achieve many Sustainable Development Goals and the CBD global targets for biodiversity. A synthesis, considering both the harvest sustainability and the conservation aspect of marine ABFMs, is of high relevance and interest for both fisheries and environmental management. Therefore, conducting a scoping review (ScR) as a starting point for this evidence-based synthesis path was deemed vital.

The objectives of this ScR are to:

- identify, map, and summarise the existing evidence on how ABFMs applied purely for fisheries management have contributed to fisheries sustainability and area-based marine conservation,
- investigate how the ABFMs' contribution to fisheries sustainability and marine conservation has been assessed and what methodologies have been applied in relevant research,
- identify and discuss knowledge gaps.

This ScR intends to provide fisheries managers and policy-makers with insights into the evidence-based knowledge about ABFMs and contribute to the policy discussion on where an ABFM should be positioned along the continuum of "effectiveness" to qualify as an OECM and contribute, together with MPAs, to the attainment of the CBD spatial targets (CBD 2010, 2022).

Materials & methods

The methods of the current ScR were specified in advance and published in an a priori protocol (Petza et al. 2021). Only minor deviations from the protocol were necessitated during the review process, mainly regarding the data extraction tool (Supplementary Table 1). The Arksey and O'Malley (2005) methodology, as advanced by Levac et al. (2010), and the Joanna Briggs Institute (JBI) methodology for scoping reviews (Peters et al. 2020) were applied for the conduction of the current ScR. The nine-stage process as proposed by the JBI methodology was followed, i.e., (1) defining and aligning the objectives and questions, (2) developing and aligning the inclusion criteria with the objectives and questions, (3) describing the planned approach to evidence searching, selection, data extraction and presentation, (4) searching for the evidence, (5) selecting the evidence, (6) extracting the evidence, (7) analysing of the evidence, (8) presenting the results, and (9) summarising the evidence about the purpose of the review, drawing conclusions, and noting any implications of the findings. The ScR was guided by the Preferred Reporting for Systematic Reviews and Meta-Analyses extension for scoping reviews, PRISMA-ScR checklist (Tricco et al. 2018) (Supplementary Table 2). A broad consultation process with topical experts was undertaken before the initiation of the ScR process to develop the review objectives and questions, the ScR inclusion and exclusion criteria, and the identification of the literature sources (both for peer-reviewed and grey literature).

The ScR was addressed by the following review question: What is the current knowledge about the extent to which ABFMs as fisheries management measures contribute to fisheries sustainability and marine conservation on a global scale? This general review question was further divided into the following sub-questions: (1) Which is the geographical distribution of the studies that have assessed the contribution of ABFMs to fisheries sustainability or marine conservation? (2) What are the characteristics of ABFMs studied in terms of typology (e.g., spatial and temporal type, duration, and area), objectives, rationale, management, and governance? (3) Which are the methodologies followed to assess the contribution of ABFMs to fisheries sustainability and marine conservation? (4) What are their key findings and knowledge gaps for future research and policy-related steps?

The inclusion criteria for the ScR, which were guided and directed by the review question, were developed in correspondence with the "Participants, Concept, and Context, PCC" mnemonic, which is highly recommended as a means to construct a clear and meaningful title, review question, and inclusion criteria (Peters et al. 2020)(Supplementary Table 3). The ScR considered all ABFMs established as purely fisheries management measures by national, regional, or international fisheries management authorities or organizations to support fisheries sustainability or broader ecosystem objectives for any fishing activity, gear, target species, and habitat. Area-based measures related to fishing activities, established for purposes other than to support fisheries sustainability, such as cross-sectoral area-based measures to conserve or restore biodiversity (within MPAs or not) or any other purpose, e.g., to protect underwater archaeological heritage or to exclude fishing activities from ports, beaches, underwater pipe or cable areas, and military areas were excluded from the ScR. Such area-based measures do not meet the definition of the ABFMs given by the CBD Decision 14/8 (CBD 2018) and thus fall out of the scope of the current study. To avoid the inclusion of area-based measures within designated MPAs, in the cases that the designation authority and the objectives were not clearly defined by the article, a search in the World Database on Protected Areas (WDPA) was performed and the articles that referred to measures within MPAs included in the WDPA were excluded. Fisheries sustainability and conservation of marine biodiversity are the two concepts studied by the current ScR, and specifically, how the contribution of ABFMs to these two concepts has been addressed so far in the literature. All studies that assessed the contribution of ABFMs to fisheries sustainability or marine conservation were considered. All methodologies applied, metrics used (e.g., ecological, economic, or social), and key findings on the effectiveness of ABFMs for fisheries sustainability or marine conservation were reviewed. Studies on ABFMs in the marine realm worldwide, established in territorial, international waters, or exclusive economic zones, were considered by the ScR. Studies on ABFMs in inland or transitional waters were not included.

The ScR considered both peer-review and grey literature from various sources. Both experimental and observational studies were reviewed. All types of documents were considered except for evidence synthesis or literature reviews. Based on the authors' language competence, studies published in English, French, German, Greek, Italian, Spanish, and Swedish were included in the ScR.

The bibliographic search was performed in three databases/ platforms, i.e., (a) Scopus, (b) Web of Science–Core Collection, and (c) Google Scholar (Supplementary Table 4). Eligible documents were also searched in other sources, namely e.g., organizational libraries and websites,, reference lists of the documents included in the ScR and documents suggested by topic experts and stakeholders.

A two-round selection procedure was followed. During the first round of article screening, relevance was assessed based on title and abstract screening. During the second round, documents that passed the first screening stage were screened in full text against the inclusion criteria. The document selection process was based on the "team approach", as recommended by Levac et al. (2010). Both rounds of the selection process along with the data extraction process were performed in SysRev (SysRev 2021) For the systematic search and review, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram was applied (Fig. 1), as proposed by Page et al. (2021) for new systematic reviews which include searches of databases, registers, and other sources.

Data were extracted from the documents included in the ScR using a data extraction tool, i.e., a charting table aligned to the objective and the questions of the ScR (Supplementary Table 5). The extracted data included specific details about the participants, the concept, the context, the study methods, key findings, and knowledge gaps relevant to the review objective and were structured in 55 fields.

Various software packages and tools were used to present and analyse the data by applying descriptive statistics, namely: Microsoft Excel 2019 MSO for bar charts, line graphs, Pareto charts, doughnut charts, radar graphs, and mosaic plots, ArcGIS 10.1 commercial GIS package (Environmental Systems Research Institute 2011) for maps, Flourish Studio (Canva UK Operations Ltd 2022) for violin plots, Shankey diagrams, chord diagrams, and network graphs. Chi-squared tests were performed in Statgraphics® Centurion 18. The reference management software 1.19.5/2019 Mendeley Ltd., Elsevier was used to generate the bibliography of the review paper. The Data Viz Color Palette Generator tool provided by Data Color Picker was used to create a series of visually equidistant colours for data visualisations (Data Color Picker 2022).

The open-access, open-source software tool EviAtlas (Haddaway et al. 2019) was used to create an interactive online visualisation of the ScR database. The atlas produced is an open-access, interactive cartographic map. It presents information regarding the documents included in the ScR and the reviewed case.

Details on the search strategy, evidence selection, data extraction and presentation are provided in Supplementary Table 6.

Results

Scoping review workflow and dataset

After removing duplicates, the search in Scopus, Web of Science, and Google Scholar led to 1669 documents, screened for eligibility by title and abstract (Fig. 1). After the first screening, 345 documents were retrieved for full-text review. At that stage, 207 documents were excluded, mainly because they referred to area-based measures established for

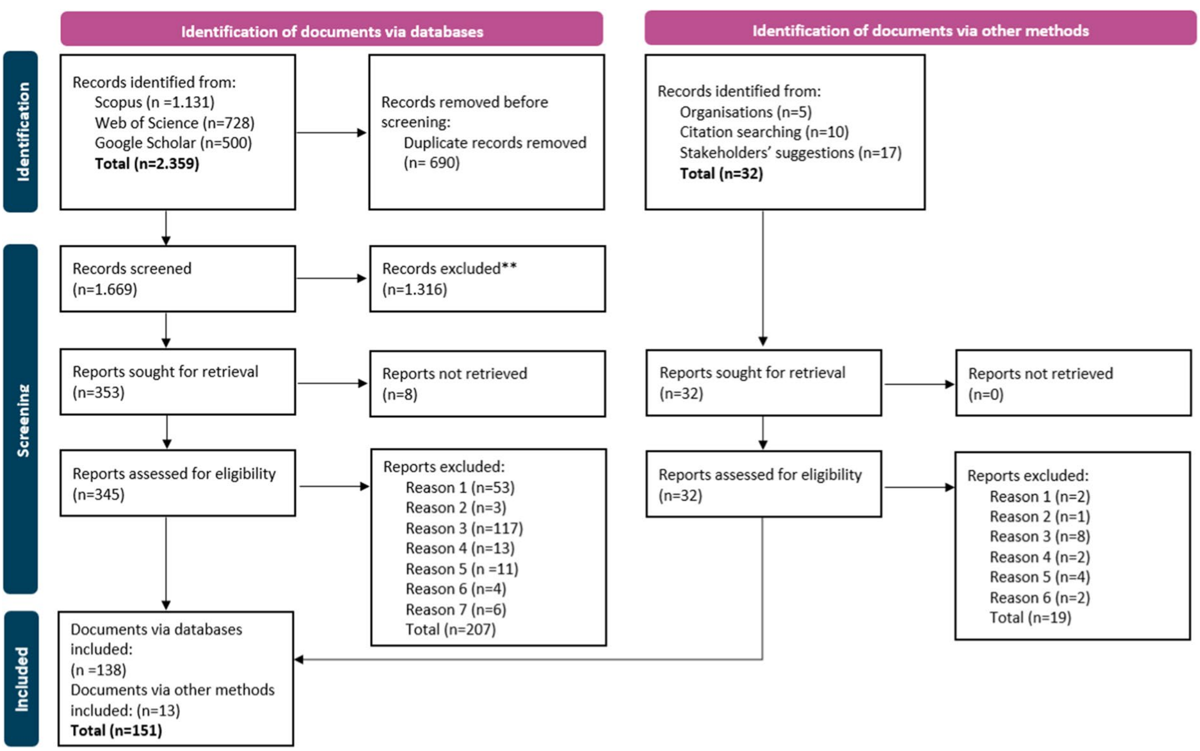


Fig. 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram for the systematic search and review (as proposed by Page et al. (2021) for new systematic reviews which include searches of databases, registers, and other sources). Reasons for exclusion: Reason 1 = ABFMs are discussed/proposed but not assessed; Reason 2 = ABFMs are not considered; Reason 3 = Area-based measures established for purposes other than to support fisheries sustainability (not ABFMs); Reason 4 = Evidence synthesis or literature reviews; Reason 5 = Modelled/ simulated ABFMs; Reason 6 = Other; Reason 7 = Study in inland or transitional waters

purposes other than to support fisheries sustainability (not ABFMs) (n = 117) or ABFMs were discussed/proposed but not assessed (n = 53) (Fig. 1). Additionally, 32 documents were identified via other methods. All of them were retrieved and assessed for eligibility, and 13 documents were included in the ScR, namely from articles' references lists (n = 6), stakeholders' suggestions (n = 4), STECF Reports Repository (n = 1), and ICES Library (n = 2) (Fig. 1). Overall, 151 documents met the criteria for inclusion in the ScR (Supplementary Table 7).

A total of 168 case studies were identified by the 151 documents included in the ScR (148 documents including one case study, one document including two, one document including five, and one document including 13). After the completion of the data extraction, the information retrieved was archived in a tabular database of 9.240 cells (Supplementary Table 8), consisting of 55 columns (one column for each field) and 168 rows (one row for each case study).

Literature characteristics

Of the 151 documents included in the ScR, 97% were peer-reviewed literature (n = 146), while only 3% (n = 5) were grey literature. Concerning the literature type of the documents, the vast majority were journal articles (n = 145). The publication timeframe was from 1982 to 2022. Approximately three-quarters of the documents were published during the last 12 years (from 2010 onwards). Since the Scopus and Web of Science search were conducted in late 2021 and Scholar Google search in early 2022, the last two years (2021–2022) were partially covered (Fig. 2).

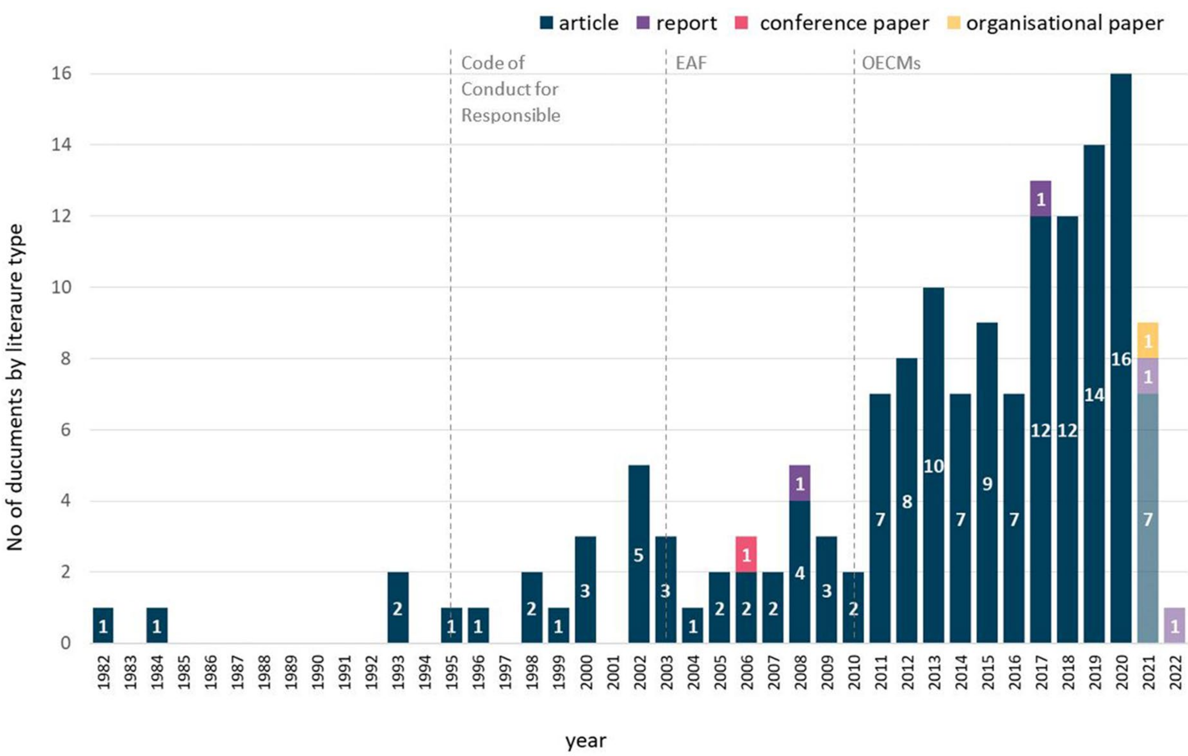


Fig. 2 The number of documents included in the Scoping Review (n = 151) by literature type (i.e., article, report, conference paper, and organisational paper) and year of publication (from 1982 to 2022). As the search of the documents was conducted in late 2021 in Scopus and Web of Science and early 2022 in Scholar Google and other sources, the search did not cover the whole year, and thus bars corresponding to 2021 and 2022 are displayed with transparent colours. (Fields #5 & 11 of the database). The years when, the fundamental concepts of the Code of Conduct for Responsible Fisheries (FAO 1995), the Ecosystem Approach to Fisheries—EAF (FAO 2003), and the Other Effective area-based Conservation Measures–OECMs (CBD 2010) were first introduced, are also depicted in the figure

The peer-reviewed documents (n = 146) were published in seventy-two different journals, with impact factors ranging from 0.536 to 12.779. Most of the documents included in the ScR were in descending order published in *Marine Policy* (14 documents) and *ICES Journal of Marine Science* (13 documents). Other commonly used journals were *Fisheries Research* (8 documents), *Canadian Journal of Fisheries and Aquatic Sciences* (7 documents), and *Marine Ecology Progress Series* (7 documents) (Supplementary Fig. 1). The citations of the documents included in the ScR ranged from 0 to 364, with a median of 19 citations (first quartile = 9, third quartile = 48; Supplementary Fig. 2). Most documents were classified in natural sciences (n = 128), and others in social sciences (n = 5). There were also some cases of documents combining multiple fields of sciences (n = 18), mostly natural & social sciences (n = 17) and in one case medical-health & social sciences (n = 1).

The case studies of the documents included present a wide global geographical distribution (Fig. 3). Many peer-reviewed case studies were in North America and Europe, some in Asia, Australia/Oceania, and South America, while only a few were in Africa. All grey literature case studies were in North America and Europe, and one in more than one continent, i.e., within the Northeast Atlantic Fisheries Commission (NEAFC) regulatory area between North America and Europe. Regarding the spatial scale, most case studies referred to ABFMs applied at the subnational level (78%), several to the supranational (21%), and only 1% at the national level (Fig. 4A). The ScR included case studies in various marine biogeographic realms (Fig. 4B). More than half of the case studies (53%) were in the Temperate Northern Atlantic, followed by the Temperate Northern Pacific (15%). Concerning continents, the bulk of case studies was conducted in North America (39%) and in Europe (32%), 11% in Asia, 9% in Oceania / Australia, 5% in South America, 2% in Africa, and 2% in more than one continent (Fig. 4C). The case studies' scope was mostly fisheries sustainability (69%), to a lesser extent, it was marine conservation (27%), and in a few cases, it was both fisheries sustainability and marine conservation (4%) (Fig. 4D).

The interactive online visualisation of the ScR database, produced using the Eviatlas tool, can be reached and navigated via a visual interface at the following link https://eviatlasmapabfms.github.io/ (hosted by GitHub, Inc. © 2022; see Supplementary Fig. 3 for a snapshot).

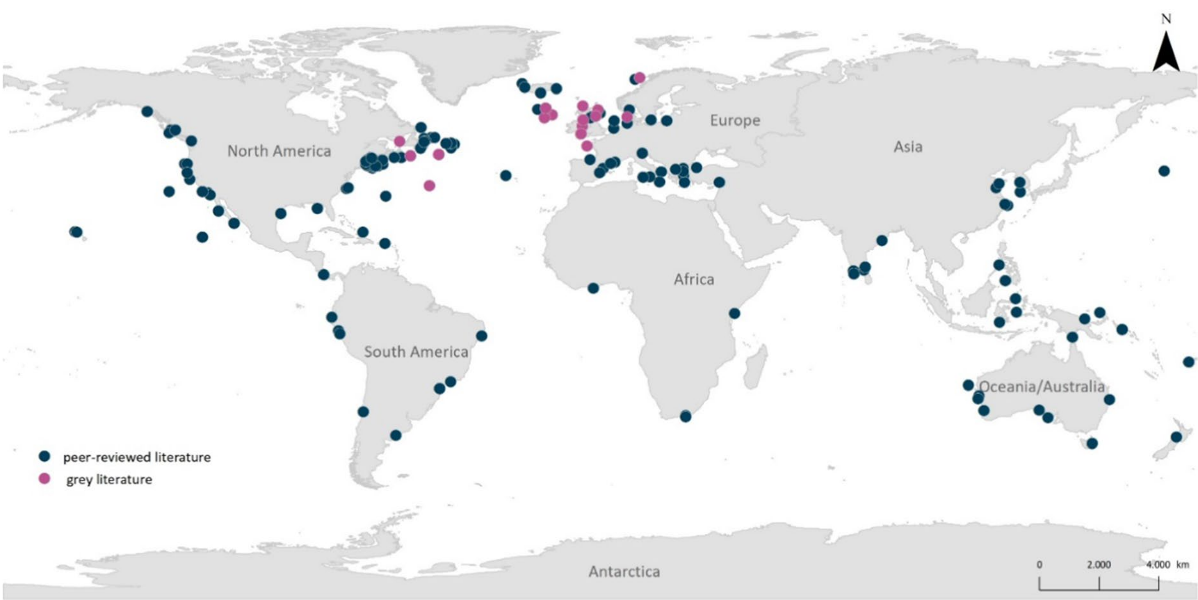


Fig. 3 Global geographic distribution of case studies included in the Scoping Review by category of literature (peer-reviewed and grey). (Fields #10, 19 & 20 of the database)

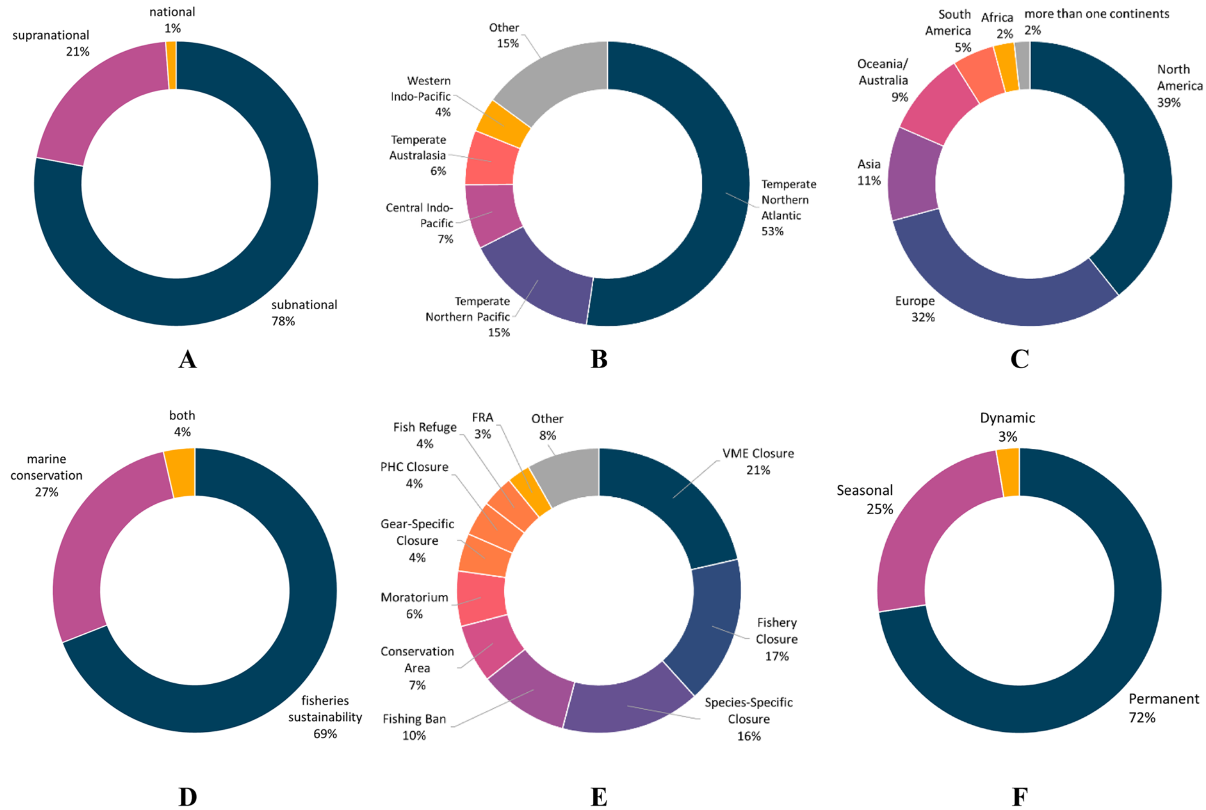


Fig. 4 Quantitative results of the reviewed documents. **A** Proportion (%) of case studies by spatial scale. **B** Proportion (%) of case studies by marine biogeographic realm. Other = Temperate South America (3%), Tropical Atlantic (3%), Arctic (3%), Tropical Eastern Pacific (3%), Temperate Southern Africa (1%), Eastern Indo-Pacific (1%). **C** Proportion of case studies by continent. **D** Proportion (%) of case studies by the scope of the study. E. Proportion (%) of Area-Based Fisheries Management Measures (ABFMs) by category. VME = Vulnerable Marine Ecosystem; PHC = Periodically Harvested Closure; FRA = Fisheries Restricted Area; Other = Reserve (2.0%), Marine Managed Area (MMA) (1.7%), Closed Season (1.3%), Spawning Closure (1.0%), Fishery Exclusion Zone (0.3%), Marine Areas for Responsible Fishing (MARF) (0.3%), Move-on Rule (0.3%), Protection Zone (0.3%), Real-Time Closure (0.3%), Rotational Closure (0.3%), Spawning Protection Area (0.3%). F. Proportion (%) of Area-Based Fisheries Management Measures (ABFMs) by temporal type. (Fields #15, 16, 17, 21, 26 & 27 of the database)

Spatial distribution, characteristics, and typology of ABFMs

The number of ABFMs considered by each document included in the ScR greatly varied. Most of the reviewed documents considered one ABFM (70%), while cumulatively 92% of the documents examine one to a maximum of ten ABFMs. Two cases considered more than one hundred ABFMs. In three documents, the number of ABFMs was impossible to be defined (Supplementary Fig. 4). Overall, 960 ABFMs were identified by the included documents, but only for 303, it was possible to extract the complete data set demanded by the methodology of the current ScR.

The extraction of the year of ABFMs establishment by the documents' full text was possible for 169 ABFMs. The bulk of ABFMs (83%) were established from 1990 to 2015. The oldest ABFM considered by the ScR was established in 1895, while the youngest was in 2019 (Supplementary Fig. 5). The ABFMs identified were mainly designated at the national level (68%) but also at the regional (31%) and rarely at the sub-national (1%) level. Information on the area was available only for 28 ABFMs included in the ScR and ranged between 1 and 103,600 km^2 (median = 587 km^2).

The ABFMs identified in the included documents were of various categories (Figs. 4E, 5, 6, and

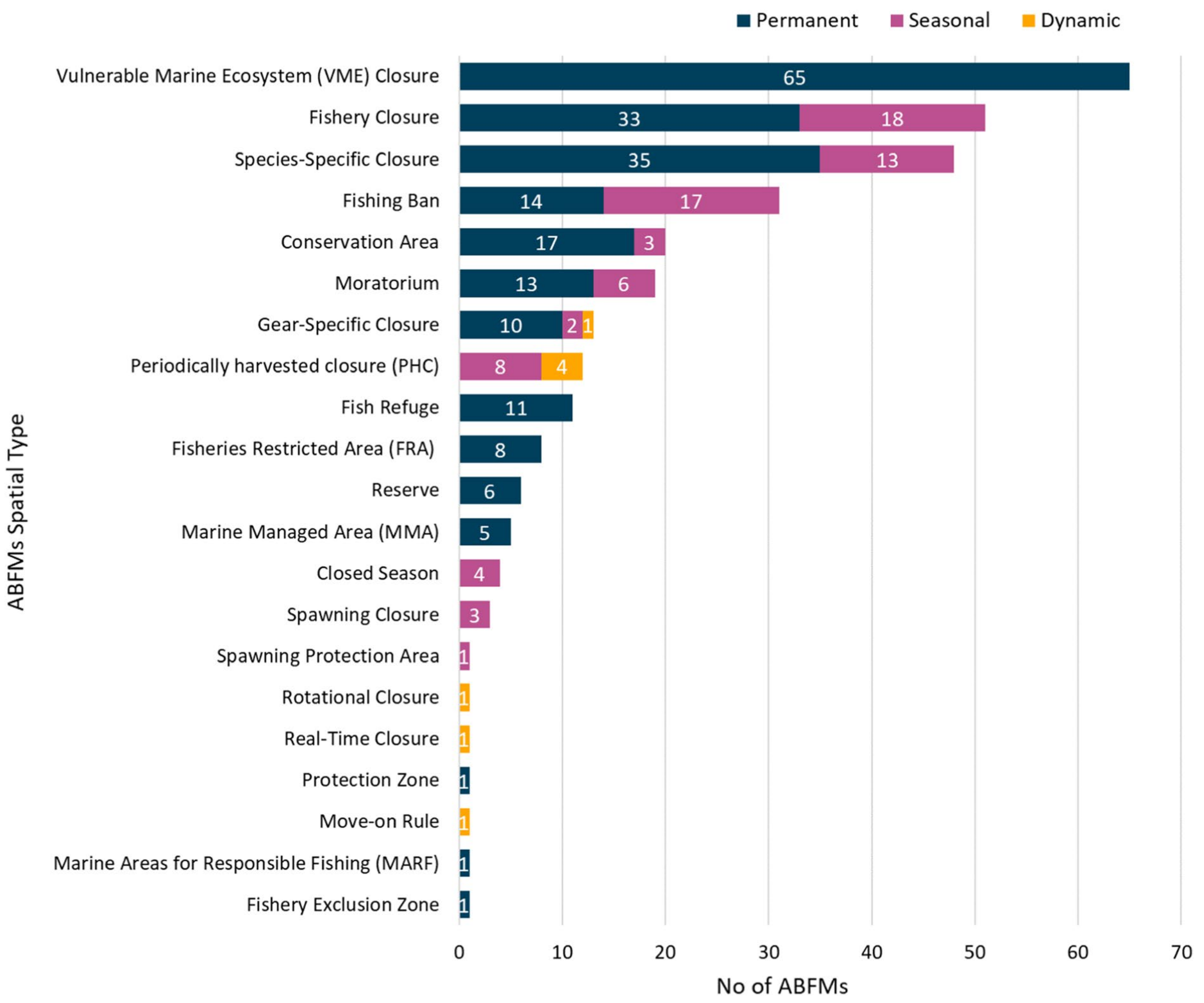


Fig. 5 Number of Area-Based Fisheries Management Measures by category and temporal type (Fields #26 & 27 of the database)

7; Supplementary Table 9). The most common type was Vulnerable Marine Ecosystem (VME) Closure (21%), followed by Fishery Closure (17%), Species-Specific Closure (16%), and Fishing Ban (10%). Most of the ABFMs were permanent (72%), while seasonal restrictions on fishing activities were applied in 25% of the ABFMs, and the remaining 3% were dynamic ABFMs (Figs. 4F, 5 and 6). VME Closures, Fisheries Restricted Areas (FRAs), and Fish Refuges were all permanent ABFMs. Species-Specific Closures, Conservation Areas, Fishery Closures, and Moratoriums were mainly permanent and, to a lesser extent, seasonal, while Fishing Bans were both seasonal and permanent. Periodically Harvested Closures (PHCs) were seasonal or dynamic. Closed seasons, Spawning Closures, and Spawning Protection Areas were all seasonal, while Rotational Closures, Real-time Closures, and Move-on Rules were all dynamic (Figs. 5, 6).

Within the reviewed ABFMs, one or more fishing gears were restricted. Overall, 41% of the reviewed ABFMs concerned restricted towed gears, 16% static gears, 11% all gears, 29% other gears (i.e., mobile gears, combinations of towed, mobile, and static gears, and various other gear types not clearly defined by the reviewed documents), and the rest were unknown (i.e., no information was provided by the study regarding the restricted fishing gear) (Fig. 6). A multidirectional flow was observed between ABFMs categories and the various types of restricted gears. FRAs related mainly to towed gears restrictions,

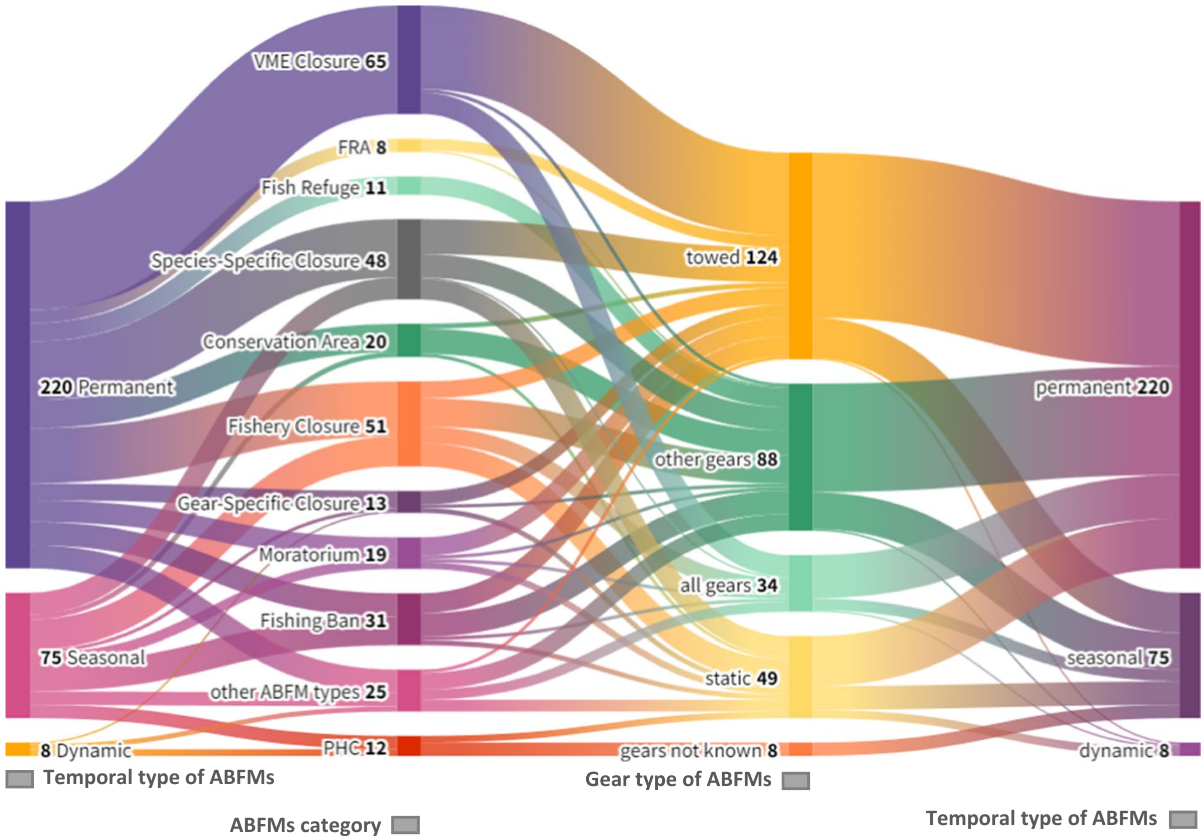


Fig. 6 Sankey diagram representing the frequency in the combination of i) the temporal type of Area-Based Fisheries Management measures (ABFMs), i.e., permanent, seasonal, dynamic, ii) the ABFMs category, i.e., VME closure, FRA, Fish Refuge, Species-Specific Closure, Conservation Area, Gear-Specific Closure, Moratorium, Fishery Closure, Fishing Ban, PHC and other ABFM types (i.e., Closed Season; Fishery Exclusion Zone; Marine Areas for Responsible Fishing (MARF); Marine Managed Area (MMA); Move-on Rule; Protection Zone; Real-Time Closure; Reserve; Rotational Closure; Spawning Closure; Spawning Protection Area) and iii) the type of gear(s) restricted within ABFM, i.e., all gears, towed, static, gears not known and other gears (i.e., mobile gears, combinations of towed, mobile and static gears and various other gear types not clearly defined by the documents reviewed). The width of the nodes and lines is proportional to the flow quantity (i.e., the number of ABFMs by temporal type, category, and gear type). The diagram was produced with Flourish Studio—Data Visualization & Storytelling tool, available at https://flourish.studio/, accessed on 12/08/2022. (Fields #26, 27 & 33 of the database)

while there is also a strong connection between VME Closures with towed gears restrictions. It is worth mentioning that all ABFMs with unknown restricted gears were of the PHC category. A less multidirectional flow was observed between the various types of restricted gears and ABFMs' temporal types. Specifically, the most extensive flow was observed between towed gears and permanent restrictions, followed by static and other gears with permanent restrictions). Furthermore, there was a strong link found between static gears and all gears with permanent restrictions, while substantial was the link between towed, static and other gears and seasonal restrictions. Most of the dynamic ABFMs were linked to static gears (Fig. 6).

In the majority of the ABFMs reviewed, the fishing gears restricted were mainly trawls and in many cases dredges, hooks and lines, gillnets and entangling nets. There were also many cases of ABFMs where all gear types were restricted. Less commonly ABFMs restricting the use of surrounding nets, traps, miscellaneous gears, and other types of gears, i.e., seine nets, recreational fishing gears, and various other types of fishing gears not clearly defined by the document, were reviewed. A large variety of

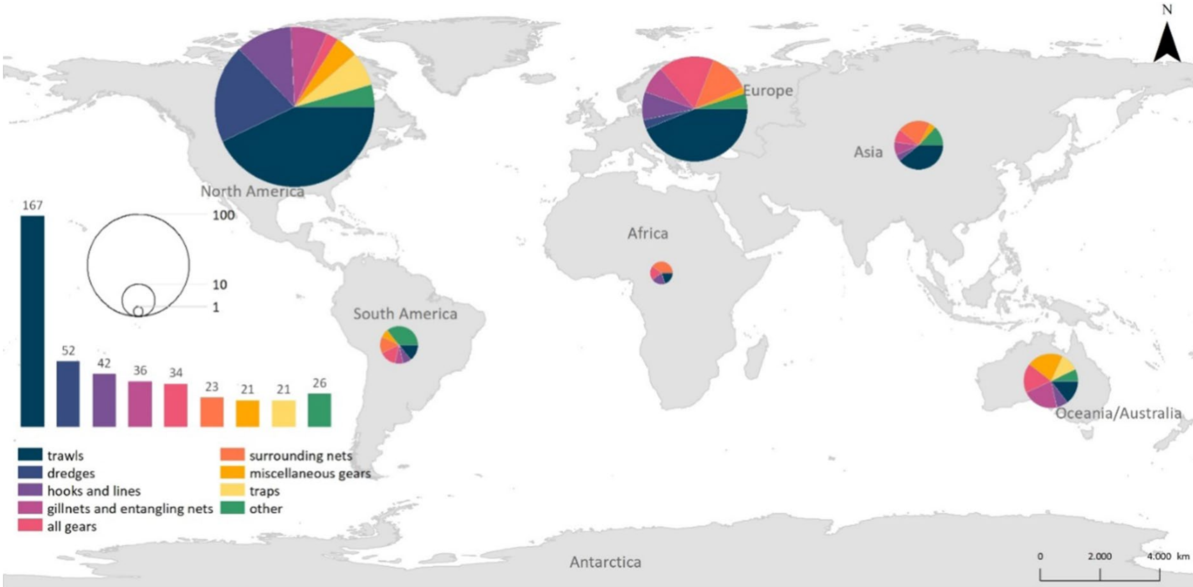


Fig. 7 Global summary of the fishing gears restricted within Area-Based Fisheries Management Measures (ABFMs) across different continents. The size of the pie charts reflects the number of ABFMs (the inset indicates the minimum and maximum dimensions). The colours indicate the different fishing gears restricted within the ABFM. Other = seine nets (n = 2); recreational fishing gears (n = 1); various other types of fishing gears not clearly defined (n = 23). In 8 cases the ABFMs restricted fishing gear was not known and/or mentioned by the documents reviewed.. Miscellaneous gears = various fishing gears and methods not specified or based on mixed principles (e.g., harpoons, hand implements, diving etc.) The map was produced with ArcGIS10.1 commercial GIS package (Environmental Systems Research Institute 2011) (Fields #17 & 33 of the database)

restricted fishing gears was observed in ABFMs in North America (mainly trawls, dredges, and hooks and lines), Europe (mainly trawls, surrounding nets, and all gears), Oceania/ Australia (mainly gillnets and entangling nets, all gears, and miscellaneous gears), Asia (mainly trawls and surrounding nets), and South America (mainly other gears). In Africa, only four different gear restrictions were found within the recorded ABFMs, i.e., trawls, hooks, and lines, surrounding nets, and all gears (Fig. 7).

Regarding the ABFMs objective, i.e., the species or group of species managed or protected via the establishment and implementation of the ABFM, Chordata–Actinopteri (n = 130) was the most common taxonomic group; Arthropoda (n = 59), Mollusca (n = 40), Porifera (n = 38), and Cnidaria (n = 35) were also relatively common (Fig. 8). The highest variation of ABFM objectives was observed in North America, where almost all taxonomic groups were reported (except for Echinodermata and Chordata–Elasmobranchii), where Chordata-Actinopteri, Arthropoda, and Porifera were the most common taxa. In South America and Oceania/ Australia, the taxonomic groups recorded were fewer (5 taxa in both). Echinodermata and Mollusca were the most common taxa in South America, and Chordata-Actinopteri, Arthropoda, and Mollusca in Oceania/Australia. In Europe, most ABFMs' objectives were species belonging to Chordata-Actinopteri. The variation in ABFMs objectives in Asia and Africa was lower (Fig. 8).

The majority (78%) of ABFMs were managed by designated management bodies. Only for a few (15%) ABFMs, it was explicitly stated that they were managed according to a management plan (in 83% of the reviewed case studies, this information was not known or mentioned). In approximately one-third of the reviewed case studies, it was stated that ABFMs were monitored, and in fewer cases (30%) that they were controlled and surveilled (Supplementary Fig. 6).

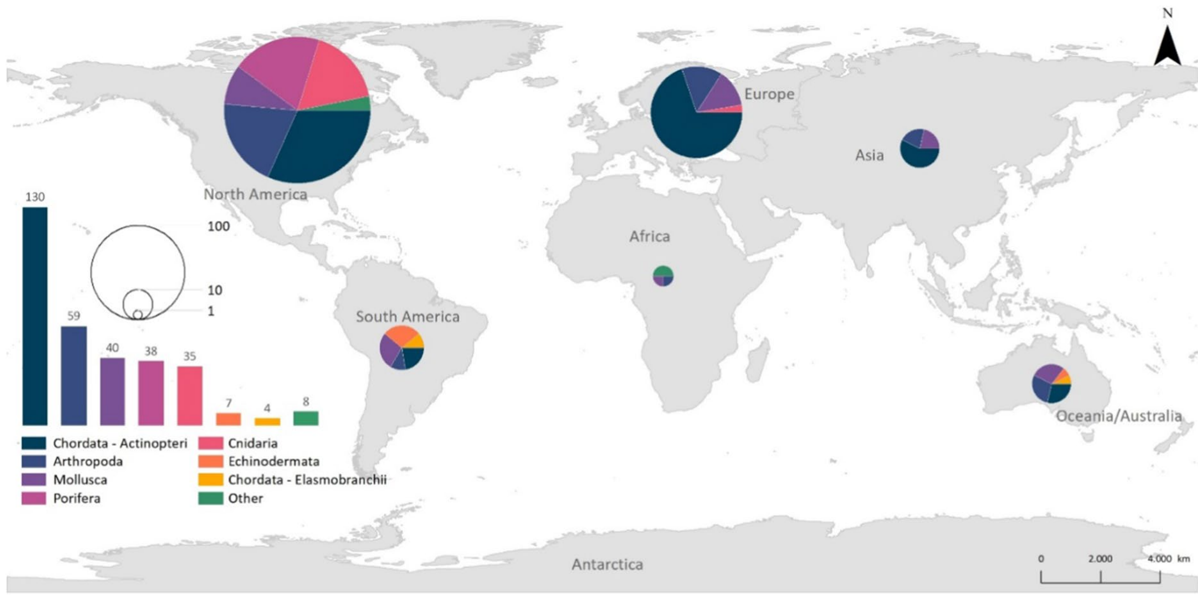


Fig. 8 Global geographic variation of Area-Based Fisheries Management Measures (ABFMs) included in the Scoping Review by ABFM objective, expressed as a taxonomic group (Phylum–Superclass or Class), per continent. The size of the pie charts reflects the number of ABFMs (the inset indicates the minimum and maximum dimensions). The bar chart represents the total number of ABFMs by ABFM objective. Other: Chordata–Reptilia (n = 3); Chordata–Aves (n = 2); Nematoda (n = 1); Chordata–Mammalia (n = 1); Annelida (n = 1). In 52 cases the taxonomic group of the ABFM objective was not known or mentioned by the documents reviewed. The map was produced with ArcGIS10.1 commercial GIS package (Environmental Systems Research Institute 2011) (Fields #17, 31 & 32 of the database)

Methodological aspects

Regarding the type of research applied for the assessment of ABFMs effectiveness, most reviewed case studies applied quantitative research (82%), few qualitative (7%), and the rest applied a mixed research approach (Supplementary Fig. 7). As for the methodological approaches applied, various data collection methods to assess the effectiveness of ABFMs were recorded. Experimental surveys/sampling (n = 91) and open data sources (n = 72) were the two most used data collection methods, followed by literature reviews (n = 38), remote sensing (n = 29), expert-based knowledge (n = 26), and interviews/social surveys (n = 24). Fishers' local ecological knowledge (n = 4) was the least common method applied (Fig. 9 & Supplementary Fig. 8A). In 78 of the 168 case studies, only one method was applied to assess the effectiveness of ABFMs. In the rest of the case studies, different data collection methods were combined, i.e., two different methods (n = 70), three (n = 15), four (n = 4), or five (n = 1) (Supplementary Fig. 8B). The most common combination was experimental surveys/sampling and open data sources, followed by experimental surveys/sampling with remote sensing and expert-based knowledge with literature review (Fig. 9).

Various data analysis methods for assessing ABFMs' effectiveness were identified in the reviewed documents. Fisheries analysis (n = 77), ecological analysis (n = 57), and modelling (n = 53, out of which 2 applied ecosystem models for scenario testing) were the three most frequently used data analysis methods. Other less frequently used methods were biological analysis (n = 39), spatial analysis (n = 38), synthesis of data without analysis (n = 27), sociological analysis (n = 22), economic analysis (n = 17), and scarcely various other methods (n = 19) such as physiological or behavioural analysis, physicochemical analysis, image analysis, genetic analysis, decision analysis, and biochemical analysis (Fig. 10 and Supplementary Fig. 8C). Except for the synthesis of data, which has been rarely combined with other methods, all the rest of the data analysis methods have been widely used in combination to assess the effectiveness of ABFMs.

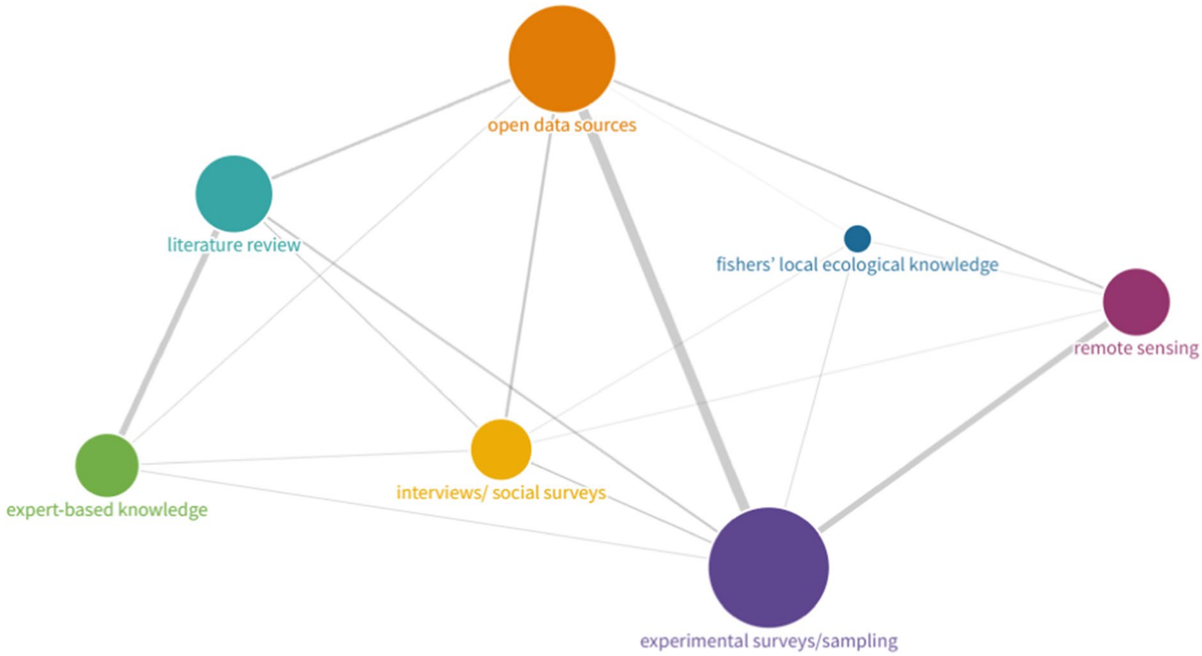


Fig. 9 Network graph representing the connections between the various data collection methods used to assess the effectiveness of area-based fisheries management measures (ABFMs) by the case studies included in the Scoping Review. The size of the links is proportional to the importance of the connection. The diagram was produced with Flourish Studio—Data Visualization & Storytelling tool, available at https://flourish.studio/, accessed on 12/08/2022. (Field #43 of the database)

Fisheries analysis and modelling were the data analysis methods that were mostly combined, followed by fisheries and ecological analysis. Other frequent combinations included modelling with spatial analysis, ecological with spatial analysis, fisheries with biological analysis, ecological with biological analysis, and fisheries with spatial analysis. In 54 out of the 168 case studies, only one data analysis method was applied to assess the effectiveness of ABFMs. Synthesis of data, fisheries, and ecological analyses were the most common data analysis methods used on their own to assess the effectiveness of ABFMs (Fig. 10 and Supplementary Fig. 8D). In the rest of the case studies considered by the ScR, different data analysis methods were combined, i.e., two different methods (n = 66), three (n = 33), four (n = 11), or five (n = 4) (Supplementary Fig. 8D). For most of the data analysis methods applied, a vast number of different metrics were used; overall, 325 different metrics were identified (Fig. 11 and Supplementary Table 10). Also, an extensive list of models was recorded for the case studies that applied the modelling analysis approach. Generalized linear models, linear mixed models, general additive models, and random forest models were the most frequently used (Supplementary Table 11).

ABFMs effectiveness and impact

In the bulk of the case studies reviewed, ABFMs' overall impact, considering any aspect examined by the study (e.g., the social, economic, and environmental impact caused by ABFMs), was found to be positive (56%), while it was negative in 22% of the cases (based on the assessments made by the authors according to the metrics used). The impact was mixed (some metrics indicated positive impact and some negative) in 14% of ABFMs, while the uncertain or lacking data cases were 8% (Supplementary Fig. 9).

Fifty-four per cent of the reviewed ABFMs were found to be effective concerning their designation rationale, as was documented by the eligible studies (Fig. 12). Considerably fewer were the ABFMs

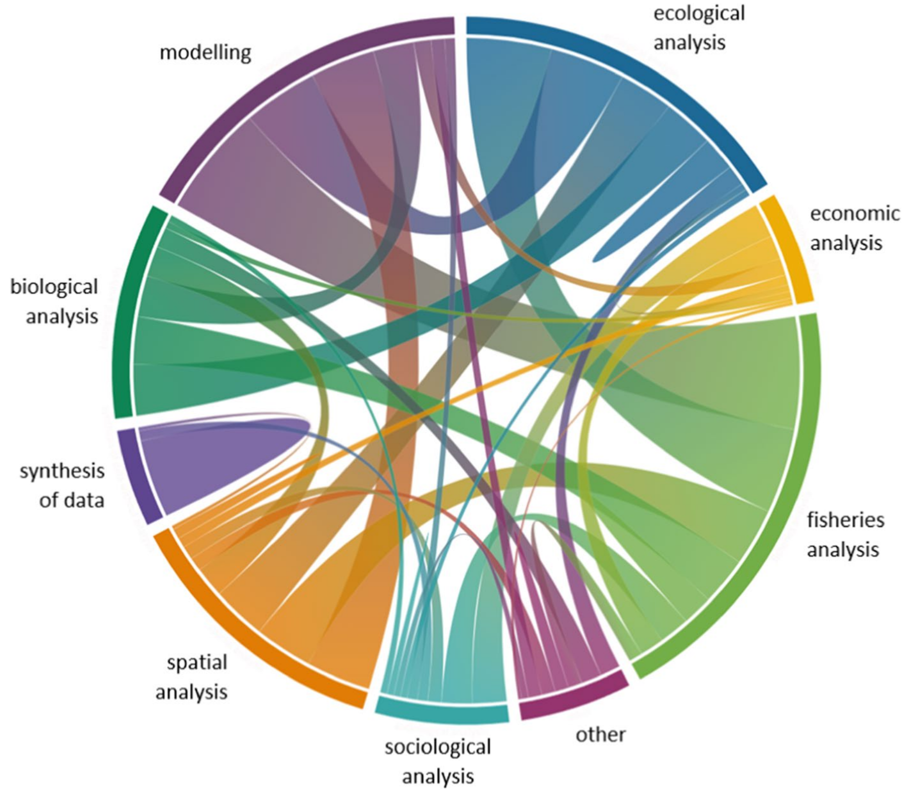


Fig. 10 Chord diagram representing the connections between the various data analysis methods used to assess the effectiveness of area-based fisheries management measures (ABFMs) by the case studies included in the Scoping Review. The size of the arc is proportional to the importance of the flow (i.e., the number of case studies by data analysis method). The diagram was produced with Flourish Studio—Data Visualization & Storytelling tool, available at https://flourish.studio/, accessed on 23/08/2022. Other = physiological or behavioural analysis; physicochemical analysis; image analysis; genetic analysis; decision analysis and biochemical analysis. (Field #44 of the database)

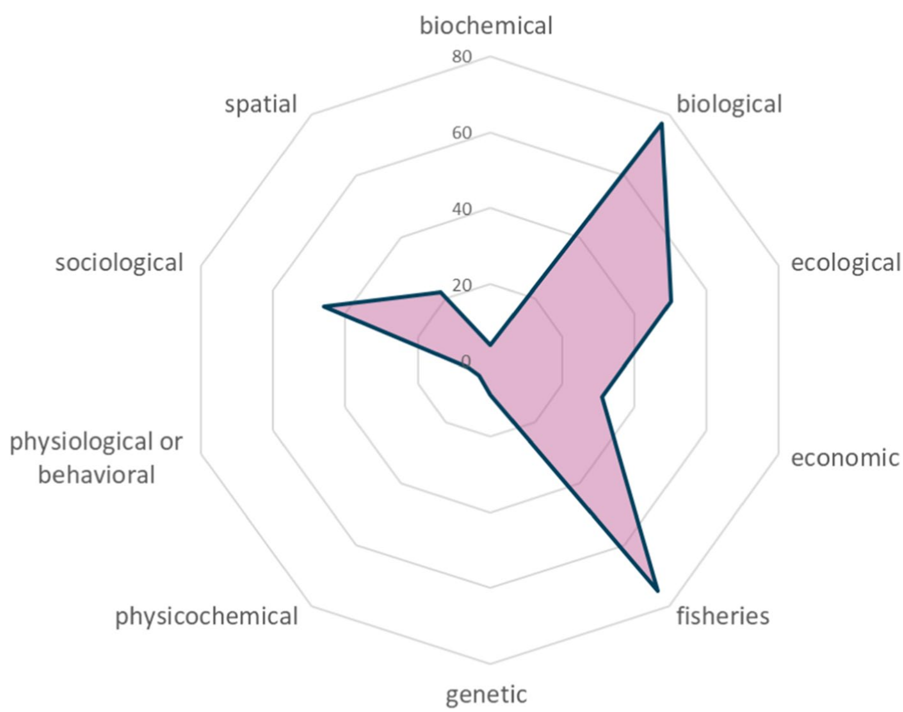


Fig. 11 Number of metrics recorded by type of data analysis methods applied to assess the effectiveness of area-based fisheries management measures (ABFMs) for the case studies included in the Scoping Review. (Field #45 of the database)

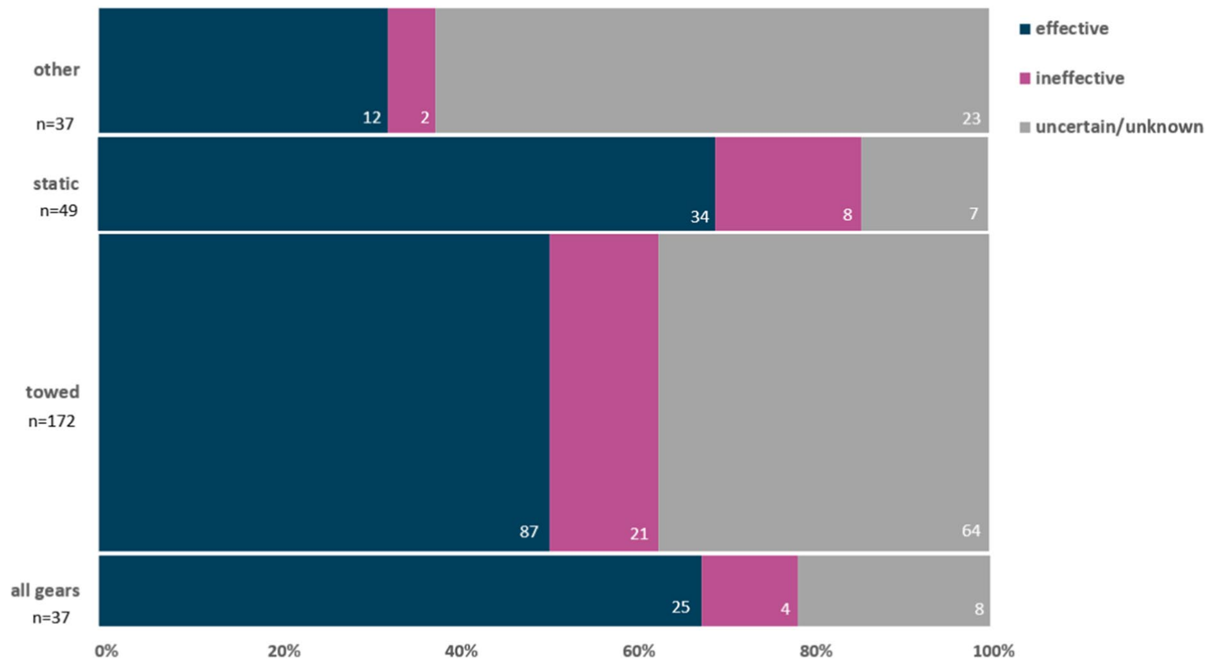


Fig. 12 Mosaic plot of the effectiveness i.e., effective, ineffective, and uncertain/ unknown of Area-Based Fisheries Management Measures (ABFMs) included in the Scoping Review by ABFMs restricted gear type, i.e., all gears, towed, static, and other gear types (i.e., mobile, combinations of static and mobile, and other types of gears not clearly defined). (Fields #33b & 47b of the database)

documented as ineffective (12%), while the effectiveness of approximately one-third of the ABFMs was uncertain or unknown (35%). The effectiveness of ABFMs significantly differed by gear type, when 'uncertain/unknown' effectiveness was kept in the analysis (chi-square test; $p=0.003$). Most of the ABFMs concerning static gears (n = 49) and all gears (n = 37) restrictions were found to be effective (69% and 68%, respectively). The ABFMs with towed gears restrictions were documented as being less effective (n = 178, 51% effective), followed by the ABFMs where 'other' gear types are restricted, i.e., mobile, various combinations of static and mobile, and other types of gears not clearly defined (n = 37, 32% effective). In the case of ABFMs concerning static gear restrictions, the uncertainty or lack of information on their effectiveness was the lowest (14%), while for the ABFMs where 'other' gear types are restricted was the highest (62%). If all uncertain/ unknown cases are omitted from the analysis, no significant difference in the effectiveness of ABFMs by gear type was found (chi-square test; $p=0.883$), which indicates that the difference in effectiveness is attributed to the significant difference in uncertainty or lack of information regarding ABFMs effectiveness observed by gear type (Fig. 12).

In most of the case studies reviewed, no biodiversity features other than the ABFMs objectives were identified (77%). In their vast majority, no pressures or threats on biodiversity were identified or discussed (96%). In very few case studies (8%) ABFMs are acknowledged as potential OECMs (all after 2010 when CBD introduced the OECMs concept) (Supplementary Fig. 10).

Knowledge gaps

Knowledge gaps and ideas for future research were proposed by many documents included in the ScR. The major issues highlighted by the reviewed literature include the application of post-ABFM establishment evaluation studies to integrate critical components in the analysis; assessments of the effort displacement and spill-over effects; evaluation of the impact of climate change; the need to expand studies in all four dimensions, i.e., also include depth and time; collecting data for the entire life cycle of the targeted species and other species. Also, the need to apply risk assessment and an interdisciplinary research approach to include the social and economic aspects along with the biological and ecological ones was acknowledged. Ideas to advance modelling and remote sensing approaches were also suggested. Lastly, the need to improve our knowledge of population dynamics and structure, movement patterns, and trophic relationships was widely discussed (Supplementary Table 12).

Discussion

The current ScR dealt with intriguing challenges. It identified and mapped the available evidence regarding the contribution of ABFMs to fisheries sustainability and broader marine conservation, recorded the characteristics of the ABFMs reviewed, listed the methodological approaches applied for the assessment of ABFMs' effectiveness, provided a comprehensive summary of the key findings, and lastly identified and discussed knowledge gaps for future research. The set of data obtained, tabulated, and mapped by this ScR may serve as a valuable source of scientific documentation for fisheries and conservation policy-makers worldwide towards the rebuilding of ecosystems (Pitcher and Pauly 1998) and the attainment of global spatial biodiversity conservation goals in the marine realm (CBD 2022). It can also be considered a rich source of information for enabling OECMs identification.

Despite the strengths discussed above, the ScR was subjected to a few limitations. As performing a scoping review is a highly demanding process in terms of resources, workload, and time (Peters et al. 2020), there is a time-lapse of approximately one year between the literature search and the completion of the review report, resulting in a partial cover of the literature published during the years 2021 and 2022. Moreover, even though a comprehensive grey-literature search strategy was designed and executed by the current ScR, grey-literature contributions might have been missed out by the search due to the complex, tricky, question-and-objective-depended characteristics of the procedure (Mahood et al. 2014; Paez 2017). Language limitations were also applied in the literature search process to meet authors' language competence (i.e., English, French, German, Greek, Italian, Spanish, Swedish), which might have led to an under-representation of literature from researchers publishing in other languages.

To fulfil its objectives, the current ScR was based on a comprehensive methodological framework (Peters et al. 2020) and was built on an a priori protocol (Petza et al. 2021). The protocol was previously published to increase the transparency of the research and the credibility of the results and primarily to inform the research community about the intent to conduct a review on the specific topic to avoid duplicate efforts (Page et al. 2021). The ScR is accompanied by a detailed database available as a supplement, which is also available in the form of an online cartographic open-access map, to provide the research community with a free, interactive means to consolidate and make use of the data produced. Open data is part of a broad global movement advancing science and scientific communication while transforming modern society and how decisions are shaped. Many benefits can be gained by open data provisions, such as increasing opportunities for scientific collaboration and partnerships, enriching the research and analytical capacity, informing policy decisions, increasing capacity for public participation and enabling transparency, and improving accountability (Huston et al. 2019). Open data are widely supported by the EU, regional and international organisations, and initiatives for fisheries and marine conservation worldwide (with obvious limitations regarding scales and details to avoid violating privacy and confidentiality of business operations). The International Council for the Exploitation of the Sea (ICES) promotes the use of data by maximising their availability to the community at large, contributing to an increased understanding of the marine environment (ICES 2023). EU also strongly supports open data use by pursuing initiatives such as EMODnet, Copernicus Marine Service, Marine Analyst etc. The open sharing of data in marine science provides substantial benefits for individuals, the scientific community and society and actions should be supported for sharing data, making use of data and developing tools for advancing open-source research and management (Halpern 2020; Huang et al 2012; Parr and Cummings 2005; Parsons et al 2014).

Also, the ScR took advantage of various data analysis and presentation tools to optimise the quality of the results and the visualisation of the ScR outcomes, as also highly recommended for systematic reviews (Peters et al. 2020). As most of the documents included in the review were obtained from reliable databases and other credible sources and were mostly peer-reviewed, the review was based on robust scientific information. Moreover, most peer-reviewed documents have been published in highly ranked, worldwide recognized, and respected research journals, which may guarantee the robustness and credibility of the evidence reviewed. The ScR also considered grey literature documents, which were retrieved from reliable sources such as fisheries management organisations, research institutes, and committees, and recognized stakeholders and experts with high relevance in fisheries and marine conservation, which can also imply the credibility of the grey literature sources. Grey literature is defined as "produced on all levels of government, academics, business and industry in print and electronic formats, but which is not controlled by commercial publishers (Bellefontaine and Lee 2014; Mahood et al. 2014; Paez 2017; Pappas and Williams 2011). Much research is unpublished or not disseminated through peer-reviewed, commercial media (Pappas and Williams 2011). Long manuscript submission processes and difficulty getting studies with inconclusive or non-significant data published may discourage some researchers from publishing data, creating a "file-drawer" effect (Conn et al 2003; Dickersin 1990; Helmer 1999; Paez 2017). Grey literature can make essential contributions to a systematic review by providing data not found within peer-reviewed literature and disseminating studies that might not otherwise be reached, such as studies with neutral or negative results, studies conducted under restricted resources or studies performed by indigenous or aboriginal communities, and in languages other than English (Hartling et al 2017; Paez 2017; Song et al. 2010). Through this perspective, grey literature may reduce publication bias, increase reviews' comprehensiveness and timeliness, and foster a balanced picture of the available evidence, which may far outweigh the cost in time and resources needed to search for it (Pappas and Williams 2011; Paez 2017).

Most of the documents included in the ScR were published during the last twelve years, i.e., after the FAO introduced the Ecosystem Approach to Fisheries (FAO 2003). The observed publication outbreak after 2010 is related to the initiation of discussions regarding the possible contribution of area-based tools other than MPAs to the attainment of spatial conservation goals and the introduction of the OECMs concept by the Aichi Target 11 of the Strategic Plan for Biodiversity 2011–2020 of the Convention for Biological Diversity (CBD 2010). This identified trend indicates that the introduction of these concepts boosted research on how ABFMs can contribute to area-based marine conservation and halting biodiversity loss.

The observed domination of the case studies in the Temperate Northern Atlantic marine realm, in marine areas of Europe and North America in particular, has been reported in many other recent global systematic reviews related to the marine environment (Mačic et al. 2018; Gissi et al. 2021; Stranga and Katsanevakis 2021). This pattern may be attributed to the higher funds for marine research that North America and Europe allocate, compared to other areas of the world (UNESCO Institute for Statistics 2022) and also to hosting many highly ranked universities (Jöns and Hoyler 2013) and research institutes (IOC-UNESCO 2020). Nevertheless, the inability of the authors to review scientific and grey literature written in all languages may have created a geographical bias in the dataset. The dominance of the English language in the scientific literature creates a large barrier for many non-English-proficient researchers to make their findings accessible to the global scientific community; this has been lately acknowledged as a widely overlooked issue (Amano et al. 2016, 2021; Khelifa et al. 2022). Although scientific literature written in native languages is routinely used as a unique source of information at the national level globally, it is almost entirely ignored at the international level due to language constraints (Amano et al. 2022). The problem could increase as co-management, sharing and devolution of management rights to coastal communities and indigenous people and local communities, and the use of local or traditional knowledge increases.

Most of the documents reviewed studied individual ABFMs, while limited research was conducted on networks of ABFMs or comparative studies between multiple ABFMs situated either in the same or in distant areas. While ABFMs are usually very specific (protecting target species or essential habitats) they may also produce broader biodiversity benefits flowing across ABFMs but also neighbouring MPAs. This may only be a speculation at this stage and counted as a knowledge gap highlighted by the current review, which can be considered of substantial importance, especially through the lens of Target 3 of the CBD Kunming-Montreal Global Biodiversity Framework, which calls for MPAs and OECMs to be well-connected and also ecologically representative and integrated into the wider seascapes (CBD 2022).

There are three main types of constraints identified for ABFMs, i.e., time (areas closed to fishing activities permanently or temporarily), space (closing all or part of a fishing ground or the EEZ), and type of fishing activities (limitations may apply to all fishing activities within an area or to some gears or socio-economic categories). The various combinations of the three alternatives and the level of restrictions may lead to a large variety of ABFMs. This is furthermore intensified when the variety of ABFMs is combined with their different potential purposes and contextual parameters related, e.g., to the oceanographic characteristics, jurisdiction, and types of governance. Because of their multiple dimensions, ABFMs cannot be easily "boxed" into simple homogenous categories (Rice et al. 2018). One of the most interesting findings of the current review was that ABFMs classified by the literature to the same category were found not to always share common characteristics in terms of temporal type, restricted gears, and management objectives. In contrast, different categories of ABFMs often shared very similar characteristics. For example, 'moratoriums' were recorded as either permanent or seasonal, within which towed, static, or other gear types were restricted, established for the protection or management of Mollusca, Echinodermata, Arthropoda, or Chordata/Actinopteri. Likewise, 'fishing bans' were recorded as either permanent or seasonal, within which towed, static, other gear types, or even all gears, were restricted, established for the protection or management of Arthropoda or Chordata/Actinopteri or Elasmobranchii. Consequently, as the various ABFMs categories have not been consistently used in the literature (and in fisheries management) or many terms are essentially used as synonyms, they cannot be considered reliable indicators of the ABFMs' characteristics and effectiveness. Thus, a case-by-case approach should be followed for their assessment, as also highlighted by Rice et al. (2018) and Himes-Cornell et al. (2022), who recently attempted a typology-based evaluation of ABFMs for meeting the OECM criteria.

Most of the ABFMs reviewed concerned fishing restrictions of towed gears (mainly trawls and dredges). While approximately half of the towed gears related ABFMs were found to be effective in terms of addressing their designation rationale, for a considerable number of cases, conclusions regarding their effectiveness were impossible to be drawn due to uncertainty or lack of information in the studies reviewed. Bottom-trawl fishing is globally considered as the most extensive anthropogenic direct physical disturbance to seabed habitats occurring worldwide (Kaiser et al. 2002; Halpern et al. 2008; Eigaard et al. 2017). Although bottom-trawl fisheries account for approximately a quarter of marine catch (Amoroso et al. 2018; Pauly et al 2020) and substantially contribute to food supply and livelihoods worldwide (FAO 2022), various direct and indirect impacts of towed gears on habitats, ecosystems, or ecosystem services have been extensively identified and discussed (Jennings and Kaiser 1998; Collie et al. 2000, 2017; Kaiser et al. 2006; Hiddink et al. 2017; Sciberras et al. 2018; Roland Pitcher et al. 2022). Thus, many management measures have been implemented to reduce or prevent trawling impacts on seabed habitats, but the knowledge base to evaluate the effectiveness of these measures is fragmented (McConnaughey et al. 2020). Although marine recreational fisheries have important economic and social benefits (Cisneros-Montemayor and Sumaila 2010; Griffiths et al. 2017; Michailidis et al. 2020) and also substantial environmental impacts (Cooke and Cowx 2004; Hyder et al. 2018, 2020; Lewin et al. 2019), they are less well-studied than commercial fisheries (Brownscombe et al. 2019) and poorly governed or managed (Potts et al. 2020; Hyder et al. 2018). Indeed, this ScR managed to identify only one document that dealt with the assessment of one ABFM for recreational fishing activities, confirming both the research and management lack acknowledged by the literature. Also, there was no information recorded on the illegal, unregulated, unreported (IUU) fishing within the ABFMs reviewed even though IUU fishing is recognised as one of the most significant threats to the sustainability of the world's fisheries, potentially responsible for the non-achievement of fisheries management goals globally (Caddell and Molenaar 2019;

Palma et al. 2010; Pitcher et al. 2002; Sumalia and Keith 2006).

In the reviewed assessments of ABFMs, an interdisciplinary approach (regarding various combinations of fisheries, environmental, biological, genetic, physicochemical, spatial, socioeconomic, and other disciplines) was often applied to analyse the data. However, social, and economic disciplines were not frequently combined with the other disciplines. Although in most of the cases recorded, a quantitative research strategy was followed (i.e., numerical data were collected and analysed), there were also some cases in which both quantitative and qualitative data were retrieved and combined. In fisheries, monodisciplinary research has approached its limits in terms of costs and utility. The interdisciplinary approach, i.e., the incorporation of the natural, economic, and social sciences with the expertise of the fishing industry and other stakeholders (e.g., NGOs, policy-makers, and consumers), has started many decades ago and is required for the Ecosystem Approach to Fisheries. Nevertheless, it is not yet systematically implemented. It can be considered the future for fisheries policy-related research, as it will broaden the objectives of fisheries policy to include the diverse concepts of ecosystem integrity, economic viability and social equity (Phillipson and Symes 2013; Jacquet and Pauly 2008).

As found by the current ScR and previously highlighted by the literature, ABFMs have been applied as fisheries management measures with the intent to directly control exploitation rates on specific life stages or habitat degradation. Assessments of ABFMs' performance have been either built on a single-stock basis (Caddy and Agnew 2005), which lacks explicit considerations of species interactions and their roles in early-life mortality, recruitment, and community structure or have been focused on ecosystem dynamics (Möllmann et al. 2015; Zhang et al. 2016). Commonly these assessments are restricted to the specific ABFMs' establishment primary objectives (Bundy and Fanning 2005; Murawski 2010). Indeed, within most case studies reviewed, the wider biodiversity of the area was not considered, while no reference to the pressures or future threats on biodiversity was made. Also, only a few documents referred to the OECMs concept and acknowledged ABFMs as potential OECMs. As for all area-based management tools, ABFMs' effectiveness is a complex issue, which depends on a series of intrinsic parameters, i.e., the appropriateness of the location, the quality of resource assessments and management advice, the suitability of measures taken inside it, and the rigour of their enforcement. It also depends on other external factors, such as the quality of fishery management, the degree of integration of measures taken in and around the ABFM, the socioeconomic conditions of the fishery, the current state of the biodiversity attributes of concern, the existence and type of subsidies, and stakeholders' engagement (Garcia et al. 2022).

Recently, Hilborn et al. (2021) reviewed what is known from scientific stock assessments about the status and management of fisheries from different regions around the world, suggesting that countries which managed their fish resources more intensively tended to have better stock status. Fisheries management measures and specifically rebuilding plans have shown particularly strong effects on reversing overfishing, while also the ratification of international fishing agreements, and harvest control rules have substantially contributed towards overfishing reduction and biomass rebuilding (Melnychuk et al. 2021). Increased application of area-appropriate fisheries science recommendations and management tools in terms of applying broad suites of management measures at local, national and international levels is needed for achieving sustainable fisheries in places where fisheries management approaches are lacking or misapplied (Hilborn et al. 2021; Melnychuk et al. 2021).

Conclusions & recommendations

This ScR represents the critical first step towards the evidence synthesis path of the research, that has been applied for assessing ABFMs' contribution to fisheries sustainability and marine conservation on a global scale using a systematic approach. Fisheries and environmental managers and policymakers may gain valuable insights from this review into the evidence-based knowledge about ABFMs and their contribution to the rebuilding of marine ecosystems (Pitcher and Pauly 1998). Our results may facilitate the policy discussion of the role of ABFMs as potential OECMs contributing to attaining the CBD spatial conservation targets (CBD 2022).

It can also be considered as a valuable tool for researchers worldwide to carry on research by filling in the knowledge gaps identified both by the reviewed documents (see Field # 48 of the ScR database, Supplementary Table 12, and Results section "Knowledge gaps") and the current evidence synthesis. Specifically, the following recommendations for filling up the knowledge gaps in future research, as emerged from the current ScR, are suggested: 1. ABFMs should be more systematically studied for effectiveness, and the OECMs may represent an opportunity to do more in that direction. 2. Open-access data on ABFMs should be promoted to enrich the research and analytical capacity and increase opportunities for scientific collaboration and partnerships. 3. Grey literature should be included in future research as it is a valuable source of information for ABFMs. 4. Research should be expanded in extended geographic areas and networks of ABFMs and MPAs to address the issues of ecological connectivity and representativeness. 5. The effectivenss of ABFMs should not be assumed based on the category to which they belong (in an ABFMs typology) but be assessed on a case-by-case basis. 6. An interdisciplinary approach should be followed to assess ABFMs and integrate the diverse concepts of ecosystem integrity, economic viability, and social equity. 7. ABFMs assessments should be performed from an integrative ecosystem-based perspective, considering the species and habitats' interrelations, ecosystem dynamics, and pressures and future threats to the area's biodiversity. 8. Research on potential ABFMs assessment against the OECMs criteria should be enforced to promote the contribution of OECMs for the attainment of the CBD spatial conservation targets, under global environmental change.

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Author contributions DP: Conceptualization, Methodology, Literature Search, Literature Selection/Screening, Data Extraction, Formal analysis and investigation, Data Presentation/Visualizations, Writing—original draft preparation, Writing—review and editing, Coordination. PA: Literature Search, Literature Selection/Screening, Data Extraction, Formal analysis and investigation, Data Presentation/Visualizations, Writing—original draft preparation. NK: Methodology, Data Presentation/Visualizations, Writing—review and editing. SKal: Literature Selection/Screening, Writing—review and editing. IL: Methodology, Literature Search, Writing—review and editing. MC, SG, MK, JR, MS: Methodology, Literature Search, Writing—review and editing. SKats: Methodology, Formal analysis and investigation, Data Presentation/Visualizations, Writing—original draft preparation, Writing—review and editing, Funding acquisition, Resources, Supervision. All authors have read and approved the submitted version.

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Data availability (data transparency) All data produced by the current scoping review are available in the Supplementary Information of the article.

Code availability (software application or custom code) Not applicable.

Declarations

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

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