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

Julie M Reimer\*<sup>1</sup>, Rodolphe Devillers<sup>2</sup>, Joachim Claudet<sup>3</sup>

<sup>1</sup> Department of Geography, Memorial University of Newfoundland, St. John's, Newfoundland, Canada

<sup>2</sup> Espace-Dev (UMR 228), Institut de Recherche pour le Développement (IRD), Maison de la Télédétection, Montpellier, France

<sup>3</sup> National Center for Scientific Research, PSL Université Paris, CRIOBE, USR 3278 CNRS-EPHE-UPVD, Maison des Océans, Paris, France

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### 1 ABSTRACT

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

and economic outcomes. Our findings provide operational guidance to support progress toward SDG 14.

The United Nations Sustainable Development Goals (SDGs) provide a transformational vision of sustainable development across the environmental, social, and economic dimensions. Sustainable Development Goal 14: Life Below Water (SDG 14) aims to “conserve and sustainably use oceans, seas, and marine resources for sustainable development”<sup>1</sup>. Through its seven primary targets, SDG 14 addresses ocean challenges: reducing marine pollution (SDG 14.1), restoring marine ecosystems (SDG 14.2), reducing ocean acidification (SDG 14.3), enabling sustainable fisheries (SDG 14.4), conserving marine areas (SDG 14.5), ending harmful fishery subsidies (SDG 14.6), and increasing economic benefits to Small Island Developing States and least developed countries (SDG 14.7). Achieving SDG 14 was shown to benefit other SDGs, most notably SDG 1: No Poverty and SDG 2: Zero Hunger<sup>2,3</sup>. A focus on sustaining marine ecosystem services may foster fair and equitable benefit-sharing that contributes to multiple interconnected SDGs<sup>4</sup>; however, SDG 14 was criticized for being largely aspirational rather than operational and measurable<sup>5</sup>, and management-level guidance is critically needed to support progress toward SDG 14 targets<sup>6–8</sup>.

Management of human activities and natural resources often has a spatial dimension, reflecting various social, sectoral, or geopolitical boundaries. This spatial lens extends to planning and management of oceans and their natural resources<sup>9–12</sup>. Planning and management can address single-sector needs, like achieving specific fisheries objectives<sup>13</sup>, or multiple objectives in the wider seascape, as with comprehensive ocean zoning or marine spatial planning<sup>14,15</sup>. Both single- and multi-sector spatial plans tend to rely on the implementation of spatial or area-based management tools (ABMTs). ABMTs are geographically defined areas where human activities are regulated for one or more purposes, delivering one or more social and ecological outcomes to achieve objectives for biodiversity conservation, sustainable resource use, or both<sup>16,17</sup>. Since ABMTs are common across ocean sectors, management objectives, and social-ecological contexts<sup>10</sup>, and given their recommended use for achieving conservation and

sustainability goals<sup>18,19</sup>, a clearer understanding of the contributions of ABMTs to SDG 14 targets may enable strategic planning toward achieving this goal. Here, we assess evidence of ecological, social, and economic ABMT outcomes, ranging from increasing organism size to maintaining ecosystem resilience to preserving access to resources and cultural traditions. We use this evidence to determine the potential contributions of prominent ABMTs to SDG 14 targets, guiding countries and practitioners in selecting the best interventions to deliver SDG 14.

### **Assessing evidence of outcomes and contributions to SDG 14**

To provide management-level guidance on the use of ABMTs for achieving SDG 14, we conducted a two-step approach, including a rapid systematic review of the scientific literature followed by an expert survey to identify evidence, and gaps in evidence, of 17 ecological, social, and economic outcomes from seven types of ABMTs (Figure 1 and Supplementary Table 1). The selected ABMTs have objectives in biodiversity conservation, sustainable resource use, particularly fisheries, or both (Supplementary Table 2). These ABMTs regulate the activities of single sectors, as is typical of gear restriction areas (GRAs), fishery closures (FCs), territorial user right fisheries (TURFs), and particularly sensitive sea areas (PSSAs), or multiple sectors, as is typical of fully protected areas (FPAs), partially protected areas (PPAs), and locally managed marine areas (LMMAs). Many of these tools may be considered ‘other effective area-based conservation measures’ (OECMs) in some contexts and these tools may overlap in their application or the types of regulations they use.

Using evidence from the literature and expert opinions, we conducted a confidence assessment of the ability of selected ABMTs to deliver selected outcomes. Confidence level was determined based on “quantity and quality of evidence” and the “level of agreement among evidence”, following a similar approach to the Intergovernmental Panel on Biodiversity and Ecosystem Services<sup>20</sup> (Figure 2, Supplementary Table 6, Supplementary Figure 3). Finally, we developed a scoring system to link ABMTs to SDG 14 targets based on the relative contributions of outcomes to the targets (see Equation 1 in Methods).

## **Evidence of ABMT outcomes**

We identified 276 records of ABMT outcomes from 177 studies (Table 1 and Supplementary References). Of these studies, 31 reported evidence through synthesis-based literature, including meta-analyses, systematic reviews, or literature reviews. Although we found evidence of fully protected areas (FPAs), partially protected areas (PPAs), gear restriction areas (GRAs), fishery closures (FCs), and territorial user right fisheries (TURFs) in these 31 studies, most reported only ecological outcomes. The majority of records from both synthesis-based evidence and evidence from individual studies reported on outcomes from FPAs and PPAs (25% and 29%, respectively). The proportion of all literature-based evidence records across outcomes was comparable for locally managed marine areas (LMMAs), GRAs, FCs, and TURFs (8%, 14%, 12%, 12%, respectively); however, no synthesis-based evidence was identified for outcomes of LMMAs. Individual studies reported 204 records of evidence for ABMT outcomes, including 95 records of positive effects, 68 records of negative effects, and 41 records documenting no effect of ABMTs on outcomes. No literature-based evidence was identified for outcomes of particularly sensitive sea areas (PSSAs).

Expert opinions collected using survey questionnaires (n=75) exhibited greater agreement on the ecological outcomes of most ABMTs than social and economic outcomes (Figure 3). Experts agreed that for most ABMTs, positive effects would occur for the majority of ecological outcomes. More than 60% of experts agreed that FPAs, PPAs, LMMAs, and FCs would have positive effects on organism size (96%, 87%, 60%, and 87%, respectively), organism abundance (89%, 91%, 67%, and 89%, respectively), maintaining habitat (96%, 92%, 67%, and 65%, respectively), ecosystem function (93%, 84%, 63%, and 61%, respectively), ecosystem resilience (92%, 81%, 61%, and 63%, respectively), and on reducing threats to species (93%, 84%, 72%, and 87%, respectively). More than 60% of experts also agreed that GRAs would have positive effects on organism size (68%), organism abundance (73%), maintaining habitat (76%), and reducing threats to species (79%).

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

#### **Confidence assessment**

Based on evidence provided by the literature and by experts, we found generally greater confidence in the delivery of ecological outcomes than social and economic outcomes from the assessed ABMTs (Figure 4). We found high confidence, assigned to “well-established” and “established but incomplete” categories (Figure 2), that multi-sector ABMTs, including FPAs, PPAs, and LMMAs, would have positive effects on organism size and abundance, species diversity, habitat, ecosystem function and resilience, and reducing threats to species. Most single sector ABMTs, including GRAs, FCs, and TURFs, were found to have positive effects on fewer ecological outcomes, including organism size and abundance, ecosystem function, and reducing threats to species, with high confidence. We also found high confidence that the seven ABMTs would have no effect on reducing impacts of acidification. While we found no literature-based evidence (Table 1), there was medium or high agreement among experts that ABMTs would have no effect on this outcome (Figure 3). Similarly, though to a lesser extent, there was agreement that none of the ABMTs studied are likely to reduce pollution, though confidence assessment was “incomplete” for LMMAs and PSSAs. Further, we found that FPAs may have the potential to reduce pollution, though evidence of this outcome was “established but unresolved”. Low confidence persisted for all outcomes of PSSAs, except the shared result of no effect of ABMTs on reducing impacts of acidification.

Across ABMTs, low confidence, assigned to “established but unresolved”, “unresolved”, and “incomplete” categories (Figure 2), was found for 43% of all assessed outcomes; however, these were assigned to only 25% of ecological outcomes compared to 63% of social and economic outcomes. There is an apparent lack of evidence of social and economic outcomes and, where evidence does exist, it agrees less often than that for ecological outcomes, resulting in low confidence (Figure 4). For ecological outcomes, 25% exhibited high quantity and quality evidence and 44% showed a high level of agreement among evidence (see data provided with Supplementary Information). In contrast, no social or economic outcome exhibited high quantity and quality evidence and only 21% showed a high level of agreement among evidence. Further, where high confidence was determined for social and economic outcomes, the effect direction on outcomes across ABMTs was not always consistent. While we found high confidence that some ABMTs have positive effects on increasing non-harvest earnings, alternative livelihood activities, maintaining access to resources, and preserving traditions, others were found to have no effect or negative effects on the same outcome. The direction of effects on social and economic outcomes were generally less consistent across tools than was found for ecological outcomes.

#### **Linking ABMTs to SDG 14 targets**

We found that the assessed ABMTs could potentially contribute to five of the seven SDG 14 targets (Figure 5): SDG 14.2 (marine ecosystems), SDG 14.4 (sustainable fisheries), SDG 14.5 (conservation), SDG 14.6 (harmful subsidies), and SDG 14.7 (Small Island Developing States) based on qualitatively determined ABMT scores (see Methods). Since we determined with high confidence that most or all of the assessed ABMTs have no effect on reducing pollution or the impacts of ocean acidification (Figure 4), we found no strong evidence that these tools contribute to SDG 14.1 (marine pollution) or SDG 14.3 (ocean acidification). Based on the confidence assessments presented here, there is currently no evidence that PSSAs on their own contribute to SDG 14 targets. We found that multi-sector ABMTs (i.e., FPAs, PPAs, and LMMAs) make greater potential contributions to targets that focus on ecological objectives, including

SDG 14.2, 14.4, and 14.5, than single-sector ABMTs (i.e., GRAs, FCs, and TURFs). This reflects the high confidence identified for positive effects of multi-sector ABMTs on more ecological outcomes than single-sector ABMTs (Figure 4). For all ABMTs, except PSSAs, the potential contributions made to these targets were greater than potential contributions to targets with social and economic objectives, including SDG 14.6 and 14.7.

While multi-sector ABMTs might make similar contributions to ecologically focused SDG 14 targets, they differ in their potential to contribute to socially and economically focused targets (Figure 5). FPAs emerged as the tool with the greatest potential to contribute to SDGs 14.2, 14.4, and 14.5; however, this tool had lower ABMT scores than LMMAs for contributing to SDG 14.6 and 14.7. PPAs had the lowest ABMT scores for contributing to SDG 14.6 and 14.7 of all assessed ABMTs, with the exception of FCs and PSSAs, which were not found to make contributions to these targets based on current evidence. We identified LMMAs as the ABMT with the greatest potential to contribute to SDG 14.6 and 14.7. Second to LMMAs, TURFS presented higher ABMT scores for these targets than other tools. Both LMMAs and TURFs were the only tools found to increase harvest earnings and maintain access to resources with high confidence (Figure 4), thus supporting their greater potential to contribute to these targets. FCs were the only single-sector ABMT found to make no contribution to SDG 14.6 and 14.7. This is likely due to the negative effect of FCs on maintaining access to resources (Figure 4), an outcome that supports these targets (see data provided with Supplementary Information).

## **DISCUSSION**

We found that, based on current evidence, FPAs hold the greatest potential to contribute to ecologically focused SDG 14 targets (i.e., SDG 14.2, 14.4, and 14.5), aiming to preserve or restore ocean ecosystems and biodiversity, followed by PPAs and LMMAs (Figure 5). Those three tools typically regulate multiple sectors and activities, while the remaining tools target activities of single sectors, particularly fisheries via GRAs, FCs, and TURFS and shipping activities via PSSAs. Our results indicate that these multi-sector ABMTs, which may involve the use of multiple single-sector ABMTs, will be important for achieving SDG 14, given their strong



potential to contribute to multiple targets. Since no single ABMT assessed was found to potentially contribute to all targets, nor was a single ABMT identified as holding the greatest potential to contribute to both ecologically and socially and economically focused targets, our findings highlight the need for a combination of tools to meet SDG 14. This resonates with a preliminary analysis by the United Nations of spatial management strategies, including marine spatial planning and integrated coastal zone management, for achieving ocean-related SDGs<sup>6</sup>. Our results also highlight the potential role of these ABMTs in contributing to conservation targets as OECMs. While we determined similar ABMT scores for multi-sector tools, an important distinction between FPAs, PPAs, and LMMAs lies in their overarching objectives: biodiversity conservation is the key goal of FPAs and PPAs<sup>21</sup>, while LMMAs prioritize sustainable resource use over conservation *per se*<sup>22</sup>.

LMMAs, a tool that has been favoured in Small Island Developing States<sup>23</sup>, are unique in their application of a suite of ABMTs under a shared management strategy that is collaborative across communities, partner organizations, and governments at the local level<sup>24</sup>. These characteristics are likely reflected in the ABMT scores we present here (Figure 5), particularly due to their ability to deliver ecological, social, and economic outcomes with high confidence (Figure 4). Despite the relatively limited evidence of LMMA outcomes in the primary literature (Table 1), this ABMT scored similarly to FPAs and PPAs that are well-documented. It is clear from our results that experts agree on generally positive expected effects of LMMAs on outcomes (Figure 3). Given these findings, LMMAs represent an opportunity for management as a potential pathway and a research priority to support the achievement of SDG 14. As a tool for ensuring a healthy and resilient ocean for sustainability<sup>25,26</sup>, FPAs undoubtedly have a central role in achieving SDG 14.2, 14.4, and 14.5; however, the overarching aim of LMMAs may enable greater delivery of outcomes contributing to SDG 14 targets that seek to sustain the social and economic systems affecting oceans and ocean resources.

While our results show how the assessed ABMTs can potentially contribute SDG 14 targets, they also highlight limitations of ABMTs. We found “incomplete” evidence for all assessed

outcomes of PSSAs (Figure 4), hence, no potential for PSSAs to contribute to SDG 14 (Figure 5). PSSAs may make other important contributions to conservation and sustainability by reducing impacts from international shipping activities. This tool has been suggested for use in areas beyond national jurisdiction for conservation<sup>27,28</sup>, where threats to biodiversity are growing<sup>29,30</sup>. We highlight a need for more research on PSSA outcomes to support this tool as a potential pathway to SDG 14 in the high seas and suggest that ABMTs contributing to conservation outcomes should be used until the role of PSSAs can be clarified, such as FPAs. Our results also demonstrate the inability of the assessed ABMTs to effectively reduce marine pollution (SDG 14.1) and impacts of ocean acidification (SDG 14.3) (Figure 5). Other ABMTs not assessed here, such as Special Areas designed under the MARPOL Convention<sup>31</sup>, may better support these targets. Our results may reflect the broader and more systemic changes required for addressing these issues; for example, regulating the consumption and disposal of plastic or large-scale actions for reducing carbon emissions and decarbonizing economies<sup>32–34</sup>. Such systemic transformations may be necessary precursors to effectively achieving SDG 14.1 and 14.3, for which little progress has been made<sup>35</sup>. It will be important to consider both non-spatial and spatial management tools, including and beyond the ABMTs assessed here, to achieve all SDG 14 targets. Holistic approaches to planning and management across the land-sea interface, like integrated coastal zone management<sup>36</sup> and ridge-to-reef management<sup>37</sup>, will likely be important for incorporating land-based regulations with ABMTs to achieve SDGs, including SDG 14<sup>6</sup>.

Through this work, we have identified several evidence gaps pertaining to ABMTs and their outcomes. We highlight low confidence and a lack of evidence pertaining to the social and economic outcomes of ABMTs (Table 1, Figure 3, Figure 4). Low confidence was found for 61% of social and economic outcomes assessed, compared to only 25% of ecological outcomes. These findings indicate a need for research to better assess social and economic outcomes of ABMTs at varying scales and for diverse stakeholders, which may first require the development of measurable indicators for targets that are presently without<sup>38</sup>. This evidence gap is again highlighted by the ABMT scores presented here, which indicate the low potential of these tools

to contribute to SDG 14.6 and 14.7 that are socially and economically focused. While recent work helped to identify social and economic outcomes of marine protected areas<sup>39</sup>, an apparent evidence gap persists in identifying these outcomes for single-sector ABMTs, including FCs, GRAs, TURFs, and PSSAs.

We recognize the inherent limitations of our study imposed by the rapid systematic review method. While efforts were made to ensure that this method captured all relevant information, it cannot be truly comprehensive as would a full systematic review capturing both primary and grey literature. Our focus on primary, peer-reviewed literature provided a common filter, ensuring a consistent rigour across the collected evidence. This method was used to conduct a high-level confidence assessment that relied on a qualitative ranking system to assess the quantity and quality of evidence (Supplementary Table 6). To compensate for differences in the availability of literature-based evidence, we surveyed experts to identify the expected effects of ABMTs. Through the selection of survey participants in primarily research institutions and government, expertise from industry, Indigenous Peoples, and communities are not present in our confidence assessments. As with any scientific synthesis, our work may be affected by publication bias with some ABMTs more represented in the literature than others, as well as a tendency for literature to report positive outcomes. As more evidence becomes available, the confidence assessments and potential contributions of tools to SDG 14 targets presented here may be refined. Our results demonstrate the qualitative potential of ABMTs to contribute to SDG 14 and their use in practice should appropriately reflect this. Further, while we did select prominent ABMTs for assessment, other tools are available to practitioners and may also prove useful for achieving SDG 14. Our study does not assess the efficacy of ABMTs, nor does it quantify the extent of outcomes. While ABMTs may deliver similar outcomes, one tool may have a stronger effect than others and our study does not account for this. Delivery of these outcomes is dependent on local social-ecological systems and may vary by target species, ecosystems, and management regimes. To reach their fullest potential, ABMTs must be appropriately designed with attention given to local needs, actively managed, and well-enforced to consistently deliver outcomes contributing to SDG 14<sup>40–42</sup>.

ABMTs are one type of management tool in a suite of tools and approaches available to decision-makers for achieving conservation and sustainability objectives. Our results confirm that no single ABMT can be used to reach all SDG 14 targets, but that a combination of tools, especially those regulating multiple sectors, will likely be necessary for achieving this goal. When multiple ABMTs are used synergistically, multiple and more diverse outcomes may occur, potentially making stronger contributions to SDG 14. Placing ABMTs into the wider picture of integrated land-sea management, including both spatial and non-spatial approaches, will be important for achieving ocean conservation and sustainability goals<sup>43,44</sup>. This is especially true for SDG 14 targets that may not be met using ABMTs, including SDG 14.1 to reduce marine pollution and SDG 14.3 to reduce ocean acidification as our results indicate. Our findings highlight important evidence gaps related to social and economic outcomes of ABMTs, especially single-sector ABMTs, providing a research agenda for future work. Through our assessment, we demonstrate which ABMTs may be most useful for achieving specific SDG 14 targets, allowing ocean planners and practitioners to make strategic decisions when selecting management tools. By linking ABMTs to SDG 14 targets, our work may support future research to assess potential contributions of existing or planned ABMTs to SDG 14 at a regional, national, and international scale.

## **METHODS**

### **Selecting ABMTs and outcomes**

The ABMTs assessed in this study were identified from a list of spatial management tools provided by Ehler and Douvère<sup>10</sup>, which included marine protected areas (MPAs), fishery closures (FCs), gear restriction areas (GRAs), and particularly sensitive sea areas (PSSAs). Here, we separated the broad category of MPAs into two distinct tools: fully protected areas (FPAs) and partially protected areas (PPAs) due to their documented differences in outcomes<sup>45</sup>. Locally managed marine areas (LMMAs) and territorial user right fisheries (TURFs) were added, as they have emerged prominently in the literature in recent years<sup>46,47</sup>. In total, we identified seven ABMTs with distinct objectives, regulations, and outcomes, though these definitions may vary

or overlap in their application (Figure 1 and Supplementary Table 2). Some ABMTs may overlay tools, for example an ABMT regulating multiple sectors, like an FPA, may make use of multiple single-sector tools, like FCs, GRAs, or PSSAs.

We assessed 17 ecological, social, and economic outcomes identified from previous reviews reporting observed and expected ABMT outcomes, particularly in the context of MPAs<sup>48</sup> and LMMAs<sup>11</sup> (Figure 1). Outcomes were assigned distinct definitions (Supplementary Table 1), and evidence of outcomes reported in literature needed to fit these definitions to be included in review. Some of these outcomes have direct links to SDG 14 targets (e.g., maintaining ecosystem resilience and SDG 14.2 on ecosystem restoration), while others are indirect (e.g., maintaining equitable access to resources and SDG 14.4 on sustainable fisheries). Since the primary aim of this research is to provide guidance on the use of ABMTs to achieve SDG 14 targets, additional outcomes not previously identified from existing reviews but with direct links to targets, such as reducing pollution and SDG 14.1, were added. Many of the assessed outcomes may be considered as indicators for monitoring and evaluation of ABMTs<sup>49–51</sup>, which may inform or align with SDG 14 indicators.

### **Rapid systematic review**

Rapid systematic reviews identify all studies meeting specific criteria, such as publication year, article type, geographic region, language, database, data type, or data extraction method<sup>52</sup>. We used a rapid review method to overcome challenges introduced by the number of ABMTs and outcomes assessed and the vastness of literature in this field of study. The review was conducted using the Web of Science between July and October 2019, and was limited to primary literature, including only articles and reviews published in English in 2002 or later. While the grey literature could have provided additional information relevant to this study, including this information would not have permitted a systematic review due to the diversity of access restriction and languages that can be found in the grey literature. Since this method excludes publications from governments, non-governmental organizations, and other research organizations, we also conducted an expert opinion survey to compensate for evidence not

found in the primary literature. The constraint on publication year was used to identify studies listing author email addresses, which were later used as contact information to invite participants for this survey<sup>53</sup>. We conducted two phases of rapid systematic review.

The first phase of rapid review was intended to capture synthesis-based evidence, including meta-analyses, systematic reviews, and standard literature reviews, and thus it was assumed that publications earlier than 2002 would have been included in these studies. Where synthesis-based evidence was identified, further review of individual studies in the second phase was not required, reducing the risk of double counting outcomes from individual studies that may have been captured by reviews. In addition to these limitations, search terms were designed to return the most relevant literature from titles, abstracts, and keywords (Supplementary Tables 3 and 4). The efficacy of search terms was tested using pilot searches to ensure that 10 pre-determined studies were returned by the selected search terms in Web of Science (Supplementary Table 5).

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

- Population: studies must observe the marine environment
- Intervention: studies must observe at least one of the seven ABMTs, aligning with the assigned definitions (Supplementary Table 2), though evidence of any assessed ABMT was recorded
- Time and place: studies must be published after 2001 in any geographic location
- Outcomes: studies must report evidence of positive, negative, or no effect on at least one of the 17 selected outcomes (Supplementary Table 1), excluding studies using strictly theoretical methods or theoretical modelling

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

In the first phase, when studies met all inclusion criteria, the following data were extracted: study type (i.e., meta-analysis, systematic review, or standard literature review), number of studies reviewed or included in the meta-analysis, geographical scope, ABMT type, outcome type (i.e., ecological, social, economic, or multiple), evidence of outcomes, and effect directions (e.g., positive effect on organism size). Additional information related to study quality, including the reporting and rigour of methods, was recorded and informed distinctions made between study type where necessary. Systematic literature reviews were distinguished from standard literature reviews such that the former reported a search strategy, including search terms, and inclusion/exclusion criteria. For each study included, the reported ABMT was classified according to the definitions used in this study (Supplementary Table 2), which in some cases differed from the ABMT that was searched in Web of Science. For example, if a study was returned by a search for FC outcomes, but the described ABMT fit this study’s definition of a GRA, the ABMT was classified as a GRA. Where it was unclear whether an MPA was fully or partially protected, MPAtlas (<http://www.mpatlas.org/>) was used to determine the appropriate ABMT type. If an MPA was reported as being entirely no-take on MPAtlas, it was classified as an FPA. All other MPAs, including those with some no-take zones according to MPAtlas, were classified as PPAs. In the second phase, data on study location, ABMT type, evidence of outcomes, and effect direction were extracted and qualitative information that clarified the nature of reported outcomes was recorded.

### **Expert opinion survey**

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

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

### **Confidence assessment**

To determine the level of confidence in the delivery of ABMT outcomes, we used an assessment method modified from the IPBES assessment process<sup>20</sup> (Figure 2, Supplementary Table 6, Supplementary Figure 3). We defined five confidence categories based on the quantity and quality of evidence and level of agreement among evidence collected via rapid systematic review and expert opinion survey. These categories are:

- Well-established: comprehensive evidence exists, and conclusions agree



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

We used a qualitative ranking system to determine the quantity and quality of evidence and the level of agreement to be either “high”, “medium”, or “low” based on the criteria presented in Supplementary Table 6, applied in a decision tree presented in Supplementary Figure 3. High quantity and quality evidence included one or more meta-analysis or systematic review or more than one standard literature review or five or more individual studies and more than 75% of experts reporting one expected effect. High agreement required the majority of studies to agree on an ABMT outcome, the majority of experts to agree on an outcome, and for the studies and experts to agree on that same outcome. Each ABMT outcome was assessed according to these criteria and assigned a confidence category (Supplementary Figure 3). Well-established and established but incomplete categories were considered to be of high confidence, reflecting high certainty that a particular ABMT would deliver a particular outcome, and were assigned confidence scores of 2 and 1, respectively. All other confidence categories were not assigned a confidence score, as these categories were considered to be of low confidence.

#### **Linking ABMTs to SDG 14 targets**

ABMT outcomes assessed in this study do not all make equivalent contributions to SDG 14 targets. To account for this, each outcome was assigned a contribution score per target. Scores ranged from one to three, depending on the type of contribution. A direct contribution (score= 3) has a central role in meeting the objectives of the target; a supporting contribution (score= 2) aids the delivery of a direct contribution; and an indirect contribution (score= 1) enables the delivery of supporting or direct contributions to a lesser extent (see data provided with

Supplementary Information). We considered contributions to the targets broadly based on their description and, where feasible, their indicators. While some indicators were used to inform contribution scores for ABMT outcomes, others were not relevant to the outcomes assessed. For example, a study reporting an ABMT outcome of healthy ocean acidity (pH), the indicator for SDG 14.3, would be considered as evidence of a direct contribution to this target. Similarly, a study reporting improved ecosystem resilience as an ABMT outcome would be considered as evidence of an indirect contribution to this target (see data provided with Supplementary Information). In contrast, the indicator for SDG 14.5, protected area coverage, is not an outcome of ABMTs and is therefore not relevant to this study. To link ABMTs to SDG 14 targets, an ABMT score was calculated according to the following equation:

$$ABMT\ score = \sum (Confidence\ score \times Contribution\ score) \quad (Eq.\ 1)$$

Possible ABMT scores ranged between 0 and 102, depending on the assigned confidence and contribution scores for the 17 assessed outcomes (see data provided with Supplementary Information). ABMT scores were qualitatively compared to determine the relative contributions of ABMTs to SDG 14 targets (Supplementary Figure 4).

## DATA AVAILABILITY

Data supporting the analyses and results of this study are available in the Supplementary Information. Correspondence regarding this data should be addressed to J.M.R.

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#### **CORRESPONDING AUTHOR**

All correspondence regarding this manuscript and requests for materials can be directed to J.M.R.

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#### **AUTHOR CONTRIBUTIONS**

All authors contributed to the conception of this research, to study design, and to editing the manuscript. J.M.R. reviewed the literature, conducted the expert opinion survey, carried out analyses, and drafted the manuscript.

#### **COMPETING INTERESTS**

The authors declare no competing interests.

#### **FIGURE LEGENDS**

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

**Figure 2.** Confidence assessment framework, adapted from IPBES<sup>20</sup>, used to determine confidence in the delivery of area-based management tool (ABMT) outcomes based on evidence from rapid systematic review and expert opinions. Criteria for determining quantity and quality of evidence and level of agreement among evidence are defined in Supplementary Table 6 and detailed in Supplementary Figure 3. “Well-established” and “established but incomplete” categories were considered to be high confidence categories, while remaining categories were considered to be low confidence, for the purpose of linking ABMTs to Sustainable Development Goal 14 targets (see Methods). Icons are attributed to Becris (LMMA), Freepik (FPA, PPA), Mavadee (PSSA), Smashicons (FC), Surang (GRA), Wichai.wi (TURF) from [www.flaticon.com](http://www.flaticon.com).

**Figure 3.** Expert opinions (n= 75) on the expected effects of area-based management tools (ABMTs) on ecological, social, and economic outcomes. See Supplementary Tables 1 and 2 for definitions of ABMTs and outcomes. FPA, fully protected area; PPA, partially protected area; LMMA, locally managed marine area; GRA, gear restriction area; FC, fishery closure; TURF, territorial user right fishery; PSSA, particularly sensitive sea area.



**Figure 4.** Confidence assessment of literature-based and expert opinion evidence for the delivery of ecological, social, and economic outcomes from area-based management tools (ABMTs). There is highest confidence in the delivery of “well-established” outcomes (green) and lowest confidence in the delivery of “incomplete” outcomes (dark orange). The effect direction for each outcome is indicated within each circle. For some “established but unresolved” and “unresolved” outcomes, more than one effect direction is indicated due to a lack of agreement among evidence. “Incomplete” outcomes do not indicate an effect direction. FPA, fully protected area; PPA, partially protected area; LMMA, locally managed marine area; GRA, gear restriction area; FC, fishery closure; TURF, territorial user right fishery; PSSA, particularly sensitive sea area. Icons are attributed to Becris (LMMA), Freepik (FPA, PPA), Mavadee (PSSA), Smashicons (FC), Surang (GRA), Wichai.wi (TURF) from [www.flaticon.com](http://www.flaticon.com).

**Figure 5.** Potential contributions of area-based management tools (ABMTs) to Sustainable Development Goal 14 (SDG 14) targets based on confidence assessments of ABMT outcomes and the potential contributions of outcomes to SDG 14 targets (see data supplied with Supplementary Information). Circle size is proportional to ABMT scores indicated in each circle (scores range from 0 to 102, see Equation 1 in Methods). Crosses indicate an ABMT score of zero, meaning no potential contribution of a tool to a target, based on current evidence and the relative contribution of an outcome to a target. FPA, fully protected area; PPA, partially protected area; LMMA, locally managed marine area; GRA, gear restriction area; FC, fishery closure; TURF, territorial user right fishery; PSSA, particularly sensitive sea area. Icons are attributed to Becris (LMMA), Freepik (FPA, PPA), Mavadee (PSSA), Smashicons (FC), Surang (GRA), Wichai.wi (TURF) from [www.flaticon.com](http://www.flaticon.com).

## TABLES

**Table 1.** Summary of literature-based evidence of area-based management tool (ABMT) outcomes collected via rapid systematic review. Blue cells indicate outcomes from synthesis-based evidence, including meta-analyses, systematic reviews, or literature reviews, and show

677 the number of studies reporting evidence. White cells indicate the number of individual studies  
678 reporting evidence, for any outcome that was not reported in synthesis-based evidence (see  
679 Methods). Values represent one study per evidence record relating to an ABMT outcome,  
680 though some studies reported evidence of more than one outcome or evidence from more  
681 than one ABMT and are therefore counted in multiple cells where relevant. Evidence may  
682 report positive (+), negative (-), or neutral effects (o) on the ABMT outcome. FPA, fully  
683 protected area; PPA, partially protected area; LMMA, locally managed marine area; GRA, gear  
684 restriction area; FC, fishery closure; TURF, territorial user right fishery; PSSA, particularly  
685 sensitive sea area.