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

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Keywords: Sustainable Development Goal 14, marine spatial planning (MSP), marine protected areas (MPA), area-based management tool (ABMT), other effective area-based conservation measure (OECM), targets, indicators, locally managed marine area (LMMA), territorial user right fishery (TURF), fishery closure

### 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

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

16

17 The United Nations Sustainable Development Goals (SDGs) provide a transformational vision of  
18 sustainable development across the environmental, social, and economic dimensions.

19 Sustainable Development Goal 14: Life Below Water (SDG 14) aims to “conserve and  
20 sustainably use oceans, seas, and marine resources for sustainable development”<sup>1</sup>. Through its  
21 seven primary targets, SDG 14 addresses ocean challenges: reducing marine pollution (SDG  
22 14.1), restoring marine ecosystems (SDG 14.2), reducing ocean acidification (SDG 14.3),  
23 enabling sustainable fisheries (SDG 14.4), conserving marine areas (SDG 14.5), ending harmful  
24 fishery subsidies (SDG 14.6), and increasing economic benefits to Small Island Developing States  
25 and least developed countries (SDG 14.7). Achieving SDG 14 was shown to benefit other SDGs,  
26 most notably SDG 1: No Poverty and SDG 2: Zero Hunger<sup>2,3</sup>. A focus on sustaining marine  
27 ecosystem services may foster fair and equitable benefit-sharing that contributes to multiple  
28 interconnected SDGs<sup>4</sup>; however, SDG 14 was criticized for being largely aspirational rather than  
29 operational and measurable<sup>5</sup>, and management-level guidance is critically needed to support  
30 progress toward SDG 14 targets<sup>6–8</sup>.

31

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

43 sustainability goals<sup>18,19</sup>, a clearer understanding of the contributions of ABMTs to SDG 14  
44 targets may enable strategic planning toward achieving this goal. Here, we assess evidence of  
45 ecological, social, and economic ABMT outcomes, ranging from increasing organism size to  
46 maintaining ecosystem resilience to preserving access to resources and cultural traditions. We  
47 use this evidence to determine the potential contributions of prominent ABMTs to SDG 14  
48 targets, guiding countries and practitioners in selecting the best interventions to deliver SDG  
49 14.

50

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

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

64

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

72 **Evidence of ABMT outcomes**

73 We identified 276 records of ABMT outcomes from 177 studies (Table 1 and Supplementary  
74 References). Of these studies, 31 reported evidence through synthesis-based literature,  
75 including meta-analyses, systematic reviews, or literature reviews. Although we found evidence  
76 of fully protected areas (FPAs), partially protected areas (PPAs), gear restriction areas (GRAs),  
77 fishery closures (FCs), and territorial user right fisheries (TURFs) in these 31 studies, most  
78 reported only ecological outcomes. The majority of records from both synthesis-based evidence  
79 and evidence from individual studies reported on outcomes from FPAs and PPAs (25% and 29%,  
80 respectively). The proportion of all literature-based evidence records across outcomes was  
81 comparable for locally managed marine areas (LMMAs), GRAs, FCs, and TURFs (8%, 14%, 12%,  
82 12%, respectively); however, no synthesis-based evidence was identified for outcomes of  
83 LMMAs. Individual studies reported 204 records of evidence for ABMT outcomes, including 95  
84 records of positive effects, 68 records of negative effects, and 41 records documenting no  
85 effect of ABMTs on outcomes. No literature-based evidence was identified for outcomes of  
86 particularly sensitive sea areas (PSSAs).

87

88 Expert opinions collected using survey questionnaires (n=75) exhibited greater agreement on  
89 the ecological outcomes of most ABMTs than social and economic outcomes (Figure 3). Experts  
90 agreed that for most ABMTs, positive effects would occur for the majority of ecological  
91 outcomes. More than 60% of experts agreed that FPAs, PPAs, LMMAs, and FCs would have  
92 positive effects on organism size (96%, 87%, 60%, and 87%, respectively), organism abundance  
93 (89%, 91%, 67%, and 89%, respectively), maintaining habitat (96%, 92%, 67%, and 65%,  
94 respectively), ecosystem function (93%, 84%, 63%, and 61%, respectively), ecosystem resilience  
95 (92%, 81%, 61%, and 63%, respectively), and on reducing threats to species (93%, 84%, 72%,  
96 and 87%, respectively). More than 60% of experts also agreed that GRAs would have positive  
97 effects on organism size (68%), organism abundance (73%), maintaining habitat (76%), and  
98 reducing threats to species (79%).

99

100 In contrast, at least 25% of experts agreed that FPAs, PPAs, LMMAs, GRAs, and FCs would have  
101 negative effects on harvest earnings (43%, 25%, 37%, and 43%, respectively), maintaining  
102 access to resources (72%, 53%, 43%, and 59%, respectively), equitable access to resources  
103 (47%, 37%, 28%, and 37%, respectively), and preserving traditions and customs (47%, 32%,  
104 31%, and 40%, respectively). Experts were less certain about outcomes of TURFs and PSSAs, as  
105 more than 20% of experts indicated either “do not know” or “prefer not to answer” for all  
106 outcomes of these tools (see Methods). Several experts commented on the difficulty of  
107 providing general information on expected effects of ABMTs, especially those pertaining to  
108 social and economic outcomes, given the context-dependency of these outcomes relative to  
109 local ABMT objectives, monitoring capacity, and social groups.

110

#### 111 **Confidence assessment**

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

129

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

146

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

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

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

163  
164 While multi-sector ABMTs might make similar contributions to ecologically focused SDG 14  
165 targets, they differ in their potential to contribute to socially and economically focused targets  
166 (Figure 5). FPAs emerged as the tool with the greatest potential to contribute to SDGs 14.2,  
167 14.4, and 14.5; however, this tool had lower ABMT scores than LMMAs for contributing to SDG  
168 14.6 and 14.7. PPAs had the lowest ABMT scores for contributing to SDG 14.6 and 14.7 of all  
169 assessed ABMTs, with the exception of FCs and PSSAs, which were not found to make  
170 contributions to these targets based on current evidence. We identified LMMAs as the ABMT  
171 with the greatest potential to contribute to SDG 14.6 and 14.7. Second to LMMAs, TURFS  
172 presented higher ABMT scores for these targets than other tools. Both LMMAs and TURFs were  
173 the only tools found to increase harvest earnings and maintain access to resources with high  
174 confidence (Figure 4), thus supporting their greater potential to contribute to these targets. FCs  
175 were the only single-sector ABMT found to make no contribution to SDG 14.6 and 14.7. This is  
176 likely due to the negative effect of FCs on maintaining access to resources (Figure 4), an  
177 outcome that supports these targets (see data provided with Supplementary Information).

178  
179 **DISCUSSION**

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



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

198  
199 LMMAs, a tool that has been favoured in Small Island Developing States<sup>23</sup>, are unique in their  
200 application of a suite of ABMTs under a shared management strategy that is collaborative  
201 across communities, partner organizations, and governments at the local level<sup>24</sup>. These  
202 characteristics are likely reflected in the ABMT scores we present here (Figure 5), particularly  
203 due to their ability to deliver ecological, social, and economic outcomes with high confidence  
204 (Figure 4). Despite the relatively limited evidence of LMMA outcomes in the primary literature  
205 (Table 1), this ABMT scored similarly to FPAs and PPAs that are well-documented. It is clear  
206 from our results that experts agree on generally positive expected effects of LMMAs on  
207 outcomes (Figure 3). Given these findings, LMMAs represent an opportunity for management  
208 as a potential pathway and a research priority to support the achievement of SDG 14. As a tool  
209 for ensuring a healthy and resilient ocean for sustainability<sup>25,26</sup>, FPAs undoubtedly have a  
210 central role in achieving SDG 14.2, 14.4, and 14.5; however, the overarching aim of LMMAs may  
211 enable greater delivery of outcomes contributing to SDG 14 targets that seek to sustain the  
212 social and economic systems affecting oceans and ocean resources.

213  
214 While our results show how the assessed ABMTs can potentially contribute SDG 14 targets,  
215 they also highlight limitations of ABMTs. We found “incomplete” evidence for all assessed

216 outcomes of PSSAs (Figure 4), hence, no potential for PSSAs to contribute to SDG 14 (Figure 5).  
217 PSSAs may make other important contributions to conservation and sustainability by reducing  
218 impacts from international shipping activities. This tool has been suggested for use in areas  
219 beyond national jurisdiction for conservation<sup>27,28</sup>, where threats to biodiversity are growing<sup>29,30</sup>.  
220 We highlight a need for more research on PSSA outcomes to support this tool as a potential  
221 pathway to SDG 14 in the high seas and suggest that ABMTs contributing to conservation  
222 outcomes should be used until the role of PSSAs can be clarified, such as FPAs. Our results also  
223 demonstrate the inability of the assessed ABMTs to effectively reduce marine pollution (SDG  
224 14.1) and impacts of ocean acidification (SDG 14.3) (Figure 5). Other ABMTs not assessed here,  
225 such Special Areas designed under the MARPOL Convention<sup>31</sup>, may better support these  
226 targets. Our results may reflect the broader and more systemic changes required for addressing  
227 these issues; for example, regulating the consumption and disposal of plastic or large-scale  
228 actions for reducing carbon emissions and decarbonizing economies<sup>32-34</sup>. Such systemic  
229 transformations may be necessary precursors to effectively achieving SDG 14.1 and 14.3, for  
230 which little progress has been made<sup>35</sup>. It will be important to consider both non-spatial and  
231 spatial management tools, including and beyond the ABMTs assessed here, to achieve all SDG  
232 14 targets. Holistic approaches to planning and management across the land-sea interface, like  
233 integrated coastal zone management<sup>36</sup> and ridge-to-reef management<sup>37</sup>, will likely be  
234 important for incorporating land-based regulations with ABMTs to achieve SDGs, including SDG  
235 14<sup>6</sup>.

236  
237 Through this work, we have identified several evidence gaps pertaining to ABMTs and their  
238 outcomes. We highlight low confidence and a lack of evidence pertaining to the social and  
239 economic outcomes of ABMTs (Table 1, Figure 3, Figure 4). Low confidence was found for 61%  
240 of social and economic outcomes assessed, compared to only 25% of ecological outcomes.  
241 These findings indicate a need for research to better assess social and economic outcomes of  
242 ABMTs at varying scales and for diverse stakeholders, which may first require the development  
243 of measurable indicators for targets that are presently without<sup>38</sup>. This evidence gap is again  
244 highlighted by the ABMT scores presented here, which indicate the low potential of these tools

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

249  
250 We recognize the inherent limitations of our study imposed by the rapid systematic review  
251 method. While efforts were made to ensure that this method captured all relevant information,  
252 it cannot be truly comprehensive as would a full systematic review capturing both primary and  
253 grey literature. Our focus on primary, peer-reviewed literature provided a common filter,  
254 ensuring a consistent rigour across the collected evidence. This method was used to conduct a  
255 high-level confidence assessment that relied on a qualitative ranking system to assess the  
256 quantity and quality of evidence (Supplementary Table 6). To compensate for differences in the  
257 availability of literature-based evidence, we surveyed experts to identify the expected effects of  
258 ABMTs. Through the selection of survey participants in primarily research institutions and  
259 government, expertise from industry, Indigenous Peoples, and communities are not present in  
260 our confidence assessments. As with any scientific synthesis, our work may be affected by  
261 publication bias with some ABMTs more represented in the literature than others, as well as a  
262 tendency for literature to report positive outcomes. As more evidence becomes available, the  
263 confidence assessments and potential contributions of tools to SDG 14 targets presented here  
264 may be refined. Our results demonstrate the qualitative potential of ABMTs to contribute to  
265 SDG 14 and their use in practice should appropriately reflect this. Further, while we did select  
266 prominent ABMTs for assessment, other tools are available to practitioners and may also prove  
267 useful for achieving SDG 14. Our study does not assess the efficacy of ABMTs, nor does it  
268 quantify the extent of outcomes. While ABMTs may deliver similar outcomes, one tool may  
269 have a stronger effect than others and our study does not account for this. Delivery of these  
270 outcomes is dependent on local social-ecological systems and may vary by target species,  
271 ecosystems, and management regimes. To reach their fullest potential, ABMTs must be  
272 appropriately designed with attention given to local needs, actively managed, and well-  
273 enforced to consistently deliver outcomes contributing to SDG 14<sup>40-42</sup>.

274  
275 ABMTs are one type of management tool in a suite of tools and approaches available to  
276 decision-makers for achieving conservation and sustainability objectives. Our results confirm  
277 that no single ABMT can be used to reach all SDG 14 targets, but that a combination of tools,  
278 especially those regulating multiple sectors, will likely be necessary for achieving this goal.  
279 When multiple ABMTs are used synergistically, multiple and more diverse outcomes may occur,  
280 potentially making stronger contributions to SDG 14. Placing ABMTs into the wider picture of  
281 integrated land-sea management, including both spatial and non-spatial approaches, will be  
282 important for achieving ocean conservation and sustainability goals<sup>43,44</sup>. This is especially true  
283 for SDG 14 targets that may not be met using ABMTs, including SDG 14.1 to reduce marine  
284 pollution and SDG 14.3 to reduce ocean acidification as our results indicate. Our findings  
285 highlight important evidence gaps related to social and economic outcomes of ABMTs,  
286 especially single-sector ABMTs, providing a research agenda for future work. Through our  
287 assessment, we demonstrate which ABMTs may be most useful for achieving specific SDG 14  
288 targets, allowing ocean planners and practitioners to make strategic decisions when selecting  
289 management tools. By linking ABMTs to SDG 14 targets, our work may support future research  
290 to assess potential contributions of existing or planned ABMTs to SDG 14 at a regional, national,  
291 and international scale.

292

## 293 **METHODS**

### 294 **Selecting ABMTs and outcomes**

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

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

306

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

319

### 320 **Rapid systematic review**

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

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

335  
336 The first phase of rapid review was intended to capture synthesis-based evidence, including  
337 meta-analyses, systematic reviews, and standard literature reviews, and thus it was assumed  
338 that publications earlier than 2002 would have been included in these studies. Where  
339 synthesis-based evidence was identified, further review of individual studies in the second  
340 phase was not required, reducing the risk of double counting outcomes from individual studies  
341 that may have been captured by reviews. In addition to these limitations, search terms were  
342 designed to return the most relevant literature from titles, abstracts, and keywords  
343 (Supplementary Tables 3 and 4). The efficacy of search terms was tested using pilot searches to  
344 ensure that 10 pre-determined studies were returned by the selected search terms in Web of  
345 Science (Supplementary Table 5).

346  
347 Search terms were designed for the seven ABMTs, for ABMT outcomes in general, for meta-  
348 analyses and reviews, and for the 17 outcomes assessed in this study. All returned literature  
349 was screened first by reviewing titles and abstracts and then by reviewing full articles where an  
350 inclusion decision could not be made confidently from the title and abstract. Literature was  
351 screened based on the following criteria:

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

360

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

370  
371 In the first phase, when studies met all inclusion criteria, the following data were extracted:  
372 study type (i.e., meta-analysis, systematic review, or standard literature review), number of  
373 studies reviewed or included in the meta-analysis, geographical scope, ABMT type, outcome  
374 type (i.e., ecological, social, economic, or multiple), evidence of outcomes, and effect directions  
375 (e.g., positive effect on organism size). Additional information related to study quality,  
376 including the reporting and rigour of methods, was recorded and informed distinctions made  
377 between study type where necessary. Systematic literature reviews were distinguished from  
378 standard literature reviews such that the former reported a search strategy, including search  
379 terms, and inclusion/exclusion criteria. For each study included, the reported ABMT was  
380 classified according to the definitions used in this study (Supplementary Table 2), which in some  
381 cases differed from the ABMT that was searched in Web of Science. For example, if a study was  
382 returned by a search for FC outcomes, but the described ABMT fit this study’s definition of a  
383 GRA, the ABMT was classified as a GRA. Where it was unclear whether an MPA was fully or  
384 partially protected, MPAtlas (<http://www.mpatlas.org/>) was used to determine the appropriate  
385 ABMT type. If an MPA was reported as being entirely no-take on MPAtlas, it was classified as an  
386 FPA. All other MPAs, including those with some no-take zones according to MPAtlas, were  
387 classified as PPAs. In the second phase, data on study location, ABMT type, evidence of  
388 outcomes, and effect direction were extracted and qualitative information that clarified the  
389 nature of reported outcomes was recorded.

390 **Expert opinion survey**

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

407

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

410

411 **Confidence assessment**

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

- 417
- Well-established: comprehensive evidence exists, and conclusions agree



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

424

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

439

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

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

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

$$457 \quad ABMT \text{ score} = \sum (\text{Confidence score} \times \text{Contribution score}) \quad (\text{Eq. 1})$$

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

462

#### 463 **DATA AVAILABILITY**

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

466

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598

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602

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609

#### 610 **AUTHOR CONTRIBUTIONS**

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

614

#### 615 **COMPETING INTERESTS**

616 The authors declare no competing interests.

617

#### 618 **FIGURE LEGENDS**

619

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

630  
631 **Figure 2.** Confidence assessment framework, adapted from IPBES<sup>20</sup>, used to determine  
632 confidence in the delivery of area-based management tool (ABMT) outcomes based on  
633 evidence from rapid systematic review and expert opinions. Criteria for determining quantity  
634 and quality of evidence and level of agreement among evidence are defined in Supplementary  
635 Table 6 and detailed in Supplementary Figure 3. “Well-established” and “established but  
636 incomplete” categories were considered to be high confidence categories, while remaining  
637 categories were considered to be low confidence, for the purpose of linking ABMTs to  
638 Sustainable Development Goal 14 targets (see Methods). Icons are attributed to Becris  
639 (LMMA), Freepik (FPA, PPA), Mavadee (PSSA), Smashicons (FC), Surang (GRA), Wichai.wi (TURF)  
640 from [www.flaticon.com](http://www.flaticon.com).

641  
642 **Figure 3.** Expert opinions (n= 75) on the expected effects of area-based management tools  
643 (ABMTs) on ecological, social, and economic outcomes. See Supplementary Tables 1 and 2 for  
644 definitions of ABMTs and outcomes. FPA, fully protected area; PPA, partially protected area;  
645 LMMA, locally managed marine area; GRA, gear restriction area; FC, fishery closure; TURF,  
646 territorial user right fishery; PSSA, particularly sensitive sea area.

647



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

659  
660 **Figure 5.** Potential contributions of area-based management tools (ABMTs) to Sustainable  
661 Development Goal 14 (SDG 14) targets based on confidence assessments of ABMT outcomes  
662 and the potential contributions of outcomes to SDG 14 targets (see data supplied with  
663 Supplementary Information). Circle size is proportional to ABMT scores indicated in each circle  
664 (scores range from 0 to 102, see Equation 1 in Methods). Crosses indicate an ABMT score of  
665 zero, meaning no potential contribution of a tool to a target, based on current evidence and the  
666 relative contribution of an outcome to a target. FPA, fully protected area; PPA, partially  
667 protected area; LMMA, locally managed marine area; GRA, gear restriction area; FC, fishery  
668 closure; TURF, territorial user right fishery; PSSA, particularly sensitive sea area. Icons are  
669 attributed to Becris (LMMA), Freepik (FPA, PPA), Mavadee (PSSA), Smashicons (FC), Surang  
670 (GRA), Wichai.wi (TURF) from www.flaticon.com.

## 671 672 **TABLES**

673  
674 **Table 1.** Summary of literature-based evidence of area-based management tool (ABMT)  
675 outcomes collected via rapid systematic review. Blue cells indicate outcomes from synthesis-  
676 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.