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Juliette Aminian-Biquet, Sašo Gorjanc, Jennifer Sletten, Timothé Vincent, Anastasiya Laznya, Nataša Vaidianu, Joachim Claudet, Juliette Young, Barbara Horta E Costa

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HAL Authorization

# 1 Over eighty percent of the European Union's marine protected area 2 only marginally regulates human activities

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## 19 **Summary**

20 To address the ongoing deterioration of marine ecosystems and its consequences on livelihood, the  
21 European Union (EU) now aims to achieve 30% coverage of Marine Protected Areas (MPAs), with  
22 10% under strict protection per region. Here, we provide the first assessment of protection levels of  
23 EU MPAs, describing the level of legal restrictions of activities and using the MPA Guide framework.  
24 While MPAs covered 11.4% of EU national waters in 2022, 0.2% were fully or highly protected. As  
25 much as 86% of MPA coverage showed low levels of protection, or would not be considered  
26 compatible with conservation objectives as they allow industrial activities. Most MPA coverage  
27 showed minimal protection across Member States, sea regions, and legal types of MPAs. The EU MPA  
28 network likely provides limited ecological outcomes. Reaching the EU's 10% strict protection target  
29 will require radical changes to the regulations on activities in EU MPAs.

30 **Keywords:** Conservation, level of protection, MPA Guide, regulations of human activities, EU  
31 Biodiversity Strategy, marine policy

## 32 **Introduction**

33 Marine Protected Areas (MPAs) have been increasingly used worldwide as a conservation  
34 tool for maintaining marine ecosystems integrity, including through the regulations of human  
35 activities at sea<sup>1</sup>. Yet, the state of marine ecosystems has shown little improvement or continued  
36 deterioration<sup>2</sup>. These developments have led to growing concerns about the benefits of existing  
37 MPAs<sup>3-6</sup>, and increasing calls for policies to focus not only on designating new MPAs but also on  
38 ensuring their effectiveness to maintain or restore ecosystems<sup>1,7</sup>. Indeed, MPAs can have a wide  
39 range of objectives, implemented through various governance systems and levels of regulations (e.g.,  
40 from no-take to areas where most maritime activities can occur). MPAs can have many social (e.g.,  
41 environmental knowledge, conflict management, participation, economic benefits<sup>8-10</sup>) and ecological  
42 impacts. Enforced regulations of activities and active management are key for MPAs to contribute to  
43 restoring and protecting ecosystems and biodiversity (e.g., maintain habitats and their functions, or  
44 increase of biomass<sup>10-16</sup>).

45 The European Union (EU) is at the forefront of marine conservation policies<sup>17,18</sup> and the 22  
46 coastal Member States have so far designated 12% of EU seas as MPAs<sup>19</sup>. MPA policies were driven  
47 by several EU legal instruments, notably the Marine Strategy Framework Directive (MSFD), and most  
48 importantly, the Birds and Habitats Directives that led all Member States to designate MPAs under  
49 the Natura 2000 umbrella<sup>20,21</sup>. In each Natura 2000 MPA, Member States must implement  
50 conservation measures relevant to the species and habitats it was designated for<sup>22</sup>. Finally, in  
51 addition to EU legislation, Regional Sea Conventions have also integrated MPAs in their strategies,  
52 leading to MPA designation under the umbrella of OSPAR (North-East Atlantic Ocean), HELCOM  
53 (Baltic Sea) and Barcelona (Mediterranean Sea) Conventions. These different legal frameworks focus  
54 on ensuring a large and ecologically representative MPA coverage; they do not require (Regional Sea  
55 Conventions) or specify (EU directives) management measures for MPAs. Nature conservation laws  
56 also interact with other legal frameworks, including national legislation and the EU Common Fishery  
57 Policy – for which implementation varies by jurisdiction<sup>20</sup>. This multi-layered legal framework  
58 resulted in a very heterogeneous network, made of national and international designations, and  
59 adapted to national priorities and administrative systems.

60 Despite these existing policies, ecological proxies indicate little or no improvements at EU scale (see  
61 for example assessments from the European Red List and the European Environment Agency notably  
62 based on reporting schemes of EU Directives<sup>23-27</sup>. Insufficient enforcement, funding and staff  
63 capacity, low political prioritization, limited participatory settings, and lack of restrictions on  
64 impactful activities hampered MPAs' ability to fulfill their socio-ecological objectives in the EU<sup>28-32</sup>.  
65 Many EU MPAs lack conservation measures though they are mandatory at least in Natura 2000 MPAs  
66 at EU scale and through several national legal frameworks<sup>21,33-36</sup>. Existing measures are also difficult

67 to assess as they are rarely specified in management plans (national schemes may require  
68 management plans, but it is not mandatory under EU legislation<sup>37,38</sup>. Overall, the few existing  
69 assessments describe low protection levels in different parts of EU seas<sup>20,39–46</sup>.

70 For the first time, the European Commission defined clear but non-legally binding goals regarding  
71 regulations of activities in EU MPAs, that should support the implementation of existing legal  
72 requirements. This was done first through the non-legally binding EU Biodiversity Strategy for 2030,  
73 welcomed by the Council of the European Union<sup>47</sup>, aiming at a 30% coverage of MPAs and Other  
74 Effective Conservation Measures and at 10% of strict protection by 2030 for each sea region. It  
75 considers “strict protection” as “fully and legally protected areas [... where] natural processes are left  
76 essentially undisturbed from human pressures and threats to the area’s overall ecological structure  
77 and functioning”<sup>48</sup>. OSPAR, HELCOM, and Barcelona Conventions also committed to the 30% target  
78 and HELCOM went further in aligning with the 10% target of strict protection. In addition, the  
79 European Commission released the non-legally binding Action Plan to protect and restore marine  
80 ecosystems calling on Member States to “phase out mobile bottom fishing” in Natura 2000 MPAs  
81 under the Habitats Directive by 2024 and in all EU MPAs by 2030<sup>49</sup>. This call was not supported by the  
82 European Parliament<sup>50</sup>. These policies brought an unprecedented focus on regulating human  
83 activities, and so on protection levels. In early 2024, most Member States have yet to present their  
84 pledges and action plans to the European Commission, including the definition and targeted  
85 coverage of strict protection for their national waters<sup>51</sup>.

86 While it would be necessary to monitor the effectiveness of MPA policies, there is no EU-wide  
87 assessment of MPAs’ protection levels. Existing and accessible databases contain dispersed and  
88 limited information on MPAs’ regulations over activities (e.g., Natura 2000, Marine Spatial Plans,  
89 EMODnet, and national databases) that have not yet been gathered to provide an overview at EU  
90 level. Only a few studies provided regional or national assessments<sup>39–42</sup> or analyses using proxies of  
91 protection levels, such as the presence of management plans, types of designations, IUCN categories,  
92 number of overlapping MPAs<sup>42,43,52,53</sup>. Research on the link between these proxies and the levels of  
93 protection through regulation of activities is limited. The IUCN categories, for example, can be taken  
94 as one such indicator, and because they are defined based on main management objectives, they  
95 could be used as a proxy of protection levels (e.g., Jacquemont et al. 2024<sup>54</sup>), or as an example of the  
96 definition of “strict” protection<sup>48</sup>. Management authorities may assign IUCN categories to their MPAs  
97 by following IUCN guidelines on activities compatible with each category<sup>55</sup>, but it is likely that current  
98 reporting does not reflect the levels of regulation on activities<sup>56,57</sup>.

99 This study therefore assesses the protection levels of EU MPAs, based on the potential impact of  
100 activities allowed within their borders. As defined by the MPA Guide framework, MPAs were  
101 classified from minimally protected to fully protected, or considered incompatible with conservation  
102 objectives if some highly impactful activities such as mining could occur (Gorud-Colvert et al. 2021).  
103 To account for uncertainty on regulated activities, we computed two scenarios of potential impacts  
104 and resulting protection levels. In the first scenario, we considered the lowest impact for each  
105 activity, and in the second scenario, we considered the highest. We examined the distribution of  
106 protection levels across EU seas and countries and we hypothesized overall low protection levels.  
107 Finally, we investigated the correlations between protection levels and various MPA features that  
108 have been previously used as proxies of protection levels, with the hypothesis that they are  
109 uncorrelated (i.e., age, protection focus, and reported IUCN categories). We also investigated the  
110 links between protection levels and legal MPA features (designation types and subtypes, the use of a  
111 zoning system with different regulations within MPAs, level of overlapping of multiple designation,  
112 and jurisdictions). We expected stronger protection levels in national waters and nationally-  
113 designated MPAs, particularly because of the shared sovereignty over fishing rights in EU waters and  
114 the lack of specific requirements in Natura 2000 MPAs. While MPAs covered 11.4% of EU waters in  
115 2022, we found that 0.2% were fully or highly protected. Eighty-six percent of EU MPA coverage was  
116 either lightly protected, minimally protected, or incompatible with conservation objectives. This  
117 pattern was consistent across Member States, sea regions, and MPA features. These results show  
118 that current protection levels of EU MPAs are therefore far from the 2030 targets. For EU MPAs to  
119 provide the expected social and ecological benefits, their role in regulating human activities to limit  
120 their negative impacts should broadly be questioned.

## 121 Results

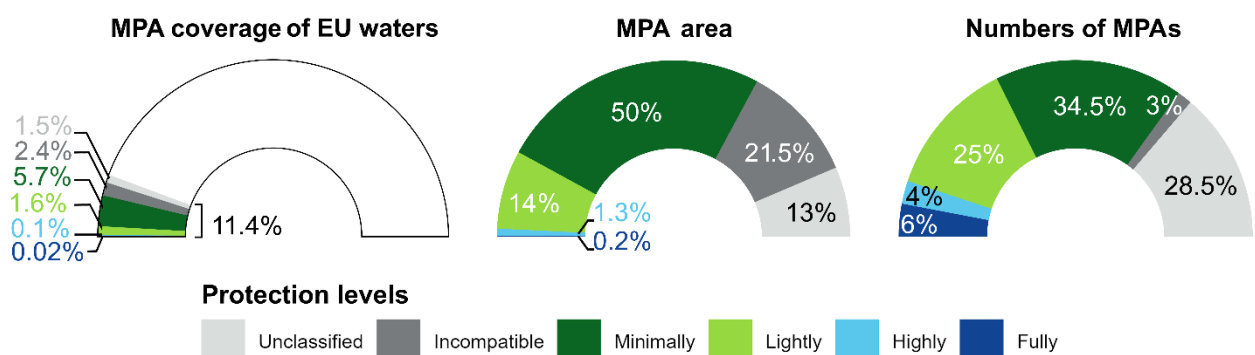
122 For a clear understanding of the results, we first present a brief introduction to the  
123 ‘Experimental procedures’ section that the reader can find at the end of the article. Protection levels  
124 were assigned following a decision tree based on the potential impacts of allowed uses within the  
125 MPA, following the MPA Guide framework<sup>13</sup>. MPAs were classified into four protection levels, i.e.,  
126 fully protected (no extractive activities), highly (low impact activities), lightly (moderate impact  
127 activities) or minimally protected (moderate to high impact activities), or were classified as  
128 incompatible with biodiversity conservation when very impactful or industrial activities can occur  
129 within the MPA<sup>13</sup>. For simplicity, we also grouped protection levels in a two-level classification of  
130 MPAs, in strong (full and high protection) and low (incompatible with conservation, minimal and light  
131 protection) protection. Because the scale and potential impacts of activities were not available at EU  
132 scale, we considered two possible scenarios of impacts for each activity. Scenario 1 considered the

133 lowest potential impacts and scenario 2 the highest (some data were sufficiently detailed to consider  
 134 the same impact for both scenarios). In the results section, when unspecified, we present results  
 135 from scenario 1. To assess our range of uncertainty, we compared our results with two expert-based  
 136 assessments (see the Experimental procedures section, describing the assessments from Horta e  
 137 Costa et al. 2019 and Roessger et al. 2022<sup>41,42</sup>).

138 We assessed protection levels of 4,858 EU MPAs (and their zones when identified) located in EU  
 139 national waters (excluding overseas territories and extended continental shelf; i.e., all MPAs reported  
 140 to the EEA in 2022). We analyzed protection levels by regions, countries, and several MPA features.  
 141 To analyze the correlation between protection levels and MPA features, we conducted Chi-square  
 142 tests. These tests allowed us to assess significant deviations from an independent distribution of  
 143 MPA coverage and differences among features (e.g., distribution of area by protection level across  
 144 different jurisdictions). When computing results in terms of MPA coverage, the highest level of  
 145 protection was retained for areas where different protection levels overlapped. When providing  
 146 results in numbers of MPAs, spatially identical MPAs were only counted once.

147 **EU-wide low protection levels**

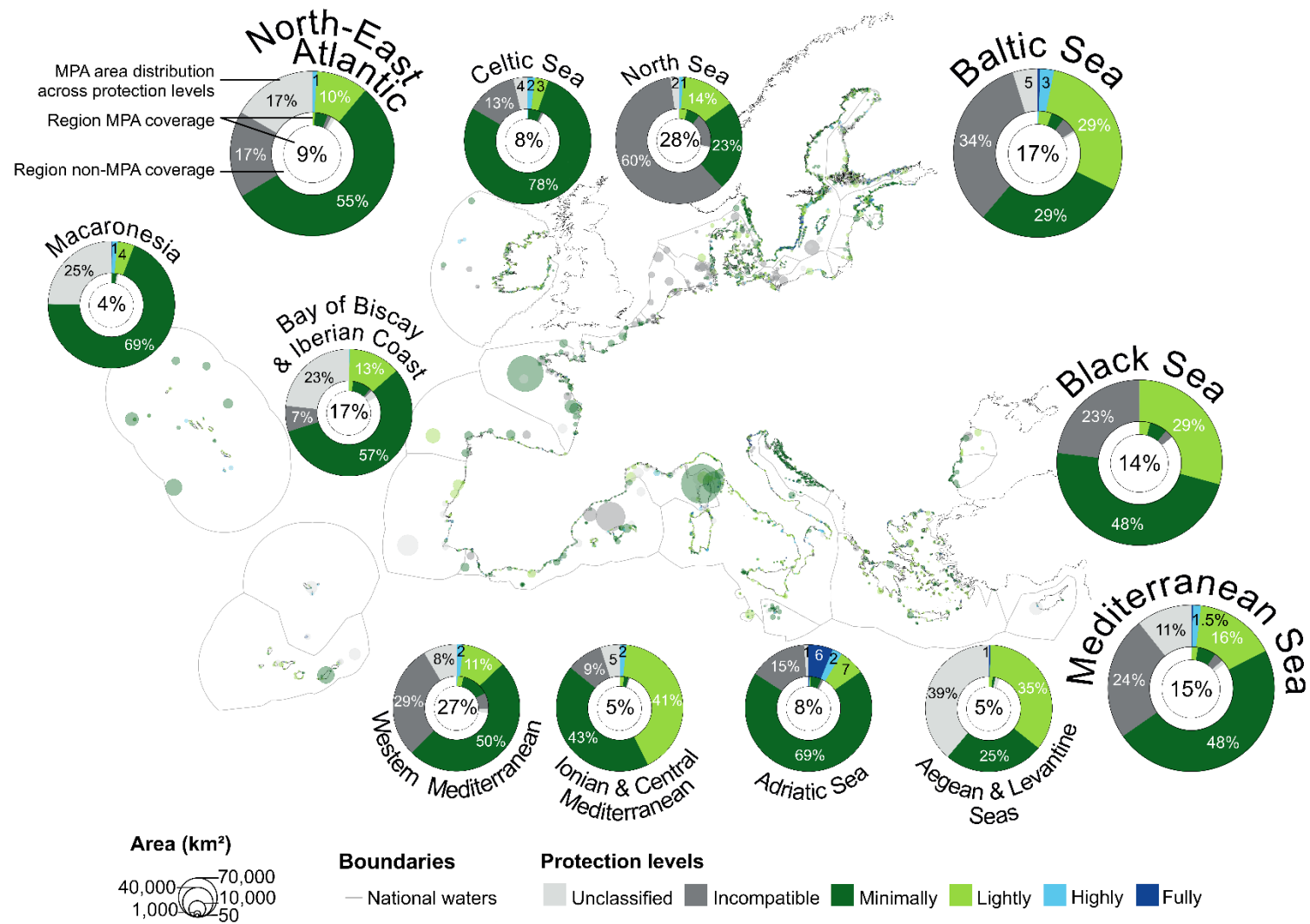
148 In terms of coverage, 11.4% of EU national waters (610,078 km<sup>2</sup>) were designated as MPAs  
 149 as of January 2022. In terms of protection levels, 0.2% of EU national waters were covered by strong  
 150 protection (0.14% of high and 0.02% of full protection), 9.7% by low protection (light or minimal  
 151 protection or allowing activities that are incompatible with conservation objectives), and 1.5% were  
 152 unclassified (Figure 1). Of the total EU MPA area, 1.5% was covered by strong protection, 85.7% by  
 153 low protection, and 12.8% were unclassified (Figure 1 shows detailed protection levels and illustrates  
 154 that despite their low coverage, strongly protected MPAs make up to 8% of MPAs). These results  
 155 changed significantly under scenario 2 (Supplemental experimental procedures). While low  
 156 protection would cover a similar 9.9% of EU waters, strong protection would cover only 0.04%, and  
 157 72.9% of MPA coverage would be classified as incompatible with biodiversity conservation (instead  
 158 of 21.5% in scenario 1).



160 *Figure 1. Distribution of protection levels across EU national waters, relative to the area declared as*  
161 *MPA, and relative to the number of MPAs.*

## 162 **Stronger protection levels in the Mediterranean and Baltic Seas**

163           When analyzing protection levels for the four main sea regions, the largest MPA coverage  
164 was located in the Baltic (16.8%), followed by the Mediterranean (14.8%) and Black (14.2%) Seas, and  
165 the smallest in the North-East Atlantic (9.1%; Figure S1, Table S1). For each, most MPA coverage  
166 could be classified (>80% of classified MPA coverage). Low protection levels were predominant in the  
167 four main sea regions (>80% of MPA area, Table S1) and strong protection covered 0.5% or less of  
168 their area. The highest coverage of strong protection was found in the Baltic and in the  
169 Mediterranean Seas (3% and 1.9% of their MPA area respectively), compared to 1% of the North-East  
170 Atlantic MPA area. No strong protection was described in the Black Sea. Figure 2 details the results  
171 for the subregions included in the main regions presented above (the Mediterranean Sea and the  
172 North-East Atlantic Ocean were subdivided following MSFD subregions).



173

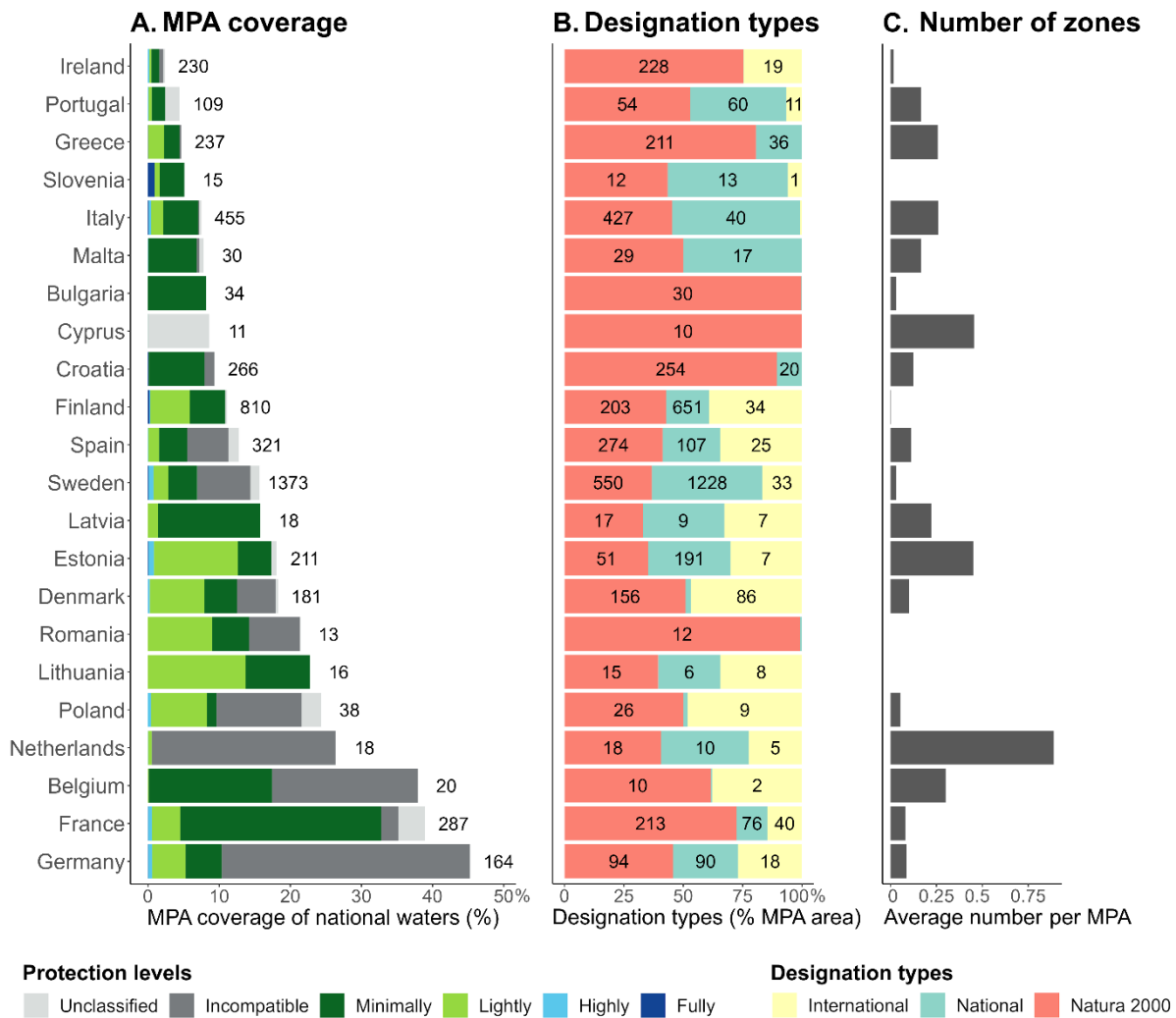
174 *Figure 2. Protection levels of the 4,858 MPAs (and their zones when identified). Distribution of protection levels for the main (bigger pie charts) and*  
 175 *subregions (smaller pies). Only percentage equal or greater than 1% are displayed. Each pie chart consists of two parts: an inner pie chart that shows the*  
 176 *distribution of protection levels across the entire region area (with the percentage of regional MPA coverage indicated at the center) and an outer pie chart*

177 *that shows the distribution of protection levels within the area designated as MPA in the region. Subregions are based on MSFD reporting. The*  
178 *Mediterranean Sea includes the Western Mediterranean, Ionian and Central Mediterranean, Adriatic, and Aegean and Levantine Seas. The North-East*  
179 *Atlantic Ocean includes the Celtic Sea, the Bay of Biscay and Iberian Coast, the North Sea, and Macaronesia. Only EU waters are included in each region.*

180 **Most MPA coverage was under low protection for all Member States**

181           The highest MPA coverage was located in Germany (45.3%), followed by France (38.9%), and  
182 Belgium (37.9%), while the lowest was in Ireland (2.4%), followed by Portugal (4.5%), Greece (4.7%),  
183 and Slovenia (5.1%; Figure 3, Table S2). All but four countries designated MPAs classified as strongly  
184 protected, covering less than 1% of each of their national waters (Figures 2 and 3, see Table S2 for  
185 details). The highest MPA coverage under strong protection was described in Slovenia (18.0% of MPA  
186 area), Ireland (7.1%), Italy (5.7%), Sweden (4.9%), and Estonia (4.7%; see Figure S2 for results in  
187 numbers of MPAs). Twenty states were found to have more than 80% of their MPA area under low  
188 protection levels (Figure 3, most of the remaining area was not classified). Although all countries  
189 showed some differences when comparing scenarios (Figure S3), for 8 countries, all the MPA  
190 coverage under strong protection switched to a low protection level under scenario 2 (including  
191 Ireland, and almost all strong protection coverage for Estonia; both showed among the highest  
192 strong protection coverage in scenario 1). For a broader perspective on national contexts, further  
193 information on national MPA networks (designation types, use of zoning within MPAs, MPA sizes)  
194 and national waters (coverage, coast length) can be found in Figure S2.

195



196

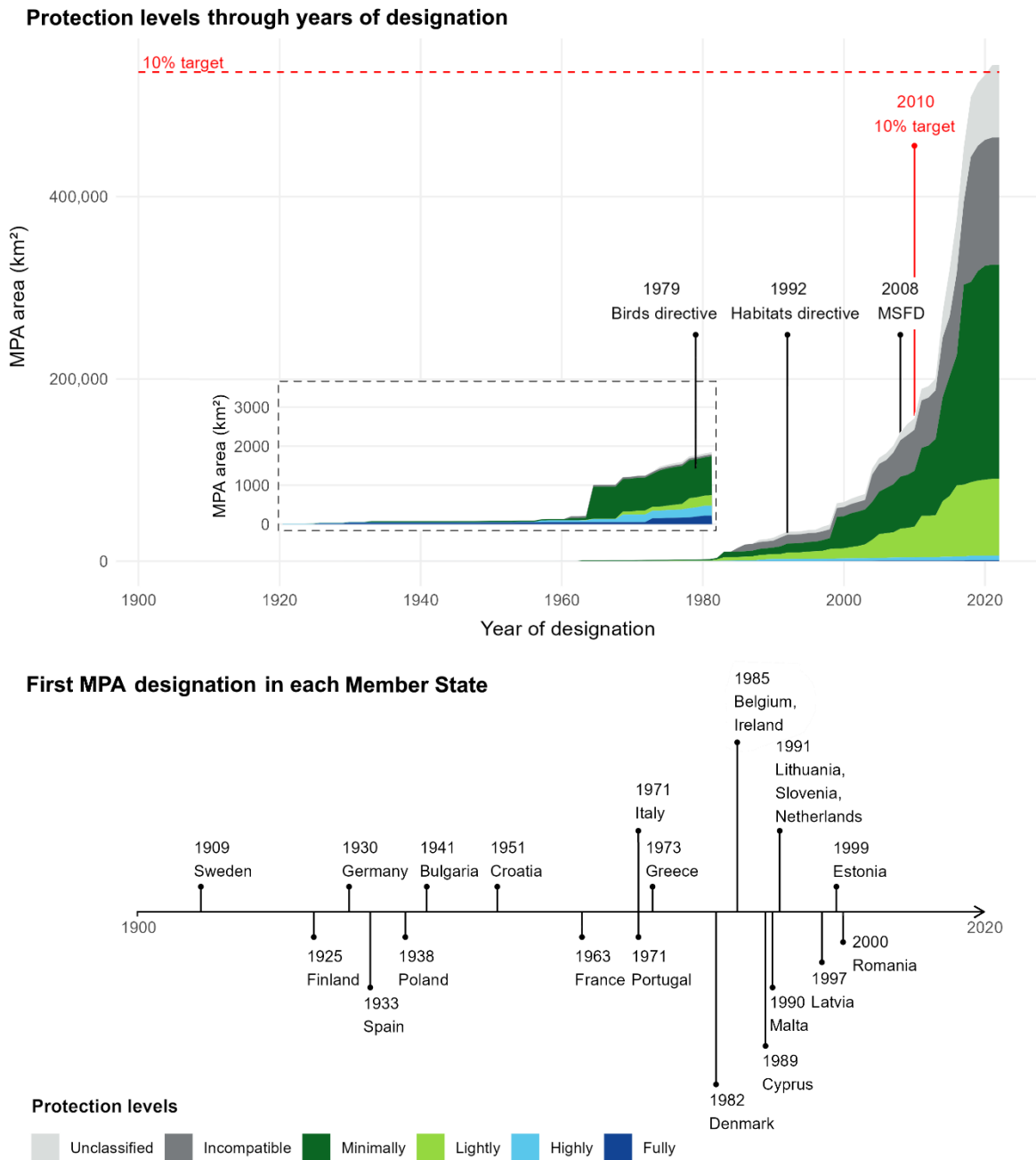
197 *Figure 3. A. Distribution of the protection levels per country. B. Distribution of designation types*  
 198 *(overlapping designations are represented twice; International designations refers to MPAs*  
 199 *designated under the OSPAR, HELCOM or Barcelona conventions; the number of MPAs for each*  
 200 *designation type is overlaid on the barplots). C. Average number of zones per MPA.*

201 **MPA features: national designations and earlier designated MPAs showed stronger protection**  
 202 **levels**

203 The first EU MPA was designated in Sweden in 1909 and the EU MPA coverage started to  
 204 rapidly increase in the 2000s (Figure 4). The relative coverage of low protection levels increased in  
 205 later designations, accounting for at least 60% of the cumulative MPA coverage since the 1960s  
 206 (Figure 4; Spearman correlation coefficient = 0.7, p-value <0.001, Figure S4). Regarding jurisdictions,  
 207 the majority of EU MPAs were located in nearshore waters (66.2%; i.e., up to 1nm, but see  
 208 Experimental procedures), while most of the MPA coverage was located in territorial waters (30.1%;  
 209 the 12 nm zone) and in offshore waters (54.6%; beyond 12 nm; Figure 2). Higher coverage of strong  
 210 protection was found in territorial (2.1% of MPA coverage) and nearshore waters (5.0%; compared to  
 211 1% in offshore waters; Figure 5A and see Figure S5, which shows significant deviations from an

212 independent distribution of protection levels for each jurisdiction and differences among  
 213 jurisdictions, Chi-square=48,560, df=10, p-value <0.001).

214



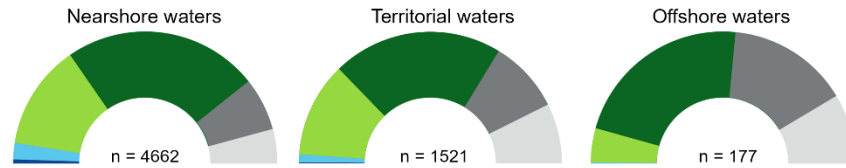
215

216 *Figure 4. Area per protection level plotted against year of designation (the current protection levels*  
 217 *are displayed for the 4,858 MPAs and their zones, see Figure S4 for further analyses). An overlay plot*  
 218 *presents the MPA coverage for the 1920-1980 period for readability. Main EU policies are indicated in*  
 219 *black (MSFD= Marine Strategy Framework Directive). The dashed red line indicates the 10% coverage*  
 220 *threshold for EU national waters, based on the United Nations “Aichi” target 11 towards 2020,*  
 221 *adopted in 2010. The second plot shows the year of designation of the first reported MPA for each*  
 222 *country.*

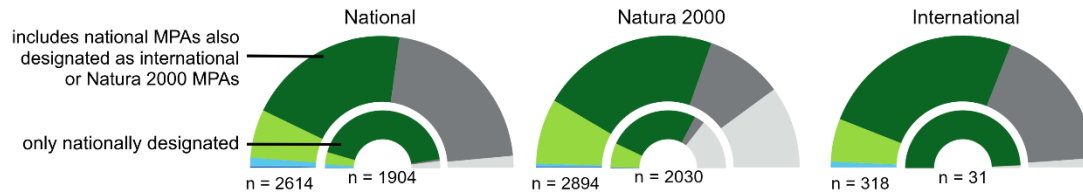
223 Most MPA coverage was designated as Natura 2000 MPAs (72.1%, Figure 3B). National designations  
224 showed the highest coverage of strong protection (Figure 5; see Figure S5, Chi-square=112,813,  
225 df=10, p-value <0.001, and see Figure S6 for results in numbers of MPAs). Most of the area classified  
226 as incompatible with conservation objectives was found in MPAs designated both nationally and  
227 internationally (under Regional Sea Conventions). As a result, almost no area was described as  
228 incompatible when excluding MPAs designated under multiple designations (Figure 5B, internal pies).  
229 Some subtypes of nationally designated MPAs showed higher coverage of strong protection (e.g.,  
230 “sanctuary”, “biotope protection site”, “private reserve”, “reserve”, and to a lesser extent “national  
231 park”; Figure S7). However, at the scale of each country, most of the subtypes showed significant  
232 coverage of low protection (Figure S8). MPAs were highly overlapping, with each MPA overlapping  
233 with three other MPAs on average. The accumulation of overlapping designations was not correlated  
234 with strong protection levels, though strongly protected MPAs were often fully included in other  
235 designations (Figure S9). MPAs were particularly found to be divided into multiple zones with  
236 different regulations in Netherlands, Cyprus, Estonia, Belgium, Italy, and Greece (Figure 3C; note that  
237 since zones were not reported in the European MPA database, we identified them from other data  
238 sources, and they could represent either MPA legal zoning or other spatial management tool within  
239 the MPA). Though it greatly varied between countries, only 11.9% of zone coverage was classified as  
240 strongly protected (e.g., overall, zones in Greece were fully protected; Figure S10).

241 Regarding MPA protection focus, higher coverage of strong protection was found in MPAs  
242 designated for ecosystems (focus summarized from management plans; Figure 5; Chi-square=26,080,  
243 df=10, p-value =0.001). Finally, we compared the protection levels described in this study with the  
244 IUCN categories reported to the World Database of Protected Areas by management authorities,  
245 which should illustrate MPAs’ management objectives. MPAs from all IUCN categories showed  
246 predominance of low protection levels (Figure 5). However, none of the MPA coverage reported as  
247 IUCN categories Ia or Ib were classified as incompatible with biodiversity conservation and categories  
248 IV, V, and VI showed lower coverage of strong protection (Figures 5, S5 and S6; Chi-square=141,586,  
249 df=35, p-value =0.001).

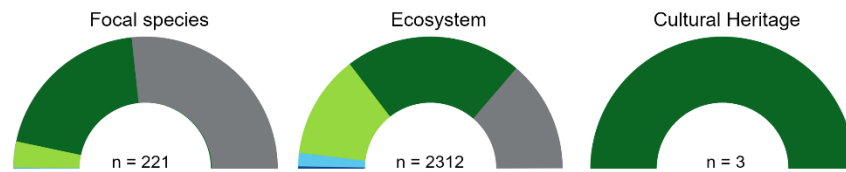
### A. Jurisdictions



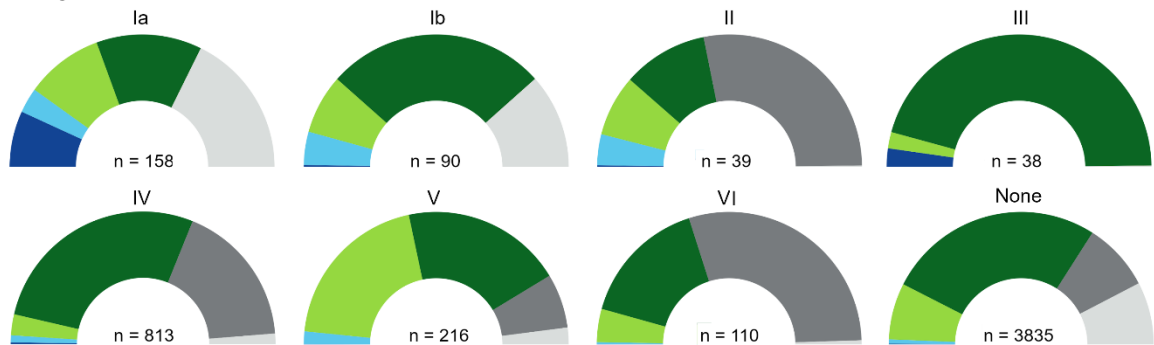
### B. Designation types



### C. Protection focus



### D. IUCN categories



250

251 *Figure 5. Distribution of protection levels (in relative MPA coverage) across A. jurisdictions (note that*  
 252 *MPAs can overlap multiple jurisdictions), B. designation types (International designations refers to*  
 253 *MPAs designated under the OSPAR, HELCOM, or Barcelona conventions), C. protection focus*  
 254 *categories, and D. IUCN categories (in all plots, zones are included in coverage calculations). Numbers*  
 255 *of MPAs are given inside of each plot. In B, the external pie charts include all MPAs of the designation*  
 256 *type of interest, the internal pie charts include only MPAs solely of the designation type of interest*  
 257 *(i.e., MPAs designated only as national, international, or Natura 2000 MPAs, where the legislation is*  
 258 *specific to that designation). In C, jurisdictions are defined as nearshore (0-1 nautical miles, though*  
 259 *the delimitation varies significantly), territorial waters (1-12nm) and offshore waters (up to 200nm).*  
 260 *In D, IUCN categories were reported by states to the WDPA database (because we merged spatially-*  
 261 *identical MPAs, one MPA can have been reported under multiple IUCN categories), and theoretically*  
 262 *correspond to MPAs managed: Ia as strict nature reserves, Ib mainly for wilderness protection, II for*  
 263 *ecosystem protection, III to protect a natural monument/feature, IV to manage a habitat/species, V*  
 264 *for seascape conservation and recreation purposes, and VI for sustainable use of natural resources.*  
 265 *Statistical analyses are shown in Figure S5.*

## 266 Discussion

267 Our study shows that the large majority of EU MPAs (62.2%) and MPA coverage (85.7%) are  
268 under low protection regimes (lightly, minimally protected, or incompatible with biodiversity  
269 conservation), across all Member States, regions and MPA features. We also show that only 1.5% of  
270 the MPA area is under strong protection (fully and highly protected), representing 0.2% of EU  
271 national waters.

272

273 Despite our efforts to gather the most up-to-date and detailed data, computed protection  
274 levels can only result from the current limited standardized reporting schemes regarding MPA  
275 regulations<sup>58</sup>, and highly heterogeneous efforts across countries to integrate regulations in  
276 management plans or report them in MSPs and other databases, despite existing guidelines  
277 available<sup>22,59</sup> (see also Aminian-Biquet et al. in prep<sup>60</sup> on database incompatibility). Our study also  
278 highlights that several descriptors of MPA objectives (i.e., IUCN categories, designation types) are  
279 likely not representative of regulations over activities and, as they are currently reported, cannot be  
280 used as indicators of protection levels. Overall, our study shows that, although Member States  
281 already bear a heavy reporting load<sup>61</sup>, data collection and reporting schemes about regulations in EU  
282 MPAs have to improve rapidly to enable effective monitoring of the implementation of the EU strict  
283 protection target.

284 Given the current data availability, classification systems assigning levels of protection based on the  
285 legal framework are among the most accessible methods to evaluate some of the potential effects of  
286 MPAs at large scale (i.e., assessing activity regulation rather than *in situ* activity intensity; see also  
287 Sullivan-Stack et al. 2022 and Pike et al. 2024<sup>62,63</sup>), notably because data on activities pressures and  
288 impacts is still insufficient to assess the actual ecological consequences of MPA policies in Europe<sup>64</sup>.  
289 In addition to the data limitation, such classification systems focus on fisheries and activities  
290 historically recognized as highly impactful, such as mineral extraction<sup>4,57,65,66</sup>. Other activities,  
291 including land-based ones, could impact marine ecosystems, and should be better incorporated into  
292 the assessment and management frameworks of MPAs, especially since many (EU) MPAs include a  
293 terrestrial part. Finally, such a legal-focused classification system cannot capture all the social-  
294 ecological processes taking place in MPAs, including the level of enforcement, the tacit rules in place,  
295 or changes in practices driven by the implementation of the MPA<sup>8</sup>.

296

297

298 Our goal was to provide the most reasonably comprehensive study at EU scale, as a basis for  
299 ongoing and future discussions on EU MPAs' protection levels. High rates of low protection levels in  
300 EU MPAs were expected<sup>20</sup>. Indeed, even based on the lowest range of impacts, our assessment  
301 showed that most of the MPA coverage would be minimally protected, while our second scenario,  
302 considering higher impacts, described most MPA coverage as incompatible with biodiversity  
303 conservation. The results from the second scenario seem more aligned with findings from former  
304 regional studies and other assessments of threats found in EU MPAs and seas<sup>39,41,67–69</sup>. Indeed,  
305 Roessger et al. (2022) described 60% of OSPAR MPAs as “unprotected”, and Claudet et al. (2020)  
306 classified 72.6% of Mediterranean MPAs (including non-EU) as “unprotected” or “not regulated”. The  
307 reality of what protection and regulations EU MPAs provide probably lies somewhere in between  
308 these two scenarios. Yet, both scenarios pointed to limited ecological outcomes from EU MPAs, even  
309 if MPAs with lower protection levels can to some extent provide ecological benefits<sup>16,70</sup>, and can act  
310 as spaces of education, innovation, and collaboration<sup>8</sup>.

311 Our study highlights significant differences across regions and Member States in data availability,  
312 protection levels, and the use of designation types and subtypes. The Mediterranean and Baltic Seas  
313 showed relatively higher coverage of strong protection compared to the North-East Atlantic Ocean,  
314 and we did not find any strong protection in the Black Sea. Most MPA coverage in the Black Sea was  
315 described as minimally or lightly protected, which might result from the later development of MPA  
316 designation and management in the region<sup>21,71</sup>. However, the identified critical lack of data in the  
317 Black Sea prevents us from drawing any firm conclusions<sup>72</sup>, as most activities, except fisheries, were  
318 poorly known<sup>72</sup>. The Atlantic part of EU waters showed low protection overall and our estimation of  
319 1% of strong protection could be an overestimation<sup>41</sup>, especially given that half of that coverage  
320 would be under low protection regime in the second scenario (e.g., all of it in Ireland). It is, however,  
321 worth noting that in addition to MPAs, other fisheries management tools have been deployed in the  
322 region<sup>73</sup> (e.g., closure to bottom fishing gears in Vulnerable Marine Ecosystems<sup>74</sup>). A relatively higher  
323 coverage of strong protection was expected in the Mediterranean<sup>21</sup> where the implementation of  
324 strong protection may have been facilitated by the MPA design approach to divide MPAs into zones  
325 with different regulations (as illustrated by Greece in our results). This approach has been frequently  
326 used in the Mediterranean<sup>73</sup>, for example to protect Posidonia meadows. We also found strongly  
327 protected MPAs that had no zoning system, notably in the Baltic, where the prevalence of strongly  
328 protected MPAs was mostly driven by Estonia, Sweden and Finland (note that for Finland, half of the  
329 area under strong protection in scenario 1 is downgraded to low protection in scenario 2, and 95%  
330 for Estonia). Though still showing high rates of low protection<sup>46</sup>, strong protection was expected to  
331 be found in Sweden and Finland, as their management systems includes local units and their long

332 history of establishing MPAs have been documented<sup>30,75</sup>. Enforcing these stronger levels of  
333 protection to secure social-ecological benefits remains a recurring challenge<sup>14</sup> (in part due to under-  
334 capacity<sup>28,29</sup>), including in the Mediterranean and Baltic Seas<sup>30,76,77</sup>, where we described higher  
335 coverage of strongly protected MPAs.

336 National designations were the most frequently used to create strongly protected MPAs, as we  
337 described for all Member States and as previously observed in the Mediterranean<sup>21</sup>. This was also  
338 clear in countries showing the highest rates of strong protection (relatively to their MPA area; e.g.,  
339 Sweden, Estonia and Italy, although Natura 2000 SAC MPAs make up to 40% of Italian strongly  
340 protected MPAs), except in Greece where Natura 2000 was the main MPA instrument<sup>21</sup>, including for  
341 strong protection. These countries and others relied on “reserves” to create strong protection, a type  
342 of MPA expected to show high restrictions<sup>78,79</sup>. Yet, designations referred to as “reserves” also  
343 showed high rates of light or minimal protection in most countries and their objectives highly vary  
344 given that they can be designated, for example, as private reserves in Finland<sup>80</sup> or fishery reserves in  
345 Spain<sup>81</sup>. This clearly shows how the nomenclature and the use of MPA subtypes to implement  
346 specific protection levels is highly country specific. In comparison to nationally-designated MPAs,  
347 Natura 2000 (except for Greek and Italian MPAs, as described above) and international designations  
348 showed smaller coverage of strong protection, were younger and larger, and represented most of  
349 the MPA coverage in territorial and offshore waters. The legal frameworks of these designations  
350 (requirements from Regional Sea Conventions, or EU directives transposed into national law) did not  
351 initially set obligations to specifically regulate activities, and continue not to<sup>37,82</sup>. At least in territorial  
352 waters, Member States could have used similar (if not the same) legal tools to implement them as for  
353 nationally designated MPAs. Indeed, national MPAs and Natura 2000 designations very often  
354 overlap, without any additional protection in terms of regulations (rejecting the use of overlapping  
355 designations as a proxy for protection levels<sup>43</sup>). It is, however, worth noting that in offshore waters,  
356 where most protection coverage is designated as Natura 2000 or international MPAs, states need to  
357 negotiate with other EU fishing fleets in their Economic Exclusive Zone, because of the Common  
358 Fishery Policy<sup>20</sup>. These offshore MPAs have therefore been designated knowing that it might take  
359 time and substantial efforts (if even achievable under the current legal framework) to develop any  
360 relevant regulations on fisheries. So far, little effort to regulate fisheries in offshore EU MPAs has  
361 been deployed by Member States under the EU policy framework<sup>20,21</sup>.

362

363 Reflecting on commonalities in EU MPAs and their policy context can help uncover reasons  
364 for low protection levels and inform future strategies. Many MPA-related policies were developed in

365 the past decades, at the EU (directives, implementation guidance, rulings, successive biodiversity  
366 strategies) and international levels, such as the current United Nations Global Biodiversity  
367 Framework, which aims at 30% MPA coverage. These policies led to the development of legal  
368 frameworks and institutions to create and manage MPAs<sup>21,83–86</sup>, and resulted in a relatively large MPA  
369 coverage<sup>20,87</sup>. However, it also contributed to the overall and increasing designation of MPAs that  
370 lightly or minimally regulate human activities. Strong protection levels were found in most countries  
371 but were restricted to small MPAs, which covered a very small area of EU waters. Although other  
372 factors could play a role, this trend of limited MPA protection is facilitated by the current legal and  
373 policy frameworks. First, and as mentioned above, EU directives, like the Habitat Directive or the  
374 MSFD, were flexible when it came to setting up conservation measures in MPAs, in terms of what to  
375 regulate and when to reach objectives<sup>88,89</sup>. This likely contributed to limited prioritization to  
376 implement strongly protected MPAs across EU seas. The limited specificity and voluntary  
377 requirements from other international agreements such as the Regional Sea Conventions and the  
378 Aichi targets might also have contributed to low protection levels<sup>82,90,91</sup>. Even with this flexibility,  
379 Member States have shown recurrent non-compliance<sup>92,93</sup>.

380 While we have so far focused on environmental policies in the EU, other maritime policies, such as  
381 the Common Fishery Policy and “Blue economy” initiatives, have a much more economic scope,  
382 often diverging from biodiversity protection<sup>20,94–96</sup>. Protection levels of EU MPAs revealed and  
383 resulted from deep-rooted conflicts between economic activities (including for livelihood) and  
384 biodiversity protection. Conflicts emerged from stakeholders’ diverging values and interests on one  
385 hand (also due to limited support of capacity to change their activity), and perceptions and  
386 expectations of MPAs on the other<sup>31,76,97–100</sup>. In some contexts, stakeholders could converge towards  
387 implementing strongly protected MPAs (see for example Bennett et al. 2019) but in many EU MPAs,  
388 low protection levels could be the result of short-term conflict avoidance. In fact, EU MPAs cover so  
389 much of EU nearshore and territorial waters<sup>19,33,102</sup>, that if MPAs were meant to strictly restrict  
390 human activities, conflicts would be inevitable.

391 Although MPAs and their contexts around the world differ greatly and cannot simply be compared to  
392 the EU context, MPA policies are increasingly important (e.g., 118 countries joined the High Ambition  
393 Coalition for Nature and People, aiming to protect 30% of the ocean). Some countries implemented  
394 relatively larger coverage of stronger levels of MPA protection compared to the world trend (e.g.,  
395 South Africa, Palau; Kirkman et al. 2021, Gruby et al. 2021; see the MPA assessments reported in the  
396 MPAtlas; Marine Conservation Institute 2024), while others are now engaging in strengthening the  
397 restrictions of activities in their MPA network (e.g., UK to ban bottom mobile gears in several MPAs;  
398 Pieraccini 2023). As we described in the EU, low levels of protection are still common<sup>4,62,63,107</sup>, and

399 any large-scale action to strengthen their regulation will require significant resources to ensure  
400 conflict management, notably through stakeholder participation, the deployment of measures to  
401 ensure justice, and stakeholders' compliance and adaptation<sup>108–110</sup>. Such actions can be informed and  
402 accompanied by in-depth investigations, so far too limited, into the social (institutional, historical,  
403 political, cultural) contexts of MPAs and their consequences for levels of protection<sup>8,31,111–114</sup>.

404

405 In conclusion, we found that protection levels were generally low across all EU seas and MPA  
406 features, likely providing limited ecological outcomes. There is now a growing push for stronger  
407 protection, as illustrated by the strict protection target set by the 2030 EU Biodiversity Strategy and  
408 the restriction of mobile bottom fishing gears in MPAs highlighted by the Action Plan. By putting  
409 pressure on Member States to make decisions, these targets are contributing to repoliticizing  
410 protection levels of EU MPAs (e.g., for MSPs, see Tafon et al. 2019<sup>115</sup>). Some EU states have already  
411 made commitments to strengthen regulations in their MPAs (e.g., France, Greece<sup>116,117</sup>). Actors are  
412 forming coalitions (e.g., “Blue up 2024!” for ocean protection or the European Bottom Fishing  
413 Alliance), gathering recognition and power to support their demands. Ultimately, these EU and  
414 national processes could lead to institutional and cultural change and set the context for improved  
415 MPA participation and enforcement<sup>118</sup>. This could lead not only to greater ecological outcomes but to  
416 increased social benefits (e.g., social and economic capital), as illustrated by several smaller scale  
417 examples<sup>81,119</sup>. It now really depends on Member States to address threats to marine ecosystems  
418 through different tools, including strongly protected MPAs and means to manage current conflicts.

419

## 420 Experimental procedures

### 421 **Resource availability**

#### 422 *Lead contact*

423 Further information and requests for resources and reagents should be directed to and will be  
424 fulfilled by the lead contact, Juliette Aminian-Biquet ([juliette.biquet@lilo.org](mailto:juliette.biquet@lilo.org)).

#### 425 *Material availability*

426 The main material generated in this study (MPA list and polygons with protection levels and studied  
427 features) and the R code to analyze and plot the data have been submitted together with the  
428 manuscript.

#### 429 *Data and code availability*

430 The data and code on protection levels generated for this study was made available in figshare at the  
431 following link (DOI: 10.6084/m9.figshare.25103450): <https://figshare.com/s/6a2c54f68567fff1c3b0>

432 The full database will be made available in Data in Brief (Aminian-Biquet et al. in prep), including all  
433 data sources, and data formatted by activity.

#### 434 **Scale of analysis**

435 We investigated protection levels at i) EU, ii) regional, and iii) national scale (the Pelagos  
436 international designation was excluded from national analyses). For ii) regional analyses, we reported  
437 protection levels for the four main regions considered in the Marine Strategy Framework Directive  
438 (MSFD), i.e., the Black Sea, Mediterranean Sea, North-East Atlantic and Baltic Sea, and their  
439 subregions (listed in Figure 2). For iii) national analyses, we considered "national waters" as the  
440 fusion of three jurisdictions (Table S2): nearshore waters<sup>120</sup> (0-1 nautical miles but their delimitation  
441 varies significantly<sup>121</sup>), territorial waters (up to 12 nautical miles for most Member States<sup>120</sup>), and  
442 offshore waters of the Economic Exclusive Zones (EEZ, beyond 12 nm up to 200 nm<sup>122</sup>). All polygons  
443 used have been filtered with MSFD polygons to extract their marine area<sup>123</sup>. For this, we excluded  
444 MSFD areas from non-EU states and high seas (excluding the Portuguese extended continental shelf).

445 When computing results in terms of coverage, polygons were merged by protection levels so that no  
446 area would be counted multiple times (the strongest protection levels have been retained for areas  
447 where different levels of protection overlap). All analyses were run on QGIS and R, notably using sf  
448 and ggplot2 packages<sup>124–126</sup>.

#### 449 **EU MPA list and marine sea regions**

450 We extracted 6,414 MPA polygons listed in the 2023 MPA database in EU states national  
451 waters from the European Environment Agency (EEA), including national, Natura 2000, and  
452 international designations (MPAs designated up to January 2022 and database accessed in February  
453 2023<sup>127</sup>). So-called international MPAs included MPAs designated in national waters under the  
454 OSPAR in the North-East Atlantic, HELCOM in the Baltic Sea and Mediterranean Sea Conventions,  
455 including the national and international parts of the Pelagos sanctuary. This analysis excluded MPAs  
456 in the extended continental shelf and MPAs' overlapping part with Monaco waters. Overlapping  
457 MPAs were merged into one MPA if they both shared at least 90% of their area or if they shared  
458 more than 70% and had the same name (whatever their designation, see Aminian-Biquet, in prep.),  
459 resulting in 4,858 MPAs after merging (Figure 6; this merging only influences results in terms of  
460 numbers of MPAs).

461 Finally, we extracted 504 zones identified in the MAPAMED database<sup>128</sup>, the Protected Seas  
462 Navigator<sup>129</sup> (2021), from the assessment of OSPAR MPAs (see Roessger et al. 2022<sup>41</sup>), and from the  
463 Portuguese assessment presented further below (based on Horta e Costa et al. 2019<sup>42</sup>). We  
464 considered as zones the polygons from these databases that were completely included in EEA MPAs  
465 without matching any of the EEA MPA polygons. These zones could represent either MPA legal  
466 zoning or another spatial management tool fully included in a MPA (e.g., fishery restriction zone).

#### 467 **Datasets on human activities in EU MPAs**

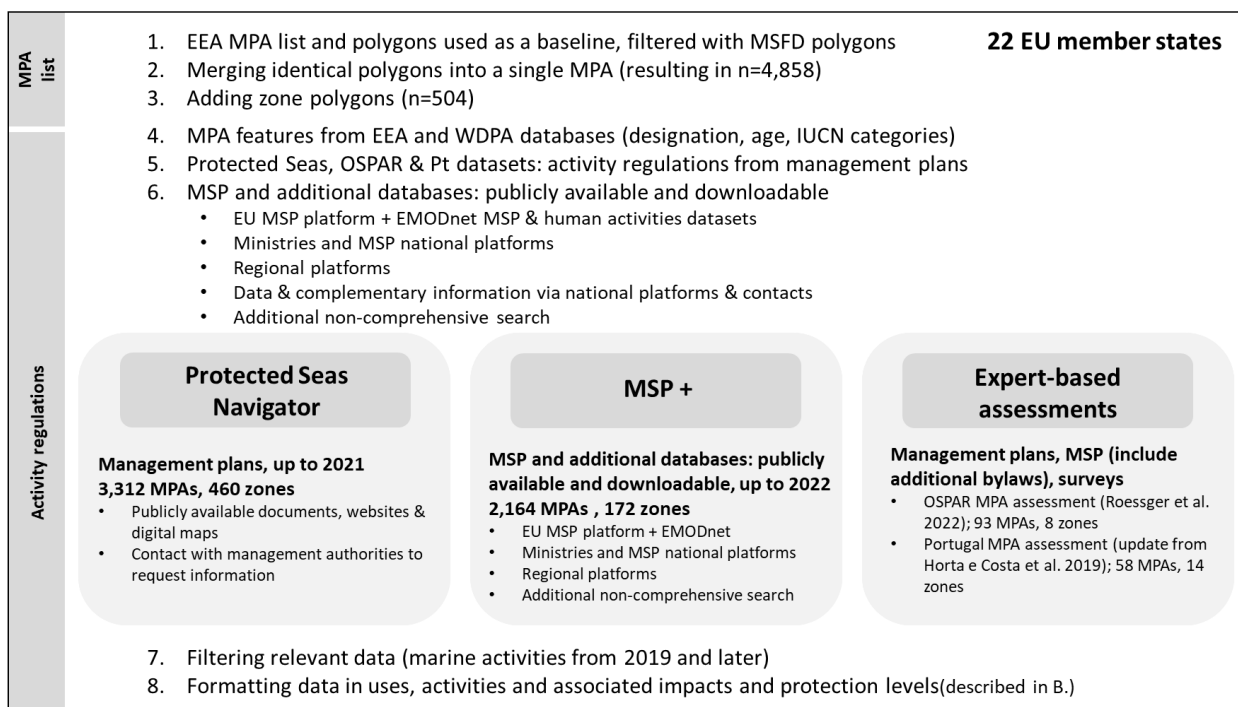
468 To compute protection levels, we searched for activities regulations in EU MPAs for the  
469 seven activities considered in the MPA Guide: mineral extraction (mining), dredging and dumping,  
470 anchoring, infrastructures (e.g., harbors, wind parks), aquaculture, fisheries, and non-extractive uses.  
471 When available, detailed types of uses (e.g., fish or algae aquaculture) were gathered in these  
472 activities (**Erreur ! Source du renvoi introuvable.**).

473 We gathered information from four different sources (**Erreur ! Source du renvoi introuvable.**; see  
474 Aminian-Biquet, in prep. for data collection and detailed description), on activities' allowances,  
475 prohibitions or restrictions, independently of the on-the-ground implementation of the regulation or  
476 whether the activity was indeed occurring. First, we used the Navigator data gathered by Protected  
477 Seas (hereafter PS), gathered up to 2021<sup>129</sup>. It included regulations of some activities (especially  
478 fisheries) explicitly mentioned in the management plans as allowed, restricted, or prohibited, and  
479 fisheries were formatted as a level of fishing protection score.

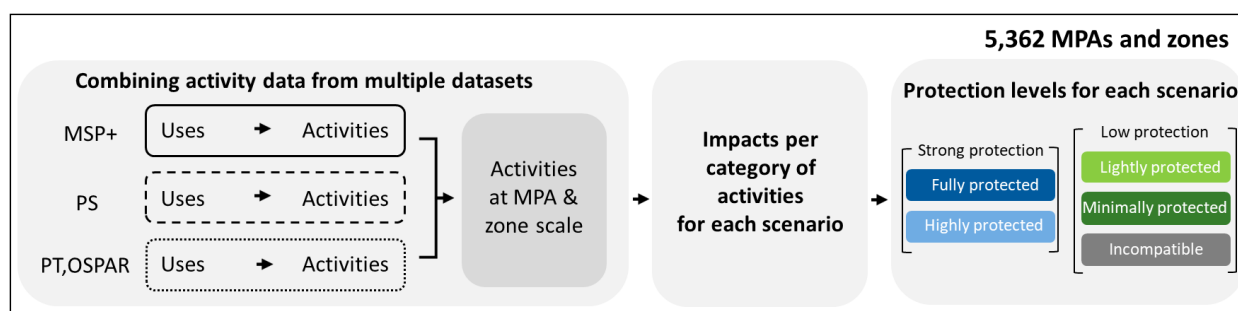
480 To overcome the lack of data from MPA-related legal texts, we gathered regulations available and  
481 downloadable as geospatial data from i) national marine spatial plans (MSP) extracted from national  
482 webpages and ii) additional national or regional databases<sup>122,130,131</sup>. Data search was conducted  
483 between April 2022 and September 2022. Data was filtered for activities overlapping with MPAs (in  
484 case of polygons about allowances, it should cover at 10% of the MPA area, 90% in case of polygons  
485 about prohibitions) from 2019 or later (2016 for harbors and ports). This dataset is referred to as  
486 MSP+.

487 Finally, we used two document- and expert-based assessments. The OSPAR MPA assessment  
488 (hereafter OSPAR) was based on management plans, GIS databases provided by some managers and  
489 surveys conducted by Roessger et al. (2022) between 2020 and 2021. The Portuguese MPA  
490 assessment (hereafter PT) was based on management plans and MSP analyses conducted up to 2022  
491 (based on Horta e Costa et al. 2019).

## A. Data collection and processing



## B. Formatting data in uses, activities and associated impacts and protection levels

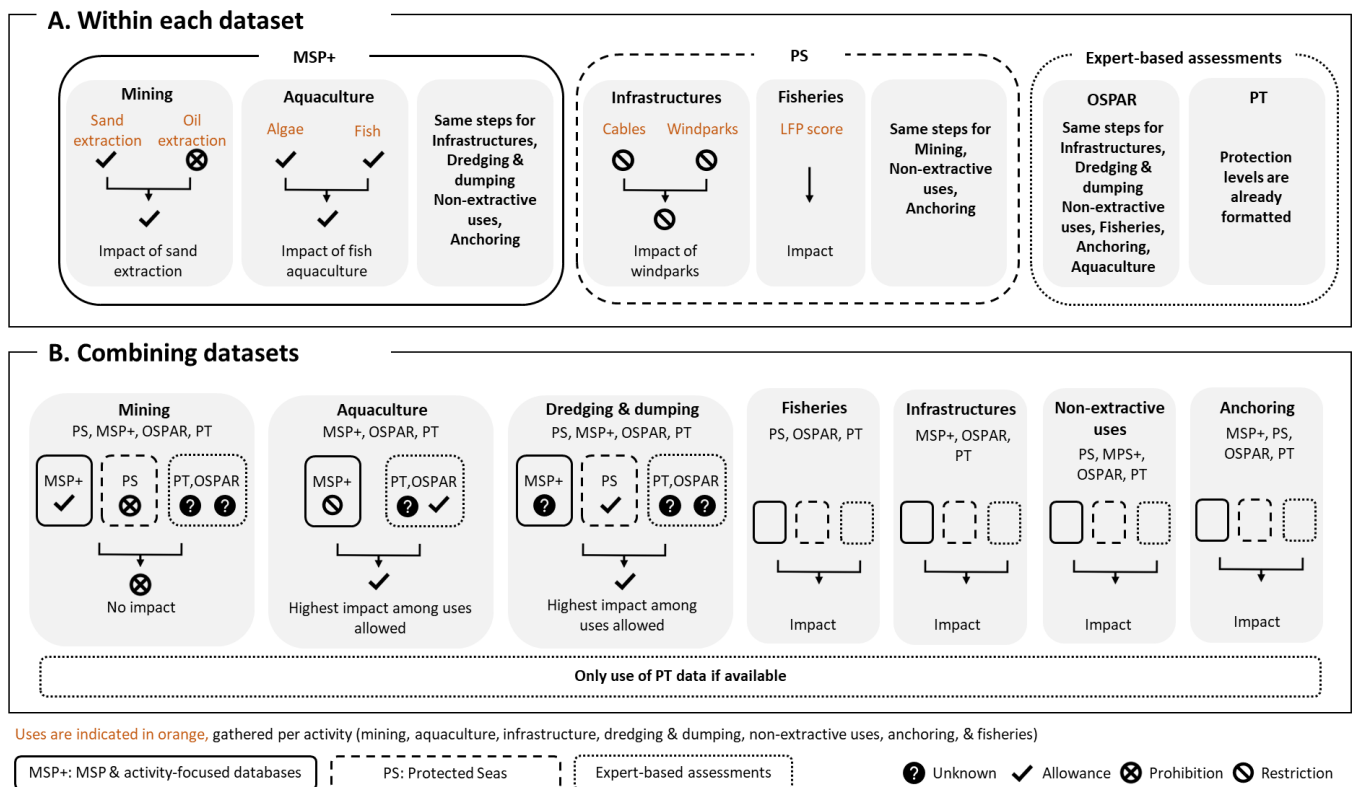


492

493 *Figure 6. A. Data collection, datasets summary, and data cleaning procedure (see Figure 7 for the*  
 494 *activities reported in each dataset). B. Protocol to compute protection levels, starting from uses, to*  
 495 *activities, to impacts, to protection levels (for more details on each step, see Figures 7 and S13).*

## 496 Combining datasets for each activity

497 For each dataset, we grouped detailed uses into the seven activities considered in the MPA  
 498 Guide (Figure 7A). If one of the types of uses was allowed, the activity it belonged to was considered  
 499 as allowed. We then combined datasets for each activity (when available for a given MPA or zone;  
 500 Figure 7B). When combining datasets, if one dataset reported an activity as prohibited, it was  
 501 considered as prohibited (i.e., even if another dataset reported it as allowed, Figure 7B). When  
 502 available, data from the PT dataset was prioritized over other datasets, as the most recent and more  
 503 detailed assessment.



504

505 *Figure 7. A. Protocol for categorizing uses by activity. B. Protocol to combine data for each activity*  
 506 *from the four datasets. We computed two scenarios of potential impacts.*

507

508            The scale and potential impacts of activities were not available at EU scale. We therefore  
 509 considered two possible scenarios of impacts for each use. Scenario 1 considered the potential  
 510 lowest impacts and scenario 2 the highest (they could be the same if information was detailed  
 511 enough). Within each scenario, if an activity was considered as allowed, its impact was computed as  
 512 the highest impact among the allowed uses of this activity, for the two scenarios of impacts (e.g., if  
 513 aquaculture was allowed, its impact would be that of fish aquaculture and not of algae aquaculture if  
 514 both are allowed, Figure 7). Maps of impacts under scenario 1 are provided in Figure S11.

515 Finally, when mining, dredging/dumping or infrastructures were reported as restricted within an  
 516 MPA or zone (and no other dataset indicated an allowance), we considered that their allowance  
 517 could be dependent on the approval from another authority, potentially leading to their prohibition.  
 518 These activities have therefore been considered as allowed under scenario 1 and as prohibited in  
 519 scenario 2.

520 **Classifying protection levels based on two scenarios**

521 Protection levels were computed following the decision tree from the MPA Guide<sup>132</sup>,  
522 adapted to the scales of impacts known for each activity, presented for the two scenarios in Figures  
523 S12 and S13. MPAs were classified into protection levels, from fully protected to minimally  
524 protected, or were classified as incompatible with biodiversity conservation (Gorud-Colvert et al.  
525 2021). We also grouped protection levels in a two-level classification of MPAs, in strong (full and high  
526 protection) and low (incompatible with conservation, minimal and light protection) protection. The  
527 classification does not consider the combined impacts of multiple activities allowed simultaneously  
528 (e.g., if mining and fishing were allowed, the protection level was based on mining activities only).  
529 Unknown activities did not downgrade the protection level, as if they had been prohibited.

530 Protection levels were computed for MPAs where i) regulations over fisheries were known (any level  
531 of impacts), or ii) dredging/dumping was known as allowed, or iii) mining was known as allowed,  
532 independently from the level of information about the other activities. This is because, i) was one of  
533 the most regulated activities in MPAs, and because if ii) and iii) were allowed, the MPA could only be  
534 classified as minimally protected or incompatible with biodiversity conservation, regardless of  
535 regulations on other activities (**Erreur ! Source du renvoi introuvable.**S12 and S13). Remaining MPAs  
536 were not classified, as their level of information was not sufficient to assign a protection level.

537 To estimate the range of uncertainty when assigning a protection level, we compared the resulting  
538 classification from the two scenarios. A total of 6.3% of MPAs were assigned the same MPA guide  
539 protection levels under the two scenarios (Figure S14A). When considering a two-level classification  
540 of MPAs, in strong (full and high protection) and low (incompatible with conservation, minimal, and  
541 light protection), 92.4% of MPAs were equally classified among the two scenarios. The scenario 1  
542 resulted in higher rates of stronger protection.

#### 543 **Comparison of protection levels with previous assessments**

544 To estimate uncertainty among dataset and scenarios, we compared protection levels  
545 obtained using PS and MSP+ datasets (the only datasets available for most MPAs) with protection  
546 levels obtained using PT and OSPAR assessments (n=74). This comparison first showed that 39.2% of  
547 the MPAs assessed in the PT and OSPAR assessments could not be assigned a protection level using  
548 PS and MSP+ datasets due to a lack of data (Figure S14B). Of those that could be classified: 26.7%  
549 (scenario 1) and 8.9% (scenario 2) ended up with the same protection levels as in the expert-based  
550 assessments. Overall, scenario 1 described higher protection levels than the expert-based  
551 assessments (60.6% of classified MPAs), while the second scenario described lower protection levels  
552 (80.5%). When considering the two-level classification, 60.0% (scenario 1) and 82.2% (scenario 2) of  
553 protection levels corresponded to the expert-based assessments. Results from scenario 1 are

554 emphasized in the main text for simplicity, assuming a bias towards stronger protection levels (see  
555 Supplemental items for more scenario 2 results).

## 556 **MPA features**

557 We investigated the relationships between protection levels and several MPA features,  
558 including age, jurisdictions, designation types and their overlapping, design in zones, and MPA  
559 objectives. We extracted the MPA year of designation from the EEA database (and kept the oldest if  
560 fully overlapping MPAs had been merged; n=4,788). For Natura 2000 sites from the Habitats  
561 directive, we used the year of recognition as a Special Area of Conservation and if not available, the  
562 year of designation as a Site of Community Importance (see below). We distinguished MPAs in three  
563 jurisdiction zones: nearshore waters, territorial waters and offshore waters of the EEZ (see the  
564 section 'Scale of analysis').

565 We differentiated three designation types (Natura 2000, International from the Regional Sea  
566 Conventions and National). We extracted and simplified MPA subtypes from the World Database of  
567 Protected Areas (WDPA<sup>133</sup>). We considered 29 MPA subtypes (n=4,570 MPAs) like reserves and  
568 national parks (subtypes within national designations, Figure S7). Natura 2000 MPAs included three  
569 subtypes Special Protection Areas (Birds Directive) and Sites of Community Importance (SCI) turned  
570 into Special Areas of Conservation (SAC) after the EU commission approval (Habitats Directive). We  
571 investigated the links between the protection levels and the designation overlap (including all  
572 designation types), which is highly common in Europe<sup>19,53,134</sup>. We considered whether multiple  
573 designations were merged or not, the number of overlapping designations, and the level of overlap  
574 (for non-merged designations, considering no overlap, 30% of the MPA area overlaps with another  
575 MPA, 30-60%, 60-90%, and above; Figure S9).

576 Finally, we used two proxies of MPAs' objectives, the protection focus reported in PS (in three levels:  
577 focal species, ecosystem or cultural heritage; n=2,536 MPAs) and the IUCN categories reported in  
578 WDPA (n=1,450; MPAs managed : Ia as strict nature reserves, Ib mainly for wilderness protection, II  
579 for ecosystem protection, III to protect a natural monument/feature, IV to manage an  
580 habitat/species, V for seascape conservation and recreation purposes, and VI for sustainable use of  
581 natural resources<sup>55</sup>).

582 The links between protection levels and categorical MPA features (IUCN categories, designation  
583 types, jurisdictions, protection focus) were tested using Chi-square tests (test of independence,  
584 modeling protection levels as a categorical variable and using kilometers square as the quantitative  
585 measure). The effect of year of designation on protection levels was tested by comparing the relative

586 area of low and strong protection (in percentage of the MPA area accumulating over years) using  
587 Spearman correlation tests (Figure S4).

588

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## 625 Competing interests

626 The authors declare no competing interests.

## 627 Author contribution

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