

1 **The Adaptive Marine Policy (AMP) Toolbox: supporting policy-makers developing adaptive**
2 **policies in the Mediterranean and Black Seas**

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34 ABSTRACT

35 Adaptive management is essential to the practical application of the Ecosystem-Based Approach (EBA).
36 There are frequent assertions that adaptive (learning-based) management is being used. However, there
37 has been only limited progress in promoting learning-based management and evidence on its success is
38 still limited. Indeed, it is difficult to bring the different elements of adaptive management together in a
39 robust and acceptable way and to choose the appropriate tools to do it. For this reason, it is necessary
40 to provide a practical framework for policy action and to enable action to be adaptive and consistent
41 with the regulations and agreements calling for the EBA. Accordingly, to operationalize the design and
42 implementation of truly adaptive policies on the basis of the EBA, the Adaptive Marine Policy Toolbox
43 (hereafter, AMP Toolbox) has been developed. The overall objective of the toolbox is to provide policy-
44 makers a practical framework to design and implement adaptive policies and reducing uncertainty
45 through learning-based management. In addition, in order to show the utility of the toolbox, the
46 guidelines and resources provided within the toolbox have been applied to the marine litter issue in the
47 Mediterranean and Black Sea as an example. The example has shown that the toolbox is a useful and
48 operational framework to build a science-policy interface according to the EBA and thus improve marine
49 governance. Some resources provided within the toolbox could be somewhat “insufficient”, however,
50 they provide a practical and useful starting point to support the application and compilation of the
51 different steps and key activities. Finally, their update and management will suppose an important
52 challenge, since the resources should be continuously adapted when new knowledge becomes available.

53

54 1. INTRODUCTION

55 Marine ecosystems provide multiple services such as provisioning of food, energy and mineral
56 resources, and also the regulation of important functions such as nutrient cycling and climate regulation.
57 However, these ecosystems, and thus the services they provide, are subjected to competing uses such
58 as fishing, food and energy production, waste disposal and marine transport to name a few (Halpern et
59 al. 2008). These impacts of these activities, together with the impacts of climate change, are leading to
60 concurrent shifts in marine ecosystems, with potentially wide-ranging biological (Bertram and Rehdanz
61 2013) and socioeconomic consequences (Sumaila et al. 2011). There are many uncertainties regarding
62 the consequences of these shifts, which introduce yet more complexity to the management of marine
63 ecosystems and resources, given that marine ecosystems are intrinsically dynamic and complex (i.e. they
64 continuously evolve through non-linear dynamics and functions) (O’Higgins, Cooper, et al. 2014).
65 Accordingly, there is need for an approach that integrates social and ecological concerns in
66 management, accounts for the value of ecosystem services, and adjusts to changing circumstances
67 (Bainbridge et al. 2011). The environmental management approach which incorporates such
68 considerations is known as the Ecosystem-based Approach (EBA) or Ecosystem Approach (EA) (Farmer et
69 al. 2012). These terms are used in the same context and could be, therefore, used inter-changeably
70 (Farmer et al. 2012), but for clarity EBA is used in this instance.

71 Several regulations such as different regional conventions (i.e. Helsinki, Oslo-Paris, Barcelona and
72 Bucharest Conventions) and the Convention on Biological Diversity (CBD) require application of the EBA
73 in order to manage human activities impacting marine ecosystems. On a European policy level, in 2008
74 the European Union adopted the Marine Strategy Framework Directive (MSFD) (European Commission
75 2008). The MSFD establishes a framework for Member States to develop marine strategies and execute
76 the necessary measures (i.e. through a Programme of Measures) to achieve or maintain Good
77 Environmental Status (GES) by 2020. Marine strategies within the MSFD are required to apply an EBA
78 to the management of human activities, ensuring that the collective pressure of such activities is kept
79 within levels compatible with the achievement of GES and that the capacity of marine ecosystems to
80 respond to human-induced changes is not compromised, while enabling the sustainable use of marine
81 goods and services by present and future generations (European Commission 2008). However, the
82 Directive does not define the concept of EBA and no further elaboration on the EBA is provided (Farmer
83 et al. 2012).

84 The CBD (Convention on Biological Diversity 2000), in contrast, provides a detailed description of the
85 EBA approach, defining it as “a strategy for the integrated management of land, water and living
86 resources that promotes conservation and sustainable use in an equitable way. It is based on the
87 application of appropriate scientific methodologies focused on levels of biological organization, which
88 encompass the essential structure, processes, functions and interactions among organisms and their
89 environment. It recognizes that humans, with their cultural diversity, are an integral component of many
90 ecosystems” (Convention on Biological Diversity 2000). In addition, the CBD requires adaptive
91 management to deal with the complex and dynamic nature of ecosystems and the absence of complete
92 knowledge or understanding of their functioning. As mentioned above, ecosystem processes are often
93 non-linear, which results in discontinuities, leading to surprise and uncertainty (Convention on Biological

94 Diversity 2000). Consequently, management must be adaptive in order to be able to respond to such
95 uncertainties and contain elements of "learning-by-doing" feedback. In fact, adaptive management is
96 seen as an evolving process that includes learning (the accumulation of understanding over time) and
97 adaptation (the adjustment of management over time). The sequential cycle of learning and adaptation
98 targets better understanding of the resource system (i.e. reducing uncertainty), and better management
99 based on that understanding (Williams and Brown 2014). Consequently, measures may need to be taken
100 even when some cause-and effect relationships are not yet fully established scientifically (Convention on
101 Biological Diversity 2000). Hence, the presence of uncertainty and knowledge gaps do not justify policy
102 inaction.

103 However, although adaptive management is essential to the practical application of the EBA and there
104 are frequent assertions that adaptive (learning-based) management is being used, there has been only
105 limited progress in promoting learning-based management and evidence on its success is still limited.
106 Indeed, it is difficult to bring the different elements of adaptive management together in a robust and
107 acceptable way and to choose the appropriate tools to do it (Farmer et al. 2012; Williams and Brown
108 2014). For this reason, it is necessary to provide a practical framework for policy action and to enable
109 action to be adaptive as well as consistent with the MSFD and international agreements calling for the
110 EBA. This is particularly important in Southern European Seas (i.e. Mediterranean and Black Sea), where
111 the geopolitical and economic disparity together with overlapped governance instruments or
112 environmental management arrangements hinders a shared action toward achieving environmental
113 goals across them, including the implementation of the MFSD (Cinnirella et al. 2014; O'Higgins, Farmer,
114 et al. 2014).

115 Accordingly, in order to operationalize the design and implementation of truly adaptive policies on the
116 basis of the EBA, the Adaptive Marine Policy Toolbox (hereafter, AMP Toolbox) has been developed. The
117 toolbox is focused on the needs of policy-makers of both EU and non-EU Member States around the
118 Mediterranean and the Black Sea, but it is not limited to this geographical context. In addition, in order
119 to show the usefulness of the AMP toolbox to design and implement adaptive measures under the
120 MSFD and additional regulations calling for the EBA, the guidelines and resources provided within the
121 toolbox have been applied to the case of the marine litter issue in the Mediterranean and Black Sea.

122 To sum up, the objective of this paper is to present the AMP Toolbox and to demonstrate its value in
123 developing adaptive policies under the MSFD and other regulations calling for the EBA. For this purpose
124 we: (i) present the core principles and structure of the AMP Toolbox (section 2); (ii) apply the AMP
125 Toolbox to the marine litter issue in the Mediterranean and Black Sea (section 3); and, (iii) provide some
126 concluding remarks (section 4).

127 2. THE ADAPTIVE MARINE POLICY TOOLBOX

128 2.1. Objective

129 The overall objective of the AMP Toolbox is to provide policy-makers within the Mediterranean and
130 Black Seas the necessary support to develop adaptive policies or measures to achieve or maintain GES
131 under the requirements of the MSFD, as well as different international and regional regulations calling

132 for the application of EBA to the management of human activities impacting marine ecosystems. The
133 tool box can be found here at the following web address: [http://www.perseus-](http://www.perseus-net.eu/en/about_the_apf_toolbox/index.html)
134 [net.eu/en/about_the_apf_toolbox/index.html](http://www.perseus-net.eu/en/about_the_apf_toolbox/index.html)

135 2.2. Structure

136 For any web-based toolbox a clear and recognizable structure is very important, as it helps users to find
137 their way easily through an abundance of information. Following the model of the United Nations Food
138 and Agriculture Organization's Ecosystem Approach to Fisheries Toolbox (hereafter, FAO-EAF Toolbox)
139 (<http://www.fao.org/fishery/en>), the AMP toolbox has been structured in four levels of information, i.e.
140 main page, steps, key activities, resources and examples (Figure 2). An overview of this structure,
141 including the formats used for each level is given below.

142 2.2.1. Level 1-Main page

143 In the first level, the structure of the toolbox is shown, which is based on the policy-making cycle
144 suggested by the MSFD (Figure 2). The policy cycle contains five steps: 1-set the scene; 2-assemble a
145 basic policy; 3-make the policy robust; 4-implement the policy; and, 5-evaluate and adjust the policies.
146 The adaptive and flexible policy making cycle is based on principles (and methodologies) used in other
147 policy fields (Holling 2005; Swanson and Bhadwal 2009; Walters 1986; Williams and Brown 2014), which
148 have been adapted to the specific needs of the MSFD. These principles include: (i) engagement of the
149 broader stakeholder community; (ii) definition of the problem and desired objectives; (iii) transfer of
150 cross-disciplinary and integrated scientific knowledge to decision-makers (i.e. learning contributes to
151 management by helping to inform decision-making); (iv) forward-looking analysis to promote the
152 identification of robust policies across different scenarios and as a basis for further learning; (v)
153 monitoring of the effects of the implementation of new policies; (vi) implementation of actions/policies
154 to allow continued environmental management while learning (reducing uncertainty); (vii) the
155 incorporation of lessons learnt from monitoring the management interventions (i.e. management
156 contributes to learning) in order to revise models and/or management actions; and, (viii) iterative
157 repetition of this cycle or part of it, so that management reduces uncertainties and leads to improved
158 management outcomes over time. Accordingly, in order to apply these principles in the policy-making
159 process, different guidelines and resources have been incorporated into the toolbox.

160 The meaning and potential application of these principles, is exemplified in Box 1 which details a possible
161 adaptive strategy for the management of the turbot in Romania and Bulgaria For a detailed description
162 of the application of the policy-cycle, see the marine litter case study in section 3.

163 The AMP has been structured in a way that allows for a step-wise, cyclical policy-making approach, as
164 well as an independent use of guidelines and resources involved in specific steps of the cycle. The step-
165 wise or the independent implementation of the cycle step will depend on the nature of the problem
166 studied and the relevance of the steps of the adaptive policy-making process. To this end, the AMP aims
167 to propose a flexible framework that could be implemented in the different stages of the marine policy-
168 making. Each policy-maker will have to adapt the framework according to her/his own need and
169 priorities. This could be the case, for example, when management actions are already in use but are

170 ineffective because they do not contemplate future uncertainties or the effectiveness of these
171 management actions is not monitored. In such cases steps 3, 4 and 5 can be directly accessed.

172 2.2.2. Level 2-Steps

173 All the steps are presented in a uniform format, including some basic information (Figure 1) on the step
174 in question. In addition, and most importantly, the key activities (level 3) necessary to accomplish each
175 step can be accessed. Note that the same activity can be addressed within different steps.

176 2.2.3. Level 3-Key activities

177 The key activities represent a series of actions which need to be performed to achieve the 5 steps. . The
178 12 activities are present in a uniform format as well, including an introduction, key questions, key
179 actions and links to the resources necessary to develop the activity in question (Figure 1).

180 2.2.4. Level 4-Resources and Examples

181 The resources comprise: (i) the “Knowledge base”, including 7 databases (i.e. Research Projects; Marine
182 valuation; Inventory of Measures; Inventory of Foresight exercises; Inventory of Ecosystem Based
183 Assessment Studies; Legal Inventory; and, Institutional Inventory); (ii) different “Tools and methods”
184 (e.g.?); (iii) the “Regional assessments and models dedicated to the Mediterranean and the Black Seas”;
185 and, (iv) “Further readings”. One of the most important objectives of the AMP Toolbox is to make
186 available scientific data, information and models (especially those developed within the PERSEUS
187 project) to users and in doing so support policy-making. Whereas the “Knowledge base” and the
188 “Regional assessments and models dedicated to the Mediterranean and Black Seas” have been
189 developed from the work performed within the PERSEUS project; the “Tools and methods” have been
190 selected from different toolboxes or references already available in the literature or on the web. These
191 include: (i) the MESMA (Monitoring and Evaluation of Spatially Managed Areas) Toolbox
192 (<https://publicwiki.deltares.nl/display/MESMA/Home>); (ii) the Marine Scotland Toolbox; and, (iii) the
193 FAO-EAF Toolbox. Moreover, some of the tools have been compiled from resources provided by
194 different governmental departments (e.g. Directorate General of Development and Cooperation,
195 EuropeAid), environmental research groups or companies. Note that a given resource can be
196 multifunctional or useful for different purposes, thus it can be linked to different key activities and steps.

197 3. INSIGHTS INTO THE AMP TOOLBOX USING MARINE LITTER AS AN EXAMPLE

198 In this section, the functioning of the AMP toolbox (including its different steps, key activities and
199 resources) is illustrated, through a practical case on marine litter, selected as being a key issue for the
200 Mediterranean and the Black Sea. In fact, the need for proper waste management in the marine
201 environment is increasingly recognized by the international community; and several agreements and
202 directives such as the MSFD require maintaining properties and quantities of marine litter at levels that
203 do not cause harm to the marine environment. Accordingly, using this important environmental
204 problem as a directorial example, we describe and discuss the guidelines provided within the toolbox;
205 and illustrate the different resources available, using information and data from the literature. In the

206 following, we assume that each user of the AMP Toolbox is in charge of developing their own place-
207 based policies to tackle their specific problem. However, this toolbox could also be useful for other
208 societal groups who are not in charge of policy-making, but interested in this process, such as: (i)
209 scientist willing to understand how scientific knowledge can be used in policy-making; (ii) stakeholder
210 who may gain or lose with the policies implementation; or, (iii) citizen interested on how our society is
211 regulated.

212 3.1. Step 1-Set the Scene

213 The first step in the AMP Toolbox is to acknowledge that there is a problem that causes negative
214 impacts and that this merits further analysis and the development of management strategies.
215 Developing a strategy to manage marine litter requires a good understanding of the source of the
216 problem, its scale and impact. Accordingly it is necessary to “*Gather information and determine existing*
217 *conditions*” (<http://www.perseus-net.eu/site/content.php?artid=2175>). For this purpose, the “*Driver-*
218 *Pressure-State-Welfare-Response (DPSWR) framework*” ([http://www.perseus-](http://www.perseus-net.eu/site/content.php?artid=2181)
219 [net.eu/site/content.php?artid=2181](http://www.perseus-net.eu/site/content.php?artid=2181)) is proposed within the AMP Toolbox. This tool is a widely-known
220 and potentially useful framework to set the scene (Cooper 2012). This framework is useful to link the
221 effects that socio-economic uses have in the marine ecosystems as well as the effects that the
222 degradation of the marine environment has on human wellbeing.

223 For example, as observed in Figure 3, land-based sources (including land-based activities and coastal
224 tourism), rather than ocean-based sources, are the main sources of marine litter in the Mediterranean
225 and Black Seas (Galgani et al. 2013; UNEP 2009). After entering the sea, litter is accumulating in the
226 Mediterranean and Black Seas ecosystems. In fact, recordings of floating litter have confirmed the
227 overwhelming presence of plastics in the Mediterranean Sea, accounting for about 83% of observed
228 marine litter items (Galgani et al. 2013). Other known ecological impacts of marine litter include the
229 alteration, damage and degradation of benthic habitats such as coral reefs and benthic macro-
230 invertebrates (Katsanevakis et al. 2007; Wright et al. 2013) as well as entanglement in and ingestion of
231 marine debris by marine organisms (Galgani et al. 2013; Pham et al. 2014). Apart from the aesthetic
232 problem, this environmental degradation causes significant socio-economic impacts such as, loss of
233 tourism and related revenues and endangerment of human health and safety. In addition, it has
234 important financial implications for the fishing sector (Galgani et al. 2013; Oosterhuis et al. 2014; Pham
235 et al. 2014).

236 Hotspots of marine litter accumulation not only include the coastline (e.g. highly populated areas,
237 beaches, etc.) or surface waters (Cózar et al. 2015), but also submarine canyons where litter from land-
238 based activities has been shown to accumulate in high densities (Pham et al. 2014). However, as a
239 consequence of the lack of standardization in the sampling and analytical methodologies used and the
240 high cost of sampling in the deep sea, limited standardized surveys have been performed across large
241 areas such as the Mediterranean Sea. Consequently, the understanding of the problem extent is also
242 limited (Pham et al. 2014). In fact, determining key sources of knowledge and finding any knowledge
243 gaps are also an important aim of this step.

244 Additionally, in this step, as well as throughout the following steps it is necessary to “*Involve experts and*
245 *stakeholders*” (<http://www.perseus-net.eu/site/content.php?artid=2167>) to make them understand the
246 extent of the problem. This will help to create the political will and support for potential action (Ten
247 Brink et al. 2009). Other authors (Bainbridge et al. 2011), have highlighted the lack of stakeholder
248 engagement in the implementation of the MSFD at all the relevant (and necessary) scales and the
249 importance of engaging public consultation and active partnerships from the beginning of the process
250 (according to the EBA). In the case of marine litter also, a wide engagement would be necessary (i.e.
251 regional, national and local authorities, maritime sector, tourism sector, fisheries and aquaculture,
252 agriculture, industry, and civil society). Accordingly, several methods are proposed such as Rapid Policy
253 Network Mapping (Bainbridge et al. 2011) and Stakeholders Mapping or Analysis (Fletcher et al. 2003) in
254 order to support policy maker at this stage. In Figure 4 the principal sectors that are affected by the
255 problem are presented by means of the “*Stakeholders Analysis*” ([http://www.perseus-](http://www.perseus-net.eu/site/content.php?artid=2195)
256 [net.eu/site/content.php?artid=2195](http://www.perseus-net.eu/site/content.php?artid=2195)) tool included in the AMP Toolbox. Additional tools to organize
257 stakeholders engagement such as “*Stakeholder meetings*” ([http://www.perseus-](http://www.perseus-net.eu/site/content.php?artid=2183)
258 [net.eu/site/content.php?artid=2183](http://www.perseus-net.eu/site/content.php?artid=2183)) and “*Stakeholder workshops*” ([http://www.perseus-](http://www.perseus-net.eu/site/content.php?artid=2189)
259 [net.eu/site/content.php?artid=2189](http://www.perseus-net.eu/site/content.php?artid=2189)) can be also found in the “Resources” section of the toolbox.

260 Once the current situation has been defined and the stakeholders engaged, and before the possible
261 solutions are listed, it is helpful to develop a clear set of objectives the policy needs to address, and the
262 particular issues it needs to take into account. Initiatives for new actions will need to build on both an
263 understanding of the problem as well as the benefits of addressing it. Indeed, for an effective delivery of
264 the EBA, apart from the multi-sectoral engagement, the valuation of ecosystem services and the
265 recognition of the tight coupling between human and ecological well-being are necessary (Bainbridge et
266 al. 2011; Tallis et al. 2010). Accordingly, it is important to “*Develop a mutual understanding and define*
267 *principles and goals*” (<http://www.perseus-net.eu/site/content.php?artid=2187>). Within the Honolulu
268 Strategy¹ (UNEP and NOAA 2011) for example, the following three objectives (and the strategies to
269 accomplish these objectives respectively) have been defined: (i) to reduce the amount and impact of
270 land-based sources of marine debris; (ii) to reduce the amount and impact of sea-based sources of
271 marine debris; and, (iii) to reduce the amount and impact of the accumulated marine debris on
272 shorelines, in benthic habitats, and in pelagic waters.

273 Overall, the adaptive policies might focus on setting goals and targets at the local level, with a
274 stakeholder-led process propagating from local spatial scales upwards toward a unified regional vision
275 and legal formalization (Bainbridge et al. 2011; Tallis et al. 2010). In fact, cooperation and coordination
276 on a regional seas basis is an asset for a meaningful development and implementation of the EBA
277 (Bainbridge et al. 2011). Accordingly, the use of existing institutional structures such as the regional seas
278 commissions and international organization should be promoted (Bainbridge et al. 2011). Indeed, the
279 process will be more effective and simpler when there is a clear understanding of the distribution of

¹ The Honolulu Strategy was created during the Fifth International Marine Debris Conference (SIMDC) co-hosted by the National Oceanic and Atmospheric Administration (NOAA) in cooperation with the United Nations Environmental Programme (UNEP) and other agencies and organizations for a comprehensive and global effort to reduce the impacts of marine debris (<https://simdc.wordpress.com/about/honolulustrategy/>).

280 authority for action and enforcement between institutions (Ten Brink et al. 2009). In the “*Institutional*
281 *inventory*” (http://www.perseus-net.eu/en/institutional_inventory/index.html) of the toolbox some of
282 the intergovernmental organizations related to the marine litter problem can be found. In Table 1, as an
283 example, some of the organizations represented in the institutional inventory as well as additional ones
284 are shown. Although, these organizations are necessary to implement consistent and cooperative
285 strategies, it is important to decentralize the authority and responsibility for decision-making to the
286 lowest effective and accountable unit of governance as mentioned above (Swanson and Bhadwal 2009).
287 This can increase the capacity of a policy to perform successfully under uncertain conditions. In fact,
288 those closely connected to the resource system are in a better position to adapt to and shape ecosystem
289 changes and dynamics than remote levels of governance (Bainbridge et al. 2011; Swanson and Bhadwal
290 2009).

291 Last but not least, existing legal and administrative obligations such as international agreements, laws
292 and regulations should be identified, with the aim of defining consistent objectives and strategies. A list
293 of examples of legal and administrative instruments managing marine litter can be found in the “*Legal*
294 *inventory*” (http://www.perseus-net.eu/en/legal_inventory/index.html) of the toolbox. In Table 2, some
295 of the instruments described in the legal inventory as well as in the literature (i.e. Commission on the
296 Protection of the Black Sea Against Pollution 2009) can be consulted. Note that although many of these
297 instruments do not target marine litter directly (since they aim at reducing marine pollution, waste
298 production and dispersal or protecting the marine environment in more general terms), they have an
299 indirect effect on marine litter.

300 3.2. Step 2-Assemble the basic policy

301 Once the problem has been addressed and the desired objectives defined, it is necessary to identify and
302 analyse different possible options. Accordingly, this step includes two activities: “*Identify measures*”
303 (<http://www.perseus-net.eu/site/content.php?artid=2219>) and “*Prioritize/assess new measures*”
304 (<http://www.perseus-net.eu/site/content.php?artid=2223>). The former requires that the policy-makers
305 look at the full range of possible solutions and develop a list of options taking into consideration the
306 objectives of the policy and the particular issues it needs to take into account. In adaptive policy-making,
307 variation is an important principle to consider in the selection of measures or instruments, since the
308 diversification of the intervention increases the possibilities of succeeding under unanticipated
309 conditions (Swanson and Bhadwal 2009). Moreover, on occasions, a policy is not feasible given political
310 commitments, potential public resistance or capacity constraints. Accordingly, participation by
311 stakeholders enhances the acceptance of instruments as well as offers ideas of whether they could be
312 successful or not. In other words, the involvement of many groups and sectors will help ensure the
313 solution to marine litter is practical and enforceable (i.e. feasible) (Ten Brink et al. 2009). For example,
314 fees for waste services are useful to cover the costs of collection and disposal of waste and also to
315 incentivize consumers to reduce the amount of waste they produce. This should, however, be
316 performed carefully to avoid perverse incentives to dump waste elsewhere. Accordingly, the policy
317 should not only include individual instruments or measures (e.g. charging for waste services) but also
318 packages of complementary instruments (e.g. awareness raising, improvement of waste discharge
319 facilities and infrastructures and simplification of procedures for discharging waste) (Ten Brink et al.

320 2009). In Table 3 for example, a list of potential actions are proposed based on the “*Measure inventory*”
321 provided within the AMP Toolbox as well as on the Regional Plan on Marine Litter Management in the
322 Mediterranean (UNEP (DEPI)/MED WG. 379/5 2013).

323 An important action at this stage is to define a set of criteria against the different alternatives will be
324 compared. This selection of criteria will depend on the international or national
325 conditions/circumstances. Ten Brink et al. (2009), for example, have defined ten criteria that can be
326 useful to analyze potential options in order to manage marine litter. These include the degree to which
327 the measure: addresses important specific objectives; has potential to offer significant environmental
328 benefits; raises useful revenues; is fair and equitable; avoids unacceptable social impacts; is consistent
329 with other important economic objectives; is likely to be cost-effective; leads to efficient pricing; is
330 understandable and credible to stakeholders and the public, and is feasible. Afterwards, Ten Brink et al.
331 (2009) recommend that these criteria be scored by experts from 1 to 5 with the aim of ranking all the
332 options. This analysis represents a simple way to prioritize different policy options, as well as to discuss
333 and define the right set of criteria against the different options will be assessed. In addition, Oosterhuis
334 et al. (2014), assess the cost of implementation, effectiveness and externalities of different economic
335 instruments to control marine litter. Though they stress that the choice of the appropriate measure is
336 case specific, largely depending on: (i) the source of pollution (land-based source, e.g. tourist tax, vs.
337 ocean-based sources, e.g. rewards for fishing vessels that return waste); (ii) the country’s institutional
338 characteristics and infrastructure (e.g. to launch a landfill tax, the country should have implemented a
339 proper waste management strategy and a properly functioning waste collection and disposal
340 procedure); (iii) consumer’s preferences and habitual behavior (i.e. the effect of a measure can
341 temporarily change the behavior and last only as long as the measure is in place); and, (iv) the
342 economy’s overall sectorial composition (Oosterhuis et al. 2014).

343 Then, several types of assessment methods exist which are useful to assess potential measures. These
344 include, for example, impact assessments, cost-effectiveness analysis, coast-benefit analysis, and multi-
345 criteria analysis. Information on these tools can be found within the “*Prioritize/assess new measures*”
346 key activity. In addition, the “*Marine valuation database*” ([http://www.perseus-](http://www.perseus-net.eu/en/database_marine_valuation/index.html)
347 [net.eu/en/database_marine_valuation/index.html](http://www.perseus-net.eu/en/database_marine_valuation/index.html)) of the AMP Toolbox contains studies regarding
348 valuations of different management strategies.

349 3.3. Step 3-Make the policy robust

350 The policy measures drafted in Step 2 must be assembled into a policy which is robust, as far as possible,
351 against future expected and unexpected conditions. This constitutes probably the most specific and
352 innovative step of the AMP Toolbox policy cycle. For this purpose it is necessary to: (i) identify key
353 factors that could affect policy performance as well as linking them to future scenarios in order to study
354 the way these factors might evolve in the future; and, (ii) develop indicators to help trigger important
355 policy adjustments when needed. Accordingly, “*Forward looking analysis: assess policy success and risk*
356 *factors*” (<http://www.perseus-net.eu/site/content.php?artid=2235>) and “*Design and implement a*
357 *monitoring plan*” (<http://www.perseus-net.eu/site/content.php?artid=2239>), are respectively
358 elementary activities within Step 3.

359 To identify the key factors that may affect policy performance it is recommendable to develop a
360 deliberative process with multiple stakeholders and experts involved in the implementation of the policy
361 as well as those who are affected (positively or negatively) by the policy in question. Potential future
362 evolution of the key factors can be projected using a combination of qualitative and quantitative
363 methods. Scenarios are a coherent package of key factors. Coherence is achieved by understanding the
364 higher-level drivers for these key factors and how these drivers influence the various key factors. In
365 Table 4 the potential future evolution of key sectors related to the marine litter is presented for the
366 Mediterranean and Black Seas. Scenarios are then quantified using predictive models. They allow
367 forecasting the potential impacts of the policy under various conditions. Models can be as informal as a
368 verbal description of system dynamics, or as formal as a detailed mathematical expression of change.

369 Regarding the marine litter case, different authors (e.g. Eriksen et al. 2014; Lebreton et al. 2012) have
370 developed and applied numerical models in order to simulate input, transport and accumulation of
371 floating debris in the ocean (i.e. coupling an ocean circulation model to a Lagrangian particle tracking
372 model). Models represent existing understanding of the system including assumptions and predictions,
373 as well as the basis for learning (i.e. learning is gained by comparing predictions generated by the
374 models and data from monitoring and assessment of actual responses, so that understanding gained can
375 provide knowledge for improving models and future management actions).

376 Once a set of alternatives have been defined and the criteria have been agreed among the stakeholders
377 (see step 2), it is useful to assess the performance of the different alternatives under the scenarios
378 defined at this step. As mentioned before, different methods exist for this purpose., for example, he
379 MCA can be a useful method to assess the robustness of the different policy alternatives under different
380 scenarios.

381 Monitoring is also a key component in adaptive policies, providing information to evaluate the status of
382 the ecosystems (i.e. environmental status, under the MSFD) and the performance of the policy, as well
383 as triggering policy adjustments in case targets are not achieved (see Steps 4 and 5). To make
384 monitoring useful, in Step 3, the motivation of the monitoring, choices on the monitoring strategy (i.e.
385 selecting the targets and associated indicators to monitor and how to monitor them), and the practical
386 limits (e.g. staff and funding) should be made a priority.

387 Environmental targets, which indicate either the desired levels of, or necessary changes to pressures,
388 state and impacts which would ultimately result in the achievement of GES, are of paramount
389 importance to guide progress toward achieving GES. In order to achieve sustainable management
390 compatible with the conservation of marine ecosystems, environmental targets for a good status must
391 be defined (Borja et al. 2012). However, due to the lack of data and knowledge on the amount of marine
392 litter in the different marine compartments and the transport (i.e. meteorological and/or hydro-
393 morphological processes) and flux mechanisms (i.e. physical fluxes such as the deposition and
394 degradation rates; and, biological fluxes such as absorption and ingestion rates) among them, it is
395 difficult to assess where an ecosystem is positioned along a trajectory toward recovery (Borja et al.
396 2012). In these cases directional/trend targets (i.e. continuous improvement in state but where a final
397 end point cannot be identified) can be useful. The advantages of this method is that it is easier to get

398 good present data than past data; and, that the method only requires relative assessments of ecological
399 quality status, which makes it largely independent of the concept of reference conditions. The absence
400 of an end-point target can be problematic in this method (Borja et al. 2012). However, as mentioned by
401 Galgani et al. (2013), trend-based targets may remain appropriate until an effective alternative is
402 produced. For example, the targets for marine litter could include a reduction percentage or rate in the:
403 (i) number of plastic/fishing/sanitary items on coastlines; (ii) litter density in areas affected by floating
404 litter; (iii) litter density in on the seabed; (iv) micro-plastics; (v) quantity of ingested marine litter by
405 region-specific species, such as the turtle in the Mediterranean Sea (Galgani et al. 2013).

406 Acknowledging these constraints, the main mandates (EcAp and MSFD) propose using trend indicators
407 to monitor the achievement of the environmental targets. The MSFD proposes four indicators regarding
408 marine litter (European Commission 2010):

- 409 (i) Trends in the amount of litter washed ashore and/or deposited on coastlines, including
410 analysis of its composition, spatial distribution and, where possible, source;
- 411 (ii) Trends in the amount of litter in the water column (including floating at the surface) and
412 deposited on the seafloor, including analysis of its composition, spatial distribution and,
413 where possible, source;
- 414 (iii) Trends in the amount, distribution and, where possible, composition of micro-particles
415 (in particular microplastics); and
- 416 (iv) Trends in the amount and composition of litter ingested by marine animals (e.g.
417 stomach analysis).

418
419 In addition, in the Mediterranean Action Plan's Ecosystem Approach, 18 "common indicators" have
420 been defined (UNEP/MAP 2014). Among these indicators the abovementioned four have also been
421 proposed. The only difference is that indicators (ii) and (iii) have been unified into a unique one.

422 Furthermore, not only should the indicators be standardized and harmonized, but also the methods to
423 monitor them. Galgani et al. (2013) make a summary of different approaches to monitor marine litter in
424 different marine compartments and their positive and negative aspects. For example, the most common
425 method to provide data on marine benthos has been trawling. During the last years with the
426 development of optical methods, the use of underwater imaging technology has increased. Both
427 methods have pro's and con's. The former has the advantage of detecting litter items, which would not
428 be detected with imaging technology. Moreover, items are recovered and thus available for analysis in a
429 laboratory. The latter can provide data in places that are difficult to access and does not damage the
430 environment or remove species from their habitat (Pham et al. 2014). Other key relevant documents
431 regarding monitoring methods include the UNEP's "Operational Guidelines for Comprehensive Beach
432 Litter Assessment" (Cheshire et al. 2009), the UNEP/MAP's "Draft Monitoring and Assessment
433 Methodological Guidance on EO10" (UNEP(DEPI)/MED WG.401/3 2014) and the NOAA's
434 "Recommendations for Monitoring Debris Trends in the Marine Environment" (Lippiatt et al. 2013).

435 The operational targets should also be defined in relation to the nature of the management action
436 required to achieve GES (e.g. amount of marine debris removed); or to assess progress towards full
437 implementation of a specific measure (e.g. percentage of fishers using alternative/modified fishing gear

438 by fishing fleet or area). Within the Honolulu Strategy (UNEP and NOAA 2011), several indicators are
439 proposed to evaluate management strategies and their enforcement, focused on three areas: (i)
440 decreasing land-based sources of marine debris; (ii) awareness (and use) of fishers and specific groups of
441 ocean users regarding proper waste storage and disposal options; (iii) removal of marine debris
442 accumulations.

443 Finally, monitoring a system does not in itself make a policy adaptive. The value of monitoring in
444 adaptive management is inherited from its contribution to decision making. Monitoring must be used to
445 reduce uncertainty (e.g. comparing predictions produced by the models with data-based estimates)
446 (Williams and Brown 2014). The analysis and assessment of monitoring data result in a better
447 understanding of system processes and the opportunity to improve management based on that
448 understanding (see steps 4 and 5). Without periodic monitoring of the relevant resource attributes,
449 learning about resource responses and subsequent adjustment of management actions is impossible
450 (Williams and Brown 2014).

451 3.4. Step 4-Implement the policy

452 In order to ensure successful policy implementation, several basic conditions need to be fulfilled or
453 arranged. In fact, implementing a policy does not only consist of preparing the legal text, but also
454 ensuring that those who face changes under the new policy understand and expect the policy, its
455 meaning and the implications of their (non-)compliance with it. Accordingly, “*Involve experts and*
456 *stakeholders*” (<http://www.perseus-net.eu/site/content.php?artid=2167>) and “*Draw up an*
457 *implementation plan*” (<http://www.perseus-net.eu/site/content.php?artid=2240>) are key activities
458 within this step. A dedicated implementation plan should provide instructions that are both sufficiently
459 flexible and specific about the actions to be carried out, including who is responsible for these actions
460 and how they can be carried out. A timeline for implementation of the policy should be also included. A
461 “Gantt chart”, as proposed in the AMP Toolbox ([http://www.perseus-](http://www.perseus-net.eu/site/content.php?artid=2240)
462 [net.eu/site/content.php?artid=2240](http://www.perseus-net.eu/site/content.php?artid=2240)), can be a useful means to organize actions along a timeline.

463 Accordingly, in the present step (see Table 5) a theoretical implementation plan to reduce marine litter
464 at sea (particularly from fishing activities) is presented as an example, following the “Guide on best
465 practices for Fishing for Litter (FfL) in the Mediterranean” (UNEP (DEPI)/MED WG.417/13). Obviously, a
466 successful strategy to reduce marine litter will need to integrate all the sectors that impact the
467 ecosystem (i.e. not only fisheries but also urban development, industry, tourism and recreation to name
468 a few). Moreover, it will be necessary to define an implementation plan based on the nature of the
469 problem and the specific alternatives identified and prioritized to deal with the problem in question (i.e.
470 through steps 2 and 3). Hence, FfL has been selected as an example in this case, since the Regional Plan
471 on Marine Litter Management in the Mediterranean (UNEP (DEPI)/MED WG. 379/5 2013) has defined
472 FfL as one of the most important and potential strategies to reduce the amounts of marine litter at sea
473 and has developed detailed guidelines to accomplish the objective. In addition, this initiative integrates
474 several aspects of adaptive management (with important environmental and socio-economic benefits),
475 such as the integration of broader stakeholder communities (including the harbour and port authorities,
476 waste managers and local authorities) and awareness rising among these sectors and the general public.

477 It also contributes to a clear objective, i.e. to remove marine litter from the sea. Furthermore,
478 implementation of the strategy allows learning about the amount and composition of litter at sea, as
479 well as the effect of removing litter from sea (i.e. reduce uncertainty). Finally, it can contribute to
480 changing practices and culture within the fishing sector. Accordingly, in the following sentences this
481 strategy is employed as an example to illustrate steps 4 and 5.

482 FfL consists of incentives for fishermen to facilitate clean-up of the floating litter and mainly the seabed
483 from marine litter caught incidentally and/or generated by fishing vessels in their regular activities
484 including derelict fishing gears. Accordingly, as mentioned above, it is very important to ensure that
485 those stakeholders (particularly fishermen but also fishing companies, port authorities and waste
486 management authorities and companies) who were involved in the earlier activities are also involved in
487 the implementation, as well as make them understanding their co-responsibility in generating and
488 solving the problem. Moreover, successful implementation also requires that the regulatory and
489 institutional frameworks will be in place, including the capacity to enforce and monitor the new policy.
490 So, it would be necessary to ensure that (UNEP (DEPI)/MED WG.417/13):

- 491 • A coordinator or coordination group has been defined, which will be in charge of: (i) contacting
492 with fishermen's associations, ports and harbors' authorities, waste management authorities
493 and companies; (ii) developing of the public relations campaigns; (iii) reporting and evaluating
494 monitoring data.
- 495 • The training needs of fishermen and vessel owners to perform these functions and achieve
496 useful outcomes, has been identified and fulfilled.
- 497 • Guidelines and bags to collect any marine litter they catch in their nets during fishing operations
498 have been provided to the vessels.
- 499 • Suitable disposal facilities in ports and harbors (e.g. permanent and large containers that are
500 emptied on regular basis and made available at the shortest possible distance from fishing boats
501 will facilitate handling of both wastes and bags) have been provided by the port authorities.
- 502 • Appropriate waste management system has been implemented to guarantee that waste is
503 segregated and recycled conveniently prioritising the recovery from the port deposit. This
504 system could: be integrated in the harbour existing waste management system; be an
505 independent management system managed by an authorised waste manager that ensures its
506 subsequent separation and recovery; or, consist of a combined system of the two previous
507 options.
- 508 • A suitable monitoring strategy or plan has been developed, including indicators of the status of
509 the coastal and marine, as well as the effectiveness of the policy.

510 Once these conditions have been fulfilled or arranged, the specific actions (i.e. "fish" marine litter at sea,
511 collect marine litter at ports and harbours and manage marine litter for recycling, energy recovery and
512 disposal) as well as the monitoring plan are put into place ("*Design and implement a monitoring plan*",
513 <http://www.perseus-net.eu/site/content.php?artid=2239>).

514 Step 5-Evaluate and adjust policies

515 This step provides both insights in the policy's outcomes and performance and a basis for its
516 adjustment. A regular review or evaluation, even when the policy seems to perform well, can help
517 address emerging issues and trigger important policy adjustments (Williams and Brown 2014).

518 Accordingly this step consists of two key activities: (i) evaluate the on-going policy ([http://www.perseus-
520 net.eu/site/content.php?artid=2244](http://www.perseus-
519 net.eu/site/content.php?artid=2244)); and, (ii) adjust to new uprising issues ([http://www.perseus-
net.eu/site/content.php?artid=2248](http://www.perseus-
net.eu/site/content.php?artid=2248)).

521 Evaluation involves assessing: (i) how much of the problem has been addressed (i.e. measuring the
522 remaining gap between the current status of the coastal and marine ecosystems and the desired
523 condition or status, through the targets and indicators defined in step 3); and, (ii) whether and to what
524 extent the policy is effective. For example, evaluating the composition (i.e. to identify sources of marine
525 litter) and weight (i.e. to ensure the final waste management) of waste brought ashore or/and the
526 number of vessels that participate in the strategy. In addition, it also can involve an analysis of cost-
527 effectiveness, distribution effects (whether certain groups are more affected than others), and
528 competitiveness effects. Well-designed policies should designate competent authorities for policy
529 evaluation. Evaluation should be conducted by a group outside the implementation team to ensure
530 objectivity. For instance, the tasks of recording weight and composition and weight of waste brought
531 ashore might be developed qualified personnel and data might be reported to the coordination team in
532 charge of the policy in order to be evaluated. Concurrently, data on the status of the coastal and marine
533 ecosystems collected from the monitoring network should be also informed to the coordination team.

534 Moreover, if evaluation has shown that policy outcomes are not what it was expected initially, in this
535 key activity what more needs to be done (i.e. corrective action or adjustments) to achieve the objective
536 is defined. If this is the case, the adjustments required should follow in a simplified way the design and
537 implementation process described in Steps 2, 3 and 4, including specific adjustments to the monitoring
538 programme.

539 For instance, if the evaluation phase reveals a problem (e.g. trends in the amount of litter deposited on
540 the seafloor do not improve), recommendations should be made by the competent authority to improve
541 the efficiency of the policy (e.g. increase incentives to collect marine litter and return litter to port
542 facilities; and/or, increase sanctions for dumping). As the new adjustments are performed, they should
543 include procedures that allow the policies to be revised without the need to recourse to lengthy legal
544 procedures (Ten Brink et al. 2009). Some capacity to revise the policies can be created within the policy
545 itself (e.g., that the coordination group responsible for the policy, can revise rates every year with broad
546 constraints) and not require new legislation (Ten Brink et al. 2009). In some cases, institutions should be
547 given the rights to fine-tune the policy (e.g., raise or lower levels) without overlong legal requirements
548 (Ten Brink et al. 2009). This can be useful to reduce the risk of political blockage of a needed
549 development of the policy (Ten Brink et al. 2009). However, for more fundamental changes, new policies
550 may be needed and the complete cycle repeated. In addition, in order to learn about the decision-
551 making process, the MSFD and EcAp require the repetition of the complete cycle periodically (e.g. 6-
552 yearly in the case of the MSFD), reconsidering the different phases of the set-up process such as the
553 setting of the objectives and the identification and selection of management alternatives.

554 4. CONCLUSIONS

555 With the overall aim of operationalizing the design and implementation of adaptive policies under the
556 requirements of the MSFD, as well as different regulations calling for the EBA, the AMP Toolbox has
557 been developed. In fact, the AMP toolbox should be understood as a practical framework to support
558 policy-makers designing and implementing adaptive policies and reducing uncertainty through learning-
559 based management, according to the EBA.

560 The AMP has been structured in a way that allows for a step-wise, cyclical policy-making approach, as
561 well as an independent use of guidelines and resources involved in specific steps of the cycle. Certainly,
562 the step-wise or the independent implementation of the cycle step will depend on the nature of the
563 problem studied and the relevance of the steps of the adaptive policy-making process. Indeed, the aim
564 of the AMP toolbox is to propose a flexible framework that could be implemented in different stages of
565 the marine policy-making. Each policy-maker will have to adapt the framework according to her/his own
566 need and priorities.

567 Additionally, in this case, in order to show the utility of the toolbox, the guidelines and resources
568 provided within the toolbox have been applied to the marine litter issue in the Mediterranean and Black
569 Sea as an example. The example has shown that the toolbox is a useful and operational framework to
570 build a science-policy interface according to the EBA and thus improve marine governance. In fact,
571 technical assistance (i.e. access to information and research) and capacity support will enhance the
572 ability of the policy-makers to design and implement adaptive effective policies and to fully comply with
573 the EBA. Although, some resources could be somewhat incomplete? and will continually evolve
574 “insufficient”, they suppose a practical and useful starting point to support the application and
575 compilation of the different steps and key activities. In addition, their update and management will
576 suppose an important challenge, since the resources should be continuously adapted when new
577 knowledge becomes available.

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582 REFERENCES

- 583 Bainbridge, J. M., Potts, T., & O'Higgins, T. G. (2011). Rapid Policy Network Mapping: A New Method for
584 Understanding Governance Structures for Implementation of Marine Environmental Policy. *PLoS*
585 *ONE*, 6(10), e26149. doi:10.1371/journal.pone.0026149
- 586 Bertram, C., & Rehdanz, K. (2013). On the environmental effectiveness of the EU Marine Strategy
587 Framework Directive. *Marine Policy*, 38, 25–40. doi:10.1016/j.marpol.2012.05.016
- 588 Borja, Á., Dauer, D. M., & Grémare, A. (2012). The importance of setting targets and reference
589 conditions in assessing marine ecosystem quality. *Ecological Indicators*, 12(1), 1–7.
590 doi:10.1016/j.ecolind.2011.06.018
- 591 Cheshire, A. C., Adler, E., Barbière, J., Cohen, Y., Evans, S., Jarayabhand, S., et al. (2009). *UNEP/IOC*
592 *Guidelines on Survey and Monitoring of Marine Litter*. (No. 186) (p. 120). United Nations
593 Environment Programme and Intergovernmental Oceanographic Commission.
594 <http://www.unep.org/regionalseas/marinelitter/publications/>
- 595 Cinnirella, S., Sardà, R., Suárez de Vivero, J. L., Brennan, R., Barausse, A., Icely, J., et al. (2014). Steps
596 toward a shared governance response for achieving Good Environmental Status in the
597 Mediterranean Sea. *Ecology and Society*, 19(4). doi:10.5751/ES-07065-190447
- 598 Commission on the Protection of the Black Sea Against Pollution. (2009). *Marine Litter in the Black Sea*
599 *Region*. http://www.blacksea-commission.org/_publ-ML.asp
- 600 Convention on Biological Diversity. (2000). *Conference of the Parties. COP 5 Decision V/6. Convention on*
601 *Biological Diversity*.
- 602 Cooper, L. (2012). The DPSWR Social-Ecological Accounting Framework: Notes on its Definition and
603 Application. Policy Brief No. 3. EU FP7 KNOWSEAS Project. [http://www.knowseas.com/links-](http://www.knowseas.com/links-and-data/policy-briefs/DPSWR_Policy%20Brief-FINAL.pdf/view)
604 [and-data/policy-briefs/DPSWR_Policy%20Brief-FINAL.pdf/view](http://www.knowseas.com/links-and-data/policy-briefs/DPSWR_Policy%20Brief-FINAL.pdf/view)

605 Cózar, A., Sanz-Martín, M., Martí, E., González-Gordillo, J. I., Ubeda, B., Gálvez, J. Á., et al. (2015). Plastic
606 Accumulation in the Mediterranean Sea. *PLoS ONE*, *10*(4), e0121762.
607 doi:10.1371/journal.pone.0121762

608 Eriksen, M., Lebreton, L. C. M., Carson, H. S., Thiel, M., Moore, C. J., Borerro, J. C., et al. (2014). Plastic
609 Pollution in the World's Oceans: More than 5 Trillion Plastic Pieces Weighing over 250,000 Tons
610 Afloat at Sea. *PLoS ONE*, *9*(12), e111913. doi:10.1371/journal.pone.0111913

611 European Commission. Directive 2008/56/EC of the European Parliament and of the Council establishing
612 a framework for community action in the field of marine environmental policy (Marine Strategy
613 Framework Directive) (2008). [http://eur-lex.europa.eu/legal-](http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0056)
614 [content/EN/TXT/?uri=CELEX:32008L0056](http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0056)

615 European Commission. Commission Decision on criteria and methodological standards on good
616 environmental status of marine waters (2010). [http://eur-](http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:232:0014:0024:EN:PDF)
617 [lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:232:0014:0024:EN:PDF](http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:232:0014:0024:EN:PDF)

618 Farmer, A., Mee, L., Langmead, O., Cooper, P., Kannen, A., Kershaw, P., & Cherrier, V. (2012). The
619 Ecosystem Approach in Marine Management. EU FP7 KNOWSEAS Project.

620 Fletcher, A., Guthrie, J., Steane, P., Roos, G., & Pike, S. (2003). Mapping stakeholder perceptions for a
621 third sector organization. *Journal of Intellectual Capital*, *4*(4), 505–527.
622 doi:10.1108/14691930310504536

623 Galgani, F., Hanke, G., Werner, S., & Vrees, L. D. (2013). Marine litter within the European Marine
624 Strategy Framework Directive. *ICES Journal of Marine Science: Journal du Conseil*, *70*(6), 1055–
625 1064. doi:10.1093/icesjms/fst122

626 Halpern, B. S., Walbridge, S., Selkoe, K. A., Kappel, C. V., Micheli, F., D'Agrosa, C., et al. (2008). A Global
627 Map of Human Impact on Marine Ecosystems. *Science*, *319*(5865), 948–952.
628 doi:10.1126/science.1149345

629 Holling, C. S. (2005). *Adaptive Environmental Assessment and Management*. Caldwell, NJ: The Blackburn
630 Press.

631 Katsanevakis, S., Verriopoulos, G., Nicolaidou, A., & Thessalou-Legaki, M. (2007). Effect of marine litter
632 on the benthic megafauna of coastal soft bottoms: A manipulative field experiment. *Marine
633 Pollution Bulletin*, 54(6), 771–778. doi:10.1016/j.marpolbul.2006.12.016

634 Lebreton, L. C.-M., Greer, S. D., & Borrero, J. C. (2012). Numerical modelling of floating debris in the
635 world's oceans. *Marine Pollution Bulletin*, 64(3), 653–661. doi:10.1016/j.marpolbul.2011.10.027

636 Lippiatt, S., Opfer, S., & Arthur, C. (2013). *Marine Debris Monitoring and Assessment: Recommendations
637 for Monitoring Debris Trends in the Marine Environment*. NOAA Technical Memorandum NOS-
638 OR&R-46.

639 O'Higgins, T., Cooper, P., Roth, E., Newton, A., Farmer, A., Goulding, I. C., & Tett, P. (2014). Temporal
640 constraints on ecosystem management: definitions and examples from Europe’s
641 regional seas. *Ecology and Society*, 19(4). doi:10.5751/ES-06507-190446

642 O'Higgins, T., Farmer, A., Daskalov, G., Knudsen, S., & Mee, L. (2014). Achieving good environmental
643 status in the Black Sea: scale mismatches in environmental management. *Ecology and Society*,
644 19(3). doi:10.5751/ES-06707-190354

645 Oosterhuis, F., Papyrakis, E., & Boteler, B. (2014). Economic instruments and marine litter control. *Ocean
646 & Coastal Management*, 102, Part A, 47–54. doi:10.1016/j.ocecoaman.2014.08.005

647 Pham, C. K., Ramirez-Llodra, E., Alt, C. H. S., Amaro, T., Bergmann, M., Canals, M., et al. (2014). Marine
648 Litter Distribution and Density in European Seas, from the Shelves to Deep Basins. *PLoS ONE*,
649 9(4), e95839. doi:10.1371/journal.pone.0095839

650 Ruckelshaus, M., Klinger, T., Knowlton, N., & Demaster, D. P. (2008). Marine Ecosystem-based
651 Management in Practice: Scientific and Governance Challenges. *BioScience*, 1, 53–63.
652 doi:10.1641/B580110

653 Sumaila, U. R., Cheung, W. W. L., Lam, V. W. Y., Pauly, D., & Herrick, S. (2011). Climate change impacts
654 on the biophysics and economics of world fisheries. *Nature Climate Change*, *1*, 449–456.
655 doi:doi:10.1038/nclimate1301

656 Swanson, D. A., & Bhadwal, S. (2009). *Creating Adaptive Policies: A Guide for Policy-making in an*
657 *Uncertain World*. Sage, IDRC. [http://idl-bnc.idrc.ca/dspace/bitstream/10625/40245/1/IDL-](http://idl-bnc.idrc.ca/dspace/bitstream/10625/40245/1/IDL-40245.pdf)
658 [40245.pdf](http://idl-bnc.idrc.ca/dspace/bitstream/10625/40245/1/IDL-40245.pdf)

659 Tallis, H., Levin, P. S., Ruckelshaus, M., Lester, S. E., McLeod, K. L., Fluharty, D. L., & Halpern, B. S. (2010).
660 The many faces of ecosystem-based management: Making the process work today in real
661 places. *Marine Policy*, *34*(2), 340–348. doi:10.1016/j.marpol.2009.08.003

662 Ten Brink, P., Lutchman, I., Bassi, S., Speck, S., Sheavly, S., Register, K., & Woolaway, C. (2009).
663 *Guidelines on the Use of Market-based Instruments to Address the Problem of Marine Litter* (p.
664 60). Brussels, Belgium and Virginia Beach, Virginia, USA: Institute for European Environmental
665 Policy (IEEP) and Sheavly Consultants.
666 <http://www.unep.org/regionalseas/marinelitter/publications/>

667 UNEP. (2009). *Marine Litter: A Global Challenge* (p. 232). Nairobi, Kenya: United Nations Environment
668 Programme (UNEP). <http://www.unep.org/regionalseas/marinelitter/publications/>

669 UNEP. (2011). *Taking Steps toward Marine and Coastal Ecosystem-Based Management. An Introductory*
670 *Guide*.

671 UNEP (DEPI)/MED WG. 379/5. (2013). *Regional Plan for the Marine Litter Management in the*
672 *Mediterranean*. [https://www.cbd.int/doc/meetings/mar/mcbem-2014-03/other/mcbem-2014-](https://www.cbd.int/doc/meetings/mar/mcbem-2014-03/other/mcbem-2014-03-120-en.pdf)
673 [03-120-en.pdf](https://www.cbd.int/doc/meetings/mar/mcbem-2014-03/other/mcbem-2014-03-120-en.pdf)

674 UNEP(DEPI)/MED WG.401/3. (2014). *Draft Monitoring and Assessment Methodological Guidance*.
675 Athens, Greece: UNEP/MAP.

676 UNEP/MAP. (2014). *UNEP(DEPI)/MED WG. 390/4. Report of the Integrated Correspondence Groups of*
677 *GES and Targets Meeting*. Athens, Greece.

678 UNEP, & NOAA. (2011). *Honolulu Strategy - A Global Framework for Prevention and Management of*
679 *Marine Debris* (p. 57). Honolulu, Hawai, USA: UNEP and NOAA.
680 <http://marinedebris.noaa.gov/solutions/honolulu-strategy>

681 Walters, C. J. (1986). *Adaptive Management of Renewable Resources*. Blackburn Press.

682 Williams, B. K., & Brown, E. D. (2014). Adaptive Management: From More Talk to Real Action.
683 *Environmental Management*, 53(2), 465–479. doi:10.1007/s00267-013-0205-7

684 Wright, S. L., Thompson, R. C., & Galloway, T. S. (2013). The physical impacts of microplastics on marine
685 organisms: A review. *Environmental Pollution*, 178, 483–492. doi:10.1016/j.envpol.2013.02.031
686