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# **Social-ecological dimensions of Marine Protected Areas and Coastal Fishing: how fishermen's Local Ecological Knowledge can inform Fisheries Management at the future "Taza" MPA (Algeria, SW Mediterranean)**

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1 **Social-ecological dimensions of Marine Protected Areas and Coastal Fishing:**  
2 **how fishermen's Local Ecological Knowledge can inform Fisheries**  
3 **Management at the future "Taza" MPA (Algeria, SW Mediterranean)**

4  
5 **Abstract**

6 The aim of this paper is to examine fishermen's Local Ecological Knowledge (LEK)  
7 relating to Marine Protected Area (MPA) planning and the overlap with fisheries  
8 management in the future "Taza" MPA (Algeria, SW Mediterranean). The case study  
9 focuses on both commercial and recreational coastal fisheries from the fishing  
10 harbour of Zياما (NE Algeria). In this area, coastal fishing is carried out by  
11 professional small-scale fishers and purse seiners for commercial fishery and by  
12 recreational boat fishers for recreational fishery. While there have been some  
13 science-based studies in the characterization of this coastal fishery by using direct  
14 observation of landings as a method for estimating catch and fishing effort,  
15 fishermen's LEK remains under-utilized in this Social-Ecological System (SES). To  
16 address this knowledge gap, perceptions regarding: (1) biological and ecological  
17 impacts of coastal fisheries, (2) marine ecosystem health and (3) attitudes towards  
18 the proposed MPA regulations were analyzed in order to assess potential social-  
19 ecological impacts which can inform more accurately on MPA planning and fisheries  
20 management in the future. To this end, thirty face-to-face semi-structured interviews  
21 with fishers at Zياما harbour were carried out between June and September 2017.  
22 The study found that the future establishment of the "Taza" MPA may affect the  
23 fisheries in this area in the short-term, and in particular the jobs and livelihoods of  
24 professional fishers by limiting the fishing area through new fishing restrictions. The  
25 fishermen's LEK provided some capacity to understand the heterogeneity of the SES  
26 in place and may be used as a tool to evaluate the outcome of fishery management  
27 actions. The results indicate higher acceptance rates among recreational than  
28 professional fishers regarding no-take zones. Professional fishers were  
29 proportionately more likely to oppose the new regulations, though 53% of the fishers  
30 surveyed were uncertain about the future positive impacts of the MPA. The LEK  
31 provides managers with a level of detail about the prediction and prevention of  
32 fishermen opposition, and can point out opportunities for improving conservation  
33 policy with respect to social acceptance.

34 **Keywords:** Social-Ecological Systems; Marine Protected Areas; Coastal Fishery;  
35 Local Ecological Knowledge; Mediterranean; Algeria.

36

## 37 **1. Introduction**

38 To sustain fisheries and manage resources more effectively, international  
39 conventions such as the Convention on Biological Diversity (CDB) acknowledge the  
40 importance of involving local knowledge and its holders in the management of Marine  
41 Protected Areas (MPAs) (Gerhardinger et al., 2009). Despite the importance of  
42 increasing the base of knowledge for more sustainable fisheries and effective  
43 management of fish stocks (Olsson et al., 2004), the conservative method to manage  
44 fisheries is founded mainly on science-based knowledge, overlooking information  
45 originating from local knowledge (Schafer and Reis, 2008). However, the integration  
46 of different systems of knowledge is still complex (Mclean et al., 2020). The benefits  
47 of integrating fishermen's Local Ecological Knowledge (LEK) are often multiple and  
48 include multiple degrees of trust among stakeholders (Miller, 2004). Despite this,  
49 fishermen's LEK remains under-utilized and there is a need for LEK to be developed  
50 to determine its effectiveness as a powerful tool for fisheries management (Wilson,  
51 2003; Pilgrim, 2006; Gerhardinger et al., 2009). The cautious use of LEK along with  
52 science-based knowledge can provide a broader and more diverse knowledge basis  
53 and can help fill major gaps in understanding Social-Ecological Systems (SESs) and  
54 conditions that scientific surveys do not capture well (Mclean et al., 2020).

### 55 *1.1. Marine Protected Areas and Fisheries Management*

56 MPAs have become a popular tool for marine biodiversity conservation and  
57 sustainable use of marine resources through fisheries management (Agardy et al.,  
58 2011; Chuenpagdee, 2013; Cook and Heinen, 2005; Edgar, 2011). Well-designed  
59 MPAs that are planned through a participatory process and use the best available  
60 knowledge can offer important benefits to specific user-groups and local  
61 communities, in addition to longer term benefits to governments and the common  
62 good (Álvarez-Fernández et al., 2020; FAO, 2011). Mediterranean MPAs cover about  
63 6.81% of the surface area of the Mediterranean Sea, with a very uneven  
64 geographical distribution (MedPAN and SPA/RAC, 2019). Aside from an estimated  
65 72.77% of the surface covered located in the western Mediterranean, 90.05% of the  
66 total surface covered by MPAs is found in European Union waters (MedPAN and

67 SPA/RAC, 2019). In 2016, there were only two MPAs in Algeria and a further six  
68 were planned, among which the “Taza” MPA (Boubekri and Djébar, 2016). Since  
69 2009, the “Taza” National Park has undertaken various initiatives to promote the  
70 effective implementation of this projected MPA through the collaboration with multiple  
71 research institutions which have been engaged in studies pertaining to the proposed  
72 MPA. One of the main results obtained was the planning of the future MPA within a  
73 concerted framework (Abbad et al., 2022).

74 Thus, this planned MPA with its 9,603 ha, is divided into three different levels of  
75 protection: 2 no-take zones (1,299 ha), a peripheral zone (6,293 ha), and 3 buffer  
76 zones (2,011 ha) (Fig. 1). The regulatory proposal for the no-take zones stipulates  
77 the authorization of vessel navigation without mooring and scientific research, while  
78 prohibiting commercial and recreational fisheries as well as all the other extractive  
79 uses (e.g. extraction of aggregates for construction) (Boubekri and Djébar, 2016).

80 The WWF called for protection of 30% of the Mediterranean Sea by 2030 under  
81 the United Nations CDB to be agreed in 2021 (Gomei et al., 2021). However, it is  
82 important to highlight that the “30 by 30” target calls not only for a 30% coverage but  
83 also for effectively managed MPAs, stating that *“considering the socio-economic  
84 impact associated with the closure of fishing areas, fishers and the fisheries sector  
85 should be fully engaged in the decision-making processes to ensure that spatial  
86 closures, fishery management plans and other management solutions to avoid  
87 unsustainable fishing are agreed, meet livelihood needs, and recognize their use  
88 rights.”* (Gomei et al., 2021).

89 MPAs are characterised by interlinked social, economic, and ecological  
90 dynamics (Picone et al., 2020). Their objectives are often multiple and include both  
91 social and ecological dimensions. However, baseline studies for MPA planning and  
92 fisheries management tend to be focused on the collection of biological and  
93 ecological data rather than social data (Thomassin et al., 2010). From May 2013 to  
94 April 2014, catch data for commercial and recreational fisheries was collected in the  
95 area of the future MPA of “Taza” (Fig. 1). Three studies on: small-scale fisheries  
96 (Boubekri et al., 2018), purse seine fisheries (Boubekri et al., 2019), and recreational  
97 fisheries (Boubekri et al., 2021) were conducted with the aim to serve as a baseline  
98 knowledge to set up future sound fishery management plans. However, the use of

99 LEK along with scientific knowledge can provide a more complete understanding of  
100 ecosystems management than each knowledge system alone (Johannes et al., 2000;  
101 Colding and Folke, 2001; Gianelli et al., 2021; Rehage et al., 2019). Thus, by  
102 integrating Ziama fishermen's LEK, this could prove extremely valuable for the  
103 managers of the future "Taza" MPA in order to establish more effective fishery  
104 management plans.

### 105 *1.2. Studies on Local Ecological Knowledge*

106 Local ecological knowledge may be described as "*knowledge held by a specific*  
107 *group of people about their local ecosystems. Because it is labeled 'ecological', it*  
108 *concerns the interplay among organisms and between organisms and their*  
109 *environment.*" (Olsson and Folke, 2001). The incorporation of LEK into marine  
110 conservation science and fisheries management is increasing. The latter can provide  
111 useful data to complement scientific assessments (Huntington, 2000; Thornton and  
112 Scheer, 2012; Gianelli et al., 2021). Consequently, LEK can be incorporated in a  
113 participatory and transparent manner, in which information is culturally transmissible  
114 and structured among and within local communities based on their perceptions (Chan  
115 et al., 2019; Wyllie de Echeverria and Thornton, 2019; Gianelli et al., 2021).  
116 Moreover, LEK can help to develop a sense of ownership and representation while  
117 giving a voice to locals in the early stages of the planning process (Schafer and Reis,  
118 2008; Smith and Berkes, 1991; White et al., 2002).

119 Recently, knowledge held by fishing communities has gained recognition in: (1)  
120 fisheries management (Kroloff et al., 2019; Palas et al., 2017; Rehage et al., 2019),  
121 (2) changes in fish diversity and catches (Azzurro et al., 2019; Edwards et al., 2016;  
122 Martins et al., 2018; Mavruk et al., 2018) and (3) marine conservation planning and  
123 MPA management (Mellado et al., 2014; André et al., 2021). In the Mediterranean,  
124 fishermen's LEK can be valuable for the management of artisanal fisheries and  
125 MPAs (Coll et al., 2014; Léopold et al., 2014; Pita et al., 2016). Accommodating  
126 fishermen's LEK adds site-specific value for understanding the societal context in  
127 which MPA establishment occurs and how fishermen's social acceptance interacts  
128 prior to the implementation process. However, the challenge still remains of how to  
129 best collect LEK and use it (McClean et al., 2020).

130

131 *1.3. Coastal Fishery Context*

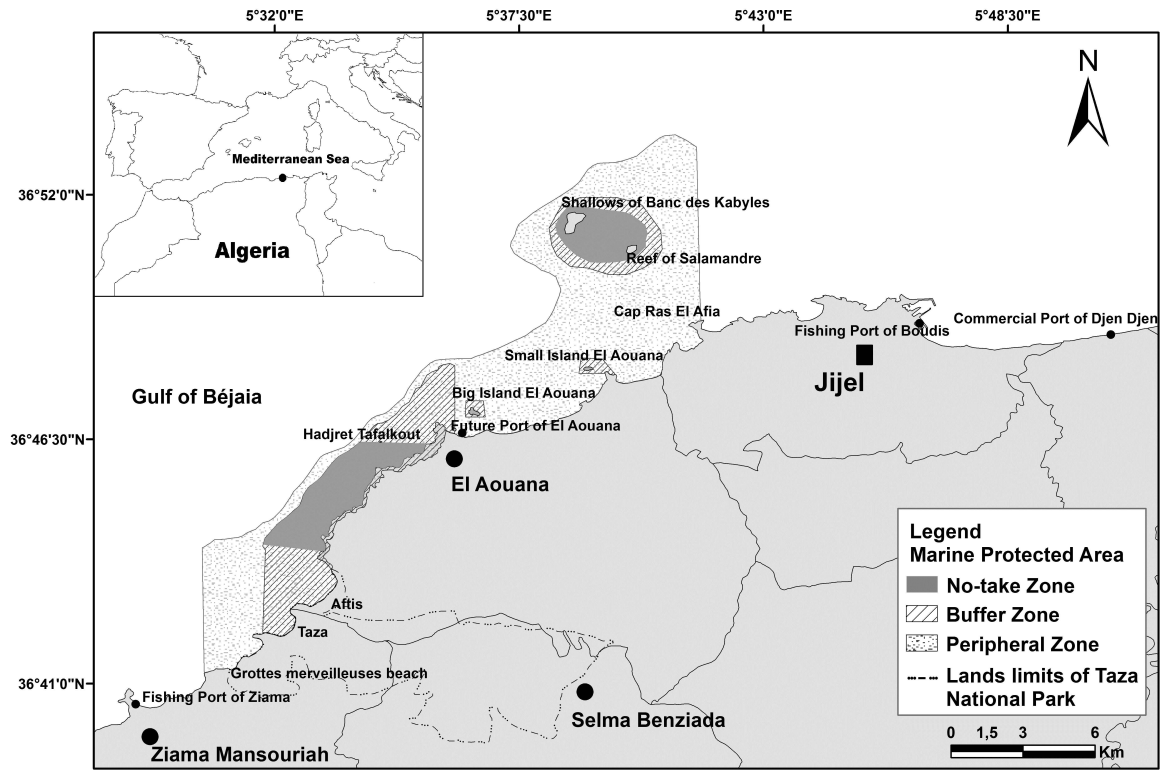
132 The municipality of Zياما Mansouriah has one of the two operational fishing  
133 harbours in the Department of Jijel (Fig. 1). Along the Algerian coast, this Department  
134 is also recognized as an important region for coastal fishing activity, third in number  
135 of skippers (644) nationwide (ONS, 2019). The fishing harbour of Zياما has  
136 traditionally been home to an important coastal fishing activity in the Gulf of Béjaia  
137 (Fig. 1), and used to represent the largest fishing fleet operating in the perimeter of  
138 the future “Taza” MPA (Kacher, 2010).

139 While the coastal fishery in the study area has expanded significantly since the  
140 1990s (Chakour, 2015), between 2004 and 2014 catches in Jijel dropped from about  
141 8,007 tonnes to about 5,060 tonnes (Boubekri and Djebbar, 2016). For instance, there  
142 are no statutory instruments for the creation of the “Taza” MPA, that was proposed in  
143 2009 as a tool for developing management approaches, that enable multiple-use on  
144 a sustainable basis for areas subjected to high anthropogenic pressure (Boubekri  
145 and Djebbar, 2016).

146 Further, the region is of global significance from many standpoints. In 2004  
147 “Taza” National Park was designated as International Biosphere Reserve and then as  
148 a Specially Protected Area of Mediterranean Importance (SPAMI) in 2005 (UNEP,  
149 2005). Coastal fishing in the department of Jijel accounts for 95% of the department’s  
150 fishing fleet, with total value of landings estimated at nearly \$7 million in 2012 (DPRH  
151 de Jijel, 2014). Notwithstanding the importance of coastal fishing in this area and its  
152 high socio-economic relevance for the local communities as a real opportunity for  
153 sustainable coastal development, we know little of the awareness and LEK of  
154 fishermen regarding marine conservation.

155 One of the aims of this study is the assessment of the fishermen’s LEK and its  
156 integrated view with the scientific knowledge in order to expand the base of  
157 knowledge needed for an ecosystem-based approach to improve the governance of  
158 this SES. This paper focuses on the roles of the fishermen’s LEK within MPA  
159 planning and fisheries management in Algeria (SW Mediterranean). To do so, we  
160 applied a mixed methods approach that combines science-based knowledge  
161 generated from previous studies (Supplementary Materials Table S1) and the LEK of  
162 fishermen. We used the coastal fishery to assess social-ecological impacts of the

163 creation of the “Taza” MPA in order to understand how fishermen’s LEK can inform  
 164 fisheries management and shape marine conservation policies. Finally, we discussed  
 165 the role that integrating both scientific and local ecological knowledge played in  
 166 fostering fishermen’s social acceptance of marine conservation projects.



167  
 168 **Fig. 1.** Map showing the location and zoning plan of the proposed “Taza” MPA (Algeria, SW  
 169 Mediterranean).  
 170

## 171 2. Material and Methods

### 172 2.1. Questionnaire Design and Data Collection

173 Useful information can be acquired from fishers’ interviews by providing data for  
 174 assessing fisheries (Wendt et al., 2016; Aylesworth et al., 2017; McCluskey and  
 175 Lewison, 2008). This method has already been used in the Mediterranean for  
 176 estimating catch and fishing effort (Forcada et al., 2010; Leleu et al., 2014; Falautano  
 177 et al., 2018). Face-to-face semi-structured interviews were conducted with  
 178 professional and recreational fishermen of the forthcoming “Taza” MPA. The  
 179 questionnaire included three main components: questions related to the basic socio-  
 180 economic conditions of fishermen and fishing activities such as demographic



181 background and reliance on income from fishing, questions related to fishers'  
182 opinions about the MPA's consultation process, and finally (the focus of this paper),  
183 question related to fishers' perceptions regarding: (1) biological and ecological  
184 impacts of coastal fisheries, (2) marine ecosystem health, and (3) attitudes towards  
185 the proposed MPA regulations. We also inquired about qualitative aspects and the  
186 future vision for the forthcoming "Taza" MPA, which were used as a proxy for  
187 awareness of technical information related to marine conservation and sustainable  
188 fisheries management. The interview contained structured Likert-type questions,  
189 multiple choice questions, and open-ended questions (Supplementary Materials  
190 Table S5). The responses to open-ended questions were recorded *verbatim* through  
191 field notes by the lead author.

192         Given the near-harbour location of the future MPA, we focused on fishers from  
193 Ziama fishing harbour most likely to be affected by the MPA's implementation  
194 because they initially expressed strong opposition to it, as they thought it would limit  
195 their activities and reduce their income (Boubekri and Djebar, 2016). To foster  
196 community engagement when the interviews took place, we organised informal  
197 discussions (May 2017) with both professional and recreational fishers in this fishing  
198 harbour where fishermen had shown their concerns about the decrease in total  
199 catches over previous years, especially high market value capture species (e.g.  
200 dusky grouper and swordfish). After disseminating information during these  
201 discussions and via the staff of the fishing harbour, the first author conducted all  
202 interviews in the Algerian Arabic dialect. Interviews were carried out between June  
203 and September 2017, and lasted between 60 and 120 minutes. Fishermen were  
204 approached at Ziama fishing harbour and interviews were conducted at a time and a  
205 location chosen by the respondent such as a café during days off or after the boat's  
206 return to the harbour. A snowball approach was subsequently used to identify other  
207 potential interview participants (i.e. asking interviewed fishermen to suggest other  
208 participants they recommended we should interview). Fishermen were asked for their  
209 consent to use their knowledge in our study, and all of them agreed even if they  
210 appeared reluctant to the idea of making an audio recording probably because their  
211 fishing activity isn't always conducted in accordance with national laws (i.e. the  
212 respect of the minimum fishing gear mesh size) or maybe to protect their identity (due  
213 to the private nature of some questions asked in this study, survey respondents were

214 assured personal data would remain confidential and would not be shared prior to the  
215 interview). Moreover, all participants in the survey showed their tacit consent for their  
216 contributions to the research in an anonymous way.

## 217 *2.2. Data Analysis*

218 We combined two knowledge systems to assess the social-ecological impacts  
219 in Ziama fishing harbour coastal fishery as potentially affected by the creation of the  
220 “Taza” MPA. Information sources are still representative and can be useful to  
221 understand fishery dynamics and the behaviour of fishers in a context of a pre-  
222 establishment of an MPA. However, official statistics derived from the fisheries  
223 administration (i.e. time-series of annual landings) could be influenced by typical  
224 biases of fisheries surveys (i.e. unreported catches or mixed species) and should be  
225 treated with care. Therefore, our study seeks to bridge both knowledge systems  
226 (scientific and local) to allow a more complete and pluralistic assessment of the  
227 outcome of fisheries management actions such as the creation of an MPA in this  
228 SES. After the Likert scores were analyzed, the corresponding science-based studies  
229 were added from the scientific literature (Supplementary Materials Table S1). Both  
230 sets of information were presented next to each other, when this was available, to  
231 compare results of each knowledge system and to highlight differences between LEK  
232 and scientific data.

233 We used a Mann-Whitney U test for post-hoc tests to assess whether there  
234 were significant differences in Likert scores as a function of different socio-economic  
235 attributes of the fishers, such as age (<40 vs.  $40 \geq$  years old), fishing experience (<15  
236 vs.  $15 \geq$  years), education level (primary vs. high school), and fishing category  
237 (professional vs. recreational) (Gianelli et al., 2021). These tests helped us to explain  
238 the contrasting perceptions per socio-economic attributes. We have chosen non-  
239 parametric statistical tests because our data did not meet the requirements for  
240 parametric statistics. The level of significance was  $\alpha = 0.05$ . All statistical analysis  
241 was performed using Prism version 5.03 for Windows.

## 242 *2.3. Dataset Summary*

243 We completed a total of thirty semi-structured interviews (20 professional fishers and  
244 10 recreational fishers) with each fisher answering every question. While this is a low

245 N overall (i.e. 10% of active fishers), it is a representative subsample of the entire  
246 fishing community in Ziama fishing harbour (i.e. ~200 professional and ~100  
247 recreational active fishers, personal observations). Out of all survey participants,  
248 100% were Algerian males. All professional fishers reside or have resided in Ziama  
249 municipality for most or all of their lives. Also, the majority (6 out of 10) of recreational  
250 fishers were from Ziama municipality where they reside (Table S2). A majority of  
251 professional fishers (55%) lived in a household size of 3 to 5 individuals. However,  
252 recreational fishers lived in a relatively small household (less than 3 individuals) (50%  
253 vs. 15%) (Table S2). When asked about their supplemental income, most  
254 professional fishers (i.e. 65%) declared that they do not have any other source of  
255 income, while 40% of recreational fishers answered that fishing represents a  
256 supplemental income for them (Table S2). Fishing experience varied between the  
257 two fishing category: 13 years is the mean fishing experience for professional fishers  
258 while 19 years for recreational fishers (Table S3). Professional fishers ranged in age  
259 from 24-65, with a mean age of 37 years old, while the age of the recreational fishers  
260 ranged from 22 to 61, and averaged at 50 years old (Table S3).. Marital status did not  
261 vary between the two fishing category: 50% of fishers were married and 50% celibate  
262 (Table S3). Education levels were generally low: 57% had some primary school  
263 education while 43% had completed high school. However, secondary education was  
264 higher among recreational fishers (60% vs. 35%) (Table S3).

### 265 **3. Results**

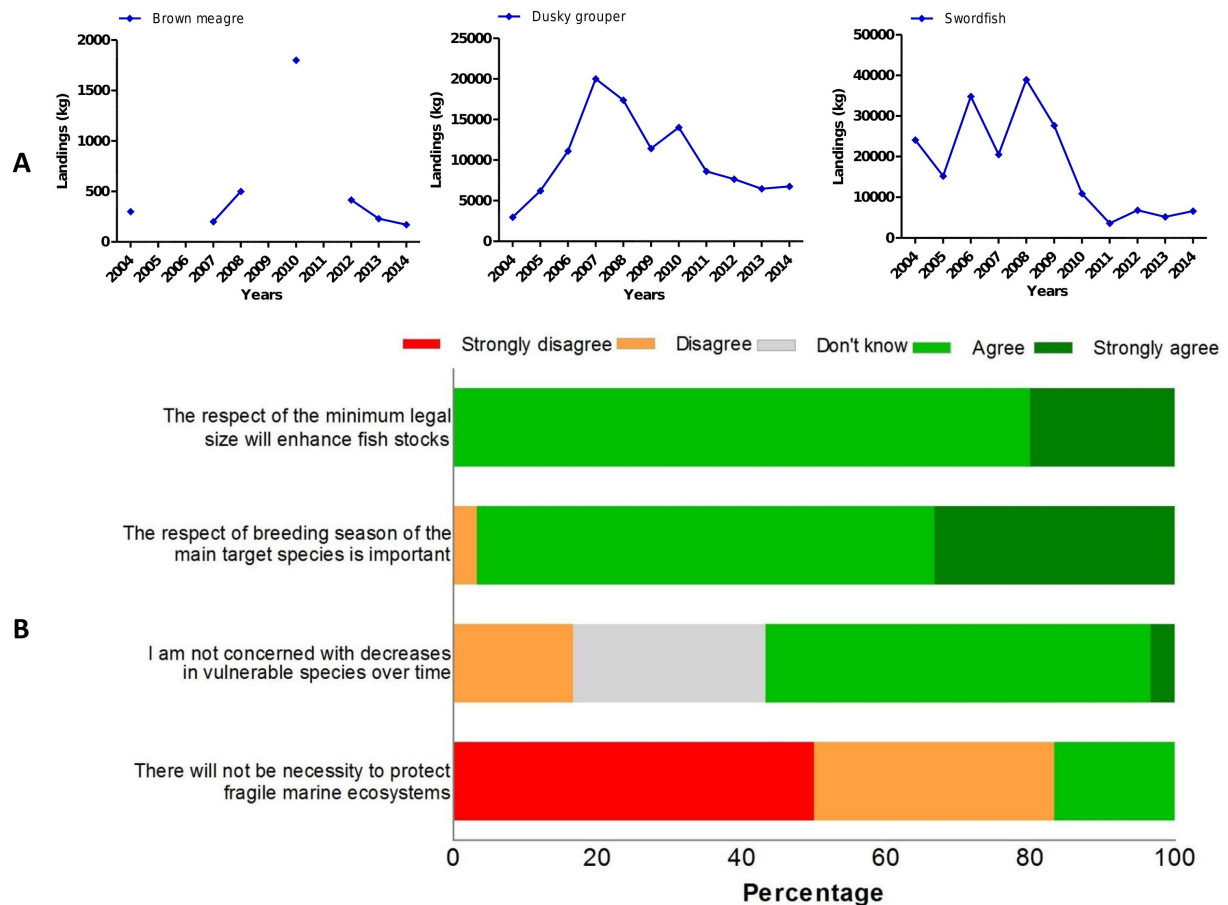
266 We present results based on scientific and local knowledge simultaneously to  
267 assess social-ecological impacts which can inform more accurately on MPA planning  
268 and fisheries management in the future MPA of “Taza” (Algeria, SW Mediterranean).

#### 269 *3.1. Biological and Ecological Impacts of Coastal Fisheries*

270 Fig. 2A summarizes annual landings of brown meagre, dusky grouper, and  
271 swordfish caught by artisanal fishermen in the department of Jijel for the period 2004-  
272 2014. Fig. 2A shows that the landings of these three vulnerable species have  
273 decreased overall over the last decade, raising concerns that the natural resources in  
274 the area of the future “Taza” MPA may be overexploited. Despite approximate values  
275 of landing statistics because of misreporting in fishery statistics (e.g. direct sale of  
276 catches to restaurants or other consumers without being declared or registered in

277 fishery statistics), landings of dusky grouper and swordfish decreased dramatically  
 278 after 2010 (Fig. 2A). This may reflect overfishing because of the economic  
 279 importance (i.e. the very high prices they attain) and high demand during the tourism  
 280 season of these two species.

281 Whilst most fishers expressed that they were not concerned by decreases in  
 282 vulnerable species (i.e. 56%), 17% were concerned and 27% were unable to answer  
 283 (Fig. 2B). While almost all fishers were worried about the respect of breeding  
 284 seasons for the main target species, only 4% were uncertain about this statement  
 285 (Fig. 2B). Moreover, the fishers of Zياما harbour were persuaded by the necessity to  
 286 protect fragile marine ecosystems and the belief that the respect of the minimum  
 287 legal size is a crucial component in preventing over-exploitation (Fig. 2B).

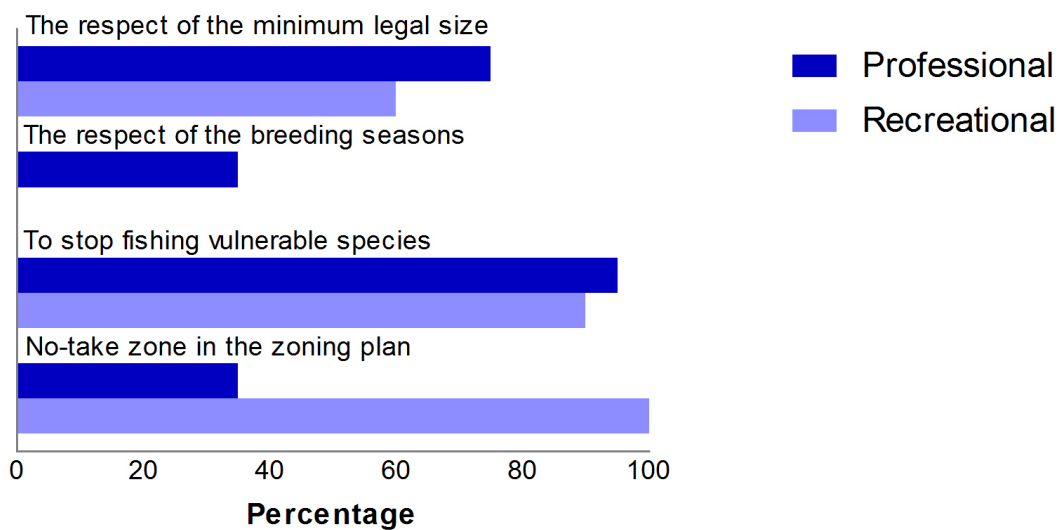


288  
 289 **Fig. 2. (A)** Annual time-series of vulnerable species landings: Brown meagre (*Sciaena umbra*), Dusky  
 290 grouper (*Epinephelus marginatus*), and Swordfish (*Xiphias gladius*) in Jijel. **(B)** Fishers' perceptions of  
 291 the biological and ecological impacts of coastal fishery in Zياما (Jijel, NE Algeria).

292 Contrasting perceptions concerning vulnerable species were explained by fishers'  
 293 age, experience, and education level (Mann-Whitney U tests, p-values <0.05, Table

294 S4). The concern about vulnerable species in this SES was marked in older and  
 295 more experienced fishers: “They should set a moratorium of 10 years for some  
 296 species such as the dusky grouper, this 2-month fishing ban for the swordfish is not  
 297 enough” (Fisher 1). Despite the raising concerns that the natural resources of “Taza”  
 298 Bay may be overexploited, recreational fishers who attended high school were more  
 299 concerned than professional fishers about marine conservation (Table S4). For  
 300 instance, a professional fisher mentioned how his livelihood suffered: “I depend  
 301 mostly on fishing as my main source of income, when they [fisheries administration]  
 302 will create the MPA, I will fish less. Because I have some loans on my boat to  
 303 reimburse, I do not always respect the minimum legal size nor the breeding seasons  
 304 of target species, especially in winter when there is scarcity of fish” (Fisher 2). Almost  
 305 three-quarters (70%) of respondents testified that they respect the minimum legal  
 306 size of commercially exploited species (Fig. 3).

### What proportion of respondent agree with the followings:



307

308 **Fig. 3.** Proportion of professional and recreational Ziama harbour fisher respondents who agree with  
 309 these four questions.

310

311 Fig. 3 shows that the fishers who do not respect the minimum legal size belong  
 312 to both fishing categories; either claiming that they ignored this information (in  
 313 general recreational fishers) or because of financial issues (mainly professional

314 fishers) (Table 1). Over three-quarters (77%) of respondents answered that they do  
 315 not respect breeding seasons for the main target species (Fig. 3).

316 Analysis found that all recreational fishers do not respect the breeding seasons  
 317 of target species, while the primary reason associated with their non-compliance was  
 318 opportunism (i.e. resource availability during this period) (Table 1). However, for  
 319 professional fishers, financial issues were the most cited responses in this regard.  
 320 Finally, only 7% of respondents indicated that they do not accept to stop fishing  
 321 vulnerable species. Fishers who accept a ban on vulnerable species cited mainly (i.e.  
 322 89% of respondents) one reason: fish population recovery and fish stock  
 323 reconstitution (Fig. 3 and Table 1).

324 **Table 1**

325 Representative sample responses showing reasons why fishers do not respect some fishing  
 326 restrictions (e.g. minimum legal size, breeding seasons, and a potential ban on vulnerable species).  
 327 The number of responses is given in parenthesis.

<b>Response samples</b>
<b>I do not know the minimum legal size for the species I am fishing (5)</b>
<b>I do not respect the minimum legal size because I have a family and I need to feed them, that's what matters most for me at the moment (4)</b>
<b>I have a very low fishing impact, I do not think my activity could have detrimental effects during the breeding season (2)</b>
<b>During the breeding season, there is more abundance and availability of resources than usual and I try to take advantage of this so yes, I am an opportunist (5)</b>
<b>I do not know when the breeding season is (3)</b>
<b>I have a family, I am the only person who works, I cannot support a long period without income, if the government supports us with a salary during this period, I will respect it (11)</b>
<b>I am not the only one fishing during the breeding seasons, there are many non-compliant fishers in this regard, but if others respect it, I am ready to follow suit (1)</b>
<b>Onboard I am a simple fisherman, I do not decide I just follow the instructions of the captain (1)</b>
<b>Yes, if we stop fishing vulnerable species which have become rare, I think we can give them a chance to recover and become like before (25)</b>
<b>We must stop fishing vulnerable species to avoid their extinction (1)</b>
<b>Vulnerable species are not essential, we can avoid them (1)</b>

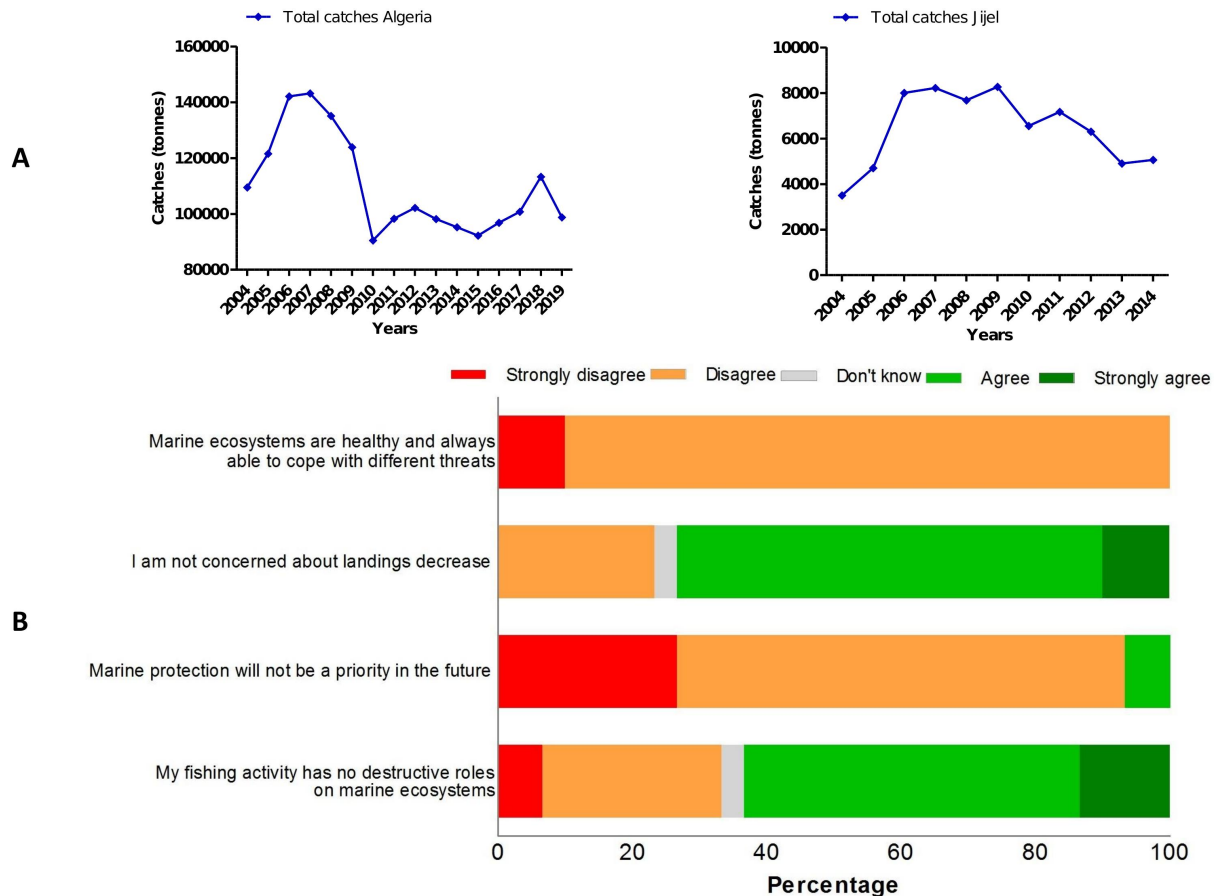
328  
 329 The SES appears to not be prepared to cope with the high levels of compliance  
 330 with the regulatory framework which may come in the wake of the creation of the  
 331 "Taza" MPA, showing a lack of awareness about vulnerable species which are  
 332 characterised by a limited reproductive potential (e.g. late maturity).

333

334

### 335 3.2. Marine Ecosystem Health

336 Between 2004 and 2019, based on catch data reported by the FAO (2021)  
337 (Food and Agriculture Organization of the United Nations), the total catches in Algeria  
338 decreased globally; first increasing and peaking at 143,161 tonnes in 2007, they then  
339 began declining thereafter to about 98,773 tonnes in 2019 (Fig. 4A). In parallel, in the  
340 department of Jijel total catches fell. Thus, the total catches dropped from about  
341 8,220 tonnes in 2007, to about 5,060 tonnes in 2014 (Fig. 4A). The drop in catches  
342 was also perceived by fishers, who stated unanimously that current fishing quantities  
343 are much lower than they were 10 or 20 years ago. *“We are fishing much less than*  
344 *before, I do not know what is happening, why the yields are not the same as before”*  
345 (Fisher 3). Almost one quarter (23%) of respondents stated that they were worried  
346 about total landings decrease, while 34% considered their fishing activity as  
347 destructive of marine ecosystems (Fig. 4B). However, all fishers were unanimous on  
348 the fact that marine ecosystems are unhealthy (Fig. 4B). In fact, this decrease may  
349 indicate that the maximum sustainable threshold of the fish catch has been  
350 exceeded, limiting the renewal ability of the fish stocks. To this end, 94% of  
351 respondents considered marine protection as a priority in the near future (Fig. 4B),  
352 mainly recreational fishers who attended high school (Table S4).



353

354 **Fig. 4. (A)** Global catches between 2004 and 2019 in Algeria and in Jijel between 2004 and 2014. **(B)**  
 355 Fishers' perceptions about marine ecosystem health in Zيام (Jijel, NE Algeria).

356 LEK reinforced the link between the need for marine ecosystem conservation  
 357 and sustainable conditions for fishing, as explained by a long-liner fisher: *"I have*  
 358 *changed the fishing technique because of the extra fees that I would have to pay.*  
 359 *The sardine became rare and too expensive to use as bait when you know that your*  
 360 *fishing will not be profitable. The small quantities which we catch no longer reimburse*  
 361 *us for the price we have to spend to buy the bait"* (Fisher 4). The consistency  
 362 between the decrease in total landings and fishers' perceptions explained the  
 363 opportunity to raise public awareness about the benefits of MPAs for marine  
 364 biodiversity conservation, but more importantly for the sustainable use of marine  
 365 resources. This could be done through the preparation of easy-to-read materials  
 366 about how the "Taza" MPA could support sustainable fisheries, in particular the  
 367 potential spillover effect.

368

369



370 *3.3. Attitudes towards the proposed MPA Regulations*

371 In 2009, small-scale fishers of Ziama harbour initially expressed strong  
372 opposition to the “Taza” MPA, as they thought it would restrict their fishing areas and  
373 reduce their income. Immediately, the “Taza” MPA working group launched a  
374 consultation process to prepare an adequate zoning plan for a multiple-use MPA. For  
375 example, one respondent explained the effect fishing restrictions could have on his  
376 livelihood as follows: *“The MPA will reduce my fishable areas; I mainly fish with*  
377 *gillnets above rocky habitats near seagrass meadows. I have a small boat and I*  
378 *cannot fish in remote areas”* (Fisher 5). Table 2 shows the 17 activities which have  
379 been defined as allowed, prohibited, or managed within the proposed zoning plan of  
380 the “Taza” MPA. The latter aims to achieve sustainable use consistent with  
381 conservation, resulting from a consultation process with all stakeholders conducted  
382 between 2009 and 2011. Over half (53%) of the fishers were uncertain about the  
383 future positive impacts of the MPA (Fig. 5). Results show that in general, the  
384 interviewees who most strongly disagree with the MPA’s establishment are  
385 professional fishers while many fishers claimed that the MPA will restrict their fishing  
386 zones (Table S4). More than a third (37%) of fishers were not able to answer if the  
387 proposed zoning plan provides the ideal platform to manage the fishery (Fig. 5).  
388 However, more than three-quarters (77%) of interviewees believed that no-take  
389 zones are crucial for a long-term fisheries management. Of all respondents, 60%  
390 (N=18) find the no-take zones well situated (Fig. 5). Moreover, 100% of recreational  
391 fishers supported no-take zones over the proposed zoning plan, compared with just  
392 35% of professional fishers (see Fig. 3).

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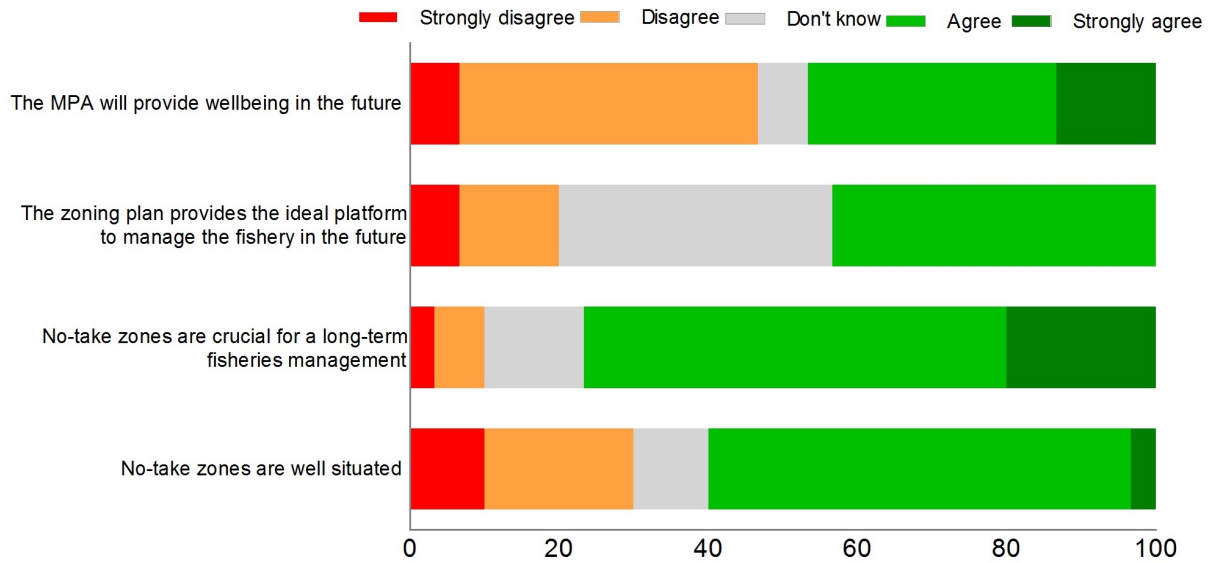
402 **Table 2**

403 Zoning and uses within the proposed "Taza" MPA. Data source: Taza National Park consultation  
 404 technical reports (based on the results of: Chakour, 2012; Grimes, 2010; Kacher, 2010; Ramos-Espla,  
 405 2010).

Uses	Zones	Peripheral zone	Buffer zone	Buffer zone	No-take zone	Observations
<b>Other zones</b>				Special protection area of islands		Remarkable places for education and training
<b>Zone characteristics</b>		Low protection	Average protection	Special protection	High protection	
<b>Function</b>		Sustainable development	Protection of the integral reserve	Education and training	Conservation and restoration of the integral area	
<b>Commercial fishing</b>						Registration, nominative application for professional fishing
Trawl fishery		+ (1)	-	-	-	(1) bottoms > 50 m
Sardine fishery		+ (2)	-	-	-	(2) bottoms > 35 m
Small-scale fishery						
Gillnets (monofilaments) (3)		-	-	-	-	(3) prohibited in all the MPA
Trammel nets		+	-	-	-	
Longlines (4)		+	+	-	-	(4) jigging prohibited
Lines (handline, trolling, fishing rod)		+	+	-	-	
<b>Recreational fishing</b>						
<i>Commercial recreational fishing (5)</i>						(5) with license
Nets (trammels only)		+	-	-	-	
Longlines		+	-	-	-	
Lines (handline, trolling, fishing rod) (6)		+	+	-	-	(6) jigging prohibited
<i>Recreational fishing only (7)</i>						(7) with license
Lines (handline, trolling, fishing rod) (8)		+	-	-	-	(8) boat, coast: jigging prohibited
Responsible spearfishing (9)		+	-	-	-	(9) with permission
<b>Tourism and leisure</b>						
Bathing		+	+	+	-	
Navigation (10)		+	+	+	+	(10) do not stop or anchor in the integral reserve
Anchorage (11)		+	+	+	-	(11) zones established
Snorkeling		+	+	+	-	
Scuba diving (12)		+	+	+	-	(12) with permission
<b>Other activities</b>						
Scientific research (13)		+	+	+	+	(13) monitoring
Education and training (14)		+	+	+	-	(14) underwater trials
Fish farming (15)		-	-	-	-	(15) prohibited in all the MPA
Wastewater discharge (16)		+	-	-	-	(16) environmental impact study
Marine works (17)		+	-	-	-	(17) environmental impact study
Other activities (18)		?	?	?	-	(18) apply the precautionary

406

407



408

409 **Fig. 5.** Fishers' perceptions and attitudes towards the proposed MPA's regulations in Ziama (Jijel, NE  
410 Algeria).

411 There was also a clear bias in this statement, with fishers who fish for pleasure  
412 more likely to support the closure of fishing areas than those fishing for a livelihood.  
413 Spatial closures within the proposed zoning plan determined different opinions  
414 according to the magnitude of their impacts. The presence of integral reserves  
415 induced some reluctance towards the establishment of the MPA, as reducing fishing  
416 areas was perceived as a threat to livelihoods. *"These zones are the only productive*  
417 *fishing areas along our coast"* (Fisher 6). Critical vulnerability, such as the  
418 unawareness of the reserve effect (i.e. facilitating net flows of fish from the protected  
419 area to adjacent ones) hindered a wider acceptance and preventing the conditions  
420 needed to cooperate with the establishment of the MPA in the long term. Another  
421 SES characteristic that may hamper long-term support to the MPA implementation is  
422 the artisanal character of this fishery that precluded exploration of new fishing areas  
423 because of the mainly traditional fishing fleet. *"My fishing equipment allows me to*  
424 *only fish near the harbour, my engine is not powerful and I am afraid of bad weather,*  
425 *if I am far away I cannot quickly return to the port"* (Fisher 7). This factor explains the  
426 high vulnerability of the SES and the consequent long-lasting detrimental socio-  
427 economic impacts of the MPA establishment. Local fishers should be informed  
428 whether the MPA will lead to increases or decreases in fish biomass and fishing  
429 yields and how long it will take for these effects to stabilize.

430

## 431 **4. Discussion**

432 By using fishermen's LEK, we provided a consistent analysis of potential social-  
433 ecological impacts of the creation of "Taza" MPA as a precondition for future coastal  
434 fishery monitoring and the implementation of this MPA. Such knowledge is not  
435 always adequately valued by scientists and natural resource managers (Chaboud et  
436 al., 2008). However, because of its limited costs, this knowledge system may be a  
437 useful tool for consideration in fisheries management as a cost-effective method for  
438 data collection, while building trust and promoting awareness among its participants,  
439 and ultimately enhancing the governance of SES in Mediterranean MPAs facing  
440 increased climate change impacts. Thus, we detail here some of the possible drivers  
441 of a future sustainable management of Ziama coastal fishery among fishers  
442 concerned about the establishment of an MPA.

443 Our results provided an important overview of factors affecting fishers'  
444 livelihoods by limiting the fishing economic potential through spatial closure, showing  
445 further evidence of a professional vs. recreational split with regards to areas with total  
446 exclusion of fishing activities. Although no-take areas were perceived (but not  
447 supported) as a solution to induce the recovery of coastal exploited fish species, a  
448 question that remains unresolved for fishers is whether restrictive regulations of  
449 fishing will be accompanied by alternative livelihood options or not. We also provided  
450 information that may help anticipate fishermen's opposition, and possible solutions  
451 for the ongoing efforts aimed at protecting marine biodiversity and socio-economic  
452 viability of coastal fisheries in a developing country context.

### 453 *4.1. Biological and Ecological Impacts of Coastal Fisheries*

454 According to the perception of the interviewed fishers, the practice of their  
455 fishing activities is not environment-friendly even if they consider the respect of  
456 breeding season of different target species as important for a more sustainable  
457 fishing in the future. Boubekri et al. (2018) show a strong coincidence between the  
458 seasonal fishing periods of the main target species and their breeding seasons in the  
459 small-scale fishery of Ziama harbour, a behaviour we could refer to as opportunistic.  
460 It is therefore a form of adaptation of fishing tactics to the ecology and dynamics of  
461 the species, because when individuals gather in large numbers to reproduce, they  
462 become vulnerable to fishing (Pellettier and Magal, 1996). Thus, fishermen's LEK of

463 Ziama harbour influences the temporal dynamics of the coastal fishery and the whole  
464 SES in place.

465 Moreover, a shared expectation among fishers was that the respect of  
466 restrictive regulations of fishing (e.g. minimum legal size) would provide advantages,  
467 such as enhanced abundance of fish, to sustainably manage the fishery in the future.  
468 This information highlights a high level of awareness about sustainable fishing  
469 among the fishing community of Ziama harbour. Furthermore, the local knowledge  
470 that fragile ecosystems should be protected also demonstrates that the fishers are  
471 concerned that fish stocks of vulnerable species may be threatened by overfishing,  
472 as has been highlighted in annual times-series of landings showing a strong  
473 decrease since 2010. However, old and experienced fishers were more concerned by  
474 the decrease in vulnerable species numbers than those with less experience. This  
475 difference could be related to the fact that older fishers had experienced that change  
476 and it shows that the LEK is experiential through learning-by-doing rather than  
477 experimental in the scientific sense (Azzurro et al., 2019; Mavruk et al., 2018; Olsson  
478 and Folke, 2001). Recognition of the importance of experiential knowledge is the  
479 basis of the paradigm of participatory approaches in the management of complex  
480 SES (Sáenz–Arroyo et al., 2005; Gunderson et al., 1995). Participatory approaches  
481 which combine local and scientific ecological knowledge can help in the co-  
482 management of resources and ecosystems (Buscher et al., 2021; Mclean et al.,  
483 2020; Voorberg and Van der Veer, 2020). For this process to work, fishers and  
484 scientists should work together to set the basis to improve the management of future  
485 human-environment interactions.

486 In the meantime, all recreational fishers interviewed declared that they did not  
487 respect the breeding season (mainly because of non-compliance of other fishers),  
488 making them the main predators of vulnerable species which are characterized by  
489 slow growth and late maturity (Roberts and Hawkins, 1999). This finding highlights  
490 the pressure that recreational fishing exerts on the coastal resources in this area. The  
491 same observation has been made in several Mediterranean MPAs. In fact,  
492 recreational fishing lacks a common definition and it has behavioural traits which  
493 challenge small-scale fishing (Gomez et al., 2021). Moreover, up to 30% of studied  
494 species in the catches of recreational fishers in the Mediterranean MPAs are  
495 classified as vulnerable (Font and Lloret, 2010; Font et al., 2012).

496 In the study area, a strong competition between recreational and professional  
497 fishers was highlighted as 81% of the 54 caught taxa were present in the catches of  
498 both fishing categories, with 4 species of high commercial value caught exclusively  
499 by recreational fishers (Boubekri et al., 2021). Thus, knowing that management of  
500 vulnerable exploited species can be an effective tool to prevent over-exploitation  
501 (García-Rubíes et al., 2013; Harmelin-Vivien et al., 2015; Mouillot et al., 2002),  
502 awareness-raising work should be more oriented towards recreational fishers at this  
503 moment. In addition, and because recreational fishers were more concerned than  
504 professional fishers by the necessity to protect fragile marine ecosystems, this value  
505 should be considered as an asset for the managers of the future “Taza” MPA to  
506 trigger a fruitful collaboration on this matter.

#### 507 *4.2. Marine Ecosystem Health*

508 Since 2006, fishermen have been experiencing a reduction in fish abundance.  
509 Young fishers are more concerned about the landings decrease, but unhealthy  
510 marine ecosystems which are unable to cope with different threats (e.g. overfishing)  
511 are the core problem as all fishers agreed on this statement. Faced with a real risk of  
512 fish stock over-exploitation and the resulting socio-economic consequences, new  
513 management tools are needed in order to preserve both fishermen’s jobs and food  
514 security. In a context of overfishing, MPAs have been used as instruments for both  
515 marine biodiversity conservation and fisheries management throughout the world  
516 (Edgar, 2014; Mellado et al., 2014; Rehage et al., 2019). Particularly, no-take areas  
517 with full protection (i.e. integral reserves), are the ones responsible for what is  
518 commonly called the ‘reserve effect’. This often translates into the net flows of fish  
519 (larvae and/or adults) from the reserve to adjacent fishing areas (Laboy-Nieves et al.,  
520 2009; Di Lorenzo et al., 2020). Although creating marine reserves promotes the  
521 recovery of fished species (Wilson et al., 2020), the spatial closure also reduce the  
522 area available to fishing (McClanahan, 2021). To this end, even if science helps to  
523 identify optimal size and spacing of MPAs, the designation of marine reserves is  
524 ultimately influenced by social concerns (Manson et al., 2021). Moreover, success in  
525 achieving increases in mean size and abundance of fished species depends entirely  
526 on the spatial planning (e.g. the spatial connection with nursery areas) (Russ, 2002;  
527 Sousa et al., 2018) and on the effective enforcement and application of fishing  
528 restrictions (Claudet & Guidetti, 2010; Gaymer et al., 2014).

529 Although our research found that marine protection will be a priority in the future  
530 for almost all the interviewed fishermen, we also found relatively low awareness of  
531 this 'reserve effect', suggesting that with limited outreach, no-take zones may have  
532 low salience within the fishermen community and fishers' opposition to integral  
533 reserves may occur due to uncertainty of MPA positive impacts. In this perspective,  
534 Chakour and Chaker (2014) developed a model to predict the benefits of the  
535 proposed "Taza" MPA. This model was used to provide comparative assessment of  
536 two management scenarios (i.e. with and without an MPA) and addressed the  
537 exploration of the impact of implementing an MPA in "Taza" Bay, as well as the  
538 temporal evolution of the fish biomass and fishing yields in a projection period going  
539 from 0 to 3 years after implementation (short-term), between 3 and 5 years (medium-  
540 term), and between 5 and 30 years (long-term), to be applied in decision-making and  
541 planning. In the simulated (no MPA) scenario, a drastic reduction in the biomass  
542 (diminishing by a quarter over 30 years) of small pelagic species was observed  
543 (Chakour and Chaker, 2014). However, the model shows that the biomass of the  
544 "Taza" MPA would be doubled after ten years following implementation and would be  
545 2.5-fold after 30 years. This scenario as an optimal management option for the  
546 benefits of no-take zones should be clearly and convincingly shown by scientists to  
547 fishers. Therefore, fishers may be supportive if they judge that no-take zones serve to  
548 increase fish biomass and fishing yields (Martínez-Ramírez et al., 2021; Silvert and  
549 Moustakas, 2011).

#### 550 *4.3. Attitudes towards the proposed MPA Regulations*

551 In the future MPA of "Taza", the proposed zoning plan fostered a multiple-use  
552 management approach that aims to achieve sustainable use consistent with  
553 conservation (Boubekri and Djebbar, 2016). Ecotourism activities were proposed to  
554 increase potential revenue for fishers due to the new fishery exclusion zone (Gomei  
555 and Di Carlo, 2012). To this end, a regional development project implemented by the  
556 WWF (SEA-Med: Sustainable Economic Activities in Mediterranean Marine Protected  
557 Areas) allowed to explore compensatory measures (financial offsetting), which will be  
558 implemented to support fishermen to create sustainable alternative livelihoods  
559 (WWF, 2014). Nevertheless, opinions of no-take zones within the proposed zoning  
560 plan was one of the main contributing factors to show an overall uncertainty to the  
561 positive outcomes of the MPA in the future. The support for enforcing regulations

562 may also depend on how people perceive spatial restriction (Mumbay et al., 2021;  
563 Hall et al., 2021; Thomassin et al., 2010). Legitimate beliefs that the MPA will prohibit  
564 fishing in some areas, contribute to a feeling that fishers and conservationists cannot  
565 work together in the same SES. Interestingly, answers concerning the overall MPA's  
566 wellbeing output in the future were well spread between professional and recreational  
567 fishers. Furthermore, the role of no-take zones was generally perceived to be positive  
568 for fisheries management in the long-term. At the same time, more than a third of  
569 respondents admitted that they do not have any opinion on the proposed zoning plan  
570 which comprises two no-take zones. It is possible that the low participation rate in the  
571 consultation process (only 5 fishers were involved) and the lack of awareness of the  
572 management objectives of this MPA on behalf of the fishing community may explain  
573 the relatively indefinite answers concerning the proposed zoning plan.

574 Zoning of MPAs, by which human activities are restricted or prohibited in  
575 specific areas, is an effective method for protecting the marine environment  
576 (Douvere, 2008; Shih and Chiau, 2009; Toonen et al., 2011). So, while the level of  
577 education was found to affect opinions on the role of no-take zones as a positive  
578 fisheries management tool, fishing category has the same effect because of the  
579 particular socio-economic context. For example, recreational fishers are mostly  
580 fishing for pleasure throughout the year and can adapt easily to a new spatial closure  
581 in contrast to professional fishers. It is important to note that the zoning framework is  
582 influenced by the relative needs of the community as a whole, and should be  
583 achieved through a participatory process through which stakeholders and user-  
584 groups can better understand reciprocal needs and concerns (Boubekri and Djebar,  
585 2016).

586 In Algeria, Law No. 11-02 of 17th February 2011 on Protected Areas (PAs)  
587 within a sustainable development context, applies the zoning concept. According to  
588 this legislation, a local department-level commission and an inter-ministerial  
589 commission for PAs should be set up to validate the classification of PAs. In the  
590 Department of Jijel, the local-level commission for PAs was set up in mid May 2021  
591 followed by the validation of the classification of the "Taza" MPA proposal on  
592 24/05/2021. This is the last step towards the legislation stipulating the creation of  
593 "Taza" MPA which will be voted later in the inter-ministerial commission for PAs.  
594 "Taza" MPA is adopting a multiple-use management approach that aims to achieve



595 sustainable use consistent with conservation. Therefore, in the proposed zoning plan,  
596 some fishing activities such as lines and long lines (except for jigging) are permitted  
597 in “buffer zones”, but only with a license, while the “peripheral zone” is dedicated to  
598 sustainable development activities such as ecotourism. For the planners of “Taza”  
599 MPA, the main management objective of this multiple-use zoning plan is to mitigate  
600 the conflict between conservation enforcement and local communities, in particular  
601 the fishing community. To this end, trawling (bottoms > 50 m), purse seining (bottoms  
602 > 35 m), and trammel nets are permitted in the “peripheral zone”, however, gillnets  
603 are prohibited throughout the whole MPA (see Table 2 for more details).

604 In addition, since late 2019 the fishing harbour of Ziama houses an antenna of  
605 the Algerian Coast Guard (in Algeria, the Algerian Coast Guard has responsibility for  
606 supervising fishing activity), which will help with rule enforcement and control of the  
607 fishing activity in this area once the MPA has been created. According to Kacher  
608 (2010), the use of nets by recreational fishers is now a common fishing technique in  
609 the study area. It should be noted that nets are not prohibited to recreational fishers  
610 provided that they hold a special authorization issued by local fisheries authorities.  
611 However, a significant number of recreational fishers sold their catch, a practice  
612 which is at odds with what the Algerian regulation defines as recreational fishing (i.e.  
613 Decree No. 2003-481 of 13 December 2003: *“any fishing exercise as a sport or as a*  
614 *leisure activity and for non-commercial purposes”*) (Boubekri et al., 2021).

615 The prediction and prevention of fishermen’s compliance by assessing the local  
616 knowledge is therefore of the utmost importance, particularly by integrating  
617 fishermen’s LEK in the critical early planning process of the MPA.

#### 618 *4.4. Implications for Fisheries Management and MPA Planning*

619 Fishers’ perceptions towards fisheries management and MPA planning can  
620 have a strong influence on public support. Recent research has revealed that the  
621 fishermen’s LEK is a crucial tool to cope with “data-poor” fisheries as part of  
622 conservation science and management of fisheries (Moreno-Báez et al., 2010; Palas  
623 et al., 2017; Martins et al., 2014). In our case study, such perceptions have been  
624 found to be influenced by age, experience, education, and fishing category. Socio-  
625 economic factors structure differences between and within communities and result in  
626 variations in the understanding of the conservation projects (Myatt-Bell et al., 2002).

627 Therefore, identifying the factors that drive differing perceptions held by fishers  
628 should be a crucial component in the “Taza” MPA ongoing process as they can offer  
629 a broader understanding of (1) the fishermen’s LEK in the field of fisheries  
630 management, (2) the awareness of the managed fishery approach with spatial  
631 closure and (3) the main issues that fishers considered to be important before the  
632 implementation of this MPA. Managers of the future “Taza” MPA may then set  
633 priorities in addressing knowledge gaps among fishers and encouraging more  
634 positive perceptions by creating innovative instruments to enable the fishing  
635 community to participate, influence, manage, and benefit from this conservation  
636 project. To this end, the use of LEK protocols could foster mutual trust between the  
637 management body and the different user-groups. For fishers, we must also consider  
638 that LEK promotes awareness among its participants and enhances the capacity to  
639 understand the heterogeneity of the SES in place.

640 Fishers found to be supportive of the future “Taza” MPA were generally from the  
641 recreational category, live in a relatively small household, mostly fish for pleasure,  
642 had a high level of education, and a positive perception of the no-take zones. In  
643 contrast, professional fishers with a lower level of education, living in a bigger  
644 household, depending mostly on fishing, and with an uncertain perception of the no-  
645 take zones showed reluctance towards the MPA. The artisanal fleet of Ziama harbour  
646 makes this coastal fishery mainly dependent on environmental conditions (Boubekri  
647 et al., 2021, 2019 and 2018), which has important implications for fisheries  
648 management. The peak activity of professional fishers in Ziama is between May and  
649 September (Boubekri et al., 2018 and 2019). In Ziama Bay, sardine is more abundant  
650 in summer inside the Gulf of Béjaia (Boubekri et al., 2019), which is targeted by  
651 professional fishers (i.e. purse seiners). Juveniles of different cohorts but also adult  
652 breeding sardine penetrate into the Gulf of Béjaia in spring and summer just after the  
653 spawning period, which occurs from November to April (Kaidi et al., 2019). Moreover,  
654 from the five identified *métiers* in the small-scale fishery of Ziama harbour, four are  
655 practiced more frequently in summer (Boubekri et al., 2018). Conversely, recreational  
656 fishing is intensively practiced throughout the year (Boubekri et al., 2021), and,  
657 although their fishing effort is lower than that of professional fishers, the proportion of  
658 the harvest attributed to recreational fishers in this area represents about 50% of the  
659 small-scale fisheries harvest (Boubekri et al., 2021). Thus, recreational fishers

660 potentially target immature and spawning adults of several demersal fish and their  
661 activity should be regulated because factors influencing recruitment are particularly  
662 important in the implementation of no-take zones, in which a potential positive  
663 spillover effect contributing to fisheries' long-term sustainability is observed  
664 (McClanahan, 2021; Sala-Coromina et al., 2021). Therefore, the spatial closure  
665 proposed in the zoning plan is a positive management measure if situated in areas  
666 relevant to the reproduction of coastal fish species.

#### 667 *4.5. Study Limitations*

668 LEK constitutes an interesting tool to evaluate the outcome of fisheries  
669 management actions such as the establishment of an MPA. Overall, our results  
670 suggest a relatively high social-ecological impact resulting from the future  
671 establishment of the "Taza" MPA. However, LEK provided some capacity to  
672 understand the heterogeneity of this SES. The presence of no-take zones within the  
673 proposed zoning plan enabled a better understanding of the fishing economic  
674 potential issue which was pivotal for addressing the ongoing challenges that a spatial  
675 closure poses to fishery. For instance, although a considerable number of fishers  
676 agreed that marine conservation is a priority for the near future, the contrasting  
677 perception about the no-take zones was mainly explained by fishing category,  
678 suggesting that attention needs to focus on a finer scale in order to be able to build  
679 support and allow each fishing category to assume positions based on differing  
680 perceptions about the impacts the "Taza" MPA may have. Moreover, data used in  
681 this study cannot be taken to be representative for much longer as the new mixed  
682 recreational and commercial fishing port of El-Aouana is likely to intensify the fishing  
683 effort near the proposed no-take zones (Fig. 1).

#### 684 **5. Conclusions**

685 LEK, if properly collected and translated, can be used as an alternative  
686 information source for fisheries management. This analysis more clearly articulates  
687 two distinct perspectives in MPA planning. Recreational fishers support the  
688 implementation of fishing restrictions as a solution for fish stock recovery, while  
689 professional fishers are rather driven by the fishing economic potential, and may not  
690 find spatial closure relevant. Therefore, we can state that it is relevant to study the  
691 LEK in order to understand the fishery related social-ecological issues within the

692 MPA context and to highlight an existing conflict between two fishing categories.  
693 Studying the LEK allowed a clear representation of the factors that must be taken  
694 into account when implementing this MPA. The use of LEK is therefore a cost-  
695 effective alternative for carrying out social-ecological studies in a data-poor situation  
696 context. It allows obtaining reliable information that will create an appropriate place  
697 for debate and enhance the acceptance of an MPA ahead of its implementation, both  
698 from ecological and socio-economic perspectives.

699 Finally, our findings highlight the need for “Taza” MPA managers to continue to  
700 engage fishermen, potentially the most affected user-group by MPA restrictions, with  
701 information about no-take zones effectiveness and their potential social-ecological  
702 impacts as part of an ecosystem-based management approach that seeks to  
703 understand the human-environment interactions against a multitude of forthcoming  
704 fisheries challenges. By means of interviews and the use of fishermen’s LEK, we  
705 generally found that the fishermen’s LEK corresponded with the best available  
706 science-based knowledge. LEK is compatible with an integrated view of sustainable  
707 fisheries management that includes the complexities of coupled SES in data-poor  
708 situations. On the basis of our findings, we recommend the integration of social  
709 dimensions in the design of marine and fishing policies to better understand  
710 contributing factors which influence social acceptance of MPAs.

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717 cooperation of the fishers of Ziama harbour.

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