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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*

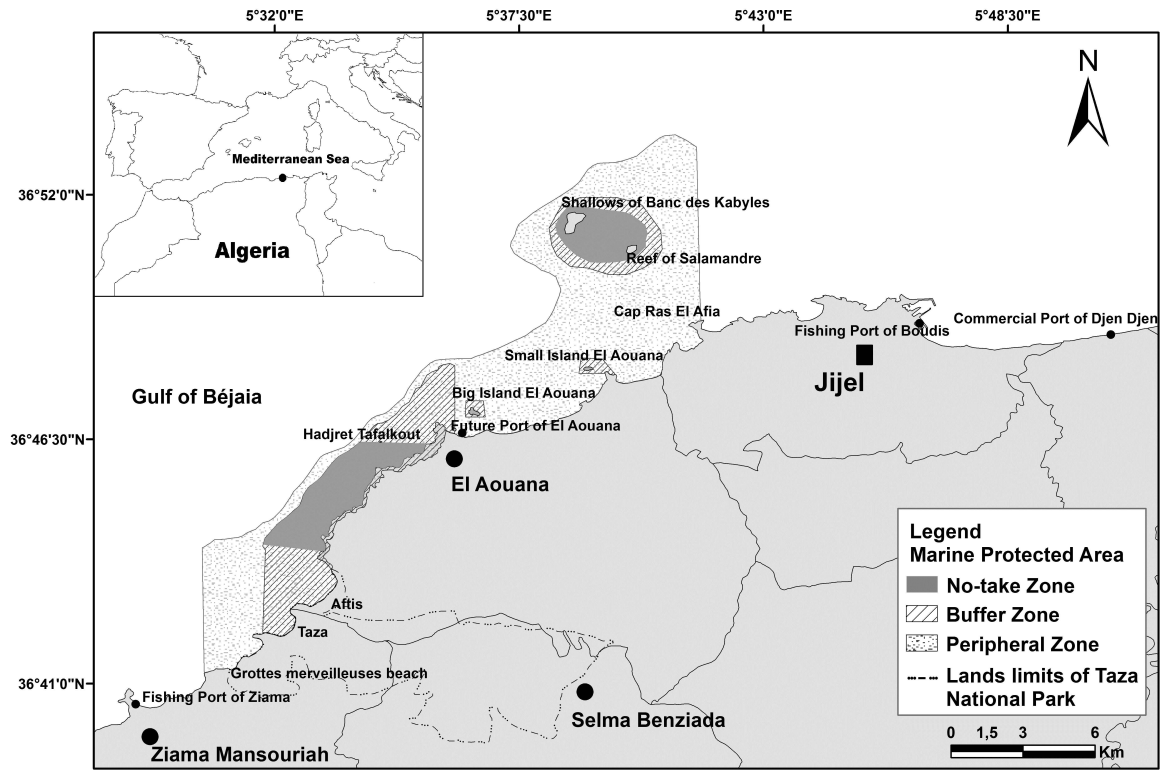
132 The municipality of Zياما Mansouriah has one of the two operational fishing
133 harbours in the Department of Jijel (Fig. 1). Along the Algerian coast, this Department
134 is also recognized as an important region for coastal fishing activity, third in number
135 of skippers (644) nationwide (ONS, 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≥ years old), fishing experience (<15
236 vs. 15≥ 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**

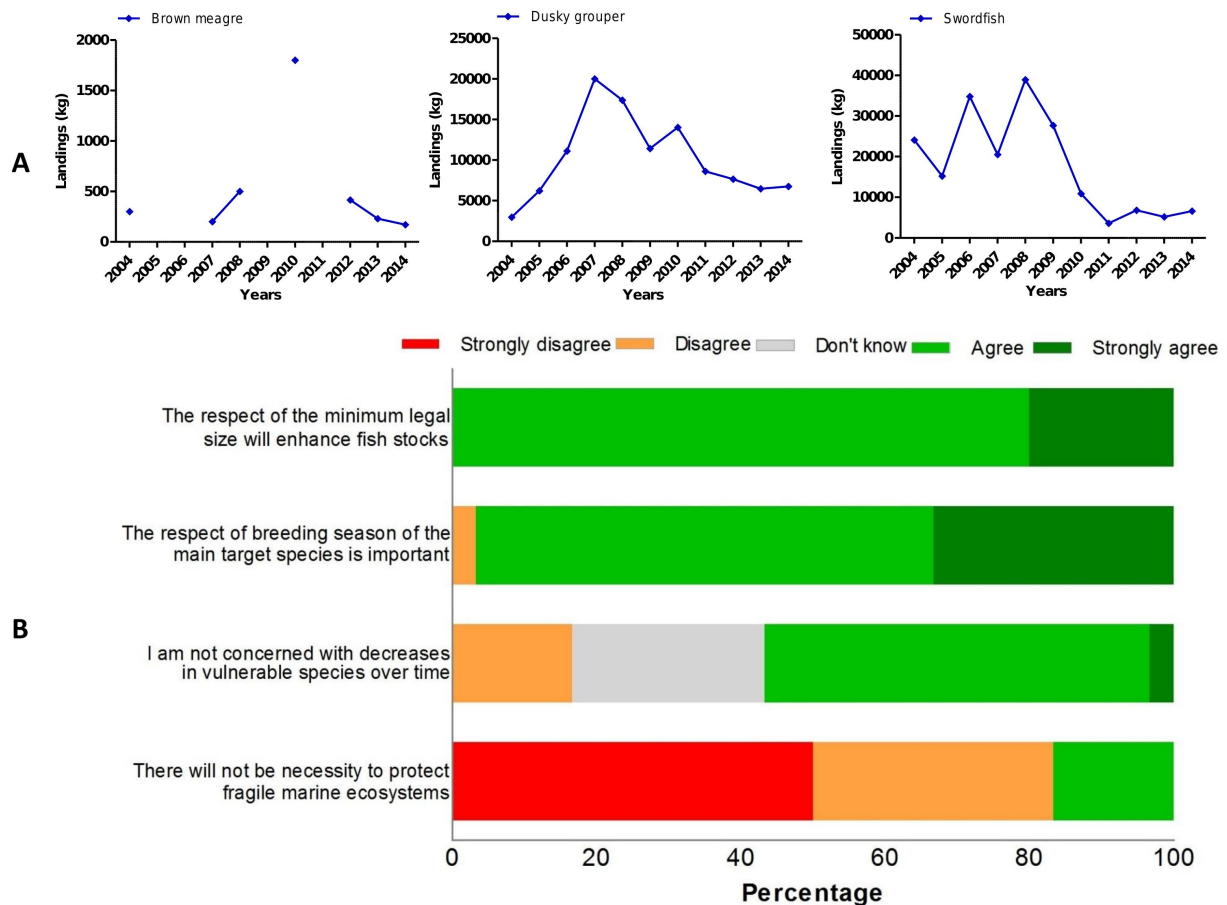
266 We present results based on scientific and local knowledge simultaneously to
267 assess social-ecological impacts which can inform more accurately on MPA planning
268 and fisheries management in the future MPA of "Taza" (Algeria, SW Mediterranean).

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).

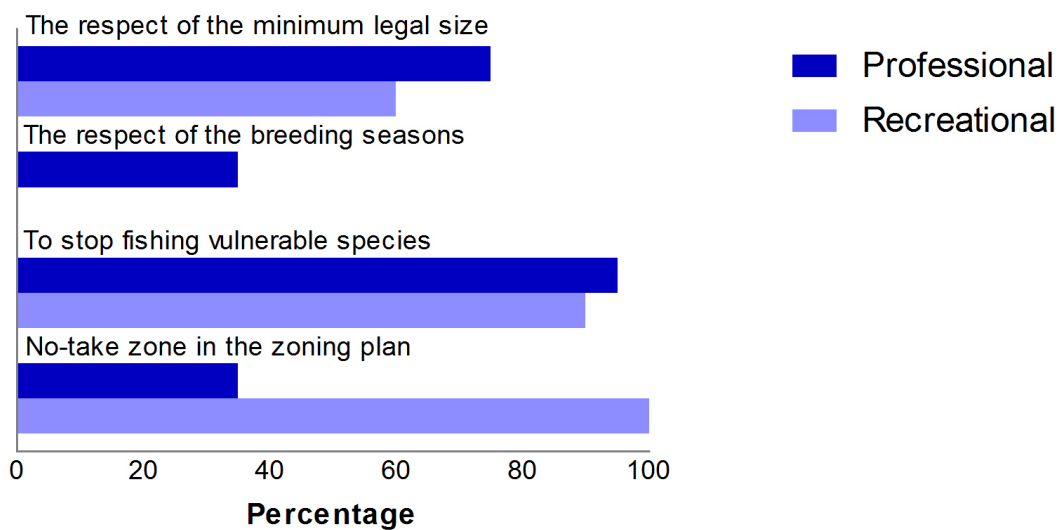


288
 289 **Fig. 2. (A)** Annual time-series of vulnerable species landings: Brown meagre (*Sciaena umbra*), Dusky
 290 grouper (*Epinephelus marginatus*), and Swordfish (*Xiphias gladius*) in Jijel. **(B)** Fishers' perceptions of
 291 the biological and ecological impacts of coastal fishery in Zياما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

| |
|---|
| Response samples |
| I do not know the minimum legal size for the species I am fishing (5) |
| 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) |
| I have a very low fishing impact, I do not think my activity could have detrimental effects during the breeding season (2) |
| 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) |
| I do not know when the breeding season is (3) |
| 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) |
| 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) |
| Onboard I am a simple fisherman, I do not decide I just follow the instructions of the captain (1) |
| 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) |
| We must stop fishing vulnerable species to avoid their extinction (1) |
| Vulnerable species are not essential, we can avoid them (1) |

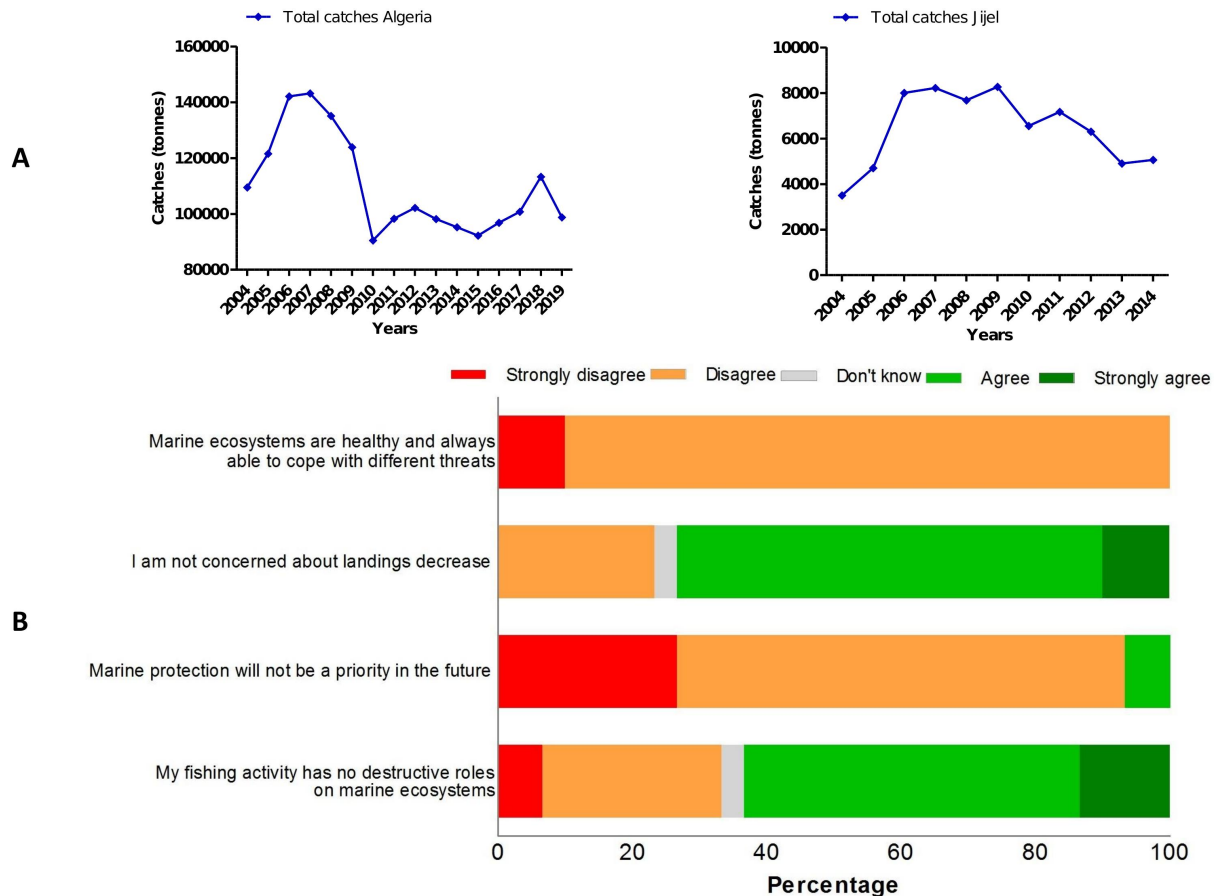
328
 329 The SES appears to not be prepared to cope with the high levels of compliance
 330 with the regulatory framework which may come in the wake of the creation of the
 331 "Taza" MPA, showing a lack of awareness about vulnerable species which are
 332 characterised by a limited reproductive potential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

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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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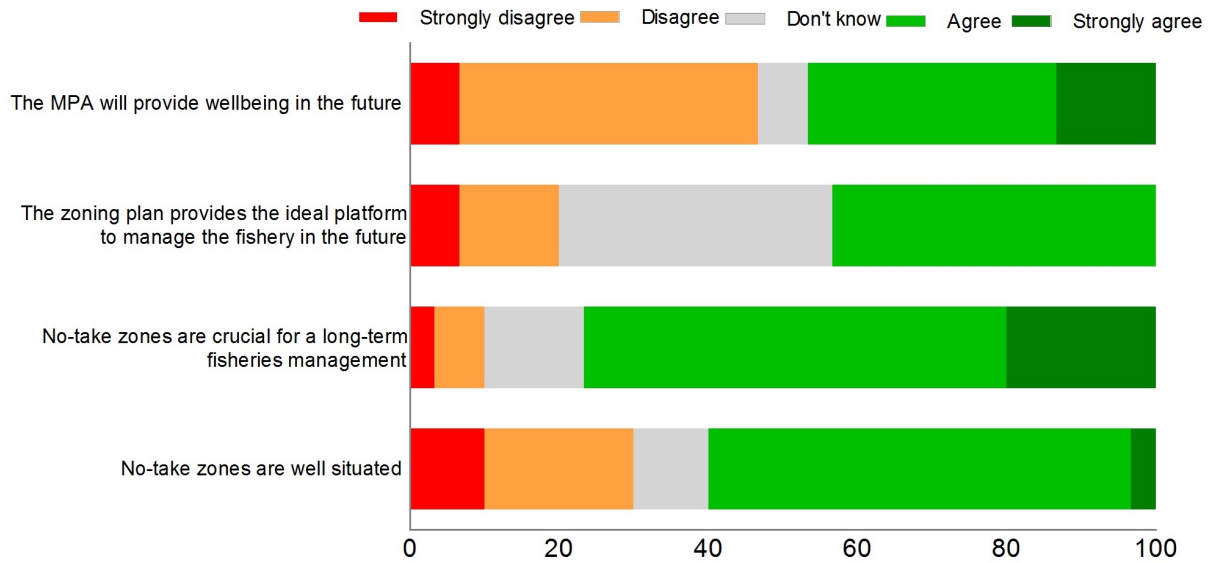
402 **Table 2**

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 |
|---|-------|-------------------------|------------------------------------|------------------------------------|---|---|
| Other zones | | | | Special protection area of islands | | Remarkable places for education and training |
| Zone characteristics | | Low protection | Average protection | Special protection | High protection | |
| Function | | Sustainable development | Protection of the integral reserve | Education and training | Conservation and restoration of the integral area | |
| Commercial fishing | | | | | | 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) | | + | + | - | - | |
| Recreational fishing | | | | | | |
| <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 |
| Tourism and leisure | | | | | | |
| 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 |
| Other activities | | | | | | |
| 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 |

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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 Djébar, 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 (Douve, 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 Djebbar,
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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