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Using Fishermen's Knowledge and GIS to Identify Fishing Grounds, Gears and Species in the Projected Marine Protected Area 'Jabal Moussa'

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Abstract: Marine spatial planning and ecosystem based management such as MPA's has been used as tools to manage human activities, to conserve coastal ecosystems and biodiversity for the sustainable use of oceans, seas and marine resources. In this study, we focused on establishing a spatial distribution of the fishing grounds used by local fishermen in the projected MPA "Jabal Moussa", identifying the most important species targeted, the gears used, and the depths of fishing grounds. A survey with 99 skippers was conducted between February and March 2019. Then data collected was analyzed and geo-referenced through geographic information system (GIS). The results identified 16 fishing grounds. Distribution of fishing gears was dominated by the blackspot seabream longline which was the most used gear. The most targeted species was the blackspot seabream. Fishing grounds where blackspot seabream was found had a deep ranging from 95.9 m to 328.9 m. Results of the study will provide managers of the projected MPA with valuable information and data to help the to adopt direct measures that can reduce the pressure on these valuable species, preserve the ecosystem and lead to a sustainable fishing.

Keywords: *Blackspot seabream, Fishing grounds, Fishermen's knowledge, Geographical information system, Marine protected area*

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1. Introduction

Artisanal fishery definition may vary from one country to another and from one region to another depending on the general context (Derdabi and Aksissou, 2021a). However, the United Nations for Food and Agriculture (UNFA) defined artisanal fishery as "Traditional fisheries involving fishing households (as opposed to commercial companies), using relatively small amount of capital and energy, relatively small fishing vessels (if any), making short fishing trips, close to shore, mainly for local consumption. In practice, the definition varies between countries, e.g. from gleaning or a one-man canoe in poor developing countries, to more than 20 m trawlers, seiners, or long-liners in developed ones. Artisanal fisheries can be subsistence or commercial fisheries, providing for local consumption or export.

Sometimes referred to as small-scale fisheries" (FAO, 2005). It is an activity that plays an important role in poverty alleviation, food security, and sustainable development all around the world, especially in developing countries (FAO, 2005; Béné, 2006; Béné et al., 2007; Daw et al., 2011; FAO 2016a). However, the artisanal fishery may have negative aspects such as overexploitation and the use of destructive and non-selective gears (Rodriguez 2014; Derdabi and Aksissou, 2021b). In response to such problems, many ecosystem conservation management strategies, including marine spatial planning have been adopted to sustainably manage fisheries. One of the most used tools in marine spatial planning is the geographical information systems GIS. It

is used in georeferencing and well understanding human and nature relationships (Conant 1994; Aldenderfer and Maschner 1996; Nyerges and Green 2000). It is a tool with growing use in the field of mapping marine resources and fishing activities (Mumby et al. 1995; Villa et al. 2002; Bates and James 2002; Turner and Klaus 2005), mainly for the industrial sector and large-scale demersal and pelagic fisheries (Jacquet and Pauly, 2008; Torres-Irineo et al., 2014). While, for artisanal fisheries, called also SSF, which is responsible for almost half of the world's seafood catch (Derdabi and Aksissou, 2021c), this kind of data is still not exploited and unreachable, thus excluding this sector from management programs and plans (Daw, 2008; James et al., 2018).

However, in the last decade, many studies showed the growing interest in promoting and integrating artisanal fishermen's knowledge into conservation and management strategies through the use of geographical information systems (GISs) (Neis et al., 1999; Jones et al., 2008), especially concerning the description of fishing areas and distribution of fishing effort (Scholz et al., 2004; Anuchiracheeva et al., 2003; Aswani and Lauer, 2006; Richardson et al., 2006; Hall and Close, 2007; Daw, 2008; Wheeler et al., 2008; De Freitas and Tagliani, 2009; Hall et al., 2009; Forcada et al., 2010; Weeks et al., 2010). Many successful experiences have been reported all around the world, such as the case of Nicaragua where reefs used by the Indian communities of Miskito have been cataloged (Nietschmann, 1995), local fishing spots in southeastern Brazil mapped thus helping fishermen in defending their territories from industrial trawlers (Begossi, 2001), and also for using the georeferenced data in designing and managing marine protected areas in the Solomon Islands (Aswani and Hamilton 2004a). The success of these experiences and others is generally related to the integration of Fishermen's knowledge, based on centuries of interaction with the ecosystem. This involvement may increase acceptance and make fishermen more collaborative and favorable to conservation measures and management strategies (Derdabi et al., 2022), and contribute to project success.

In Morocco, the concept of marine spatial planning is new. The very first national meeting on marine spatial planning and sustainable blue economy in Morocco took place in Rabat in September 2020 as part of a pilot project in the Western Mediterranean (Marine spatial global planning, 2021). Through this work, we aim to elaborate a baseline resource map based on the local knowledge of fishermen to be used in future ecosystem conservation strategies.

2. Materials and methods

2.1. Study area

This study was carried out in the marine part of the projected protected area 'Jabal Moussa'. It is located in the strait of Gibraltar and concerns three fishing sites (Belyounech, Oued El Marsa, and Dalia) (Figure 1).

The area around Jabal Moussa, which is part of the RBIM, defined within the framework of the MAB program (TMSA 2010), has swells ranging from 1—1.5 m. The tide is semi-diurnal with slight diurnal irregularity (SOGREAH 2007). The area hosts great biological diversity in species and habitats, and in particular species such as red coral (Corallium rubrum), coralline red alga (Lithophyllum byssoides), colonial orange coral (Astroides calycularis), and eelgrass (Zoostera marina), which are protected by several international conventions (PNUE/PAM-CAR/ASP, 2016).

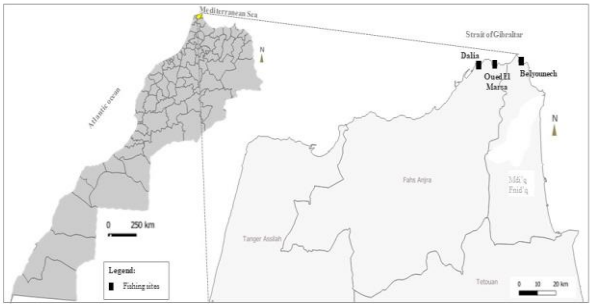


Figure 1: Fishing sites within the marine projected area Jabal Moussa (QGIS 3.20)

2.2. Data collection and analysis

Data were collected between February and March 2019 and consisted face to face interviews with the skippers of 99 boats, but in case of their absence or refusal to collaborate, we interviewed another crew member, so that only one person per boat was interviewed. The interview lasted around 15 minutes and was generally held once the fishermen come back from a fishing session. The interview aimed to collect data about fishing grounds and the gears used by local fishermen and to identify the most important species targeted. One field trip to each fishing site was done with one boat. The geographical coordinates of the fishing grounds, as well as the depths, were collected using a sonar/GPS fish finder Garmin striker 4'. This data combined with the data collected through the surveys were geo-referenced in a standard map of the area using QGIS 3.20.

3. Results

3.1. Fishing grounds

Sixteen fishing grounds were identified. The identification of these fishing grounds by fishermen is generally linked to landmarks, such as mountains, mosques, houses, and wind turbines. The names given to these grounds were related to the location and mountains. Table 1 summarizes the geographical coordinates, the local names, and the depths of the fishing grounds. These geographical coordinates were then presented on the map (Figure 2).

Fourteen fishing grounds were inside the future marine protected area and two were near the boundaries. The depths of fishing grounds vary from 25 m for the lowest to 328,9 m for the deepest.

Generally, fishermen frequent the nearest fishing grounds to their site, but sometimes, they can access other farthest grounds depending on the species targeted.

3.2. Fishing gears

The surveys conducted with fishermen allowed us to determine the gears used in each fishing ground. Figure 3 below reports the distribution of use of the gears based on fishing grounds.

The spatial distribution of fishing gears shows that the most used gears in the area were the blackspot seabream longline, the longline with small hook, and the trammel net. The blackspot seabream longline is the most cited gear. It is responsible for a high rate of catches and it is easy to use. Handline and octopus jig are the less used gears. The octopus jig use is related to octopus fishing seasons. The use of surface gillnet which targets species belonging to the Scombridae family depends on the migrational season of these species. According to fishermen two or three fishing gears can be combined together such as the use of the longline with small hook and the trammel net or the handline and trammel net.

3.3. Species of fishes

The most important species targeted in the study area are presented in Table 2.

The blackspot seabream is the most cited species. The other species cited by fishermen belong to different orders. However, the perciforms order regroups the majority of species with high commercial value. According to fishermen, the composition of catches can vary from one site to another and from a month to another.

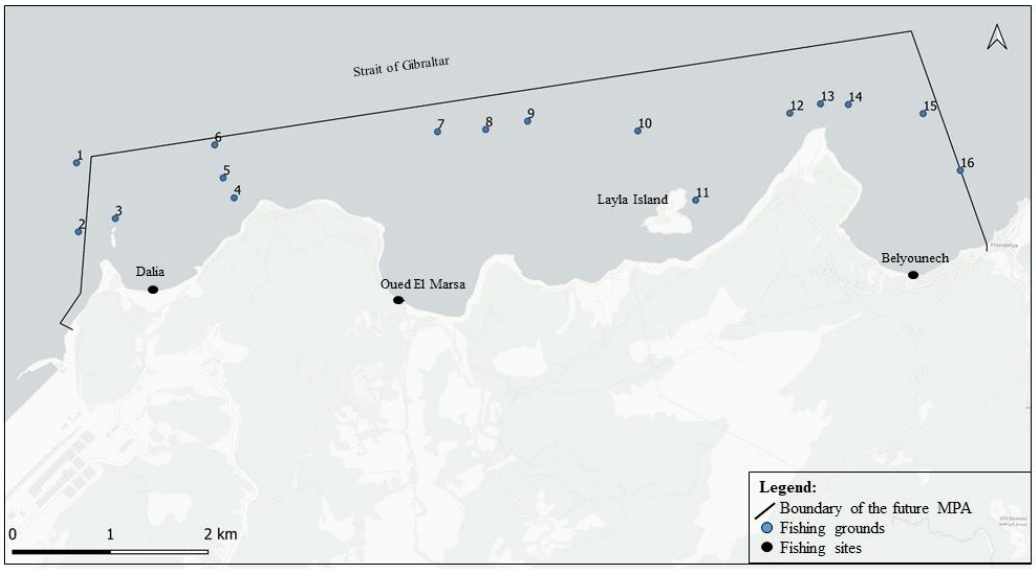
Table 1: Geographical coordinates, local names and depths of the fishing grounds

Nb	Fishing ground name	Coordinates N	Coordinates W	Depths
1	Louardyane El Ali	35°55.044'	005°29.161'	95.9
2	Msyed foum El oued	35°54.662'	005°29.136'	30.7
3	Ras Louardyane	35°54 741'	005°28 888'	14.7
4	Rass Lwaeer	35°54.872	005°28.084'	25
5	Rass lhmiyar	35°54.981'	005°28.162'	38
6	Betna Dalia	35°55.163'	005°28.225'	130.2
7	Betna Oued Marsa	35°55.267'	005°26.713'	98.6
8	Msyed Oued Marsa	35°55.286'	005°26.386'	115.4
9	Nakouba Oued Marsa	35°55.338'	005°26.103'	86
10	Gzira 1	35°55.299'	005°25.352'	101.4
11	Gzira 2	35°54.923'	005°24.947	37.6
12	Nefakha	35°55.418'	005°24.322'	328.9
13	Marsa Kassarin	35°55.474'	005°24.115'	105.3
14	Rass Kassarin	35°55.474'	005°23.926'	205.4
15	Betna Belyounech	35°55.434'	005°23.416'	201.4
16	Dakhla Cabriya	35°55.124'	005°23.754'	75.2

Table 2: High value species in the study area

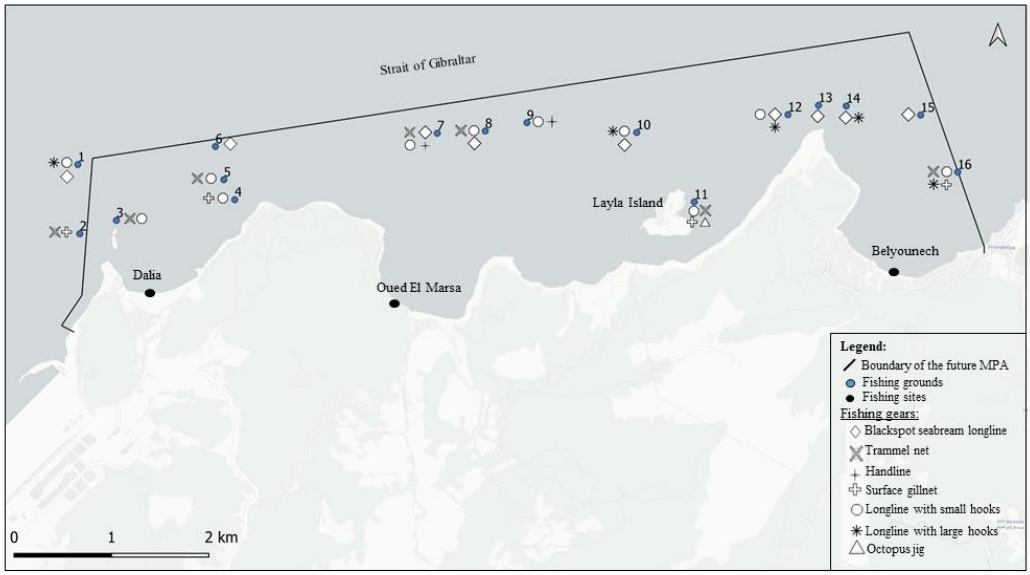
Taxon	Common name	Local name
FISHES		
O/PERCIFORMES		
F/Sparidae		
Pagellus erythrinus (Linnaeus, 1758)	Common pandora	Lobar
Pagrus pagrus (Linnaeus, 1758)	Common seabream	Paghar
Diplodus cervinus cervinus (Lowe, 1841)	Zebra seambream	Boubradaa
Pagrus caeruleostictus (Valenciennes, 1830)	Bluespotted seabream	Chama
Diplodus vulgaris (E.Geoffroy St.-Hilaire, 1817)	Common two banded seabream	Chargho
Pagellus acarne (Risso, 1826)	Axillary seabream	Bjok
Dentex dentex (Linnaeus, 1758)	Common dentex	Denss
Pagellus bogaraveo (Brunnich, 1768)	Blackspot seabream	Voracé
F/Scombridae		
Auxis rochei (Risso, 1810)	Bullet tuna	Melba
Katsuwonus pelamis (Linnaeus, 1758)	Skipjack tuna	Listao

Euthynnus alletteratus (Rafinesque, 1810)	Little tunny	Tounina
F/Carangidae		
Trachurus trachurus (Linnaeus, 1758)	Horse mackerel	Chral
F/Moronidae		
Dicentrarchus labrax (Linnaeus, 1758)	European seabass	Lhrech/Lep
F/Mullidae		
Mullus sp.	Mullet	Salmonete
O/SCORPAENIFORMES		
F/Scorpaenidae		
Scorpaena scrofa (Linnaeus, 1758)	Red scorpionfish	Gallinita
O/ANGUILLIFORMES		
F/Congridae		
Conger conger (Linnaeus, 1758)	European conger	Ghrong
F/Muraenidae		
Muraena helena (Linnaeus, 1758)	Mediterranean moray	Mrayna
O/PLEURONECTIFORMES		
F/Soleidae		
Solea vulgaris vulgaris (Quensel, 1806)	Common sole	Lenguado
O/ZEIFORMES		
F/Zeidae		
Zeus faber (Linnaeus, 1758)	John dory	Chatra/Saint pierre
O/GADIFORMES		
F/Phycidae		
Phycis phycis (Linnaeus, 1766)	Fork beard	Brotola



1.Louardyane El Ali	7. Betna Oued Marsa	13. Marsa Kassarin
2.Msyed foum El oued	8. Mesyed Oued Marsa	14. Rass Kassarin
3.Ras Louardyane	9. Nakouba Oued Marsa	15. Betna Belyounech
4.Rass Lwaeer	10. Gzira 1	16. Dakhla Cabriya
5.Rass Lhmiyar	11. Gzira	
6.Betna dalia	12. Nefakha	

Figure 2: Map distribution of fishing grounds in the future MPA Jbel Moussa



1.Louardyane El Ali	7. Betna Oued Marsa	13. Marsa Kassarin
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5.Rass Lhmiyar	11. Gzira	
6.Betna dalia	12. Nefakha	

Figure 3: Map distribution of fishing gears use in the future MPA Jbel Moussa

4. Discussion

The artisanal fishery is a very important activity in the projected marine protected area "Jabal Moussa". However, this activity can have negative consequences on the ecosystem and fish stocks, and lead to overexploitation (Rodriguez-Rodriguez, 2014; Derdabi and Aksissou, 2021b) if it's incorrectly managed. However, we observe actually, a growing interest in fishing practices that integrate respect for the environment and the sustainable and rational exploitation of fisheries resources, which is in perfect harmony with the guidelines of Sustainable Development Goal 14 (SDG14) which aims to conserve and sustainably use the oceans, seas and marine resources for sustainable development (ONU, Agenda 2030).

This conservation is done in the field by management tools such as MSP. In our case study, we observe that there has been a management and appropriation of marine space and fishing areas by fishermen across generations. This know-how has allowed fishermen to orient themselves and characterize the different fishing grounds and specialize in the fishing of blackspot seabream, contributing as well as indirectly to the management of their own resources. Therefore, the use of an area by fishermen is not by chance but is generally due to acquired fishing strategies.

Fishermen used landmarks such as mountains, mosques, houses, turbines, etc, to identify fishing grounds, they used also other data such as the nature of the bottoms, the nature of the currents, etc

Results showed also that the fishing grounds where blackspot seabream was targeted are all characterized by great depths, which is explained by the nature of the species, which frequents great depths of up to 500m. The fishing grounds identified are within the zoning of the future MPA, only two fishing areas are outside but near to the boundaries. In Jabal Moussa, artisanal fishing activities constitute the main source of income for the majority of the population. Limiting access to fishing or adopting « no-take zones » without proposing compensatory measures would surely lead to a repudiation and resistance to the establishment of the MPA (Mikalsen et al., 2007; Havard et al., 2015; Pieraccini & Cardwell, 2016; Derdabi et al., 2022). These conflicts can be avoided through communication among different stakeholders, especially fishermen (Markantonatou et al., 2016) who already have a clear vision of the subject.

Results obtained also from this study showed that the artisanal fishery in the study area is heterogeneous and uses 8 fishing techniques (Only 7 used), which were not always present in the three sites. Our results are identical to many other Mediterranean regions which are also characterized by heterogeneous artisanal fisheries (Battaglia et al., 2010; Di Franco, 2014; Falautano et al.,

2018). The choice of use of one gear or another depends generally on the topography of the fishing ground, the species migration, the periods of biological rest, weather conditions, selling prices, and the nature of recent catches made by other fishermen and fishermen from neighboring villages.

Studies that have focused on the fishing gears used by the artisanal fishery in the Mediterranean have shown that gillnets and trammel nets were the most used gears (Battaglia et al., 2010; Matic-Skoko et al., 2011; Rodriguez-Rodriguez, 2014). In the current case, the most used gear was the blackspot seabream longline, which was a very selective and respectful gear for the environment, targeting only the blackspot seabream. This distinction from other Mediterranean fisheries is due to the abundance of this species in the waters of the Strait of Gibraltar, both on the Moroccan and Spanish coasts. According to the surveys carried out among the fishermen, this is a fishery that started in the 1950s and has developed strongly since the 1980s. On the Spanish coasts, this fishery started to appear in the mid-1970s by some boats from Ceuta, although its expansion started in 1983 (García Del Hoyo et al., 2001). Targeting this species especially is also due to the fact that the species has one of the highest commercial values and whose fishing operation made by means of the blackspot seabream longline is easy to do. However, the artisanal fishery in the study area didn't target only blackspot seabream, it's multispecific, targeting a wide range of resources, particularly high-value species as many other fisheries in the Mediterranean Sea (Farrugio et al., 1993; Falautano et al., 2018).

5. Conclusion

The identification of fishing grounds and gears distribution use based on fishermen's experience, and geo-referenciation of data through maps, will undoubtedly give an additional value to the artisanal fishing activity in the area, and make fishermen more aware and more engaged in the preservation of their own resources, and thus ensuring the wellness of the whole ecosystem. Taking these skills and know-how into account, as well as valuing decades of experience by decision-makers and managers of the future MPA, are the keys to sustainable and successful management of fisheries resources and the marine environment. This can be done by strengthening communication, education, and training, as well as through the adoption of a co-management system allowing fishermen to be integrated into all the processes of creation and management of the future MPA. Our study is the first study that has defined the fishing grounds in the future MPA "Jabal Moussa". Through this work, we aim to provide decision-makers and MPA managers with geo-referenced informations based on centuries of fishermen's knowledge to help develop appropriate management measures in the future and contribute to bridging the gap between different stakeholders.

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