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Baseline data for Marine Protected Areas planning and fisheries monitoring: Potential conflicts between recreational IUU and commercial fisheries in the proposed “Taza” MPA (Algeria, SW Mediterranean)

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Abbreviations: IUU: Illegal, Unreported, and Unregulated; REC: Recreational fisheries; SSF: Small-Scale Fisheries; MPA: Marine Protected Area; CPUE: Catch Per Unit of Effort; DPRH: Directorate of Fisheries and Aquaculture; RBF: Recreational Boat Fishing; MedPAN: Mediterranean Protected Areas Network; SR: Species Richness; MC: Mean Catch; FT: Fishing Trips; TEK: Traditional Ecological Knowledge; ESRI: Environmental Systems Research Institute.

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Abstract

Nowadays, recreational fisheries (REC) have a great impact on marine ecosystems and create conflicts with other human coastal activities such as commercial small-scale fisheries (SSF). In the proposed “Taza” marine protected area (MPA) (Algeria, SW Mediterranean), recreational boat fishing is poorly regulated and its catches remain unmonitored. In addition, a significant number of REC fishers sell their catch illegally, an activity we could refer to as IUU (Illegal, Unreported, and Unregulated) fishing. This study is a good opportunity to evaluate the potential conflicts between recreational IUU and commercial fisheries and can be extremely valuable in terms of MPA planning and fisheries monitoring by providing baseline data for setting up sound fisheries management and conservation plans. Two fishing harbors are located near the proposed “Taza” MPA: Boudis and Zياما. Illegal REC boats from Zياما harbor were studied via a direct observation method of landings developed by the Ifremer (French Research Institute for Exploitation of the Sea). A comparison between illegal REC and SSF boats was highlighted in terms of catches and fishing effort. A total of 54 taxa belonging to 24 families were observed in the catches of the 32 recreational active boats in this harbor between May 2013 and April 2014. The proportion of the harvest attributed to illegal REC represented about 50% of the SSF harvest. Illegal REC in the proposed “Taza” MPA is an important socioeconomic activity which is intensively practiced throughout the year. From November to April, the mean catch was almost the same for both fishing categories. Strong competition between recreational and professional fishers for the natural resources was highlighted as 81% of the 54 caught taxa were present in the catches of both fishing categories (i.e. 44 taxa). Moreover, 4 species of high commercial value were caught exclusively by recreational fishers. Finally, the managers of the proposed “Taza” MPA must address and regulate all fishing activities and use the best available information in order to provide important benefits to marine ecosystems, fishers, and the local population.

Keywords: Recreational fisheries; Small-scale fisheries; Marine protected areas; Mediterranean; Algeria.

1. Introduction

Nowadays, there is growing concern about the impact of recreational fisheries (referred to as REC throughout this article) on marine ecosystems (Lloret et al., 2019) and the related conflicts with other human activities, such as commercial fisheries (Cooke and Cowx, 2006; Arlinghaus and Cooke, 2009). While commercial fisheries are the dominant fisheries worldwide (McPhee et al., 2002; Post et al., 2002; Cooke and Cowx, 2004), a growing portion of many harvested fish stocks over the world is carried out by recreational fishers (Coleman et al., 2004; Arlinghaus and Cooke, 2005; Lewin et al., 2006). According to Hyder et al. (2018), in some European countries, fish removals by marine REC for northern European sea bass (*Dicentrarchus labrax*) and western Baltic cod (*Gadus morhua*) stocks, represent 27% of the total catches (recreational and commercial). In 2012, recreational fishers were responsible for up to 53% of the total fish removals of European sea bass in Belgium (Hyder et al., 2018). In the Mediterranean, REC represent an important share of the fish caught and may locally amount up to 50% of the total commercial catches (European Commission, 2004; FAO, 2008; Font et al., 2012;), however they are still poorly managed and less studied compared to commercial fisheries (Font and Lloret, 2014; Prato et al., 2016; Pita et al., 2020). An increasing number of studies supports the idea that the increasing REC effort can have similar, or even higher effects on fish populations than artisanal fishing (Cooke and Cowx, 2006; Lloret et al., 2008; Zischke et al., 2012).

During the summer, the human population increases considerably in coastal areas, when the pressure of local tourism is highest. Consequently, aquatic leisure activities such as scuba-diving and REC (i.e. boat angling, shore angling, and spearfishing) have flourished on the Mediterranean shores and their additional impact on coastal and maritime ecosystems has grown (Morales-Nin et al., 2005). Therefore, fisheries managers need to consider all forms of harvesting if they are to manage these resources sustainably by improving national data reporting of recreational catches (Hyder et al., 2014; Ryan et al., 2016; Freire et al., 2020).

In Algeria, to practice REC only boat-owners are required to have recreational fishing authorizations (licenses), while spearfishers need an individual license (Babali et al., 2018). These licenses are issued by local fisheries authorities after payment of an annual fee and must be renewed each year. Up until December 2014, in the department of Jijel (SW Mediterranean, NE Algeria) where the proposed “Taza” MPA

is planned (Fig. 1), the fishing fleet had a capacity of 776 fishing boats (309 professional and 467 recreational), with only 292 updated licenses for recreational boat-owners (of these, 59 individual licenses are for spearfishers) issued by the DPRH (Directorate of Fisheries and Aquaculture) of Jijel (DPRH, 2014). Nevertheless, recreational boats have started to become more important since 2012, with their number doubling in a very short timeframe and almost filling the carrying capacity of Zlami fishing harbor (Boubekri and Djebbar, 2016). Moreover, the impact of REC on coastal ecosystems can be greater in marine protected areas (MPAs), given the increasing number of visitors fishing for pleasure (Cooke and Cowx, 2006). MPAs are often seen as a way to develop and demonstrate the benefits of management methods that allow multiple-use to coexist sustainably in areas that are subjected to a variety of pressures (Lester et al., 2009; Pike et al., 2010; Horta e Costa et al., 2013).

The recent data on the number of recreational fishers and fishing effort within the European Mediterranean countries has been estimated to be approximately 2.8 million and 20.9 million sea fishing days per year, respectively (Hyder et al., 2018). However, the estimates in non-European Mediterranean countries remain scarce or totally absent despite the popularity of REC in these countries (Belhabib et al., 2013; Babali et al., 2018; Ben Lamine et al., 2018). In Algeria, the REC sector is poorly regulated and its catches remain unmonitored (Babali et al., 2018). More recently, efforts are underway in Algeria to reconstruct preliminary estimates of recreational catches, based on catch data reported by the Ministry of Fisheries and Aquaculture. Between 1970 and 2010, the total estimated landings from recreational boats increased globally until the early 2000s, peaked at 1200 t·year⁻¹ in 2002, and began declining thereafter to about 1000 t·year⁻¹ in 2010 (Belhabib et al., 2013), raising concerns that the Algerian coastal resources may be overexploited. Another study also highlighted the great economic impact of REC which deprives the Algerian national treasury - through lost tax, license income, and revenues from illegal sales of fish - of 45 million USD annually (Babali et al., 2018). In addition, recreational fishers have been without legal restrictions for a long time (Abdelguerfi, 2002).

The most popular REC technique in Algeria by far is the recreational boat fishing (referred to as RBF throughout this article) which means fishing on board of recreational boats. According to Belhabib et al. (2013), RBF in Algeria represents

80% of REC. The term “recreational fisheries” can be considered as part of “small-scale fisheries” even though many differences between the two fishing categories are pointed out (Table 1). In the present study “professional fisheries” indicates any fishing exercise reserved for fishers holding certificates of registration to a professional category without any reference to fishing boat categories, while “small-scale fisheries” indicates strict implication of the “professional fisheries”. In the Algerian context, the difference between recreational and professional fisheries is so highly nuanced - with many recreational fishers selling illegally their landings - that we could refer to “IUU (Illegal, Unreported, and Unregulated) recreational fishing”. Throughout this article we will refer to “illegal REC” due to the common usage of this term in the Algerian context as well as to SSF (Small-Scale Fisheries) when referring to “commercial fisheries” because all the small-scale boats surveyed were practicing commercial fishing.

Table 1. Definitions of the different fishing categories in Algeria.

Fishing category	Definition	Foundation text
Recreational fishing (REC)	Any fishing exercise as a sport or as a leisure activity and for non-commercial purposes.	Decree No. 2003-481 of 13 December 2003 (Art. 61)
Professional fishing	Any fishing exercise reserved for fishers holding a professional booklet.	Decree No. 2003-481 of 13 December 2003 (Art. 3)
Small-Scale Fishing (SSF)	Any traditional fishing practiced in territorial sea. This fishing activity is carried out with boats less than 12 m in length.	Law No. 07-12 of 31 December 2007 (Art. 55)
Commercial fishing	Any fishing exercise reserved for fishers holding a professional booklets onboard professional boats with an active tax assessment.	Decree No. 2003-481 of 13 December 2003 (Art. 5)
Recreational Boat Fishing (RBF)	Fishing on board of recreational boats.	Decree No. 2003-481 of 13 December 2003 (Art. 13)
Recreational boats	Boats with recreational fishing authorizations (licenses). The fishing authorization is issued to the boat-owner.	Decree No. 2003-481 of 13 December 2003 (Art. 13)
Professional boats	Boats with professional fishing authorizations (licenses). The fishing authorization is issued to the boat-owner.	Decree No. 2003-481 of 13 December 2003 (Art. 13)

The increase in REC effort can have similar or even greater effects than that of commercial fishing on the structure of some fish populations (Bianchi et al., 2000; Coll et al., 2004; Lewin et al., 2006), and also on the conservation status of certain species (Lloret et al., 2018), such as endangered and vulnerable ones (Morales-Nin et al., 2010; Lloret et al., 2012; Biton-Porsmoguer and Lloret, 2018). Unfortunately no statutory instrument has yet been adopted to date for the creation of the “Taza” MPA and this situation can result in a huge conflict over the exploitation of resources and the use of space between recreational and professional fishers in the near future.

The zoning plan of the proposed “Taza” MPA comprises 2 no-take zones (Fig. 1). The regulatory proposal for the no-take zones stipulates the authorization of boat navigation without mooring and scientific research, while prohibiting recreational and commercial fisheries as well as all the other marine extractive uses (e.g. extraction of aggregates for construction). However, both REC and SSF are allowed in the buffer and the peripheral zones where fishers can use only lines and trammel nets (Boubekri and Djebbar, 2016). Thus, the benefits of the proposed “Taza” MPA in terms of protection and sustainable management of commercial fish stocks can fail if the basic data on REC are missing (e.g. effort and catches). Alongside the ecological impact of REC on coastal fish stocks and the potential risks of overfishing arising from the use of forbidden gears, the illegal selling of recreational catches in the local market is creating unfair competition and conflict between REC and SSF fishers in the area of the proposed “Taza” MPA.

The aim of this study is to evaluate the potential conflicts between illegal REC and commercial SSF and to compare their catches and fishing effort in the area of the proposed “Taza” MPA. This study can be extremely valuable in terms of MPA planning and fisheries monitoring by providing baseline data for the managers of this proposed MPA in their work to set up sound fisheries management and conservation plans. To this end, SSF data were used together with REC data from the perspective of the development of integrated fisheries management plans. Therefore, the future management plan of this MPA will serve as a scientific reference for ensuring both safeguarding of the commercial fisheries, especially SSF which is the main socio-economic activity in the study area (Chakour, 2012), and the sustainability of the REC which become increasingly important in the economies of a number of Mediterranean countries (Pita et al., 2017; Babali et al., 2018; Lloret et al., 2018). Moreover, the study is geographically focused on the southern part of the Mediterranean basin, a region where little is known about REC and on a forthcoming MPA that will play a crucial role to stimulate the implementation of specific measures for enhancing fisheries management in this region.

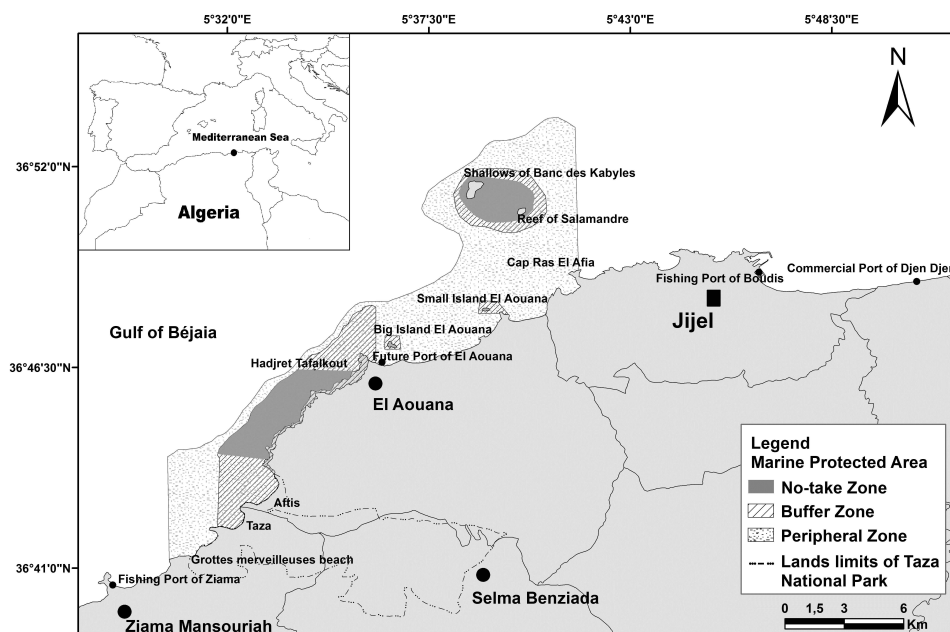


Fig. 1. Map showing the location and zoning plan of the proposed “Taza” MPA, Algeria.

2. Materials and Methods

2.1. Study area

Two fishing harbors are located near the proposed “Taza” MPA: Boudis (latitude 36° 49' 6"N, longitude 5° 46' 27"E) and Zama (latitude 36° 40' 37"N, longitude 5° 28' 44"E) pending the completion of work to build a third port in the municipality of El-Aouana (Fig. 1). This study was conducted in the fishing harbor of Zama, located in the South-Western Mediterranean Sea off the Gulf of Béjaia in Algeria (Fig. 1). In 2009, with the support of the network of MPA managers in the Mediterranean (MedPAN), Taza National Park began a process to include its adjacent marine area covering 9603 ha (Boubekri and Djebbar, 2016). The planned MPA (latitude 36° 41' 13"N and 36° 53' 19"N; longitude 5° 30' 26"E and 5° 41' 15"E) is located in the East part of the Gulf of Béjaia and extends about 23 km along rocky coasts and sandy beaches (Fig. 1). Along this Gulf, the fishing harbor of Zama has traditionally been home to an important fishing community including both recreational and professional fishers (Boubekri et al., 2019).

Furthermore, one of the specificities of this fishing harbor is the absence of the Algerian Coast Guard (in Algeria, the Algerian Coast Guard has responsibility for supervising fishing activity), which encouraged a practice of illegal REC on a large

scale (Kacher, 2010). According to Kacher (2010), the use of nets in RBF is now a common fishing technique for almost half of the REC fishers in the study area. It should be noted that nets are not prohibited to REC fishers provided that they are holding a special authorization issued by local fisheries authorities. However, a significant number of recreational fishers sold their catch, a practice which is at odds with what the Algerian regulation defines as recreational fishing (see Table 1).

2.2. Data collection

The fishing harbor of Ziamia is the only harbor in the study area where recreational catches are reported. In this study, catch data were collected via a direct observation method of landings (Griffiths et al., 2007; Merrien et al., 2008). On a daily basis from May 2013 to April 2014, and with the help of two observers from the DPRH of Jijel, all the recreational boats involved in illegal REC in the fishing harbor of Ziamia were surveyed. In total, 32 recreational boats out of 46 (70%) were considered in this study. For these boats, all fishing trips were taken into account.

It should be noted that the same survey method was used by Boubekri et al. (2018) for SSF for the surveying of 24 small-scale boats. Moreover, both REC and SSF surveys did cover the same study area and were conducted throughout the same studied year. Details of SSF survey are given in Boubekri et al. (2018). The catch and fishing effort data of SSF were used in this article to highlight the potential conflicts between commercial SSF and illegal REC. For each fishing category three variables were considered in this study: 1) the mean Fishing Trips (FT) - this was calculated monthly as the number of fishing trips per boat per day and used as an indicator of fishing effort; 2) the Mean Catch (MC) - this was calculated monthly as mean catch per active boat per day (kg/boat/day); and 3) average Species Richness (SR) in the catch - this was calculated monthly as the total number of species (or higher taxonomic level) caught per boat per day.

The choice of Ziamia harbor allowed us to overcome logistical constraints (i.e. widespread geographical dispersion of landing places) while targeting a significant component of illegal recreational boats that are mainly operational in the western perimeter of the proposed “Taza” MPA (Fig. 1). As boats returned to the harbor, catch data was collected by counting the number of fish crates and expressing the weight in (kg). However, when fish crates were not classified by species (i.e. genus

or family), the weights recorded were grouped at a higher taxonomic level (please see Appendix A for more details about the concerned species).

In addition, weekly surveys were conducted using semi-quantitative questionnaires to obtain information on: 1) target species, 2) fishing gear used, and 3) visited fishing ground (depth, location, and habitat characteristics). For the latter, map-based interviews were conducted with fishers, for which the interviewer and the informant used a hard copy map (Close and Hall, 2006). It should be noted that fishers' Traditional Ecological Knowledge (TEK) is recognized as an effective tool for the management of artisanal fisheries and MPAs in the Mediterranean (Coll et al., 2014; Léopold et al., 2014; Pita et al., 2016).

In contrast to the survey carried out for SSF in this fishing harbor (see Boubekri et al., 2018), the collection of catch data classified by gear was not possible because illegal recreational fishers appeared reluctant to provide this information, most likely because they are practicing IUU fishing. In its place, an inventory of the fishing gears used by illegal recreational fishers was listed based on field observation (see Table 3).

2.3. Data analysis

We used a Kruskal-Wallis H test to test for main differences between the three variables: fishing trips (FT), mean catch (MC), and specific richness (SR) among the four seasons, and a Mann-Whitney U test to test the same variables (FT, MC, and SR) using seasonal mean values for comparisons between illegal REC and SSF. In this perspective we ran the Kruskal-Wallis H test among the seasonal mean daily values, while the Mann-Whitney U test was run between the mean daily values of illegal REC and SSF. We have chosen non-parametric statistical tests because our data did not meet the assumptions required for parametric statistics. The level of significance was $\alpha = 0.05$. All the statistical analysis was performed using Prism version 5.03 for Windows.

The fishing grounds visited by recreational and professional fishers as inferred from the map-based interviews, have been processed in relation to the number of fishing trips (frequency of visits), using the software ArcGIS 10.3.1. ESRI (Falautano et al., 2018). In order to evaluate spatial competition between the two fishing

categories, the total counts of fishing trips directed by illegal REC and SSF in each fishing area is represented as a point with geographical coordinates corresponding to the center of that area and visualized on a georeferenced map as a pie chart whose width is proportional to the total frequency of visits partitioned per illegal REC and SSF.

3. Results

3.1. Illegal REC fleet composition, gears used, target species, and fishing effort

3.1.1. Illegal REC fleet composition

In total 1839 fishing trips, covering 16 fishing grounds were completed during the study year and 32 recreational boats were found to be active.

RBF in the area of the proposed “Taza” MPA was carried out by 46 boats. 70% of these boats (32 boats) were considered in this study (Table 2). This is the total number of recreational boats that sold their catches to sale operators inside the fishing harbor of Zياما and involved in illegal REC.

Table 2. Fleet characteristics (range and average) of the overall length (m) and engine power (kW) of the two fishing boats categories: REC, illegal recreational boat (present study) and SSF, small-scale boats (Boubekri et al., 2018).

Boat category	Number of active boats	Fleet characteristics	
		Overall length (m)	Engine power (kW)
Recreational (REC)	32	3.5 – 5.8 (4.61)	7 – 63 (17.05)
Professional (SSF)	24	4.8 – 10 (6.53)	15 – 180 (46.07)

3.1.2. Gears used and target species

The illegal REC fishers of Zياما Harbor use a variety of gears and target a wide range of commercial species (Table 3). Among the gears used, we count nets the use of which is restricted.

Table 3. Gears used and target species of REC (present study) and SSF (Boubekri et al., 2018) at the fishing harbor of Zياما, Jijel, Algeria. (REC, illegal recreational fishing; SSF, small-scale fishing). *Sensu* FAO (1980).

Fishing category	Gear	Standard abbreviation	FAO code	Main target species
SSF & REC	Set gillnets (anchored)	GNS	07.1.0	<i>Pagellus</i> spp., European hake, scorpionfish
SSF & REC	Driftnets	GND	07.2.0	Atlantic Bonito, bullet tuna
SSF & REC	Trammel nets	GTR	07.5.0	Red mullets, sparids, cuttlefish
SSF & REC	Gillnets (not specified)	GN	07.9.1	Sparids, Greater amberjack
REC	Handlines and pole-lines (hand operated)	LHP	09.1.0	Atlantic bonito <i>Serranus</i> spp., <i>Dentex</i> spp. <i>Pagellus</i> spp.
REC	Handlines and pole-lines (mechanized)	LHM	09.2.0	<i>Dentex</i> spp., <i>Epinephelus</i> spp.
REC	Drifting longlines	LLD	09.4.0	Swordfish
REC	Trolling lines	LTL	09.6.0	Greater amberjack, Atlantic bonito
REC	Hooks and lines (not specified)	LX	09.9.0	<i>Serranus</i> spp., sparids

3.1.3. Fishing effort

The total counts of fishing trips carried out by recreational fishers identified a more equally distributed effort between spring and summer, where most of the fishing trips occurred, and also between autumn and winter (Table 4). Spring was thus the season where recreational fishers carried out the most fishing trips during the year with 31.64% followed by summer which accounted for 31.04% of the total fishing trips (Table 4).

Table 4. Number of the total fishing trips per month and per season for REC (present study) and SSF (Boubekri et al., 2018) at the fishing harbor of Zياما, Jijel, Algeria. (REC, illegal recreational fishing; SSF, small-scale fishing). The numbers of the total monthly active boats between May 2013 and April 2014 are indicated between brackets. An active boat is defined as a boat carrying out at least 1 fishing trip during the month.

Months	May-13	Jun-13	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13	Dec-13	Jan-14	Feb-14	Mar-14	Apr-14
REC	205 (22)	227 (24)	220 (25)	124 (19)	114 (20)	136 (20)	85 (18)	125 (18)	143 (19)	83 (20)	123 (15)	254 (24)
SSF	175 (18)	278 (21)	130 (13)	98 (14)	53 (10)	33 (8)	43 (8)	136 (10)	93 (8)	39 (7)	97 (19)	155 (11)
Total	Summer			Autumn			Winter			Spring		
REC	571 (32)			335 (29)			351 (25)			582 (31)		
SSF	506 (24)			129 (13)			268 (11)			427 (19)		

The difference in fishing effort allocation among seasons was not significant for REC but it was highly significant for SSF (Table 5).

Table 5. Kruskal-Wallis H analysis of variance for FT, MC, and SR and Mann-Whitney U comparisons between REC (present study) and SSF (Boubekri et al., 2018). FT, fishing trips; MC, mean catch; SR, specific richness; REC, recreational boat fishing; SSF, small-scale fishing; SUM, summer; AUT, autumn; WIN, winter; SPR, spring. Between brackets Standard Deviations s.d.

Catch and effort Characteristics	Kruskal-Wallis H for REC					Kruskal-Wallis H for SSF				
	SUM	AUT	WIN	SPR	P	SUM	AUT	WIN	SPR	P
FT mean values (s.d.)	8.157 (4.193)	6.321 (3.675)	7.313 (3.697)	8.083 (4.238)	0.0526	8.437 (4.696)	3.824 (1.466)	5.000 (1.927)	6.412 (2.274)	< 0.0001
MC mean values (s.d.)	5.299 (5.202)	3.343 (1.851)	3.760 (1.654)	4.019 (2.024)	0.0591	21.02 (15.54)	7.866 (7.623)	4.509 (1.689)	9.669 (10.59)	< 0.0001
SR mean values (s.d.)	5.942 (3.338)	3.740 (2.058)	5.043 (2.377)	5.761 (3.647)	0.0010	9.371 (3.612)	4.156 (2.952)	4.628 (2.171)	6.368 (4.772)	< 0.0001

However, by using seasonal mean values of FT, the Mann-Whitney U test showed significant differences in the fishing effort between REC and SSF only in the cold season (autumn and winter) (Table 6).

Table 6. Mann-Whitney U comparisons for FT, MC, and SR between REC (present study) and SSF (Boubekri et al., 2018). FT, fishing trips; MC, mean catch; SR, specific richness; REC, recreational boat fishing; SSF, small-scale fishing; SUM, summer; AUT, autumn; WIN, winter; SPR, spring. Between brackets Standard Deviations s.d.

Catch and effort Characteristics		Mann-Whitney U test for REC vs. SSF							
REC	SUM	AUT		WIN		SPR			
FT mean values (s.d.)	8.157 (4.193)	6.321 (3.675)		7.313 (3.697)		8.083 (4.238)			
MC mean values (s.d.)	5.299 (5.202)	3.343 (1.851)		3.760 (1.654)		4.019 (2.024)			
SR mean values (s.d.)	5.942 (3.338)	3.740 (2.058)		5.043 (2.377)		5.761 (3.647)			
SSF	SUM	AUT		WIN		SPR			
FT mean values (s.d.)	8.437 (4.696)	3.824 (1.466)		5.000 (1.927)		6.412 (2.274)			
MC mean values (s.d.)	21.02 (15.54)	7.866 (7.623)		4.509 (1.689)		9.669 (10.59)			
SR mean values (s.d.)	9.371 (3.612)	4.156 (2.952)		4.628 (2.171)		6.368 (4.772)			
REC vs. SSF	U	P	U	P	U	P	U	P	
FT	2481	0.9884	517	0.0008	636	0.0015	1998	0.0585	
MC	421	< 0.0001	531.5	0.0013	775	0.0406	1554	0.0002	
SR	1201	< 0.0001	798	0.9885	904	0.3877	2375	0.8702	

3.2. Catch composition and seasonal distribution patterns

3.2.1. Catch composition

A total of 54 taxa belonging to 24 families were observed in the catches of the 32 illegal recreational active boats, reflecting a highly varied exploitation of the fauna, constituted of 50 species (or higher taxonomic level) of fish (47 Actinopterygii and 3 Elasmobranchii), 2 species of crustaceans *Palinurus elephas* and *Scyllarides latus*, and 2 species of cephalopod molluscs *Octopus vulgaris* and *Sepia officinalis*. The Sparidae family was the best represented in the total catches because 20 of the 54 species belonged to that family. In total, 7.7 tons of illegal REC total catch were assessed, of which 40.58% consisted of the 5 main target species: the bullet tuna *Auxis rochei* (10.78%) and 4 species of Sparidae: *Pagellus acarne* (11.10%), *Diplodus* spp. (7.73%), *Pagrus* spp. (5.71%), and *Pagellus bogaraveo* (5.26%) (Fig. 2). It should be noted that the bullet tuna is the dominant catch during the month of June which coincides with its coastal presence, while it is almost absent the rest of the year as opposed to the other species (Fig. 2). Moreover, the resulting mean catch among seasons was not significant for REC but it was highly significant for SSF (see Table 5). By using the seasonal mean values of the MC, the Mann-Whitney U test showed that the difference in the mean catch between REC and SSF is significant among all seasons, especially in the warm season (spring and summer) (see Table 6).

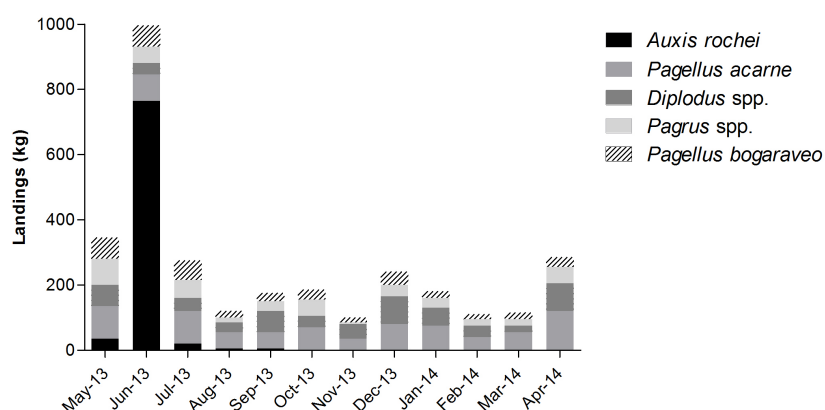


Fig. 2. Monthly mean of daily landings of the most-abundant species (those that accounted for over 5% of the total catch) for illegal REC (present study).

For SSF, a total of 40 taxa belonging to 27 families were observed in the catches of the 28 small-scale boats of the harbor of Ziamia between May 2013 and

April 2014, comprising of 36 species (or higher taxonomic level) of fish (31 Actinopterygii and 5 Elasmobranchii), 1 of crustaceans *Palinurus elephas*, and 3 of cephalopod molluscs *Loligo vulgaris*, *Octopus vulgaris*, and *Sepia officinalis*. In total, 15.215 tons of catch were assessed, of which 60.50% consisted of the 5 main target species: *Auxis rochei* (26.55%), *Pagellus acarne* (13.31%), *Euthynnus alletteratus* (7.76%), *Squalus acanthias* (7.46%), and *Scorpaena* spp. (5.42%) (Fig. 3). The data obtained are summarized in Appendix A where the list of species (or higher taxonomic level) caught and their total catches per fishing category are reported.

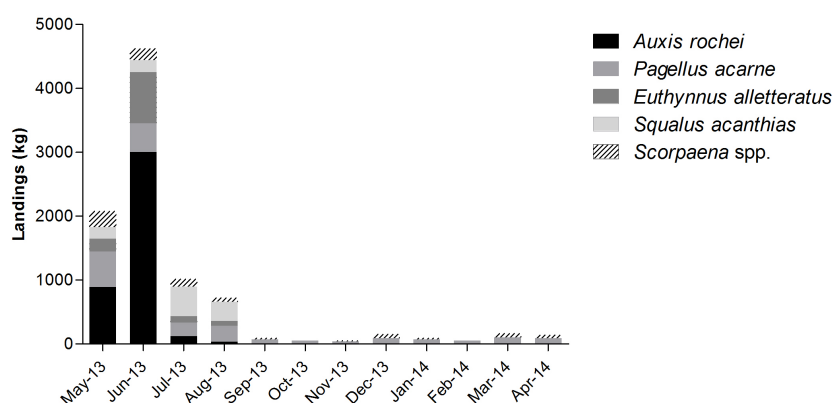


Fig. 3. Monthly mean of daily landings of the most-abundant species (those that accounted for over 5% of the total catch) for SSF (Boubekri et al., 2018).

3.2.2. Seasonal distribution patterns

The monthly mean of daily values for the two variables (MC and SR) showed that illegal REC and SSF varied throughout the year (Fig. 4). However, the results of the Kruskal-Wallis statistical test showed that FT did not vary significantly between seasons for illegal REC ($H = 7.704$, $P = 0.0526$), while the difference was extremely significant for SSF ($H = 53.90$, $P < 0.0001$) (see Table 5). Fig. 4b shows that during the warm season (i.e. May to September); MC for SSF was higher than for illegal REC. However, for the rest of the year, this variable was almost the same for both fishing categories. Species richness varied consistently at the temporal scale (i.e. months) for both professional and recreational fisheries, with higher values during the warm season (from May to September) (Fig. 4c). However, the SR in the catches of SSF decreased significantly after September while it increased for illegal REC and maintained such higher values during the whole cold season (i.e. from October to April).

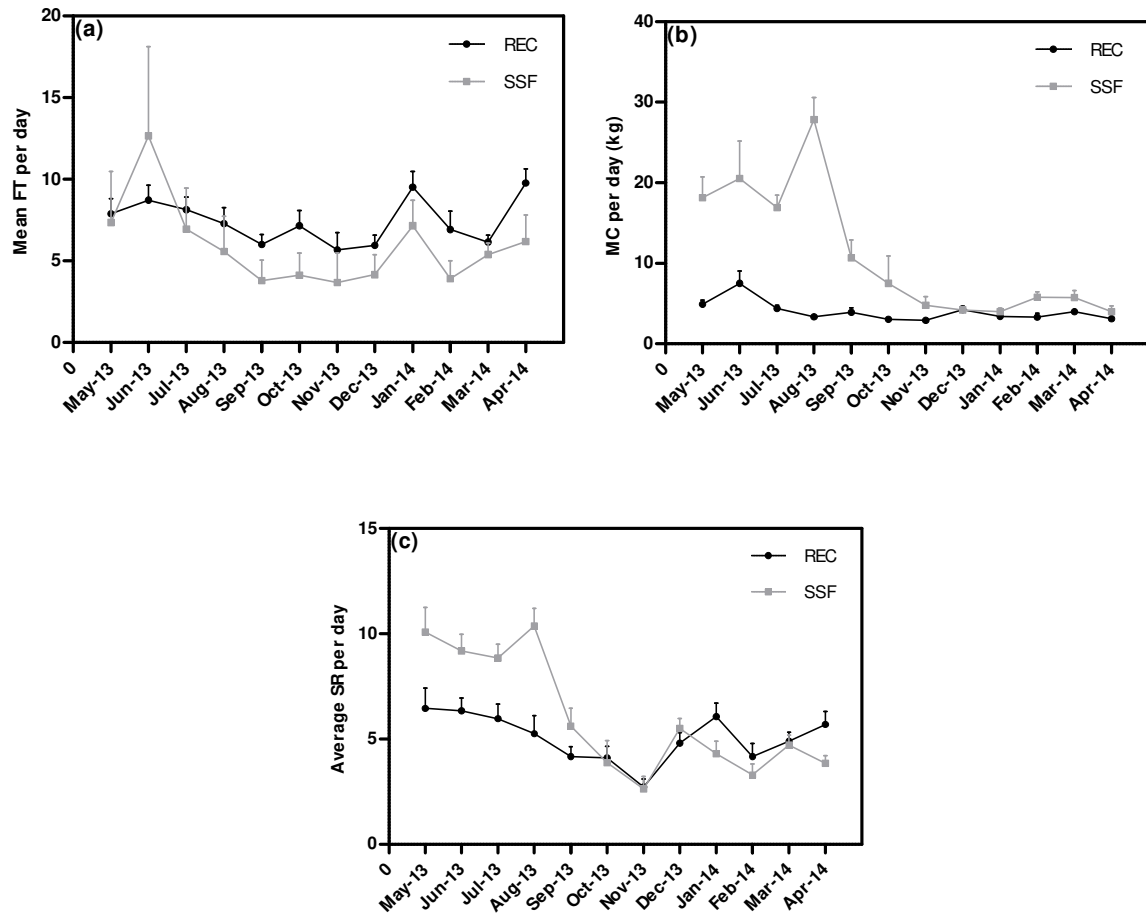


Fig. 4. (a) Monthly mean of daily Fishing Trips (FT + s.e.), (b) Monthly mean of daily catch (kg) (MC + s.e.), and (c) Monthly average of daily Species Richness (SR + s.e.) for REC (present study) and SSF (Boubekri et al., 2018) at Zياما fishing harbor, Algeria (SW Mediterranean). REC, illegal recreational fishing; SSF, small-scale fishing.

3.3. Catch economic value

High economic value species such as *Scyllarides latus*, *Xiphias gladius*, *Zeus faber*, and *Sphyræna* spp. were caught exclusively by illegal REC while *Dicentrarchus labrax* was caught exclusively by SSF (Fig. 5). Whilst the recreational and the professional fishers competed for *Sparus aurata* and *Seriola dumerili* (between 40% and 50% for species caught respectively by illegal REC), species such as *Mullus barbatus barbatus*, *Mullus surmuletus*, *Balistes carolinensis*, *Merluccius merluccius*, and *Palinurus elephas* were caught mainly by SSF (between 73% and 94% of species caught). For the remaining high economic value species, they were caught mainly by illegal REC between 70% (i.e. *Phycis* spp. and *Sciaena umbra*), 80% (i.e. *Dentex* spp. and *Pagrus* spp.), and 92% and 98% for *Epinephelus costae* and *Epinephelus marginatus*, respectively (Fig. 5).

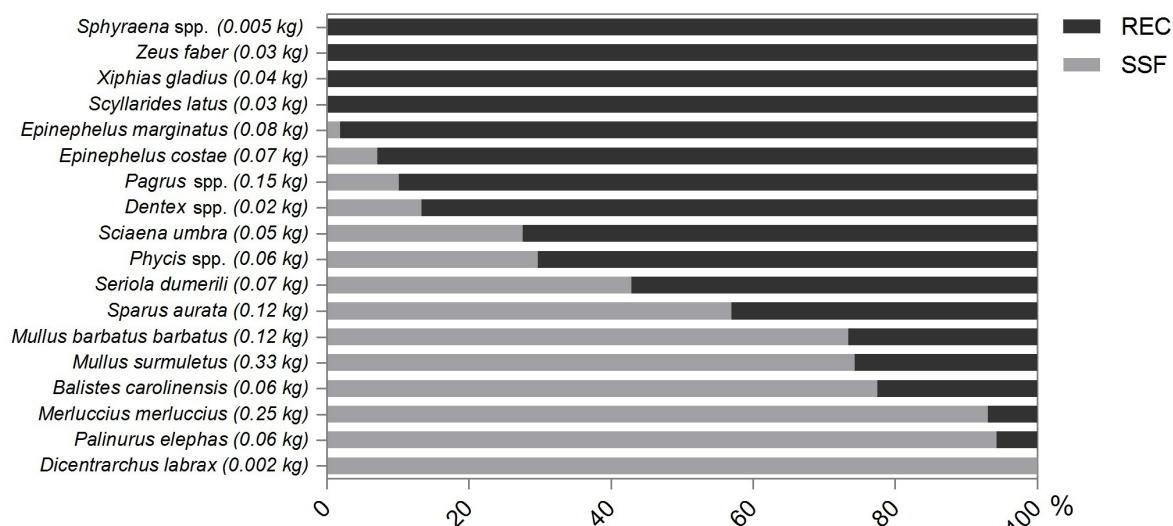


Fig. 5. Mean daily catch (kg) of high economic value fish species (as defined by Ben Lamine et al., 2018, see also Appendix B for further details), for REC (present study) and SSF (Boubekri et al., 2018) and percentage per fishing category. REC, illegal recreational fishing; SSF, small-scale fishing. Daily catch calculated on the number of total fishing trips.

3.4. Spatial fishing effort distribution

The area of the proposed “Taza” MPA is home to many fishing grounds used by both recreational and professional Ziama harbor fleets (Fig. 6). The 16 fishing grounds used by the Ziama harbor SSF boats, as identified in a previous study by Boubekri et al. (2018), were also exploited by the illegal recreational boats in this study (Fig. 6). Four fishing grounds located inside the perimeter of the proposed “Taza” MPA were used by recreational fishers representing 32.08% of total fishing trips. Moreover, the REC spatial patterns showed a high concentration of fishing effort near the harbor, especially at a depth between - 20 and - 100 m (Fig. 6). In addition, the relatively offshore fishing grounds were mainly used by SSF fishers while the most costal ones were largely exploited by recreational fishers (Fig. 6).

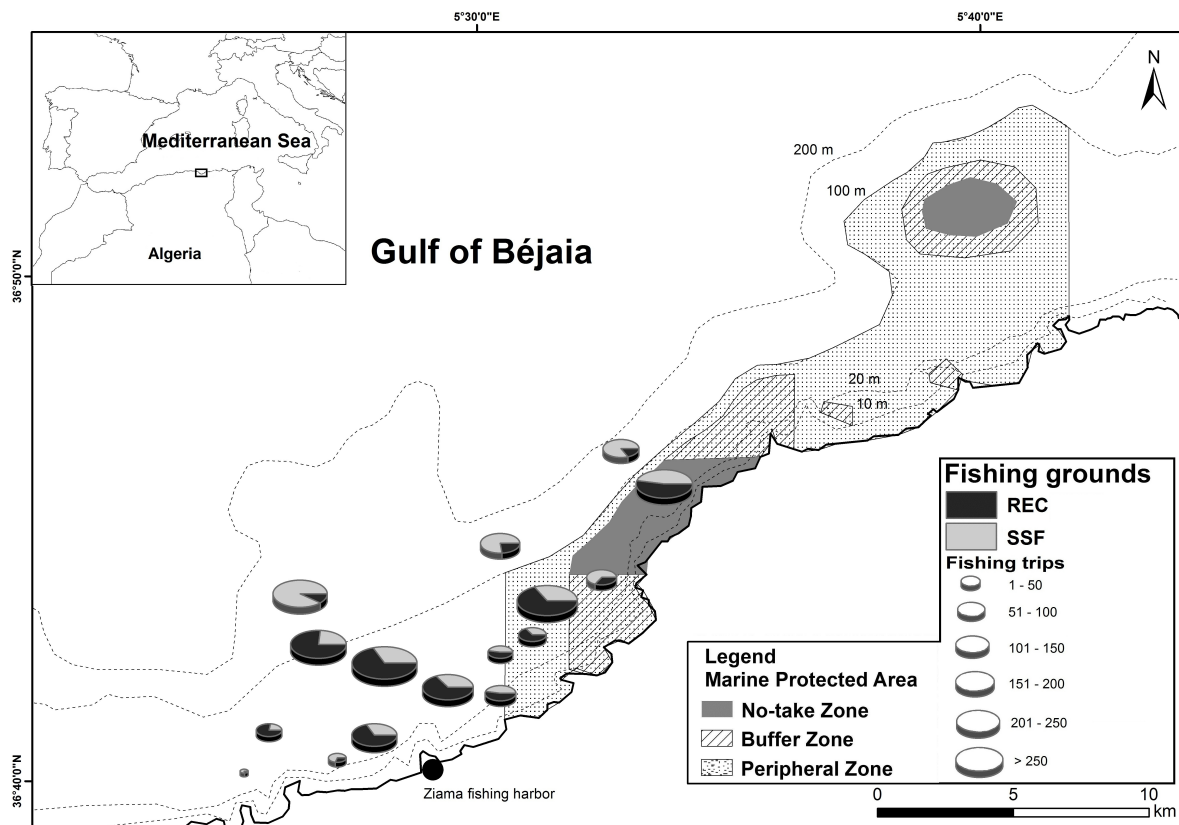


Fig. 6. Concentration of fishing trips within the different fishing grounds. The width of the pie chart is proportional to the total number of fishing trips in each fishing area (frequency of visits) partitioned per REC (present study) and SSF (Boubekri et al., 2018). REC, illegal recreational fishing; SSF, small-scale fishing

4. Discussion

The present study provides relevant information on the illegal REC in the area of the proposed “Taza” MPA (SW Mediterranean, NE Algeria). Illegal recreational fishers use all fishing gears SSF fishers use except the purse seine (Boubekri et al., 2018), they compete in some target species and sell their catch illegally rather than using it for personal or family consumption. This finding is in agreement with what Ben Lamine et al. (2018) have reported at two future MPAs in Tunisia (SW Mediterranean). Furthermore, Kacher (2010) already indicated a strong competition between recreational and professional fishers in the area of the proposed “Taza” MPA. In Mediterranean MPAs, recreational fishing competes for space and resources with other marine uses such as traditional artisanal fishing (Lloret and Font, 2013; Prato et al., 2016; Tunca et al., 2016; Ben Lamine et al., 2018; Venturini et al., 2019).

Given that MPAs are crucial tools for marine biodiversity conservation and sustainable utilization of marine resources through fisheries management (García-Charton et al., 2008; Alós and Arlinghaus, 2013), monitoring of REC must be a priority for MPA managers, or else consequences of such an unmonitored activity may negate the expected conservation outcomes. Moreover, the combined impact of recreational and commercial fisheries leads to serious consequences on the management of coastal fisheries (Albouy et al., 2010; Veiga et al., 2010; Lloret and Font, 2013; Marengo et al., 2015; Prato et al., 2016).

The proposed “Taza” MPA is used extensively as a recreational fishing location by the local population. These recreational fishers use a wide variety of gears and the total count of fishing trips show a more equally distributed effort within two periods of the year; from October to April (cold season) and from May to September (warm season). Our results highlight the pressure that the illegal recreational fishers exert on the coastal resources in this area, where the sea fishing days mean is 7.56 ± 4.04 days per month. Lower values for individual monthly fishing effort have been observed in other western Mediterranean regions (spear fishers included) such as in Majorca Island (5.5 ± 0.11 ; Morales-Nin et al., 2005), the Portofino MPA (2.08 ± 1.75 ; Venturini et al., 2019), and in Tunisia (4 ± 2 ; Ben Lamine et al., 2018), while comparable values have been found in Cap de Creus (8.13, typically during the weekends, and 5.78 typically between April and September; Lloret et al., 2008). Moreover, the monthly fishing effort of illegal REC is also higher than what Boubekri et al. (2018) have found for SSF (i.e. 6.38 ± 2.49 days per month), which can most likely be attributed to the fact that illegal REC is practiced intensively during the whole year.

Spatial information is a crucial element in the zonal management and design of MPAs (Costello et al., 2010; Parnell et al., 2010). The knowledge of the spatial distribution of the fishing effort thus provides valuable elements to the managers of the proposed “Taza” MPA in terms of identification of the most frequented areas in order to estimate the pressures and impacts on the fishing habitats. The proposed zoning plan was conceived with support from the MedPAN network within the MedPAN South Project (Gomei and Di Carlo, 2012). Data from the survey conducted between 2009 and 2012 in this area assessed marine biological diversity (Ramos-Espla, 2010), fisheries (Kacher, 2010), and socio-economic aspects (Chakour, 2012;

Grimes, 2010) and served as a basis to achieve the final proposal which was then subjected to a wide consultation process within the different user-groups of the proposed MPA to avoid social conflicts and economic impacts.

In our case study, the spatial patterns of the fishing activity show a competition between illegal REC and SSF in all the 16 fishing grounds although at different levels. However, the frequency of fishing trips results and their spatial distribution show that both illegal REC and SSF are practiced regularly in one of the proposed no-take zones. This argues for a strengthening of controls in this area once the MPA is established. Moreover, and taking into account the distances to the fishing harbor, our results show a higher concentration of fishing effort by illegal REC than by SSF in fishing grounds near the fishing harbor, while the SSF boats operate mainly in the most remote fishing grounds. This disparity can be related to the differences in boat technical characteristics. In fact, the characteristics of the SSF boats (larger than recreational ones) allow them to explore offshore fishing areas. Furthermore, the results of the monthly distribution of fishing activity do not show seasonality for illegal REC, in contrast to SSF where summer represents the season of highest fishing activity (i.e. maximum number of fishing trips).

According to Boubekri et al. (2018), the activity of SSF in the fishing harbor of Ziamia is distinctly seasonal, requiring fishers to rotate between various métiers throughout the year and to adapt to variations in resource availability. Due to the illegal selling of the catch by recreational fishers, a similar behavior to SSF fishers is now observed for REC fishers. Illegal REC is thus practiced year-round with almost the same intensity, using a variety of gears (e.g. rod, lines, nets, etc.) and capturing a total number of 54 fish species. Our results do not coincide with those obtained for recreational boat fishers in Spain which are characterized by a pronounced seasonality in the distribution of fishing activity, with a maximum in summer and a minimum in winter (Morales-Nin et al., 2005; Lloret et al., 2008), nor with those reported by Ünal et al. (2010) in Turkey, where autumn and winter are the preferred seasons for recreational boat-based fishing. These disparities in seasonality are due to the fact that most recreational fishers in the study area are practicing REC for livelihood and commercial purposes rather than leisure as opposed to many especially in developed countries around the Mediterranean basin who practice it mainly for pleasure during summer holidays.

In the proposed “Taza” MPA the SSF show discernible seasonal fishing effort patterns with the highest activity during summer. This corresponds to the period of cessation of trawler activity in the three nautical mile zone (starting on the 1st of May and ending on the 31th of August each year) as advocated by the Algerian legislation (Decree No. 04-74 of 24 April 2004). In fact, this is the period where most of the fishing trips occur for SSF (51.20%) which can be responsible for the statistically significant differences in the fishing trips between illegal REC and SSF (Mann-Whitney test; $U = 21386$, $P = 0.0006$). Boubekri et al. (2018) have mentioned the spatial competition and conflicts between small-scale and trawl fisheries in relatively offshore areas, while this study shows a new conflict with recreational fishers in most coastal fishing areas (near the harbor). The SSF appear thus to be the most affected by this spatial competition.

Consequent to this high fishing effort, recreational fishers target a large number of species (i.e. 54) and one of the highest compared to the number of species caught in other western Mediterranean regions (e.g. 58 species in the MPA of Cap de Creus; Lloret and Font, 2013; 54 species in Majorca Island; Morales-Nin et al., 2005; 51 species in the Strait of Çanakkale; Ünal et al., 2010; 44 species in Portofino MPA; Venturini et al., 2017; and 32 species in Serra Gelada Marine Park; Luna-Pérez, 2010). According to Sheaves et al. (2016), some recreationally targeted species are being overexploited. As a result, in some cases effort is shifted towards new target species which may include endangered ones (Bower et al., 2014). Thereby, five of the species caught by illegal REC in the study area are included in Annex III of the Barcelona Convention (i.e. *Epinephelus marginatus*, *Palinurus elephas*, *Sciaena umbra*, *Scyllarides latus*, and *Xiphias gladius*), which lists those species whose exploitation should be regulated because they are vulnerable to fishing (UNEP-MAP-Barcelona Convention, 2011). Furthermore, four species are also included in the Red List of the IUCN as endangered: *Epinephelus marginatus* or vulnerable: *Dentex dentex*, *Merluccius merluccius*, and *Sciaena umbra* (Abdul Malak et al., 2011). However, it is noteworthy to mention here that these species are not yet frequently caught by illegal recreational fishers. The increase of recreational boat anchoring areas also causes huge damages on coastal habitats and especially seagrass meadows, one of the key habitats of two iconic Mediterranean marine coastal fish: *Sciaena umbra* and *Dentex dentex* (Marengo et al., 2015).

Comparing illegal REC catches from this study with commercial SSF catches is interesting. In the fishing harbor of Ziana, 24 professional SSF boats operate in the area of the proposed “Taza” MPA, predominantly gillnetters. Their commercial landings amount was 15.2 tons between May 2013 and April 2014 (Boubekri et al., 2018). The annual illegal REC catch studied here for the same period, was about 7.7 tons. Consequently, the illegal REC contribute significantly to fishing mortality as the proportion of the harvest attributed to illegal REC represents about 50% of the small-scale fishery harvest. This is by far higher than the world average (12% according to Cooke and Cowx, 2004) and also compared to what has been reported (i.e. ~30%) in many Mediterranean regions such as Cap de Creus in Spain (Lloret et al., 2008) and the Strait of Çanakkale in Turkey (Ünal et al., 2010). Our results therefore show a huge biological impact of illegal REC, which can exacerbate the magnitude of the negative effects of high fishing mortality on coastal fish stocks, especially vulnerable species characterized by slow growth and late maturity, by limiting their reproductive potential (Roberts and Hawkins, 1999). Moreover, the competition between illegal REC and SSF for the natural resources in the proposed “Taza” MPA is highly important since the two main species targeted by SSF (i.e. *Pagellus acarne* and *Auxis rochei*) (Boubekri et al., 2018) are among the most-abundant species (accounting each for over 10% of the total catch) targeted by recreational fishers.

In addition, compared with commercial fishing mean catch per day (i.e. 12.08 ± 9.42 kg/boat/day) (Boubekri et al., 2018), recreational catches in this study represent ~35% (i.e. 4.18 ± 1.38 kg/boat/day) of the mean catch. In Tunisia, Ben Lamine et al. (2018) have reported a similar value (i.e. 40%) in two future MPAs. However, regarding the temporal variations, for illegal REC the catch rates do not change significantly between seasons, as is the case in Tunisia, but also in other Mediterranean MPAs (Lloret and Font, 2013; Marengo et al., 2015). The CPUEs can be strongly influenced by the varying characteristics of fishing gear, the heterogeneity of fishermen’s local knowledge, seasonal patterns of abundance, and outlying data due to exceptional catches (Maunder and Punt, 2004; Smith et al., 2006). For SSF, the results of Boubekri et al. (2018) show the highest catch rate in summer, which may be a consequence of the spatial patterns that characterize the study area instead of the allocated fishing effort. Indeed, during July and August, and despite an almost identical fishing effort intensity (number of fishing trips) to the period from

September to April, SSF record a much higher MC in summer. In fact, the fishing grounds visited by SSF boats during that period, when there is less competition with illegal REC, can be responsible for this situation. This is unfortunate for them, since SSF fishers cannot keep the same yields throughout the year because of the trawling activity carried out in these fishing grounds between September and April, the period where SSF boats are forced to return to explore more coastal fishing grounds and then record a lower MC, almost equivalent to those of illegal REC. The drop in MC observed for SSF between September and May can most likely be attributed to the high competition with illegal recreational boats in exploiting the same fishing grounds. Moreover, the characteristics of the nets (i.e. big size) used by SSF allow fishers to record highest MC in relatively offshore areas characterized by soft bottoms. In more coastal fishing grounds however, recreational fishers are more efficient in terms of fishing techniques. For instance, using small size nets, which are easily manoeuvrable, allows them to explore hard bottoms better than SSF fishers.

Recreational activities have a core social role for coastal populations (Bellanger and Levrel, 2017). In the context of this study, REC includes the activity of people fishing for commercial purposes or to obtain some extra income. The current economic difficulties of the local population therefore, are now putting many recreational fishers in unfair competition with professional ones through selling their catch on the local market. Moreover, this form of IUU fishing leads to a devastating and perverse outcome of encouraging non-compliance. Furthermore, the cost of a professional boat license is about 1200 USD per year while that of a recreational boat is about 30 USD (DPRH of Jijel, 2014). As a consequence, a huge number of small-scale professional fishers prefer to convert to recreational because of the higher operational costs (i.e. from paying taxes) and consequent lower profit they obtain compared to that of recreational fishers. The potential economic impact of illegal REC for the future of commercial fisheries is therefore extremely significant, especially as the Government does not collect any taxes from recreational fishers, assuming fishers abide by the law (Babali et al., 2018).

The establishment of MPAs, particularly of multiple-use areas, aims to protect natural populations and ecosystems and the goods and services they provide to society (Watson et al., 2014; Rodríguez-Rodríguez et al., 2019). Even though partially protected areas (or partial reserves) that restrict some extractive uses or

regulate professional and recreational fishing in different ways can potentially enhance fish density and biomass (Zupan et al., 2018), the strongest fisheries outcome benefits occur in areas with total exclusion of fishing activities (Roberts et al., 2008; Di Lorenzo et al., 2016). The proposed “Taza” MPA is conceived as a tool for developing management approaches that enable multiple-use on a sustainable basis (Gomei and Di Carlo, 2012). However, unsuitable MPA establishment might result in low effectiveness or even deterioration of the existing condition. This study shows that REC should be taken into account given its huge impact linked to the rising concern about overfishing. Indeed, the latter represents one of the main challenges in marine conservation, with MPA zoning and multi-use management regarded as a critical fisheries management tool (Costanza et al., 1998). To this end, the development of an efficient monitoring system is a key element for understanding and addressing the issues of REC (Green et al., 2005). However, to assess all recreational boats operating in the area of the proposed “Taza” MPA, survey techniques are required which are usually expensive and onerous to assess because of the widespread geographical distribution of landing places. However, attempts to better quantify the biosocioeconomic implications of REC and its relative contribution to overall fishing pressure will provide managers of the proposed “Taza” MPA the baseline needed to guide management actions and fisheries restrictions.

According to Font and Lloret (2014), subsistence fishing appears to be increasing in some areas of the Mediterranean due to the current economic crisis, and it is becoming increasingly difficult to distinguish between people who fish for pleasure and people who fish for food. However, it is noteworthy to mention that this study does not take into account subsistence fishing (i.e. fishing for food rather than for commercial purposes) nor other techniques of recreational fishing (e.g. angling, spearfishing, etc.). It would therefore be recommendable to collect data on all recreational fishing techniques for future monitoring programs. In fact, identifying the impact of each fishing technique would certainly lead to more accurate estimations of recreational fishing pressure on coastal resources.

5. Conclusion

This study highlights the importance of the characterization of REC in a proposed MPA considering the annual dynamic of the fishing effort and the resulting catches in order to set up a sustainable fisheries management, one which takes into account the global picture of the fishing pressure on coastal resources. Our results show the presence of an important illegal REC in the study area with a great potential impact on the coastal resources, but also on the socioeconomic situation because of the unfair competition with commercial fisheries. Therefore, based on the information and the data presented, some fisheries restrictions should be applied to prevent an overexploitation of fishing resources, which could compromise the role of the establishment of this MPA in a context of a data-poor situation and low regulation enforcement. To this end, more monitoring effort is needed to detect the significant number of illegal recreational fishers who use the same fishing gears as the professional ones (i.e. nets) and target the same species. Moreover, illegal REC distort the estimates of the real fishing effort and bias the stock assessment on a national level since REC catches are not reported in official statistics.

Appendix A

List of caught taxa and their total weight (kg) for catches of SSF (Boubekri et al., 2018) and REC (present study). SSF, small-scale fisheries; REC, illegal recreational fisheries. For some species, the recorded weights were grouped at a higher taxonomic level; please see footnote for the concerned species.

Caught taxa	SSF landings (kg)	REC landings (kg)
Elasmobranchii		
Dasyatidae	15	25
Rajidae	195	175
Scyliorhinidae		
<i>Scyliorhinus canicula</i>	750	-
Squalidae		
<i>Squalus acanthias</i>	1135	-
Torpedinidae		
<i>Torpedo</i> spp.	75	125
Actinopterygii		
Balistidae		
<i>Balistes carolinensis</i>	155	45
Carangidae		
<i>Seriola dumerili</i>	90	120
<i>Trachurus trachurus</i>	-	305
Congridae		
<i>Conger conger</i>	20	150
Coryphaenidae		
<i>Coryphaena hippurus</i>	-	5
Gadidae		
<i>Phycis</i> spp.	55	130
Lophiidae		
<i>Lophius</i> spp.	170	-
Merlucciidae		
<i>Merluccius merluccius</i>	735	55
Moronidae		
<i>Dicentrarchus labrax</i>	5	-
Mugilidae¹	55	70
Mullidae		
<i>Mullus barbatus barbatus</i>	290	105
<i>Mullus surmuletus</i>	780	270
Muraenidae		
<i>Muraena helena</i>	30	165
Sciaenidae		
<i>Sciaena umbra</i>	40	105
Scombridae		
<i>Auxis rochei</i>	4040	830
<i>Euthynnus alletteratus</i>	1180	30.00
<i>Sarda sarda</i>	340	135
<i>Scomber</i> spp.		10
Scorpaenidae		
<i>Scorpaena</i> spp.	825	115
Serranidae		
<i>Epinephelus costae</i>	15	195
<i>Epinephelus marginatus</i>	5	255
<i>Serranus</i> spp.	-	25

Appendix A continued

Caught taxa	SSF landings (kg)	REC landings (kg)
Soleidae	35	-
Sparidae		
<i>Boops boops</i>	-	85
<i>Dentex</i> spp. ²	10	65
<i>Diplodus</i> spp. ³	380	595
<i>Lithognathus mormyrus</i>	50	65
<i>Oblada melanura</i>	20	65
<i>Pagellus acarne</i>	2025	855
<i>Pagellus bogaraveo</i>	50	405
<i>Pagellus erythrinus</i>	290	215
<i>Pagrus</i> spp. ⁴	50	440
<i>Sarpa salpa</i>	225	160
<i>Sparus aurata</i>	5	170
<i>Spicara smaris</i>	-	150
Sphyraenidae		
<i>Sphyraena</i> spp.	-	15
Xiphiidae		
<i>Xiphias gladius</i>	-	130
Zeidae		
<i>Zeus faber</i>	-	95
Trachinidae		
<i>Trachinus draco</i>	85	-
Triglidae		
<i>Trigla Lucerna</i>	115	-
Cephalopoda		
Loliginidae		
<i>Loligo vulgaris</i>	315	-
Octopodidae		
<i>Octopus vulgaris</i>	135	240
Sepiidae		
<i>Sepia officinalis</i>	260	385
Malacostraca		
Palinuridae		
<i>Palinurus elephas</i>	165	10
Scyllaridae		
<i>Scyllarides latus</i>	-	110
Total (kg)	15215	7700

662 ¹ *Mugil cephalus*, *Chelon labrosus*, *Liza aurata*, *Liza ramada*, and *Liza saliens*.

663 ² *Dentex dentex*, *Dentex gibbosus*, *Dentex maroccanus*, and *Dentex macrophthalmus*.

664 ³ *Diplodus annularis*, *Diplodus cervinus cervinus*, *Diplodus puntazzo*, *Diplodus sargus sargus*, and
665 *Diplous vulgaris*.

666 ⁴ *Pagrus auriga*, and *Pagrus pagrus*.

Appendix B

Fish species economic value in Algeria. As defined by Ben Lamine et al. (2018): high economic value species: price per kg>the daily remuneration (i.e. 600 DZD) (18000 DZD is the minimum guaranteed wage per month in 2014 in Algeria <http://www.ons.dz/-Masse-Salariale->).

Fish species	Commercial interest	Landing price per kg (DZD)
<i>Palinurus elephas</i>	High	1800
<i>Merluccius merluccius</i>	High	950
<i>Dicentrarchus labrax</i>	High	900
<i>Xiphias gladius</i>	High	900
<i>Zeus faber</i>	High	900
<i>Mullus surmuletus</i>	High	850
<i>Mullus barbatus barbatus</i>	High	800
<i>Dentex</i> spp.	High	800
<i>Scyllarides latus</i>	High	800
<i>Epinephelus marginatus</i>	High	800
<i>Epinephelus costae</i>	High	700
<i>Pagrus</i> spp.	High	700
<i>Sciaena umbra</i>	High	700
<i>Seriola dumerili</i>	High	700
<i>Sparus aurata</i>	High	700
<i>Sphyræna</i> spp.	High	700
<i>Balistes carolinensis</i>	High	600
<i>Phycis</i> spp.	High	600

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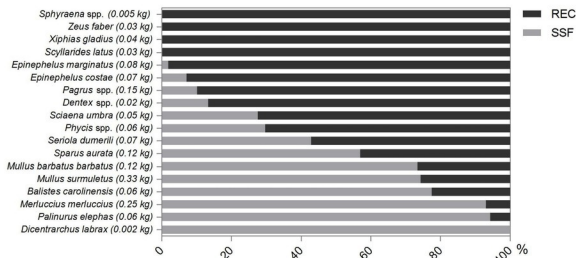
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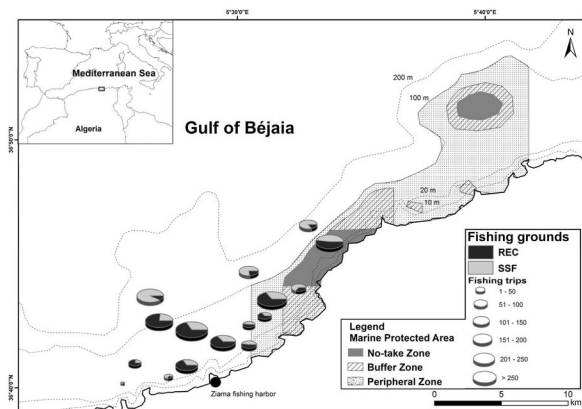
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Mean daily catch (kg) of high economic value fish species



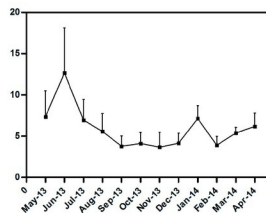
Concentration of fishing trips within the different fishing grounds

Commercial boats

SSF

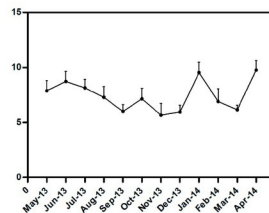


Fishing trips

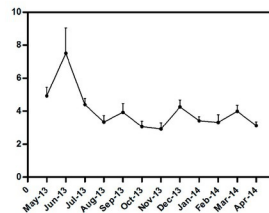
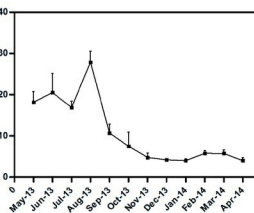


Recreational boats

REC



Mean catch (kg)



Species richness

