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Abstract

Artisanal Small-Scale Fisheries (SSFs) are a primordial and very diverse activity in the Mediterranean, also within Marine Protected Areas (MPAs). This diversity is explained in terms of target species, gears, and fishing strategies. The main objective of this work was to investigate the spatio-temporal dynamics of artisanal SSFs of the future MPA of “Taza” (Algeria, SW Mediterranean). Data were collected through direct assessment of daily landings and using questionnaires. They were the subject of multivariate analyses that allowed us to identify the métiers practiced by artisanal fishers. During the one year (May 2013 to April 2014) field work period, 1330 fishing trips and 1613 fishing operations in 16 fishing grounds were recorded in the Ziama fishing harbor, where 15.2 tons of total catch was assessed. Our results show that, in the study area, the boats are predominantly gillnetters and that among the five métiers characterized by target species, gear type, fishing grounds, and fishing seasons, two métiers (“Mullus surmuletus trammel net” and “Sparids monofilament gillnet”) are practiced throughout the year, while the remaining three (“Sarda sarda driftnet”, “Merluccius merluccius set gillnet”, and “Pagellus set gillnet”) are specific to a determined period of the year. The ‘Mullus surmuletus trammel net’ métier represents 40% of the total fishing operations, of which 57.5% are carried out in the coastal sector at ≤ 25 m. This study could contribute to defining the appropriate management approaches for SSFs in the future MPA of “Taza” by providing baseline information to build a sound management plan. In Algeria, it will certainly serve as a scientific reference in terms of zoning, protection of biodiversity, and specific monitoring at particular locations and periods of the year for the sustainable management of MPAs.

Keywords: Marine protected areas; Algeria; Taza; Mediterranean; small-scale fisheries.

Introduction

Artisanal fisheries represent more than 46% of global catches (including inland catches) and employ about 90% of the 120 million full-time and part-time commercial catchers (FAO, 2016a), the same source indicating that 90% of artisanal fisheries operate in developing countries. There is currently almost no common and universal definition of this activity. Generally, the term “artisanal” is difficult to define, its criteria varying according to the spatio-temporal and socio-cultural context (Griffiths et al., 2007; Carvalho et al., 2011). Artisanal fisheries are defined in the FAO glossary (FAO, 2005) 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, 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”. One of the most commonly used definitions refers to vessels less than 12 m in length corresponding to about 85% of the world’s fishing vessels in 2014 (FAO, 2016b). Diverse terminology is used to define this fishing activity as it varies from region to region. Thus, “artisanal fisheries” are often referred to as “small-scale fisheries”, although as Di Franco et al. (2014) report, some subtle differences between the two definitions are sometimes underlined. The term “artisanal” refers to the little technology used on fishing trips without reference to vessel size, while the term “small-scale” refers to the small size of the vessels without any implication of the degree of technology used (Di Franco et al., 2014).

In the Mediterranean context, with a considerable proportion of small vessels (<12 m) using basic technology,
the term “artisanal small-scale fisheries” could be employed (Griffiths et al., 2007).

Throughout this article, we will refer to the term “artisanal small-scale fisheries” because of the common use of this term in both Mediterranean and Algerian contexts.

Artisanal small-scale fisheries and the Mediterranean MPAs

In the Mediterranean Sea, the artisanal small-scale fisheries (SSFs) have a high socio-economic relevance for the local communities as they represent an important share of the fish caught and constitute about 80% of the fisheries in terms of fishing vessels (Maynou et al., 2013). They are characterized by a diversity of target species, gear, and fishing tactics. As a result, this activity is very variable in time and space (Farrugio & Le Corre 1993; García-Rodriguez et al., 2006; Maynou et al., 2013; Moutupoulos et al., 2014; Grati et al., 2018). Despite the fact that SSFs are a prordial activity around the Mediterranean, including within Marine Protected Areas (MPAs) (Francour et al., 2001), the diversity and the great variety of their métiers create great uncertainty from the perspective of the protection and sustainable management of marine resources. Pelletier & Ferraris (2000) consider that the métiers correspond to fishing practices at the scale of the fishing operation, defined as the combination of four variables: one or more target species, a fishing gear, a fishing ground, and a period of the year (Biseau, 1998). Therefore, the identification of the main métiers practiced, as well as the distribution of effort and the catches associated with them, are essential elements for characterizing such fishing activity.

The establishment of zoned MPAs attempts to best meet the relative needs of the multiple user-groups (Francour et al., 2001). MPAs, coupled with other management tools, can fulfill biodiversity conservation and fisheries management objectives (Hilborn et al., 2004; Di Franco et al., 2016). Thus, the creation of an MPA may initially result in the displacement of fishing effort to the surrounding areas (Halpern et al., 2004) and the direct benefits to fishermen are observed only after a sufficient amount of time (Clauet et al., 2008). In the Mediterranean MPAs, these benefits have been documented in a few studies and explained through three main phenomena: 1) an increase in abundance, biomass, and average size of fish (Ojeda-Martínez et al., 2007; García-Charton et al., 2008; Guidetti et al., 2014; Harmelin-Vivien et al., 2015; Giakoumi et al., 2017), 2) an enhancement of fisheries yields within the MPA (Gori et al., 2010; Guidetti & Clauet, 2010), and finally 3) an increase in fishing catch, but also effort near the boundaries of the no-take MPAs due to the fish “spillover” effect (Stelzenmüller et al., 2007). The latter is defined as the net emigration of juveniles, subadults, and adults beyond the boundaries of the MPA resulting in fishery benefits in neighboring areas (Harrison et al., 2012; Colléter et al., 2014; Di Lorenzo et al., 2016). However, such benefits could be achieved if only adequate fisheries management rules and strategies are implemented. Following Di Franco et al. (2016), the presence of a SSF management plan is one of the five key attributes that can increase an MPA’s performance in terms of fisheries management.

In the northern Mediterranean, several studies have investigated SSFs in the context of MPAs, most of which have described the structure of the different métiers practiced by small-scale fishers (i.e. Stergiou et al., 2006; Tzanatos et al., 2006; Forcada et al., 2010; Maynou et al., 2011; Leleu et al., 2014) and their impacts and pressure on fish stocks and habitats (i.e. Seytre & Francour, 2008; Cadiou et al., 2009; Guidetti et al., 2010). Other aspects of SSFs linked to MPAs have also been studied, such as: the socio-economic and socio-cultural dimensions (Himes, 2003; Unal, 2003; Battaglia et al., 2010; Unal & Franquesa, 2010; Maynou et al., 2013), the catch species composition (Stergiou et al., 2006; Forcada et al., 2009; Rocklin et al., 2009; Dimitriadis et al., 2015), and the potential bio-economic value (Merino et al., 2008 & 2009).

Studies of SSFs in the context of MPAs are scarce in the southern part of the Mediterranean. Tunisian coasts have been the focus of a few studies carried out mainly in the waters of the Gulf of Gabes by Jabeur et al. (2000) and in the North of the country by Abdessalem (1995) and Romdhane (1998). These studies focused respectively on the typology of the fleet and fishing techniques. In Algeria, the limited number of studies on artisanal fisheries has focused on the bio-economic modeling of small pelagic fish in the bays of Ziama in Jijel (Chakour, 2008) and Bou-Ismail in Tipaza (Maouel et al., 2014).

Small-scale artisanal fisheries are considered to be the dominant type of fishing in Algeria (Olivier & Franquesa, 2005; Chakour & Guedri, 2014). This activity is practiced by small boats three to nine meters long with between five and 40 horsepower and a crew of two to eight fishermen depending on the gear used (Sahi & Bouaicha, 2003). With 2972 boats in 2007, the artisanal small-scale fleet in Algeria represents almost three quarters of the Algerian fishing fleet (MPRH in Bouzourine, 2009). Between 1999 and 2007, the growth rate of artisanal small-scale fishing boats reached 92% while that of purse-seiners and trollers did not exceed 51% and 34% respectively (Bouzourine, 2009). This dissimilarity is related to the topography of the restricted and rugged continental shelf as a whole limiting fishing grounds to the coastal areas (Coppola, 2006; Derbal, 2007). In recent years, the artisanal SSFs in Algeria have been facing several challenges such as declining yields, pollution, habitat degradation, illegal and illicit fishing systems (Bellhabib et al., 2012; Chakour & Guedri, 2014). That is why Algeria, like many countries, tries to protect its marine living resources, ecosystems, and related fisheries. In the context of the future establishment of MPAs along the Algerian coast, there is a need to systematically collect SSF data in order to characterize this activity and therefore provide a baseline that could be extremely valuable to set up sound management plans.
Given the future establishment of the “Taza” MPA and its potential impact on SSFs (Boubekri & Djebar, 2016), the present study aims to describe and analyze the artisanal SSF activity in the study area. To this end, given the lack of administrative monitoring and the declarative catches system for artisanal SSFs, landings were observed on a daily basis to describe fishing activities which is useful for understanding the spatio-temporal patterns of effort allocation and the resulting catches (Griffiths et al., 2007; Merrien et al., 2008).

The list of caught species and observed fishing yields for each métier will be useful for subsequent comparisons between the pre- and post-MPA periods.

Materials and Methods

Study area

The study area is located within the future MPA of Taza (Algeria, South-Western Mediterranean). In 2009, with the support from the network of MPA managers in the Mediterranean (MedPAN), Taza National Park began a process to include its adjacent marine area covering 9603 ha (Fig. 1). It is located in the West of the province of Jijel and extends along the three municipalities of Jijel, El-Aouana, and Ziama Mansouriah (Fig. 1). The shallows, Banc des Kabyles and Salamandre reef (Fig. 1), form abrupt ascents of the seafloor, which passes from -100 m to -50 m, and even to -13 m, very quickly. The bottom relief in this area is mostly rugged, with deep falls or slopes and steep canyons with a sandy facies at a depth of -50 m then beyond a mud facies at a depth of -200 m (Leclaire, 1972). However, in the East of the Gulf of Béjaïa (Fig. 1), between -100 and -500 m deep, there is a facies of coastal mud where Pennatula phosphorea and Pennatula rubra are found at depths of up to -200 m and deep mud where Funiculina quadrangularis and Kophobelemnon leuckartii are found at depths greater than -350 m (Refes, 2011). However, the presence of shallows in this area justifies the catch of Scorpaena spp. species in soft bottoms.

The future MPA of Taza comprises 2 no-take zones (Fig. 1). The regulatory proposal for the no-take zones stipulates the authorization of vessel navigation without mooring and scientific research, while prohibiting commercial and recreational fisheries as well as all the other extractive uses (e.g. extraction of aggregates for construction). Two fishing ports are located near the future MPA: Boudis (36.81833° N, 5.774167° E) and Ziama (36.67694° N, 5.478889° E) pending the completion of work to build a third port in the municipality of El-Aouana (Fig. 1).

![Fig. 1: Map showing fishing harbors, location and zoning plan of the future MPA of “Taza”, Algeria. Source: Boubekri & Djebar (2016).](http://epublishing.ekt.gr)
Experimental design and data collection

Official fleet data (length, horse power, and tonnage) were provided by the local Directorate of Fisheries and Aquaculture (DPRH of Jijel). In the study, catch data were collected via a direct observation method of landings on a daily basis between May 2013 and April 2014. Given the lack of administrative monitoring and the declarative catches system of artisanal small-scale fisheries, direct observations are commonly used to evaluate the effort and catches of this activity (Griffiths et al., 2007, Merrien et al., 2008). This methodology was suited to our case, so we drew inspiration from Ifremer’s (French Research Institute for Exploitation of the Sea) Fisheries Information System - SIH (Merrien et al., 2008).

To draw the artisanal small-scale fishery activity in Zama harbor, during an annual cycle, daily observations were made with the help of two observers from the DPHR of Jijel. As vessels returned to the harbor to land their catch, the following data was collected: 1) vessel name by direct observation and 2) catches by interviewing fishers after sale to the operators which is carried out immediately after the vessels return to the harbor. When interviews with fishers were not possible in some cases, operators were surveyed. It should be noted that each vessel has some kind of informal contract with a well-defined operator whereby the sale of fish is exclusively reserved for her/him. Also, an operator may have several contracts with several vessels. Since the price of each species is different, the fishers classified the catch before landing operations while the operators weighted it (kg). However, for some caught fishes (e.g. seabreams, dentex, and scorpionfish), different species were landed together in the same fish crate and sold at the same price, in which case the weights recorded were grouped at a higher taxonomic level (i.e. genus or family) (please see the Appendix for more details about the concerned species). Catches were recorded for all the active vessels. Each day was thus characterized by an exhaustive record of catches for all fishing operations carried out by fishers.

In addition, weekly surveys were conducted using questionnaires to obtain information on the target species, the gear used (length, mesh size, and soak time), and the 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 & Hall, 2006). Once these data had been transformed from paper into a GIS (Geographic Information System), it was possible to draw the 16 locations frequented by the artisanal fishers of Zama. In addition to the information provided by the fishers during the weekly surveys, some sea trips were organized to verify this information and limit the spatial uncertainty related to our cartographic representation. The drawings were obtained using the different reference marks and geographic coordinates, if any, provided by the fishers. 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).

Interview data show that this approach can produce a lot of useful information for assessing fisheries (Neis et al., 1999; Rocha et al., 2004). This method has already been used in the Mediterranean to assess landings and the fishing effort (Stelzenmüller et al., 2007; Merino et al., 2008; Cadiou et al., 2009; Forcada et al., 2010; Leleu et al., 2014; Falautano et al., 2018).

The choice of the harbor of Zama allowed us to overcome logistical constraints while targeting a fleet that is mainly operational in the perimeter of the future MPA and which represents the largest segment in this area. For the small-scale boats of El-Aouana and Jijel, the widespread geographical dispersion of their places of landing made it impossible to conduct field observations.

In total, 1330 fishing trips and 1613 fishing operations in 16 fishing grounds were recorded, while 24 small-scale active boats out of the 28 observed were considered in this study. This is the set of boats that use nets as the main fishing gear. For these boats, all fishing trips were taken into account, even those taking place outside the zoning proposed for this future MPA. The remaining 4 observed active boats use lines and hooks as their main fishing gear. The data for the fishing operations of these boats were excluded in the statistical analysis because of their very small number.

Data analysis

The structure of the artisanal fleet by gear used and by: 1) tonnage, 2) horsepower, and 3) boat length was evaluated for Zama harbor.

A Multiple Correspondence Analysis (MCA) was applied to the data from the active variables: target species, gear type, fishing ground, and fishing period. Then, the main factorial axes were kept for the Hierarchical Cluster Analysis (HCA) (Pelletier & Ferraris, 2000) based on Ward’s criterion. The latter provided us with a scree plot to which a partition was applied. The cutoff level of the scree plot is determined by the number of clusters that should not be too large for the typology to be interpretable and by the inter-cluster inertia/total inertia ratio that must be high to reflect the structure of the fishing operations (Benzecri, 1982). The statistical analysis was carried out with the software Excel STAT®.

Each cluster obtained from the multivariate analyses is considered as a métier. Each métier is characterized by target species and/or groups of target species (5 categories), fishing gear (4 categories), depth (3 categories), and season (4 categories). Each cluster was further defined by: 1) fishing period, 2) main habitats, 3) depth and distance to the harbor, 4) soak time, and 5) stretched mesh size from the characteristic of the fishing operations included in it.

The number of species in the total landed catch was raised from the family to the higher taxonomic level. Re-
Regarding the target species, we retained in our study the approach of declarations by the fishers. This information was obtained when weekly surveys were carried out.

Also, the mean catch per 100 m of nets was calculated, for all species together and for the 5 most common species (in terms of frequency of occurrence) of each métier.

Fishing grounds were manually reported using geographic information system software (ArcGIS 9.3%). Each polygon was then considered as a fishing ground and the distance to the harbor was calculated from its center. The spatial distribution of the fishing effort of the various métiers is represented on the basis of the number of fishing operations carried out in the different fishing grounds observed.

Results

Fleet structure

The fishing fleet present in the study area is mainly artisanal. In 2013, the category of small-scale boats accounted for approximately 77% of the total fleet registered in the department of Jijel (DPRH of Jijel, 2014), with 84 small-scale boats registered at Ziama harbor. If the small-scale boats operating as “purse-seiners” and the vessels outside this fishing harbor are excluded, only 59 remain. Of these, only 28 vessels were active between May 2013 and April 2014.

Gillnetting is common on all boats regardless of their length (Fig. 2). However, boats less than 7 m long represent 85% of the small-scale boats in Ziama harbor. The average length of the 28 active boats is 6.53 m, with lengths ranging between 4.80 and 10 m (Fig. 2A). In the category of <5 m boats, 90% were found to be inactive during the study period (Fig. 2A). The average engine power of active boats is 46.07 horsepower (HP), with engine powers ranging from 15 to 180 HP (Fig. 2B). The inactive boats have an average engine power of 24.67 HP, the average of exclusive gillnetters is higher than the global average with 51.15 HP. The total engine power of the active fleet is 1290 HP, or about 63% of the overall small-scale fleet (Fig. 2B). The average gross registered tonnage (grt) of the boats is 0.90 grt and the active boats are the largest, the widest, and the most powerful (Fig. 2C).

Métiers identification

Nine axes were needed to describe the entire inertia of the dataset (Table S1). The first 5 axes represent 81.28% of the inertia. Axis 1 with 24.94% of inertia is represented by the target species “Sarda sarda” with a 13.09% contribution to its construction (Table S2; Fig. S1). The representative gear of this axis is the driftnet with 13.09%, the “summer” season, and a depth of >40 m (16.57%). Axis 2 with 18.70% of inertia is represented by the group of target species “Sparids” with 21.67% and the monofilament gillnet (Table S2). Axis 3, with 17.80% of inertia, is characterized by 3 species and/or groups of target species: “Sparids” with 9.93%, “Sarda sarda” with 9.44%, and “Mullus surmuletus” with 9.44%. Axis 4 represents 11.48% of inertia, their 2 target species are “Pagellus spp.” and “Merluccius merluccius”, while these species constitute almost all of its construction with respectively 26.73% and 24.54% (Table S2).

Fig. 2: Structure of artisanal small-scale fleet in the harbor of Ziama per gear used and per: A, boat length, B, horsepower, and C, gross registered tonnage over the studied year. Source: DPRH of Jijel.

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The level of partition chosen from the dendrogram according to the gain of inertia between two levels of successive cuts gives 5 different clusters (Fig. S2). The inertia gain at the selected partition is 2.07 accounting for 69.26% of the total inertia of the dataset (Table S3). Thus, five clusters (hereafter called métiers) were obtained from the HCA. Each métier was named after the species and/or group of target species with which it was strongly related. Each métier is also characterized by a single gear: 1) the set gillnet for Pagellus (Pagellus spp.) and hake (Merluccius merluccius), 2) the driftnet for bonito (Sarda Sarda), 3) the trammel net for surmullet (Mullus surmuletus), and 4) the monofilament gillnet for Sparids (Table S4).

With regard to the depths at which the fishing operations are carried out, 96% of the fishing operations of the "Sparids monofilament gillnet" métier take place in depths ≤25 m, whereas the "surmullet trammel net" métier operates almost exclusively at depths of less than 40 m (i.e. 99.5%) (Table S4). 88.9% and 72.7% of the fishing operations of the "Pagellus set gillnet" and "hake set gillnet" métiers take place at depths >40 m respectively while the fishing operations of the "bonito driftnet" métier take place exclusively at depths >40 m (Table S4).

Each identified métier is characterized by a fishing period called the "season". "Pagellus set gillnet" fishing operations are characterized by the period from May to September and "bonito driftnet" from May to August, thus they are more frequently in summer (Table 1). Conversely, the "hake set gillnet" métier (December - April) is characterized by two seasons, spring and winter (Table 1). The "surmullet trammel net" and "Sparids monofilament gillnet" métiers are characterized primarily by the summer season (May - August); however, they can also be practiced in winter and spring (Table 1). Thus, the seasonality of the métiers is well marked in Ziama’s small-scale fisheries.

Regarding the habitats frequented, the "Pagellus set gillnet" and "hake set gillnet" métiers are exclusively practiced on sandy substrates (Table 1). As for the "surmullet trammel net" and "Sparids monofilament gillnet" métiers, they mainly fish above rocky habitats near to Posidonia seagrass meadows (Table 1). However, the "bonito driftnet" métier is also practiced on sandy and rocky substrates.

Regarding to the average distances to the fishing harbor, the "Pagellus set gillnet" and "bonito driftnet" métiers operated in the most remote locations compared to the other métiers at respectively 5855 and 5760 m, whereas the fishing operations of "hake set gillnet" and "Sparids monofilament gillnet" métiers take place in the first 2000 m with the respective percentages of 78% and 87% of their number (Table 1).

Each net was characterized by a length of 150 to 2000 m maximum and a mesh size of 22 to 45 mm according to the targeted species (Table 1). The net lengths observed varied considerably according to the métier practiced by the SSFs of Ziama. Thus, the "Sparids monofilament gillnet", "surmullet trammel net", and "hake set gillnet" métiers more frequently use nets of lengths <500 m, whereas for the "Pagellus set gillnet" and "bonito driftnet" métiers, they use lengths between 500 and 1000 m (Table 1). The "Pagellus set gillnet" métier is the one that uses the widest range of lengths, ranging from 150 to 2000 m (Table 1). The observation of the soaking times of the nets by fishing operation shows the existence of 3 distinct categories: 1) the category of "Pagellus set gillnet" and "hake set gillnet" métiers, the latter having long soaking times, with minimum durations of 24 h and maximums of 74 h and 72 h respectively (Table 1), 2) the category of "Sparids monofilament gillnet" and "surmullet trammel net" métiers, characterized by mid-range soaking times (i.e. between 20 and 26 h), and finally 3) the category that represents the shortest average soaking time (i.e. 5.3 h), characterizing the "bonito driftnet" métier (Table 1).

**Catch composition and target species**

A total of 40 taxa belonging to 27 families were observed in the catches of the 28 small-scale boats of the harbor of Ziama between May 2013 and April 2014, comprised of 36 species (or higher taxonomic level) of fish (31 Actinopteri and 5 Elasmobranchii), 1 species of crustaceans Palinurus elephas, and 3 species of cephalopod mollusces Loligo vulgaris, Octopus vulgaris, and Sepia officinalis. In total, 15,215 tons of catch were landed, of which 85.80% consisted in the 14 main and accessory target species (see Table 1). The data obtained are summarized in Appendix where the list of species (or higher taxonomic level) caught and their total catches per métier are reported.

The evolution of monthly landings of the main target species of the five métiers (Fig. 3) shows that the Axillary seabream (Pagellus acarne) fishing period is from May to August (Fig. 3A), that of the European hake (Merluccius merluccius) from March to October (Fig. 3B), and that of the Atlantic bonito (Sarda sarda) from May to August (Fig. 3E), thus marking a seasonal fishing activity. On the other hand, the striped red mullet (Mullus surmuletus) and the different species of seabreams (Diplodus spp.) are landed throughout the year (Figs 3C, D).

**CPUE**

The average values of the biomasses captured per 100 m of net or Catch Per Unit Effort (CPUE) of all métiers are greater than two kg (Fig. 4). The lowest CPUEs are those of the "Pagellus set gillnet", "hake set gillnet", and "surmullet trammel net" métiers (Fig. 4), while the overall CPUE of the "Sparids monofilament gillnet" métier is 2.5 kg/100 m net.

Species with the highest CPUE are often the main target species for the different métiers (Table 2). Thus, for the "Pagellus set gillnet" métier, Pagellus acarne represents the highest CPUE with 1.07 kg/100 m of net. In the same way, for the "hake set gillnet" métier, Merluccius merluccius represents the largest CPUE with 2.76 kg/100 m.
Table 1. Description of the métiers according to the characteristics of the fishing operations included in each cluster. Each métier is described through its target species (main and accessory), its fishing period, the habitat visited (P: *Posidonia oceanica* meadow; R: rocky substrata; S: sandy substrata), the fishing ground (fishing depth and distance from the fishing port), and the net characteristics (mesh size, length, and soak time). Fishing period of each métier corresponds to the gray shading; no shading: less than 5% of the whole fishing operations observed during the specific month; light gray shading: between 5 and 10%; dark gray shading: more than 10% (sensu FAO, 1980).

| Métier and gear (FAO code) | Target species | Fishing period (month) | Fishing ground | Net characteristics |
|---------------------------|----------------|------------------------|----------------|---------------------|
|                           |                |                        | Depth (m)      | Distance to the fishing port (m) |
|                           |                |                        | Mesh size (mm) | Length of net (m) |
|                           |                |                        | Soak time (h)  | (mean ± sd)        |
|                           |                |                        |               | Range              |
|                           |                |                        | Mean ± sd     | Mode               |
|                           |                |                        | Mean ± sd     | Range              |
| Pagellus Pagellus acarne | Squalus acanthias |                          | S 24 - 450 | 609 - 10470 | 30 - 40 | 150 - 2000 | 24 - 74 |
| Set gillnet              | Scyliorhinus canicula |                          | 225.6 ± 136.8 | 5854.6 ± 2213.8 | 30 | 1211 ± 681.4 | 49.1 ± 11.2 |
| 07.1.0                    | Merluccius merluccius |                          |                |                    |        |                |
| Hake Merluccius merluccius | Scyliorhinus canicula |                          | S 20 - 240 | 609 - 6936 | 30 - 30 | 150 - 2000 | 24 - 72 |
| Set gillnet              | Pagellus acarne |                          | 49.4 ± 20.9 | 1702.4 ± 1159.3 | 30 | 376.8 ± 465.4 | 37.8 ± 15.5 |
| 07.1.0                    |                |                          |                |                    |        |                |
| Bonito Sarda sarda        | Auxis rochei   |                          | S, R 45 - 400 | 979 - 10470 | 45 - 50 | 200 - 1600 | 2 - 8 |
| Driftnet                 | Euthynnus alleteratus |                       | 103.9 ± 46.4 | 5760.1 ± 3815 | 45 | 590 ± 374.2 | 5.3 ± 2.1 |
| 07.2.0                    |                |                          |                |                    |        |                |
| Surmul-let Mullus surmuletus | Septia officinalis |                          | R, P, S 10 - 48 | 609 - 1047 | 22 - 40 | 200 - 800 | 10 - 44 |
| Trammel net              | Mullus barbatus |                          | 24.4 ± 7.8 | 2424.3 ± 2096.9 | 22 | 362.8 ± 215.2 | 22.7 ± 8.9 |
| 07.5.0                    | Diplodus spp.  |                          |                |                    |        |                |
| Sparids Diplodus spp.     | Sarpa salpa    |                          | P, R, S 5 - 110 | 609 - 7938 | 45 - 45 | 200 - 300 | 18 - 26 |
| Monofilament gillnet     | Sarda sarda    |                          | 18 ± 16.8 | 1571.3 ± 1564.8 | 45 | 202.6 ± 15.7 | 20.6 ± 2.6 |
| 07.9.1                    | Seriola dumerili |                         |                |                    |        |                |
of net, while scorpionfish Scorpaena spp., the accessory target species for this métier (see Table 1), ranks second with 1.92 kg/100 m of net (Table 2). The 3 species of the family Scombridae, Euthynnus alletteratus, Auxis rochei, and Sarda sarda, have the highest CPUEs within the “bonito driftnet” métier with respective values of: 4.73, 4.12, and 3.72 kg/100 m of net. The CPUE of the striped red mullet Mullus surmuletus is the highest among the other species caught by the “surmullet trammel net” métier with an average value of 1.80 kg/100 m of net (Table 2). As for the “Sparids monofilament gillnet” métier, and even if the different species of the Sparidae family represent the majority of the species most fished in terms of frequency of occurrence (in particular the Diplodus genus), the greater amberjack Seriola dumerili and the Atlantic bonito Sarda sarda record the highest CPUE for this métier (Table 2).

**Fishing effort distribution**

The area of the future MPA of “Taza” is mostly exploitable by the fishing fleet of Ziama harbor. The fleet of the harbor of Boudis (trawlers and purse-seiners) is active almost exclusively in the bay of Jijel (Fig. 1). The 16 fishing grounds used by the small-scale fishing vessels of Ziama are mainly concentrated in the western perimeter of the future MPA (Fig. 5) while the eastern sector remains potentially exploitable, notably by the fishers of El-Aouana and some of the small-scale fishers of Jijel. Thirteen of the fishing grounds are mainly at depths <100
m (Fig. 5) while five of them are located within the perimeter of the future MPA (Fig. 5). The fishing grounds located inside the future MPA represent almost half of the total fishing effort (i.e. 47.42% of total fishing operations) (Fig. 6). The patterns of activity show a high concentration of the fishing effort within the proposed no-take zone, especially for the métiers recording the highest CPUEs (see Fig. 4). This is the case for the “bonito driftnet” (Fig. S5) and “Sparids monofilament gillnet” métiers (Fig. S7).

The fishing effort of the “Pagellus set gillnet” métier is concentrated in the Large Sec Bara fishing ground (Fig. S3). As a consequence, more than three quarters of its fishing effort (83.47%) is outside the MPA. The “hake set gillnet” métier largely shares the fishing grounds of the “Pagellus set gillnet” métier (Fig. S4). The “bonito driftnet” métier is used mainly inside and around the proposed MPA (Fig. S5). More than half of the fishing effort (57.80%) of this métier takes place in the grounds inside the MPA and is deployed exclusively beyond 40 m deep (Fig. S5). The “surmullet trammel net” métier has the highest fishing effort (i.e. 40.3% of global fishing operations, Table S4). It is used mainly in the most coastal fishing areas and shows the highest values around the harbor.

Fig. 4: Mean CPUE of the five métiers calculated as kilogrammes per 100 m of net from the fishing operations.

### Table 2. Mean CPUE (biomass landed in kg per 100 m of net) and standard error (s.e.) for the five first species and/or groups of species most fished (in terms of frequency of occurrence) for the five métiers. Parenthetically, the number of productive fishing operations for each métier.

| Métier                        | Species       | CPUE s.e. | Species       | CPUE s.e. | Species       | CPUE s.e. | Species       | CPUE s.e. | Species       | CPUE s.e. |
|-------------------------------|---------------|-----------|---------------|-----------|---------------|-----------|---------------|-----------|---------------|-----------|
| Pagellus set gillnet          | Pagellus      | 1.07      | Merluccius merluccius | 2.76    | Auxis rochei | 4.12     | Malus         | 1.80      | Diplodus spp. | 2.68      |
|                               | Pagellus      | 0.07      | Merluccius     | 0.23    | Auxis rochei | 0.54     | surmulletus   | 0.07      | Diplodus spp. | 0.12      |
|                               | Scyliorhinus  | 0.75      | Loligo         | 2.30    | Balistes     | 1.40     | M. barbatus    | 1.68      | Sarda sarda   | 3.50      |
|                               | Pagellus      | 0.06      | Pagellus       | 0.33    | Sepia officinalis | 1.56 | S. officinalis | 0.11      | S. officinalis | 0.61      |
|                               | Pagellus      | 0.04      | Pagellus       | 0.39    | Sciaena umbra | 2.90     | Pagellus erythrinus | 1.64      | Pagellus erythrinus | 2.50      |

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and one of the two future no-take zones, targeting all five fishing grounds situated inside the perimeter of the future MPA (Fig. S6). The fishing effort of the “Sparids monofilament gillnet” métier is distributed mainly inside the perimeter of the future MPA with almost three quarters (71.35%) of the fishing effort of this métier within one of the two future no-take zones (Fig. S7).

**Discussion**

As in other Mediterranean artisanal fisheries (i.e. Farrugio & Le Corre, 1993; Stergiou et al., 2006; García-Rodríguez et al., 2006; Rocklin et al., 2009; Maynou et al., 2011; Leleu et al., 2014), the artisanal fishery of Ziama is characterized by SSFs by means of boats of small sizes and powers, as well as by the use of passive fishing gear. This activity is carried out mainly in the first three nautical miles off the coast, in areas that can be reached within 1 to 2 hours of navigation from the harbor. A total of five métiers, using four different gears and targeting 5 main species and/or groups of species, were identified in the Ziama artisanal small-scale fisheries. Such a variety of fishing gear and target species has also been reported in the western (Maynou et al., 2011; Leleu et al., 2014), central (Colloca et al., 2004), and eastern (Tzanatos et al., 2005) sectors of the northern Mediterranean shore. In terms of fishing gear, gillnets, which account for 59.7% of total fishing operations, are the more common gear used by the Ziama small-scale fleet. However, trammel nets are more common within Mediterranean SSFs and the prevalence of gillnets could be related to the limited rocky bottoms in the study area.

Observation of the monthly landings showed that the fishing of the target species is distinctly seasonal, demanding that fishers tend to rotate between various métiers throughout the year and adapt to variations in resource availability. This seasonal rotation of fishing gear, a specific characteristic of the Mediterranean artisanal small-scale fisheries (García-Rodríguez et al., 2006, Leleu et al., 2014), is determined not only by the abun-
dance and availability of fisheries resources but also, and most importantly, by the breeding season of the majority of target species as reported by Forcada et al. (2010) or Maynou et al. (2011). When individuals gather in large numbers to reproduce, they become, as explained by Pelletier & Magal (1996), vulnerable to fishing. It is therefore a form of adaptation of fishing tactics to the ecology and dynamics of the species.

The temporal dynamics found in the study area are not comparable to that found in some northern Mediterranean small-scale fisheries. Indeed, our results do not agree with those obtained for the fisheries of Scandola (Le Diréach et al., 2008), Port Cros (Bonhomme et al., 2010), or Bonifacio (Rocklin et al., 2009) in France, for which these authors have reported the presence of a season without activity (i.e. winter). However, our results are in agreement with those of Forcada et al. (2010) for the Tabarca MPA in Spain as well as for the Marine Park of the Côte Bleue near Marseille (Leleu et al., 2014). These disparities in the dynamics of the métiers practiced are due to the dissimilarities of the natural, historical, and cultural characteristics of the environment of each fishery (Farrugio & Le Corre, 1993; Forcada et al., 2010).

Although there is evidence of the rotation of métiers, and consequently of the gear, throughout the year in order to favor the optimization of fishing yields, the fishing activity during the breeding periods of the target species could, as shown by Tzanatos et al. (2005), have negative effects on the state of the stocks. This is the case of Diplodus spp. off eastern Algerian coasts, where most species of this genus breed in the spring period (Benchalel & Kara, 2013; Derbal & Kara, 2013), which corresponds to the peak in the activity of the “Sparids monofilament gillnet” métier targeting this range of species. The spatial distribution of the fishing effort is a crucial element in the spatialization of pressures and impacts on the environment (Costello et al., 2010; Parnell et al., 2010). The creation of maps, as well as the knowledge of the spatial distribution of the fishing effort, provides valuable elements to the managers of this future MPA for the identification of the most frequented areas in order to estimate the pressures and impacts on the fishing habitats. The...
fishing grounds observed are characteristic of the métiers practiced, and therefore suitable habitats for the capture of the targeted species. Thus, the fishing zones drawn from the information provided by the fishers during the field surveys and our trips to sea can contribute to the development of management measures intended to spatially limit the pressures and the impacts of small-scale fisheries in this area.

The spatial distribution of the fishing effort of the five métiers needs to be monitored more closely in order to detect any potential effects related to the creation of an MPA in this area such as the displacement of the fishing effort to its surrounding areas (Halpern et al., 2004). However, the Catch Per Unit Effort (CPUE) results and spatial distribution of the métiers show an interesting correlation. The most intensive fishing effort was recorded (i.e. “bonito driftnet” and “Sparids monofilament gillnet”) are practiced intensively in one of the proposed no-take zones. This argues for a strengthening of controls in this area once the MPA is established.

This study provides a baseline on which to judge the future impact of the MPA by disaggregating the CPUEs for the fishing fleet to métier level which will certainly make it easier to monitor the effects of the MPA on different métiers once the “Taza” MPA is established.

Indeed, MPAs have attracted much attention as a tool for sustainable fisheries management, restoring depleted fisheries stocks, and maintaining ecosystems. When studies suggest that an MPA may not benefit fish productivity or recovery, extenuating factors such as insufficient time since MPA creation, poor enforcement, inadequate design, and poorly defined management objectives are generally blamed rather than the failure of the MPA concept itself (Gruss et al., 2014). We often forget that not all species are equally vulnerable to fishing, nor are all species likely to recover at the same rate. Takashina & Mougi (2014) found that MPAs can have either a positive effect or almost no effect on the recovery of depleted fishing stocks, depending on fish migration patterns and fishing policies. Thus, unsuitable MPA planning might result in low effectiveness or even deterioration of the existing condition.

Many meetings between members of the Project Working Group of the future MPA of “Taza”, experts, scientific researchers, fisheries associations, municipalities, NGOs, the local population, and the press were held in the three coastal municipalities of Jijel, El-Aouana, and Ziama Mansouriah between 2009 and 2011 (Boubekri & Djebbar, 2016). The aim of these meetings was to discuss the zoning proposal through a participatory process that preceded finalization of the zoning plan. The latter was conceived with support from the network of MPA managers in the Mediterranean (MedPAN) within the MedPAN South Project (MSP). Data from the MSP conducted between 2009 and 2012 in the area which assessed marine biological diversity (Ramos-Espla, 2010), fisheries (Kacher, 2010), and socio-economic aspects (Chakour, 2012; Grimes, 2010) served as a basis to achieve the final proposal which was subject to a wide consultation process within the different user-groups of this future MPA.

However, non-professional fishing appears to be causing most conflict in the area of the future MPA of “Taza”. According to Kacher (2010), the current economic difficulties of the local population are now leading to unfair competition between the many illegal fishers and artisanal fishers because their fishing activity is conducted in contravention of national laws. Thus, they use the same fishing gear as the professional fishers and also target the same species, but sell their catch illegally.

Conclusions

Artisanal fishing is the main socio-economic activity in the area of the future MPA of “Taza”. The activity of the boats is concentrated in the coastal sector, where 57.3% of fishing operations are carried out at <40 m. Moreover, our results show a strong coincidence between 3 features: 1) the fishing grounds; particularly littoral, 2) the seasonal fishing periods of the main target species, and 3) the breeding seasons of the main target species.

Despite it still being rather early to judge the proposed zoning on the basis of CPUE results and the spatio-temporal distribution of métiers, onboard data could provide additional information (e.g. estimation of discards). However, and for a more relevant assessment, it would be interesting to estimate discards and bycatch by participating in the trip at sea as part of the regular monitoring of the 2 no-take zones of the future MPA. In addition, a strong illegal fishing activity is present in the area of the future MPA of “Taza”. This activity should be addressed in future studies because of its diverse impacts: 1) biological, through the significant fish mortality, 2) ecological degradation and fragmentation of habitats, and finally 3) socio-economic because the fishing effort of non-professional vessels is underestimated, leading to an overexploitation of fishing resources and compromising the role of any management decisions based on biased data in a context of a data-poor situation.

Our results show that the spatio-temporal dynamics of artisanal SSFs is a crucial component for the effective management of the future MPA of “Taza”. Understanding the dynamics of the fishery and the behavior of the fishers are two fundamental elements that must be integrated into the management approach, strictly conditioned by close collaboration between scientists, fishers, and local managers.

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References

Abdessalem, F., 1995. La pêche côtière dans la région Nord de la Tunisie. Cahier CERES Série géographique, 11, 173-202.
Battaglia, P., Romeo, T., Consoli, P., Scotti, G., Andaloro, F., 2010. Characterization of the artisanal fishery and its socio-economic aspects in the central Mediterranean Sea (Aeolian Islands, Italy). Fisheries Research, 102 (1), 87-97.
Belhabib, D., Zeller, D., Harper, S., Pauly, D., 2012. Marine Fisheries Catches in West Africa, 1950-2010, Part I. Fisheries Centre Research Reports, Vol. 20, No 3, 104 pp.
Benchalle, W., Kara M.H., 2013. Age, growth and reproduction of the white seabream Diplodus sargus sargus (Linnaeus, 1758) off eastern coast of Algeria. Journal of Applied Ichthyology, 29 (1), 64-70.
Benzecri, J.P., 1982. Construction d’une classification ascendante hiérarchique par la recherche en chaîne des voisins réciproques. Cahiers d’Analyse des Données, 7 (2), 209-218.
Biseau, A., 1998. Definition of a directed fishing effort in a mixed-species trawl fishery, and its impact on stock assessments. Aquatic Living Resources, 11 (3), 119-136.
Bonhomme, P., Roubaud, V., Roubaud, V., Rogeau, E., Goujard, A., Le Diriéch, L. et al., 2010. Suivi de l’effort de pêche professionnelle dans les eaux du Parc national de Port-Cros. Année 2009. Contrat Parc national de Port-Cros & GIS Posidonie, Marseille, France.
Boubeki, I., Djehar, A.B., 2016. Marine protected areas in Algeria. Future marine protected area of “Taza” (SW Mediterranean), continuing challenges and new opportunities facing an integrated coastal management. Ocean and Coastal Management, 130, 277-289.
Bouzourenne, A., 2009. Essai d’évaluation de l’impact socio-économique de la création d’une réserve marine protégée sur la pêche artisanale locale: Cas du Parc de Taza. Thèse de Magistère en Sciences Agronomiques. Ecole Nationale Supérieure Agronomique El-Harrach, Algérie, 94 pp.
Cadiou, G., Boudouresque, C. F., Bonhomme, P., Le Diréché, L., 2009. The management of artisanal fishing within the marine protected area of the Port-Cros National Park (north-west Mediterranean Sea): A success story? ICES Journal of Marine Science, 66 (1), 41-49.
Carvalho, N., Edwards-Jones, G., Isidro, E., 2011. Defining scale in fisheries: small versus large-scale fishing operations in the Azores. Fisheries Research, 109 (2), 360-369.
Chakour, S.C., 2008. Sustainable management of artisanal fisheries in developing countries, the need for expert systems: The case of the Péchakour Expert System (PES). WIT Transactions on Ecology and the Environment, 108, 210-217.
Chakour, S.C., 2012. Etude socio-économique pour la future aire marine du Parc National de Taza. Commandée par WWF MedPO, 50 pp. + annexes. Retrieved March 18, 2014 from.
Chakour, S.C., Guidetti, S.E., 2014. Sustainable management of artisanal fisheries in Algeria: The contribution of an empirical approach. Merit Research Journal of Business and Management, 2 (3), 30-39.
Claudet, J., Olsenberg, C.W., Benedetti-Cecchi, L., Domenici, P., Garcia-Chariton, J.A. et al., 2008. Marine reserves: Size and age do matter. Ecology Letters, 11 (5), 481-489.
Close, C.H., Hall, G.B., 2006. A GIS-based protocol for the collection and use of local knowledge in fisheries management planning. Journal of Environmental Management, 78 (4), 341-352.
Coll, M., Carreras, M., Ciérocoles, C., Cornax, M.-J., Gorelli, G. et al., 2014. Assessing fishing and marine biodiversity changes using fishers’ perceptions: The Spanish Mediterranean and Gulf of Cadiz case study. PLoS One, 9 (1), e85670.
Collèt, M., Gascuel, D., Albouy, C., Francour, P., De Moraís, L.T. et al., 2014. Fishing inside or outside? A case studies analysis of potential spillover effect from marine protected areas, using food web models. Journal of Marine Systems, 139, 383-395.
Colloca, F., Crespi, V., Cerasi, S., Coppola, S.R., 2004. Structure and evolution of the artisanal fishery in a southern Italian coastal area. Fisheries Research, 69 (3), 359-369.
Coppola, S.R., 2006. Inventory of artisanal fishery communities in the western and central Mediterranean. Volume 77, FAO, 82 pp.
Costello, C., Rassweiler, A., Siegel, D., De Leo, G., Micheli, F. et al., 2010. The value of spatial information in MPA network design. Proceedings of the National Academy of Sciences, 107 (43), 18294-18299.
Derbal, F., 2007. L’ichthyofaune des côtes de l’Est algérien: Ecologie de quatre téloétoïsties (Diplodus cervinus cervinus, D. punctazzo, Sciaena umbra, Epinephelus costae) et contribution à la biologie du sar tambour Diplodus cervinus cervinus (Lowe, 1838). Thèse de Doctorat d’Etat en Sciences Naturelles. Université d’Annaba Badji Mokhtar, Algérie, 179 pp.
Derbal, F., Kara, M.H., 2013. Age, croissance et reproduction du sar tambour Diplodus cervinus cervinus (Purpuridae) des côtes de l’Est algérien. Cybium, 37 (4), 247-254.
Di Franco, A., Bodilis, P., Piante, C., Di Carlo, G., Thiriet, P. et al., 2014. Fishermen engagement, a key element to the success of artisanal fisheries management in Mediterranean marine protected areas. MedPAN North Project. WWF France, 135 pp.
Di Franco, A., Thiriet, P., Di Carlo, G., Dimitriades, C., Francour, P. et al., 2016. Five key attributes can increase marine protected areas performance for small-scale fisheries management. Scientific reports, 6, 38135.
Di Lorenzo, M., Claudet, J., Guidetti, P., 2016. Spillover from marine protected areas to adjacent fisheries has an ecological and a fishery component. Journal for Nature Conservation, 32, 62-66.
Dimitriades, C., Carranza, A., Vilela, R., Casadevall, M., 2015. A rapid assessment of trends in the multi-specific small-scale fishery of Palamós (Catalonia, Spain). ICES Journal of Marine Science, 72 (9), 2638-2649.
Falautano, M., Castriotta, L., Cillari, T., Vivona, P., Finot, M.G. et al., 2018. Characterization of artisanal fishery in a coastal area of the Strait of Sicily (Mediterranean Sea): Evaluation of legal and IUU fishing. Ocean & Coastal Management, 151, 77-91.
FAO, 1980. International standard statistical classification of fishing gear (ISSGF): Coordinating working party (CWP) - Report of the 10th session, (Eds). FAO Fisheries Report, R242, FAO, Madrid, Spain.
FAO, 2005. Fisheries and aquaculture topics. Small-scale and

http://epublishing.ekt.gr | e-Publisher: EKT | Downloaded at 22/11/2018 10:58:44 |
artisanal fisheries. Key features of small-scale and artisanal fishing. In: FAO- Fisheries and aquaculture department, Rome.

FAO, 2016a. Directives volontaires visant à assurer la durabilité de la pêche artisanale dans le contexte de la sécurité alimentaire et de l’éradication de la pauvreté. Food and Agriculture Organization (FAO), 17 pp.

FAO, 2016b. The State of World Fisheries and Aquaculture 2016. Contributing to food security and nutrition for all. Food and Agriculture Organization (FAO), 200 pp.

Farrugio, H., Le Corre, G., 1993. A sampling strategy and methodology for assessment and monitoring of Mediterranean small-scale fisheries. Scientia Marina, 57 (2-3), 131-137.

Forcada, A., Valle, C., Bonhomme, P., Croquet, G., Cadiou, G., et al., 2009. Effects of habitat on spillover from marine protected areas to artisanal fisheries. Marine Ecology Progress Series, 379, 197-211.

Forcada, A., Valle, C., Sánchez-Lizaso, J.L., Bayle-Sempere, J.T., Corsi, F., 2010. Structure and spatio-temporal dynamics of artisanal fisheries around a Mediterranean marine protected area. ICES Journal of Marine Science, 67 (2), 191-203.

Franceur, P., Harmelin, J.G., Pollard, D., Bartoreto, S., 2001. A review of marine protected areas in the northwestern Mediterranean region: siting, usage, zonation and management. Aquatic conservation: marine and freshwater ecosystems, 11 (3), 155-188.

García-Charton, J.A., Pérez-Ruzafa, A., Marcos, C., Claudet, J., Badalamenti, F. et al., 2008. Effectiveness of European Mediterranean MPAs: Do they accomplish the expected effects on populations, communities and ecosystems? Journal for Nature Conservation, 16 (4), 193-221.

García-Rodríguez, M., Fernández, A.M., Esteban, A., 2006. Characterisation, analysis and catch rates of the small-scale fisheries of the Alicante Gulf (SE Spain) over a 10 years time series. Fisheries Research, 77 (2), 226-238.

Giaoumi, S., Sciana, C., Plass-Johnson, J., Micheli, F., Grodul-Colvert, K., et al., 2017. Ecological effects of full and partial protection in the crowded Mediterranean Sea: a regional meta-analysis. Scientific reports, 7 (1), 8940.

Goñi, R., Hilborn, R., Díaz, D., Mallol, S., Adlerstein, S., 2010. Net spillover from a marine reserve to fishery catch. Marine Ecology Progress Series, 400, 233-243.

Gratl, F., Aladzau, A., Azzurro, E., Bolognini, L., Carbonara, P. et al., 2018. Seasonal dynamics of small-scale fisheries in the Adriatic Sea. Mediterranean Marine Science, 19 (1), 21-35.

Griffiths, R.C., Robles, R., Coppola, S.R., Camillas, J.A., 2007. Is there a future for artisanal fisheries in the western Mediterranean? FAO-COPESMED, 117 pp.

Grimes, S., 2010. Fréquentation des plages de la zone de Taza. Direction Générale des Parcs, Parc National de Taza (Wildlife of Jijel). WWF-MedPAN Sud, Rapport No 2, 39 pp.

Grüss, A., Robinson, J., Heppel, S.S., Heppel, S.A., Semmens, B.X., 2014. Conservation and fisheries effects of spawning aggregation marine protected areas: what we know, where we should go, and what we need to get there. ICES Journal of Marine Science, 71 (7), 1515-1534.

Guidetti, P., Baiata, P., Ballesteros, E., Di Franco, A., Hereu, B. et al., 2014. Large-scale assessment of Mediterranean marine protected areas effects on fish assemblages. PLoS One, 9 (4), e91841.

Guidetti, P., Bussotti, S., Pizzolante, F., Ciccioella, A., 2010. Assessing the potential of an artisanal fishing co-management in the marine protected area of Torre Guaceto (southern Adriatic Sea, SE Italy). Fisheries Research, 101 (3), 180-187.

Guidetti, P., Claudet, J., 2010. Co-management practices enhance fisheries in marine protected areas. Conservation Biology, 24 (1), 312-318.

Halpern, B.S., Gaines, S.D., Warner, R.R., 2004. Confounding effects of the export of production and the displacement of fishing effort from marine reserves. Ecological Applications, 14 (4), 1248-1256.

Harmelin-Vivien, M., Cottalorda, J.M., Dominici, J.M., Harmelin, J.G., Le Diréach, L. et al., 2015. Effects of reserve protection level on the vulnerable fish species Sciaena umbra and implications for fishing management and policy. Global Ecology and Conservation, 3, 279-287.

Harrison, H. B., Williamson, D.H., Evans, R.D., Almany, G.R., Thorrold, S. R. et al., 2012. Larval export from marine reserves and the recruitment benefit for fish and fisheries. Current Biology, 22, 1023-1028.

Hilborn, R., Stokes, K., Maguire, J. J., Smith, T., Botsford, L. W. et al., 2004. When can marine reserves improve fisheries management? Ocean & Coastal Management, 47 (3-4), 197-205.

Himes, A.H., 2003. Small-scale Sicilian fisheries: Opinions of artisanal fishers and socio-cultural effects in two MPA case studies. Coastal Management, 31 (4), 389-408.

Jabeur, C., Gobert, B., Missaoui, H., 2000. Typologie de la flottille de pêche côtière dans le golfe de Gabès (Tunisie). Aquatic Living Resources, 13 (6), 421-428.

Kacher, M., 2010. Vers un Plan d'Aménagement et de Gestion des Pécheries de la Future Aire Marine Protégée de Taza. PNTaza, 66 pp.

Le Diréach, L., Bonhomme, P., Donata, M., 2008. Suivi de l’effort de pêche professionnelle dans la réserve naturelle de Scandola (Corse). Données 2007. GIS Posidonie, 43 pp.

Leclaire, L., 1972. La sédimentation holocène sur le versant méridional du bassin algéro-balearès (précontinent algérien). Mémoire Museum National Histoire Naturelle, Série C, Tome XXIV, Ed. du Muséum, Paris, 391 pp.

Léopold, M., Guillemond, N., Rocklin, D., Chen, C., 2014. A framework for mapping small-scale coastal fisheries using fishers’ knowledge. ICES Journal of Marine Science, 71 (7), 1781-1792.

Maouel, D., Maynou, F., Bedrani, S., 2014. Bio-economic analysis of small pelagic fishery in central Algeria. Turkish Journal of Fisheries and Aquatic Sciences, 14, 897-904.

Maynou, F., Recasens, L., Lombarte, A., 2011. Fishing tactics dynamics of a Mediterranean small-scale coastal fishery. Aquatic Living Resources, 24(2): 149–159.

Maynou, F., Morales-Nin, B., Cabanelas-Rebero, M., Palmer, M., Garcia, E. et al., 2013. Small-scale fishery in the Balearic Islands (W Mediterranean): A socio-economic approach. Fisheries Research, 139, 11-17.

Merino, G., Morales-Nin, B., Maynou, F., Grau, A.M., 2008. Assessment and bio-economic analysis of the Majorca (NW Mediterranean) trammel net fishery. Aquatic Living Resources, 21 (2), 99-107.

Merino, G., Maynou, F., Boncoeur, J., 2009. Bio-economic model for a three-zone marine protected area. A case study of Medes Islands (Northwest Mediterranean). ICES Journal of Marine Science, 66 (1), 147-154.

Merrien, C., Lesspagnol, P., Badts, V., 2008. Manuel de l’ob-
Medit. Mar. Sci., 19/3, 2018, 555-571

surveillance des marées au débarquement pour les navires de moins de 12 mètres. Irfenner, pp 59.

Moutopoulos, D.K., Ramfos, A., Moukas, C., Katselis, G., 2014. Description of a daily fishing activity from a small-scale fisherman in central Greece (Korinthiakos Gulf). International Aquatic Research, 6 (2), 1-9.

Neis, B., Schneider, D.C., Felt, L., Haedrich, R.L., Fischer, J. et al., 1999. Fisheries assessment: What can be learned from interviewing resource users? Canadian Journal of Fisheries and Aquatic Sciences, 56 (10), 1949-1963.

Ojeda-Martínez, C., Bayle-Sempere, J.T., Sánchez-Jerez, P., Forcada, A., Valle, C., 2007. Detecting conservation benefits in spatially protected fish populations with meta-analysis of long-term monitoring data. Marine Biology, 151 (3), 1153-1161.

Olivier, P., Franquesa, R., 2005. Fisheries in the Mediterranean. International Center for Advanced Mediterranean Agromonic Studies (CIHEAM), CIHEAM analytic note, No 3, 38 pp.

Parnell, P.E., Dayton, P.K., Fisher, R.A., Loarie, C.C., Darrow, R.D., 2010. Spatial patterns of fishing effort off San Diego: Implications for zonal management and ecosystem function. Ecological Applications, 20 (8), 2203-2222.

Pelletier, D., Magal, P., 1996. Dynamics of a migratory population under different fishing effort allocation schemes in time and space. Canadian Journal of Fisheries and Aquatic Sciences, 53 (5), 1186-1199.

Pelletier, D., Ferraris, J., 2000. A multivariate approach for defining fishing tactics from commercial catch and effort data. Canadian Journal of Fisheries and Aquatic Sciences, 57 (1), 51-65.

Pita, P., Fernández-Vidal, D., García-Galdo, J., Muiño, R., 2016. The use of the traditional ecological knowledge of fishermen, cost-effective tools and participatory models in artisanal fisheries: Towards the co-management of common octopus in Galicia (NW Spain). Fisheries Research, 178, 4-12.

Ramos-Espla, A.A., 2010. Rapport mission Parc National de Taza. Biodiversité Marine. PNTaza-WWF MedPO, 76 pp.

Refes, W., 2011. Contribution à la connaissance de la biodiversité des fonds chalutables de la côte algérienne: Les peuplements ichthyologiques des fonds chalutables du secteur oriental de la côte algérienne. Thèse de Doctorat en Sciences de la Mer. Université d’Annaba Badji Mokhtar, Algérie, 242 pp.

Rocha, F., Gracia, J., González, Á.F., Jardón, C.M., Guerra, Á., 2004. Reliability of a model based on a short fishery statistics survey: Application to the North-East Atlantic monkfish fishery. ICES Journal of Marine Science, 61 (1), 25-34.

Rocklin, D., Santoni, M.C., Culoli, J.M., Tomasini, J.A., Pelletier, D. et al., 2009. Changes in the catch composition of artisanal fisheries attributable to dolphin predation in a Mediterranean marine reserve. ICES Journal of Marine Science, 66 (4), 699-707.

Romdhane, M.S., 1998. La pêche artisanale en Tunisie. Évolution des techniques ancestrales. In: Mélanges de l’école française de Rome. Antiquité, 110 (1), 61-80.

Sahi, M.A., Bouaicha, M., 2003. La pêche artisanale en Algérie. FAO-COPEMED, 23 pp.

Seytre, C., Francour, P., 2008. Is the Cape Roux marine protected area (Saint-Raphaël, Mediterranean Sea) an efficient tool to sustain artisanal fisheries? First indications from visual censuses and trammel net sampling. Aquatic Living Resources, 21 (3), 297-305.

Stelzenmüller, V., Maynou, F., Martin, P., 2007. Spatial assessment of benefits of a coastal Mediterranean marine protected area. Biological Conservation, 136 (4), 571-583.

Stergiou, K.I., Petrakis, G., Politou, C.Y., 1996. Small-scale fisheries in the South Euboikos Gulf (Greece): Species composition and gear competition. Fisheries Research, 26 (3), 325-336.

Stergiou, K.I., Moutopoulos, D.K., Soriguer, M.C., Puente, E., Lino, P.G. et al., 2006. Trammel net catch species composition, catch rates and métiers in southern European waters: A multivariate approach. Fisheries Research, 79 (1), 170-182.

Takashina, N., Mougi, A., 2014. Effects of marine protected areas on overfished fishing stocks with multiple stable states. Journal of theoretical biology, 341, 64-70.

Tzanatos, E., Dimitriou, E., Katselis, G., Georgiadis, M., Koutsikopoulos, C., 2005. Composition, temporal dynamics and regional characteristics of small-scale fisheries in Greece. Fisheries Research, 73 (1), 147-158.

Tzanatos, E., Somarakis, S., Tserepis, G., Koutsikopoulos, C., 2006. Identifying and classifying small-scale fisheries métiers in the Mediterranean: A case study in the Patraikos Gulf, Greece. Fisheries Research, 81 (12), 158-168.

Únal, V., 2003. Socio-economic analysis of small-scale fisheries, Foca (Aegean Sea). Ege Journal of Fisheries and Aquatic Science, 20 (1), 165-172.

Únal, V., Franquesa, R., 2010. A comparative study of socio-economic indicators and viability in small-scale fisheries of six districts along the Turkish coasts. Journal of Applied Ichthyology, 26 (1), 26-34.
Appendix

List of caught taxa and their total weight (kg) per métier in the catches of the 28 small-scale vessels considered for this study.

| Species                  | Pagellus | Hake | Bonito | Mullets | Sparids | Total (kg) |
|--------------------------|----------|------|--------|---------|---------|------------|
| **Elasmobranchii**       |          |      |        |         |         |            |
| Dasyatidae               |          | 10.00|      | 5.00    |         | 15.00      |
| **Rajidae**              |          | 15.00| 15.00  |         |         | 195.00     |
| Scylliorniidae           |          |      |        |         |         |            |
| Scylliorminus canicula   | 730.00   | 20.00|      |         |         | 750.00     |
| **Squalidae**            |          |      |        |         |         |            |
| Squalus acanthias        | 1135.00  |      |      |         |         | 1135.00    |
| **Torpedinidae**         |          |      |        |         |         |            |
| Torpedo spp.             | 5.00     | 10.00|      |         |         | 75.00      |
| **Actinopteri**          |          |      |        |         |         |            |
| Balistidae               |          |      |        |         |         |            |
| Balistes carolinensis    | -        | 5.00 | 20.00  | 130.00  |         | 155.00     |
| **Carangidæ**            |          |      |        |         |         |            |
| Seriola dumerili         | -        | -    | -      | -       | 90.00   | 90.00      |
| **Congridæ**             |          |      |        |         |         |            |
| Conger conger            | 5.00     | -    | -      | 15.00   | -       | 20.00      |
| **Gadidæ**               |          |      |        |         |         |            |
| Phycis spp.              | 40.00    | 15.00|      | -       | -       | 55.00      |
| **Lophiidiæ**            |          |      |        |         |         |            |
| Lophius spp.             | 165.00   | 5.00 | -      | -       | -       | 170.00     |
| **Merlucciidiæ**         |          |      |        |         |         |            |
| Merluccius merluccius    | 460.00   | 205.00|      | 70.00   | -       | 735.00     |
| **Muraenidæ**            |          |      |        |         |         |            |
| Dicentrarchus labrax     | -        | -    | -      | 5.00    | -       | 5.00       |
| **Mugilidæ**             |          |      |        |         |         |            |
| Mugilidæ                 | -        | -    | -      | 25.00   | 30.00   | 55.00      |
| **Mullidæ**              |          |      |        |         |         |            |
| Mullus barbatus barbatus | 45.00    | 5.00 | -      | -       | 225.00  | 15.00      |
| Mullus surmuletus         | -        | -    | -      | -       | 775.00  | 5.00       |
| **Muraenidæ**            |          |      |        |         |         |            |
| Muraena helena           | -        | -    | -      | 30.00   | -       | 30.00      |
| **Sciaenidæ**            |          |      |        |         |         |            |
| Sciaena umbra            | 5.00     | 25.00| 10.00  | -       | -       | 40.00      |
| **Scombridæ**            |          |      |        |         |         |            |
| Atherinidae              |          |      |        |         |         |            |
| Atherinoides              |          |      |        |         |         |            |
| **Scomberidæ**           |          |      |        |         |         |            |
| Euthynnus alletteratus   | -        | -    | 1180.00| -       | -       | 1180.00    |
| **Scorpaenidæ**          |          |      |        |         |         |            |
| Scorpaena spp.           | 595.00   | 65.00| -      | 160.00  | 5.00    | 825.00     |

(continued)
### Appendix continued

| Species     | Pagellus | Hake | Bonito | Mullets | Sparids | Total (kg) |
|-------------|----------|------|--------|---------|---------|------------|
| **Soleidae**|          |      |        |         |         |            |
| Soleidae    | 10.00    | 15.00| -      | 10.00   | -       | 35.00      |
| **Sparidae**|          |      |        |         |         |            |
| Dentex spp. | 5.00     | -    | -      | -       | 5.00    | 10.00      |
| Diplodas spp.| 10.00    | 10.00| 5.00   | 210.00  | 145.00  | 380.00     |
| Lithognathus mormyrus | 10.00 | - | - | 15.00 | 25.00 | 50.00 |
| Oblada melanura | - | - | - | 5.00 | 15.00 | 20.00 |
| Pagellus acarne | 1850.00 | 35.00| - | 140.00 | - | 2025.00 |
| Pagellus bogaraveo | 35.00| 5.00 | - | 5.00 | 5.00 | 50.00 |
| Pagellus erythrinus | 20.00 | 35.00| - | 190.00 | 45.00 | 290.00 |
| Pagrus spp. | 20.00    | -    | -      | 20.00   | 10.00   | 50.00      |
| Sarpa salpa  | 10.00    | -    | -      | 145.00  | 70.00   | 225.00     |
| Sparus aurata | - | - | - | - | 5.00 | 5.00 |
| **Trachinidae**|          |      |        |         |         |            |
| Trachinidae  |          |      |        |         |         |            |
| Trachus draco | - | 15.00| - | 70.00 | - | 85.00 |
| **Triglidae**|          |      |        |         |         |            |
| Trigla lucerna | 75.00 | 40.00| - | - | - | 115.00 |
| **Cephalopoda**|          |      |        |         |         |            |
| Loliginidae  |          |      |        |         |         |            |
| Loligo vulgaris | 280.00 | 35.00| - | - | - | 315.00 |
| Octopodidae  |          |      |        |         |         |            |
| Octopus vulgaris | 30.00 | 5.00 | 35.00 | 65.00 | - | 135.00 |
| Sepiidae     |          |      |        |         |         |            |
| Sepia officinalis | 15.00 | 10.00| - | 220.00 | 15.00 | 260.00 |
| **Malacostraca**|          |      |        |         |         |            |
| Palinuridae  |          |      |        |         |         |            |
| Palinurus elephas | 165.00 | - | - | - | - | 165.00 |
| **Total (kg)**| **5780.00** | **550.00** | **5535.00** | **2795.00** | **555.00** | **15215.00** |