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Assessment of conservation value of Cap des Trois Fourches (Morocco) as a potential MPA in southern Mediterranean

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Abstract The marine habitats surrounding Cap des Trois Fourches (Mediterranean coast of Morocco) was explored in the framework of the MedMPAnet Project. Ten different communities were identified in the studied area, among which it is remarkable the presence of some key conservational habitats: seagrass meadows, dark and semidark cave communities, maërl beds and corraligenous assemblages. All the data was included in a GIS program (Geographic Information System) to elaborate a cartographic map of marine communities and species distribution. All the scientific data obtained support the proposal of Cap des Trois Fourches as a marine protected area. We also provided a map of management, suggesting the stricter protection of the areas with higher conservational interest.

Keywords Cap des Trois Fourches · Benthic assemblages · MPA · Cartography · Voronoi polygons

Introduction

Identification of priority areas such as 'hotspots' or high biodiversity areas is an essential tool for conservation planning in marine systems (Myers et al. 2000; Brooks et al. 2006). In this sense, Mediterranean Sea has been widely recognized as a priority place to be considered in marine conservation (Myers et al. 2000; Selig et al. 2014 and references therein). Even though many biological and socioeconomic measures are potentially important for determining places of high conservation value, relative levels of biodiversity are among important considerations for conservation prioritization efforts (Hughes et al. 2002; Roberts et al. 2002). Mediterranean biodiversity is being reduced today by global threats, including anthropogenic pressures, alien species and climate change (Pairaud et al. 2014). In this context, the ecological and conservation relevance of the Western Mediterranean basin and, specifically, the Alboran Sea has been pointed out by several authors (Coll et al. 2010; Templado et al. 2006). Furthermore, the Strait of Gibraltar, with the adjacent Alboran Sea and African coast, have been identified as important habitats for many threatened or endangered species (Coll et al. 2010).

Related cartographic products are main tools used for support ecosystem based coastal zone management (Agardy 2010). Nevertheless, getting these maps can be greatly difficult. In fact, the data collection for mapping parameters related to benthic habitats are usually costly (Sheehan et al. 2010), equipment and time-demanding procedures (Álvarez-Berastegui et al. 2014). However, the first stage of any environmental management plan involves recording the existing situation by mapping the main benthic assemblages and bottom types (Pasqualini et al. 1997). The initial survey of an area for which there is little available data, involves the use of small-scale cartographical techniques (Pergent et al. 1995). Unfortunately, in the marine domain the situation is particularly dramatic because of the lack of suitable tools and knowledge of protected structures and functions, together with the need for such basic information as the benthic cartography (Sardá et al. 2012). Furthermore, modelling and mapping,

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using Geographical Information Systems (GIS) in a particular location, provides the information for a correct decision making.

Because of its geographical situation, as the first Mediterranean basin for the inflowing Atlantic water, marine communities inhabiting the Alboran Sea are of great biogeographic interest. This importance is especially high in the waters surrounding the Cap des Trois Fourches, due to the biogeographical asymmetries between the north and the south border of the Alboran Sea; while in the north coast the composition of benthic species shows a gradual substitution of Mediterranean and Atlantic species, this transition is more pronounced in the south coast, being mainly located in Cap des Trois Fourches (González 1994; Cebrián and Ballesteros 2004). So, the distribution of many Mediterranean endemisms and genuine Atlantic species only overlap at Cap des Trois Fourches (González 1994; Cebrián and Ballesteros 2004).

At Mediterranean scale, the South coasts show a scarcity of MPAs in comparison with the North ones (see Portman et al. 2012). These authors report that the mean distance among MPAs is 53 km in the Mediterranean, but the gaps found in Mediterranean Morocco exceed largely this distance.

Since 1993, the Moroccan authorities identified, along the Mediterranean coast of the country (including the strait of Gibraltar) (ca 350 km), 10 Sites of Biological and Ecological Interest (SBEI) that should benefit of conservation and management measures (PDAPM 1996). However, until now, the National Park of Al Hoceima is the lonely officially declared MPA in the area. Recently, under its new law on Protected Areas (2010) and in order to meet its national and international commitments, Morocco has developed a vision for 2020 aiming at establishing a national network of protected areas, representative, coherent and functional at both ecological and socio-economic levels.

In the Moroccan Mediterranean, a recent prioritization of SBEI, based on a multicriteria approach and updated data, identified the Cap des Trois Fourches as a priority site to be designed as an MPA (PNUE-PAM-CAR/ASP 2012). The site was recognized by the Moroccan government as a SBEI (PDAPM 1996) and as a RAMSAR site of international importance (Bazairi et al. 2011). With an area of 5000 ha, the SBIE occupies the extremity of the Cap des Trois Fourches and is limited to the east by Tibouda and to the west by Cala Charrana.

In order to compile detailed information about the conservational status of the Cap des Trois Fourches, a previous survey was conducted in 2012 (see PNUE-PAM-CAR/ASP 2013; Espinosa et al. 2014). Results revealed that Cap des Trois Fourches meets all the scientific criteria for designation as a MPA, considering that the area displays high environmental quality, a variety of habitats (meadows, coralligenous assemblages, marine caves etc.) and hosts many endangered species and key habitats for the Conservation in the Mediterranean (PNUE-PAM-CAR/ASP 2013; Espinosa et al. 2014). Moreover, human pressure on the marine environment of the site is low, with limited touristic activities, low coastal development and periodical artisanal fisheries as the principal socio-economic activity of the inhabitants of the area. However, trawl fishing as well as uncontrolled recreational fishing targeting emblematic species such as the dusky grouper *Epinephelus marginatus* are the major threats identified within the limits of the SBEI.

The designation of a MPA in Cap des Trois Fourches (from the Tibouda to Charrana areas) is a first step to meet the Moroccan 2020 vision on MPA in the Moroccan Mediterranean. It could also ameliorate the connectivity between MPA, enhancing the MPA network in the southern Mediterranean.

However, to have enough information for management policy, it is necessary to know the spatial distribution of dominant assemblages. The aim of the present study was to collect this essential field data to allow the decision-makers to implement a MPA.

Material and methods

Field work was carried out between 10th and 19th September 2013. Ninety five sampling stations were established for the benthic cartography of the marine communities surrounding the Cap des Trois Fourches (Fig. 1). These points were haphazardly distributed between 5 and 30 m depth from Punta de la Mina (35°24′6″ N; 2°57′14″ W) to Cala Charrana (35°23′21″N; 3°00′38″W). Precise geographic coordinates of each point were recorded using a Topcom GPS and benthic characterization was performed by imagine analyses. For depths below 20 m, images and videos were recorded by scuba divers with an Olympus 1030 SW and Olympus Tough underwater cameras, equipped with a Sony Marine Pack Light HVL-ML20M and flash INON S-2000 respectively. Deeper stations were explored with the aid of a Remote Operational Vehicle (ROV, model Micro 1.0, Albatros Technologies), provided with a video-camera connected by umbilical to a boat. The use of ROVs has been previously highlighted as a very suitable method for the description and mapping of benthic biocenosis (Ninio et al. 2003; Parry et al. 2003; Sardá et al. 2012). Sampling effort was similar with the two methodologies (both divers and ROV's record several minutes of video in each point). All pictures and videos were posteriorly analyzed in the computer to identify the dominant species inhabiting each station. Dominant communities were established following the classification in Calvín-Calvo (2000) with modifications.

Considering a number of points in a Euclidian plane, there are different areas associated with these points. Inside each area, any possible site is closer to one of these points than with any other considered point. These areas are known such as

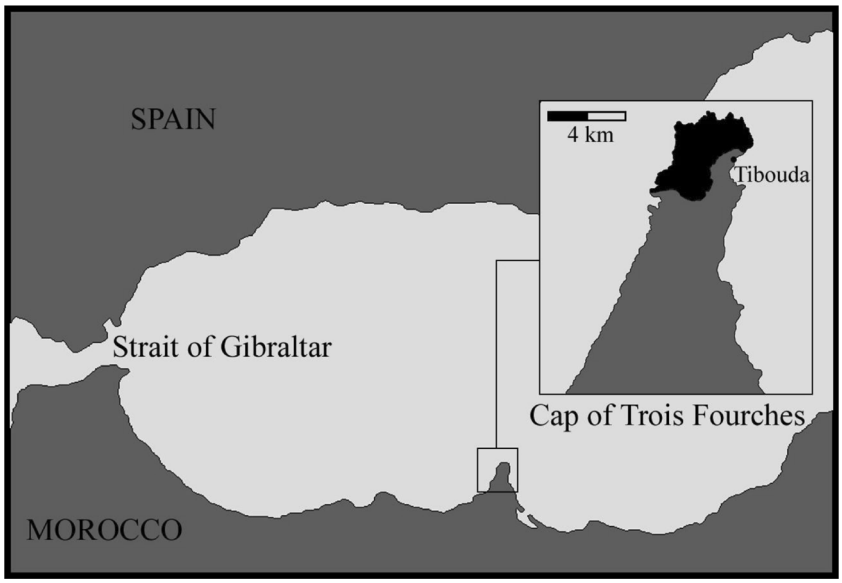

Fig. 1 Map of the study site. Site of Biological and Ecological Interest (SBEI) is shown in black

Voronoi polygons (Voronoi 1909). We have used this approach (Kolahdouzan and Shahabi 2004) to map benthic assemblages by means of Geographical Information Systems (GIS).

Results

A relevant heterogeneity of bottoms can be found in the Cap des Trois Fourches (Fig. 2). Sandy bottoms are dominant in

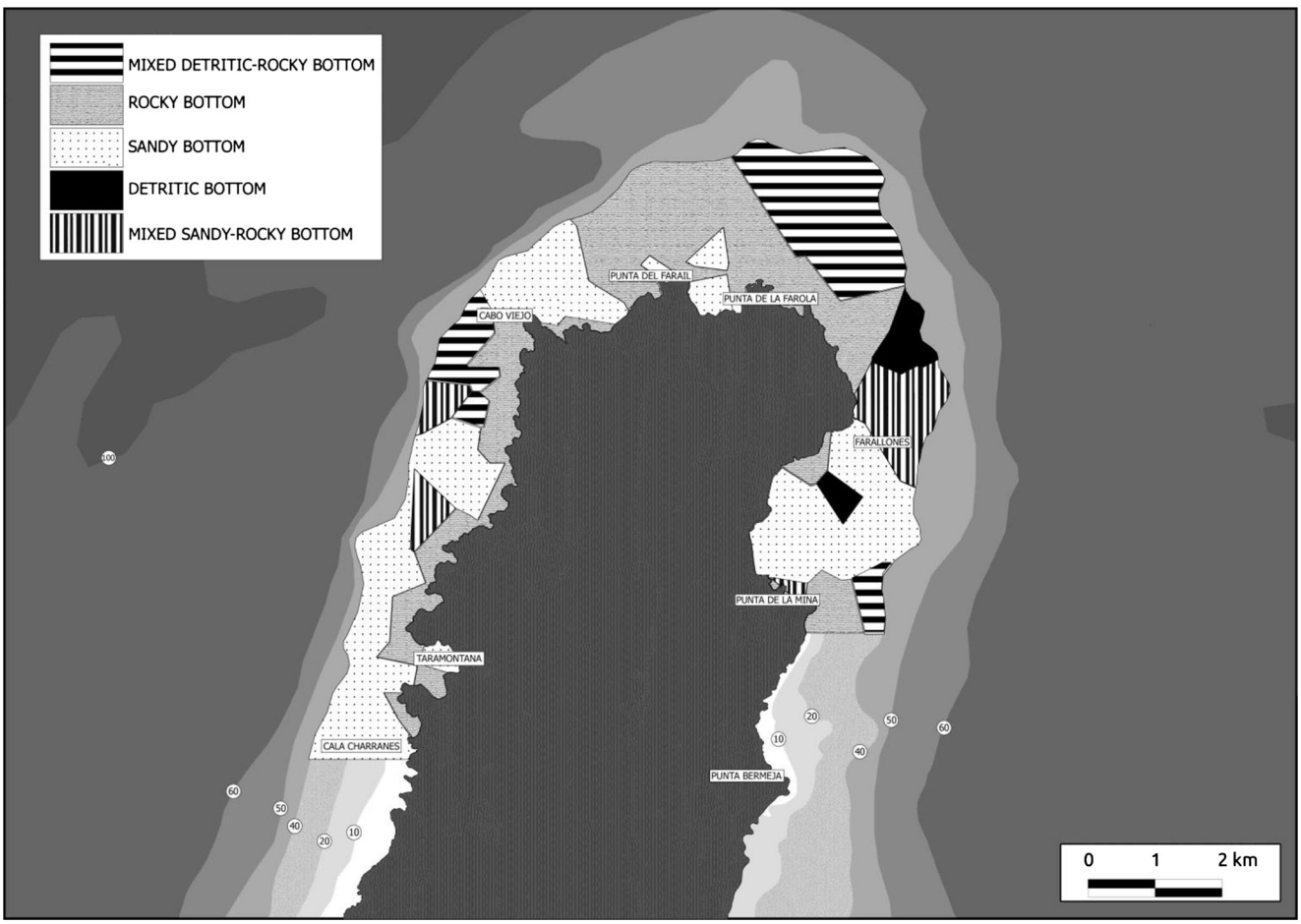

Fig. 2 Types of bottoms found in Cap des Trois Fourches. Numbers inside circles indicate depth

the western side from 10 m in depth and also in the Bay of Tibouda, located in the eastern coast. Rocky bottoms can be found both in the North side, where they are the dominant habitats through a wide range of depths, and in shallow waters (0–10 m) of the western area. Finally, detritic bottoms were detected in deeper zones (from 20 m in depth), well mixed with a rocky substrate or isolated.

Many different assemblages were surveyed (Fig. 3). Seagrass meadows of *Cymodocea nodosa* were present in the western side, although the surface covered was reduced to limited zones. Sandy bottoms dominated the western side from 10 m in depth and also the Bay of Tibouda in the eastern one. Assemblages of photophylic algae like *Cystoseira* sp., *Stypocaulon* sp., *Asparagopsis* sp. or *Plocamium* sp. were well represented through the entire area, especially in the western and north sides. Finally, coralligenous assemblages were restricted to the Farallones area and rodolithes were observed in deeper sites of western and eastern shores.

A lot of endangered species included in several international treaties were found in the area (Table 1), whereas a list of MPAs in the Alboran Sea has been compiled in Table 2.

Discussion

Marine biodiversity has experienced dramatic changes over the past decades (Hooper et al. 2012). In this sense, protecting biodiversity and the ecosystems services it supports has become a priority for the scientific community, resource managers and international policy agreements, including the Convention on Biological Diversity (CBD). Furthermore, relative levels of biodiversity and human impact are among important considerations for conservation prioritization efforts (Hughes et al. 2002; Jenkins et al. 2013). In fact, temperate intertidal and subtidal rocky reefs are experiencing dramatic changes in populations, species, or entire functional groups leading to regime shifts that could be irreversible (Bellwood et al. 2004).

Many MPAs provide for multiple uses in zoning schemes (Kelleher 1993), consistent with concepts of sustainable development as well as highly protected areas (Marine Reserves / No Take Zones). A large proportion of MPAs are ineffective or only partially effective (Toropova, et al. 2010) and the difference between MPA objectives and the objectives of users can be the root of many governance challenges (Jones

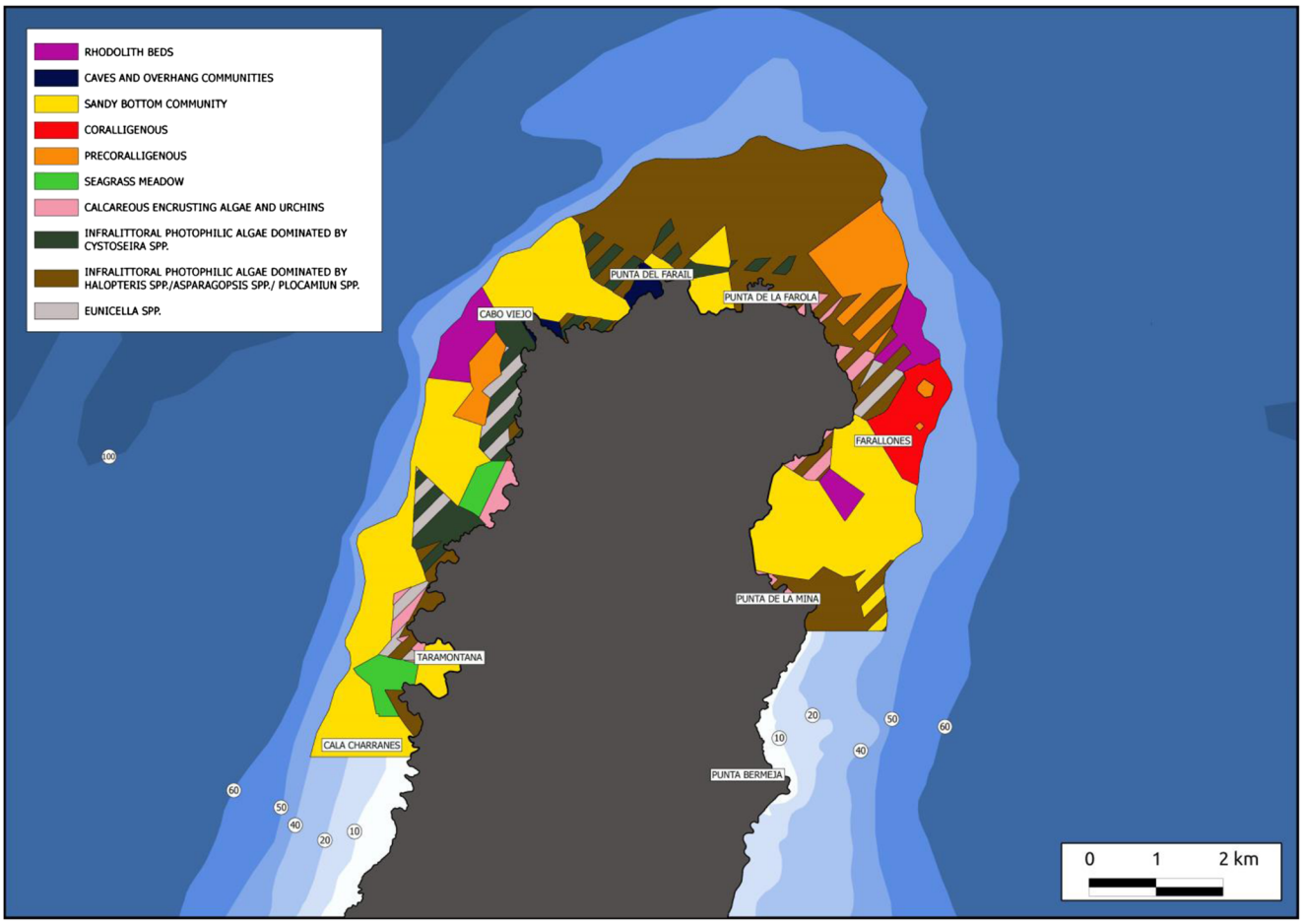

Fig. 3 Map of biological communities found in Cap des Trois Fourches. Numbers inside circles indicate depth

Table 1 List of species present in Cap des Trois Fourches included in international conservation conventions. EU=European Union Habitats Directive (1992), *CBa* Convention of Barcelona (2011). *CBe* Convention of Berne (1996). *CITES* Convention of International Trade in Endangered Species

Protected species	International treaties			
	EU	CBa	CBe	CITES
Flora				
Cymodocea nodosa		II	I	
Cystoseira mediterranea		II	I	
Cystoseira tamariscifolia		II		
Lithophyllum byssoides		II	I	
Fauna				
Astroides calycularis		II	II	
Charonia lampas		II	II	
Cymbula nigra		II	II	
Dendropoma petraeum		II	II	
Epinephelus marginatus		III	III	
Luria lurida		II	II	
Lithophaga lithophaga	IV	II	II	II
Ophidiaster ophidianus		II	II	
Paracentrotus lividus		III	III	
Patella ferruginea	IV	II	II	
Pinna rudis		II		
Savalia savaglia		II	II	
Scyllarus arctus		III	III	

Table 2 Marine Protected Areas located in the Alboran Sea by international figures of protection. *SCI* Site of Community Importance. *SPA* Special Protected Area for birds. *SPAMI* Specially Protected Area of Mediterranean Importance

Marine protected area		Protection figure	Size (ha)
North side	Palmones River	SCI	88
	Gibraltar	SPA	414
	Estrecho Oriental	SCI	23,641
	Guadiaro River	SCI	102
	Estepona's Bay	SCI	552
	Saladillo-Punta de Baños	SCI	1755
	Calahonda	SCI	1094
	Maro-Cerro Gordo	SCI, SPA, SPAMI	1410
	Punta de la Mona	SCI	99
	Tesorillo-Salobreña	SCI	1012
	Calahonda-Castell de ferro	SCI	842
	Adra Lagoon	RAMSAR	131
	Punta Encinas-Sabinar	SCI	3963
	Roquetas de Mar	SCI	204
	Cabo de Gata-Nijar	SCI, RAMSAR, SPA, SPAMI	11,613
Alborán island		SCI, SPA, SPAMI	26,367
South side	Monte Hacho	SCI, SPA	839
	Al Hoceima	SPAMI	10,600
	Aguadú cliffs	SCI	56
	Nador Lagoon	RAMSAR	14,000
	Molouya river estuary	RAMSAR	3000
	Chafarinas Islands	SCI, SPA	506
	Habibas Islands	SPAMI	2700

2014). Top-down and simultaneous bottom-up design and management of MPAs is therefore considered the most effective processes (Jones 2014; Kelleher 1993). As it mentioned in the introduction, the traditional fishing occurs at Cap des Trois Fourches. It is important that conservation objectives maintain a balance with fishing activities, allowing that the protected ecosystem is sustainable in the long term.

The Cap des Trois Fourches has been previously assessed from a conservational perspective (see Espinosa et al. 2014), and showed a high environmental quality, hosting several endangered species. The present cartography provides spatial information for management purposes, indicating a great heterogeneity of habitats including seagrasses and coralligenous assemblages, which are the most biodiverse habitats in the Mediterranean (Boudouresque 2004). Moreover, Fraschetti et al. (2013) indicated that protected meadows showed a significant higher density than unprotected ones, suggesting a stronger resistance to local human activities. In this way, coralligenous assemblages have been seriously impacted by human disturbances, reducing populations through the Mediterranean (Garrabou et al. 1998; Ballesteros 2006). Nevertheless, MPAs has been proved as a valuable tool for conservation purposes (Halpern and Warner 2003; García-Charton et al. 2008; Fraschetti et al. 2013). The exclusion or management of human activities within MPAs results in enhancing the stability of the structural components of protected marine systems (Fraschetti et al. 2013). Allison et al. (1998) described the term 'reserve' as an areas within MPAs of high, spatially explicit protection, where most or all human activities are restricted and compliance with those restrictions is high. Accordingly, we suggest not only the protection of this valuable site, but also the implementation of reserve areas (zone A) within this site that cover the most vulnerable assemblages such as meadows and coralligenous (Fig. 4).

Due to its conservational values (PNUE-PAM-CAR/ASP 2013; Espinosa et al. 2014), the Cap des Trois Fourches is included by the Moroccan authorities among the priority sites to be designed as MPA on the Mediterranean coast of Morocco. This is an important step for Morocco to meet its vision on protected areas for 2020, aiming at establishing a national network of protected areas, representative, coherent and functional at both ecological and socio-economic levels.

The designation of cap des Trois Fourches as MPA will be established following the national process according to the

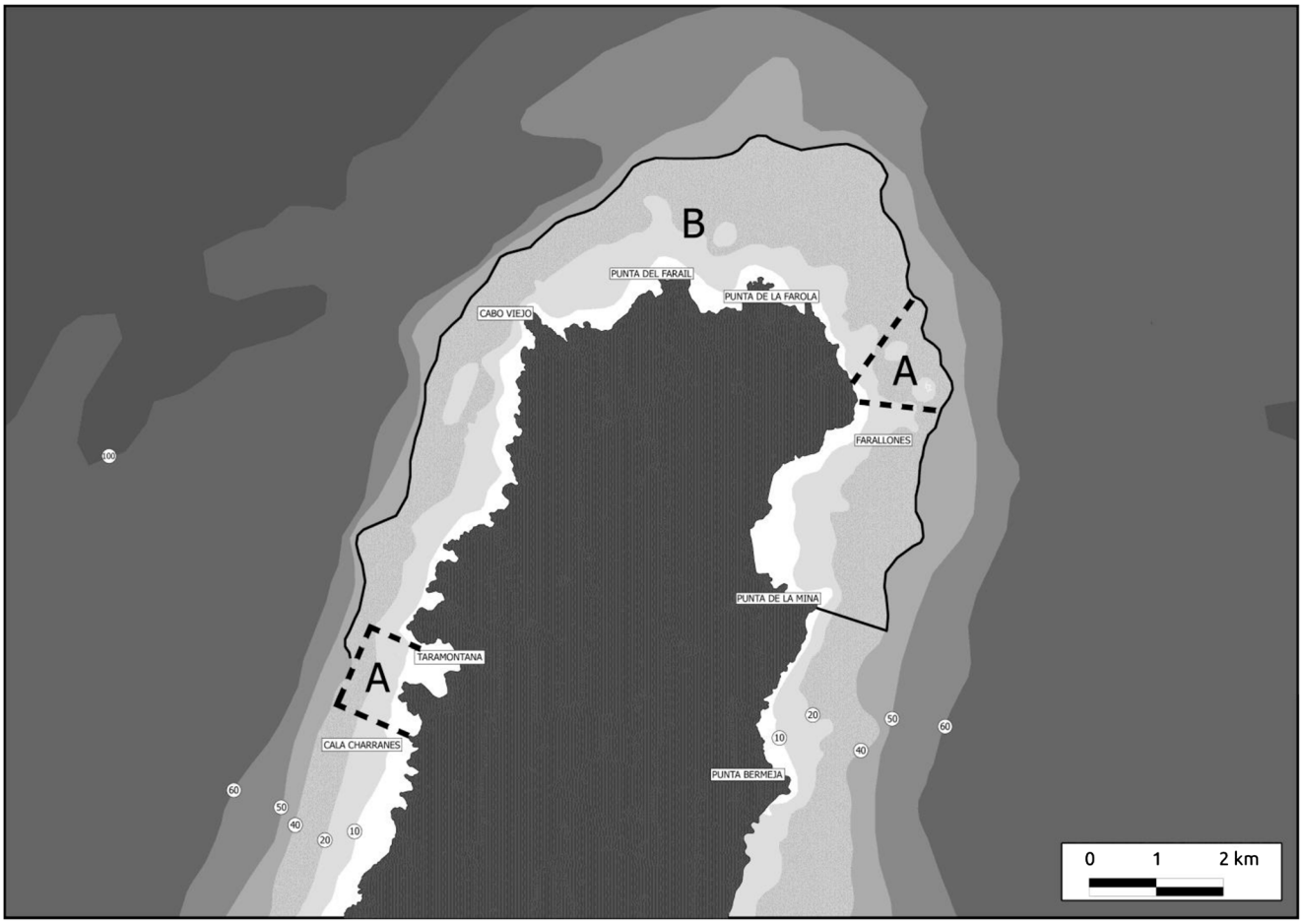

Fig. 4 Zonation proposed in Cap des Trois Fourches according with the results of the surveys. A: reserve area (no take-no entry zone); B: zone of common regulation. Black line indicates the limit of the proposed MPA. Numbers inside circles indicate depth

Moroccan new law on Protected Areas (2010). A management plan (MP) of the MPA is being prepared as a second phase of the MedMPAnet Project in Morocco. The process is intended to be integrated and based on participation at local and national scales.

This MP is being developed by considering the outputs of the diagnostic phase of the MedMPAnet Project and by considering the challenges and objectives of management identified from consultation with all stakeholders involved in the site. In this context, the map of management, proposed by the present study, provided a background to the zoning of the MPA that was adopted with minor amendment (caves identified as suitable for the Monk Seal should also be considered as Zone A).

Conclusion

Cap des Trois Fourches hosts very important marine habitats and communities, including seagrass meadows and coralligenous. Mapping of marine assemblages is essential to management purposes in order to establish zonation schemes. Farallones and Charrana areas should be considered as no take-no entry zones in a future MPA.

If properly managed and protected, the Cap des Trois Fourches could contribute to preserve marine biodiversity and connectivity at Mediterranean scale.

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