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Assessment of coastal fish assemblages before the establishment of a new marine protected area in the central Mediterranean: its role in formulating a zoning proposal

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Abstract

The fish assemblages of the coastal area of the promontory of Cape Milazzo (Italy, Central Mediterranean), which has been recently designated by Italian Law to become a national marine protected area (MPA), were characterized by visual censuses carried out over different habitats (rocky algal reef, *Posidonia oceanica* meadow and soft bottom) and depth ranges (0-3, 4-7, 12-16 and 24-30 m) to identify areas of major concern for the MPA zoning. The study area was divided into 6 sectors to assess spatial-related differences in the assemblage parameters, such as species composition and richness, and the size structure of species of recreational (e.g. SCUBA diving) interest. A total of fifty-eight taxa (56 species and 2 genera) and 20 families of fishes were recorded. Species composition was significantly affected by habitat and depth, whereas no significant changes were detected among sectors. Conversely, species richness and total density of fish showed no significant differences among sectors, habitat types and depth ranges. The majority of species of recreational value was recorded only off the north-western part of the promontory. The implementation of a fishing ban in such an area, characterized by the presence of a rocky bank, would contribute to the recovery of the populations of certain emblematic species (e.g. groupers and other large predators) and to the enhancement of environmentally sustainable activities such as scuba diving. Throughout the investigated area and, especially, along the eastern and south-western coasts of the promontory, several species were almost exclusively represented by small and medium-sized individuals, a likely consequence of intense fishing pressure.

Keywords: Fish assemblage, MPA zoning, Mediterranean Sea.

Introduction

Investigating the assemblage composition and structure of coastal fish, a key component of marine ecosystems, is of overwhelming importance in preliminary studies for the establishment of marine protected areas (MPAs). The distribution pattern of fishes, especially for those species of commercial, recreational and/or conservation value, might have important implications for the design of a new MPA (Curley *et al*., 2002), as well as for the regulation and management of fisheries and the development of recreational activities such as SCUBA diving (Roberts & Polunin, 1993; Zabala, 1999; Agnesi *et al*., 2001).

Long term monitoring studies on fish populations both before and after the enforcement of environmental protection measures allow researchers to assess the effect of reserves on the recovery of target species suffering from habitat loss or overexploitation. The increase in density and mean size of individuals of overexploited species, along with recolonization of shallower habitats, are among the most evident and documented effects of protection within MPAs (La Mesa & Vacchi, 1999; Côté *et al*., 2001; García-Charton *et al*., 2004; Claudet *et al*., 2006; Guidetti & Sala, 2007; Lester *et al.*, 2009; Aburto-Oropeza *et al.*, 2011; Guidetti *et al.*, 2014; Hackradt *et al*., 2014).

The coastal areas of the Mediterranean Sea are mainly characterized by a patchy distribution of rocky reefs, seagrass beds and unvegetated sandy habitats. Comparative studies have clearly demonstrated substantial differences in fish assemblage composition and structure among these habitats, mainly driven by interspecific differences in the habitat requirements of fishes (Guidetti, 2000; Tunesi *et al*., 2006; Giakoumi & Kokkoris, 2013). The spatial variability of fish assemblages observed within inshore habitats has been frequently ascribed to differences in depth range (Dufour *et al*., 1995; Reñones *et al*., 1997; Letourneur *et al*., 2003; Tunesi *et al*., 2006; La Mesa *et al*., 2010). The implementation of a stratified (by depth and habitat type) sampling design is thus highly recommended to assess appropriately the general characteristics of fish populations in poorly investigated areas by means of observational studies.

In Italy, a first formal step in locating MPAs is the inclusion on a national list of sites identified by national legislation (Tunesi & Diviacco, 1993). The most common zoning scheme, applied to the multiple-use Italian MPAs, consists of one or more "no-entry/no-take" zones (defined as 'A or integral reserve zones'), surrounded by 'general reserve zones' ('B') and by buffer zones (defined as 'C or partial reserve zones'), where restrictions on human uses are progressively limited (Villa *et al.*, 2002). One of the sites recently identified by Italian legislation for MPA status is Cape Milazzo (southern Tyrrhenian Sea). To our knowledge, no information is currently available on the fish fauna living along the coasts of Cape Milazzo, apart from data concerning the fish assemblages associated with a near shore vermetid reef (Consoli *et al.*, 2008) and some shipwrecks located off Milazzo and in nearby coastal areas (Consoli *et al.*, 2015).

The aim of this work was to characterise the fish assemblages inhabiting the coastal waters of the foreseen MPA by means of visual census surveys. Furthermore, in order to identify areas of major concern for the oning MPA zoning process, the collected data were analysed (1) to test for differences in the assemblage species composition and richness in relation to geographic sector, habitat type and depth range, (2) to identify differences in fish total density among geographic sectors and depth ranges and (3) to assess spatial-related differences in the size distribution of species of recreational value (i.e. species attractive for SCUBA diving). The proposed standardised sampling protocol, easily replicable in time and space, was tested in the study area also in order to evaluate its usefulness as a reference tool for the establishment of future MPAs, in which fish resource management and conservation are primary objectives.

Materials and Methods

Study area

The study area is located along the north-eastern coast of Sicily (Italy, Central Mediterranean) and includes the coastal waters of Cape Milazzo. The promontory extends northward for about 6 km, with a maximum width of 1.5 km, and is mostly characterized by high and rocky shores. According to the coastal geomorphology and orientation, six sectors, two on each side of the promontory (western, northern and eastern side), have been identified (Fig. 1).

In sectors I, III and VI, medium to steep sloping rocky bottoms with presence of large blocks or pebbles and large patches of *Posidonia oceanica* are predominant down to 10-15 m depth. Below this depth, seashores are generally composed of sand, gravel, or *P. oceanica* beds (except in sector III, where rocky bottoms are still dominant). Sectors II, IV and V are characterized by the presence of sand-gravel inlets. The seafloor is gently sloping with a patchy distribution of rocky reef (not below 15 m depth), *P. oceanica* beds and soft sediment (sand or gravel). The northern and western sides of the promontory are the most frequently exposed to sea waves (the prevailing winds blow from the NW quadrant) and are characterized by high hydrodynamism. The entire area is intensively

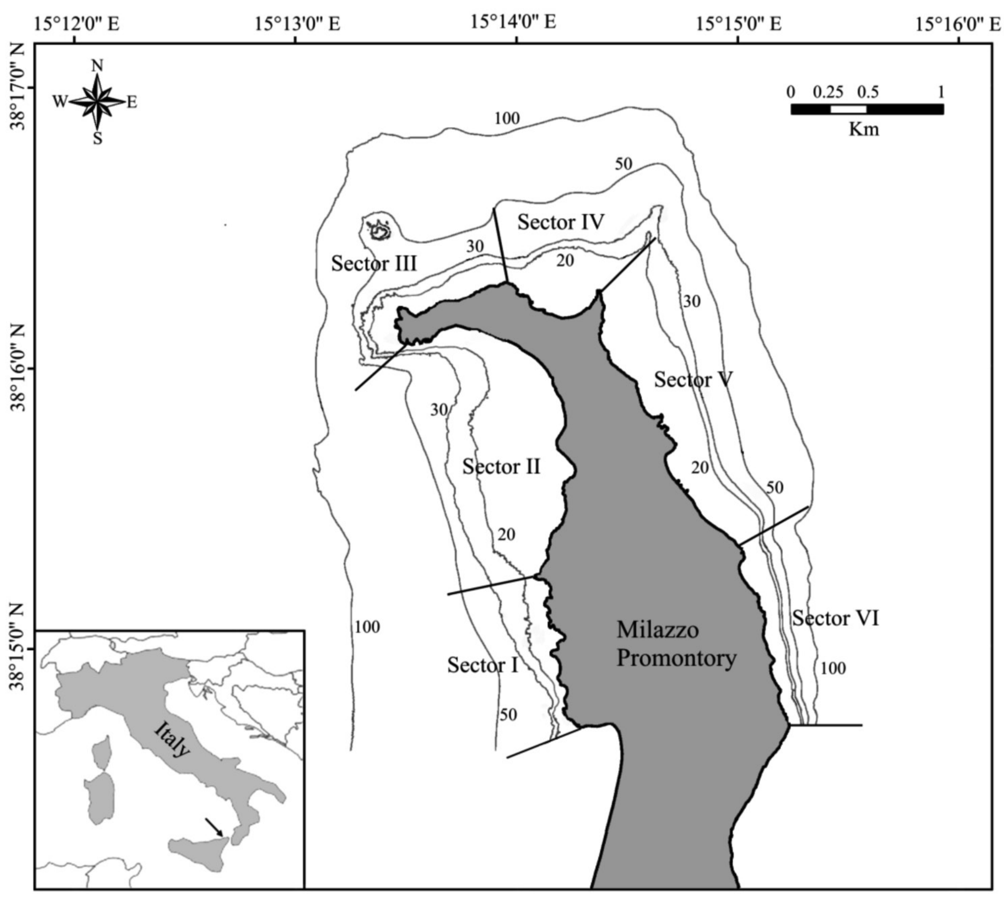

Fig. 1: Map of the study area with indication of sampling sectors around the promontory of Milazzo.

exploited by fishing activities, both professional (artisanal) and recreational (including line and spear fishing), although the preferred fishing grounds are located along the eastern and northern sides of the promontory. The professional fishery sector is typically composed by multiple-gear (especially gillnets and trammel nets) and multispecies small-scale fisheries.

Data collection

The coastal fish assemblages of Cape Milazzo were visually censused during summer 2015 by means of SCUBA diving. Diving activities were generally carried out between 10:00 am and 16:00 pm and with good sea-weather conditions.

Visual census surveys were carried out using two complementary methods, the "transect" and "random courses" (Harmelin-Vivien *et al.*, 1985) methods. The former method is specifically suited for the collection of quantitative data for several common species but it is not very effective for censusing shy and/or rare species, which are conversely more easily sighted by random courses. At each transect (25 x 5 m, 125 m^2), the abundance of fish (number of individuals per transect) was estimated by counting single specimens or, with schools larger than 10 individuals, using six abundance classes (11-30, 31-50, 51-100, 101-200 individuals). The midpoint of each abundance class was used to estimate mean fish density (Harmelin-Vivien *et al.*, 1985). Fish size (total length) was evaluated using three size categories (small, medium and large), each corresponding to one-third of the recorded maximum total length of the species (Froese & Pauly, 2016). In the random courses (each lasting 10 min), all fish species within the observer's visual field (up to a distance of 20 metres from the centre of the pathway, depending on sea bottom morphology) were recorded and the size of individuals was estimated according to the above mentioned size categories.

In each sector of the promontory, fish censuses were stratified according to habitat type and depth. The random courses were implemented over three habitats (rocky algal reef, RAR; *P. oceanica* meadow, POM; soft bottom, SOB) and four depth ranges (0-3, 4-7, 12-16 and 24-30 m), in order to increase the chance of encountering species with different habitat preferences. Abundance data along transects were conversely collected focusing on one habitat type (RAR) and two bathymetric ranges (4-7 and 12-16 m), where the most representative species of coastal fish fauna usually occur. At each sampling stratum (i.e. combination of habitat type and depth range), three transects and one or two random courses were conducted. The number of sampling units (i.e. transects and random courses) changed with sectors, due to the lack of some strata in certain sectors. Overall, 27 transects and 64 random courses were implemented, as shown in Table 1.

Data analysis

Multivariate differences in the species composition of fish assemblages among the investigated sectors, depth ranges and habitats were assessed using presence/absence data collected by means of random courses. The influence of each variable was evaluated by constrained ordination (with sector, habitat or depth as constraining factor) using canonical analysis of principal coordinates, or CAP, based on Bray-Curtis dissimilarities (Anderson & Willis, 2003). The canonical correlations were tested using 999 random permutations of the raw data. Distinctness of groups was assessed using leave-one-out allocation success (Anderson & Robinson, 2003).

Data from random courses were also used to assess univariate differences in species richness among sectors, habitat types and depth ranges. These differences were tested using a three-way permutational analysis of variance (Permutational ANOVA) (Anderson 2001a; McArdle & Anderson, 2001). The experimental design consisted of factor Sector (6 levels, fixed), Habitat (3 levels, fixed) and Depth (4 levels, fixed). The analysis was based on the Bray-Curtis similarity matrix under a full model, using 999 random permutations of residuals (Anderson, 2001b).

Table 1. Number of transects (T) and random courses (C) carried out at each habitat type (RAR=rocky-algal reef; POM=*Posidonia oceanica* meadow; SOB=soft bottom), depth range and sector.

Habitat type	**Depth range** (m)	Sector I	II	III	IV	V	VI
RAR	0-3	2C		1C	1C	2C	1C
	4-7	3T, 1C	3T, 1C	3T, 1C	3T, 1C	3T, 1C	3T, 1C
	12-16	3T, 2C	3T, 1C	3T, 2C		1C	
	24-30			1C			
POM	0-3		1C			2C	1C
	4-7	1C	1C	1C	1C	1C	1C
	12-16	1C	2C	2C	1C	1C	
	24-30	1C	1C	1C	2C	2C	
SOB	0-3		1C		1C	2C	1C
	4-7		1C		2C		
	12-16		1C		2C		1C
	24-30	1C	1C		2C	2C	2C

A further comparison among sectors was carried out using a subsample of target species (i.e. species of interest for SCUBA diving) encountered during the random courses. The attractiveness of sectors for SCUBA diving was evaluated in relation to the occurrence of these target species, according to the hypothesis that large individuals are more attractive than small and medium ones. Thus, an increasing score was assigned to each target species depending on the presence of small, medium or large individuals (1, 2 or 3, respectively). The sum of these scores were calculated for each sector and used to rank their attractiveness using a three-point scale.

Abundance data, collected by transects on RAR habitat, were used to assess univariate differences in fish total density among sectors and depth ranges. These differences were evaluated by two-way Permutational ANOVA (Anderson, 2001a; McArdle & Anderson, 2001). The experimental design consisted of factor Sector (6 levels, fixed) and Depth (2 levels, fixed). The analysis was based on the Bray-Curtis similarity matrix under a full model, using 999 random permutations of residuals (Anderson, 2001b).

Multivariate and univariate analyses were made using PRIMER v6 + PERMANOVA (Plymouth Marine Laboratory, UK) and Statistica 6.0 (Statsoft), respectively.

Results

General description of fish assemblages

Overall, 58 taxa of Teleosts (56 species and 2 genera, *Atherina* and *Pomatoschistus*) belonging to 19 families (excluding Mugilidae, which were not identified at species level) were recorded during the study (Table 2). The families represented by the largest number of species were Labridae and Sparidae (11 species), followed by Gobiidae (7 species) and Serranidae (5 species). The highest and lowest number of species were observed respectively in sector II (n=39) and sectors V and VI (n=26). The number of exclusive species ranged from 5 (sectors I and III) to 1 (sector V). Among the recreationally relevant species censused (13 in total), only some sparids (*Diplodus sargus*, *Diplodus vulgaris* and *Oblada melanura*) occurred in all sectors and with some regularity. All the remaining target species were scantly recorded, often in only one sector and during the random courses.

Multivariate and univariate analyses on fish assemblages

Canonical analysis of principal coordinates indicated that both habitat type and depth had a significant influence on species composition, whereas the separation among sampling units belonging to different sectors was weak. In the plot of the canonical axes corresponding to habitat effect, the first axis separated SOB sampling units from those collected on RAR and POM habitats, which in turn were segregated along the second axis (squared canonical correlation $\delta^2 = 0.65$, $P = 0.001$; 73.7% of sampling units correctly classified) (Fig. 2a). The plot obtained using depth as the independent variable showed a clear separation of sampling units located below 12 m depth from the shallower ones (i.e.

Table 2. List of fish taxa recorded along the transects (T) and random courses (C) at each sector. R=species of recreational value.

Taxa	Sector					
	I	II	III	IV	V	VI
Apogonidae						
Apogon imberbis	TC	TC	TC	TC	TC	TC
Atherinidae						
Atherina sp.	C	C	C		C	
Blenniidae						
Parablennius incognitus	C					
Parablennius sanguinolentus		C				
Paralipophrys trigloides	C					
Bothidae						
Bothus podas				C		
Carangidae						
Trachinotus ovatus (R)		C				
Seriola dumerili (R)			C			
Centracanthidae						
Spicara maena	TC	TC	C	C	C	C
Spicara smaris	TC	TC	C		C	
Gobiidae						
Gobius auratus				C		
Gobius bucchichi		C		C	C	
Gobius cobitis						C
Gobius geniporus						C
Pomatoschistus sp.					C	

(continued)

Table 2 *(continued)*

Taxa	**Sector**					
	I	II	III	IV	V	VI
Pomatoschistus bathi				C		
Pomatoschistus marmoratus				C		
Pomatoschistus quagga		C		C		
Labridae						
Coris julis	TC	TC	TC	TC	TC	TC
Labrus viridis (R)	TC		C	TC		
Symphodus doderleini	C	T				
Symphodus mediterraneus	TC	TC	TC	TC	TC	C
Symphodus melanocercus		T	C			
Symphodus ocellatus	TC	TC	TC	TC	TC	TC
Symphodus roissali	TC	TC	TC	TC	TC	TC
Symphodus rostratus	T	TC	TC	TC	TC	TC
Symphodus tinca	TC	TC	TC	TC	TC	TC
Thalassoma pavo	TC	TC	TC	TC	TC	TC
Xyrichtys novacula		C		C		C
Mugilidae	C	C	C	C	C	
Mullidae						
Mullus barbatus		C				C
Mullus surmuletus	TC	TC	C	C	TC	TC
Muraenidae						
Muraena helena (R)	C		C			C
Pomacentridae						
Chromis chromis	TC	TC	TC	TC	TC	TC
Scaridae						
Sparisoma cretense		TC	C			TC
Scorpaenidae						
Scorpaena maderensis	TC	TC	C	C		
Scorpaena porcus		C		C		
Serranidae						
Anthias anthias			C			
Epinephelus costae (R)		C	C			
Epinephelus marginatus (R)		C	TC			C
Serranus cabrilla	C	C	TC	TC	TC	C
Serranus scriba	TC	TC	TC	TC	TC	TC
Sparidae						
Boops boops	TC	TC	TC	TC	C	C
Dentex dentex (R)			C			
Diplodus annularis	TC	TC	TC	C	TC	TC
Diplodus puntazzo (R)			C			
Diplodus sargus (R)	TC	TC	TC	C	C	C
Diplodus vulgaris (R)	TC	TC	TC	TC	TC	TC
Oblada melanura (R)	TC	TC	TC	TC	TC	TC
Pagellus acarne	C	C				
Sarpa salpa	TC	TC	TC	TC	TC	TC
Sparus aurata (R)		C				
Spondyliosoma cantharus	TC	TC	C	C	C	
Sphyraenidae						
Sphyraena viridensis (R)			C			
Synodontidae						
Synodus saurus				TC	C	
Trachinidae						
Trachinus draco		C		C		
Tripterygiidae						
Tripterygion delaisi	C					
Tripterygion melanurus	C					
Tripterygion tripteronotus	C					
Total no. of species	33	39	35	33	26	26
No. of exclusive species	5	3	5	4	1	2

at 0-3 m and 4-7 m), which largely overlapped (squared canonical correlation $\delta^2 = 0.80$, $P = 0.001$; 63.2% of sampling units correctly classified) (Fig. 2b).

The patterns of variation in species richness among sectors, habitat types and depth ranges are reported in Figure 3. The highest species richness was observed in sectors III and I, the lowest in sectors IV and V. The number of species recorded in POM habitat was higher compared to the other two habitats. Weak differences in species richness were finally observed among the investigated depth range, the maximum and minimum values being recorded at 4-7 m and 24-30 m depth, respectively. As suggested by the results of Permutational ANOVA, species richness was not significantly influenced by sector, habitat type, depth and their interactions (Table 3).

The patterns of variation in fish total density in RAR habitat related to sector and depth range are given in Figure 4. Total density showed some differences among sectors, with the highest and lowest values in sector IV and V,

Table 3. Results of Permutational ANOVA (PERMANOVA) testing for differences in species richness among sectors, habitats and depth ranges on the basis of Bray-Curtis similarities on presence/absence data collected during random courses. The test was done using 999 permutations under the full model. ns: non-significant (P > 0.05).

Effect	df	MS	Pseudo-F
Sector (S)	5	375.94	2.68 ns
Habitat (H)	2	501.13	3.57 ns
Depth (D)	3	670.30	4.77 ns
S x H	9	313.52	2.23 ns
S x D	15	428.22	3.05 ns
H x D	6	397.81	2.83 ns
S x H x D	8	461.30	3.27 ns
Residual	15	140.38	
Total	63		

(a)

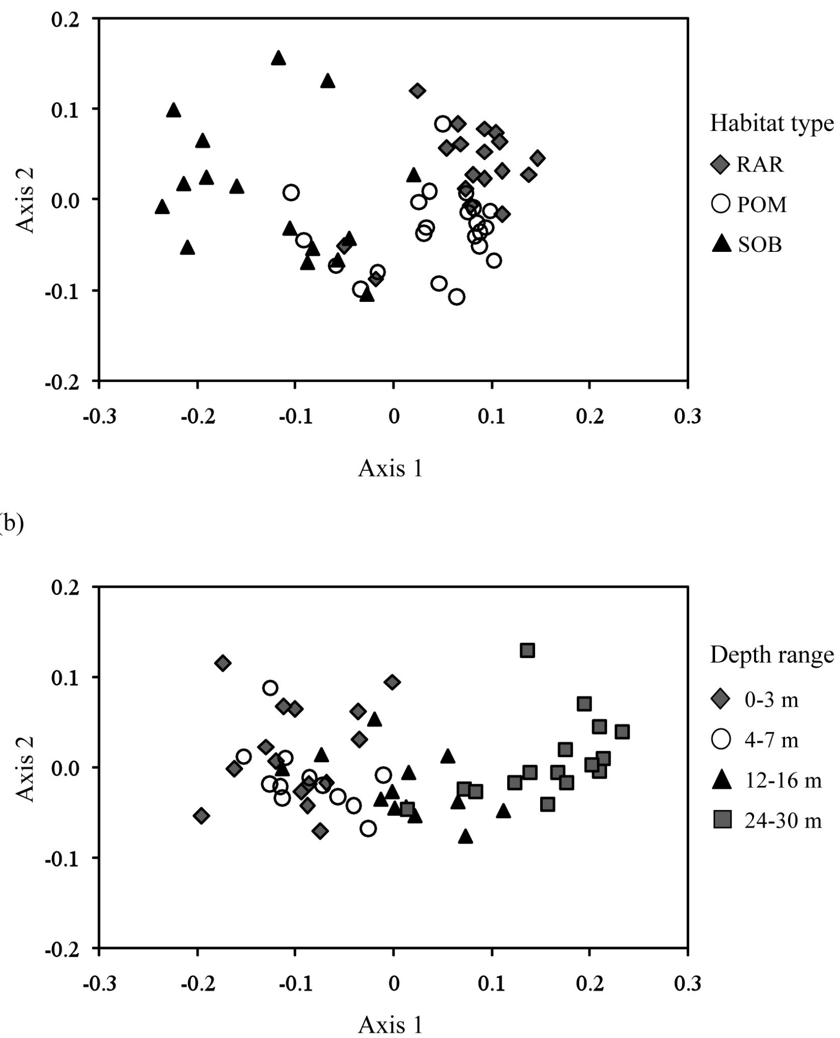

Fig. 2: Scatter plot of the canonical analysis of principal coordinates (CAP) based on the Bray–Curtis dissimilarities on the effects of (a) habitat type (RAR=rocky-algal reef; POM=*Posidonia oceanica* meadow; SOB=soft bottom) and (b) depth range.

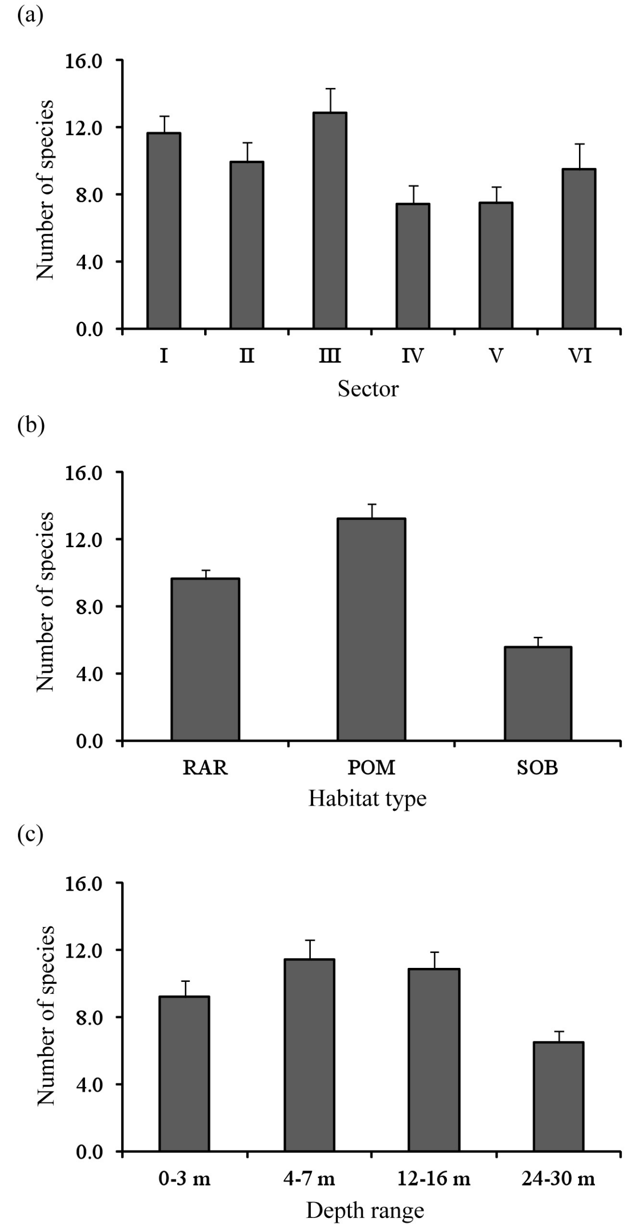

Fig. 3: Species richness (mean number of species ± S.E.) of fishes recorded along the random courses at each (a) sector, (b) habitat type (POM=Posidonia oceanica meadow; RAR=rocky-algal reef; SOB=soft bottom) and (c) depth range.

and a slight increase with depth. Again, the effect of sector, depth and their interaction on fish density was not significant (Table 4).

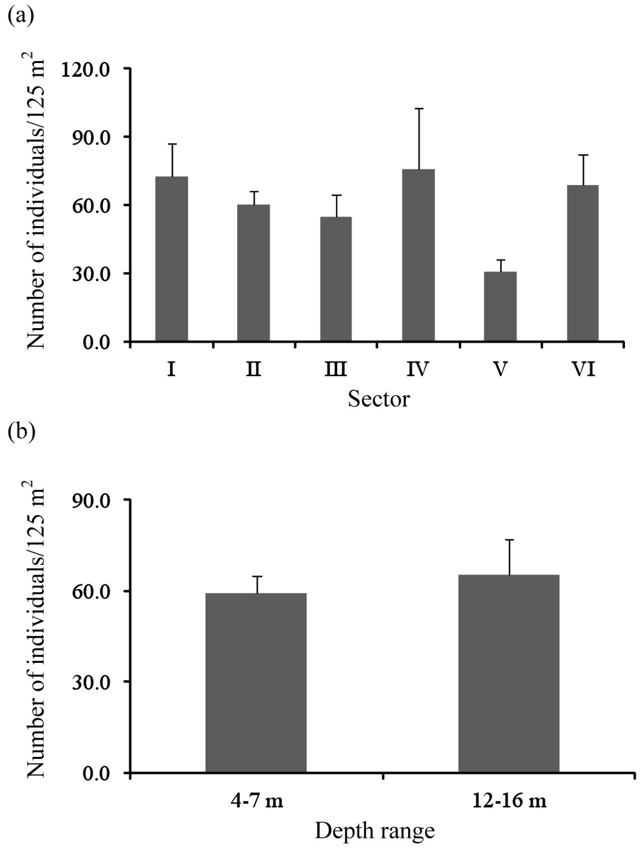

Fig. 4: Total density (mean number of individuals/125 m^2 ± S.E.) of fishes recorded along the transects at each (a) sector and (b) depth range.

Size class distributions of species of recreational value

Overall, 13 species of interest for SCUBA diving were recorded in the investigated area during the random courses (Table 5). The number of these target species was higher in sector III (11 species) than in the other sectors, where it ranged between 6 (sector II) and 3 (sector V). Eight out of 11 species observed in sector III were recorded along a random course conducted on a rocky bank named "Secca di Ponente" located about 0.3 nautical miles from the coast. Large-sized individuals were recorded for 4 species only, namely *Diplodus puntazzo* and *D. sargus* (in sector III), *D. vulgaris* (in sectors II and III) and *O. melanura* (in sector IV). As evidenced by the results of the scoring procedure, sector III ranked first as

Table 4. Results of Permutational ANOVA (PERMANOVA) testing for differences in fish total density among sectors and depth ranges on the basis of Bray-Curtis similarities on abundance (number of individuals/125 m^2) data collected along transects. The test was done using 999 permutations under the full model. ns: non-significant (P > 0.05).

Effect	**df**	**MS**	**Pseudo-F**
Sector (S)	5	652.69	1.45 ns
Depth (D)	1	201.86	0.45 ns
S x D	2	190.23	0.42 ns
Residual	18	450.51	
Total	26		

regards attractiveness for diving activities, followed by sector II (Table 5).

Only 5 species of recreational value (*D. sargus*, *D. vulgaris*, *Epinephelus marginatus*, *Labrus viridis* and *O. melanura*) were observed along the transects. Size class frequency distributions obtained by pooling the abundance data of these species for each depth range are given in Figure 5. Large fish were usually absent or strongly underrepresented compared to small and medium-sized individuals, depending on sector and depth range.

Table 5. Size classes (S=small; M=medium; L=large) of species of recreational value recorded along the random courses at each sector. Scores and attractiveness ranking were assigned according to the procedure described in Materials and methods section.

Species	**Sector**					
	I	II	III	IV	V	VI
Dentex dentex			M			
Diplodus puntazzo			S, L			
Diplodus sargus	S		S, M, L	S	S	S
Diplodus vulgaris	S, M	S, M, L	S, M, L	S	S	S, M
Epinephelus costae		S	M			
Epinephelus marginatus		S, M	S			S
Labrus viridis	S		S	S		
Muraena helena	S		M			M
Oblada melanura	S, M	S, M	S, M	S, M, L	S, M	S, M
Seriola dumerilii			S			
Sparus aurata		S				
Sphyraena viridensis			M			
Trachinotus ovatus		M				
Sum of scores	9	16	30	9	5	10
Attractiveness ranking	3	2	1	3	3	3

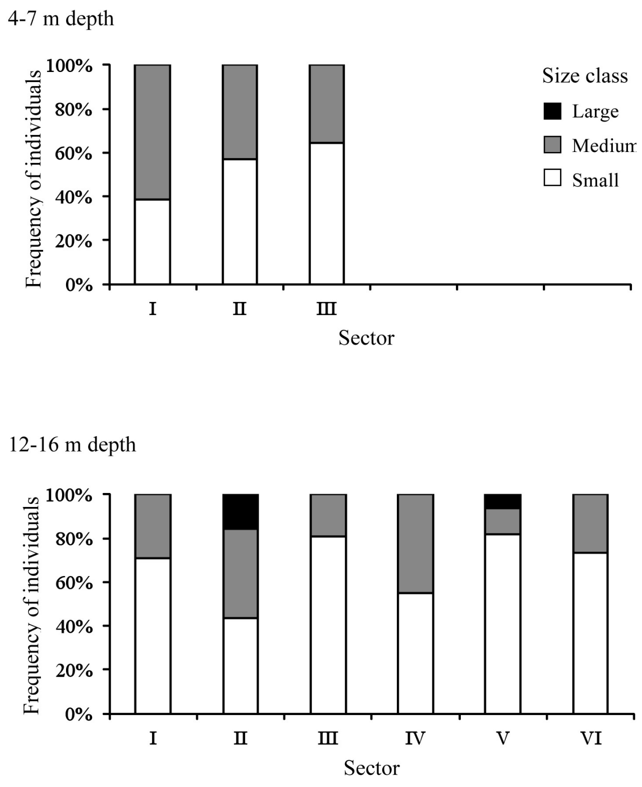

Fig. 5: Size class frequency distributions of species of recreational value (i.e. attractive for SCUBA diving) recorded along the transects at each sector and depth range.

Discussion

This is the very first study providing a general view of fish assemblages inhabiting the coastal area of Cape Milazzo across multiple habitats and depth ranges. Despite the fact that the visual census surveys were carried out only once in the early summer, many species usually occurring along the western and central Mediterranean coasts are included in our inventory. As in other areas of the Mediterranean Sea, the inshore fish fauna of Cape Milazzo was dominated by Sparidae, Labridae and Gobiidae (Harmelin, 1987; La Mesa & Vacchi, 1999; Guidetti, 2000; Tunesi & Salvati, 2003). The family Serranidae was also well-represented, whereas Blenniidae was rather limited, probably because SCUBA censuses did not allow exploration of the intertidal zone, where several blennies occur preferentially. In fact, we did not observe *Salaria pavo* and *Scartella cristata*, which were conversely reported by Consoli *et al*. (2008), who investigated the upper infralittoral fringe (between 0 and 3 m depth) of the northern rocky shores of Cape Milazzo by snorkelling surveys. Five other species (i.e. *Dicentrarchus labrax*, *Gobius cruentatus*, *Labrus merula*, *Parablennius gattoruggine* and *Symphodus cinereus*) included in the list of Consoli *et al*. (2008) were not observed during our censuses. In a recent study, the fish assemblages associated with four different shipwrecks located off Milazzo and in nearby areas were investigated using a remotely operated underwater vehicle (ROV) (Consoli *et al.*, 2015). The species list reported for the shipwreck of Milazzo (located at 45 m depth) included two species, *Scorpaena scrofa* and *Serranus hepatus*, which were not recorded during this study. The addition of these nine species to our inventory brings the total number of species visually observed in the area to 65.

From a biogeographic point of view, all the species encountered were native and seven of them (*Epinephelus costae*, *E. marginatus*, *Sparisoma cretense*, *Sphyraena viridensis*, *Thalassoma pavo*, *Trachinotus ovatus* and *Xyrichthys novacula*) belonged to the thermophilic ichthyofauna (Azzurro, 2008). No alien fishes were detected during this study and there are very few records of this species group along the coasts of Milazzo (*Fistularia commersonii*, Castriota *et al*., 2014) and the neighbouring areas (*Platycephalus indicus* and *Saurida undosquamis* in the Strait of Messina, Castriota *et al*., 2009; *Siganus luridus* off Capo d'Orlando, Castriota & Andaloro, 2008).

As suggested by the results of multivariate analyses, fish assemblage composition showed very weak differences at the spatial scale of sectors, whilst it was largely determined by the effect of habitat and depth range. The overwhelming role of habitat and depth in structuring near shore fish assemblages, previously demonstrated in other Mediterranean areas (Dufour *et al*., 1995; Reñones *et al*., 1997; Guidetti, 2000; García-Charton & Pérez-Ruzafa, 2001; Letourneur *et al*., 2003; La Mesa *et al*., 2010), emphasizes the usefulness of a stratified sampling design to exhaustively appreciate the resident fish diversity and suggests inclusion of all the investigated habitats and depth ranges in the zoning proposal for the protected area of Milazzo where, as in other multiple-use MPAs, biodiversity and habitat conservation are primary aims.

Results from univariate comparisons in relation to mean species richness and total density of fish revealed the absence of significant differences among sectors, habitat types and depth ranges. On the other hand, the overall number of species observed in sectors II and III was about one third greater than that censused in sectors V and VI. Indeed, the majority of species of recreational value (*Dentex dentex*, *E. costae*, *Diplodus puntazzo*, *Sparus aurata*, *S. viridensis*, *Seriola dumerilii* and *T. ovatus*) was exclusively recorded off the north-western part of the promontory (sectors II and III), one of the most exposed and, presumably, less accessible zone of the investigated area.

The suitability of sectors II and III for many large predatory fish, mostly due to the presence of a rocky bank and other complex rocky habitats, could effectively contribute to the recovery of these species along the coasts of Milazzo after the enforcement of protection measures. Moreover, the presence in these sectors of medium and large-sized individuals - currently very sporadic - would likely increase, making them particularly attractive for underwater activities such as SCUBA diving. The ecological role of rocky banks in aggregating fish, including large predators such as *E. marginatus*, *D. dentex*, *S. dumerili* and *S. viridensis,* has been clearly demonstrated in other Mediterranean areas (Vacchi *et al*., 1999; Sahyoun *et al.,* 2013). The occurrence of these charismatic fishes on rocky banks, frequently used as feeding and/or spawning areas, makes this habitat very attractive for fishermen and SCUBA divers.

All the species of interest for SCUBA diving listed in this work are targeted by local fisheries, due to their commercial value. As a result, size distribution is highly skewed towards small and medium-sized individuals, a situation commonly observed in other unprotected areas (e.g. Di Franco *et al*., 2009; La Mesa *et al*., 2010; Hackradt *et al*., 2014). The effect of intense fishing pressure and other forms of human disturbance was particularly evident in sectors I, V and VI, where no large individuals belonging to the target species were recorded. As confirmed by local fishermen, the proximity of marinas makes these sectors the most frequently used fishing grounds.

The overall view on the fish fauna emerging from this study provides useful suggestions for the management of the future MPA, especially regarding those human activities that have a primary interest for these organisms, such as recreational diving and fishing.

The frequent overlap between fishing grounds and zones used by divers can create conflicts that, in the process of setting up a new marine protected area, should be properly assessed and, where possible, resolved. Around the coasts of Milazzo, an area particularly suited to the development of diving is located in sector III, from the coastline to the "Secca di Ponente" rocky bank. The potential of such an area for the restoration and maintenance of fish of high aesthetical value for recreational diving, such as *E. marginatus*, the only species of conservation concern observed in this study, could be developed only in the absence of fishing activities. For these reasons, the area should be classified as a specific" no-take" zone (zone Bs), where all human activities usually allowed in zone B, except fishing, are permitted. This would allow both SCUBA divers and snorkelers to observe, even close to the shore, fish species that have become increasingly rare and to appreciate the beneficial effects of environmental protection. The increase in density and size of commercial species in the Bs zone will positively affect the fish populations of neighbouring areas open to fishing, with positive effects on fishing yields, as frequently observed in other MPAs (Goñi *et al.*, 2008; Harmelin-Vivien *et al.*, 2008). This effect would compensate local fishermen for the loss of a fishing ground.

The unhealthy population structure of many species of commercial interest, which were almost exclusively represented by small-sized individuals, requires the application of urgent regulatory measures for most impacting human practices, such as fishing. According to the Italian MPA regulation scheme, both professional (artisanal or "small-scale") and recreational fisheries are generally allowed in general and partial reserves (zones B and C). At Milazzo, these fisheries are numerically important (over 150 fishing boats), closely interrelated and have contributed to overexploitation of fishing resources. Therefore, to achieve a sustainable level of fishing pressure, it is very important not only to allow fishing for "local" professional or recreational fishermen, but also to adopt specific limits and carefully control the type and number of gears (Guidetti & Claudet, 2010). It is also crucial to plan long-term monitoring programs, which are useful to effectively assess the effect of the implemented protection measures on fish fauna and, according to an adaptive management, refine aspects related to zoning and/or the regulation of human activities.

The sampling protocol and analysis presented here, being developed for and tested on a single MPA, can be successfully exported to other areas, to support the decision-making process for new MPAs with scientifically valuable information.

Finally, it is worth noting that fishes are only one of the environmental components relevant to the proper assessment of the environmental value of an area. To identify zones deserving specific protection measures (e.g. no entry/no take zones), data on fish assemblages need to be supplemented with other spatially-related information, concerning both the presence of other faunistic groups and the multiple human uses of marine space (Agardy, 2000; Villa *et al.*, 2002).

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