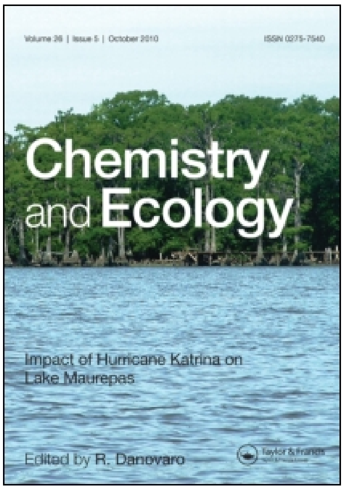

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Fish assemblage of the marine protected area of Cinque Terre (NW Mediterranean Sea): First characterization and assessment by visual census

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Fish assemblage of the marine protected area of Cinque Terre (NW Mediterranean Sea): First characterization and assessment by visual census

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The main objective of this study is to improve the knowledge of the coastal fish assemblage of 'Cinque Terre' Italian national Marine Protected Area (Ligurian Sea), focusing on the characterization of the fish fauna in the core zone A (no entry–no take). The study relates to the main sea-bottom types and bathymetric ranges, and evaluates the effect of the protection on fish abundance and size composition in this 5-yr-old MPA. Field activities were carried out in 2003 by means of visual census techniques. In the A zone, fish-assemblage composition are strictly related to depth and sea-bottom type. Recorded data did not permit detection of a clear reserve effect on fish fauna, probably due to the recent institution of the MPA. Several significant differences were detected only considering the size-class composition of target species.

Keywords: Fish; Marine reserves; NW Mediterranean Sea; Visual census; Management

1. Introduction

In the last 30 yr, concern about marine protected areas (MPAs) as a relevant tool for conservation and management of coastal areas has been growing [1–3]. One of the main goals of the institution of MPAs is the durable use of species and ecosystems, with particular reference to commercial fish species [4]. The fish assemblage of the Mediterranean coastal zones is characterized by a high diversity and by the presence of several species that, in ecological terms, seem to be sensitive to incorrect fishery management [5]. Taking into account this aspect, several studies have highlighted the positive effect of the cessation of fishing within Mediterranean marine reserve for coastal fish communities, in terms of abundance, biomass, and mean size of exploited species [6–11].

The MPA of Cinque Terre (Italy—Ligurian Sea) was established in 1997 due to its ecological relevance, as testified by several studies, mainly focusing on benthic assemblages [12–19].

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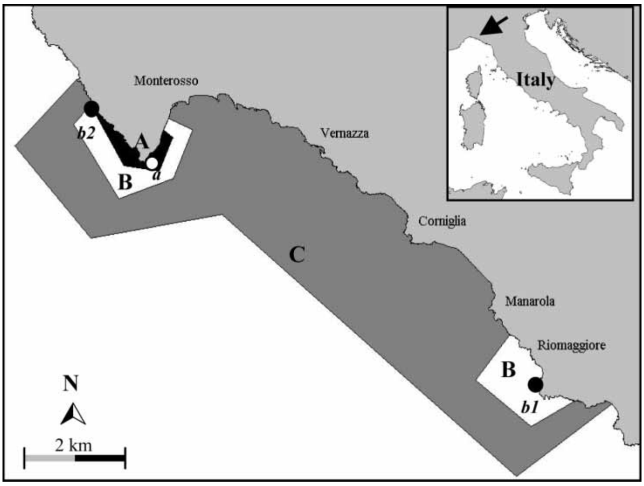

Figure 1. Study area showing the Cinque Terre MPA zoning (A, B, and C zones) and the position of the VC sites (a, *b*1, and *b*2).

The geological nature of the rocks, schistose and friable, the high rainfall, and the main coastal current, running east to west along the coast [20], bringing terrigenous materials from the Magra river [21], lead to a significant sedimentation rate in this coastal area [22, 23].

Fish fauna is an effective reference point for the assessment of the efficacy of the MPA management and represents a main component in the implementation of recreational activities such as scuba diving [3, 24, 25]. The zoning of the Cinque Terre MPA (figure 1) regulates fishing activities, but the available information on fish assemblages in this area is poor and mainly on demersal resources [26, 27].

The study was devoted to two main topics: first, to study the fish-assemblage composition in relation to sea-bottom type and bathymetric range in the A zone of the Cinque Terre MPA (the intention was to create a preliminary list of species for the MPA and to collect information useful to design specific scuba diving paths for visitors, relevant tools to support the development of economic environmental sustainable activities); second, to look for possible effects of the 5 yr protection on class-size composition of the target species of fishing activity.

2. Materials and methods

Visual census (VC) techniques [28], the main methodologies used to study fish in MPA because of their very low impact on natural resources [29], were applied at two sampling times (May and October 2003) in the Cinque Terre MPA (figure 1). The fish-assemblage composition related to sea-bottom type and depth was studied inside the A zone (79 ha), assuming that this no-entry no-take area would offer the most 'natural composition'. Data were recorded by means of scuba-diving paths (15 min long), randomly located and stratified according to the three main sea-bottom types present in the area (hard bottom, soft bottom, *Posidonia oceanica* bed), and to four depth ranges (0–3 m; 4–7 m; 12–16 m; 24–30 m), according to the main approach applied when studying fish assemblages in Italian MPAs [30, 31]. Correspondence analysis (CA) was applied on presence–absence data [32, 33], Lebart tables [34] were examined to evaluate the significance of the axes.

Data useful for evaluating the effect of the protection (fish density of whole assemblage and only target species for professional fishing and scuba-diving activities) were recorded by means of scuba-diving transects (25 m large and 5 m wide) on hard bottom, performed at two depth ranges (4–7 m; 12–16 m), at three different sites (figure 1): *a* inside the A zone ('no-entry no-take'), and *b*1 and *b*2 inside the B zones, where fishing activities are regulated and allowed only to the local people using small-scale fishery equipment.

Analysis of variance (ANOVA) was calculated to identify any differences between the abundances recorded in the sites inside the A and B zones (*a*, *b*1, and *b*2), taking into account the whole fish assemblage and target species. The factor 'Protection' (two levels: P = protected vs. F = fished) was considered as fixed. The homogeneity of the variance was tested by means of Cochran's C test.

In order to investigate a possible reserve effect among sites (*a*, *b*1, and *b*2) in the size-class composition of the target species for professional fishing and scuba-diving activities, the chi-square test was used to determine any statistically significant differences.

3. Results

In all, 13 paths and 96 transects were performed, and 48 fish species belonging to 13 families were recorded (table 1). Forty-nine per cent of the recorded species were Labrids and Sparids. Forty species were recorded in the A zone, compared with 38 and 28 in the two B zones, respectively. Seven species were recorded only in the A zone, four of these being relevant for fishing and recreational scuba diving (*Conger conger*, *Phycis phycis*, *Pagrus pagrus*, and *Sparus aurata*).

In the *b*2 VC site, four exclusive species were detected, and two were detected in *b*1. The two identified in *b*1 are target species for fishing and scuba diving (*Scorpaena scrofa* and *Sciaena umbra*). Taking into account the sea-bottom type, 45 species were found associated with rocky bottoms (22 exclusive), 23 with *Posidonia oceanica* beds (one exclusive) and 15 with soft bottoms (2 exclusive) (table 1). Twelve species were detected in all the considered depth ranges, and 11 species were registered only in one depth range.

CA performed on species presence/absence to analyse fish-assemblage composition in relation to sea-bottom type and depth range indicated the relevance of depth in explaining the variability of the fish assemblage in the A zone (figure 2). The strata points ordination along the first axis identifies three main groups: shallow and intermediate rocky bottoms (second quadrant), intermediate sandy bottoms and *Posidonia* meadows (fourth quadrant), and deep stations (third quadrant).

Following the indication given by the CA on the very small differences between R2 and R3 assemblages on rocky bottom, the investigation on the effect of protection on fish abundance and size composition was carried out, pooling together data collected on rocky bottom at 4–7 m and 12–16 m applying scuba-diving transects.

Figure 3 shows the mean fish abundance per transect detected in each VC site (*a*, *b*1, and *b*2) both for the whole fish assemblage and for the target species of professional fishing and scuba diving. The analysis of variance (ANOVA) did not allow the detection of statistical differences between mean fish abundances collected in the three VC sites, either for the whole fish assemblage or for the target species. However, taking into account the size-class composition of the target species, which in the A zone shows a higher abundance of large individuals, the calculation of a contingency table (3 × 3), gives a chi-square value ($\chi^2_4 = 33.61$), higher than critical value ($P = 0.01$), meaning a statistically significant relation between the number of the large specimens and the level of protection. Moreover, the observed frequency of large

Table 1. Fish species recorded in the MPA of Cinque Terre with indications of sea bottom type, depth range, and site where found[a].

Family	Species	Sea-bottom type	Depth range	VC site
Apogonidae	*Apogon imberbis* (Linnaeus, 1758)	R	1, 2, 3, 4	*a*, *b*1, *b*2
Belonidae	*Belone belone belone* (Linnaeus, 1761)	R	3	*b*2
Blenniidae	*Parablennius incognitus* (Bath, 1968)	R	2	*a*
	Parablennius rouxi (Cocco, 1833)	R	2, 3, 4	*b*1, *b*2
	Parablennius tentacularis (Brünnich, 1768)	R	1	*a*
	Parablennius zvonimiri (Kolombatovich, 1892)	R	2, 3	*b*1, *b*2
Centracantidae	*Spicara maena* (Linnaeus, 1758)	RPS	2, 3, 4	*a*, *b*2
	Spicara smaris (Linnaeus, 1758)	RPS	2, 3	*a*, *b*2
Congridae	*Conger conger** (Linnaeus, 1758)	RP	3	*a*
Gadidae	*Phycis phycis** (Linnaeus, 1766)	R	3	*a*
Gobiidae	*Gobius bucchichi Steindachner*, 1870	R	2	*b*2
	Gobius cruentatus (Gmelin, 1789)	R	2	*b*2
Labridae	*Coris julis Linnaeus*, 1758	RPS	1, 2, 3, 4	*a*, *b*1, *b*2
	Labrus merula (Linnaeus, 1758)	R	2, 3, 4	*a*, *b*1, *b*2
	Labrus viridis Linnaeus, 1758	RP	2, 3	*a*, *b*2
	Symphodus cinereus (Bonnaterre, 1788)	S	3	*a*
	Symphodus doderleini Jordan, 1891	RPS	2, 3, 4	*a*, *b*1, *b*2
	Symphodus mediterraneus (Linnaeus, 1758)	RP	1, 2, 3, 4	*a*, *b*1, *b*2
	Symphodus melanocercus (Risso, 1810)	RP	1, 2, 3, 4	*a*, *b*1, *b*2
	Symphodus ocellatus Forsskål, 1775	RP	1, 2, 3	*a*, *b*2
	Symphodus roissali (Risso, 1810)	R	1, 2, 3	*a*, *b*1, *b*2
	Symphodus rostratus (Bloch, 1797)	RP	2, 3, 4	*a*, *b*1, *b*2
	Symphodus tinca (Linnaeus, 1758)	RPS	1, 2, 3, 4	*a*, *b*1, *b*2
	Thalassoma pavo (Linnaeus, 1758)	R	1, 2, 3	*a*, *b*1, *b*2
Mugilidae	–	R	2	*b*2
Mullidae	*Mullus surmuletus** Linnaeus, 1758	RPS	2, 3, 4	*a*, *b*1, *b*2
Muraenidae	*Muraena helena** Linnaeus, 1758	R	1, 2, 3, 4	*a*, *b*1, *b*2
Pomacentridae	*Chromis chromis* Linnaeus, 1758	RPS	1, 2, 3, 4	*a*, *b*1, *b*2
Sciaenidae	*Sciaena umbra** Linnaeus, 1758	R	2, 3	*b*1
Scorpaenidae	*Scorpaena notata* Rafinesque, 1810	RP	2, 3	*a*, *b*1
	Scorpaena porcus Linnaeus, 1758	RP	1, 2, 3, 4	*a*, *b*1, *b*2
	*Scorpaena scrofa** Linnaeus, 1758	R	3	*b*1
Serranidae	*Epinephelus marginatus** (Lowe, 1834)	R	1, 2, 3	*a*, *b*2
	Serranus cabrilla (Linnaeus, 1758)	RPS	1, 2, 3, 4	*a*, *b*1, *b*2
	Serranus scriba (Linnaeus, 1758)	RP	1, 2, 3, 4	*a*, *b*1, *b*2
Sparidae	*Boops boops* Linnaeus, 1758	RP	2, 3	*a*, *b*2
	*Dentex dentex** Linnaeus, 1758	R	2, 3	*a*, *b*1, *b*2
	Diplodus annularis Linnaeus, 1758	RPS	2, 3, 4	*a*, *b*1, *b*2
	*Diplodus puntazzo** Cetti., 1789	R	1, 2, 3	*a*, *b*1, *b*2
	*Diplodus sargus** Linnaeus, 1758	RPS	1, 2, 3	*a*, *b*1, *b*2
	*Diplodus vulgaris** Geoffrey Saint-Hilaire, 1817	RPS	1, 2, 3, 4	*a*, *b*1, *b*2
	Oblada melanura (Linnaeus, 1758)	RS	1, 2, 3	*a*, *b*2
	*Pagrus pagrus** (Linnaeus, 1758)	S	3, 4	*a*
	Sarpa salpa (Linnaeus, 1758)	R	1, 2	*a*, *b*1, *b*2
	*Sparus aurata** Linnaeus, 1758	P	3	*a*
	Spondyliosoma cantharus (Linnaeus, 1758)	RPS	1, 2, 3, 4	*a*, *b*1, *b*2
Tripterygiidae	*Tripterygion delaisi* Cadenat & Blache, 1970	R	1, 2, 3	*a*, *b*2
	Tripterygion tripteronotus (Risso, 1810)	R	1, 2, 3	*a*, *b*2

Note: R: rocky bottom; P: Posidonia bed; S: sandy bottom; 1: 0–3 m; 2: 4–7 m; 3: 12–16 m; 4: 24–30 m.
*Target species.

individuals in the A zone is higher than the expected frequency, whereas the observed frequency of large individuals in VC site *b*1 is lower than expected. This result suggests that the larger individuals are significantly more present in the A zone than in B, and the same considerations could be applied to the smaller individuals, preferring *b*2 VC site. The size-class composition

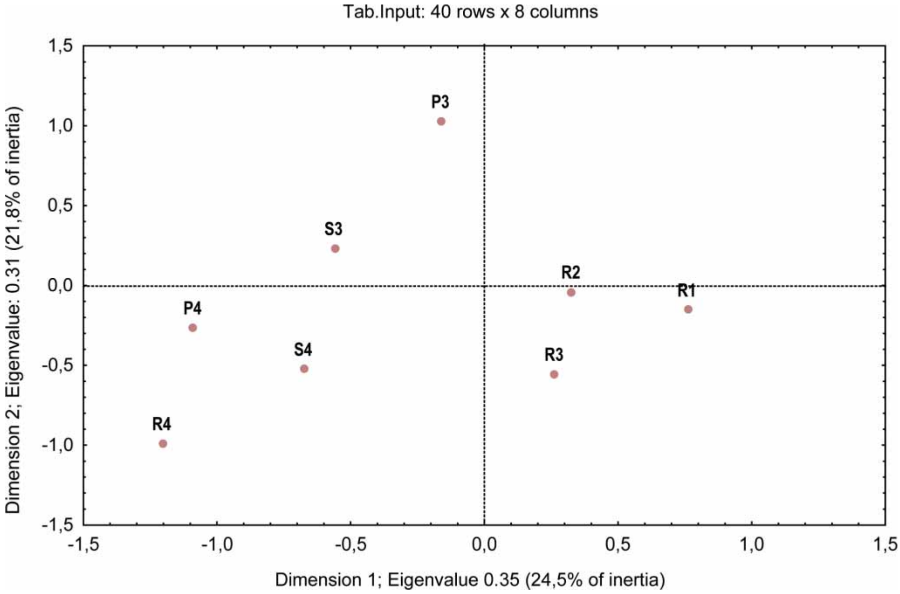

Figure 2. Correspondence analysis on fish species presence/absence data recorded in the A zone. Ordination of the strata points (sea bottom type and range of depth), along the first two axis (both significant). Legend: R1 = Rocky/0–3 m; R2 = Rocky/4–7 m; R3 = Rocky/12–16 m; R4 = Rocky/24–30 m; P3 = Posidonia Meadow/12–16 m; P4 = Posidonia Meadow/24–30 m; S3 = Sandy bottoms/12–16 m; S4 = Sandy bottoms/24–30 m.

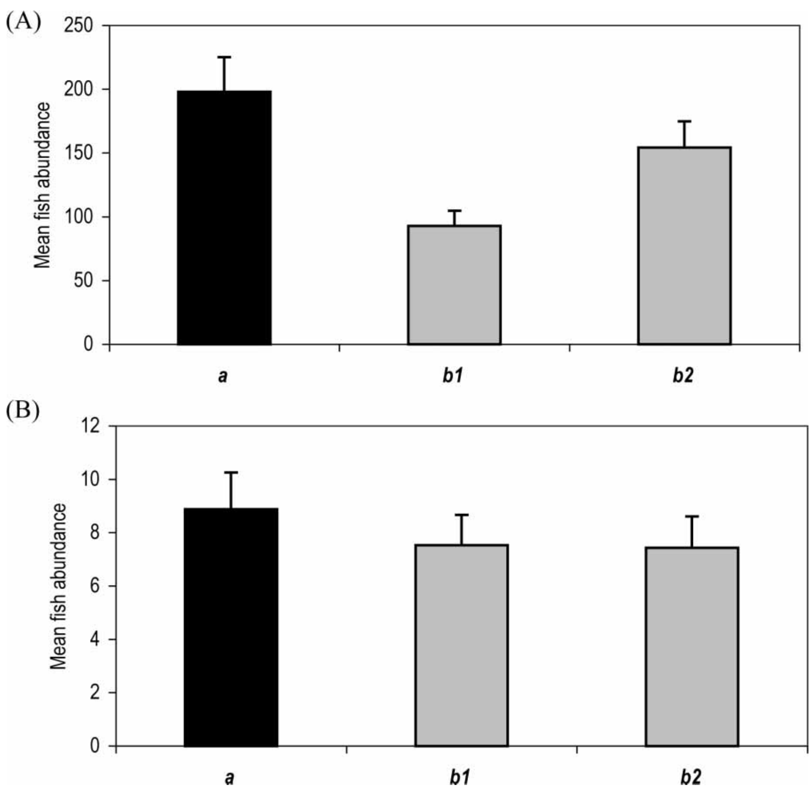

Figure 3. Mean fish abundance (±SE: number of individuals per 125 m^2) of the whole fish assemblage (A) and of the target species for professional fishing and recreational scuba diving (B), recorded in the VC sites (*a*, *b*1, and *b*2).

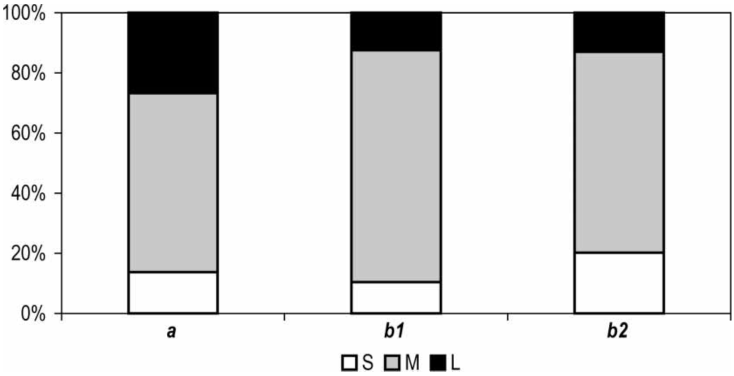

Figure 4. Size-class composition (relative percentage) of target fish species recorded in the three VC sites (a, *b*1, and *b*2).

Table 2. Size-class composition (relative percentage) of each considered target fish species recorded in the three VC sites (*a*, *b*1, *b*2).

	a			*b*1			*b*2		
	Small (%)	Medium (%)	Large (%)	Small (%)	Medium (%)	Large (%)	Small (%)	Medium (%)	Large (%)
Conger conger	0.0	0.0	100.0	–	–	–	–	–	–
Dentex dentex	0.0	100.0	0.0	0.0	100.0	0.0	–	–	–
Diplodus puntazzo	22.7	27.3	50.0	0.0	60.0	20.0	50.0	50.0	0.0
Diplodus sargus	0.0	56.3	43.7	5.6	69.4	12.5	8.0	41.3	25.3
Diplodus vulgaris	17.8	65.0	17.2	8.4	72.5	9.6	19.5	70.4	5.0
Epinephelus marginatus	25.0	75.0	0.0	–	–	–	33.3	66.7	0.0
Mullus surmuletus	19.0	76.2	4.8	20.0	80.0	0.0	26.1	39.1	17.4
Muraena helena	20.0	40.0	40.0	100.0	0.0	0.0	33.3	66.7	0.0
Pagrus pagrus	100.0	0.0	0.0	–	–	–	–	–	–
Scorpaena scrofa	–	–	–	0.0	0.0	50.0	–	–	–
Sciaena umbra	0.0	100.0	0.0	0.0	100.0	0.0	–	–	–

is described in more detail in figure 4 (whole target species) and table 2 (each target species), using the relative percentage value.

4. Discussion

The collected data help to describe the fish assemblage of Cinque Terre MPA. The fish fauna is found to be poorer in species than the Marine Protected Area of Portofino (94 fish species [35]), located only 50 km west from this site. This strong difference could be explained by the strong geomorphologic differences, the richer benthic habitats of the Portofino Promontory [27, 36], and the higher sedimentation rate in Cinque Terre [37].

In the studied area, the species composition is characterized by species belonging to the Labridae and Sparidae families, confirming their relevance in the coastal fish assemblage composition of the north-western Mediterranean [30, 38–40].

The collected data also confirm the strong relevance of depth, which was found to be more relevant than the sea-bottom type in explaining the species composition in fish assemblages. This aspect could be due to the particular feature of the steep sea-bottom profile within the A zone of the Cinque Terre MPA where each habitat covers narrows stretches of bottom, and the adopted visual census technique was adequate but often not sufficient to avoid the so-called 'border effect' [41], especially for soft bottom. Nevertheless, the rocky bottom sea type was found to be the richest in both exclusive species and not, suggesting its relevance for the design of new scuba diving paths for guided visits [42].

The *a* VC site, located in the A zone, is characterized by a slightly higher abundance of individuals both considering whole assemblage and target species for fishing and scuba-diving activities, especially compared with the *b*1 VC site. Moreover, some target species (*C. conger*, *P. phycis*, *S. aurata*, *P. pagrus*, and *E. marginatus)*, were recorded only in the *a* VC site and in the adjacent *b2* VC site. This result could be considered as a first positive effect of the protection on the fish assemblage.

The analysis of the size composition of the fish assemblages, although highlighting a general dominance of medium-sized specimens, shows a higher number of large fishes in the A zone (mainly *C. conger*, *M. helena*, *D. puntazzo*, and *D. sargus*) and a relevant percentage of small individuals in the neighbouring B zone (mainly *D. puntazzo*, *E. marginatus*, and *M. Helena* at *b*2 site). However, this result could mainly be explained taking into account the geomorphology of the *b*2 site, characterized by shallow waters hosting medium-large boulders, creating a habitat conducive to juveniles settlement [40, 43]. This could also be considered first evidence of a positive effect on adults in the A zone and an indication of a 'recruitment' effect in the B zone [44]: as a matter of fact, the greater presence of small fishes in the VC site *b2* could also be explained by the drift of juvenile and larvae from more to less protected zones. This hypothesis could be confirmed, taking account both the main oceanographic features of the area, characterized by an east–west current [37]. On the contrary, the oceanographic situation (far from the A zone and located to the east) and geomorphology are totally different for *b*1.

The faunistic richness recorded in the A zone underlines the importance of opening a part of this core zone of the MPA to scuba-diving guided visits. The presence of an interesting fish assemblage suggests the development of eco-tourism activities such as guided scuba-diving tours, compatible with the conservation aims of the MPA and the attractive opportunity to observe several conspicuous resident species such as the grouper *E. marginatus*, the European conger *C. conger*, and the forkbeard *P. phycis*.

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