



Evaluation of the economic crisis on the conservation of the ichthyofauna in Marine Protected Areas

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ABSTRACT

The use of marine protected areas can be an effective way to simultaneously achieve both conservation and fisheries management objectives. The creation of marine protected areas, in addition to many benefits, also entails several costs, including the need for financing to maintain adequate surveillance and conservation. The recent economic crisis significantly lowered budgets for the maintenance of Spanish Marine Protected Areas, that may have had serious consequences for the marine resources sustainability. In this study we evaluated the indirect impact of the 2008 economic crisis on the conservation of fish stocks in Marine Protected Areas. We compared the number of species, abundance and biomass levels of the ichthyofauna, and abundance and biomass of selected species in two marine reserves (Cabo de San Antonio and Tabarca Island) with control areas, two years before (2008 and 2010) and two years after (2014 and 2015) the budget cut. Results in San Antonio revealed a decrease in total abundance, total biomass and number of species after the crisis, which translates into a decrease in the reserve effect. While in Tabarca no reduction has been observed in these variables, so the reserve effect was maintained after the crisis. We have found that of the 18 species analyzed, in San Antonio the abundance and biomass of 8 and 6 species respectively have decreased after the crisis, while in Tabarca the abundance and biomass of 6 and 8 species respectively have decreased after the crisis. Therefore, surveillance in marine reserves is necessary for the conservation of the species.

1. Introduction

In many cases, traditional management methods are inadequate to deal with the multiple anthropic impacts that the marine environment supports, such as overfishing, certain types of fishing, pollution, coastal development, as well as other impacts derived from human activity [38]. Currently, in the Mediterranean Sea more than 90% of the evaluated fish assemblage are overexploited, producing intense human activities and impacts on biodiversity and marine habitats [24]. The use of marine protected areas (MPAs) can be an effective way to simultaneously achieve both conservation and fisheries management objectives [53]. MPAs can provide: i) an impact-free environment for the conservation of threatened species and habitats; ii) reference areas with minimal disturbances for the scientific study of different aspects; iii) places to develop environmental education; iv) areas for the management of the different uses that occur in the sea (e.g. commercial fishing,

recreational fishing, diving, bathing,.) and thus avoid possible conflict between them; and v) areas where other non-fishing economic activities can be promoted [51]. Numerous studies have already detected evidence of the recovery of fish stocks inside MPAs [17,26,28,41]. Generally, these studies have shown higher abundances and biomass of fish within the MPA compared to areas where fishing is allowed. Globally, the MPAs with the highest biomass and the greatest diversity of fish are the oldest, largest, fully protected from fishing and isolated [12,23], although small reserves are easier to protect [41].

The use of marine protected areas is increasing as a key tool to achieve sustainable management of coastal resources [51], becoming currently the main tool used in marine conservation programs in most of the world [18]. In fact, there are 1 215 MPAs and OECMs (Other Effective area-based Conservation Measures) in the Mediterranean covering 171 362 km² which places a surface of 6.81% under a legal designation. Over 72.77% of the surface covered is located in the

Abbreviations: MPA, Marine Protected Area; OECM, Other Effective area-based Conservation Measures; MAGRAMA, Ministerio de Agricultura, Alimentación y Medio Ambiente; SCUBA, Self-Contained Underwater Breathing Apparatus; NGO, Non-Governmental Organization; ANOVA, Analysis of Variance; PERMANOVA, Permutational Multivariate Analysis of Variance; nMDS, non-metric Multidimensional Scaling; SNK, Student-Newman-Keuls.

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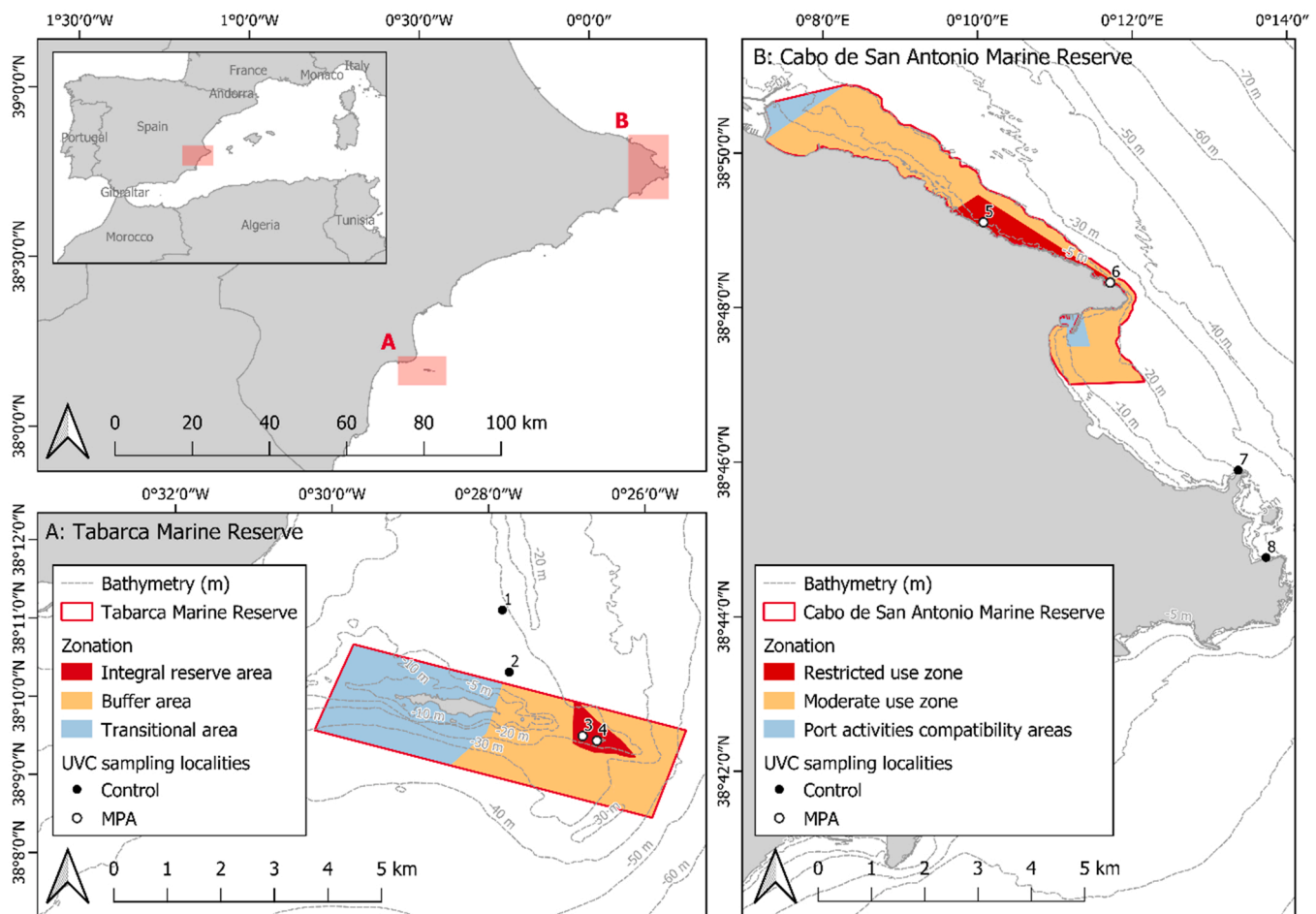


Fig. 1. Study area. Tabarca Marine Reserve and Cabo de San Antonio Marine Reserve location; their limits and zonation are included. The position of the localities sampled in MPA and control areas are also indicated. Additional information about localities is showed in Table 1.

Western Mediterranean, and 90.05% of the total surface covered by MPAs and OECMs are found in EU waters [45]. In Spain, the use of MPAs as fisheries management tools began in 1986, when the Tabarca Marine Reserve was established [49]. Thus began a decided development policy of these conservation measures for marine resources [56]. Since then, the marine areas on the Spanish coast that enjoy a legal protection status, such as maritime parks or marine reserves, add up to a total of 26 [52].

However, the creation of marine protected areas, in addition to the above-mentioned benefits, also entails several costs, among which the need for financing should be highlighted [54]. The economic costs of establishing an MPA, such as surveillance, monitoring and education, are essential for its proper functioning, so these costs must be considered within a sustainable financing strategy [57]. Many reserves have management problems due to a lack of technical and financial resources [21] and, in these cases, no positive ecological effects on marine ecosystems should be expected [23]. Gill et al. [35] did global assessments of MPA efficacy and identified a lack of effective management – due to financial and staff capacity deficiencies – as a primary factor impeding successful MPA implementation. Although many MPAs with low management capacity in their study had positive ecological impacts, in general the magnitude of ecological effects was strongly linked to the available human and financial capacity for MPA management.

The economic austerity regime introduced in many countries of the global North since the 2008 financial crisis transformed environmental policies and the governance of natural resources. This has been particularly evident in European natural protected areas [40] so they may also be endangering the conservation of marine resources. In Spain, this

crisis began between 2008 and 2011, with a resurgence of the crisis during 2012 and 2013, to end up normalizing the situation in 2014 [5].

The creation of the Tabarca Marine Reserve had as main objectives the protection of species and ecosystems, as well as the management of artisanal fishery resources [50]. The competences for the management and use of the reserve are shared between the Ministry of Agriculture, Fisheries and Food, which regulates external waters (60% of the area), and the Ministry of Agriculture, Rural Development, Climate Emergency and Ecological Transition of the Generalitat Valenciana, which regulates internal waters (40% of the area). Several studies show a "reserve effect" on fish stocks [26]. The abundance and total weight of fish in the Tabarca Marine Reserve are respectively 92% and 317% higher than those observed in other control areas where fishing is allowed. Forcada (\$year \$) [26]. In addition, it has also been observed that an exportation process of individuals takes place from within MPA to adjacent waters, since a decreasing gradient in abundance of fish was detected across the boundaries of the Tabarca Marine Reserve [28]. In fact, data from a study carried out with experimental fisheries [29] and those obtained in a study carried out directly on the catches of the artisanal fleet [36], are those that corroborate that the export process takes place, showing that the highest catches are obtained at the boundaries of the MPA and decrease with distance. In the Cabo de San Antonio Marine Reserve there are not as many studies as in Tabarca. According to Forcada [27], the Cabo de San Antonio Marine Reserve failed to recover the fish stock inside, showing similar levels to those observed in control areas where fishing is allowed. However, Bayle Sempere et al., [7] observed higher total biomass in the Cabo de San Antonio Marine Reserve than areas close to the previous one but without protection. Moreover, these

Table 1
Sampling data information. The locality numbers correspond to those showed in Fig. 1 (study area).

MPA	Status of Protection	Locality number	Average depth (m)	Latitude	Longitude	Number of samples			
						Before		After	
						2008	2010	2014	2015
Tabarca	Control	1	16	38°11'6"N	0°27'50"W	8	8	8	8
		2	12	38°10'18"N	0°27'44"W	8	8	8	8
	MPA	3	9	38°09'29"N	0°26'48"W	8	8	8	8
		4	9	38°09'26"N	0°26'37"W	8	8	8	8
San Antonio	MPA	5	8	38°49'6"N	0°10'50"E	8	8	8	8
		6	13	38°48'19"N	0°11'43"E	8	8	8	8
	Control	7	12	38°45'54"N	0°13'22"E	8	8	8	8
		8	14	38°44'46"N	0°13'44"E	8	8	8	8

authors verified that the number of species, and total abundance and biomass values in Cabo de San Antonio Marine Reserve were higher than those observed in that same area during the years 2000–2002 by Forcada [26], probably due to the longer time under the effects of protection. All these data confirm that both, Tabarca Marine Reserve and Cabo de San Antonio Marine Reserve are valid for the management of artisanal fisheries, being a useful tool to achieve sustainable fishing of coastal resources. However, the economic austerity measures carried out in Spain led to a budget cut for the Tabarca Marine Reserve, going from € 550 000 per year in the period 2008–2011, to € 150 000 in 2012 [42]. This meant that the number of guards in this reserve was reduced from 8 in 2011 (guaranteeing protection 24 h a day, 365 days a year) to 2 in 2012 [47]. The 70% reduction in funding (approx.) also occurred in a similar way in other MPAs in Spain [20], such as in the Cabo de San Antonio Marine Reserve, where surveillance of the reserve was completely suspended during 2013 due to these cuts [43]. The decrease in conservation budgets leads to a decrease in surveillance activities, so that marine resources, protected for decades, may have been exposed to illegal fishing, being in vain all the time and investment dedicated to its conservation. The economic crisis, beyond the socio-economic implications, may also be giving rise to an “ecosystem crisis”.

The importance that the use of marine protected areas is gaining for proper management of coastal resources has already been explained, being a key tool to achieve adequate conservation and sustainable fishing of coastal resources. Simultaneously, the recent economic crisis significantly lowered budgets for the maintenance of Spanish MPAs, causing funding gaps that may have had serious consequences for the marine resources sustainability. Therefore, the objective of this work is to evaluate the indirect impact of the economic crisis on the conservation of fish stocks in MPAs. To test the hypothesis that the biomass and abundance of fish assemblage decreased after the crisis, abundance and biomass levels of the ichthyofauna in the marine reserves of Cabo de San Antonio and Tabarca Island will be compared with control areas, before and after the budget cut.

2. Material and methods

2.1. Study area

This study was conducted on Alicante coast (South-western Mediterranean Sea, Spain) in two marine protected areas, and in control areas without this management measure, but with similar underwater topography. Tabarca Marine Reserve, whose extension reaches 1 400 ha, is located just 4 km from the coast of Santa Pola and was created in 1986. This MPA is zoned in three management zones with different levels of protection ([49]; Fig. 1): (I) the Integral reserve area (100 ha), where all human uses and activities are forbidden, except the scientific research; (II) the Buffer area (630 ha), in which some selective fishing methods are allowed (trap nets that target on pelagic species); and (III) the Transitional area (670 ha), in which a few activities are permitted (selective fishing techniques, swimming, SCUBA diving, mooring of yachts). The

surveillance in this marine reserve consisted of 8 guards until 2012, between 2012 and the end of 2013 it was reduced to 2 guards due to budget cuts, and from that moment until today the vigilance increased to 6 guards [47,22]. The 900-ha Cabo de San Antonio Marine Reserve is located between Jávea and Denia, and was created in 1993. However, in 2002 it was incorporated into the Natural Resources Management Plan of the Montgó Natural Park, increasing its extension. Along with this expansion, a zoning was carried out, and two units were clearly separated: (I) Restricted use zone (which coincides in extension with the entire previous reserve, 110 ha) and (II) Moderate use zone, which contains two areas generically called “port activities compatibility areas”. In each of these areas, different activities and uses are prohibited, authorized and permitted depending on their impact on the marine environment. Always have been 2 guards in this reserve, except during 2013 when the vigilance was completely suspended due to budget cuts [44,43] and restored in 2014 until today.

2.2. Sampling design and data collection

In each Marine Protected Area (Tabarca and San Antonio), four random localities were positioned in different protection status (two inside the MPA and two in control areas). In each locality, two sites were randomly located, and finally, four random visual counts (replicates) were done in each site. To assess for the temporal consistency in the results, we repeated this sampling two times before (2008 and 2010) and two after the crisis (2014 and 2015) (Table 1).

Fish assemblage was sampled by means of underwater visual census techniques. These sampling methods have been used extensively in MPAs because they are non-destructive and guarantee that the fish community is not affected by sampling, avoiding interference with previous evaluations of the effects of protection. The abundance and size (total length in classes of 2 cm) of each fish species were recorded by a SCUBA diver within a 25 × 5 m transects. This procedure is quite precise after a training period [9]. Each observation was assigned to one of nine predetermined abundance classes [39], the limits of which coincide approximately with the terms of a base two geometric series. Geometric means of each fish abundance class were used for further calculations. This system of recording numbers, which is usual for fish censuses, leads to similar degrees of error over a wide range of abundances, and insures the homogeneity of variances when performing analyses with log-transformed data [33]. All underwater visual census were carried out on infralittoral rocky bottoms, composed primarily of boulders of diverse sizes interspersed with patches of sand and *Posidonia oceanica* seagrass meadow. All the data obtained in each transect were processed with the ecoCEN v1 software [8], a visual census management program developed by the Marine Biology Unit of the University of Alicante.

2.3. Data analysis

Analysis of variance (ANOVA) [60] was used to test for significant differences in the number of species and in abundance and biomass, total

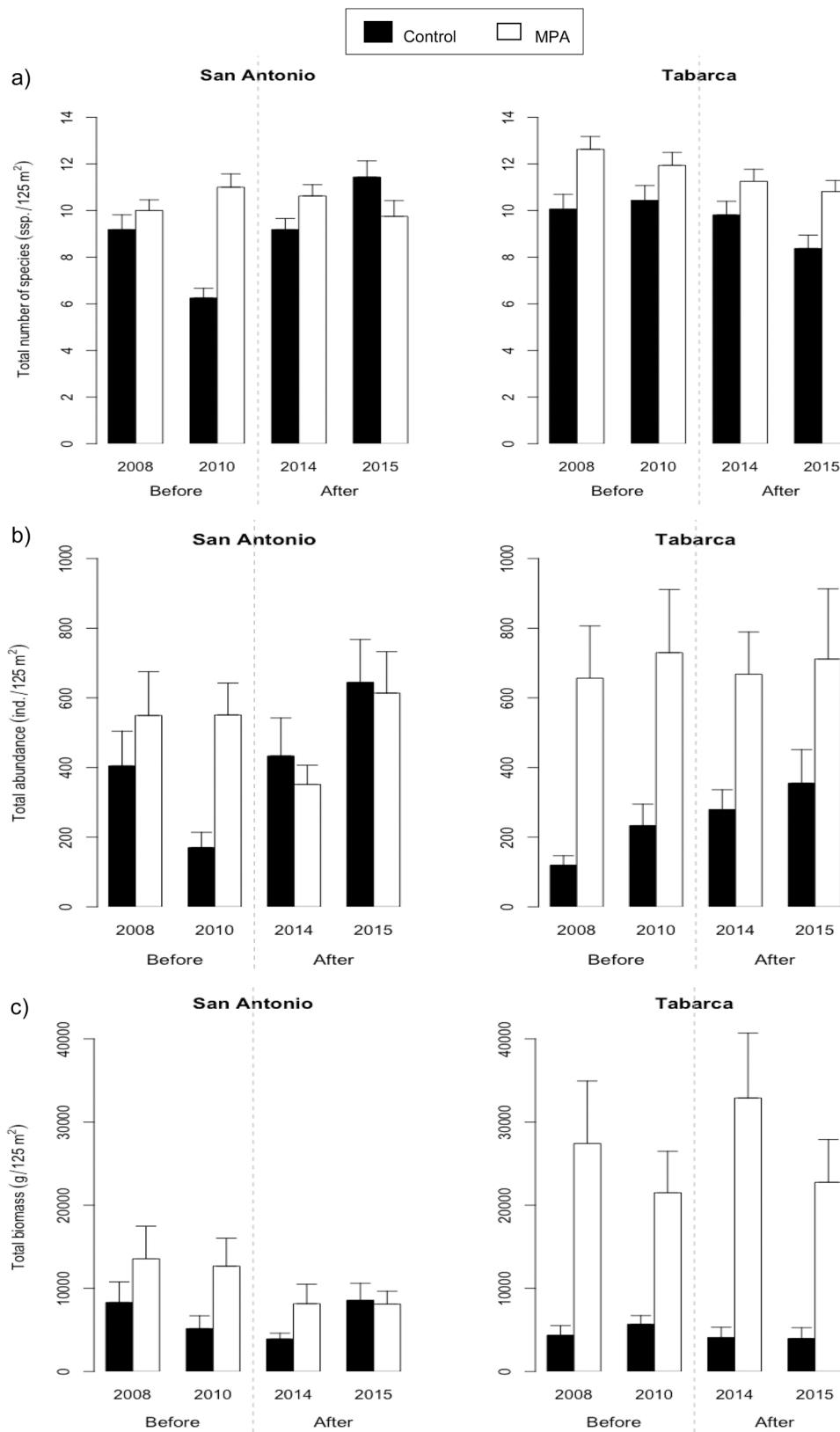


Fig. 2. Mean values \pm standard error of the (a) number of species, (b) total abundance and (c) total biomass in San Antonio and Tabarca reserves, and their respective controls, during the different sampling years before and after the crisis.

Table 2

Results of the analysis of variance (ANOVA) with six factors (C: crisis, A: area, P: protection, T: time, L: locality and S: site) for each one of the fish assemblage variables. d.f.: degrees of freedom; M.S.: mean squares; F: F-value. Levels of significance were * $p < 0.05$ and ** $p < 0.01$ and *** $p < 0.001$. Dash (–) indicates that there is no transformation.

Source	d.f.	Number of species			Total abundance			Total biomass			F versus
		M.S.	F	P	M.S.	F	P	M.S.	F	P	
C	1	0.062	0.012	0.924	3.540	45.874	0.021 *	0.943	1.353	0.365	T(C)
A	1	62.016	4.697	0.163	2.184	0.781	0.470	4.045	3.208	0.215	A × T(C)
P	1	175.563	13.736	0.066	37.790	155.079	0.006 **	85.059	95.793	0.010 **	P × T(C)
T(C)	2	5.313	0.730	0.497	0.077	0.043	0.958	0.697	0.347	0.712	L(T(C) × A × P)
C × A	1	87.891	6.657	0.123	0.244	0.087	0.796	0.185	0.146	0.739	A × T(C)
C × P	1	36.000	2.817	0.235	6.848	28.103	0.034 *	0.043	0.048	0.847	P × T(C)
A × P	1	6.891	0.164	0.725	7.132	3.818	0.190	30.101	26.663	0.036 *	A × P × T(C)
A × T(C)	2	13.203	1.813	0.195	2.797	1.560	0.240	1.261	0.627	0.547	L(T(C) × A × P)
P × T(C)	2	12.781	1.755	0.205	0.244	0.136	0.874	0.888	0.442	0.65	L(T(C) × A × P)
C × A × P	1	31.641	0.753	0.477	0.445	0.238	0.674	3.451	3.057	0.223	A × P × T(C)
A × P × T(C)	2	42.016	5.770	0.013 *	1.868	1.042	0.375	1.129	0.562	0.581	L(T(C) × A × P)
L(T(C) × A × P)	16	7.281	0.880	0.595	1.793	0.591	0.867	2.01	0.973	0.506	S(L(T(C) × A × P))
S(L(T(C) × A × P))	32	8.273	1.922	0.004 **	3.032	4.831	0.000 ***	2.066	2.628	0.000 ***	Residual
Residual	192	4.305			0.628			0.786			Residual
Transformation		–			ln(x + 1)			ln(x + 1)			

and by species. Analyses by species were performed only on those non-pelagic taxa (Table A1 in Appendix A, Spatial categories 3, 4, 5 and 6) sufficiently frequent throughout the study, i.e. with a frequency of $\geq 10\%$. Experimental design used to evaluate our hypothesis was symmetrical and balanced, with six factors of variability and two levels on each one. Three factors were fixed and orthogonal including: Crisis (before and after the crisis), Area (Tabarca Marine Reserve and San Antonio Marine Reserve) and Protection (marine protected areas (MPAs) and unprotected (control zones that are not MPAs)). In addition, three random factors were used, one of them to include temporal variability: Time (nested in Crisis); and the others two to include spatial variability: Locality (nested in interaction of Protection, Area and Time) and Site (nested in Locality). When the ANOVA *F*-test was significant, post hoc analyses were conducted using Student-Newman-Keuls (SNK) multiple comparisons [59]. Before analysis, Cochran's test [15] was used to test for homogeneity of variance. When significant heterogeneity was found, the data were transformed by $\sqrt{x + 1}$ or $\ln(x + 1)$. When transformations did not remove heterogeneity, analyses were performed on the untransformed data, but with the *F*-test α -value set at 0.01, since ANOVA is robust to departures from this assumption, especially when the design is balanced and contains a large number of samples or treatments [60].

Additionally, we used multivariate techniques that are suited for ecological data because this allowed the production of a diagnostic on the change of the entire fish assemblage. Therefore, a permutational multivariate analysis of variance (PERMANOVA, [1]) was used to assess differences in the abundance and biomass of the structure of the fish assemblage within levels of the factors considered. Furthermore, a non-metric multidimensional scaling (nMDS) [14] was used as ordination plot, which will help to uncover the nature of any differences among groups detected by PERMANOVA [3]. PERMANOVA was conducted following the prior experimental designs, wherein each term in the analysis was tested using 4 999 random permutations of the appropriate units [1]. PERMANOVA was quite robust to heterogeneity of multivariate dispersions among groups for balanced designs [2]. For the overall multivariate testing technique, similarities among samples were calculated using the Bray-Curtis similarity index [13]. Analyses were performed by R statistical computing software [48] and the R's statistical software packages GAD [55] and Vegan [46].

3. Results

A total of 119 511 individuals of 53 different species were estimated (Table A1 in Appendix A). The most observed families were *Sparidae* and *Labridae*, with 15 species each one. More than 90% of the registered

individuals corresponded to 6 species (*Chromis chromis*, *Oblada melanura*, *Diplodus vulgaris*, *Sarpa salpa*, *Boops boops* and *Coris julis*). The total estimated biomass from the visual census was 30 577.4 kg, and around 90% of the observed biomass belonged to 9 species (*S. salpa*, *Epinephelus marginatus*, *D. vulgaris*, *C. chromis*, *O. melanura*, *Diplodus sargus*, *Sciaena umbra*, *Mycteroperca rubra* and *Mugil spp*). In general, the mean of total number of species, total abundance and total biomass were 10.17 ± 0.16 species/125 m² (s.e., standard error), 466.84 ± 30.21 individuals/125 m² and $11\,944.29 \pm 1\,062.11$ g/125 m² respectively.

Regarding the assessment of the indirect effect of the economic crisis on the conservation of the ichthyofauna, considering the average total number of species, higher values were found in the protected areas of both reserves compared to the control areas, except in the last year after the crisis in San Antonio, where the number of species was higher in the control areas (Fig. 2-a). However, in the protected areas of both, San Antonio and Tabarca, there was a slight decrease in the number of species after the crisis. In the control areas of Tabarca a similar effect was observed, meanwhile in San Antonio the number of species after the crisis increased. In the ANOVA of the number of species, the triple interaction between Time, Area and Protection was significant (Table 2), thereby indicating a significant temporal variability between years. The SNK results showed a significantly higher number of species in the MPAs than in the control areas in San Antonio only in 2010, and in Tabarca in 2008 and 2015. In addition, a significant spatial variability was observed in the number of species at site scale (Table 2).

In relation to the effect of the crisis on the mean total abundance, the differences observed between the protected areas and control areas were lower after the crisis, in both San Antonio and in Tabarca (Fig. 2-b). The highest abundances were normally observed in the protected areas in both reserves, except in 2015 in San Antonio, where greater abundances were censused in the control areas. The ANOVA indicated that the double interaction between Crisis and Protection was significant (Table 2) showing higher levels of abundance in protected areas, both before and after the crisis. In addition, a significant spatial variability at site scale was observed in abundance (Table 2).

About the mean total biomass, the highest values were generally observed in the protected areas of the two reserves, except in the last sampling year after the crisis in San Antonio (Fig. 2-c). Regarding the effect of the crisis, only the protected area of San Antonio showed a decrease in biomass after the crisis. The double interaction between Area and Protection was significant (Table 2), indicating significantly higher biomass levels in Tabarca reserve than in the control areas, meanwhile in San Antonio there were no significant differences between the protected and the control areas. Once again, a significant spatial variability at the site scale was observed also for biomass (Table 2).

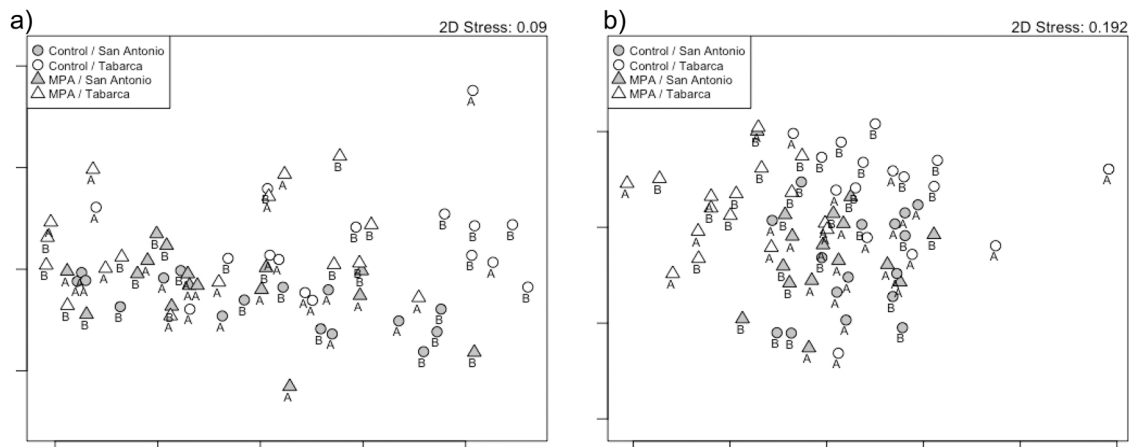


Fig. 3. Two dimensional nMDS ordination of (a) abundance and (b) biomass of the fish assemblage for each level of fixed factors: Crisis (A: after, B: before), Area (white: Tabarca, gray: San Antonio) and Protection (circle: control zone, triangle: MPA).

Table 3

Results of permutational multivariate analysis of variance (PERMANOVA) with six factors (C: crisis, A: area, P: protection, T: time, L: locality and S: site) for abundance and biomass of the fish assemblage. d.f.: degrees of freedom; M.S.: mean squares; F: F-value. Levels of significance were * $p < 0.05$, ** $p < 0.01$ and *** $p < 0.001$.

Source	d.f.	Abundance			Biomass			F versus
		M.S.	F	P	M.S.	F	P	
C	1	10,857.7166	1.6123	0.2146	8897.0506	1.3475	0.2386	T(C)
A	1	18,186.92	8.0575	0.0012 **	29,839.6962	7.4618	0.0002 ***	A × T(C)
P	1	19,281.1906	5.9919	0.0028 **	31,203.2748	8.1186	0.0002 ***	P × T(C)
T(C)	2	6734.3094	2.0008	0.0374 *	6602.4546	1.405	0.1124	L(T(C) × A × P)
C × A	1	5174.5523	2.2925	0.0918	6774.4313	1.694	0.1194	A × T(C)
C × P	1	6614.4718	2.0555	0.1202	3467.9784	0.9023	0.5458	P × T(C)
A × P	1	8842.6473	2.1247	0.1132	18,731.9626	3.4165	0.0058 **	A × P × T(C)
A × T(C)	2	2257.138	0.6706	0.7736	3999.0035	0.851	0.6758	L(T(C) × A × P)
P × T(C)	2	3217.8607	0.956	0.4766	3843.4349	0.8179	0.7152	L(T(C) × A × P)
C × A × P	1	4216.7655	1.0132	0.4454	9970.5957	1.8185	0.0896	A × P × T(C)
A × P × T(C)	2	4161.7643	1.2365	0.2516	5482.8237	1.1668	0.2618	L(T(C) × A × P)
L(T(C) × A × P)	16	3365.8726	0.6772	0.9846	4699.1028	0.9398	0.6904	S(L(T(C) × A × P))
S(L(T(C) × A × P))	32	4970.3398	2.9196	0.0002 ***	5000.2414	2.0099	0.0002 ***	Residual
Residual	192	1702.4244			2487.7977			Residual

No trend related with factor Crisis was detected in the abundance neither the biomass of the multivariate structure of fish assemblage (Fig. 3). The nMDS performed with the abundance neither showed a clear trend in the multivariate structure of fish assemblage according to the other factors studied (Fig. 3-a), even though the PERMANOVA showed significant differences between levels of factor Area and factor Protection (Table 3). However, for biomass nMDS clearly separated the fish assemblage from Tabarca and San Antonio (Fig. 3-b). Additionally, in Tabarca there is a separation between protected and control samples. PERMANOVA corroborated these trends showing a significant interaction between Area and Protection in the biomass of the fish assemblage (Table 3). Post hoc analysis showed that the multivariate structure of fish assemblage biomass was significantly different in protected than in control zones in Tabarca, but not in San Antonio ($P < 0.01$). The fish assemblage had in both, abundance and biomass, a significant spatial variability at sites scale (Table 3).

Of the 53 species surveyed, we only selected 18 species to individually analyze their abundance and biomass, after excluding species belonging to pelagic taxa and those with less than 10% frequency. In general, all these selected species showed a very marked temporal variability between years in their abundance and biomass, both before and after the crisis. Analyzing the abundance (Figs. B1-B3 in Appendix B, ANOVA results in Table A2 in Appendix A) and biomass (Figs. B4-B6 in Appendix B, ANOVA results in Table A3 in Appendix A) of the selected species (Table 4, summary table of the results shown in Tables A2 and A3), 11 different patterns were detected depending on the differences

between the control areas and the protected areas. The first pattern detected was much higher abundance and biomass values in the protected areas than in control areas, before and after the crisis. This pattern was observed in San Antonio for abundance of *S. umbra* (Fig. B2-e) and *S. ocellatus* (Fig. B3-d) and for biomass of *C. julis* (Fig. B4-a), *S. umbra* (Fig. B5-e, $p < 0.05$) and *S. ocellatus* (Fig. B6-d); and in Tabarca for abundance and biomass of *D. puntazzo* (Figs. B1-d and B4-d; $p < 0.01$, $p < 0.05$ respectively) and *E. marginatus* (Figs. B2-a and B5-a respectively; $p < 0.01$ biomass), and in biomass of *D. sargus* (Fig. B4-e, $p < 0.05$). The second pattern consisted of higher abundance and biomass values in the protected areas than in control areas, before and after the crisis, but the differences between protected and control areas were smaller before the crisis. This pattern was found in San Antonio for abundance of *E. marginatus* (Fig. B2-a); and in Tabarca for abundance of *D. sargus* (Fig. B1-e) and *S. scriba* (Fig. B3-a) and for abundance and biomass of *T. pavo* (Figs. B3-f and B6-f; $p < 0.05$, $p < 0.01$ respectively). The third pattern was similar to the second, but the differences between protected areas and control areas were smaller after the crisis. We detected this pattern in San Antonio for abundance of *C. julis* (Fig. B1-a) and *S. scriba* (Fig. B3-a) and for biomass of *M. surmuletus* (Fig. B5-c) and *S. scriba* (Fig. B6-a; $p < 0.05$); and in Tabarca for abundance of *D. dentex* (Fig. B1-b), *D. vulgaris* (Fig. B1-f) and *S. salpa* (Fig. B2-d, $p < 0.05$) and for biomass of *S. umbra* (Fig. B5-e, $p < 0.05$) and *S. salpa* (Fig. B5-d, $p < 0.05$). The fourth pattern showed higher abundance and biomass values in control areas than in protected areas, both before and after the crisis. This pattern was observed in abundance and biomass of *S. cabrilla*

Table 4

Summary table of the ANOVA results shown in Tables A2 and A3 of Appendix A. Species found to be significant in the analysis of variance (ANOVA) for abundance and biomass are shown, together with their level of significance: * $p < 0.05$, ** $p < 0.01$ and *** $p < 0.001$, when there is no homogeneity of variance, the levels of significance being: · $p < 0.01$; ·· $p < 0.001$; ··· $p < 0.000$.

Source	Abundance		Biomass						
	Specie	Level of significance	Specie	Level of significance					
C	<i>D. puntazzo</i>	*	<i>D. puntazzo</i>	**					
	<i>S. salpa</i>	*	<i>E. marginatus</i>	·					
	<i>S. tinca</i>	*	<i>L. merula</i>	*					
A	<i>S. salpa</i>	*	<i>S. mediterraneus</i>	*					
			<i>S. salpa</i>	**					
			<i>D. annularis</i>	**					
			<i>D. sargus</i>	*					
			<i>E. marginatus</i>	·					
P	<i>D. puntazzo</i>	**	<i>D. puntazzo</i>	*					
			<i>S. salpa</i>	*					
			<i>T. pavo</i>	**					
			<i>D. sargus</i>	*					
			<i>D. vulgaris</i>	*					
			<i>E. marginatus</i>	·					
T(C)	<i>T. pavo</i>	*	<i>S. scriba</i>	*					
			<i>S. umbra</i>	*					
			<i>T. pavo</i>	*					
			<i>D. sargus</i>	*					
			<i>D. annularis</i>	*					
			<i>D. sargus</i>	*					
CxA			<i>S. salpa</i>	*					
			<i>D. sargus</i>	*					
			<i>S. salpa</i>	*					
CxP	<i>S. salpa</i>	*	<i>E. marginatus</i>	··					
AxP	<i>T. pavo</i>	*							
AxT(C)	<i>T. pavo</i>	*							
PxT(C)			<i>E. marginatus</i>	·					
					CxAxP			<i>D. puntazzo</i>	*
L(T(C)	xAxP)		<i>S. salpa</i>	**					
					S(L(T(C)	xAxP))	<i>D. dentex</i>	**	
									<i>D. sargus</i>
<i>C. julis</i>	···								
		<i>D. annularis</i>	*						
				<i>D. puntazzo</i>	***				
<i>D. vulgaris</i>	***								
		<i>E. marginatus</i>	··						
				<i>L. merula</i>	*				
<i>S. ocellatus</i>	**								
		<i>S. umbra</i>	***						

(Figs. B2-f and B5-f respectively), in both reserves, Tabarca and San Antonio. In the fifth pattern we can observe higher biomass in protected than in control areas before the crisis, meanwhile after the crisis higher biomasses were found in control than in protected areas. We obtained this trend for biomass of *S. aurata* (Fig. B6-b) in San Antonio and for that of *L. merula* (Fig. B5-b) in Tabarca. The sixth pattern was higher biomass values in protected areas than in the control areas after the crisis, on the contrary, before the crisis, higher biomasses were found in control than in protected areas. This trend was found for biomass of *D. puntazzo* (Fig. B4-d, $p < 0.05$) in San Antonio and for that of *S. scriba* (Fig. B6-a, $p < 0.05$) in Tabarca. In the seventh pattern, no trend was detected between the protected and the control areas after the crisis, while before the crisis the values were higher in protected than in control areas. We can observe this pattern in San Antonio for abundance of *D. sargus* (Fig. B1-e), *L. merula* (Fig. B2-b), *M. surmuletus* (Fig. B2-c) and *S. tinca* (Fig. B3-e), and for biomass of *D. sargus* (Fig. B4-e, $p < 0.05$); and additionally in Tabarca for abundance of *S. umbra* (Fig. B2-e) and *S. aurata* (Fig. B3-b) and for biomass of *S. ocellatus* (Fig. B6-d), *D. dentex* (Fig. B4-b), *D. vulgaris* (Fig. B4-f, $p < 0.05$) and *S. aurata* (Fig. B6-b). In the eighth pattern, no trend before and higher values in protected than in control areas after the crisis was found. This trend was found in San Antonio for abundance of *S. mediterraneus* (Fig. B3-c) and for biomass of *D. vulgaris* (Fig. B4-f, $p < 0.05$), *E. marginatus* (Fig. B5-a) and

S. mediterraneus (Fig. B6-c); and in abundance of *D. annularis* (Fig. B1-c) in Tabarca. The ninth pattern consisted of higher values in the control areas than in the protected areas before the crisis and without trend after the crisis. This trend was found in Tabarca for abundance and biomass of *S. mediterraneus* (Figs. B3-c and B6-c respectively) and biomass of *C. julis* (Fig. B4-a). The tenth pattern found showed higher values in control areas than in protected areas after the crisis and no trend before the crisis. We can observe this pattern in San Antonio for abundance of *D. annularis* (Fig. B1-c) and *S. aurata* (Fig. B3-b), and for biomass of *D. dentex* (Fig. B4-b) and *D. annularis* (Fig. B4-c); and in Tabarca for abundance and biomass of *M. surmuletus* (Figs. B2-c and B5-c respectively). Finally, in the eleventh pattern, no trend was found between protected areas and control areas, neither before nor after the crisis. No pattern was observed in San Antonio for the abundance of *D. dentex* (Fig. B1-b), *D. puntazzo* (Fig. B1-d), *D. vulgaris* (Fig. B1-f), *S. salpa* (Fig. B2-d) and *T. pavo* (Fig. B3-f), nor in biomass of *L. merula* (Fig. B5-b), *S. salpa* (Fig. B5-d), *S. tinca* (Fig. B6-e) and *T. pavo* (Fig. B6-f); nor either in the abundance of *C. julis* (Fig. B1-a), *L. merula* (Fig. B2-b), *S. ocellatus* (Fig. B3-d) and *S. tinca* (Fig. B3-e); nor in biomass of *D. annularis* (Fig. B4-c) and *S. tinca* (Fig. B6-e) in Tabarca.

In addition to all the above trends, significant spatial variability at site scale has been detected in abundance of *D. puntazzo*, *D. vulgaris*, *S. ocellatus*, *S. tinca* and *S. umbra*; and in biomass of *C. julis*, *D. annularis*, *D. puntazzo*, *D. vulgaris*, *E. marginatus*, *L. merula*, *S. ocellatus* and *S. umbra*. A significant spatial variability at local scale has also been found in biomass of *D. dentex* and *D. sargus*. On the other hand, a significant temporal variability caused by the interaction between Area, Protection, Crisis and Time has been obtained in abundance of *S. salpa* and in biomass of *D. puntazzo* and *S. salpa*. We also obtained a significant temporal variability resulting from the interaction between Area, Crisis and Time in the biomass of *S. scriba*, as well as in the abundance and biomass of *T. pavo*. Finally, an inter-annual temporal variability caused by the interaction between Crisis and Time, has also been found in biomass of *D. sargus* and in the abundance and biomass of *T. pavo*.

4. Discussion

To test our main hypothesis that the protection effect has decreased after the crisis due to budget cuts, we have compared the reserve areas with the control areas of marine reserves, before and after the economic crisis. The expected result would be that the differences in the levels of the variables between the control zones and the reserve zones would be lower after the crisis than before. This would indicate that after the crisis, the protected areas resemble the control areas, so they would no longer enjoy the same level of conservation.

Although both reserves seem to behave in a similar way, when we talk about the analyzed species, if we focus on the total values (number of species, total abundance and total biomass) we observe that completely different things have happened in each reserve. This may be due to what happened in each reserve during the years of the budget cut. Until 2012, Tabarca had 8 guards with 2 boats, guarding 24 h a day, 365 days a year and without defined schedules, so the surveillance was unpredictable. In 2012 there was an 80% budget cut that lasted until the end of 2013 (La Vanguardia, 2012), and during this period only 2 guards remained in the reserve [47]. From the end of 2013 onwards, the number of guards increased again, becoming 6 guards. From this moment on, they are organized into 3 vigilance shifts with 2 guards on each shift, plus a reinforcement team in summer (2 more guards) [22]. It should be noted that Tabarca marine reserve is well signposted with 6 perimeter buoys provided with lighting equipment. In the Cabo de San Antonio marine reserve there have always been 2 guards with 1 boat performing rotating shifts [44], except during 2013 when surveillance from the sea was completely suspended due to budget cuts and there was only surveillance from the coast [43]. This reserve is not marked with perimeter buoys like those of Tabarca, but it does have small beacons that delimit the outer perimeter.

The lack of effective management, due to financial and staff capacity deficiencies, is the primary factor impeding successful MPA implementation [35,58]. In a work carried out by Balmford et al. [4], it was observed that only 13 (15.7%) of the 83 studied MPAs throughout the world had sufficient funding to achieve effective resource conservation. These financing problems can lead to a decrease in the surveillance effectiveness and there may be an increase in illegal fishing within MPAs. Illegal fishing, even at low levels, can erode all biodiversity conservation benefits that may have taken decades to produce [41] and usually occurs when illegal fishers perceive that no one is going to detect their infringement [10]. According to Haines et al. [37], public funding is declining in many locations, as witnessed in the MPAs of Torre Guaceto (Italy), Iroise (France) and Cabrera (Spain), for which shrinking funds endanger both the environmental and economic success of MPAs and their long-term continuation. Something similar may have occurred in San Antonio marine reserve, where a decrease in the reserve effect has been observed after the crisis, which may be due to a lack of surveillance during the budget cut, resulting in a loss of the stock to be protected. The study by Davis et al. [17] suggests that an increase in the surveillance effort of MPAs may lead to a decrease in illegal fishing, as offenders feel greater pressure to be detected. In addition, if the surveillance vessels have a logo easily recognizable by fishermen, it can also reduce the infringement rate within the MPAs, as they act as a deterrent. However, if this surveillance is predictable over time, such as fixed schedules, experienced fishers have more opportunities to fish within the MPA without being detected. These authors have also found that, even if surveillance is low and predictable, there can be good levels of compliance as long as stakeholders are involved. Several authors argued that if the support of fishermen is obtained regarding MPAs, the objectives can be achieved with lower costs and surveillance, since the fishermen themselves would reduce illegal fishing and could participate in surveillance [12,18,19,30,32,34,6]. In Tabarca marine reserve, despite cuts in funding and a reduction in surveillance personnel, no decrease in the reserve effect has been observed after the crisis. This may be due to the efforts of the 2 guards who worked without defined schedules to be unpredictable to illegal fishing, and/or good compliance by the fisheries' sector.

Illegal fishing by small-scale fisheries, as well as recreational fishermen, has occurred in the two marine reserves of this study (Tabarca and San Antonio) (MPA guards, personal communication). Professional fishermen who commit illegal fishing within the reserve usually use active gear, such as trolling or handlines, since these are the most difficult gears to detect. However, there have also been cases of passive gear, both nets (gillnets or trammelnets) and longlines, set inside the reserve, but these are less frequent. In the Mediterranean, recreational fishing is essentially carried out by hook and line (from boat or from shore) and by spear-fishing [31]. The guards of both reserves acknowledge that all of these recreational fishing techniques have at one time or another conducted illegal fishing within the reserves. In Tabarca marine reserve, boat fishing has the greatest extractive potential, with spearfishing and shore fishing being less frequent since the reserve is located on an island. However, in the San Antonio reserve, since it is on the coast, there are more cases of spear and shore fishing, as well as boat fishing. Of the analyzed species, only the large sparids (*S. aurata*, *D. sargus*, *D. dentex*), *E. marginatus* and *M. surmuletus* are target species for both professional and recreational fishing [25,27]. However, the rest of the analyzed species are frequent accessory species. Possibly for this reason we found a decrease in abundance and biomass of *D. sargus*, *M. surmuletus* and *S. aurata* and biomass of *D. dentex* in San Antonio, and a decrease of *M. surmuletus*, *S. aurata* and *D. dentex* in Tabarca. While the decline in abundance and/or biomass of some of the accessory species appears to be more random. Although *E. marginatus* is a target species, no decline in abundance or biomass was detected in either reserve.

It is becoming increasingly important that public funding is

complemented by alternative sources, particularly self-generated sources that are not time-limited (such as direct payments by tourists, i.e., payment for ecosystem services) [37]. Ideally, use a variety of different sources of funding to increase resilience against possible changes, such as public and NGO grant funding and private investments.

There are several cases of success in the MPAs due to the use of self-generated financing sources that could be applied to the MPAs of Tabarca and San Antonio to avoid the lack of financing. For example, the Egadi MPA (Italy) utilizes funds raised from fines for illegal activities, permits/authorizations, tourist entrance fees [16]. The Cabrera MPA (Spain) uses a mix of ferry company license fees, diver fees, mooring fees, tourism facilities including a hostel and museum and guided tour services [11]. Bonaire National Marine Park (Dutch Caribbean) uses park user fees, including a dive tag fee of US\$25 per year and US\$10 per year fee for all other recreational activities (e.g., snorkeling, sailing) (local residents are exempted). The independence of funding sources from the government is a benefit for the management authority, as it both ensures its autonomy and guards it against a possible reduction in the available public funding that may result from changes in political priorities [37].

5. Conclusions

Lack of funding, and therefore lack of surveillance, is one of the most problems facing marine protected areas. In this study we have detected the effect of the budget reduction on the MPA effectiveness, which may be affecting the conservation of the Cabo de San Antonio marine reserve. In the Tabarca Island Marine Reserve, the combination of good surveillance guidelines with few personnel and possible good compliance by the fishing sector, maintained the reserve's conservation levels despite the large reduction in funding. Therefore, surveillance in marine reserves is necessary for the conservation of the species. To avoid that future crisis or future budget cuts by the administration endanger the conservation of marine reserves, they should try to find alternative sources of self-financing (such as fees for the use of the reserve). In addition, it is also advisable to involve all stakeholders of the reserve, such as fishing sector, as they can increase compliance and surveillance of the reserve.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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Appendix A. Tables

See Tables A1–A3.

Table A1

Mean values \pm standard error of abundance (individuals/125 m²) and biomass (g/125 m²) of the recorded species during the underwater visual census carried out in Tabarca and San Antonio Marine Reserves and in control areas. For each species are indicated its corresponding spatial category (1: very mobile pelagic species, 2: moderately sedentary pelagic species, 3: demersal species moving moderately along vertical axis, 4: nekto-benthic species, 5: relatively sedentary species, 6: cryptic species).

Family	Species	Spatial category	Mean abundance	Mean biomass	% Frequency of occurrence
Muraenidae	<i>Muraena helena</i> (Linnaeus, 1758)	6	0.04 \pm 0.01	103.62 \pm 37.40	3.91
Gadidae	<i>Phycis phycis</i> (Linnaeus, 1766)	6	0.01 \pm 0.01	0.34 \pm 0.34	0.39
Serranidae	<i>Epinephelus costae</i> (Valenciennes, 1828)	5	0.03 \pm 0.01	37.06 \pm 21.13	2.73
	<i>Epinephelus marginatus</i> (Lowe, 1834)	5	0.46 \pm 0.09	2607.17 \pm 576.10	23.83
	<i>Mycteroperca rubra</i> (Bloch, 1793)	5	0.06 \pm 0.02	265.12 \pm 130.05	3.13
	<i>Serranus cabrilla</i> (Linnaeus, 1758)	5	0.33 \pm 0.05	7.64 \pm 1.45	22.27
	<i>Serranus hepatus</i> (Linnaeus, 1758)	5	0.003 \pm 0.003	0.003 \pm 0.003	0.39
	<i>Serranus scriba</i> (Linnaeus, 1758)	5	2.41 \pm 0.58	68.13 \pm 6.43	75.78
Moronidae	<i>Dicentrarchus labrax</i> (Linnaeus, 1758)	1	0.02 \pm 0.01	9.84 \pm 7.94	1.17
Apogonidae	<i>Apogon imberbis</i> (Lacepède, 1801)	6	2.13 \pm 0.42	18.09 \pm 3.41	34.77
Carangidae	<i>Seriola dumerili</i> (Risso, 1810)	1	0.05 \pm 0.04	32.93 \pm 24.58	0.78
Haemulidae	<i>Pomadasys inciscus</i> (Bowdich, 1825)	4	0.02 \pm 0.01	1.71 \pm 1.23	0.78
Sciaenidae	<i>Sciaena umbra</i> (Linnaeus, 1758)	5	1.40 \pm 0.37	297.70 \pm 58.09	23.05
Mullidae	<i>Mullus surmuletus</i> (Linnaeus, 1758)	4	1.08 \pm 0.24	26.87 \pm 6.21	21.48
Sparidae	<i>Boops boops</i> (Linnaeus, 1758)	1	13.69 \pm 3.91	92.17 \pm 25.85	10.16
	<i>Dentex dentex</i> (Linnaeus, 1758)	3	0.28 \pm 0.09	96.25 \pm 31.25	13.67
	<i>Diplodus annularis</i> (Rafinesque, 1810)	3	1.85 \pm 0.34	25.65 \pm 3.91	33.20
	<i>Diplodus cervinus</i> (Lowe, 1841)	3	0.20 \pm 0.06	42.87 \pm 12.90	8.20
	<i>Diplodus puntazzo</i> (Cetti, 1789)	3	0.63 \pm 0.08	107.65 \pm 16.62	29.69
	<i>Diplodus sargus</i> (Linnaeus, 1758)	3	5.87 \pm 1.07	595.15 \pm 85.01	75.78
	<i>Diplodus vulgaris</i> (Geoffroy Saint-Hilaire, 1817)	3	27.29 \pm 4.34	1611.76 \pm 252.36	92.19
	<i>Oblada melanura</i> (Linnaeus, 1758)	1	32.30 \pm 6.43	1022.97 \pm 255.15	45.70
	<i>Pagellus acarne</i> (Risso, 1827)	3	0.01 \pm 0.01	0.41 \pm 0.34	0.78
	<i>Pagellus erythrinus</i> (Linnaeus, 1758)	3	0.04 \pm 0.02	5.16 \pm 3.26	1.95
	<i>Pagrus pagrus</i> (Linnaeus, 1758)	3	0.03 \pm 0.02	0.81 \pm 0.46	2.73
	<i>Pagrus auriga</i> (Valenciennes, 1843)	3	0.00 \pm 0.00	3.44 \pm 3.44	0.39
	<i>Sarpa salpa</i> (Linnaeus, 1758)	3	18.43 \pm 2.97	2703.70 \pm 461.18	41.80
	<i>Sparus aurata</i> (Linnaeus, 1758)	3	0.18 \pm 0.05	72.34 \pm 18.86	12.89
	<i>Spondyliosoma cantharus</i> (Linnaeus, 1758)	3	0.10 \pm 0.03	2.73 \pm 1.12	5.08
Centracanthidae	<i>Spicara maena</i> (Linnaeus, 1758)	1	1.09 \pm 0.64	8.66 \pm 4.30	3.91
	<i>Spicara smaris</i> (Linnaeus, 1758)	3	1.00 \pm 0.60	16.58 \pm 8.57	5.08
Pomacentridae	<i>Chromis chromis</i> (Linnaeus, 1758)	2	326.68 \pm 24.37	1538.32 \pm 145.98	92.58
Labridae	<i>Coris julis</i> (Linnaeus, 1758)	5	10.99 \pm 0.89	113.91 \pm 7.19	95.70
	<i>Ctenolabrus rupestris</i> (Linnaeus, 1758)	5	0.01 \pm 0.01	0.07 \pm 0.07	0.39
	<i>Labrus bergylta</i> (Ascanius, 1767)	5	0.00 \pm 0.00	0.33 \pm 0.33	0.39
	<i>Labrus merula</i> (Linnaeus, 1758)	5	0.14 \pm 0.03	32.35 \pm 7.29	11.72
	<i>Labrus viridis</i> (Linnaeus, 1758)	5	0.03 \pm 0.01	3.49 \pm 1.73	3.13
	<i>Symphodus cinereus</i> (Bonnaterre, 1788)	5	0.03 \pm 0.01	0.31 \pm 0.15	2.34
	<i>Symphodus doderteini</i> (Jordan, 1981)	5	0.01 \pm 0.01	0.05 \pm 0.04	0.39
	<i>Symphodus mediterraneus</i> (Linnaeus, 1758)	5	0.23 \pm 0.04	4.40 \pm 0.74	17.19
	<i>Symphodus melanocercus</i> (Risso, 1810)	5	0.06 \pm 0.02	0.23 \pm 0.08	5.47
	<i>Symphodus melops</i> (Linnaeus, 1758)	5	0.01 \pm 0.01	0.07 \pm 0.05	0.78
	<i>Symphodus ocellatus</i> (Forsskal, 1775)	5	1.63 \pm 0.26	10.68 \pm 4.28	30.86
	<i>Symphodus roissali</i> (Risso, 1810)	5	0.15 \pm 0.04	1.68 \pm 0.45	9.38
	<i>Symphodus rostratus</i> (Bloch, 1797)	5	0.10 \pm 0.02	1.32 \pm 0.32	8.20
	<i>Symphodus tinca</i> (Linnaeus, 1758)	5	2.44 \pm 0.20	112.15 \pm 9.06	71.48
	<i>Thalassoma pavo</i> (Linnaeus, 1758)	5	3.63 \pm 0.46	31.79 \pm 4.51	56.25
Sphyraenidae	<i>Sphyraena sphyraena</i> (Linnaeus, 1758)	1	0.02 \pm 0.01	9.98 \pm 8.14	2.73
Mugilidae	<i>Mugil spp.</i>	2	0.55 \pm 0.19	126.11 \pm 42.51	12.11
	<i>Liza aurata</i> (Risso, 1810)	2	0.18 \pm 0.11	54.31 \pm 29.94	1.56
Atherinidae	<i>Atherina hepsetus</i> (Linnaeus, 1758)	1	8.89 \pm 3.67	17.67 \pm 8.37	4.30
Scorpaenidae	<i>Scorpaena notata</i> (Rafinesque, 1810)	6	0.00 \pm 0.00	0.07 \pm 0.07	0.39
	<i>Scorpaena porcus</i> (Linnaeus, 1758)	6	0.01 \pm 0.01	0.47 \pm 0.47	0.39

Table A2

Results of the analysis of variance (ANOVA) with six factors (C: crisis, A: area, P: protection, T: time, L: locality and S: site) for the abundance of the selected species. d.f.: degrees of freedom; M.S.: mean squares; F: F-value. Levels of significance were * $p < 0.05$, ** $p < 0.01$ and *** $p < 0.001$. Dash (-) indicates that there is no transformation; ϖ : indicates that there is no homogeneity of variance, the levels of significance being: * $p < 0.01$; ** $p < 0.001$.

Source	d.f.	<i>C. julis</i>			<i>D. annularis</i>			<i>D. dentex</i>			F versus
		M.S.	F	P	M.S.	F	P	M.S.	F	P	
C	1	346,891.000	0.728	0.483	3516.000	0.059	0.831	4785.000	3356.000	0.208	T(C)
A	1	5,076,562.000	12,979.000	0.069	328,516.000	26.48	0.036	4785.000	3.470	0.204	A×T(C)
P	1	1,350,563.000	5591.000	0.142	0.391	0.008	0.938	2848.000	3299.000	0.211	P × T(C)
T(C)	2	476,281.000	1.980	0.171	60,031.000	1491.000	0.255	1426.000	0.422	0.663	L(T(C)×A×P)
C×A	1	945,563.000	2417.000	0.260	37,516.000	3024.000	0.224	1.410	1023.000	0.418	A×T(C)
C×P	1	841.000	3481.000	0.203	0.016	0.000	0.988	3754.000	4348.000	0.172	P × T(C)
A×P	1	2,013,766.000	35,175.000	0.027	54,391.000	0.639	0.508	5941.000	1319.000	0.370	A×P × T(C)
A×T(C)	2	391,141.000	1626.000	0.228	12,406.000	0.308	0.739	1379.000	0.408	0.672	L(T(C)×A×P)
P × T(C)	2	241,578.000	1004.000	0.388	50,781.000	1261.000	0.31	0.863	0.255	0.778	L(T(C)×A×P)
C×A×P	1	643,891.000	11,247.000	0.079	112,891.000	1326.000	0.369	3754.000	0.833	0.458	A×P × T(C)
A×P × T(C)	2	57.250	0.238	0.791	85,156.000	2115.000	0.153	4504.000	1333.000	0.291	L(T(C)×A×P)
L(T(C)×A×P)	16	240,578.000	1082.000	0.409	40,258.000	1088.000	0.405	3379.000	1821.000	0.073	S(L(T(C)×A×P))
S(L(T(C)×A×P))	32	222,313.000	1543.000	0.040	37,008.000	1.52	0.046	1855.000	0.967	0.523	Residual
Residual	192	144,052.000			24,354.000			1918.000			Residual
Transformation		ϖ			ϖ			ϖ			
Source	d.f.	<i>D. puntazzo</i>			<i>D. sargus</i>			<i>D. vulgaris</i>			F versus
		M.S.	F	P	M.S.	F	P	M.S.	F	P	
C	1	0.549	32.047	0.03 *	672.754	0.634	0.509	2815.629	1.647	0.328	T(C)
A	1	0.501	5.013	0.155	988.316	2.115	0.283	8224.223	1.144	0.397	A×T(C)
P	1	2.907	599.843	0.002 * *	1401.566	2.873	0.232	16,721.723	2.983	0.226	P × T(C)
T(C)	2	0.017	0.083	0.92	1061.316	3.816	0.044	1709.973	0.194	0.826	L(T(C)×A×P)
C×A	1	0.003	0.027	0.884	35.254	0.075	0.809	4024.316	0.560	0.532	A×T(C)
C×P	1	0.065	13.407	0.067	312.848	0.641	0.507	531.879	0.095	0.787	P × T(C)
A×P	1	2.144	3.412	0.206	84.41	0.237	0.674	4136.098	0.625	0.512	A×P × T(C)
A×T(C)	2	0.1	0.487	0.623	467.191	1.68	0.218	7191.707	0.815	0.460	L(T(C)×A×P)
P × T(C)	2	0.005	0.024	0.977	487.832	1.754	0.205	5606.051	0.635	0.543	L(T(C)×A×P)
C×A×P	1	0.155	0.247	0.668	647.066	1.82	0.31	4735.160	0.716	0.487	A×P × T(C)
A×P × T(C)	2	0.628	3.061	0.075	355.457	1.278	0.306	6615.379	0.749	0.489	L(T(C)×A×P)
L(T(C)×A×P)	16	0.205	0.425	0.964	278.113	0.733	0.742	8827.473	1.101	0.394	S(L(T(C)×A×P))
S(L(T(C)×A×P))	32	0.483	2.273	0 * **	379.652	1.495	0.053	8018.348	2.052	0.002 *	Residual
Residual	192	0.213			253.98			3906.845			Residual
Transformation		ln(x + 1)			ϖ			ϖ			
Source	d.f.	<i>E. marginatus</i>			<i>L. merula</i>			<i>M. surmuletus</i>			F versus
		M.S.	F	P	M.S.	F	P	M.S.	F	P	
C	1	5641.000	1003.000	0.422	0.879	13,235.000	0.068	2441.000	0.072	0.814	T(C)
A	1	5641.000	20,056.000	0.046	0.191	0.392	0.595	262,035.000	6946.000	0.119	A×T(C)
P	1	37,516.000	7062.000	0.117	0.316	0.910	0.441	15,504.000	2556.000	0.251	P × T(C)
T(C)	2	5625.000	2156.000	0.148	0.066	0.362	0.702	33,926.000	1569.000	0.239	L(T(C)×A×P)
C×A	1	1891.000	6722.000	0.122	0.191	0.392	0.595	4785.000	0.127	0.756	A×T(C)
C×P	1	2641.000	0.497	0.554	0.473	1.360	0.364	55,316.000	9118.000	0.094	P × T(C)
A×P	1	8266.000	29,389.000	0.032	0.004	0.034	0.870	23.160	3285.000	0.212	A×P × T(C)
A×T(C)	2	0.281	0.108	0.898	0.488	2.660	0.101	37,723.000	1744.000	0.206	L(T(C)×A×P)
P × T(C)	2	5312.000	2036.000	0.163	0.348	1894.000	0.183	6066.000	0.28	0.759	L(T(C)×A×P)
C×A×P	1	0.766	2722.000	0.241	0.004	0.034	0.870	43,066.000	6108.000	0.132	A×P × T(C)
A×P × T(C)	2	0.281	0.108	0.898	0.113	0.617	0.552	7051.000	0.326	0.726	L(T(C)×A×P)
L(T(C)×A×P)	16	2609.000	0.865	0.610	0.184	0.922	0.555	21,629.000	2558.000	0.012	S(L(T(C)×A×P))
S(L(T(C)×A×P))	32	3016.000	1608.000	0.028	0.199	1264.000	0.170	8457.000	0.653	0.923	Residual
Residual	192	1875.000			0.158			12,941.000			Residual
Transformation		ϖ			ϖ			ϖ			

(continued on next page)

Table A2 (continued)

Source	d.f.	<i>C. julis</i>			<i>D. annularis</i>			<i>D. dentex</i>			<i>F</i> versus
		M.S.	<i>F</i>	<i>P</i>	M.S.	<i>F</i>	<i>P</i>	M.S.	<i>F</i>	<i>P</i>	
Source	d.f.	<i>S. aurata</i>			<i>S. cabrilla</i>			<i>S. mediterraneus</i>			<i>F</i> versus
		M.S.	<i>F</i>	<i>P</i>	M.S.	<i>F</i>	<i>P</i>	M.S.	<i>F</i>	<i>P</i>	
C	1	0.316	0.256	0.663	1129.000	0.376	0.602	1.000	64.000	0.015	T(C)
A	1	0.035	0.148	0.738	20,816.000	8314.000	0.102	3062.000	6759.000	0.122	A×T(C)
P	1	1.410	1111.000	0.402	1129.000	4446.000	0.169	0.391	0.962	0.430	P × T(C)
T(C)	2	1238.000	2156.000	0.148	3004.000	2337.000	0.129	0.016	0.051	0.950	L(T(C)×A×P)
C×A	1	1723.000	7.230	0.115	3285.000	1312.000	0.371	0.062	0.138	0.746	A×T(C)
C×P	1	0.473	0.372	0.604	0.035	0.138	0.746	0.141	0.346	0.616	P × T(C)
A×P	1	0.473	0.437	0.577	0.098	0.385	0.598	2641.000	5281.000	0.148	A×P × T(C)
A×T(C)	2	0.238	0.415	0.667	2504.000	1948.000	0.175	0.453	1487.000	0.256	L(T(C)×A×P)
P × T(C)	2	1.270	2211.000	0.142	0.254	0.198	0.823	0.406	1333.000	0.291	L(T(C)×A×P)
C×A×P	1	1723.000	1592.000	0.334	0.316	1246.000	0.380	0.016	0.031	0.876	A×P × T(C)
A×P × T(C)	2	1082.000	1884.000	0.184	0.254	0.198	0.823	0.500	1641.000	0.225	L(T(C)×A×P)
L(T(C)×A×P)	16	0.574	0.778	0.697	1285.000	1778.000	0.081	0.305	0.722	0.752	S(L(T(C)×A×P))
S(L(T(C)×A×P))	32	0.738	1.450	0.067	0.723	1687.000	0.017	0.422	1237.000	0.193	Residual
Residual	192	0.509			0.428			0.341			Residual
Transformation		- ^m			- ^m			- ^m			
Source	d.f.	<i>S. ocellatus</i>			<i>S. salpa</i>			<i>S. scriba</i>			<i>F</i> versus
		M.S.	<i>F</i>	<i>P</i>	M.S.	<i>F</i>	<i>P</i>	M.S.	<i>F</i>	<i>P</i>	
C	1	2801.000	9045.000	0.095	13,675.000	22,801.000	0.041 *	19,141.000	0.185	0.709	T(C)
A	1	4195.000	2038.000	0.290	30,923.000	38,564.000	0.025 *	118,266.000	0.670	0.499	A×T(C)
P	1	3341.000	2767.000	0.238	43,632.000	94,878.000	0.010 **	264,063.000	2407.000	0.261	P × T(C)
T(C)	2	0.310	0.463	0.637	0.600	0.235	0.793	103,227.000	1149.000	0.342	L(T(C)×A×P)
C×A	1	7039.000	3419.000	0.206	5.350	6672.000	0.123	72.250	0.409	0.588	A×T(C)
C×P	1	0.062	0.051	0.842	10,151.000	22,073.000	0.042 *	50,766.000	0.463	0.567	P × T(C)
A×P	1	0.223	0.523	0.545	24,423.000	1.540	0.340	17,016.000	0.191	0.705	A×P × T(C)
A×T(C)	2	2059.000	3079.000	0.074	0.802	0.314	0.735	176,445.000	1964.000	0.173	L(T(C)×A×P)
P × T(C)	2	1207.000	1806.000	0.196	0.460	0.180	0.837	109,727.000	1222.000	0.321	L(T(C)×A×P)
C×A×P	1	1.160	2719.000	0.241	5174.000	0.326	0.626	138,062.000	1547.000	0.340	A×P × T(C)
A×P × T(C)	2	0.427	0.638	0.541	15,859.000	6208.000	0.010 **	89,258.000	0.994	0.392	L(T(C)×A×P)
L(T(C)×A×P)	16	0.669	0.796	0.680	2555.000	1537.000	0.147	89.820	1037.000	0.448	S(L(T(C)×A×P))
S(L(T(C)×A×P))	32	0.840	1548.000	0.039 *	1663.000	0.644	0.930	86,633.000	1014.000	0.455	Residual
Residual	192	0.543			2581.000			85,477.000			Residual
Transformation		ln(x + 1)			ln(x + 1)			- ^m			
Source	d.f.	<i>S. tinca</i>			<i>S. umbra</i>			<i>T. pavo</i>			<i>F</i> versus
		M.S.	<i>F</i>	<i>P</i>	M.S.	<i>F</i>	<i>P</i>	M.S.	<i>F</i>	<i>P</i>	
C	1	1122.000	30,289.000	0.031 *	96,285.000	1663.000	0.326	8036.000	1305.000	0.372	T(C)
A	1	0.156	0.919	0.439	75,473.000	1.090	0.406	18,657.000	3293.000	0.211	A×T(C)
P	1	1416.000	3665.000	0.196	326,254.000	7612.000	0.110	19,981.000	117,331.000	0.008 **	P × T(C)
T(C)	2	0.037	0.040	0.961	57.910	1282.000	0.304	6157.000	4812.000	0.023 *	L(T(C)×A×P)
C×A	1	2061.000	12,156.000	0.073	33,785.000	0.488	0.557	0.047	0.008	0.936	A×T(C)
C×P	1	0.003	0.008	0.936	79,879.000	1864.000	0.305	0.365	2144.000	0.281	P × T(C)
A×P	1	0.176	0.061	0.828	36,754.000	0.981	0.426	26,352.000	28,034.000	0.034 *	A×P × T(C)
A×T(C)	2	0.170	0.183	0.834	69,238.000	1533.000	0.246	5666.000	4429.000	0.029 *	L(T(C)×A×P)
P × T(C)	2	0.386	0.417	0.666	42,863.000	0.949	0.408	0.170	0.133	0.876	L(T(C)×A×P)
C×A×P	1	0.545	0.189	0.706	44,723.000	1193.000	0.389	0.448	0.476	0.561	A×P × T(C)
A×P × T(C)	2	2883.000	3113.000	0.072	37,473.000	0.830	0.454	0.940	0.735	0.495	L(T(C)×A×P)
L(T(C)×A×P)	16	0.926	1232.000	0.298	45.160	0.693	0.779	1279.000	1573.000	0.135	S(L(T(C)×A×P))
S(L(T(C)×A×P))	32	0.752	1636.000	0.023 *	65,145.000	2613.000	0.000 **	0.813	1395.000	0.090	Residual
Residual	192	0.460			24,928.000			0.583			Residual
Transformation		ln(x + 1)			- ^m			ln(x + 1)			

Table A3

Results of the analysis of variance (ANOVA) with six factors (C: crisis, A: area, P: protection, T: time, L: locality and S: site) for the biomass of the selected species. d.f.: degrees of freedom; M.S.: mean squares; F: F-value. Levels of significance were * $p < 0.05$, ** $p < 0.01$ and *** $p < 0.001$. Dash (-) indicates that there is no transformation; ϖ : indicates that there is no homogeneity of variance, the levels of significance being: * $p < 0.01$; ** $p < 0.001$.

Source	d.f.	<i>C. julis</i>			<i>D. annularis</i>			<i>D. dentex</i>			F versus
		M.S.	F	P	M.S.	F	P	M.S.	F	P	
C	1	2136.173	0.244	0.670	1.401	0.345	0.617	5.224	3.737	0.193	T(C)
A	1	283,522.970	13.565	0.066	157.498	379.793	0.003 **	18.770	2.517	0.253	A×T(C)
P	1	75,704.083	40.548	0.024	24.951	3.921	0.186	0.915	0.158	0.729	P × T(C)
T(C)	2	8755.231	0.501	0.615	4.066	1.011	0.386	1.398	0.154	0.859	L(T(C)×A×P)
C×A	1	3996.610	0.191	0.705	13.206	31.845	0.030 *	0.781	0.105	0.777	A×T(C)
C×P	1	11,549.532	6.186	0.131	2.855	0.449	0.572	1.346	0.233	0.677	P × T(C)
A×P	1	245,253.991	39.335	0.024	4.344	0.331	0.623	24.180	3.174	0.217	A×P × T(C)
A×T(C)	2	20,901.259	1.196	0.328	0.415	0.103	0.903	7.456	0.821	0.458	L(T(C)×A×P)
P × T(C)	2	1867.034	0.107	0.899	6.364	1.582	0.236	5.786	0.637	0.542	L(T(C)×A×P)
C×A×P	1	10,119.103	1.623	0.331	10.990	0.838	0.457	3.586	0.471	0.564	A×P × T(C)
A×P × T(C)	2	6234.934	0.357	0.705	13.108	3.259	0.065	7.617	0.839	0.450	L(T(C)×A×P)
L(T(C)×A×P)	16	17,470.707	0.846	0.629	4.022	1.043	0.443	9.081	3.324	0.002 **	S(L(T(C)×A×P))
S(L(T(C)×A×P))	32	20,646.162	2.293	0.000 ***	3.857	1.546	0.040 *	2.732	0.800	0.770	Residual
Residual Transformation	192	9004.937	- ^ϖ		2.496			3.416			Residual
Source	d.f.	<i>D. puntazzo</i>			<i>D. sargus</i>			<i>D. vulgaris</i>			F versus
		M.S.	F	P	M.S.	F	P	M.S.	F	P	
C	1	17.570	114.560	0.009 **	22.505	0.491	0.556	1.971	0.279	0.650	T(C)
A	1	11.087	1.253	0.379	75.537	35.466	0.027 *	52.735	8.173	0.104	A×T(C)
P	1	62.213	20.037	0.046 *	124.618	28.117	0.034 *	35.028	18.490	0.050 *	P × T(C)
T(C)	2	0.153	0.030	0.971	45.868	4.450	0.029 *	7.074	0.567	0.578	L(T(C)×A×P)
C×A	1	0.028	0.003	0.960	142.682	66.991	0.015 *	6.747	1.046	0.414	A×T(C)
C×P	1	1.827	0.588	0.523	5.140	1.160	0.394	11.135	5.878	0.136	P × T(C)
A×P	1	42.784	1.463	0.350	16.567	0.539	0.539	10.470	1.536	0.341	A×P × T(C)
A×T(C)	2	8.851	1.710	0.212	2.130	0.207	0.815	6.452	0.517	0.606	L(T(C)×A×P)
P × T(C)	2	3.105	0.600	0.561	4.432	0.430	0.658	1.894	0.152	0.860	L(T(C)×A×P)
C×A×P	1	5.410	0.185	0.709	29.048	0.945	0.434	0.645	0.095	0.787	A×P × T(C)
A×P × T(C)	2	29.248	5.650	0.014 *	30.752	2.984	0.079	6.817	0.546	0.590	L(T(C)×A×P)
L(T(C)×A×P)	16	5.176	0.471	0.944	10.307	2.007	0.046 *	12.486	1.581	0.132	S(L(T(C)×A×P))
S(L(T(C)×A×P))	32	10.980	2.163	0.001 ***	5.134	0.901	0.623	7.895	2.136	0.001 ***	Residual
Residual Transformation	192	5.075			5.696			3.696			Residual
Source	d.f.	<i>E. marginatus</i>			<i>L. merula</i>			<i>M. surmuletus</i>			F versus

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Table A3 (continued)

Source	d.f.	<i>C. julis</i>			<i>D. annularis</i>			<i>D. dentex</i>			<i>F</i> versus	
		M.S.	<i>F</i>	<i>P</i>	M.S.	<i>F</i>	<i>P</i>	M.S.	<i>F</i>	<i>P</i>		
		M.S.	<i>F</i>	<i>P</i>	M.S.	<i>F</i>	<i>P</i>	M.S.	<i>F</i>	<i>P</i>		
C	1	131,746,923.086		119.889	0.008 *	18.206	90.448	0.011 *	34,530.931	1.936	0.299	T(C)
A	1	1,184,168,107.916		242.972	0.004 *	2.399	0.338	0.620	172,889.640	9.391	0.092	A×T(C)
P	1	1,510,232,212.661		488.241	0.002 *	7.111	1.451	0.352	47,961.000	2.339	0.266	P × T(C)
T(C)	2	1,098,907.378		0.039	0.962	0.201	0.066	0.937	17,831.791	1.154	0.340	L(T(C)× A×P)
C×A	1	147,364,577.133		30.237	0.032	5.538	0.779	0.470	37,694.223	2.047	0.289	A×T(C)
C×P	1	159,686,028.931		51.625	0.019	11.815	2.411	0.261	26,961.640	1.315	0.370	P × T(C)
A×P	1	1,351,391,799.142		3630.568	0.000 * *	0.864	0.281	0.649	52,992.040	2.671	0.244	A×P × T(C)
A×T(C)	2	4,873,683.597		0.174	0.842	7.106	2.318	0.131	18,410.838	1.192	0.329	L(T(C)× A×P)
P × T(C)	2	3,093,213.317		0.111	0.896	4.900	1.598	0.233	20,502.806	1.327	0.293	L(T(C)× A×P)
C×A×P	1	114,911,834.094		308.715	0.003 *	0.054	0.017	0.907	23,409.000	1.180	0.391	A×P × T(C)
A×P × T(C)	2	372,225.977		0.013	0.987	3.071	1.002	0.389	19,840.315	1.284	0.304	L(T(C)× A×P)
L(T(C)×A×P)	16	27,945,835.701		0.145	1.000	3.065	0.723	0.751	15,447.560	1.972	0.050	S(L(T(C)× A×P))
S(L(T(C)× A×P))	32	193,286,543.452		3.563	0.000 * *	4.240	1.512	0.048 *	7834.169	1.021	0.444	Residual
Residual	192	54,244,674.377				2.803			7673.906			Residual
Transformation		- ^m				ln(x + 1)			- ^m			
Source	d.f.	<i>S. aurata</i>			<i>S. cabrilla</i>			<i>S. mediterraneus</i>			<i>F</i> versus	
		M.S.	<i>F</i>	<i>P</i>	M.S.	<i>F</i>	<i>P</i>	M.S.	<i>F</i>	<i>P</i>		
C	1	21.384	1.389	0.360	2.075	0.267	0.657	5.780	25.490	0.037 *	T(C)	
A	1	5.206	1.637	0.329	87.632	13.201	0.068	10.190	5.482	0.144	A×T(C)	
P	1	9.122	0.879	0.447	7.901	8.284	0.102	0.513	0.557	0.533	P × T(C)	
T(C)	2	15.395	3.161	0.070	7.765	3.416	0.058	0.227	0.210	0.813	L(T(C)×A×P)	
C×A	1	7.262	2.284	0.270	7.302	1.100	0.404	0.002	0.001	0.975	A×T(C)	
C×P	1	2.973	0.286	0.646	0.000	0.000	0.993	0.703	0.763	0.475	P × T(C)	
A×P	1	32.780	3.188	0.216	2.399	4.161	0.178	8.275	3.778	0.191	A×P × T(C)	
A×T(C)	2	3.180	0.653	0.534	6.638	2.920	0.083	1.859	1.722	0.210	L(T(C)×A×P)	
P × T(C)	2	10.377	2.131	0.151	0.954	0.419	0.664	0.922	0.854	0.444	L(T(C)×A×P)	
C×A×P	1	12.681	1.233	0.382	1.568	2.719	0.241	0.107	0.049	0.846	A×P × T(C)	
A×P × T(C)	2	10.282	2.111	0.154	0.577	0.254	0.779	2.190	2.029	0.164	L(T(C)×A×P)	
L(T(C)×A×P)	16	4.871	1.192	0.325	2.273	1.458	0.178	1.079	0.684	0.788	S(L(T(C)×A×P))	
S(L(T(C)× A×P))	32	4.086	1.221	0.206	1.560	1.149	0.279	1.577	1.154	0.273	Residual	
Residual	192	3.347			1.358			1.366			Residual	

(continued on next page)

Table A3 (continued)

Source	d.f.	<i>C. julis</i>			<i>D. annularis</i>			<i>D. dentex</i>			<i>F</i> versus
		M.S.	<i>F</i>	<i>P</i>	M.S.	<i>F</i>	<i>P</i>	M.S.	<i>F</i>	<i>P</i>	
Transformation		ln(x + 1)			ln(x + 1)			ln(x + 1)			
Source	d.f.	<i>S. ocellatus</i>			<i>S. salpa</i>			<i>S. scriba</i>			<i>F</i> versus
		M.S.	<i>F</i>	<i>P</i>	M.S.	<i>F</i>	<i>P</i>	M.S.	<i>F</i>	<i>P</i>	
C	1	0.005	0.001	0.979	50.850	4.028	0.183	10.006	3.292	0.211	T(C)
A	1	2.924	1.631	0.330	165.802	99.693	0.010 **	16.942	0.455	0.569	A × T(C)
P	1	9.001	2.631	0.246	185.967	28.324	0.034 *	48.600	85.103	0.012 *	P × T(C)
T(C)	2	6.147	2.983	0.079	12.626	0.978	0.398	3.040	0.539	0.594	L(T(C) × A × P)
C × A	1	10.244	5.713	0.139	40.653	24.444	0.039 *	0.093	0.003	0.965	A × T(C)
C × P	1	0.163	0.048	0.847	57.805	8.804	0.097	1.732	3.033	0.224	P × T(C)
A × P	1	0.143	0.082	0.802	121.050	1.335	0.367	6.003	5.320	0.147	A × P × T(C)
A × T(C)	2	1.793	0.870	0.438	1.663	0.129	0.880	37.198	6.591	0.008 **	L(T(C) × A × P)
P × T(C)	2	3.421	1.660	0.221	6.566	0.508	0.611	0.571	0.101	0.904	L(T(C) × A × P)
C × A × P	1	1.065	0.611	0.516	81.842	0.903	0.442	3.186	2.824	0.235	A × P × T(C)
A × P × T(C)	2	1.744	0.846	0.447	90.664	7.021	0.006 **	1.128	0.200	0.821	L(T(C) × A × P)
L(T(C) × A × P)	16	2.061	0.632	0.834	12.913	1.232	0.298	5.644	1.544	0.144	S(L(T(C) × A × P))
S(L(T(C) × A × P))	32	3.260	1.926	0.004 **	10.483	0.766	0.813	3.656	1.312	0.136	Residual
Residual	192	1.693			13.683			2.788			Residual
Transformation		ln(x + 1)			ln(x + 1)			ln(x + 1)			
Source	d.f.	<i>S. tinca</i>			<i>S. umbra</i>			<i>T. pavo</i>			<i>F</i> versus
		M.S.	<i>F</i>	<i>P</i>	M.S.	<i>F</i>	<i>P</i>	M.S.	<i>F</i>	<i>P</i>	
C	1	2.626	0.117	0.765	5.705	1.974	0.295	17.720	0.717	0.486	T(C)
A	1	63.592	3.871	0.188	8.511	0.845	0.455	83.376	4.397	0.171	A × T(C)
P	1	43.125	0.552	0.535	188.272	29.046	0.033 *	63.079	422.354	0.002 **	P × T(C)
T(C)	2	22.487	0.303	0.743	2.890	0.209	0.813	24.713	5.095	0.019 *	L(T(C) × A × P)
C × A	1	123.230	7.501	0.111	0.345	0.034	0.870	2.588	0.136	0.747	A × T(C)
C × P	1	37.609	0.481	0.560	2.725	0.420	0.583	2.716	18.184	0.051	P × T(C)
A × P	1	62.768	0.268	0.656	10.965	1.312	0.371	74.724	13.028	0.069	A × P × T(C)
A × T(C)	2	16.429	0.222	0.804	10.076	0.730	0.497	18.964	3.910	0.041 *	L(T(C) × A × P)
P × T(C)	2	78.186	1.055	0.371	6.482	0.469	0.634	0.149	0.031	0.970	L(T(C) × A × P)
C × A × P	1	13.389	0.057	0.833	7.190	0.860	0.452	0.786	0.137	0.747	A × P × T(C)
A × P × T(C)	2	234.069	3.157	0.070	8.358	0.605	0.558	5.736	1.183	0.332	L(T(C) × A × P)
L(T(C) × A × P)	16	74.142	1.573	0.134	13.809	0.753	0.722	4.850	1.661	0.108	S(L(T(C) × A × P))
S(L(T(C) × A × P))	32	47.132	1.382	0.096	18.336	3.857	0.000 ***	2.920	1.372	0.101	Residual
Residual	192	34.115			4.754			2.128			Residual
Transformation		sqrt(x + 1)			ln(x + 1)			ln(x + 1)			

Appendix B. Figures

See Figs. B1–B6.

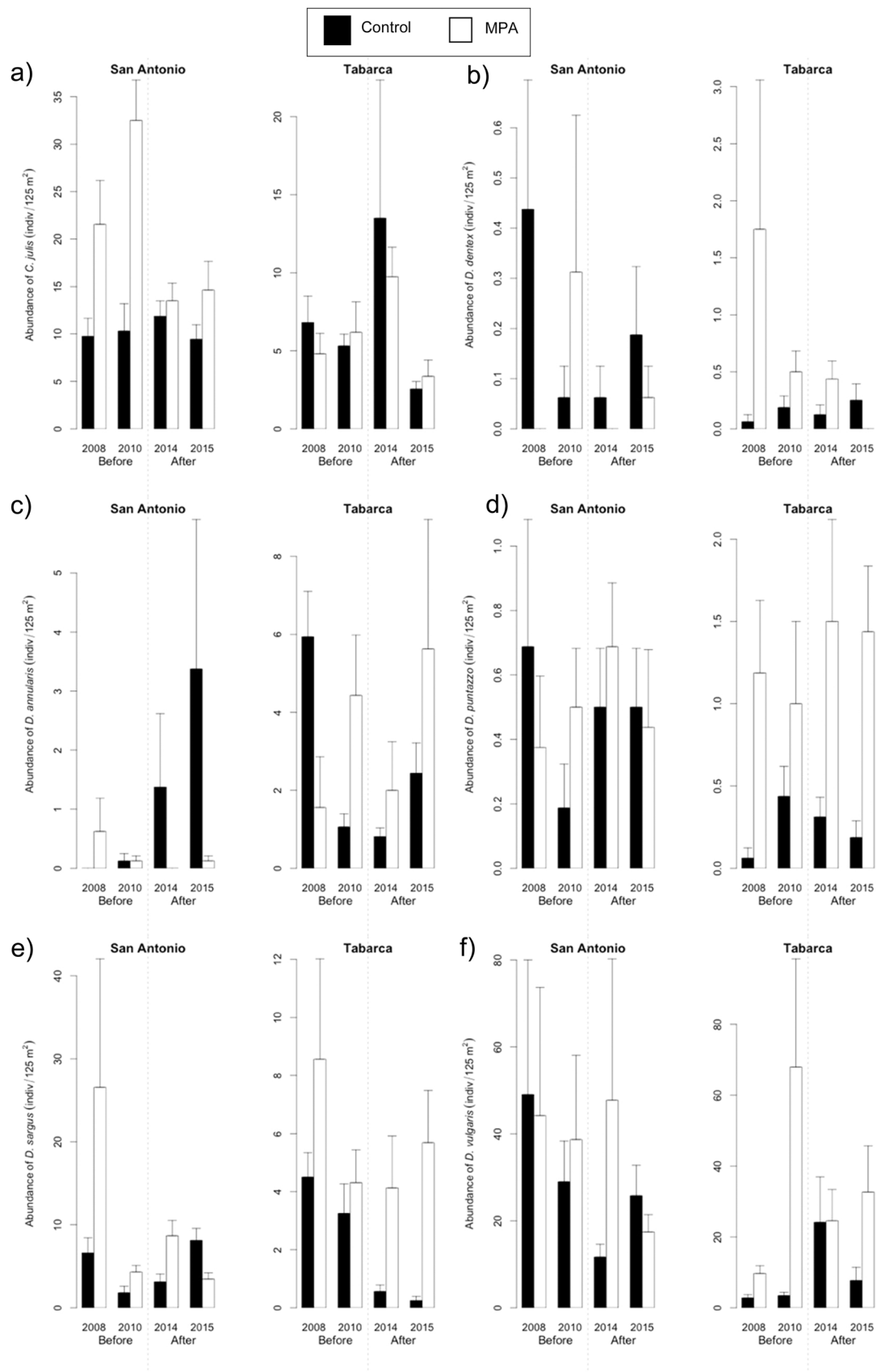


Fig. B1. Mean abundance values ± standard error of: (a) *Coris julis*, (b) *Dentex dentex*, (c) *Diplodus annularis*, (d) *Diplodus puntazzo*, (e) *Diplodus sargus* and (f) *Diplodus vulgaris* in San Antonio and Tabarca reserves, and their respective controls, during the different sampling years before and after the crisis.

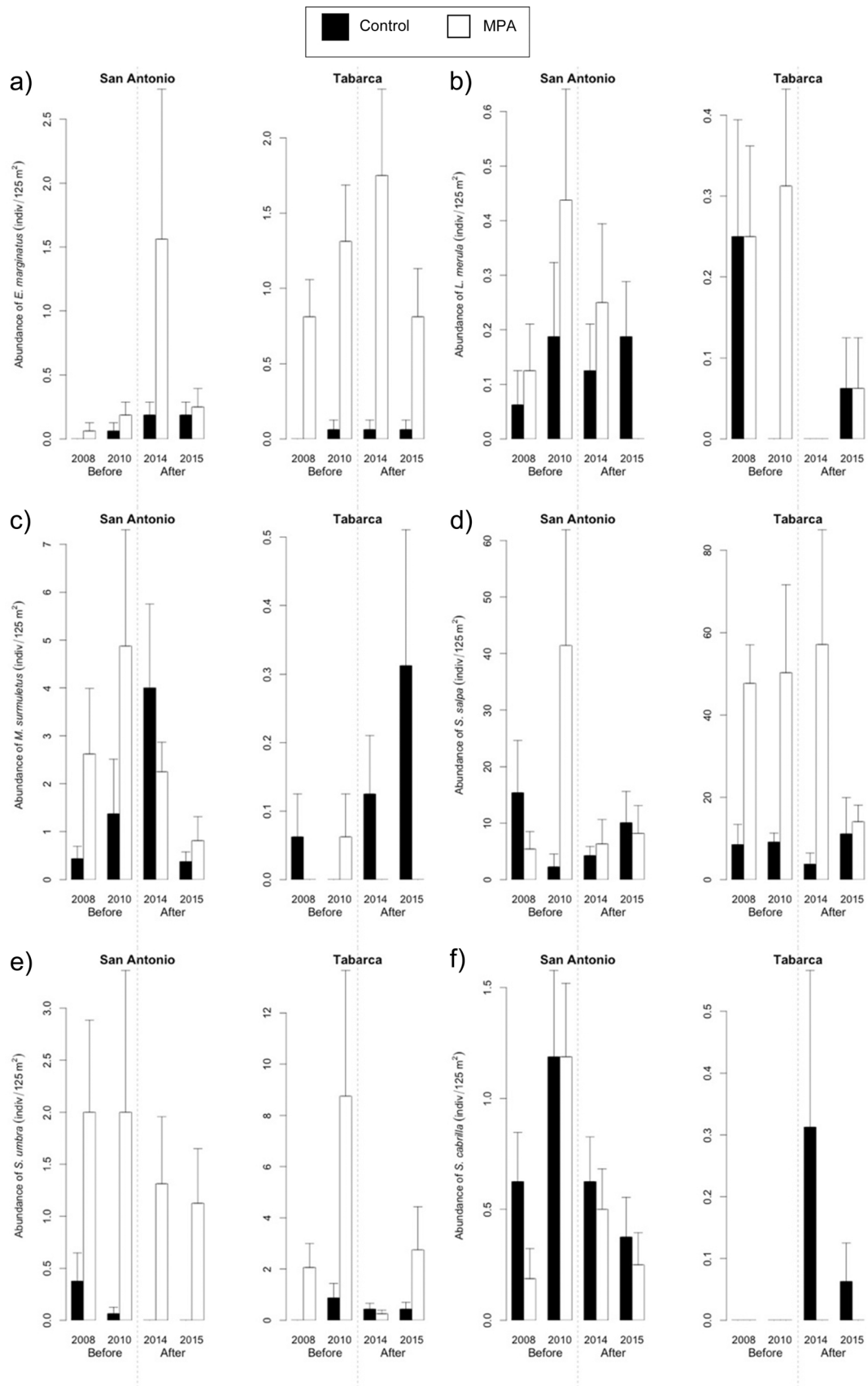


Fig. B2. Mean abundance values ± standard error of: (a) *Epinephelus marginatus*, (b) *Labrus merula*, (c) *Mullus surmuletus*, (d) *Sarpa salpa*, (e) *Sciaena umbra* and (f) *Serranus cabrilla* in San Antonio and Tabarca reserves, and their respective controls, during the different sampling years before and after the crisis.

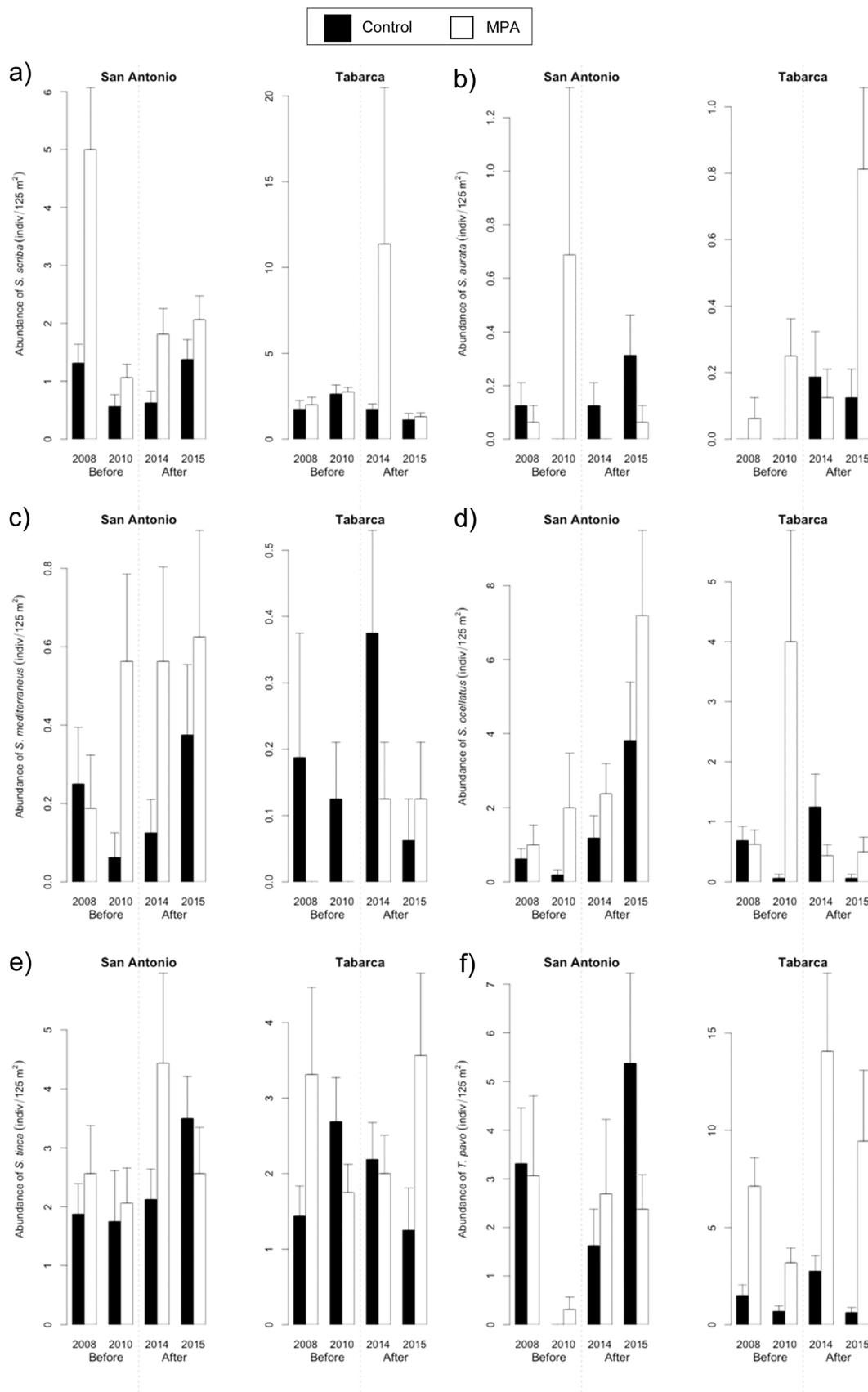


Fig. B3. Mean abundance values \pm standard error of: (a) *Serranus scriba*, (b) *Sparus aurata*, (c) *Symphodus mediterraneus*, (d) *Symphodus ocellatus*, (e) *Symphodus tinca* and (f) *Thalassoma pavo* in San Antonio and Tabarca reserves, and their respective controls, during the different sampling years before and after the crisis.

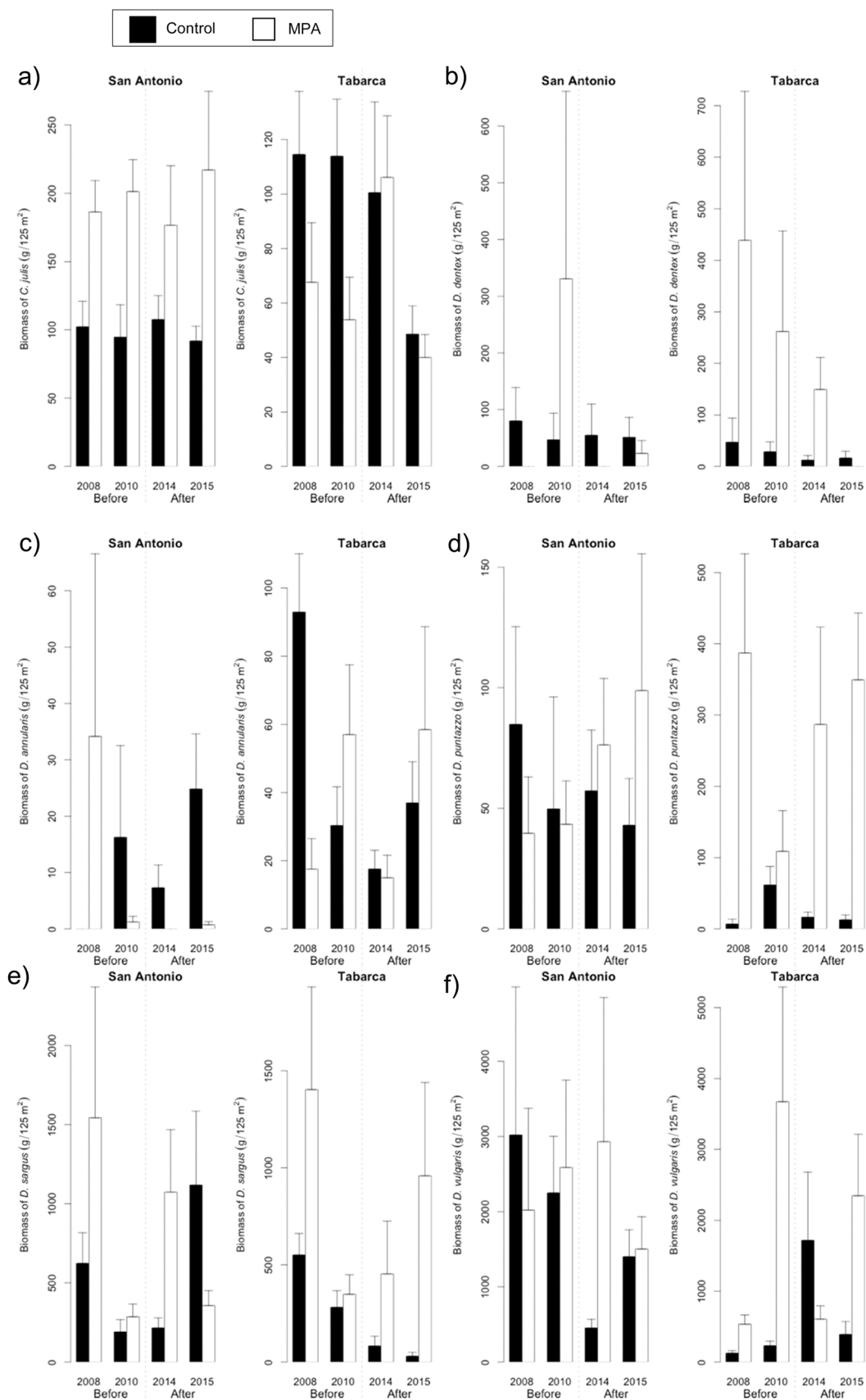


Fig. B4. Mean biomass values ± standard error of: (a) *Coris julis*, (b) *Dentex dentex*, (c) *Diplodus annularis*, (d) *Diplodus puntazzo*, (e) *Diplodus sargus* and (f) *Diplodus vulgaris* in San Antonio and Tabarca reserves, and their respective controls, during the different sampling years before and after the crisis.

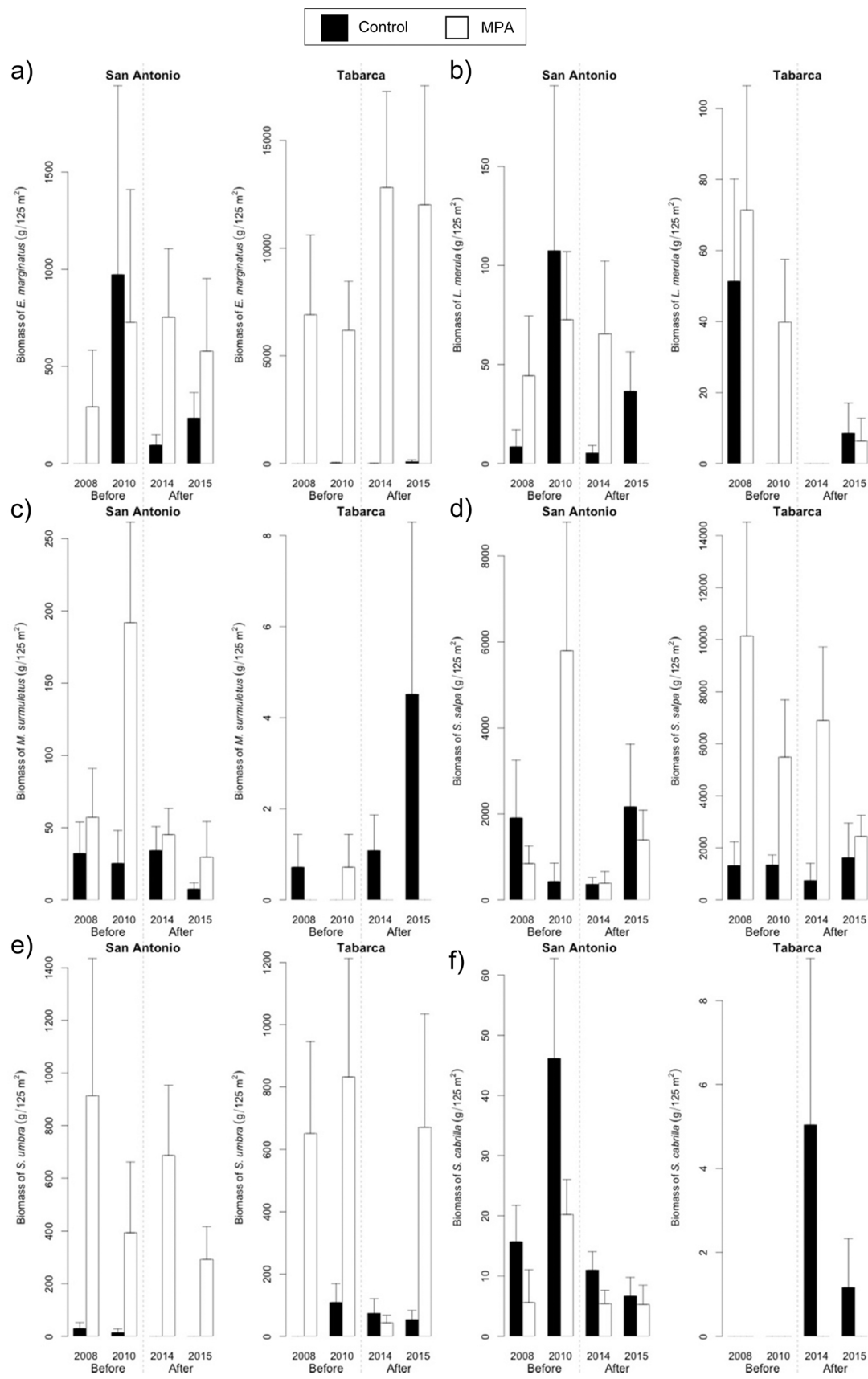


Fig. B5. Mean biomass values \pm standard error of: (a) *Epinephelus marginatus*, (b) *Labrus merula*, (c) *Mullus surmuletus*, (d) *Sarpa salpa*, (e) *Sciaena umbra* and (f) *Serranus cabrilla* in San Antonio and Tabarca reserves, and their respective controls, during the different sampling years before and after the crisis.

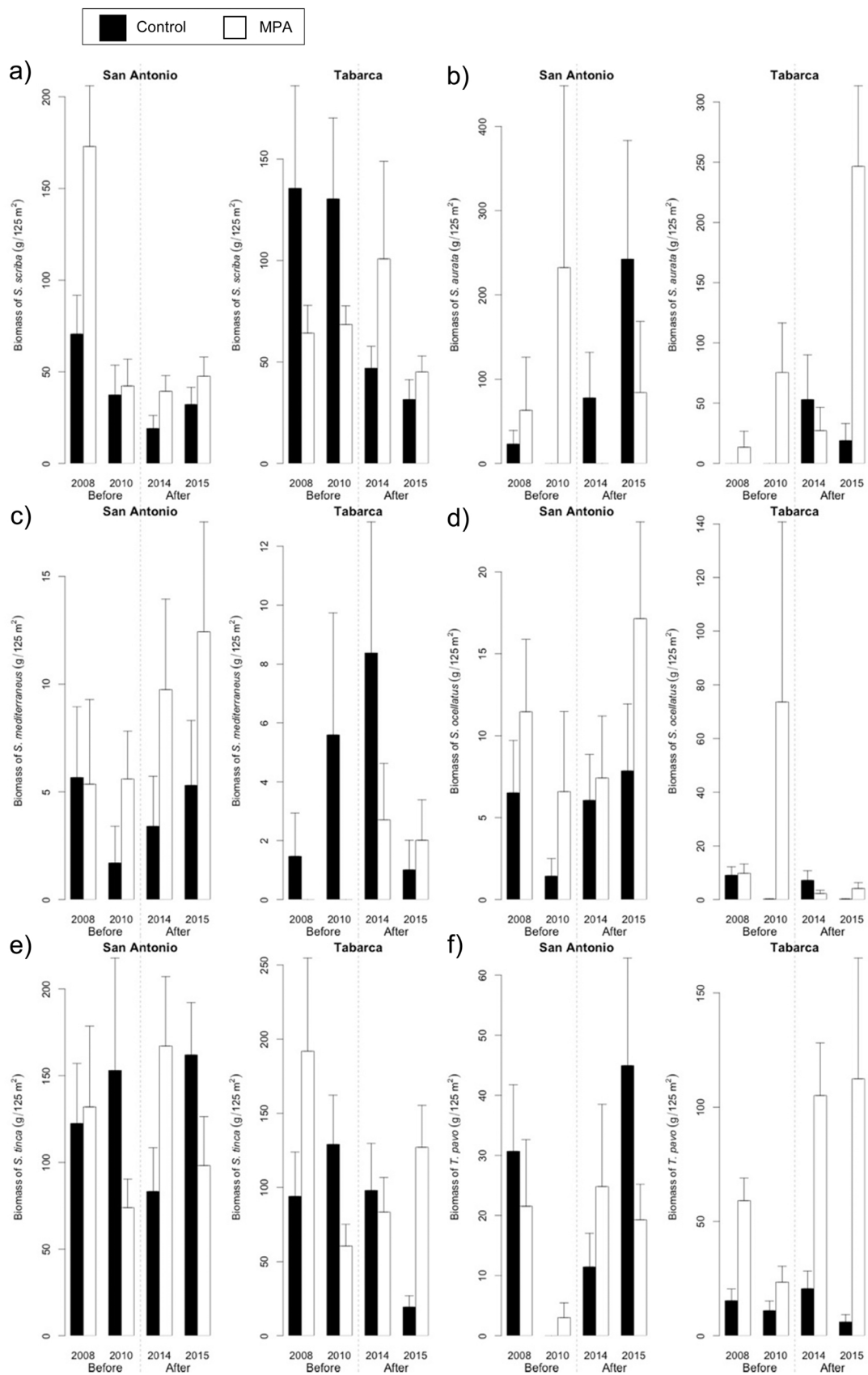


Fig. B6. Mean biomass values ± standard error of: (a) *Serranus scriba*, (b) *Sparus aurata*, (c) *Symphodus mediterraneus*, (d) *Symphodus ocellatus*, (e) *Symphodus tinca* and (f) *Thalassoma pavo* in San Antonio and Tabarca reserves, and their respective controls, during the different sampling years before and after the crisis.

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