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Effects of protection on the demographic structure and abundance of *Epinephelus marginatus* (Lowe, 1834). Evidence from Cabrera Archipelago National Park (West-central Mediterranean)

*Effets de la protection sur la structure démographique et l'abondance d'*Epinephelus marginatus *(Lowe, 1834). L'exemple du Parc national de l'archipel des îles Cabrera (Méditerranée centre-ouest)*

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Mots clés : Epinephelus marginatus*, effets de la protection, réserve marine, mer Méditerranée.*

ABSTRACT

Reñones O., R. Goñi, M. Pozo, S. Deudero, J. Moranta, 1999 - Effects of protection on the demographic structure and abundance of Epinephelus marginatus *(Lowe, 1834). Evidence from Cabrera Archipelago National Park (West-central Mediterranean).* Mar. Life*, **9** (2) : 45-53.*

This study investigates the effects of the cessation of fishing on the density, size structure and depth distribution of dusky grouper, Epinephelus marginatus *(Lowe, 1834) (formerly* E. guaza*) in the Cabrera Archipelago National Park (Balearic Islands, Western Mediterranean). Underwater visual counts of* E. marginatus *were carried out on rocky substrates at depths of 5-10 m and 20-25 m during the summers of 1996 and 1998. Counts were done in areas of the Park closed to all fishing (since 1995) and closed only to sport fishing (since 1991) and in locations outside the Park open to all fishing. The two depth strata were chosen to evaluate possible bathymetric changes in distribution and size structure of* E. marginatus *as a result of the protection measures. In the Park, mean density of dusky grouper was higher in 1998 than in 1996. The size distribution also differed between the two time periods exhibiting a tendency towards rebuilding the natural size structure over time. The comparison of the* E. marginatus *population in the Park with those in areas open to all fishing corroborates the increase in mean density reported in other studies of Mediterranean marine protected areas. The size composition in exploited areas evidences a narrowing of the size structure with the virtual disappearance of small and large individuals. The results of the temporal and spatial comparisons suggest a strong response to protection or "reserve effect" in the population of* E. marginatus *in the Cabrera Archipelago National Park.*

RÉSUMÉ

*Reñones O., R. Goñi, M. Pozo, S. Deudero, J. Moranta, 1999 - [Effets de la protection sur la structure démographique et l'abondance d'*Epinephelus marginatus *'Lowe, 1834). L'exemple du Parc national de l'archipel des îles Cabrera (Méditerranée centre-ouest)].* Mar. Life*, **9** (2) : 45-53.*

Cette étude évalue les effets de la protection (cessation de la pêche sportive et professionnelle) sur la densité, la structure démographique et la distribution bathymétrique du mérou Epinephelus marginatus *(Lowe, 1834) (anciennement* E. guaza*) dans le Parc national de Cabrera (îles Baléares, Espagne,). Pendant les étés 1996 et 1998, des recensements visuels de mérous on été réalisés sur des fonds rocheux, à des profondeurs comprises entre 5-10 m et 20-25 m. Les recensements ont été effectués dans les secteurs du parc où toute sorte de pêche est interdite (depuis 1996) ; dans les secteurs où seule la pêche sportive est interdite (depuis 1991) ; et hors du parc, dans deux secteurs-témoins, ouverts à toutes les activités de pêche. Les deux fourchettes de profondeur ont été considérées afin d'évaluer les changements éventuels de la distribution bathymétrique des mérous associés avec les mesures de protection. Dans le parc, la densité moyenne des mérous était plus importante en 1998 qu'en 1996. La distribution des tailles est aussi différente pour ces deux périodes et elle montre une tendance vers la "naturalisation" de la structure de la population. La comparaison entre les populations dans le parc et dans les secteurs ouverts à la pêche confirme les accroissements de densité de mérous notés dans d'autres études des aires marines protégées en Méditerranée. La composition des tailles dans les zones exploitées montre une meilleure homogénéité de la structure de la population avec la disparition virtuelle des grands et des petits individus. Les résultats des comparaisons temporelle et spatiale suggèrent une forte réponse à la protection -ou "effet réserve"- des peuplements de mérous dans le Parc national de Cabrera.*

INTRODUCTION

Epinephelus marginatus (Lowe, 1834) (formerly *E. guaza*) (Pisces: Serranidae) is a sequential protogynous hermaphrodite fish with slow growth, relatively long life-span and sedentary habits (Chauvet, 1988). In the Atlantic Ocean its range extends from the British Isles to South Africa in the East and from Bermuda to Brazil in the West (Heemstra, Randall, 1993). It also occurs throughout the Mediterranean Sea, but it is absent from the Black Sea.

Like most other species of this genus, *E. marginatus* is of considerable importance to sport and commercial fisheries in the Mediterranean Sea, being one of the most emblematic, sought-after fish species. Its vulnerability to fishing, especially to spear fishing, together with variable recruitment and absence of juveniles in the North-Western Mediterranean (Chauvet, 1991), have lead to its designation as a species in need of special protection in the Mediterranean (Boudouresque *et al*., 1991) and to the establishment of a spear fishing moratorium in France. Most of the studies aimed at evaluating the effects of protection (i.e. cessation or reduction of fishing) in Mediterranean fish assemblages have evidenced a positive response (increased abundance and size) of *E. marginatus* populations (García-Rubíes, Zabala, 1990; Harmelin, 1990; Bayle-Sempere, Ramos-Espla, 1993; Dufour *et al*., 1995).

The Cabrera Archipelago National Park was created in 1991 (Balearic Islands, Western Mediterranean). Composed of 19 small Islands, it is one of the largest marine reserves in the Mediterranean with a coastline of 54 km and 87 km^2 of marine protected area. Since the creation of the Park the marine area has been subject to two types of fishery regulations. In 1991 trawling and all sport fishing were banned, leaving the Park open only to small-scale fishing. In 1995 some areas were set aside as integral reserves where only scientific activities were permitted, while the remainder of the Park continued to be open to small-scale fishing (figure 1).

In 1989, two years before the creation of the National Park, García-Rubíes (1993) studied the bathymetric distribution of *E. marginatus* in Cabrera waters between 5 and 40 m of depth. This author found low densities of *E. marginatus* with small specimens present in shallow waters and large individuals exhibiting a deeper distribution, In 1993, only two years after sport fishing had been banned, this species already appeared in the National Park in higher densities (Coll *et al*., 1995; Reñones *et al*., 1997) than those reported by García-Rubíes (1993).

The present study set out to investigate the population dynamics of *E. marginatus* population protected in the park and to identify the changes which may be associated with the protective measures (cessation of all fishing and sport fishing).

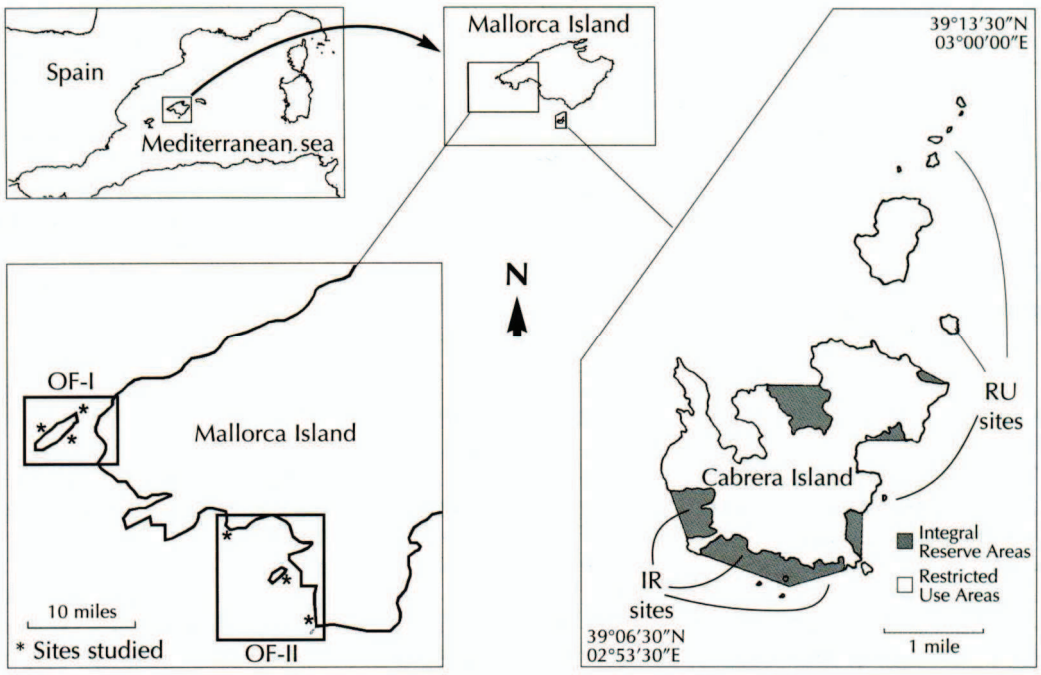

Figure 1 - Location of the study areas in Mallorca and Cabrera Islands (Balearic Islands, Western Mediterranean). IR: integral reserve areas where only scientific activities are allowed; RU: restricted use areas where only small-scale fishing is allowed; OF-I and OF-II: open fishing locations outside the Park where all fishing is allowed. / *Localisation des zones d'étude aux îles de Majorque et de Cabrera (îles Baléares, Méditerranée occidentale,). IR : réserve intégrale où seules les activités scientifiques sont autorisées ; RU : zones à utilisation restreinte où seule la pêche artisanale est autorisée ; OF-I et OF-II: zones ouvertes à la pêche, en dehors du parc, où toutes les pêches sont autorisées.*

Specifically, we wanted to know if dusky grouper were larger and more abundant inside the Park than in areas open to all fishing and if there were differrences between areas of the Park open to small-scale fishing and areas closed to all fishing. We were also interested in ascertaining possible changes in bathymetric distribution of *E. marginatus* associated with the various fishing regulations.

MATERIAL AND METHODS

Study locations

Visual counts were carried out in areas subject to the following management regimes: integral reserve (IR) where no fishing is allowed, restricted use areas (RU) where only small-scale fishing is allowed, and areas open to fishing (OF) where commercial and sport fishing are allowed. In 1998 two OF locations were surveyed (OF-I and OF-II) while in 1996 only one OF location was studied (OF). The Cabrera Archipelago National Park, where the IR and RU study areas are located, lies 5 miles South of Mallorca Island (Balearic Islands). The OF study areas are located about 23 nautical miles from the National Park on the South-West coast of Mallorca Island (figure 1). The OF locations were chosen on the basis of their similarity to those of the National Park in relief, substrate, oceanographic regime and bathymetric distribution of benthic communities. Hydrographically, all locations belong to the Algerian Basin, characterised by the presence of Modified-Atlantic-Water, which is warmer and less saline surface water than that of the Catalano-Balear Basin to which the North and West coasts of Mallorca Island belong (López-Jurado, 1990).

To assess bathymetric differences in distribution and abundance of *E. marginatus* and possible changes due to protection, two depth strata were considered: shallow (5-10 m) and deep (20-25 m). Similarly, to account for possible differences in density due to orientation, exposure or small-scale variability within each study area and depth stratum sampling was repeated at three sites chosen at random.

Sampling

Abundance and size of *E. marginatus* were estimated by underwater visual censuses along random 50 x 5 m transects in extended zones of medium to large boulders (less than 4 m high). The specimens detected out of the holes were recorded by a diver swimming slowly along the transect 1 m above the bottom. A second diver examining the holes under the blocks completed this census. To correct possible biases in density estimation due to different behaviour of *E. marginatus* in areas with and without spear fishing, in the OF locations the counts made by both divers were pooled to calculate the density in each transect. In the IR and RU locations only the specimens recorded out of the holes were taken into account. This correction does not interfere with the main results because the numbers of fish in the OF locations were always lower than in the IR and RU locations. Density was expressed as number of individuals per 250 m^2. The mean precision obtained in estimating fish size underwater was 4 and 8 cm for fish smaller and larger than 50 cm respectively. All sampling was done between 9 and 14 h GMT on clear days with a minimum horizontal underwater visibility of 20 m.

Spatial comparison

In 1996 three areas (IR, RU, OF) and two depth strata (shallow: 5-10 m and deep: 20-25 m) were surveyed. Three sites per study area and depth stratum combination were sampled and at each site 3 replicate transects were done over the period of 23 July-20 August. In 1998 four areas (IR, RU, OF-I and OF-II) and the same depth strata were sampled over the period of 7 July - 10 August. Three sites were randomly chosen within each study area and depth stratum combination and at each site 6 replicate transects were sampled.

The effects of location, depth and site on density of *E. marginatus* were tested by a three-factor partially hierarchical ANOVA. Location and depth were considered fixed factors and site was random and nested within location and depth. Tukey's test was used for comparison of significant effects after ANOVA (Zar, 1984). Before applying parametric tests the assumptions of normality and homoscedasticity were tested by Kolmogorov-Smirnov and Cochran's tests, respectively. When these assumptions were not met, data were transformed by Ln (x+1) (Underwood, 1981). Since the number of study locations (1996: 3; 1998: 4) and of replicate transects per site (1996: 3; 1998: 6) in the two study years differed, to avoid problems associated with unbalanced analysis of variance (Underwood, 1997) the spatial comparisons were carried out for 1996 and 1998 separately.

Marine reserve temporal comparisons

Differences of density of *E. marginatus* between 1996 and 1998 were assessed using visual count data from the IR and RU areas of the Park. To obtain equal sample sizes for the two years, 3 replicate samples were drawn from the 6 censuses carried out in 1998 at each site. Since the spatial analyses did not detect significant differences of density among sites, censuses from the 3 sites within each location and depth stratum combination were pooled. The effects of time and depth (fixed factors) on density were tested by a two-factor ANOVA.

Size frequency distribution

To assess depth related differences in size structure as well as their evolution over time, the length frequency distributions of *E. marginatus* were compared by the Kolmogorov-Sminnov test (Zar, 1984). A level of p=0.05 was used for significant differences between size distributions. The statistic used in the comparison is D_{max} largest absolute difference in any one category of the cumulative frequencies of the two size distributions compared. Due to the low number of specimens observed, counts from

the OF-I and OF-II areas sampled in 1998 were pooled. The number of specimens observed in the OF area surveyed in 1996 was very low and these size data were excluded from the analysis.

RESULTS

A total of 54 and 144 visual censuses of *E. marginatus* were carried out in 1996 and 1998 respectively. Mean densities (number of specimens per 250 m^2) by study area, depth stratum and year are presented in figure 2.

Spatial comparison

The spatial comparison yielded different results in the two time periods studied (table I). In 1996 there were significant differences in density of *E. marginatus* between areas with different fishery regulations and also between depths. Densities were significantly lower in the open fishing area (OF) than in the two areas inside the park (IR and RU) in which dusky grouper density was similar (table I). The density of *E. marginatus* was also significantly higher in the deep stratum than in the shallow one. These bathymetric differences were more pronounced in the RU area than in the IR area (figure 2). Site-related differences in density of *E. marginatus* were not significant.

For the 1998 data transformation did not entirely eliminate heterogeneous variances. Nevertheless ANOVA was carried out as it is robust to minor violations of this assumption (Underwood, 1981). The analysis revealed that dusky

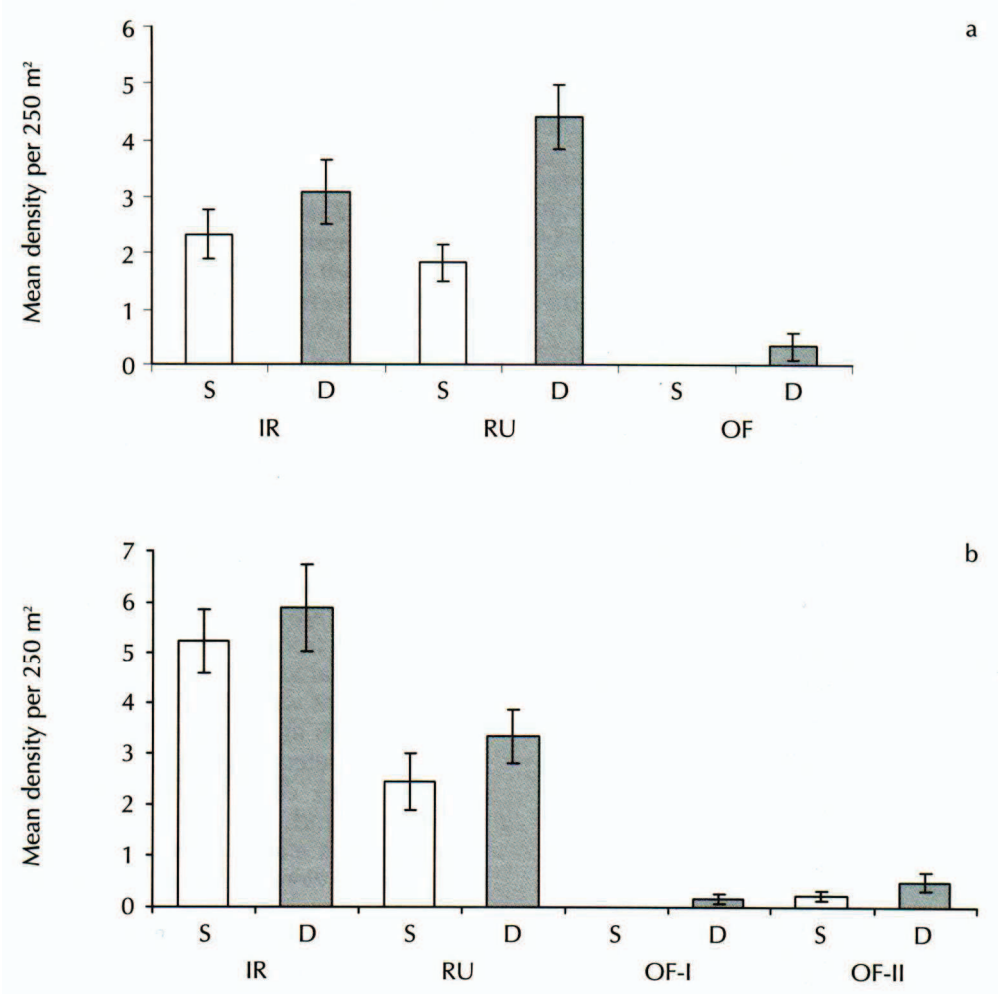

Figure 2 - Mean number of *E. marginatus* by 50 x 5 m transects in the integral reserve (IR) and in the restricted use (RU) areas of the Cabrera Archipelago National Park and in the open fishing (OF) areas studied off the Island of Mallorca in 1996 (a) and 1998 (b). S = shallow (from 5 to 10 m); D = deep (from 20 to 25 m). */ Nombre moyen de E. marginatus par transects de 50 x 5 m au sein des zones de réserve intégrale (IR) et à utilisation restreinte (RU) du Parc national de l'archipel de Cabrera, et dans les zones ouvertes à la pêche (OF), étudiées au large de l'île de Majorque en 1996 (a) et en 1998 (b). S = zone peu profonde (5 - 10 m) ; D = zone profonde (20 - 25 m).*

Table I - Effects of location, depth and site (nested within location and depth) on density of *Epinephelus marginatus* in Cabrera Archipelago National Park and Mallorca Island in 1996 (a) and 1998 (b). Analysis was a three-factor partially hierarchical ANOVA. The factors location and depth are fixed. Data were Ln (x+1) transformed. The results of the Tuckey's test (p critical: 0.05) are given. DF: degrees of freedom, MS: mean squares, n.s: non significant at p=0.05. / *Effets de la position géographique, de la profondeur et du site sur la densité de* E. marginatus *dans le Parc national de l'archipel de Cabrera et à l'île de Majorque en 1996 (a) et en 1998 (b). L'analyse est une ANOVA partiellement hiérarchique à trois facteurs. Les facteurs de localisation et de profondeur sont fixes. Les données sont transformées par Ln (x+1). Les résultats du test de Tuckey (p critique : 0,05) sont donnés. DF : degrés de liberté ; MS : carrés moyens ; ns : non-significatif à p=0,05.*

a

Source of variation	DF	MS	F - ratio	Probability	Tuckey's test
Location	2	8.231	38.50	p < 0.001	(IR = RU) > OF
Depth	1	1.733	8.105	p < 0.025	Depth > Shallow
Location x Depth	2	0.729	3.409	n.s.	
Site (Location, depth)	12	0.214	1.398	n.s.	
Residual	36	0.153			
Total	53				

b

Source of variation	DF	MS	F - ratio	Probability	Tuckey's test
Location	3	23.184	90.80	p < 0.001	IR > RU > OF-I = OF-II)
Depth	1	1.015	3.98	n.s.	
Location x Depth	3	0.070	0.78	n.s.	
Site (Location, depth)	16	0.255	1.33	n.s.	
Residual	120	0.192			
Total	143				

grouper density was higher in the IR than in the RU areas and that in both was higher than in the OF areas studied (table I). Mean density of *E. marginatus* was slightly higher in the deep than in the shallow stratum (figure 2), but the difference was not significant. For the two depth strata combined, mean density in the IR area was about twice that in the RU area and 30 times that found in the OF areas. As in 1996, site-related differentces in density were not significant.

Marine reserve temporal comparison

The density of *E. marginatus* in the IR and the RU areas of the National Park present different trends during the study period. In the integral reserve the density was significantly higher in 1998 than 1996 and this was consistent in the two depths examined (table II). In both years the mean density of *E. marginatus* was higher in the deep stratum than in the shallow one, although not significantly (table II and figure 2). Pooling the data from the two depths, in 1998 the mean density of *E. marginatus* in the integral reserve was about 5.5 individuals per 250 m^2, a two-fold increase since 1996.

In contrast, in the restricted use area mean density of *E. marginatus* did not change over time, with the overall mean values remaining around 3 individuals per 250 m^2. However, here density in the deep stratum was significantly higher than in the shallow one (table II). These bathymetric differences were more pronounced in 1996 than in 1998 (figure 2).

Table II - Effects of year and depth on density of *E. marginatus* in the integral reserve (IR) and restricted use (RU) locations of Cabrera Archipelago National Park. Analysis was a two factor ANOVA. The factors depth and year are fixed. Data were Ln (x+1) transformed which eliminated heterogeneous variances at a significance level of p = 0.05. DF: degrees of freedom, Ms: mean squares, n.s.: non significant at p=0.05. *I Effets de l'année et de la profondeur sur la densité de* E. marginatus *dans les zones de réserve intégrale (IR) et d'utilisation restreinte (RU) du Parc national de l'archipel de Cabrera. L'analyse est une ANOVA à deux facteurs. Les facteurs profondeur et année sont fixes. Les données sont transformées par Ln (x+1), ce qui élimine les variances hétérogènes à un niveau de signifiance de p=0,05. DF : degrés de liberté ; MS : carrés moyens ; ns : non-significatif à p=0,05.*

IR

Source of variation	DF	MS	F - ratio	Probability
Year	1	2.169	8.75	P < 0.025
Depth	1	0.298	1.21	n.s
Year x Depth	1	0.392	1.58	n.s
Residual	24	0.134		
Total	35			

RU

Source of variation	DF	MS	F - ratio	Probability
Year	1	0.079	0.484	n.s
Depth	1	3.570	21.768	p < 0.05
Year x Depth	1	0.152	0.928	n.s
Residual	24	0.368		
Total	35			

Table III - Mean total length (TL), standard deviation (SD) and length range of *Epinephelus marginatus* observed in 1996 and 1998 in the locations studied under different fishing regulations. / *Longeur totale moyenne (TL), écart type (SD) et éventail de longueurs des* Epinephelus marginatus *observés en 1996 et en 1998 dans les sites étudiés sous les différentes réglementations.*

Year	Regulation	Depth	Mean TL (cm)	SD	Length range (cm)
1996	Integral Reserve	Shallow	28.9	7.09	16 - 40
		Deep	37.8	13.15	16 - 92
	Restricted Use	Shallow	25.8	8.35	12 – 40
		Deep	40.3	11.60	24 - 76
1998	Integral Reserve	Shallow	33.1	12.52	8 - 60
		Deep	49.2	15.44	20 – 92
	Restricted Use	Shallow	34.0	12.05	12 – 60
		Deep	45.1	11.93	20 - 76
	Open Fishing	Shallow	25.0	6.00	20 - 32
		Deep	36.3	8.26	24 - 48

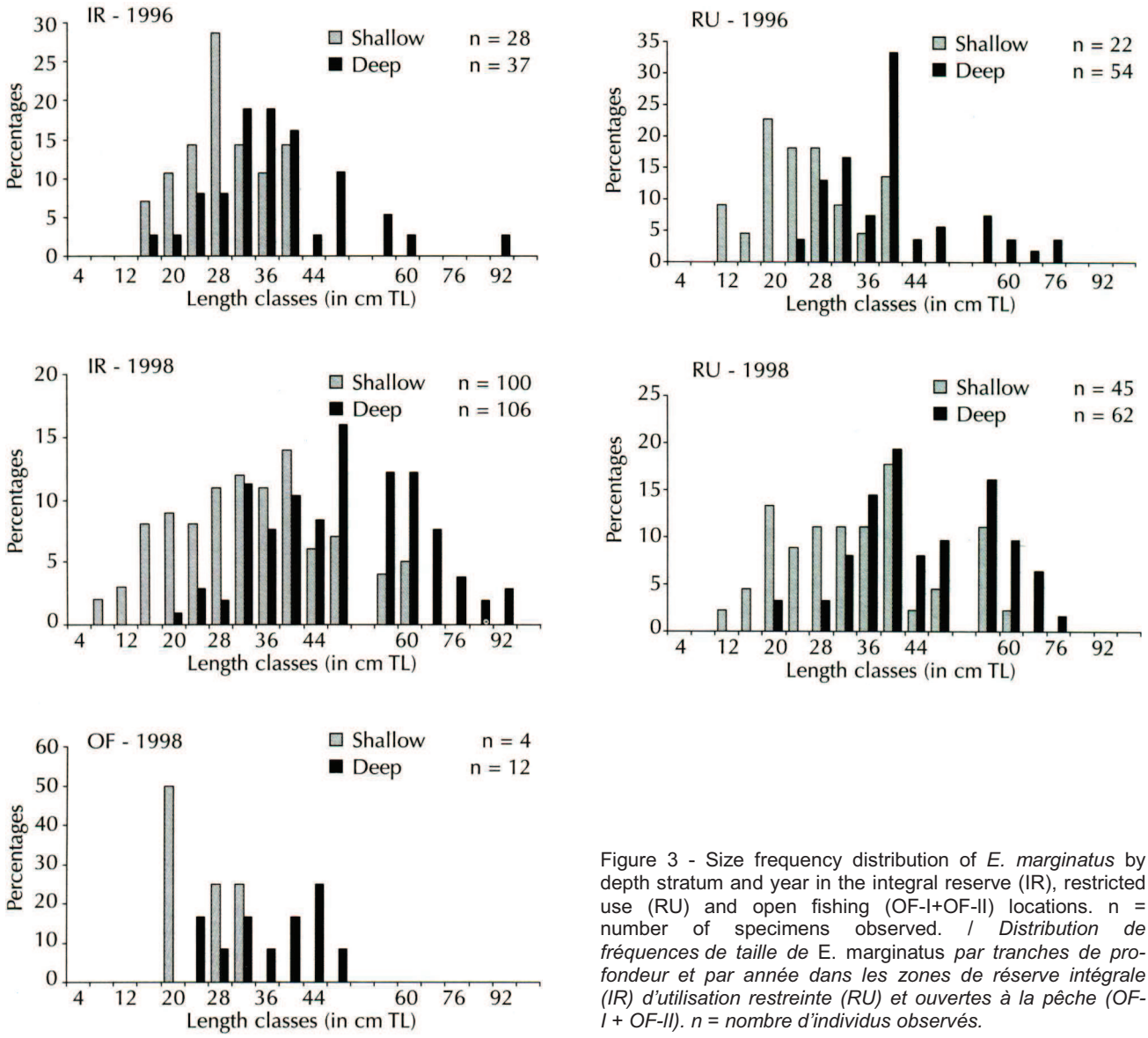

Figure 3 - Size frequency distribution of *E. marginatus* by depth stratum and year in the integral reserve (IR), restricted use (RU) and open fishing (OF-I+OF-II) locations. n = number of specimens observed. / *Distribution de fréquences de taille de* E. marginatus *par tranches de profondeur et par année dans les zones de réserve intégrale (IR) d'utilisation restreinte (RU) et ouvertes à la pêche (OF-I + OF-II). n = nombre d'individus observés.*

Size distribution

In the integral reserve the population of *E. marginatus* showed a different size distribution pattern with depth (1996: D_{max}=0.63, p>0.05; 1998: D_{max}=0.6, p<0.05). In 1996 the size range comprised specimens from 16 to 92 cm TL. All individuals observed in the shallow stratum were smaller than 40 cm TL and the modal length was 28 cm, whereas in the deep stratum the maximum and modal sizes were 92 cm and 32-36 TL respectively. Similar trends were observed in 1998 but with a widening of the range and a clear displacement of the modal and mean sizes towards higher values (table III and figure 3). This year, the length range was 8 to 92 cm TL, with maximum and modal sizes of 60 cm and 40 cm TL in shallow waters and of 92 cm and 48 cm in deep waters.

In the restricted use area, bathymetric differences in size structure were detected only in 1996 (D_{max}=0.58, p<0.05). The maximum size observed was 40 cm TL in the shallow stratum and 76 cm TL in the deep one, with the modal lengths at each depth clearly separated (figure 3). Relative to 1996, a net increase in modal and mean size was observed in the 1998 size distributions (table III, figure 3). In 1998 the size range in the shallow stratum was 12 to 60 cm TL, while in the deep stratum it was 20 to 76 cm TL, and the modal length in both strata was 40 cm TL.

The maximum difference (D_{max}=0.84, p<0.05) was found between the size distributions in the open fishing areas and those in the Park in 1998. When compared to the open fishing areas (OF-I + OF-II), size distributions in the IR and RU locations were characterised by a wider size range and a larger mean size, regardless of depth (table III and figure 3). The only three individuals observed in the OF location in 1996 were comprised between 40 and 48 cm TL.

DISCUSSION

The spatial comparisons show that the density and the mean and modal sizes are greater in the populations of *E. marginatus* in the Cabrera Archipelago National Park where sport fishing is forbidden (IR and RU areas) than in comparable areas open to all fishing outside the Park. With variations, these differences are maintained over time. Since this species is not affected by trawl fishing, this result suggests that protection from sport fishing has led to the recovery of the local population of *E. marginatus* in the National Park. This is not unexpected given the strong fishing pressure to which this species is subject throughout its Western Mediterranean range (Chauvet, 1991). The observed increase in density and mean size of *E. marginatus* as a result of reduced fishing pressure is consistent with results reported in most studies aimed at assessing the effects of protection on fish assem-blages in temperate and tropical areas (e.g. Bell, 1983; Cole *et al*., 1990; García-Rubíes, Zabala, 1990; Bayle-Sempere, Ramos-Espla, 1993; Polunin, Ro-berts, 1993; Watson, Ormond, 1994; Harmelin *et al*., 1995; Roberts, 1995; Jennings *et al*., 1996). The present study is based on data collected 5 and 7 years after the creation of the National Park, and 1 and 3 years after the creation of the integral reserves. Given that no comparable data are available from protected and control sites before fishing restrictions were in place (see below), the above statements are not con-clusive and the possibility that differences between fished an unfished areas existed prior to the establishment of the Park cannot be ruled out.

The result of the temporal comparison indicates that the abundance of *E. marginatus* is growing in the areas of the Park where all fishing is banned (IR), whereas in the locations open to small-scale (RU) on to both small-scale and sport fishing (OF), density has remained constant during the study period. These results suggest that the differences observed between fished and unfished areas are mainly due to increased survivorship in the IR areas. To be sure, a longer time-series of standardised density estimates would be required to assess the extent to which inter-annual variability in population distribution also plays a role in the observed abundance trends. Density of *E. marginatus* in the Park was estimated two years before (García-Rubíes, 1993) and two years after its creation in 1991 (Coll *et al*., 1995; Reñones *et al*., 1997) and in one open fishing area off Mallorca Island in 1994 (Moranta *et al*., 1997). However the use of repeated sampling of fixed transects in these studies, rather than of random transects as in the present study, precludes quantitative comparisons between the two sets of data.

The higher density observed in the IR areas relative to the UR areas indicates that the impact of small-scale fishing on the population of *E. marginatus* in the Park may be significant. This impact would be responsible for the lower densities of *E. marginatus* in RU areas relative to IR areas only 3 years after they were established. Since overall fishing effort (number of units) in the Park appears to have remained unchanged since 1995 (Park wardens' sighting data), an indirect effect of the reduction of fishing grounds caused by the creation of IR areas may have been a displacement of fishing effort towards the nearby RU areas. The lower abundance of *E. marginatus* in the RU areas is consistent with widely reported responses of populations of target species to increased exploitation (e.g. Koslow *et al*., 1988; Russ, Alcala, 1989, 1996; Alcala, Russ, 1990; Watson, Ormond, 1994; Jennings, Lock, 1996; Goñi, 1998). However, in spite of this plausible increase in effort in RU areas, on board sampling in fishing units operating in the Park does not suggest a high fishing mortality of this species by the small-scale fishing. A certain degree of poaching by spear fishers is another factor that may have contributed the stabilisation of E. marginatus in RU areas. Most of the RU areas lie in the Northern part of the Park that is closer to Mallorca harbours and relatively isolated from the core of the Park. We believe that the Park wardens have difficulty controlling poaching by sport fishers in these areas. During our surveys it

was not rare to observe specimens with spear marks in some RU sites.

The narrow size distribution and low density of *E. marginatus* observed in the exploited areas outside the Park is indicative of a strong, non size-selective fishing pressure exerted on this species by a wide variety of fishing activities in Mallorca island. In contrast, examination of the size distributions of *E. marginatus* in IR versus RU areas and in 1996 versus 1998 indicates of a swift response of local populations to the cessation of fishing. Accordingly, the size distribution in IR areas has evolved to include most of the age classes and probably in proportions approaching those of unfished, natural populations. The progressive colonisation of shallow habitats by larger specimens has also taken place together with an increase in mean size in shallow and deep waters, as has been found in other protected populations (e.g. Buxton, Smale, 1989; Roberts, Polunin, 1991; Harmelin *et al*., 1995). Inspection of the size distributions of *E. marginatus* in the shallow stratum indicates that only specimens below 16 cm total length (age classes 0 and 1 according to Chauvet, 1988), are restricted to shallow habitats, and the size increases with depth.

The size frequency distributions observed in all areas of the Cabrera National Park is very different from those reported in other Western Mediterranean marine reserves (Chauvet, Francour, 1989; Chauvet *et al*., 1991; García-Rubíes, Zabala, 1995). In Cabrera the population is dominated by specimens smaller than 60 cm TL whereas the largest ones (above 85 cm TL) are infrequent. In the marine reserves located North of the Cabrera Archipelago, such as the Medes Islands, Port-Cros on Carry-le-Rouet, the local populations of *E. marginatus* appear to be mainly composed of specimens in the medium and larger size classes. This size structure has been attributed to the absence of recruitment in these populations, which would depend on recruitment taking place further South and by the immigration of subadults. In contrast the size structure of *E. marginatus* observed in the Cabrera National Park suggests that the population is self-recruiting. Young of the year can be easily observed from 0.5 to 2 m of depth in rocky littoral areas all around Mallorca and Cabrera Islands (personal observations). This fact may have contributed to the rapid build-up of the *E. marginatus* populations only seven years after the first protective measures were introduced.

Ongoing assessment of *E. marginatus* populations in the different areas of the National Park and adjacent fishing grounds using standardised methods should help determine the extent of the population build-up, possible spill-over effects and the impact of small-scale fishing. An important but as yet little tested prediction made for marine reserves is that catches surrounding a marine reserve will increase due to net movement out of the protected area (Roberts, Polunin, 1993; Russ, Alcala, 1996). If true, this would compensate fishermen for possible lost production in the integral reserve areas and make maintenance of fishing restrictions in the Cabrera Archipelago National Park economically and socially attractive.

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