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Protection measures and juveniles of dusky grouper, *Epinephelus marginatus* (Lowe, 1834) (Pisces, Serranidae), in the Marine Reserve of Ustica Island (Italy, Mediterranean Sea)

Mesures de protection et juvéniles de mérou, Epinephelus marginatus *(Lowe, 1834) (Pisces, Serranidae), dans la Réserve marine de l'île d'Ustica (Italie, mer Méditerranée)*

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ABSTRACT

Vacchi M., G. La Mesa, M.G. Finoia, P. Guidetti, S. Bussotti, 1999 - Protection measures and juveniles of dusky grouper, Epinephelus marginatus *(Lowe, 1834) (Pisces, Serranidae), in the Marine Reserve of Ustica Island (Italy, Mediterranean Sea).* Mar. Life*, **9** (2) : 63-70.*

The density and the spatial distribution of juveniles of the dusky grouper Epinephelus marginatus *(Lowe, 1834) was assessed from September 1995 to September 1997 in the Marine Reserve of Ustica. Visual censuses were seasonally carried out in the shallow coastal waters of the island. The study area was constituted by several sampling sites in the three zones of the reserve that are characterised by different levels of protection. The influence of protection level, sampling period and bottom morphology on the density of grouper juveniles was evaluated by means of statistical analysis. No significant difference in abundance was detected among the three zones for the smallest size class (0-10 cm TL) whereas the number of the larger juveniles (11-30 cm TL) was positively correlated with the protection level. The grouper density showed seasonal variations, with the lowest values occurring in winter. Neither the substratum morphology and the bottom slope seemed to affect the distribution pattern of juveniles.*

RÉSUMÉ

Vacchi M., G. La Mesa, M.G. Finoia, P. Guidetti, S. Bussotti, 1999 - [Mesures de protection et juvéniles de mérou, Epinephelus marginatus *(Lowe. 1834) (Pisces, Serranidae), dans la Réserve marine de l'île d'Ustica (Italie, mer Méditerranée)].* Mar. Life*, **9** (2) : 63-70.*

Le mérou Epinephelus marginatus *(Lowe, 1834) a été étudié de septembre 1995 à septembre 1997 dans la Réserve marine de l'île d'Ustica par des recensements visuels saisonniers, afin d'évaluer la densité et la distribution des juvéniles dans les eaux côtières superficielles. Le recensement a été effectué dans plusieurs sites, dans les trois zones de la Réserve caractérisée par différents niveaux de protection. L'analyse statistique des données d'abondance a permis d'évaluer l'influence du niveau de protection, de la période d'échantillonnage et de la morphologie du fond sur les juvéniles de mérou. Pour la plus petite classe de taille considérée (0-10 cm LT), on n'a pas enregistré de différence significative d'abondance entre les trois zones, tandis que le nombre des autres juvéniles (11-30 cm LT) est positivement corrélé au niveau de protection. La densité des petits mérous a montré des différences saisonnières, avec une diminution en hiver. Par contre, la morphologie du fond ou la pente semblent peu influencer la distribution des petits mérous.*

INTRODUCTION

The dusky grouper *Epinephelus marginatus* (Lowe, 1834) is one of the most popular Mediterranean littoral fishes. During the last decades, this species has suffered increasing levels of fishing pressure because of its high commercial value, resulting in the dramatic decline of dusky grouper stocks in the NW Mediterranean aggravated by further decline due to its ecological and biological fea-

tures. In such a context, this serranid has become more and more bashful and fearful thus shifting to deeper bottoms (Bruslé, 1985).

However, the prohibition or the regulation of the fishing activities in the marine protected areas allowed the dusky grouper to reach a reasonable population density at very shallow depth as well (Harmelin *et al*., 1995; Zabala *et al*., 1997). Such a situation was observed in the marine reserve of Ustica, during a study carried out on the fish assemblage of the island (La Mesa, Vacchi, 1999).

Starting from our first findings, we have collected data on the distribution pattern and density of the juveniles of *E. marginatus* in the shallowest coastal zone of the island.

In this paper the role of protection level, seasonality and habitat features on grouper abundance variability was evaluated.

MATERIAL AND METHODS

Ustica is a small volcanic island (area 8 Km^2) in the Southern Tyrrhenian Sea (Mediterranean Sea), 36 miles North of the Sicilian coast. Established in 1986, the reserve of Ustica is one of the most important Italian marine protected areas, in terms of size and management efficiency. The coastal area of the island is divided into three different zones, A, B and C, characterised by a decreasing level of protection (figure 1).

In zone A (integral reserve), a small area (350 m offshore) located along the Northwestern coast, all fishing activities and navigation are forbidden. This core zone is surrounded by zone B (general reserve), in which local small-scale fishing, angling and diving are permitted. In zone C (partial reserve), which includes the South coastal area of the island, local small-scale fishing (with municipal authorization) and all types of recreational fishing (including spear fishing) are allowed.

During five surveys carried out from September 1995 to September 1997, the shallow-water population of dusky grouper (*E. marginatus*) was visually censused at several sites in the three reserve zones (figure 1). Overall, 145 censuses were performed using the random time-transect technique (Harmelin-Vivien *et al*., 1985; Harmelin, Marinopoulos, 1993) along strips of 5 m width, randomly placed between the coastline and 3 m depth. For each time-transect, the observer snorkelled during 15 min and recorded the number and size (total length, TL) of individuals and some bottom features (slope, type of substratum). The length of each time-transect ranged from 30 m to 45 m (from 150 m^2 to 225 m^2 censused surface areas).

Three types of hard substratum covered by photophilic algae have been identified: rocks (RAF), boulders (diameter larger than 30 cm) (BAF) and pebbles (diameter smaller than 30 cm) (PAF). The bottom slope (a) was defined as gentle ($0 < a < 23°$),

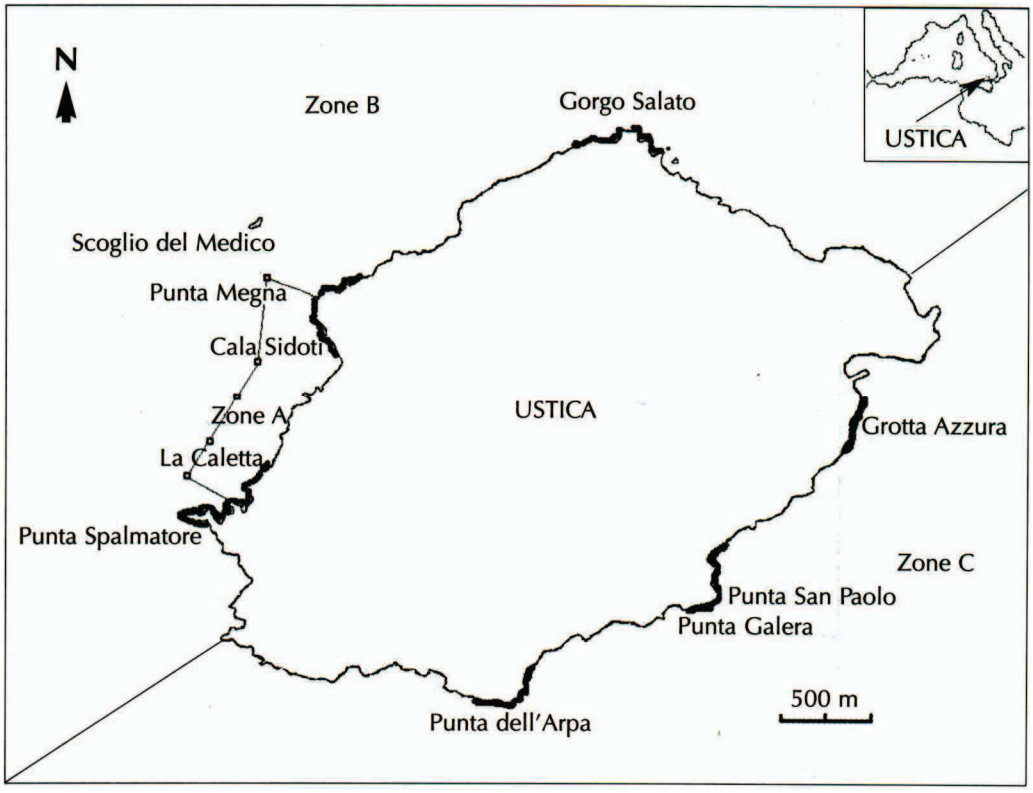

Figure 1 - Study area and location of sampling sites. / *Zone d'étude et localisation des sites de prélèvements.*

medium (23<a<45°), steep (45<a<67°) and sheer (67<a<90°) (Harmelin-Vivien *et al*., 1995).

Although the surface area censused during each transect was variable, a constant value, 150 m^2, was used for calculating the mean density of grouper. The censused individuals were grouped into three size classes 5-10 cm, 11-20 cm and 21-30 cm. The whole data set has been analyzed by means of a discriminant analysis. The influence of protection level on grouper density was evaluated by comparing the mean density of individuals estimated in the three reserve zones. To evaluate the abundance variability in time and according to the type of substratum and bottom slope, data collected in zones A, B and C was analyzed separately. The bottom slope data were grouped into two classes (gentle-medium and steep-sheer) and separately analyzed for the different substrata, when sampling was statistically sufficient. All statistical comparisons were performed by means of a Mann-Whitney U test.

RESULTS

Most of the grouper (95%) censused in the 0-3 m depth zone were young individuals (TL = 5-30 cm). As few individuals larger than 30 cm TE were observed, they were not considered in the analysis of data. The smallest grouper (TL = 5 cm) were sampled on September 1995 and were the early post-settlement individuals (0^+ age class) of that year (Chauvet, 1988).

The discriminant analyses attest that abundance was significantly related ($p<0.0001$) to the protection level (*i.e*. the sampling zone) (figure 2) or to the sampling period (tested as dependent variables). The factor scores assigned to zones A and C are clearly separated, whereas those of zones C and B partially overlap. The greatest contribution to this zone discrimination comes from the abundance data of the 21-30 cm size class.

Table I - Results of the Mann-Whitney U test for the differences in density among the three zones of the reserve. *P<0.05; **P<0.01; ***P<0.001. / *Résultats du test Mann-Whitney U des différences de densité entre les trois zones de la réserve. *P<0.05 ; **P<0,01 ; ***P<0.001.*

Size class	Zones			
11-20 cm	A	>	C	**
	B	>	C	*
21-30 cm	A	>	B	*
"	A	>	C	***
"	B	>	C	*

An evident shift can be detected between the factor scores of August 1996 and those of the other periods (mainly March 1997 and September 1997) which partially overlap. The 5-10 cm size class was mainly responsible for this shift.

In order to investigate the results of the discriminant analysis, the Mann-Whitney Test has been applied to the abundance data of the three size classes.

The mean density of grouper recorded in zones A, B and C during the whole study period has been calculated (figure 3). Density increased signifycantly with protection level for the 11-20 and 21-30 cm size classes, whereas it tended to decrease for the 5-10 cm class size (table I).

There is a notable variability in time of the mean density of grouper censused in the three zones of the Ustica reserve (figure 4). A remarkable decrease of grouper abundance in winter was the main seasonal

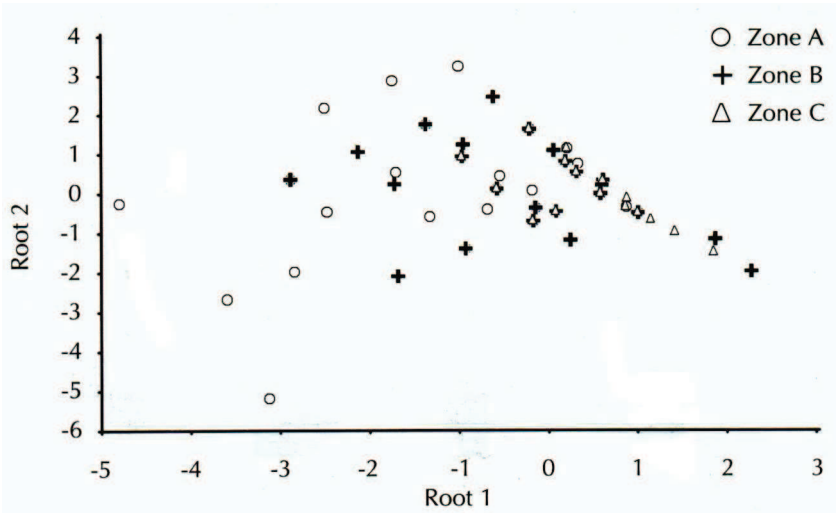

Figure 2 - Discriminant analysis of the whole abundance data. Scatter plot of discriminant functions among the three zones of the Ustica Reserve. / *Analyse discriminante de l'ensemble des données d'abondance. Courbe de dispersion des fonctions discriminantes entre les trois zones de la Réserve d'Ustica.*

Table II - Results of the Mann-Whitney U test for the difference in density among the sampling periods in the three zones of the reserve. *P<0.05; **P<0.01. / *Résultats du test Mann-Whitney U des différences de densité entre les périodes de prélèvement dans les trois zones de la réserve. *P<0.05 ; **P<0.01.*

Zone	Size class	Sampling periods			
A	0-10 cm	August 1996	>	March 1997	*
	"	"	>	September 1997	*
	11-20 cm	September 1995	>	March 1997	*
	"	June 1996	>	March 1997	*
	"	August 1996	>	March 1997	*
	21-30cm	September 1995	>	June 1996	*
	"	"	>	August 1996	*
	"	"	>	March 1997	*
	"	June 1996	>	March 1997	*
	"	September 1997	>	March 1997	*
B	0-10 cm	August 1996	>	September 1995	**
		"	>	June 1996	*
	"	"	>	March 1997	*
	"	"	>	September 1997	**
	11-20 cm	June 1996	>	March 1997	*
C	0-10 cm	August 1996	>	September 1997	**

trend, as evidenced by the significant differences among the surveys (table II). As for yearly differences, the comparison between the warm seasons shows that the highest density of individuals of the 0-10 cm size class was recorded on August 1996 (table II).

The mean density of grouper in relation to the type of substatum, calculated for the whole study period in zones A, B and C, is reported in figure 5. The highest number of individuals of 21-30 cm size class was everywhere observed in the BAF substratum, while the highest density of grouper of 5-10 and 11-20 cm size classes was registered on a different substratum within each zone. In zone A, a significantly higher number of individuals (the median) of 11-20 cm was censused on the RAF than on the PAF

Table III - Results of the Mann-Whitney U test for the difference in density among the different bottom types in the three zones of the reserve. BAF: boulders with photophilic algae; PAF: pebbles with photophilic algae; RAF: rock with photophilic algae. *P<0.05. / *Résultats du test Mann-Whitney U des différences de densité entre les différents types de fonds dans les trois zones de la réserve. BAF : éboulis rocheux à algues photophiles ; PAF : galets à algues photophiles. RAF: rochers à algues photophiles. *P<0.05.*

ZONE	SIZE CLASS	BOTTOM TYPES			
A	11-20 cm	RAF	>	PAF	*
C	0-10 cm	PAF	>	BAF	*

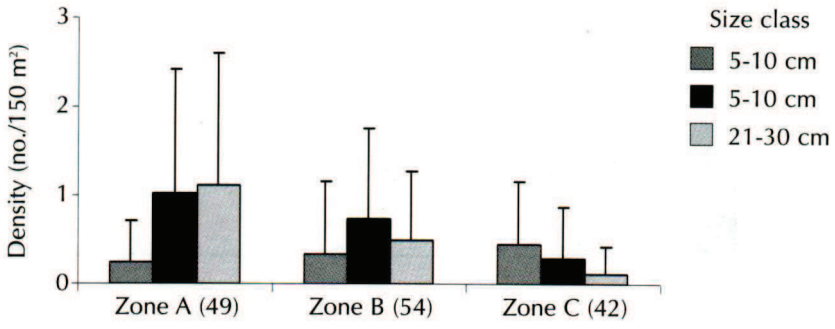

Figure 3 - Mean density (+ SD) of grouper in the three zones of the reserve. In brackets: number of performed time-transect. / Densité moyenne (+ écart-type) de mérous dans les trois zones de la réserve. Entre parenthèses : nombre de transects-temps réalisés.

substratum (table III). Conversely, in zone C the density of grouper of the 0-10 cm size class was higher on PAF than on RAF substratum.

The mean density of grouper calculated for the different bottom slope categories (figure 6) generally peaks on bottoms with gentle-medium siope in the three zones of the reserve. To evaluate the influence of bottom slope on grouper density, only one substratum has been considered for each zone, namely the RAF substratum for zones A and C and the BAF substratum for zone B. None of the comparisons showed any significant difference.

DISCUSSION

In the present study conducted in the marine reserve of Ustica Island the abundance of dusky grouper was assessed on a 0-3 m depth range. The location of recruitment habitats in such a shallow coastal area justified our sampling strategy.

The sampling design allowed us to evaluate differences in abundance in relation to protection degree, sampling season and bottom topography that characterise each zone of the marine reserve.

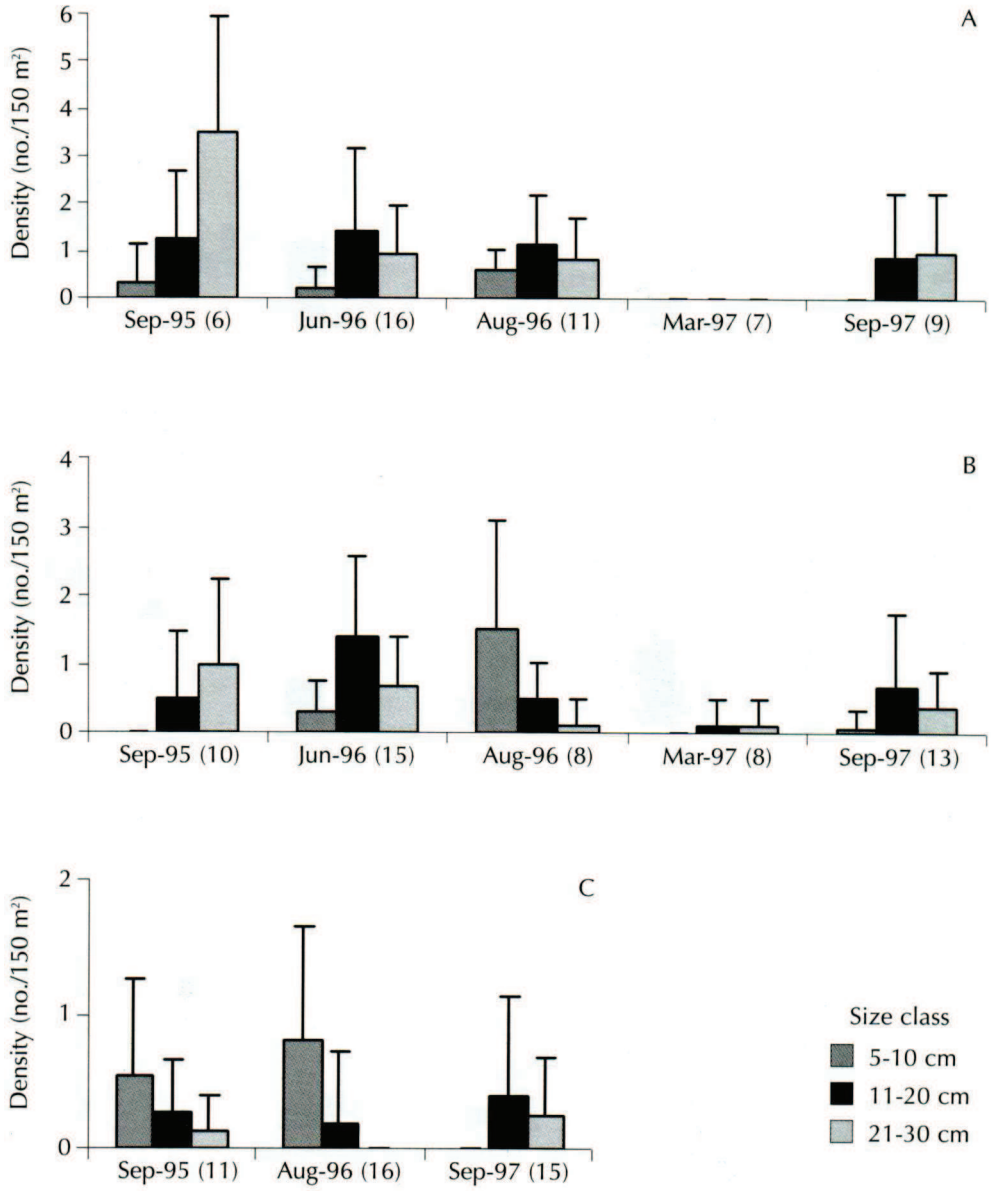

Figure 4 - Mean density (+ SD) of grouper in the three zones (A, B and C) of the reserve during each sampling period. In brackets: number of performed time time-transects. / *Densité moyenne (+ écart type) de mérous dans les trois zones de la réserve (A, B et C) pendant chaque période de prélèvements. Entre parenthèses : nombre de transects-temps réalisés.*

The discriminant analysis applied on the whole abundance data shows that both the protection level and the sampling season influenced the population density. The most relevant protection-related differrences were between zones A and C. Zone A contrasts with the other zones mainly because of the frequency of the 21-30 cm size class. This finding is probably due to the reserve effect in zone A on the larger grouper which, in the other zones, can be caught by the fishermen. The comparable density of the smaller individuals among zones suggests that they have a similar potential for recruitment.

As regards the variability in time of grouper abundance, the discriminant analysis indicates a partial overlap between the different surveys, except for August 1996. The significant yearly differences observed among the summer surveys for the smallest size class could be due to changes in post-settlement survival, for instance.

As suggested by our data, the decrease of grouper occurrence in the coastal area during winter, already observed for adults in some areas of North Western Mediterranean (Chauvet, Francour, 1989; Chauvet, 1991; Chauvet *et al*., 1991), seems to be an

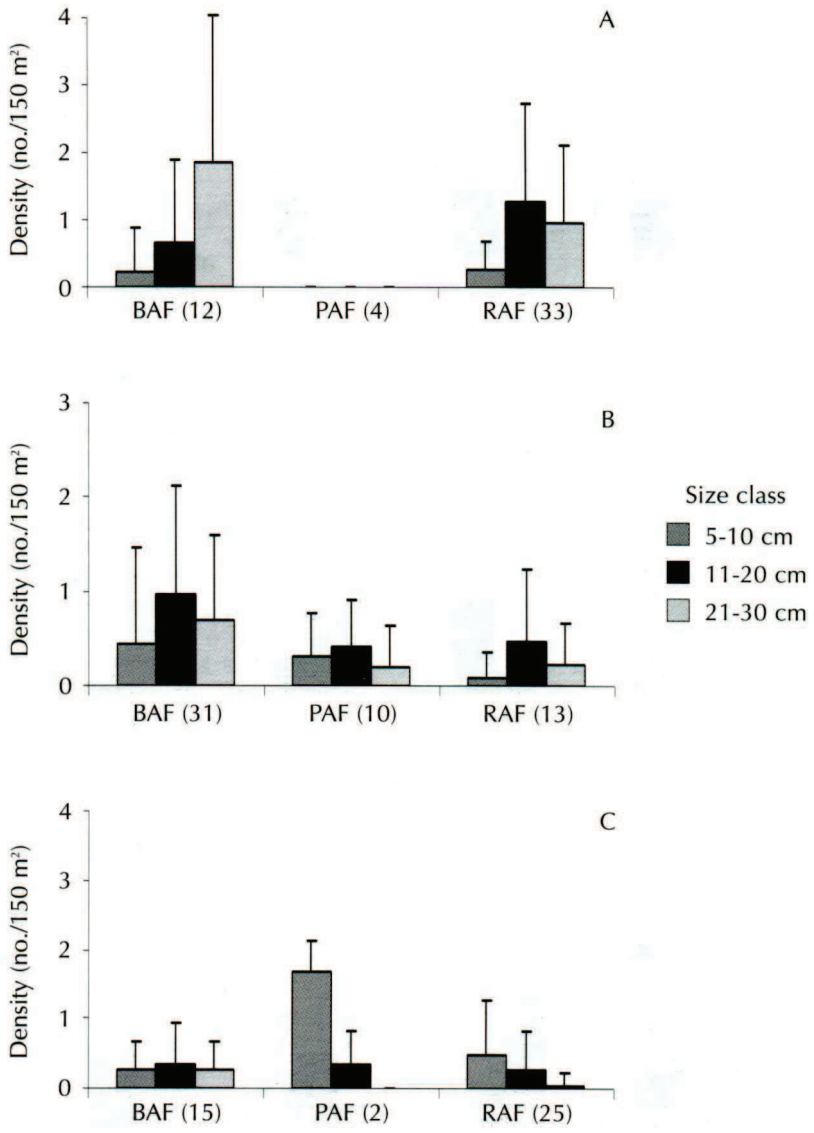

Figure 5 - Mean density censused on different substrata in the three zones (A, B and C) of the reserve. BAF: boulders with photophilic algae; PAF: pebbles with photophilic algae; RAF: rock with photophilic algae. In brackets: number of performed time-transect. / *Densité moyenne (+ écart-type) recensée sur différents substrats dans les trois zones de la réserve (A, B et C). BAF : éboulis rocheux à algues photophiles ; PAF : galets à algues photophiles; RAF : rochers à algues photophiles. Entre parenthèses : nombre de transects-temps réalisés.*

age-independent phenomenon, concerning also juveniles.

Although the discriminant analysis did not provide a significant model for the substratum type variable, the differences in abundance between the different substrata tested by means of the Mann-Whitney test were sometimes significant. Nevertheless, the above results should be considered with caution due to the small number of censuses for some substrata. However, the observed juveniles seemed to have no clear preference for substrate topography or bottom slope.

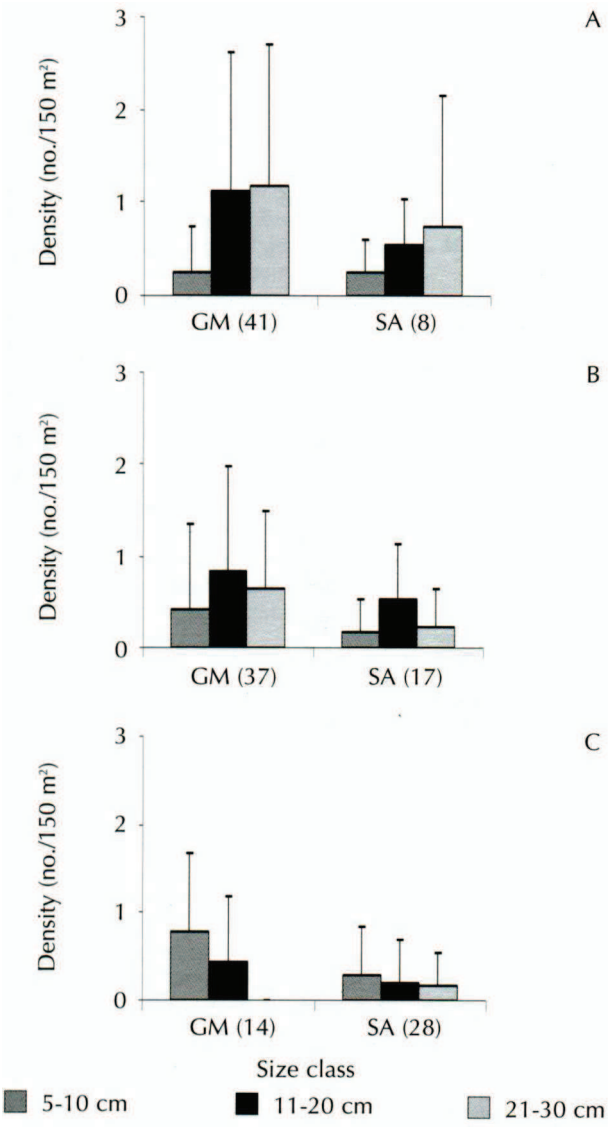

Figure 6 - Mean density (+ SD) of grouper censused on different bottom slope categories in the three zones (A, B and C) of the reserve. GM: gentle-medium slope; SA: steep-abrupt slope. In brackets: number of performed time-transect. / *Densité moyenne (+ écart type) recensée sur des différentes catégories de pentes de fond dans les trois zones de la réserve (A, B et C). GM : pente douce-moyenne ; SA : pente raide-abrupte. Entre parenthèses : nombre de transects-temps réalisés.*

CONCLUSION

The widespread distribution of dusky grouper in the shallow coastal zone of the Ustica marine reserve represents the most interesting finding revealed by the present study. The habitat suitability and the enforcement of restrictive measures on fishing activities probably interact in promoting this process.

The shallow rocky shores of all the three zones of the reserve seem to be suitable for the post-settlement phase of early juveniles. Conversely, the density of the larger young grouper increases with the level of protection, probably as a consequence of fishery exploitation (e.g. spear fishing).

The habitat suitability does not seem to be affected by the bottom heterogeneity defined on a large spatial scale (150 m^2 transect). Thus, holes and crevices in the rocky plateau could provide to young individuals the same shelter opportunities as offered by more uneven substrata (e.g. with boulders or pebbles).

The scarcity of records of grouper during winter is not still fully understood. An offshore migration or a stronger tendency to stay inside shelters in the wintertime could be hypothesized to explain such a phenomenon.

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