

Habitat use by the juvenile dusky grouper *Epinephelus marginatus* and its relative abundance, in Santa Catarina, Brazil

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Abstract

The dusky grouper (*Epinephelus marginatus*) is a species whose stock management deserves special attention. It has an important role in hard-bottom ecosystems and, as a protogynous hermaphrodite; it is especially susceptible to overfishing. Data on the species' use of habitat, and on the way environmental and behaviour parameters influence its abundance can help to improve management and conservation strategies. The aim of this study was to evaluate the influence of bottom type, temperature and species behaviour on the abundance of *E. marginatus*, using a quadrat for visual census. An area of 80 m², divided between rocky shore, rocky outcrop and sandy habitats was surveyed monthly. Densities of juveniles were: 1.16 groupers m⁻² over the rocky shore and 1.47 groupers m⁻² over the rocky outcrop, while no groupers were found over sand. Analysis of the yearly variation in abundance revealed a migratory pattern of dispersal and gathering. All size groups observed in this study were below the first maturation length.

Zusammenfassung

Der Braune Zackenbarsch (*Epinephelus marginatus*) ist eine Art, deren Bestand-Management besondere Beachtung verdient. Die Art nimmt eine wichtige Rolle in den Ökosystemen harter meeresböden ein, und als protogynen Hermaphrodit ist sie besonders empfindlich gegen Überfischung. Daten über die Biotopausnutzung dieser Art und die damit verbundenen Umwelt- und Verhaltensparameter, die den Bestand beeinflussen, können für verbesserte Bewirtschaftung und Erhaltungsstrategien von Nutzen sein. Das Ziel dieser Untersuchung war die Auswertung der Einflüsse von Bodenmaterial, Temperatur und Artverhalten auf den Bestand von *E. marginatus*, unter Verwendung eines Quadrates für visuelle Zählung. Ein Gebiet von 80m²,

entlang felsiger Küsten, an vortretenden Felsen und auf Sandbiotopen wurde in monatlichen Abständen inspiziert. Die beobachteten Dichten der vorkommenden Jungfische waren wie folgt: 1.46 Zackenbarsche pro Quadratmeter entlang der Felsküste und 1.47 Zackenbarsche an vorstehenden während auf dem sandigen Boden keine Zackenbarsche gefunden wurden. Auswertung der jährlichen Bestandsvariation zeigte ein treibendes Muster von Verteilung und Zusammenkommen an. Die in dieser Studie untersuchten Größengruppen befanden sich alle unterhalb der ersten Ausgewachsenen-Länge.

Résumé

Le mérout *Epinephelus marginatus* est une espèce dont la gestion du stock réclame une attention spéciale. Son rôle est important dans les écosystèmes à fonds durs et en tant qu'hermaphrodite protogyne; il est particulièrement sensible à la surpêche. Des données sur l'utilisation de l'habitat par l'espèce et sur la façon dont les paramètres d'environnement et de comportement déterminent sa fréquence peuvent aider à améliorer les stratégies de gestion et de préservation. L'objectif de cette étude consiste à évaluer l'impact du type de substrat, de la température et du comportement de l'espèce sur l'abondance de *E. marginatus*, à l'aide d'un quadrat de recensement visuel. Une surface de 80m², composée de littoral rocheux, d'affleurements rocheux et d'habitats sableux, a été contrôlée mensuellement. Les densités de juvéniles étaient de: 1,16 mérout au m⁻² sur le littoral rocheux et de 1.47 au m⁻² sur les affleurements, alors qu'ils n'apparaissaient pas sur les fonds sableux. L'analyse de la variation annuelle en abondance a révélé un schéma migratoire de dispersion et de rassemblement. Tous les groupes observés dans cette étude avaient une taille inférieure à celle de la première maturation.

Sommario

La cernia fosca (*Epinephelus marginatus*) è una specie il cui controllo merita un'attenzione particolare. Essa

svolge un ruolo importante negli ecosistemi dei fondali rocciosi e, in quanto ermafrodita protogino, è particolarmente soggetto a depauperamento per pesca eccessiva. Informazioni sull'occupazione dell'habitat e sul modo in cui i parametri ambientali ed etologici ne influenzano l'abbondanza possono essere d'aiuto per migliorare le strategie di controllo delle popolazioni e la loro conservazione. Scopo di questo studio è la valutazione dell'influenza del tipo di fondale, della temperatura e del comportamento sull'abbondanza di *E. marginatus*, utilizzando un quadrato per il censimento visivo. Un'area di 80m², divisa in scogliere, affioramenti rocciosi e fondali sabbiosi è stata controllata a scadenze mensili. Le densità di individui giovani erano : 1.16 per m⁻² sulle scogliere, 1.47 per m⁻² sugli affioramenti roccioso, mentre nessun individuo è stato osservato sui fondali sabbiosi. L'analisi della variazione annuale dell'abbondanza è compatibile con un modello di dispersione e riunificazione. Tutti gli individui censiti erano esemplari di taglia inferiore a quella di individui maturi.

Introduction

The dusky grouper, *Epinephelus marginatus* (Lowe, 1834) (Serranidae, Epinephelinae) (Fig. 1) inhabits rocky bottoms, from shallow water to depths of more than 200 meters and lives in caves, crevices and on ledges (Tortonese, 1986). Juveniles tend to occur close to the shore more frequently than adults (Sluka *et al.*, 2001), and are often found in rocky tidal pools (Bertoncini, 1999). This is a well-known teleost fish, widely distributed along the southern coast of Brazil and also throughout the Mediterranean and the eastern Atlantic from the British Isles to South Africa, the Azores, Madeira, the Canaries and Cape Verde, with a few records from the Indian Ocean (Barreiros, 1995).

As a predator at the top of its food chain, *E. marginatus* can play an important role in maintaining the ecological balance of hard-bottom ecosystems (La Mesa *et al.*, 2002). Besides its ecological importance, *E. marginatus* is a commercially valuable species in Brazil (Figueiredo & Menezes, 1980). It has an important economic role for local fisheries along the coast of Santa Catarina (Medeiros *et al.* 1997) and is also a target species for spearfishing and of interest to scuba diving.

E. marginatus is a protogynous hermaphrodite that forms reproductive aggregations and shows a complex social structure. A strongly biased sex ratio is characteristic of most Epinephelinae, making grouper stocks particularly susceptible to fishery pressure. Falcón *et al.* (1996), believe that fishery pressure exerts a strong impact on the abundance and distribution of commercial valuable species with such characteristics (see also Coleman *et al.*, 2000; Parker *et al.* 2000). These facts suggest that, in order to detect a decline in abundance due to overfishing, stocks of *E. marginatus* and variations in its environment should be monitored.

The aim of this study is to provide baseline data for management and conservation strategies. This paper presents data on habitat utilization and on some environmental/behavioural parameters, which may influence the abundance of *E. marginatus* juveniles.

Materials and Methods

Underwater Visual Censuses (UVC) were carried out monthly, from December 1998 to December 1999, on the rocky coast of Sepultura (048°29'W 27°09'S) (Fig. 2), Santa Catarina State, Brazil, using an 80 m² (2 x 40 m) quadrat. On each occasion, data on the abundance and size structure of the juvenile grouper were gathered during three 30-minute dives in the same area.

The quadrat was marked out with two measuring tapes and divided into three zones: rocky shore, rocky outcrop, and sandy (Fig. 3). The size and shape of the quadrat were chosen to give habitat heterogeneity as proposed by Krebs (1998).

Whenever a grouper was encountered, its length (TL) was estimated to the nearest 5cm and it was allocated to one of four size categories: 1) TL 5 - 15cm, 2) TL 16 - 25cm, 3) TL 26 - 35cm and, 4) TL 35- 45cm. Water temperature and depth were also recorded.

The Spearman test was used to test data correlation. The median abundance within samples was calculated by unifactorial analysis ($\alpha=0,05$). Significance was tested by the Turkey test; the Bartlett test was applied in order to verify the homogeneity of variances (Zar, 1996).

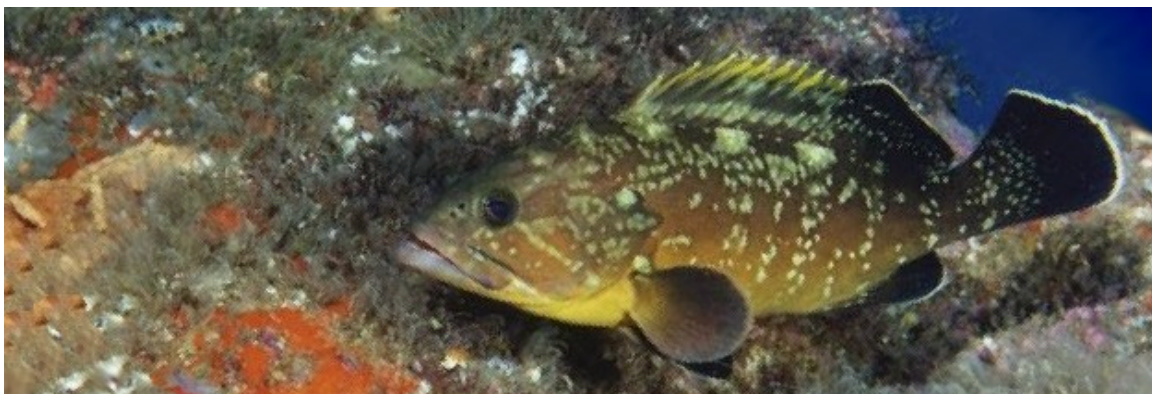


Fig. 1. Dusky grouper juvenile (*Epinephelus marginatus*). Photo by J.P. Cauduro Filho.

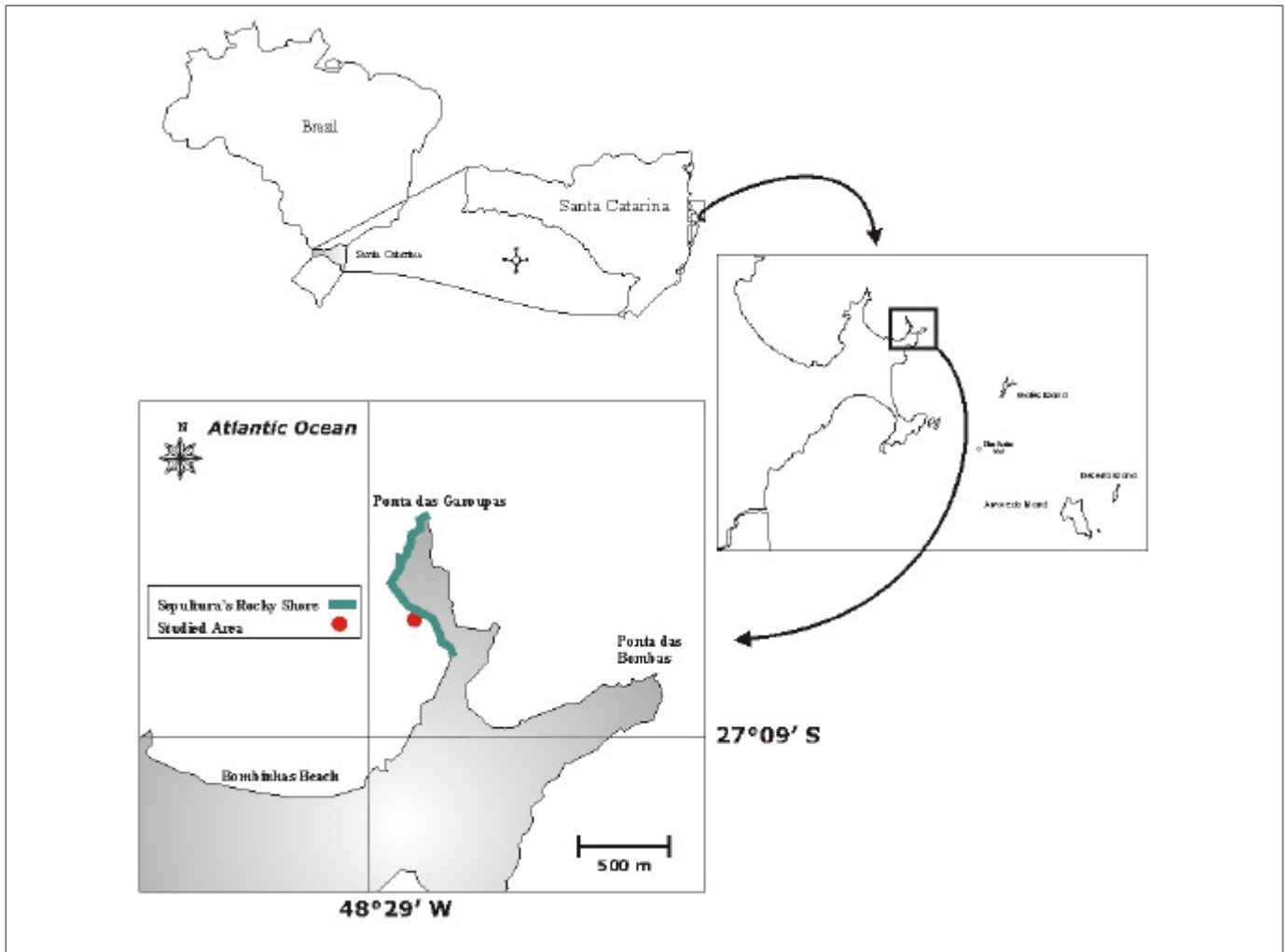


Fig. 2. Study site.

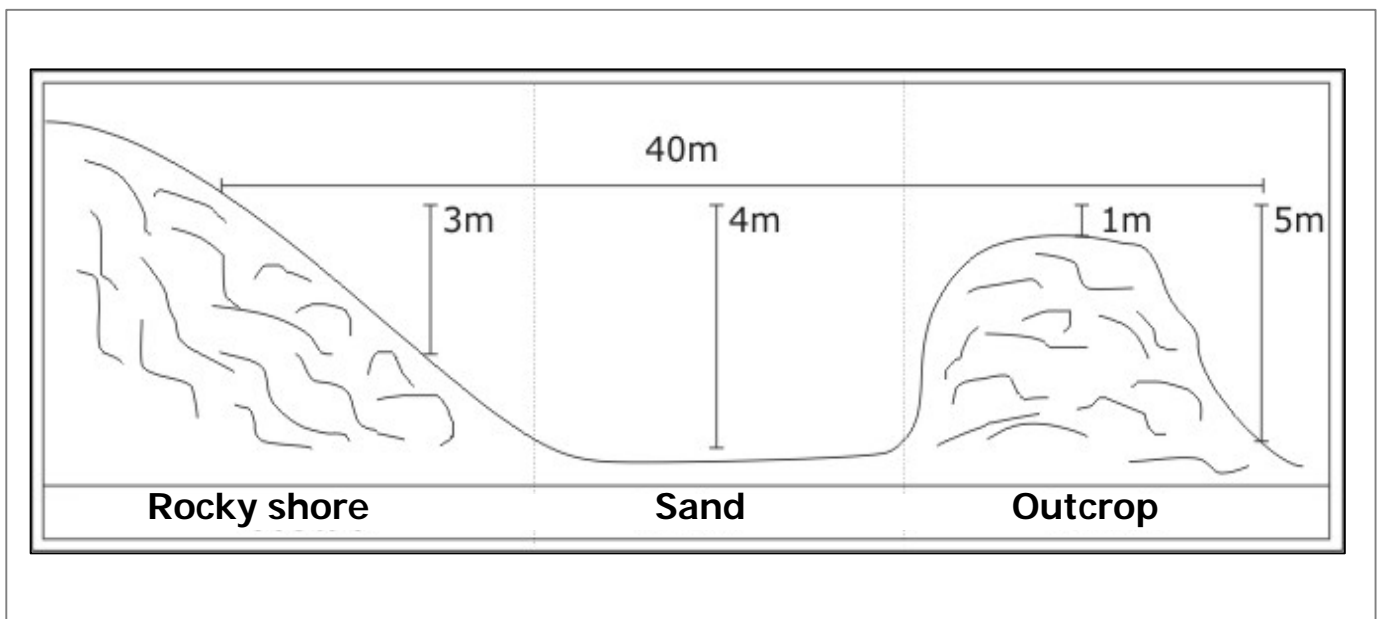


Fig. 3. Sampling area scheme.

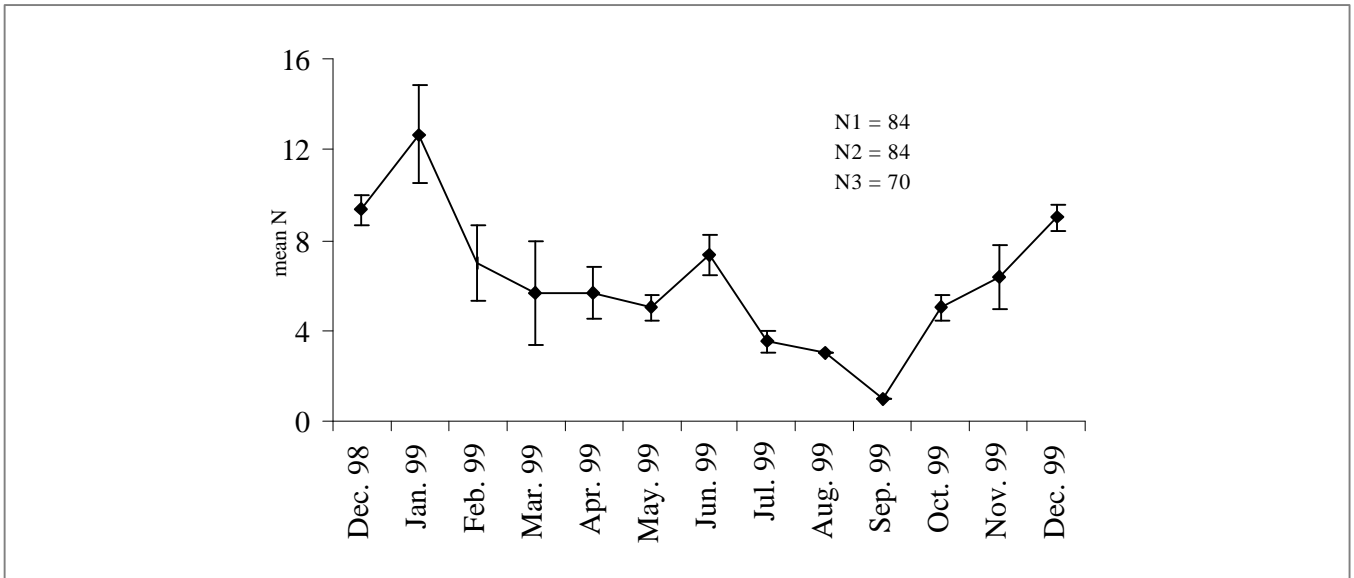


Fig. 4. Monthly mean number of groupers observed. Ni = total no. in the sample i. I = Confidence limits.

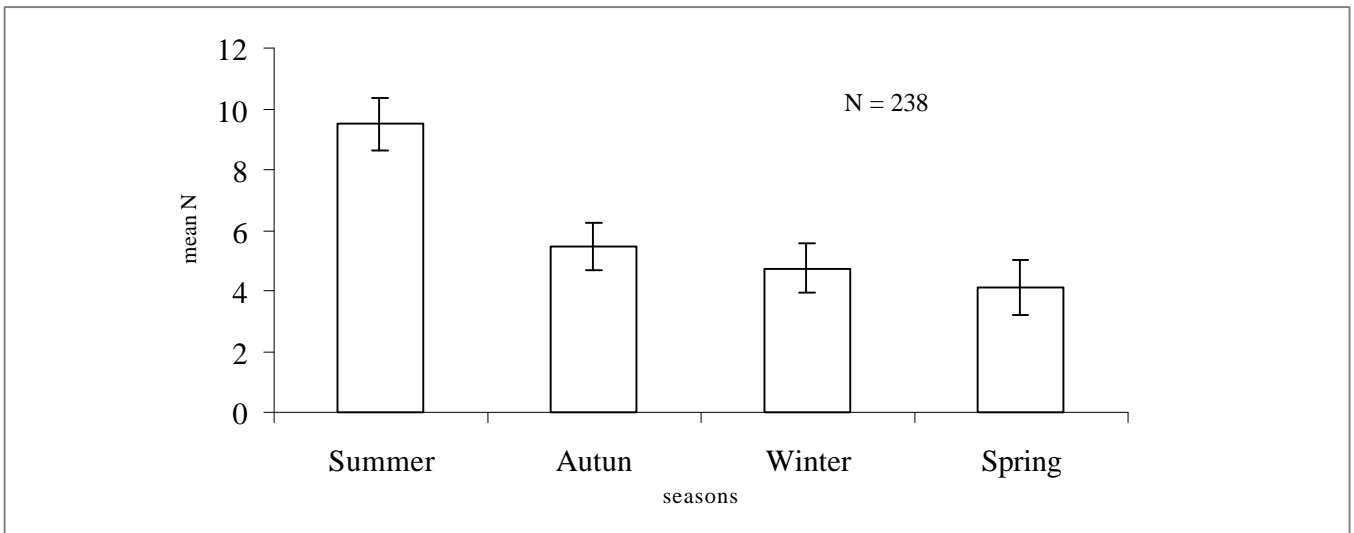


Fig. 5. Seasonal abundance of grouper juveniles.

Results and Discussion

There was a strong annual variation in the fish densities within the study area, suggesting a migratory pattern of a "dispersal-gathering" type. Groupers started to disperse immediately after the January's 1999 peak and the aggregation started in September 1999 (Fig. 4).

A similar abundance distribution pattern was found for *E. marginatus* in the Medes Islands Marine Reserve, NW Mediterranean, where its reproduction was also assessed (Zabala et al., 1997). Seasonal analysis showed that juveniles were significantly more abundant in the summer ($t = 4.1529, p < 0.01$). In subsequent seasons, the abundance fell and stayed low without significant variations (Fig. 5). It is known that smaller groupers (TL < 90cm) undertake small-scale seasonal migrations

along shallow rocky shores from one summer to the next, but this process remains poorly understood (Chauvet & Francour, 1991).

Spearman's coefficient showed a significant correlation between the abundance of juveniles and water temperature ($r_s = 0.5836, p < 0.05$). A decrease in the number of groupers was evident when the temperature remained low for some months (Fig. 6).

This tendency persisted until October 1999, when both temperature and juvenile abundance began to rise again. In December 1999, the figures reached the same values as December 1998, thus completing an annual cycle.

The quadrat method, which was selected in order to avoid inaccuracy on data due to substrate complexity (Parker Jr. et al., 1994), provided good results for the study of *E. marginatus*. It enabled observers to search

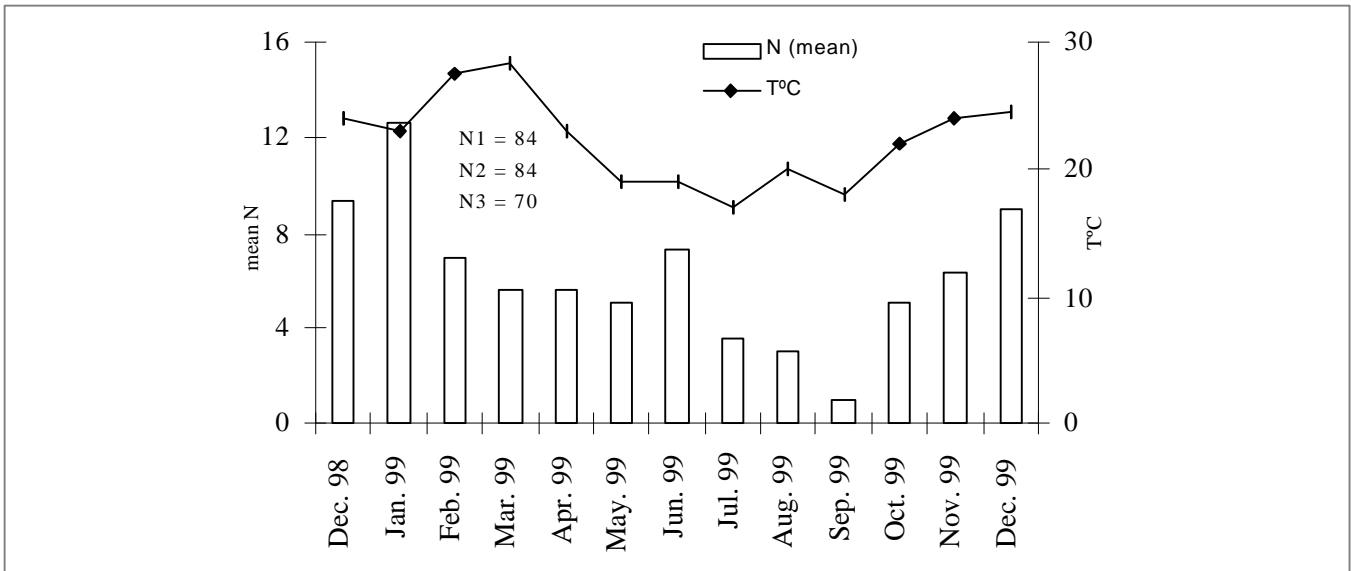


Fig. 6. Monthly variation of groupers (N) and water temperature (T°C). Ni= total no. in the sample i.

Table I. Mean total length of groupers in the three different quadrat zones.

Environments	Mean TL	t (0.05)
Rock shore	13.8 cm	2.31
Outcrop	18.3 cm	
Sand	-	
t(0.05) = t student value (95% confidence)		

for groupers among the rocks and in small caves and crevices, getting closer to them, and eliminating factors such as visibility, substrate complexity and the “wintering” phenomenon, described by Zabala *et al.* (1997) as a period where groupers become more cautious and sedentary, lowering their metabolism and remaining “invisible” for most of the winter.

The mean density of juveniles over the rocky shore zone was 1.16 fish m⁻², whereas in the outcrop zone it was 1.47 fish m⁻². No groupers were found in the sandy zone, showing the preference of juveniles for caves, crevices and ledges. However, adult groupers have already been observed on sandy bottoms close to their shelters in deeper waters among the coastal islands of Santa Catarina, the Azores, Madeira and the Mediterranean.

Juveniles observed in the area ranged from 5 to 45 cm total length. The average size of those associated with the rocky shore zone was significantly less than that of those found in the outcrop zone, where there were larger holes providing shelter (Table I). The size of shelter available in the study area probably influenced the distribution of juveniles by length. The availability of shelter is certainly an important factor in determining the suitability of a microhabitat for juvenile groupers (La Mesa *et al.*, 2002).

Many studies correlate fish abundance and biomass with physical features of the environment (Zabala *et al.*, 1997; La Mesa *et al.*, 2002). Sluka *et al.* (2001) working with the coral dwelling serranids, *Cephalopholis cruentata*, *Epinephelus morio*, and *Mycteroperca bonaci*, indicated that an increase in structural complexity of the environment results in an increase in fish abundance and richness.

The lower size limit (5.0 cm), suggests that newly settled individuals are recruited from nursery sites to shallow rocky shore areas such as those of Sepultura. Bertoncini (1999) reported that the largest *E. marginatus* found in a tidal pool close to Bombinhas (Fig. 2) was 6.5 cm (TL).

Tidal pools are probably the main source of juvenile groupers that settle and colonize shallow littoral areas. These exposed environments (tidal pools and shallow rocky shores) should receive closer attention, especially during late spring and summer, when settlement takes place. Juvenile groupers may be threatened by littoral habitat degradation as well as by over-fishing (Sluka *et al.*, 1994).

No groupers larger than 45 cm (TL) were found in the study area, and probably from this size upward, dispersal typical of this species' ontogeny occurs. Juvenile groupers (*Epinephelus marginatus* and *E. morio*) remain in shallow areas, until they disperse, finding the habitat and taking on the behaviour typical of adults (Barreiros, 1993; Lowe-McConnell 1999).

It is important to highlight the possibility that the shallow area studied is significant in exporting juveniles that may later colonize deeper waters and even the surrounding islands, such as those in the Arvoredo Biological Marine Reserve (see Fig. 2).

Two main hypothesis *viz.* sexual maturation and intraspecific competition may explain the migration pattern observed in our study site.

Firstly, it is known that juveniles of *E. morio* (a species with similar characteristics) remain associated with coastal reefs until they reach first maturation size (45 cm SL) (Lowe-McConnell, 1999). Along the Santa Catarina coast, *E. marginatus* is known to reach sexual maturity when the females reach 47 cm (TL) (Bertoncini *et al.*, *in press*), approximately the size category of the largest groupers found in the shallow water study area.

Secondly, *E. marginatus* is strongly dependent on the shelter provided by crevices, which implies serious space limitations during its life cycle. Such limitations might be important for the recovery of stock in depleted areas, taking into account the influence of habitat on grouper abundance (Sluka *et al.*, 2001). However, if satisfactory yield is desired in the management of sport and local fisheries, some areas must clearly be protected.

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