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Diel Seasonality of a Shallow-Water Fish Assemblage in a Sandy Beach at Canto Grande, Santa Catarina, Brazil

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ABSTRACT

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A shallow-water fish assemblage, over a soft, sandy bottom, at Canto Grande, Santa Catarina, Brazil, was sampled at bimonthly intervals with a beach seine. Sampling was undertaken at 3 h intervals over 24 h on a bimonthly basis between April 1996 and February 1997. Each monthly set of samples was divided into day and night catches. A total of 67 species, belonging to 56 genera and 33 families, were collected. From these, ten occurred only in the day catches and 18 only at night. There was seasonal variation and day/night differences in the number of species (49/57), density of fishes (63.3/62.4 fish 1000 m^{-2}) and biomass (316.3/626.9 g 1000 m^{-2}). The highest values occurred in summer night samples (182.1 fish 1000 m^{-2}, 1893.0 g 1000 m^{-2}). In terms of density both day and night catches were dominated by *Lycengraulis grossidens* while in terms of biomass day catches were dominated by *Harengula clupeola* and night catches by *Trichiurus lepturus*. Despite a slight tendency for greater night values, species diversity (H') and evenness (J') were not significantly different between the two periods. The largest change in the assemblage structure occurred between winter months (July and August) and the other seasons, especially due to the distribution of the main predators found *Pomatomus saltator* (winter and night) and *Trichiurus lepturus* (summer and night). Most of the species observed were either juvenile fish or small pelagic and strongly gregarious species.

ADDITIONAL INDEX WORDS: *Fish diversity, species richness, day/night variations, sandy bottoms.*

INTRODUCTION

Differences between day and night fish assemblages are very important to the understanding of a community structure. Diel variations in species abundance are an indicator of a species separation and habitat partition with time, that is, niche differentiation. These variations can present advantages such as i) reduction of competition for food and space and ii) reduction of predatory pressure (ROSS, 1986; ROSS *et al.*, 1987). Shallow water areas are known to constitute important feeding and nursery grounds for many fish species (MCERLEAN *et al.*, 1973; BENNETT, 1989; BROWN and MCLACHLAN, 1990; SANTOS *et al.*, 1994) and have been studied in numerous systems (*e.g.* SANTOS and NASH, 1995; VARGAS and SIELFELD, 1997; ARAÚJO and COSTA DE AZEVEDO, 2001). In these habitats authors refer to a distinct periodicity to the catch rate over 24h periods and a seasonal change in the species composition, which is also reflected in the diel variations within the assemblage structure (NASH, 1988; WRIGHT, 1989; NASH *et al.*, 1994; NASH and SANTOS, 1998). Some studies show greater catches in daytime (ALLEN *et al.*, 1983) while others show a tendency for night values to be higher (NASH and SANTOS, 1998). The reasons for diel periodicity of assemblage structure remain unclear. Some differences may be due to net avoidance during daytime sampling, but this bias is unlikely to be solely responsible for the observed patterns (see NASH and SANTOS, 1998). It has also been demonstrated that some of the changes in diel periods are due to net avoidance, which is greater in daytime (MCCLEAVE and FRIED, 1975; WRIGHT, 1989; NASH *et al.*, 1994).

In a previous work (BARREIROS *et al.*, 2004b), we verified that the fish assemblage of Canto Grande is highly influenced by season. Biomass, diversity and evenness are significantly higher in summer months. In this study we examine the importance of diel fluctuations in near shore fish communities: i) day/night catches of shallow-water fishes over a 1 year period; ii) description of the major assemblage types in this area and, iii) variability of the day and night components over the same period. We also examine change in the catch rate of individual species, as they constitute obvious causes of change within a given assemblage.

METHODS

Study Site

This study was carried out in Canto Grande beach. This is a 600 m long sandy beach, sheltered and intensively used for shellfish culture (*Perna perna*, *Ostrea puelchana* and *Crassostrea rizophorae*). The beach is located at the southernmost tip of the Bombinhas peninsula (27°08′ S, 48°30′W), facing

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Table 3. *Mean Biomass (B) and mean Density (D) (Day/Night) values for the most important species collected in Canto Grande, SC, Brazil (maximum values in* **bold**).

Species	D (n° ind. 1000 m^{-2})				B (g 1000 m^{-2})			
	Day	%	Night	%	Day	%	Night	%
Atherinella brasiliensis	5.2	8.2	8.5	13.6	27.3	8.6	42.4	6.1
Brevoortia pectinata	2.7	4.3	6.2	9.9	32.5	10.3	92.5	13.3
Eucinostomus argenteus	2.9	4.6	1.8	2.9	15.9	5.0	5.8	0.8
Eucinostomus gula	0.6	0.9	0.7	1.1	11.1	5.5	10.1	1.4
Eucinostomus melanopterus	0.8	1.3	0.9	1.4	9.4	3.0	14.8	2.1
Harengula clupeola	11.9	18.8	3.3	5.3	37.7	11.9	23.5	3.4
Hemiramphus brasiliensis	0.3	0.5	2.7	4.3	6.6	2.1	30.3	13.0
Lycengraulis grossidens	15.6	24.6	11.7	18.8	20.2	6.4	28.8	4.1
Orthopristis ruber	0.2	0.3	0.8	1.3	0.4	0.1	14.8	2.1
Pomatomus saltator	0.9	1.4	3.7	5.9	15.7	1.8	37.2	5.3
Sardinella brasiliensis	2.6	4.1	6.5	10.4	10.6	3.4	41.0	5.9
Sphoeroides testudineus	0.2	0.3	0.4	0.6	1.6	0.5	17.0	2.4
Trachinotus carolinus	1.3	2.3	0.7	1.1	7.0	2.2	2.4	0.3
Trachinotus falcatus	1.8	2.8	0.7	1.1	7.4	2.3	2.4	0.3
Trichiurus lepturus	0.3	0.5	1.7	2.7	23.2	7.3	107.4	15.4
Total	63.3	74.7	62.4	80.7	316.3	70.4	696.6	76.3

similarity between night and day samples is higher than between adjacent months samples (Figure 2, Table 5).

DISCUSSION

Diel changes in fish communities are well known in coral reefs (HOBSON, 1991) and were thoroughly described by GIBSON *et al.* (1996). However, as stated by NASH and SANTOS (1998) that level of knowledge is much lower when dealing with sandy bottoms. Authors agree that differences do exist between day/night fish assemblages (e.g. WRIGHT, 1989).

In this study, the structure of the fish assemblage shows little change between day/night periods, being always dominated by schools of small sized pelagic fish, mainly from families Clupeidae, Atherinidae, Engraulidae and, to a lesser extent, Carangidae and Gerreidae. Although diversity and evenness values are very similar and almost constant, similarity between samples is low, which indicates differences in the day/night assemblages.

Biomass is significantly higher at night and this is due to the nocturnal habits of species that are less numerous and less gregarious but that occur as adults (bigger individuals). This is the case of *Hemiramphus brasiliensis* (winter) and of *Isopisthus parvipinnis* (summer). The occurrence of a vast number of juvenile bluefish in winter is probably connected to their cyclic movements along the South American coastline (JUANES and CONOVER, 1995).

However, the most singular important change in this as-

Table 4. *Species that occurred exclusively at day (D) and at night (N) in Canto Grande, SC, Brazil.*

Species	D	N
Caranx latus	X	
Chloroscombrus chrysurus	X	
Dactylopterus volitans	X	
Exocoetus volitans	X	
Hemicaranx sp.	X	
Menticirrhus americanus	X	
Micropogonias furnieri	X	
Opisthonema oglinum	X	
Selene vomer	X	
Strongylura timucu	X	
Bryx dunckeri		X
Chaetodipterus faber		X
Chaetodon ocelatus		X
Cynoscion leiarchus		X
Epinephelus niveatus		X
Fistularia tabacaria		X
Gobiesox barbatulus		X
Hemicaranx amblyrhynchus		X
Hypleurochilus fissicornis		X
Isopisthus parvipinnis		X
Mycteroperca acutirostris		X
Oligoplites palometa		X
Pellona harroweri		X
Pseudupeneus maculatus		X
Scorpaena plumieri		X
Sphyraena tome		X
Stellifer rastrifer		X
Synodus foetens		X

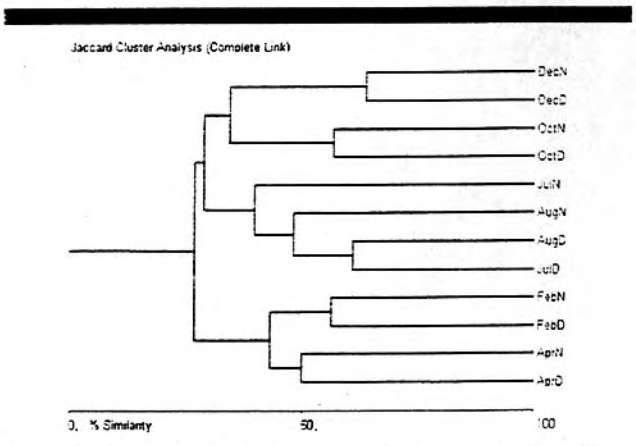

Figure 2. Percent similarity between night/day samples from Canto Grande, south Brazil, between April 1996 and February 1997.

Table 1. *Sampling dates, photoperiod length, number of daylight and nighttime samples from CG, SC, Brazil (Source: Observatório Meteorológico e Hidrológico de Itajaí, SC, Brazil).*

Sampling dates	Photoperiod (hours)	Nº daylight samples (triplets)	Nº nighttime samples (triplets)
27–28 April 1996	11:46	3	5
6–7 June 1996	11:33	3	5
24–25 August 1996	11:21	3	5
19–20 October 1996	13:18	4	4
6–7 February 1996	14:38	4	4
17–18 December 1997	12:58	5	3

south, approximately 30 km north of Santa Catarina Island. Both east and west borders of the beach are rocky. The maximum tidal range is 1 m and maximum depth is 3 m.

Collection of Data

Samples were collected between April 1996 and February 1997 using a 30m beach seine that measured 3m in the centre tapering to 2m on each end with 10mm mesh. The beach seine was fitted with 50 m hauling ropes and set parallel to the shore. Each haul had an effective fishing area between 3 m depth and the shore, allowing for efficiency at the wings of about 1036 m^2 (according to the calculation method of KUBECKA and BOHM, 1991). Three hauls of the beach seine were made at 3 h intervals for 24 h on each sampling date, coinciding with high, mid-falling, low and mid-rising tide. Sea-surface temperature and salinity were measured in all sampling dates. All catches taken after official sunrise and before sunset were classified as daytime (data provided by Capitania dos Portos de Itajaí).

The total number of individuals and total weight for each species were recorded. Individual total weights (g) were sub sampled (N = 200) for each sample. The three samples at each sampling time were summed to give one total. An average catch was then calculated for each month (Table 1).

Species diversity was measured from the number of species and the Shannon diversity index (H') and equitability between species was measured with Pielou's evenness function (J') (PIELOU, 1977). Richness was compared using the rarefaction analysis (MAGURRAN, 1988; 2004). The percent similarity (species composition) between samples is based on the Jaccard Coefficient.

Differences between variables were tested with the sign-test (z differences) since this, according to LUDWIG and REYNOLDS (1988), is the most applicable to qualitative pairs of non-parametric data.

RESULTS

Abiotic Variations

Over the sampling period temperatures varied between 16.3°C (July) and 26.2°C (December). Salinity varied between a minimum of 27.4 (February) and a maximum of 33.8 (December). The drop in salinity in February was due to a great increase of river outflow and heavy rains (for details on temperature and salinity variations see BARREIROS *et al.*, 2004b).

Table 2. *Density (D) (fish 1000 m^{-2})* and Biomass (B) (g 1000 m^{-2}) from night and day samples in CG, SC, Brazil.

Samples	D Day	D Night	B Day	B Night
April 1996	92.7	44.7	469.4	697.0
July 1996	111.5	47.3	301.4	586.3
August 1996	54.2	51.3	250.4	630.4
October 1996	31.0	64.7	288.5	709.4
December 1996	37.1	23.8	106.9	259.9
February 1997	75.5	182.1	393.4	1893.0

Day vs. Night Variations

From the 67 species collected in Canto Grande (see BARREIROS *et al.*, 2004b), 49 species occurred in daytime samples and 57 in nighttime. Day biomass was of 21 630.05g (27.8%) and night was 56 313.50 g (72.2%). Day samples yielded 4325 fish (46.2%) and night samples 5045 (53.8%). Density (nº fish 1000 m^{-2}) and average biomass (g 1000 m^{-2}) are shown in Table 2.

Although day/night densities are not correlated nor are significantly different ($p > 0.05$), day/night average biomasses are weakly correlated ($r_s = 0.829$; $p = 0.042$) and show significant differences (sign test: $z = 2.041$; $p < 0.05$) (Figure 1, Table 2). This is especially true for February 1997, when large numbers of *Trichiurus lepturus* entered the community. Similarly, schools of juvenile bluefish, *Pomatomus saltator*, entered the bay in July in important densities (3.7 fish 1000 m^{-2}) and a biomass of 37.2 g 1000 m^{-2}.

In terms of density, the most important species in both day and night samples was *Lycengraulis grossidens* (respectively 15.6 and 11.7 fish 1000 m^{-2}). Higher biomasses were found for *Harengula clupeola* (daytime: 37.7 g 1000 m^{-2}) and *Trichiurus lepturus* (night-time: 107.4 g 1000 m^{-2}) (Table 3).

Ten species occurred only in day catches and 18 occurred exclusively at night (Table 4).

Diversity, Evenness and Similarity Between Samples

Neither diversity (H') nor evenness (J') showed significant differences between day and night periods ($p > 0.05$) or were they correlated ($p > 0.05$).

With the exception of the winter months (July and August),

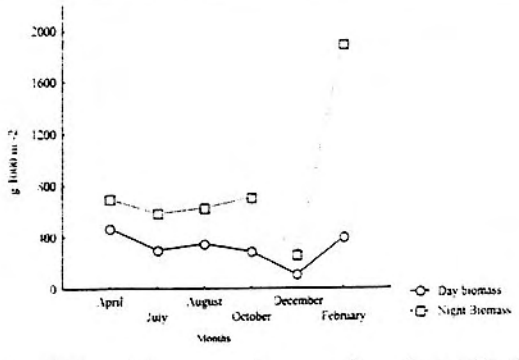

Figure 1. Night and day average biomasses for each sampling date in Canto Grande, south Brazil

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RESUMO

A comunidade de peixes de fundos móveis arenosos de Canto Grande, Santa Catarina, Brasil, foi estudada por amostragens bimensais com recurso a redes de praia. As amostragens realizaram-se durante períodos de 24 h com intervallos de 3 h, numa base bimensal entre Abril de 1996 e Fevereiro de 1997. Cada conjunto mensal de amostras foi dividido em capturas diurnas e nocturnas. Colectaram-se 67 espécies de peixes, correspondendo a 56 géneros e 33 famílias. De entre estas espécies, 10 ocorreram apenas de dia e 18 exclusivamente de noite. Verificou-se uma variação sazonal e diferênças dia/noite no número de espécies (49/57), densidade de peixes (63.3/62.4 peixes 1000 m^{-2}) e biomassa (316.3/626.9 g 1000 m^{-2}). Os valores mais elevados verificaram-se nas amostras nocturnas de Verão (182.1 peixes 1000m^{-2}, 1893.0 g 1000m^{-2}). Em termos de densidade, tanto as amostras diurnas como as nocturnas foram dominadas por *Lycengraulis grossidens* enquanto que em termos de biomassa as amostras diurnas forma dominadas por *Harengula clupeola* e as nocturnas por *Trichiurus lepturus*. Apesar de se notar uma certa tendência para valores nocturnos mais elevados, a diversidade (H') e equitabilidade (J') não foram significativamente diferentes entre os valores de dia e de noite. A maior variação na estrutura da comunidade ocorreu entre os meses de Inverno (Julho e Agosto) e as outras estações, devido sobretudo à distribuição dos principais predadores *Pomatomus saltator* (Inverno e noite) e *Trichiurus lepturus* (Verão e noite). A maior parte das espécies observadas foram juvenis ou pequenos peixes pelágicos fortemente gregários.

Table 5. *Diversity (H')*, Evenness (*J'*) and Richness (Sp. and $E(S_{50})$) from day (D) and night (N) samples in Canto Grande, SC, Brazil.

Samples	*H'*	*J'*	$E(S_{50})$	Sp.
April D	1,964	0,626	22,91	23
April N	2,038	0,593	30,67	31
July D	1,285	0,416	21,81	22
July N	1,858	0,610	20,85	21
August D	1,428	0,527	14,96	15
August N	1,915	0,575	27,99	28
October D	2,042	0,694	18,46	19
October N	1,740	0,522	27,08	28
December D	1,944	0,701	15,91	16
December N	2,413	0,805	19,35	20
February D	2,216	0,639	31,38	32
February N	1,911	0,567	28,70	29
Total D	2,545	0,655	48,90	49
Total N	2,785	0,689	56,94	57

semblage is the large numbers of the nocturnal predator *Trichiurus lepturus*, this being probably connected to the abundance of small clupeids and engraulids in this same area.

On the other hand, small gregarious fish that are more common by day may do evening offshore migrations as a way to avoid these nocturnal predators in a more efficient way. The trophic relationships of this and other shallow-water sandy and rocky fish communities are being studied and partly appear elsewhere (BARREIROS *et al.*, 2004a.)

Nevertheless, and as detected before (BARREIROS *et al.*, 2004b), beach seines are by no means an ideal method for determining the species composition of a given area. Common species (e.g. *Citharichthys spilopterus* and *Synodus foetens*) from this site (JPB, pers. obs.) were very rarely caught in the seine. This is probably due to their ability to burry in sand when detecting the trap. Underwater observation is impossible due to an almost zero visibility but additional techniques, such as hook and line, steel mesh dredge fitted with a heavy duty nylon mesh bag at the bag, suction pipes or vertical nets, may add a significant number of species and a better understanding of the system.

Diel changes do not form a typical occurrence pattern in fish assemblages from sandy beaches (BROWN and MCLACHLAN, 1990). Short-term variations may even exceed long-term seasonal changes (LASIAK, 1984).

In conclusion, this assemblage may be characterised by an annual interchange of species by seasonal effect and a partition of the habitat in three groups: i) diurnal species; ii) nocturnal species and iii) species occurring in both day and night catches but predominantly in one or the other periods.

Day/night changes or differences may also be directly influenced by "human" disturbance, which, in CG is particularly high in summer due to tourism and shellfish culture (see BARREIROS *et al.*, 2004b).

Documenting community changes through diel and annual cycles becomes further complicated due to the dynamics of the system. Through one year, young individuals recruit to the area, while residents still go on growing. Emigration of predators in opposed seasons is a matter that deserves further study as well as a new effort on characterising shallow water and rocky areas along this understudied part of the Brazilian shoreline.

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