The influence of seasonality on fish life stages and residence in surf zones: a case of study in a tropical region

Fábio Magno da Silva Santana[1,4,5], William Severi[2], Caroline Vieira Feitosa[3] & Maria Elisabeth de Araújo[1]

[1]Grupo de Ictiologia Marinha Tropical – IMAT, Departamento de Oceanografia,
Universidade Federal de Pernambuco – UFPE, Av. Prof. Moraes Rego,1235, Cidade Universitária,
CEP 50670-901, Recife, PE, Brazil. http://www.ufpe.br/docean
[2]Laboratório de Ictiologia, Departamento de Pesca e Aquicultura,
Universidade Federal Rural de Pernambuco – UFRPE, Rua Dom Manoel de Medeiros, s/n, Dois Irmãos,
CEP 52171-900, Recife, PE, Brazil. http://www.depaq.ufrpe.br
[3]Instituto de Ciências do Mar, Universidade Federal do Ceará – UFC,
Av. da Abolição, 3207, Meireles, CEP 60165-081, Fortaleza, CE, Brazil.
http://www.labomar.ufc.br - Grupo de Ictiologia Marinha Tropical – IMAT
[4]Unidade Acadêmica Especializada em Ciências Agrárias, Escola Agrícola de Jundiaí,
Universidade Federal do Rio Grande do Norte– UFRN, Rod. RN 160, Km 03, Distrito de Jundiaí,
CEP 59280-000, Macaíba, RN, Brazil. http://www.eaj.ufrn.br/site/
[5]Corresponding author: Fábio Magno da Silva Santana, e-mail: emaildefabio@uol.com.br

SANTANA, F.M.S., SEVERI, W., FEITOSA, C.V. & ARAÚJO, M.E. **The influence of seasonality on fish life stages and residence in surf zones: a case of study in a tropical region**. Biota Neotrop. (13)3: http://www.biotaneotropica.org.br/v13n3/en/abstract?article+bn03813032013

Abstract: Resident fishes and their seasonal use of a surf zone were characterized and identified in the Jaguaribe beach, located on the Island of Itamaracá, state of Pernambuco, northeastern Brazil. Monthly towings (March 2006 to February 2007) with a beach seine net (20 m long, 1.5 m high, 5 mm mesh size) in different moon phases and periods of the day (day and night) were conducted. A total of 6,407 specimens, 35 families and 90 species were recorded. Seven species were considered as annual residents (*Anchoa tricolor*, *Anchoviella lepidentostole*, *Bairdiella ronchus*, *Larimus breviceps*, *Lycengraulis grossidens*, *Polydactylus virginicus* and *Pomadasys corvinaeformis*), three resident throughout the dry season (*Conodon nobilis*, *Lile piquitinga* and *Menticirrhus americanus*) and two resident species in the rainy period (*Cathorops spixii* and *Nicholsina usta*). Among these 12 species, concerning their life cycle, three of them (*A. tricolor*, *C. spixii* and *L. piquitinga*) showed only adult individuals, while *B. ronchus*, *M. americanus* and *N. usta* were the only species represented exclusively by juvenile in both seasons. The surf zone of Jaguaribe beach presents a considerable ecological importance as it encompasses a great diversity of fishes, including species considered rare for this ecosystem, as well as species which are resident annually or seasonally. The distribution pattern of species found in this study shows that the ichthyofauna of the surf zone in Jaguaribe beach is rich, mainly dominated by small-sized individuals including juveniles of several species, with the presence of some species most commonly found in neighboring environments, such as seagrass beds, estuaries and reefs. As an integrated component of interconnected environments in coastal areas of Pernambuco, and owing to its function in the life cycle of coastal fishes, the surf zone of Jaguartibe beach presents an apparently common ecological pattern for tropical sandy beaches.
Keywords: *ichthyofauna, Itamaracá, sandy beach, juvenile fish.*

SANTANA, F.M.S., SEVERI, W., FEITOSA, C.V. & ARAÚJO, M.E. **A influência da sazonalidade sobre os estágios de vida e residência de peixes em zonas de arrebentação: um estudo de caso em uma região tropical**. Biota Neotrop. (13)3: http://www.biotaneotropica.org.br/v13n3/pt/abstract?article+bn03813032013

Resumo: As espécies de peixes residentes e seu uso sazonal na zona de arrebentação foram caracterizados e identificados na praia de Jaguaribe, na Ilha de Itamaracá, estado de Pernambuco, nordeste do Brasil. As coletas foram mensais (março/2006 a fevereiro/2007), nas fases de lua nova e crescente, nos períodos diurno e noturno, com rede de arrasto do tipo picaré (20 m × 1,5 m × 5 mm), durante a baixa-mar. No total, foram coletados 6.407 exemplares pertencentes a 35 famílias e 90 espécies. Sete espécies foram consideradas residentes anuais (*Anchoa tricolor*, *Anchoviella lepidentostole*, *Bairdiella ronchus*, *Larimus breviceps*, *Lycengraulis grossidens*, *Polydactylus virginicus* e *Pomadasys corvinaeformis*), três residentes durante a estiagem (*Conodon nobilis*, *Lile piquitinga* e *Menticirrhus americanus*) e duas residentes na estação chuvosa (*Cathorops spixii* e *Nicholsina usta*). Das 12 espécies analisadas, quanto ao estágio de vida, três delas (*A. tricolor*, *C. spixii* e *L. piquitinga*) apresentaram apenas indivíduos adultos, enquanto *B. ronchus*, *M. americanus* e *N. usta* foram as únicas representadas exclusivamente por jovens nas duas estações. A zona de arrebentação da Praia de Jaguaribe possui considerável importância ecológica, uma vez que engloba uma grande diversidade de peixes, incluindo espécies consideradas raras para este ecossistema, bem como espécies que são residentes anual ou sazonalmente. O padrão de distribuição das espécies registradas neste estudo demonstra que a ictiofauna da zona de arrebentação da praia de Jaguaribe é rica, dominada principalmente por indivíduos de pequeno tamanho, incluindo a fase juvenil de várias espécies, com a presença de algumas encontradas comumente em ambientes adjacentes, como banco de fanerógamas, estuários e recifes. Como um componente de ambientes interconectados em áreas costeiras de Pernambuco e por sua função no ciclo de vida de peixes costeiros, a zona de arrebentação da praia de Jaguaribe apresenta um padrão ecológico aparentemente comum em praias arenosas tropicais.
Palavras-chave: *ictiofauna, Itamaracá, praias arenosas, peixes juvenis.*

Introduction

Coastal zones are areas of ecological transition sites that enable a connection between terrestrial and marine ecosystems, through genetic and biomass exchanges, characterizing them as dynamic and biologically diverse environments (Robertson & Lenanton 1984, Monteiro-Neto et al. 2008). Sandy beaches can occur in any type of coast subject to the availability and sufficient volume of sediments to be deposited by the waves above the sea level (Veloso & Neves 2009). Many marine species, such as most of Haemulidae and the juveniles of Carangidae, use these sites for different purposes (e.g. breeding, feeding, for shelter and migration) at different stages of their development (Blaber 2002).

Surf zones may be defined as dynamic environments, characterized by the turbulence and the high energy from waves, tides and currents motion (Romer 1990). They are considered as a part of the foreshore, which is the submerged portion of the beach profile, extending from the wave break line up to the lower border of the beach face. The kind of wave break depends on the declivity of the bottom and is produced by the destabilization of the waves originated with the reduction of depth (Veloso & Neves 2009).

Studies on the ichthyofauna have demonstrated the presence of many species in surf zones, mainly in the juvenile stage, highlighting its importance for these species in this stage of life cycle (Robertson & Lenanton 1984, Godefroid et al. 2001). However, feeding and also shelter are another important use of the surf zone area by fishes (Blaber & Blaber 1980, Lasiak 1984a, b, Whitfield 1996). Fish species living in these places are represented by active planktivores, detritivores, piscivores, beach nesters and migrants from adjacent ecosystems (Moyle & Cech 2000). The understanding of the trophic relationships between species, as well as the strategies, used to reduce mortality in early stages of their life cycle can be monitored by tracking the spatial and temporal variations of ichthyofauna in sandy environments (Pessanha & Araújo 2003, Falcão et al. 2006).

Despite the relevance of the recruitment of coastal fish, there are few studies on the composition of fish assemblages in surf zones, in comparison with other coastal habitats (Wilber et al. 2003). And there is a lot of doubt about the factors that influence and control temporal variations of these assemblages in such areas (Clark et al. 1996). In Brazilian waters, researches aimed to understand the ecological role of species that reside or temporarily inhabit this ecosystem. In northeastern Brazil, for example, it can be mentioned studies on the composition of the ichthyofauna of three sandy beaches of Maceió, Alagoas (Teixeira & Almeida 1998) and Jaguaribe Beach, Pernambuco (Lira & Teixeira 2008, Santana & Severi 2009). Nevertheless, there is no publication that compares the composition and temporal variation on the fish assemblage structure in the surf zone in relation to other coastal environments, distribution of their life stages, or identification of those that are residents. Actually, most of the coastal zone is heavily human populated (Beatley et al. 2002) and the surf zones hold an increasing encumbrance as the focal area of recreation and suffer pollution from nearby urban centers (Chant et al. 2008). Determining the degree, to which surf-zone assemblages vary temporally, as well as the knowledge on the ichthyofauna in coastal areas and its use at any time, may serve as parameters for further observations and gathering of diagnoses about these sites. These information will help scientists better understand about the ecology and dynamics of the fauna, which can be critical to coastal and ocean management.

The present study aimed to characterize the ichthyofauna of the surf zone in Jaguaribe beach, Itamaracá-PE, analyzing the day and night parameters, as well as moon phases, and identifying the resident species and their seasonal use.

Material and Methods

1. *Study area*

Jaguaribe beach (Figure 1) is located in the northern portion of Itamaracá island (Pernambuco) (07° 43' 08" and 07° 45' 32" S, 034° 50' 14"and 034° 51' 05" W). It constitutes a flat area at low altitude (30-60 m) with sharp drop near the coast. The adjacent coastal marine environment, locally called "inner sea", is sheltered by a reef line parallel to the shore, about 3-4 km from the beach front, with a profile perpendicular to it, with low declivity and maximum depth of 5 m, usually less than 2 m (Kempf 1970). The benthos are characterized by little active or dead coralline formations and encrusting coralline algae, sitting on sandstone foundation (Medeiros & Kjerfve 1993). It presents waves predominantly towards southeast, with the mainstream to the north (Santana & Severi 2009). Its substrate consists of sandy bottom with high content of calcium carbonate derived from the decomposition of the rock formation originated from coastal erosion, and sediment composed of quartz sand, shells of mollusks, foraminifera and fragments of *Halimeda* and *Lithothamnium* calcareous algae (Lopes 1999, Guerra et al. 2005). Extensive stands of seagrass beds *Halodule wrightii* are associated with mixed banks interspersed with *Caulerpa, Sargassum* and *Halimeda* (Kempf 1970).

2. *Field collection*

Collections were performed monthly between March 2006 and February 2007, at new and first quarter moons, encompassing spring and neap tides, in day and night periods, always at low tide. A beach seine net, 20 m long, 1.5 m high and 5 mm internode mesh, was used.

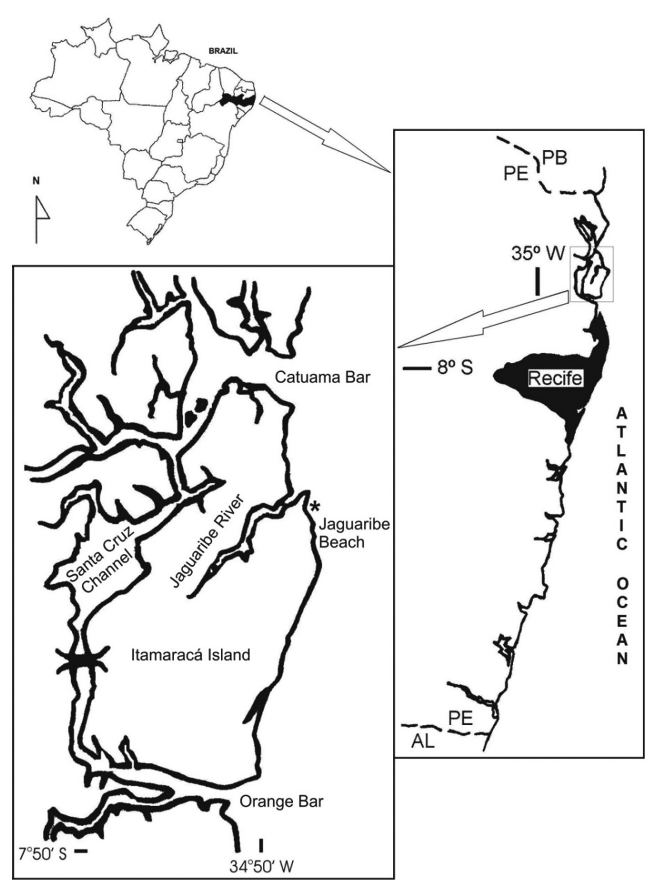

Figure 1. Map of Itamaracá Island location, on the northern coast of Pernambuco state, and indication of the collection site (*) in Jaguaribe beach.

Two manual trawling were made in day and night periods, totaling 8 trawling/month, each lasting about 10 minutes. Trawling was parallel to the coast and towards north, at depth inferior to 1.50 m, along a 25 m segment of beach strip (07° 43' 42.9" S, 034° 49' 32.1" W).

The specimens were fixed in 10% formalin and preserved in 70% ethanol. The taxonomic identification was based on Figueiredo (1977), Figueiredo & Menezes (1978, 1980, 2000), Menezes & Figueiredo (1980, 1985), Carpenter (2002a, b), Araújo et al. (2004) and Marceniuk (2005) and the classification of families according to Nelson (2006). The specimens were stored in the ichthyological collection at the Laboratory of Ichthyology, Department of Fisheries and Aquaculture, Federal Rural University of Pernambuco.

3. *Rainy and dry seasons*

Since the pluviometric distribution showed no well-defined pattern, the rainy season was considered as the months with rainfall exceeding 100 mm, being the remaining months regarded as dry season, according to the data obtained from Laboratório de Metereologia de Pernambuco (Laboratório... 2011). During the study period, the rainy season was established including the months from March to August of 2006 and February of 2007, and the dry season from September 2006 to January 2007.

4. *Data analysis*

The abundance and frequency of occurrence for each fish species were based on the pooled samples from the two trawlings made in each collection, which were analyzed per period and tide, and later grouped for the analysis per month and season (dry and wet). The combined influence of tide and period of the day on data was evaluated per month and season. The Kolmogorov-Smirnov test ($P<0.05$) was used to verify data normality. For normally distributed data, it was used the One-Way ANOVA and the Fisher's *post hoc* test ($P<0.05$). When the data were not distributed normally, the nonparametric tests Mann-Whitney and Kruskal-Wallis ($P <0.05$) were used, employing the Statistica software (Statsoft 2008).

The characterization of abundance and occurrence frequency of species was adapted from Garcia & Vieira (2001). It was considered abundant, in a certain season, the species that had a percentage of individuals (PN%) higher than the ratio 100/S, where S is the number of species present in that season. The species that had an occurrence frequency (OF%) higher than 50% at that season were considered frequent. From this point, the species were classified and grouped according to their values of PN% and FO% in: (1) Abundant and frequent (AF) (PN% ≥ 100/S and FO% ≥ 50); (2) Abundant and little frequent (ALF) (PN% ≥ 100/S and FO% <50); (3) little abundant and frequent (LAF) (PN% < 100/S and FO% ≥ 50) and (4) little abundant and infrequent (LAI) (PN% <100 /S and FO% < 50).

The abundant and frequent species (AF) were considered resident. Those that were AF both in the rainy and in the dry seasons were treated as annual resident (AR). Those which were abundant and frequent (AF), in only one of the seasons were considered resident in the dry (RD) or in the rainy season (RR), accordingly.

For the analysis of life stages and Bray-Curtis similarity, the resident species were also selected. Two phases of life were considered: juvenile and adult. To determine the age limit for adult phase, scatter plots were made with the cut corresponding to 25% of the maximum size of the species (Vazzoler et al. 1999), period at which the animal is presumably able to breed, therefore being considered an adult. Animals that were below this line were considered juvenile. The maximum size of each species (Lmax) was based on Figueiredo & Menezes (1978), Menezes & Figueiredo (1980, 1985) and Carpenter (2002a, b).

In the analysis of grouping between species, a matrix of Bray-Curtis similarity was elaborated and the data of monthly abundance were transformed by the fourth root. The results were expressed as a dendrogram, using the grouping by unweighted arithmetic mean (UPGMA), employing the PRIMER statistical package version 4.0 (Primer-E 2000).

Results

A total of 6,407 individuals were sampled belonging to 90 species and 35 families. The families, which are most representative in number of species, were Sciaenidae (10), Engraulidae, Haemulidae (9), Carangidae (8), Achiridae, Ariidae, Clupeidae, Gerreidae (4), and Cynoglossidae (3). These nine families represented about 62% of all species caught. The 15 most numerically abundant species amounted to almost 91% of total individuals. They were *Anchoviella lepidentostole, Bairdiella ronchus, Lycengraulis grossidens, Polydactylus virginicus, Larimus breviceps, Anchoa tricolor, Chirocentrodon bleekerianus, Pomadasys corvinaeformis, Stellifer stellifer, Stellifer rastrifer, Lile piquitinga, Conodon nobilis, Menticirrhus americanus, Pellona harroweri* and *Anchoa marinii* (Table 1)

Figure 2 illustrates the classification of the fish species caught in the surf zone regarding their abundance and frequency in the rainy and dry seasons and year-round. Only *A. tricolor, B. ronchus, L. breviceps* and *P. virginicus* showed 100% occurrence (Table 1). It is observed that the rarest and least abundant species correspond to nearly70% of the fish sampled.

Between dry and rainy seasons the total number of fish did not differ significantly ($F = 1.39$, $p = 0.265$). Regarding daytime and nighttime collections the total number of fish was significantly different ($U = 11{,}500$, $p = 0.00048$) in the annual analysis, as well as in the dry ($F = 10.54$, $p = 0.012$) and in the rainy season ($U = 6{,}500$, $p = 0.02145$), with the highest number of fish being found during the day in all cases analyzed. In the analysis that groups moon-day data a significant difference in the total number of fish was found ($KW = 16.0337$, $p = 0.0011$). Daytime showed a higher number of fish (5078) compared to night time (1329) in crescent and new moons. Regarding seasonality of all species analyzed, seven were annual residents (*A. tricolor, A. lepidentostole, B. ronchus, L. breviceps, L. grossidens, P. virginicus* and *P. corvinaeformis*), three were resident probably only in the dry season (*C. nobilis, L. piquitinga* and *M.*

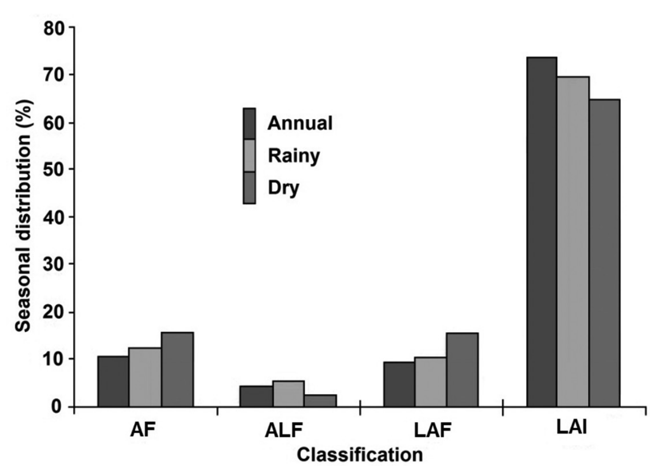

Figure 2. Seasonal distribution (in percentage) of the 6,407 specimens captured in the surf zone of Jaguaribe (PE) and classified as abundant and frequent (AF), abundant and little frequent (ALF), little abundant and frequent (LAF) and little abundant and little frequent (LAI).

Table 1. List of species collected in the surf zone of Jaguaribe beach (PE), from March 2006 to February 2007, presented in descending order of frequency of occurrence (%) (FO). Legends: n = abundance during rainy and dry seasons, PN = percentage of individuals in rainy and dry seasons, FO = frequency of occurrence during the rainy and dry seasons, C = constant during rainy and dry seasons, nC = abundance in the rainy season, PNC = percentage of individuals in rainy season, FOC = frequency of occurrence in rainy season, CC = constant in rainy season, nE = abundance in dry season, PNE = percentage of individuals in dry season, FOE = frequency of occurrence in dry season, CE = constant in dry season. Constancy classification: abundant and frequent (AF), abundant and little frequent (ALF), little abundant and frequent (LAF) and little abundant and infrequent (LAI).

Families (35)	Species (92)	n	PN(%)	FO(%)	C	nC	PNC(%)	FOC(%)	CC	nE	PNE(%)	FOE(%)	CE
Engraulidae	*Anchoa tricolor* (Spix & Agassiz, 1829)	244	3.81	100.00	AF	94	3.03	100	AF	150	4.53	100	AF
Sciaenidae	*Bairdiella ronchus* (Cuvier, 1830)	1192	18.60	100.00	AF	594	19.17	100	AF	598	18.08	100	AF
Sciaenidae	*Larimus breviceps* Cuvier, 1830	411	6.41	100.00	AF	294	9.49	100	AF	117	3.54	100	AF
Polynemidae	*Polydactylus virginicus* (Linnaeus, 1758)	573	8.94	100.00	AF	180	5.81	100	AF	393	11.88	100	AF
Engraulidae	*Anchoviella lepidentostole* (Fowler, 1911)	1532	23.91	91.67	AF	817	26.36	86	AF	715	21.61	100	AF
Sciaenidae	*Menticirrhus americanus* (Linnaeus, 1758)	84	1.31	91.67	AF	8	0.26	71	LAF	76	2.30	100	AF
Engraulidae	*Lycengraulis grossidens* (Agassiz, 1829)	735	11.47	83.33	AF	66	2.13	71	AF	669	20.22	100	AF
Haemulidae	*Conodon nobilis* (Linnaeus, 1758)	104	1.62	83.33	AF	30	0.97	86	LAF	74	2.24	80	AF
Haemulidae	*Pomadasys corvinaeformis* (Steindachner, 1868)	153	2.39	83.33	AF	93	3.00	71	AF	60	1.81	100	AF
Clupeidae	*Lile piquitinga* (Schreiner & Miranda Ribeiro, 1903)	111	1.73	58.33	AF	7	0.23	43	LAI	104	3.14	80	AF
Pristigasteridae	*Chirocentrodon bleekerianus* (Poey, 1867)	196	3.06	41.67	ALF	133	4.29	43	ALF	63	1.90	40	ALF
Sciaenidae	*Stellifer rastrifer* (Jordan, 1889)	142	2.22	33.33	ALF	132	4.26	29	ALF	10	0.30	40	LAI
Sciaenidae	*Stellifer stellifer* (Bloch, 1790)	175	2.73	25.00	ALF	173	5.58	29	ALF	2	0.06	20	LAI
Pristigasteridae	*Pellona harroweri* (Fowler, 1917)	79	1.23	16.67	ALF	76	2.45	14	ALF	3	0.09	20	LAI
Engraulidae	*Anchoa marinii* Hildebrand, 1943	77	1.20	16.67	ALF	0	0.00	0	-	77	2.33	40	APF
Hemiramphidae	*Hyporhamphus roberti* (Valenciennes, 1847)	43	0.67	75.00	LAF	33	1.06	71	LAF	10	0.30	80	LAF
Hemiramphidae	*Hyporhamphus unifasciatus* (Ranzani, 1841)	24	0.37	75.00	LAF	16	0.52	71	LAF	8	0.24	80	LAF
Carangidae	*Trachinotus carolinus* (Linnaeus, 1766)	18	0.28	75.00	LAF	10	0.32	86	LAF	8	0.24	60	LAF
Achiridae	*Trinectes paulistanus* (Miranda Ribeiro, 1915)	34	0.53	75.00	LAF	13	0.42	71	LAF	21	0.63	80	LAF
Sciaenidae	*Menticirrhus littoralis* (Holbrook, 1847)	21	0.33	66.67	LAF	6	0.19	43	LAI	15	0.45	100	LAF
Ariidae	*Cathorops spixii* (Agassiz, 1829)	63	0.98	58.33	LAF	53	1.71	71	AF	10	0.30	40	LAI
Ophichthidae	*Myrichthys ocellatus* (Lesueur, 1825)	10	0.16	50.00	LAF	8	0.26	57	LAF	2	0.06	40	LAI
Engraulidae	*Anchovia clupeoides* (Swainson, 1839)	16	0.25	50.00	LAF	8	0.26	43	LAI	8	0.24	60	LAF
Atherinopsidae	*Atherinella brasiliensis* (Quoy & Gaimard, 1825)	13	0.20	50.00	LAF	4	0.13	29	LAI	9	0.27	80	LAF
Clupeidae	*Harengula clupeola* (Cuvier, 1829)	14	0.22	41.67	LAI	8	0.26	43	LAI	6	0.18	40	LAI
Carangidae	*Trachinotus falcatus* (Forsskaal, 1755)	7	0.11	41.67	LAI	6	0.19	57	LAF	1	0.03	20	LAI
Labridae	*Nicholsina usta* (Valenciennes, 1840)	44	0.69	41.67	LAI	44	1.42	57	AF	0	0.00	0	-
Albulidae	*Albula vulpes* (Linnaeus, 1758)	14	0.22	33.33	LAI	9	0.29	14	LAI	5	0.15	60	LAF

Table 1. Continued...

Families (35)	Species (92)	n	PN(%)	FO(%)	C	nC	PNC(%)	FOC(%)	CC	nE	PNE(%)	FOE(%)	CE
Mugilidae	*Mugil* sp.	14	0.22	33.33	LAI	13	0.42	43	LAI	1	0.03	20	LAI
Carangidae	*Selene vomer* (Linnaeus, 1758)	9	0.14	33.33	LAI	4	0.13	29	LAI	5	0.15	40	LAI
Achiridae	*Achirus lineatus* (Linnaeus, 1758)	5	0.08	33.33	LAI	2	0.06	29	LAI	3	0.09	40	LAI
Tetraodontidae	*Sphoeroides greeleyi* (Gilbert, 1785)	4	0.06	33.33	LAI	2	0.06	29	LAI	2	0.06	40	LAI
Narcinidae	*Narcine brasiliensis* (Olfers, 1831)	3	0.05	25.00	LAI	0	0.00	0	-	3	0.09	60	LAF
Engraulidae	*Anchoa januaria* (Steindachner, 1879)	30	0.47	25.00	LAI	15	0.48	14	LAI	15	0.45	40	LAI
Engraulidae	*Anchoa spinifer* (Valenciennes, 1848)	11	0.17	25.00	LAI	10	0.32	29	LAI	1	0.03	20	LAI
Ariidae	*Sciades herzbergii* (Bloch, 1794)	7	0.11	25.00	LAI	2	0.06	14	LAI	5	0.15	40	LAI
Belonidae	*Strongylura timucu* (Walbaum, 1792)	3	0.05	25.00	LAI	1	0.03	14	LAI	2	0.06	40	LAI
Epinephelinae	*Mycteroperca* sp.	8	0.12	25.00	LAI	5	0.16	14	LAI	3	0.09	40	LAI
Lutjanidae	*Lutjanus synagris* (Linnaeus, 1758)	15	0.23	25.00	LAI	15	0.48	43	LAI	0	0.00	0	-
Haemulidae	*Haemulon plumieri* (Lacepède, 1801)	6	0.09	25.00	LAI	6	0.19	43	LAI	0	0.00	0	-
Haemulidae	*Haemulon steindachneri* (Jordan & Gilbert, 1882)	12	0.19	25.00	LAI	12	0.39	43	LAI	0	0.00	0	-
Labridae	*Cryptotomus roseus* Cope, 1871	4	0.06	25.00	LAI	3	0.10	29	LAI	1	0.03	20	LAI
Paralichthyidae	*Citharichthys arenaceus* Everman & Marsh, 1900	3	0.05	25.00	LAI	0	0.00	0	-	3	0.09	40	LAI
Engraulidae	*Anchoa lyolepis* (Evermann & Marsh, 1900)	5	0.08	16.67	LAI	4	0.13	14	LAI	1	0.03	20	LAI
Ariidae	*Sciades* sp.	2	0.03	16.67	LAI	2	0.06	29	LAI	0	0.00	0	-
Atherinopsidae	*Membras* cf. *dissimilis* (Carvalho, 1956)	6	0.09	16.67	LAI	2	0.06	14	LAI	4	0.12	20	LAI
Scorpaenidae	*Scorpaena plumieri* Bloch, 1789	3	0.05	16.67	LAI	3	0.10	29	LAI	0	0.00	0	-
Triglidae	*Prionotus punctatus* (Bloch, 1793)	2	0.03	16.67	LAI	1	0.03	14	LAI	1	0.03	20	LAI
Centropomidae	*Centropomus undecimalis* (Bloch, 1796)	5	0.08	16.67	LAI	0	0.00	0	-	5	0.15	40	LAI
Carangidae	*Caranx latus* Agassiz, 1831	3	0.05	16.67	LAI	1	0.03	14	LAI	2	0.06	20	LAI
Haemulidae	*Haemulon parra* (Desmarest, 1823)	18	0.28	16.67	LAI	18	0.58	29	LAI	0	0.00	0	-
Paralichthyidae	*Etropus crossotus* Jordan e Gilbert, 1882	2	0.03	16.67	LAI	2	0.06	14	LAI	0	0.00	0	-
Clupeidae	*Ophistonema oglinum* (Lesueur, 1818)	1	0.02	8.33	LAI	0	0.00	0	-	1	0.03	20	LAI
Engraulidae	*Anchoa filifera* (Fowler, 1915)	4	0.06	8.33	LAI	4	0.13	14	LAI	0	0.00	0	-
Ariidae	*Aspistor luniscutis* (Valenciennes, 1840)	1	0.02	8.33	LAI	1	0.03	14	LAI	0	0.00	0	-
Batrachoididae	*Thalassophryne nattereri* Steindachner, 1876	1	0.02	8.33	LAI	1	0.03	14	LAI	0	0,00	0	-
Holocentridae	*Holocentrus adscensionis* (Osbeck, 1765)	2	0.03	8.33	LAI	0	0.00	0	-	2	0.06	20	LAI
Syngnathidae	*Microphis brachyurus brachyurus* (Bleeker, 1853)	1	0.02	8.33	LAI	1	0.03	14	LAI	0	0.00	0	-
Syngnathidae	*Syngnathus pelagicus* Linnaeus, 1758	6	0.09	8.33	LAI	0	0.00	0	-	6	0.18	20	LAI

Table 1. Continued...

Families (35)	Species (92)	n	PN(%)	FO(%)	C	nC	PNC(%)	FOC(%)	CC	nE	PNE(%)	FOE(%)	CE
Epinephelinae	*Alphestes afer* (Bloch, 1793)	1	0.02	8.33	LAI	1	0.03	14	LAI	0	0.00	0	-
Mugilidae	*Mugil liza* Valenciennes, 1836	1	0.02	8.33	LAI	0	0.00	0	-	1	0.03	20	LAI
Carangidae	*Carangoides bartholomaei* (Cuvier, 1833)	1	0.02	8.33	LAI	1	0.03	14	LAI	0	0.00	0	-
Carangidae	*Carangoides chrysos* (Mitchill, 1815)	1	0.02	8.33	LAI	0	0.00	0	-	1	0.03	20	LAI
Carangidae	*Chloroscombrus chrysurus* (Linnaeus, 1766)	1	0.02	8.33	LAI	1	0.03	14	LAI	0	0.00	0	-
Carangidae	*Selene setapinnis* (Mitchill, 1815)	2	0.03	8.33	LAI	0	0.00	0	-	2	0.06	20	LAI
Lutjanidae	*Ocyurus chrysurus* (Bloch, 1791)	5	0.08	8.33	LAI	5	0.16	14	LAI	0	0.00	0	-
Gerreidae	*Eucinostomus argenteus* Bairde Girard, 1855	1	0.02	8.33	LAI	0	0.00	0	-	1	0.03	20	LAI
Gerreidae	*Eucinostomus lefroyi* (Goode, 1874)	3	0.05	8.33	LAI	3	0.10	14	LAI	0	0.00	0	-
Gerreidae	*Eucinostomus melanopterus* (Bleeker, 1863)	1	0.02	8.33	LAI	1	0.03	14	LAI	0	0.00	0	-
Gerreidae	*Eugerres brasilianus* (Valenciennes, 1830)	1	0.02	8.33	LAI	1	0.03	14	LAI	0	0.00	0	-
Haemulidae	*Genyatremus luteus* (Bloch, 1790)	1	0.02	8.33	LAI	0	0.00	0	-	1	0.03	20	LAI
Haemulidae	*Haemulon aurolineatum* Cuvier, 1830	12	0.18	8.33	LAI	12	0.39	14	LAI	0	0.00	0	-
Haemulidae	*Haemulon* sp.	6	0.09	8.33	LAI	6	0.19	14	LAI	0	0.00	0	-
Haemulidae	*Haemulon squamipinna* (Rocha & Rosa, 1999)	13	0.20	8.33	LAI	13	0.41	14	LAI	0	0.00	0	-
Sparidae	*Archosargus probatocephalus* (Walbaum, 1792)	1	0.02	8.33	LAI	1	0.03	14	LAI	0	0.00	0	-
Sciaenidae	*Isopisthus parvipinnis* (Cuvier, 1830)	1	0.02	8.33	LAI	0	0.00	0	-	1	0.03	20	LAI
Sciaenidae	*Stellifer brasiliensis* (Schultz, 1945)	1	0.02	8.33	LAI	1	0.03	14	LAI	0	0.00	0	-
Sciaenidae	*Stellifer* sp.	1	0.02	8.33	LAI	0	0.00	0	-	1	0.03	20	LAI
Ephippididae	*Chaetodipterus faber* (Broussonet, 1782)	2	0.03	8.33	LAI	0	0.00	0	-	2	0.06	20	LAI
Sphyrnidae	*Sphyraena barracuda* (Walbaum, 1792)	1	0.02	8.33	LAI	1	0.03	14	LAI	0	0.00	0	-
Trichiuridae	*Trichiurus lepturus* Linnaeus, 1758	1	0.02	8.33	LAI	0	0.00	0	-	1	0.03	20	LAI
Scombridae	*Scomberomorus cavalla* (Cuvier, 1829)	1	0.02	8.33	LAI	1	0.03	14	LAI	0	0.00	0	-
Achiridae	*Achirus achirus* (Linnaeus, 1758)	1	0.02	8.33	LAI	1	0.03	14	LAI	0	0.00	0	-
Achiridae	*Trinectes microphthalmus* Chabanaud, 1928	1	0.02	8.33	LAI	0	0.00	0	-	1	0.03	20	LAI
Cynoglossidae	*Symphurus sp.*	1	0.02	8.33	LAI	0	0.00	0	-	1	0.03	20	LAI
Cynoglossidae	*Symphurus plagusia* (Bloch & Schneider, 1801)	1	0.02	8.33	LAI	1	0.03	14	LAI	0	0.00	0	-
Cynoglossidae	*Symphurus tessellatus* (Quoy & Gaimard, 1824)	1	0.02	8.33	LAI	0	0.00	0	-	1	0.03	20	LAI
Tetraodontidae	*Sphoeroides spengleri* (Linnaeus, 1785)	4	0.06	8.33	LAI	4	0.13	14	LAI	0	0.00	0	-
Diodontidae	*Chilomycterus spinosus spinosus* (Linnaeus, 1758)	1	0.02	8.33	LAI	0	0.00	0	-	1	0.03	20	LAI
Total		**6.407**	**100.00**			**3.099**	**100.00**			**3.308**	**100.00**		

americanus) and two (*C. spixii* and *N. usta*) in the rainy season, and the latter one was recorded only in this season (Table 2).

Considering the life stage of species, three of them (*A. tricolor, C. spixii* and *L. piquitinga*) were recorded only in adulthood in both rainy and dry seasons. *Bairdiella ronchus, M. americanus* and *N. usta* were present only in juvenile stage. For the other species, the stages of life varied according to the season (Table 2).

The analysis of similarity between species originated two main groups separating the annual resident species (A) from the seasonal resident (B) ones, except for *P. corvinaeformis*, an annual resident, although it seems to have been gathered in the latter group for presenting a total abundance quite lower than that of annual resident species (Figure 3).

The grouping of annual resident species (A) was subdivided into two subgroups: one with a regular (A1) and another with an irregular distribution in the seasons (A2). The subgroup with resident species with an irregular distribution has a subgroup (A3) formed by *L. grossidens* and *P. virginicus*, which, although being annual residents, presented their abundance peak during the dry season, while *A. tricolor* and *L. breviceps* (subgroup A4) did not show the same pattern (Figure 3).

Within the other group (B), *N. usta* and *C. spixiii* (subgroup B1) were considered residents of the surf zone during the rainy season, whereas *L. piquitinga, M. americanus, C. nobilis* and *P. corvinaeformis* formed subgroup B2, containing only the dry season resident species, except for the annual resident *P. corvinaeformis*. The subgroup B3, included in the latter subgroup, encompasses *L. piquitinga* and *M. americanus* which were detached from subgroup B4 because they presented low number of individuals in the rainy season (Figure 3).

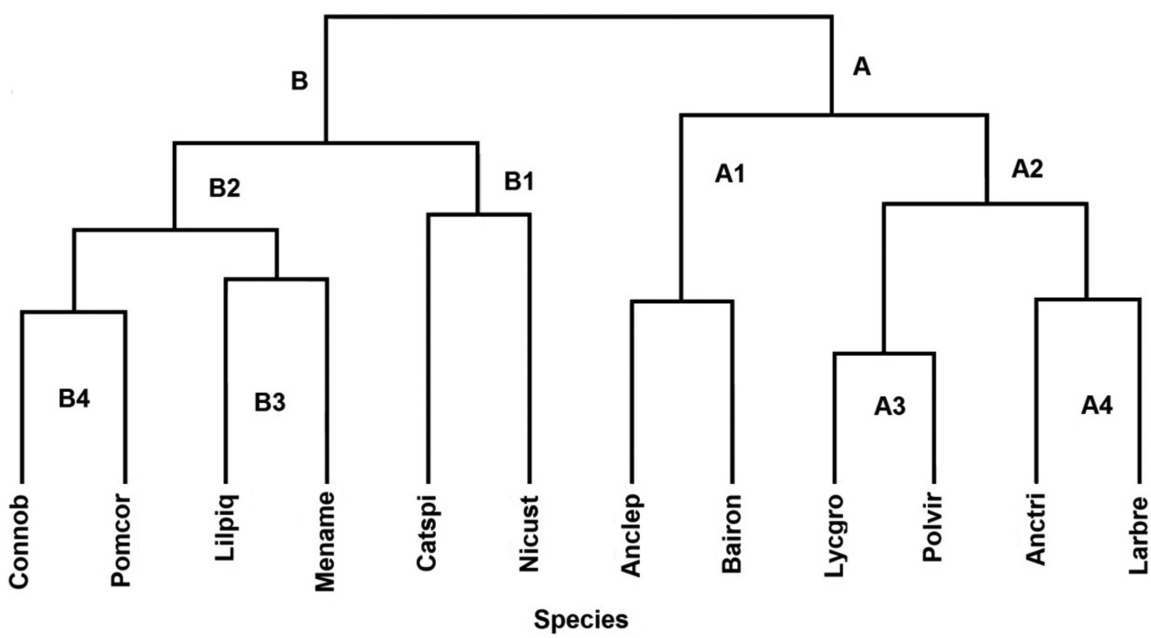

Figure 3. Dendrogram of the grouping of similarity between the species living in the surf zone in Jaguaribe beach, collected between March 2006 and February 2007. The abbreviations of the species are listed in Table 2.

Table 2. Life stage (J = juvenile, A = adult) per season (dry and rainy) of fish species in the surf zone of Jaguaribe beach, between March 2006 and February 2007. The resident species are indicated (RA = annual resident; RE = resident in the dry season; RC = resident in the rainy season).

Species	Abbreviation	Seasonal Residence	Life Stage	
			Rainy	Dry
Cathorops spixii	Catspi	RC	A	A
Nicholsina usta	Nicust	RC	J	-
Conodon nobilis	Connob	RE	J, A	J, A
Lile piquitinga	Lilpiq	RE	A	A
Menticirrhus americanus	Mename	RE	J	J
Anchoa tricolor	Anctri	RA	A	A
Anchoviella lepidentostole	Anclep	RA	J, A	J, A
Bairdiella ronchus	Bairon	RA	J	J
Larimus breviceps	Larbre	RA	J, A	J, A
Lycengraulis grossidens	Lycgro	RA	A	J
Polydactylus virginicus	Polvir	RA	J, A	J, A
Pomadasys corvinaeformis	Pomcor	RA	J, A	J, A

Discussion

The number of families (35) and species found (90) was higher than the 15 families and 25 species found by Lira & Teixeira (2008) in this same beach. Although the same fishing gear was used in both studies (beach seine net), the differences between them seem to be related to divergences in net size and collecting period, both larger in our study. This research performed manual trawling and this is the best methodology when compared with trawling realized by motor boat, once the motor noise can drive off some individuals (Pereira et al. 2010).

The occurrence of rare species is constant in surf zones (Veloso & Neves 2009). Among those recorded in the present study, some stood out for their varied life habits: *Achirus achirus, Chilomycterus spinosus spinosus, Genyatremus luteus, Isophistus parvipinis, Stellifer brasiliensis, Thalassophyrne nattereri, Trichiurus lepturus, Ocyurus chrysurus, Selene setapinnis, Alphestes afer, Archosargus probatocephalus, Chaetodipterus faber, Carangoides bartholomaei, Carangoides chrysos, Holocentrus adscencionis, H. aurolineatum, H. squamipinna, Scomberomorus cavalla, Sphoeroides spengleri* and *Sphyraena barracuda*. It is also noteworthy mentioning that the latter eleven species are usually found near or associated to reefs, and have been recorded along reef formations off the southern coast of Pernambuco and northern coast of Alagoas states (Ferreira & Cava, 2001). However, the relative occurrence of reef fish species cited above were not discussed in this manuscript as these species were considered little abundant and infrequent (LAI). The exception was *N. usta*, because although it was rare, was classified as annual resident.

As most of the dominant species in the surf zone (*Anchoviella lepidentostole, Anchoa tricolor, Bairdiella ronchus, Larimus breviceps, Lycengraulis grossidens*) form shoals and have an annual occurrence, they seem to have contributed for the total number of individuals not having differed between the dry and rainy seasons. The number of individuals was higher during the day in both annual and seasonal analysis. During the day phytoplankton activity enables a greater supply of food thus attracting many consumer individuals. Being prominently shallow regions, surf zones concentrate an even greater amount of these microorganisms (Schlacher et al. 2008). Fish species with nocturnal habits are generally predators (Helfman et al. 2009), and are less abundant than low trophic level ones. Furthermore, many carnivorous or omnivorous species are planktivorous as juveniles (Helfman et al. 2009). Considering that the surf zone is dominated by juvenile or small individuals (Robertson & Lenaton 1984), the highest total abundance for the ichthyofauna is indeed expected at daytime, independent of moon phase. Besides, fishes alter their behavior between periods by a vertical migratory activity, which bring them from near the bottom during the day into midwater at night (Beamish 1966). Differences in fish fauna composition and abundance between periods of the day also have been attributed to foraging and predator avoidance strategies (Gibson et al. 1996, Félix-Hackradt et al. 2010). The ability to shoal and the role of dominant species in total abundance associated to differences in their use of interconnected habitats throughout the day, such as estuaries/mangroves (Faunce & Serafy 2006) and seagrass meadows (Parrish 1989) in the "inside sea", may explain the predominant abundance reduction during night period in the study area.

Among the species analyzed, seven species were considered annual residents: *Anchoa tricolor, Anchoviella lepidentostole, Bairdiella ronchus, Conodon nobilis, Larimus breviceps, Lycengraulis grossidens, Polydactylus virginicus* and *Pomadasys corvinaeformis*, as they are abundant and frequent (AF) in both seasons. For *Anchoa tricolor* and *Larimus breviceps* the largest samples and individuals were captured at the end of the rainy season and early dry season. Within Itamaracá ecosystem, *A. tricolor* is characterized as a marine dependent species, which means its uses estuarine waters for feeding or to accomplish a late phase of its reproductive cycle (Vasconcelos Filho & Oliveira 1999), and *Larimus breviceps* was also regarded as resident by Fagundes et al. (2007) in the surf zone of Santos Bay, São Paulo. It is probable that *Anchoa tricolor* inhabit the surf zone and spawn in the estuary, also used for nursery and recruitment phases (El-Deir 2005). *Larimus breviceps* might use this area as a nursery as well and when adult (late rainy season and early dry season) migrate to areas of greater depth known on the Island of Itamaracá as "outer sea".

The species *Anchoviella lepidentostole* and *Bairdiella ronchus* were found in the surf zone during almost the whole period of the study, with the later one being represented mainly by juveniles. Both are common in ichthyofaunal surveys for this ecosystem in other areas of the Brazilian coast (Godefroid et al. 2004, Oliveira-Neto et al. 2008). However *A. lepidentostole* was not recorded on the assessment of ichthyofauna conducted with the same fishing gear on Jaguaribe beach (Lira & Teixeira 2008) and in the Channel of Santa Cruz (Vasconcelos Filho & Oliveira 1999), both located on Itamaracá Island. This might be due to the lower sampling effort evidenced in these studies in relation to the present one, since *A. lepidentostole* is commonly found in estuarine areas along the Brazilian coast (Paiva Filho et al. 1986, Paiva Filho & Giannini 1990, Chaves & Vendel 2008), including Pernambuco (Paiva & Araújo 2010). Concerning the use of estuaries, *A. lepidentostole* is a semi-anadromous fish and its arrival in the estuary is through shoals composed by older individuals, whereas the younger ones remain in the sea to feed and grow, entering the estuary later, when they reach sexual maturity (Camara et al. 2001). *B. ronchus* has been regularly recorded to breed in this ecosystem (Chaves & Bouchereau 2004). The surf zone is used as a feeding and growing ground (Santana & Severi 2009) by *A. lepidentostole*, as well as a nursery area by *B. ronchus*. This species is known to use different coastal habitats for completion of the reproductive cycle, such as mangroves, estuaries and adjacent coastal environments, as previously reported elsewhere (Chaves 1995, Castro et al. 1999). Due to the predominance of juveniles throughout the whole year, it can be stated that *Polydactylus virginicus* uses the surf zone as a nursery and growing place as the species cited above. Adults occurred in a smaller number and had two peaks, one at the beginning and another one at the end of the dry season. These might be the periods when they migrate to marine demersal regions, where they complete their life cycle. The individuals that live in demersal areas of some parts of the Brazilian coast (Souza & Chaves 2007, Moraes et al. 2009) have larger sizes than those found in this study.

Regarding the occurrence of life phases between seasons, a different pattern was observed in the resident species *Lycengraulius grossidens* and *Pomadasys corvinaeformis* in the study area. *L. grossidens* is a marine (Anacleto & Gomes 2006) and estuarine (Schifino et al. 2004) species, and is well distributed in the estuaries of Pernambuco (Paiva & Araújo 2010), including that of Jaguaribe river - Itamaracá (El-Deir 2005). In our study, only adult individuals were found in the rainy season and only juveniles in the dry season. In the estuary of Lagoa dos Patos (RS), eggs and larvae of this species are the most numerous and abundant ones among the collected species. They occur during the summer because water temperature, instead of salinity, presents a stronger influence on spawning (Anacleto & Gomes 2006).

During the rainy season in the northeastern region, adult fish might use the surf zone to feed and then migrate to the estuary at the end of this season. The recruitment in the surf zone occurs during the dry season. The opposite was recorded for *Pomadasys corvinaeformis*. This species inhabits demersal, marine and estuarine areas (Cervigón 2003), with records for the Jaguaribe river estuary (El-Deir 2005), Itamaracá. Although juveniles prevailed during the rainy season, January represented the peak for this life phase, and the predominance of adults occurred during the dry season. The results of this study corroborate with those of Costa et al. (1995) on the coast of Ceará, which associated the abundance of the species with rainfall. However, Chaves (1998) disagreed with Costa et al. (1995) because the abundance of the species in Guaratuba Bay (PR) depended more on the reduction of water temperature rather than the pluviometric indicators. It is noteworthy the divergences between the climates of the two areas, given that there are only two seasons in northeast and four in south Brazil, which make difficult a direct ecological comparison.

In this study, five species showed seasonal residence: *Cathorops spixii, Conodon nobilis, Lile piquitinga, Menticirrhus americanus* and *Nicholsina usta*. *Cathorops spixii* and *N. usta* were considered resident of the rainy season. The first one is the most common catfish species on the Brazilian coast, preferably living in estuaries (Carvalho-Filho 1999). In the Channel of Santa Cruz, Itamaracá, this species is known to spend its entire life cycle in such environments, but it can also be found in coastal marine habitats and fresh waters (Vasconcelos Filho & Oliveira 1999). Its residence on the rainy season, corroborating with Lira &Teixeira (2008), was represented only by adult individuals in the surf zone, with a peak between May and July. According to Chalom et al. (2008), *C. spixii* is opportunistic, eating most of the available food in the environment, and shrimp being one of the most representative items of its diet. Therefore, the large amount of specimens found in the rainy season in Jaguaribe beach seems to be related to the high abundance of penaeid shrimp, also found during this season in the surf zone, in accordance with personal observations made throughout this research. Differing from *C. spixii, N. usta* is characteristic of coral reefs (Randall 1990), occurring in the surf zone exclusively in this season. Only juvenile individuals represented this species, with its peak in March and April. The species lives associated with marine phanerogam meadows (Arrivillaga & Baltz 1999, Ordoñez-López & García-Hernández 2005, Allen et al. 2006, Prado & Heck Junior 2011). Since there is no record of this species in the estuaries of Pernambuco (Paiva & Araújo 2010), and the surf zone of Jaguaribe beach is rich in *Halodule wrightii* marine phanerogam (Kempf 1970), the species possibly migrates from the reef areas to graze in the surf zone during its recruitment period.

Some species had higher frequency in a determinate season. These were the case of *Lile piquitinga* and *Menticirrhus americanus*. *Lile piquitinga* is a characteristic species of the Northeastern region (Figueiredo & Menezes 1978). It occurred in the surf zone of Jaguaribe beach, even though it was not registered in this site by Lira & Teixeira (2008). Considered as marine dependent on the Santa Cruz Channel estuary (Vasconcelos Filho & Oliveira 1999), it is widely found in the estuaries of Pernambuco (Paiva & Araújo 2010). In the surf zone, it was represented by adults and showed a well-defined seasonal pattern of occurrence, being frequent in the dry season, with its peak in December. In the Jaguaribe River estuary, this species was found in the rainy season (El-Deir 2005), suggesting that it is using the estuary in this season and the surf zone during the dry season, before migrating to deeper areas. Differently, *M. americanus*, represented only by juveniles, was little abundant, although frequent in the rainy season, and abundant and frequent during the dry season. The results of this study indicate the surf zone as a nursery area for this species, corroborating with Godefroid et al. (2001), who noted the presence of larvae and juveniles in Pontal do Sul beach (PR). Adults do not usually occur in the surf zone, but are regularly caught in deeper water (Souza & Chaves 2007). The species depends on the estuary to complete its reproductive cycle (Vasconcelos Filho & Oliveira 1999), and has been recorded in several estuaries of Pernambuco (Paiva & Araújo 2010). *M. americanus* possibly alternates the type of ecosystem used as nursery, according to the season of the year: the surf zone (dry period) and estuary (rainy period).

The haemulid *Conodon nobilis* was represented in both seasons, mainly by juvenile individuals, with its peak in January (end of the dry season). Adults of this species are commonly caught incidentally in demersal areas during shrimp fishing (Vianna et al. 2004, Souza & Chaves 2007), considering that juvenile individuals might use the surf zone as nursery, and the month of January being the recruitment period. In the region of Itamaracá, this species was considered as a visitor to the Santa Cruz Channel (Vasconcelos Filho & Oliveira 1999) and as frequent in Jaguaribe beach (Lira & Teixeira 2008), corroborating with the present study.

Although not being a resident species in either of the seasons, some species showed a defined pattern of occurrence, such as *Chirocentrodon bleekerianus, Hyporhamphus roberti, Stellifer rastrifer* and *Trinectes paulistanus*. *Chirocentrodon bleekerianus* presented a regular abundance in determinate months (July to October). It is a characteristic species of coastal areas (Carvalho-Filho 1999), but there are only two previous records for the coast of Pernambuco (Lira & Teixeira 2008, Santana et al. 2009). Adults might reach the surf zone in search for food, as they eat some fish and crustaceans (Corrêa et al. 2005), preys commonly found in this ecosystem. The time of higher incidence of *C. bleekerianus* coincided with the peak of juvenile Engraulidae and post-larvae of penaeid shrimp (personal observation) in this season (July-October). *Stellifer rastrifer* also prey on penaeid shrimp (Camargo & Isaac 2004), and has its peak of abundance coinciding with the time when the peak of such prey occurred (in August). This species occurs in coastal shallow waters (Carvalho-Filho 1999), characteristic of estuarine areas (Araújo et al. 2004), being registered in the Santa Cruz Channel (Vasconcelos Filho & Oliveira 1999). It is occasionally found in Jaguaribe beach (Lira & Teixeira 2008, Santana & Severi 2009). This species occurred from July to October, peaking in August, being represented by juvenile and adults. *Hyporhamphus roberti* was represented only by adults during the year of study, peaking in July. As this species occurs in estuarine areas (Carpenter 2002a), having been recorded in the estuary of Jaguaribe River (El-Deir 2005), it probably comes to shore to eat shrimps, which are abundant in the rainy season (personal note). Hiatt & Strasburg (1960) cited in Randall (1967) reported small fish and planktonic crustaceans as food items for fish of this genus. *Trinectes paulistanus* was little abundant in Jaguaribe beach, corroborating with Mendonça & Araújo (2002) that analyzed the temporal distribution of this species in Sepetiba Bay (RJ). It occurs in estuarine and marine environments (Figueiredo & Menezes 2000), being present in the northeastern coast (Araújo et al. 2004). Only the adults occupied the surf zone in both seasons (wet and dry). The occurrence of larvae and juveniles of this species is recorded in estuarine areas (Michele & Uieda 2007), whereas adults inhabit different areas, including shores (Godefroid et al. 2004). The species possibly uses the surf zone environment as an intermediary one between the Jaguaribe River estuary and the “outer sea”.

Coastal marine systems are among the most ecologically and social-economically vital ones for the planet, therefore subject to the cumulative effects of global change, including climate change, increased population, pollutant discharge and eutrophication (Harvey et al. 2006, Rabalais et al. 2009). Thus, estuarine and coastal waters are potentially bound to biodiversity loss and community disruption, with unpredictable consequences on fish stocks and fishery sustainability, unless surf zones’ role on coastal fishes’ life cycle is better understood and incorporated in conservation practices and environmental management actions.

The surf zone of Jaguaribe beach presents an ecological importance as it encompass a great diversity of fishes, including species considered rare for this ecosystem, as well as species which are resident annually or seasonally. The distribution patterns of species found in this study show that the ichthyofauna of the surf zone in Jaguaribe beach is rich, mainly dominated by small-sized individuals including juvenile phase of several species, with the presence of species most commonly found in neighboring environments, such as seagrass beds, estuaries and reefs. The role of surf zones as an integrated component of interconnected environments in coastal areas of Pernambuco, and their function in the life cycle of coastal fishes is probably a common ecological pattern for the beaches on tropical coastal.

Acknowledgments

The authors are grateful to Fundação Apolônio Salles de Desenvolvimento Educacional (FADURPE), for its essential logistical support for the accomplishment of this work; Fundação de Amparo à Ciência do Estado de Pernambuco (FACEPE), PELD and Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), for having granted a PhD scholarship to the former author, and a researcher scholarship to the latter; and Biologist Analiza Cristina, for her invaluable assistance during collection activities.

References

ALLEN, T., JIMÉNEZ, M. & VILLAFRANCA, S. 2006. Estructura y categorías tróficas de peces asociados a praderas de *Thalassia testudinum* (Hydrocharitales, Hydrocharitaceae) en el golfo de Cariaco, Estado de Sucre, Venezuela. Invest. Mar. 34(2):125-136.

ANACLETO, E.I. & GOMES, E.T. 2006. Relações tróficas no plâncton em um ambiente estuarino tropical: Lagoa dos Patos (RS), Brasil. Saúde Amb. Rev.1(2):26-39.

ARAÚJO, M.E., TEIXEIRA, J.M.C. & OLIVEIRA, A.M.E. 2004. Peixes estuarinos marinhos do nordeste brasileiro: Guia Ilustrado. Editora UFC, Fortaleza.

ARRIVILLAGA, A. & BALTZ, D.M. 1999. Comparison of fishes and macroinvertebrates on seagrass and bare-sand sites on Guatemala's Atlantic Coast. Bull. Mar. Sci. 65(2):301-319.

BEAMISH, F.W.H. 1966. Vertical migration by demersal fish in the Northwest Atlantic. J. Fish. Res. Board Can. 23:109-139. http://dx.doi.org/10.1139/f66-009

BEATLEY, T., BROWER, D. J. & SCHWAB, A. K. 2002.An introduction to coastal zone management. 2nd ed. Island Press, 329p.

BLABER, S.J.M. 2002. 'Fish in hot water': the challenges facing fish and fisheries research in tropical estuaries. J. Fish Biol. 61(A):1-20.

BLABER, S.J.M. & BLABER, T.J. 1980. Factors affecting the distribution of juvenile estuarine and inshore fish. J. Fish Biol.17:143-162. http://dx.doi.org/10.1111/j.1095-8649.1980.tb02749.x

CAMARA, J.J.C., CERGOLE, M.C., CAMPOS, E.C. & BARBIERI, G. 2001. Estrutura populacional, crescimento, mortalidade e taxa de explotação do estoque de manjuba, *Anchoviella lepidentostole* (Pisces, Engraulidae), do rio Ribeira de Iguape, sudeste do estado de São Paulo, Brasil, durante o período de 1993 a 1996. Bol. Inst. Pesca 27(2):219 -230.

CAMARGO, M. & ISAAC, V. 2004. Food categories reconstruction and feeding consumption estimates for the Sciaenid *Macrodon ancylodon* (Bloch & Schneider), and the congeneric fishes *Stellifer rastrifer* (Jordan) and *Stellifer naso* (Jordan) (Pisces, Perciformes) in the Caeté Estuary, Northern Coast of Brazil. Rev. Bras. Zool. 21(1):85-89.

CARPENTER, K.E. (ed.). 2002a. The living marine resources of the Western Central Atlantic.Volume 2: Bony fishes part 1 (Acipenseridae to Grammatidae). FAO, Rome.

CARPENTER, K.E. (ed.). 2002b. The living marine resources of the Western Central Atlantic. Volume 3: Bony fishes part 2 (Ophistognathidae to Molidae), sea turtles and marine mammals. FAO, Rome.

CARVALHO-FILHO, A. 1999. Peixes: costa brasileira. Melro, São Paulo.

CASTRO, L.T., SANTOS-MARTINEZ, A. & ACERO, P.A. 1999. Reproducción de *Bairdiella ronchus* (Pisces: Sciaenidae) em la Ciénaga Grande de Santa Marta, Caribe Colombiano. Rev. Biol. Trop. 47(3):1-7.

CERVIGÓN, F. 1993. Los peces marinos de Venezuela. Volume 2. Fundación Científica Los Roques, Caracas.

CHALOM, A., MUTO, E.Y. & SOARES, L.S.H. 2008. Variabilidade trófica na alimentação do bagre-amarelo *Cathorops spixii* (Agassiz, 1829) no litoral do estado de São Paulo. In Oceanografia e mudanças globais III Simpósio brasileiro de oceanografia (E.S. Braga, coord.). Instituto Oceanográfico da Universidade de São Paulo, São Paulo, p.257-272.

CHANT, R.J., WILKIN, J., WEIFENG, Z., CHOI, B., HUNTER, E., CASTELAO, R., GLENN, S., JURISA, J., SCHOFIELD, O., HOUGHTON, R., KOHUT, J., FRAZER, T.K. & MONLINE, M.A. 2008. Dispersal of the Hudson River Plume on the New York Bight. Oceanography 21(4):149-162. http://dx.doi.org/10.5670/oceanog.2008.11

CHAVES, P.T.C. 1995. Atividade reprodutiva de *Bairdiella ronchus* (Cuvier) (Pisces, Sciaenidae) na Baía de Guaratuba, Paraná, Brasil. Rev. Bras. Zool. 12(4):759-766.

CHAVES, P.T.C. 1998. Estrutura populacional de *Pomadasys corvinaeformis* (Steindachner) (Teleostei, Haemulidae) na Baía de Guaratuba, Paraná, Brasil. Rev. Bras. Zool. 15(1):203-209.

CHAVES, P.T.C. & BOUCHEREAU, J.L. 2004. Trophic organization and functioning of fish population in the Bay of Guaratuba, Brazil, on the basis of a trophic contribution factor. Acta Adriat. 45(1):83-94.

CHAVES, P.T. & VENDEL, A.L. 2008. Análise comparativa da alimentação de peixes (Teleostei) entre ambientes de marisma e de manguezal num estuário do sul do Brasil (Baía de Guaratuba, Paraná). Rev. Bras. Zool. 25(1):10-15.

CLARK, B.M., BENETT, B.A. & LAMBERTH, S.J. 1996a. Factors affecting spatial variability in the seine net catches of fish in the surf zone of False Bay, South Africa. Mar. Ecol., Prog. Ser. 131:17-34.

CORRÊA, C.E., CHAVES, P.T.& GUIMARÃES, P.R.B. 2005. Biology of *Chirocentrodon bleekerianus* (Poey, 1867) (Clupeiformes: Pristigasteridae) in a Continental Shelf Region of Southern Brazil. Braz. Arch. Biol. Technol. 48(3):419-427.

COSTA, P.S.R., SANTOS, M.A.M., ESPÍNOLA, M.F.A. & MONTEIRO-NETO, C. 1995. Biologia e biometria do coró, *Pomadasys corvinaeformis* (Steindachner) (Teleostei: Pomadasyidae), em Fortaleza, Ceará, Brasil. Arq. Cienc. Mar. 29(1-2):20-27.

EL-DEIR, A.C.A. 2005. Composição e distribuição espaço-temporal de formas iniciais de peixes no estuário do rio Jaguaribe, Itamaracá, litoral norte de Pernambuco, Brasil. Tese de doutorado, Universidade Federal da Paraíba, João Pessoa.

FAGUNDES, L., TOMÁS, A.R.G., CASARINI, L.M., BUENO, E.F., LOPES, G.M., MACHADO, D.A.L., ROSA, R.A., BRAGA, A.C.A., CAMARGO, F.B.F., OBERG, I.M.F. & PELLEGRINI, S.O.P. 2007. A pesca de arrasto-de-praia na ilha de São Vicente, São Paulo, Brasil. Série Relatórios Técnicos, São Paulo, v.29, p.1-45.

FALCÃO, M.G., SARPÈDONTI, V., SPACH, H.L., OTERO, M.E.B., QUEIROZ, G.M.L.N. & SANTOS, C. 2006. A ictiofauna em planícies de maré das Baías das Laranjeiras e de Paranaguá, Paraná, Brasil. Rev. Bras. Zoocienc. 8(2):125-138.

FAUNCE, C.H. & SERAFY, J.E. 2006. Mangroves as fish habitat: 50 years of field studies. Mar. Ecol., Prog. Ser. 318:1-18

FÉLIX-HACKRADT, F.C., SPACH, H.L., MORO, P.S., PICHLER, H.A., MAGGI, A.S., HOSTIM-SILVA, M.& HACKRADT, C.W. 2010. Diel and tidal variation in surf zone fish assemblages of a sheltered beach in southern Brazil. Lat. Am. J. Aquat. Res. 38(3):447-460.

FERREIRA, B.P. & CAVA, F. 2001. Ictiofauna marinha da Apa Costa dos Corais: lista de espécies através de levantamento da pesca e observações subaquáticas. Bol. Téc. Cient. CEPENE 9:25-36.

FIGUEIREDO, J.L. 1977. Manual de peixes marinhos do sudeste do Brasil. I. Introdução. Cações, raias e quimeras. Museu de Zoologia, Universidade de São Paulo, São Paulo.

FIGUEIREDO, J.L. & MENEZES, N.A. 1978. Manual de Peixes Marinhos do Sudeste do Brasil. II. Teleostei (1). Museu de Zoologia, Universidade de São Paulo, São Paulo.

FIGUEIREDO, J.L. & MENEZES, N.A. 1980. Manual de Peixes Marinhos do Sudeste do Brasil. III. Teleostei (2). Museu de Zoologia, Universidade de São Paulo, São Paulo.

FIGUEIREDO, J.L. & MENEZES, N.A. 2000. Manual de Peixes Marinhos do Sudeste do Brasil. VI. Teleostei (5). Museu de Zoologia, Universidade de São Paulo, São Paulo.

GARCIA, A.M. & VIEIRA, J.P. 2001. O aumento da diversidade de peixes no estuário da Lagoa dos Patos durante o episódio El Niño 1997-1998. Atlântica 23:85-96.

GIBSON, R.N., ROBB, L., BURROWS, M.T. & ANSELL, A.D. 1996. Tidal, diel and long term changes in the distribution of fishes on a Scottish sandy beach. Mar. Ecol., Prog. Ser. 130:1-17. http://dx.doi.org/10.3354/meps130001

GODEFROID, R.S., SANTOS, C., HOFSTAETTER, M. & SPACH, H.L. 2001. Occurrence of Larvae and Juveniles of *Eucinostomus argenteus*, *Eucinostomus gula*, *Menticirrhus americanus*, *Menticirrhus littoralis*, *Umbrina coroides* and *Micropogonias furnieri* at Pontal do Sul beach, Paraná. Braz. Arch. Biol. Technol. 44(4):411-418.

GODEFROID, R.S., SPACH, H.L., SANTOS, C., MacLAREN, G. & SCHWARZ JUNIOR, R. 2004. Mudanças temporais na abundância e diversidade da fauna de peixes de um infralitoral raso de uma praia, sul do Brasil. Iheringia, Zool. 94(1):95-104. http://dx.doi.org/10.1590/S0073-47212004000100017

GUERRA, N.C., KIANG, C.H. & SIAL, A.N. 2005. Carbonate cements in contemporaneous beachrocks, Jaguaribe beach, Itamaracá island, northeastern Brazil: petrographic, geochemical and isotopic aspects. Ann. N.Y. Acad. Sci. 77(2):343-352.

HARVEY, C.D.G., HUGHES, A.R., HULTGREN, K.M., MINER, B.G., SORTE, C.J.B., THORNBER, C.S., RODRIGUEZ, L.F., TOMANEK, L. & WILLIAMS, S.L. 2006. The impacts of climate change in coastal marine systems. Ecol. Lett. 9:228-241. PMid:16958887. http://dx.doi.org/10.1111/j.1461-0248.2005.00871.x

HELFMAN, G., COLLETTE, B.B., FACEY, D.E. & BOWEN, B. 2009. The diversity of fishes. Biology, evolution and ecology. 2nd ed. John Wiley & Sons, Willey-Blackwell.

HIATT, R.W. & STRASBURG, D.W. 1960. Ecological relationships of the fish fauna on coral reefs of the Marshall Islands. Ecol. Monogr. 30(1):65-127.

KEMPF, M. 1970. Nota Preliminar Sobre os Fundos Costeiros da Região de Itamaracá (Norte do Estado de Pernambuco, Brasil). Trab. Oceanogr. Univ. PE (9):95-110.

LABORATÓRIO DE METEOROLOGIA DE PERNAMBUCO - LAMEPE. http://www.itep.br/LAMEPE. (último acesso em 20/06/2011).

LASIAK, T.A. 1984a. Structural aspects of the surf-zone fish assemblage at King's beach Algoa Bay, South Africa: long-term fluctuations. Estuar. Coast. Shelf Sci. 18:459-483.

LASIAK, T.A. 1984b. Structural aspects of the surf zone fish assemblage at King's Beach, Algoa Bay, South Africa: Short - term fluctuations. Estuar. Coast. Shelf Sci. 18(4):347-360.

LIRA, A.K.F. & TEIXEIRA, S.F. 2008. Ictiofauna da Praia de Jaguaribe, Itamaracá, Pernambuco. Iheringia, Zool. 98(4):785-780.

LOPES, P.R.D. 1999. Nota sobre a alimentação de *Albula vulpes* (Linnaeus, 1758) (Actinopterygii: Albulidae) na Praia de Jaguaribe (Ilha de Itamaracá), Pernambuco. Stientibus 20:15-22.

MARCENIUK, A.P. 2005. Chave para identificação das espécies de bagres marinhos (Siluriformes, ariidae) da costa brasileira. Bol. Inst. Pesca. 31(2):89-101.

MEDEIROS, C. & KJERFVE, B. 1993. Hydrology of a tropical estuarine system: Itamaracá, Brazil. Estuar. Coast. Shelf Sci.36:495-515. http://dx.doi.org/10.1006/ecss.1993.1030

MENDONÇA, P. & ARAÚJO, F.G. 2002. Composição das populações de linguados (Osteichthyes, Pleuronectiformes) da Baía de Sepetiba, Rio de Janeiro, Brasil. Rev. Bras. Zool. 19(2):339-347.

MENEZES, N.A. & FIGUEIREDO, J.L. 1980. Manual de Peixes Marinhos do Sudeste do Brasil. IV. Teleostei (3). Museu de Zoologia, Universidade de São Paulo, São Paulo.

MENEZES, N.A. & FIGUEIREDO, J.L. 1985. Manual de Peixes Marinhos do Sudeste do Brasil. IV. Teleostei (4). Museu de Zoologia, Universidade de São Paulo, São Paulo.

MICHELE, O.D.A & UIEDA, V.S. 2007. Diet of the ichthyofauna associated with marginal vegetation of a mangrove forest in southeastern Brazil. Iheringia, Zool. 9(4):486-497.

MONTEIRO-NETO, C., TUBINO, R.A., MORAES, L.E.S., NETO, J.P.M., ESTEVES, G.V. & FORTES, W. L. 2008. Associações de peixes na região costeira de Itaipu, Niterói, RJ. Iheringia, Zool. 98(1):50-59. http://dx.doi.org/10.1590/S0073-47212008000100007

MORAES, L.E., ROMERO, R.M., ROCHA, G.R.A.& MOURA, R.L. 2009. Ictiofauna demersal da plataforma continental interna ao largo de Ilhéus, Bahia, Brasil. Biota neotrop. 9(4): http://www.biotaneotropica.org.br/v9n4/pt/abstract?inventory+bn01409042009 (último acesso em 31/08/2012)

MOYLE, P.B. & CECH, J.J. 2000. Fishes: an Introduction to Ichthyology. 4th ed. Upper Saddle River, Prentice Hall.

NELSON, J.S. 2006. Fishes of the World. 4th ed. John Wiley & Sons Inc., New York.

OLIVEIRA-NETO, J.F., SPACH, H.L., SCHWARZ-JR, R. & PICHLER, H.A. 2008. Diel variation in fish assemblages in tidal creeks in southern Brazil. Braz. J. Biol. 68(1):37-43.

ORDOÑEZ-LÓPEZ, U. & GARCÍA-HERNÁNDEZ, V.D. 2005. Ictiofauna juvenil associada a *Thalassia testudinum* en Laguna Yalahau, Quintana Roo. Hidrobiológica 15(2):195-204.

PAIVA, A.C.G. & ARAÚJO, M.E. 2010. Environmental characterization and spatial distribution of fish fauna in estuaries in the state of Pernambuco, Brazil. Trop. Oceanogr. 38(1):1-46.

PAIVA-FILHO, A.M., ZANI-TEIXEIRA, M.L. & KIHARA, P.K. 1986. Contribuição ao conhecimento da biologia da manjuba, *Anchoviella lepidentostole* (Fowler, 1911), no estuário de São Vicente, SP (Osteichthyes, Engraulidae). Bol. Inst. Oceanogr. 34(único):71-77.

PAIVA-FILHO, A.M. & GIANNINI, F.B.R. 1990. A pesca da manjuba *Anchoviella lepidentostole* (Engraulidae) no estuário de São Vicente, SP. Rel. Int. Inst. Oceanogr. 29(1):1-6.

PARRISH, J.D. 1989. Fish communities of interacting shallow water habitats in tropical oceanic regions. Mar. Ecol., Prog. Ser. 58: 143-160.

PEREIRA, P.H.C., FERREIRA, B.P. & REZENDE, S.M. 2010. Community structure of the ichthyofauna associated with seagrass beds (*Halodule wrightii*) in Formoso River estuary - Pernambuco, Brazil. An. Acad. Bras. Ciênc. 82(3):617-628

PESSANHA, A.L.M. & ARAÚJO, F.G. 2003. Spatial, temporal and diel variations of fish assemblages at two sandy beaches in the Sepetiba Bay, Rio de Janeiro, Brazil. Estuar. Coast. Shelf Sci. 57:1-12. http://dx.doi.org/10.1016/S0272-7714(02)00411-0

PRADO, P. & HECK JUNIOR, K.L. 2011. Seagrass selection by omnivorous and herbivorous consumers: determining factors. Mar. Ecol., Prog. Ser. 429:45-55. http://dx.doi.org/10.3354/meps09076

PRIMER-E. 2000. Plymouth Routines in Multivariate Ecological Research. Plymouth: Plymouth Marine Laboratory.

RABALAIS, N.N., TURNER, R., DÍAZ, R.J. & JUSTIC, D. 2009. Global change and eutrophication of coastal waters. ICES J. Mar. Sci. 66:1528-1537. http://dx.doi.org/10.1093/icesjms/fsp047

RANDALL, J.E. 1967. Food habits of reef fishes of the West Indies. Stud. Trop. Oceanogr. 5:665-847.

RANDALL, J.E. 1990. Scaridae. In Check-list of the fishes of the eastern tropical Atlantic (CLOFETA) (J.C. Quero, J.C. Hureau, C. Karrer, A. Post & L. Saldanha, eds.). JNICT, Lisbon; SEI, Paris; UNESCO, Paris, v.2, p.883-887.

ROBERTSON, A.I. & LENANTON, R.C.J. 1984. Fish community structure and food chain dynamics in the surf-zone of sandy beaches: the role of detached macrophyte detritus. J. Exp. Mar. Biol. Ecol.84:265-283. http://dx.doi.org/10.1016/0022-0981(84)90185-0

ROMER, G.S. 1990. Surf zone fish community and species response to wave energy gradient. J. Fish Biol. 36:279-287. http://dx.doi.org/10.1111/j.1095-8649.1990.tb05609.x

SANTANA, F.M.S. & SEVERI, W. 2009. Composição e estrutura da assembléia de peixes da zona de arrebentação da praia de Jaguaribe, Itamaracá - Pernambuco. Bioikos 23(1):3-17.

SANTANA, F.M., SILVA-FALCÃO, E.C. & SEVERI, W. 2009. Ocorrência de *Chirocentrodon bleekerianus* (Teleostei; Pristigasteridae) na costa do estado de Pernambuco - Brasil. Rev. Bras. Eng. Pesca 4(1):144-154.

SCHIFINO, L.C., FIALHO, C.B. & VERANI, J.R. 2004. Fish community composition, seasonality and abundance in Fortaleza Lagoon, Cidreira. Braz. Arch. Biol. Technol. 47(5):755-763.

SCHLACHER, T.A., SCHOEMAN, D.S, DUGAN, J., LASTRA, M., JONES, A., SCAPINI, F. & McLACHLAN, A. 2008. Sandy beach ecosystems: key features, sampling issues, management challenges and climate change impacts. Mar. Ecol. 29(1):70-90. http://dx.doi.org/10.1111/j.1439-0485.2007.00204.x

SOUZA, L.M. & CHAVES, P.T. 2007. Atividade reprodutiva de peixes (Teleostei) e o defeso da pesca de arrasto no litoral norte de Santa Catarina, Brasil. Rev. Bras. Zool.24(4):1113-1121.

STATSOFT. 2008. STATISTICA (data analysis software system), version 7.0. www.statsoft.com. Statsoft Inc., Tulsa.

TEIXEIRA, R.L. & ALMEIDA, G.I. 1998. Composição da ictiofauna de três praias arenosas de Maceió-AL, Brasil. Bol. Mus. Biol. Mello Leitão 8:21-38.

VASCONCELOS FILHO, A.L. & OLIVEIRA, A.M.E. 1999. Composição e ecologia da ictiofauna do canal de Santa Cruz (Itamaracá - PE, Brasil). Trab. Oceanogr. Univ. PE27(1):101-113.

VAZZOLER, A.E.M., SOARES, L.S.H. & CUNNINGHAM, P.M. 1999. Ictiofauna da Costa brasileira. In Estudos ecológicos de comunidades de peixes tropicais (R.C. Lowe McConnell, ed.). Editora da Universidade de São Paulo, São Paulo, p.424-467.

VELOSO, V.G. & NEVES, G. 2009. Praias arenosas. In Biologia Marinha (R.C. Pereira & A. Soares-Gomes, eds.). Interciência, Rio de Janeiro, p.339-360.

VIANNA, M, COSTA, F.E.S & FERREIRA, C.N. 2004. Length-weight relationship of fish caught as by-catch by shrimp fishery in the southeastern coast of Brazil. Bol. Inst. Pesca 30(1):81-85.

WHITFIELD, A.K. 1996. A review of estuarine ichthyology in South Africa over the past 50 years. Trans. R. Soc. S.Afr. 51:79-89. http://dx.doi.org/10.1080/00359199609520601

WILBER, D.H., CLARK, D.G., BURLOS, M.H., RUBEN, H. & WILL, R.J. 2003.Spatial and temporal variability in surf zone fish assemblages on the coast of northern New Jersey. Estuar. Coast. Shelf Sci. 56:291-304. http://dx.doi.org/10.1016/S0272-7714(02)00163-4

Received 09/02/2012
Revised 08/17/2013
Accepted 09/17/2013