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Long-term variation in the ichthyofauna of Flamengo Cove, Ubatuba, São Paulo

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ABSTRACT

The Brazilian coastline extends along more than 8,000 km covering approximately 38 degrees of latitudinal range through tropical, subtropical and warm-temperate climates and includes a wide variety of marine environments such as sandy beaches, estuaries, rocky shores and reefs. This heterogeneity of habitats is reflected in the diversity of marine fishes found in Brazilian waters which sums approximately 1,300 known species. Approximately 600 marine species are estimated to occur off the coast of São Paulo State. Long-term studies are useful to better access variation in the fish community due to slow processes, rare or episodic events, and highly variable or complex phenomena. Our survey of the fishes of Flamengo Cove, Ubatuba, São Paulo, included two periods set apart 10 years from each other (1990 and 2000), in which the soft-bottom ichthyofauna was sampled with an otter trawl in autumn and spring. We sampled 782 individuals weighing 18,113.3 g representing 37 species and 19 families. Five species are considered as threatened in the State of São Paulo, three of them under threat of overexplotation in the federal context, and two are included in the IUCN's Red List. The dominant family was the Sciaenidae, with eight species from both periods. We evidenced a significant variation in the structure of the ichthyofauna between 1990 and 2000, and between autumn and spring, although the number of species did not change. The most important species in terms of number of individuals and biomass were Ctenosciaena gracilicirrhus *and* Paralonchurus brasiliensis, *respectively. Data on both of these species indicate that recruitment occurred during spring, when more and smaller individuals were sampled. More long-time studies such as this are encouraged to better understand differences in the variation of the structure of fish communities in Brazilian marine waters.*

Key-Words: Coastal environment; *Ctenosciaena gracilicirrhus;* Marine fish; Near-shore soft bottoms; Sciaenidae.

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INTRODUCTION

Fishes comprise slightly more than one-half of the vertebrate diversity, with marine fishes including nearly 16,000 species (Nelson, 2006; Menezes, 2011). More than 8,000 marine fish species inhabit tropical shallow areas less than 200 m deep on the continental shelf, a zone far richer in terms of species than oceanic pelagic and deeper zones (Lowe-McConnell, 1999). Different habitats can be found within the coastal zone, each with characteristic faunas. Among them, near-shore soft bottoms cover most of the continental shelf and slope, a substrate mainly composed of sand, silt, broken shells and other fine materials (Moyle & Cech, 2004). According to the latter authors although the number of fish species in a given soft-bottomed area is usually low, the most abundant species often have major commercial importance and trawl fisheries usually target fishes occurring in these areas.

The Brazilian coastline extends along more than 8,000 km covering approximately 38 degrees of latitudinal range through tropical, subtropical and warm-temperate climates and includes a wide variety of marine environments such as sandy beaches, estuaries, rocky shores and reefs. This heterogeneity of habitats is reflected in the diversity of marine fishes found in Brazilian waters which sums approximately 1,300 known species to date (Menezes *et al.,* 2003; Menezes, 2011). In Brazil, Vazzoler (1996) mentioned that 45% of marine fishes are found along the coastal zones, and Knoppers *et al.* (2002) cited that more than 50% of the national marine production is provided by the southern and southeastern regions of Brazil. The ichthyofauna along the Brazilian coast is constituted by tropical and temperate species (Vazzoler *et al.,* 1999), and many of them are restricted to the Argentinian Province (between Cabo Frio, Rio de Janeiro State, Brazil and Península Valdés, Argentina – from 22°S to 43°S), an area representing the geographic limit of tropical and temperate species which was interpreted as a region of faunistic transition (Figueiredo, 1981). It was recently estimated that the coast of São Paulo State, located within this province, harbors approximately 600 species (Rossi-Wongtschowski *et al.,* 2009; Menezes, 2011).

Ubatuba is a city in the northern coast of São Paulo State, a place where marine fishes have been studied for decades and although several works regarding marine fish ecology were conducted off the coast of Ubatuba (*e.g.,* Nonato *et al.,* 1983; Braga & Goitein, 1984; Rossi-Wongtschowski & Paes, 1993; Cunningham, 1995; Giannini & Paiva Filho, 1995; Rocha & Rossi-Wongtschowski, 1998; Soares & Vazzoler, 2001; Vianna *et al.,* 2004; Souza *et al.,* 2008; Rocha *et al.,* 2010; Gondolo *et al.,* 2011), none of them dealt with long-term variation of ecological parameters in the southeastern region of Brazil. In addition, as stated by Rossi-Wongtschowski *et al.* (2009) and Menezes (2011), although the marine fishes off the coast of São Paulo are relatively well known in relation to the rest of the Brazilian coast, much is yet to be done concerning our knowledge of these organisms.

Tropical and temperate shorelines are frequently under high levels of anthropogenic impacts as two-thirds of the human population inhabits coastal regions (*e.g.,* McLachlan & Erasmus, 1983; Strömberg, 1997; Hoefel, 1998). Strömberg (1997) highlighted that although global scale impacts in the marine environment may result from transport of pollutants and emission of greenhouse gases, these effects are more immediate and pronounced in coastal areas especially due to accelerated population growth near these areas which brings alterations associated with over fishing, euthrophization and pollution. Valiela *et al.* (1992), for instance, mentioned that coastal waters are among the most enriched in the world in terms of nutrients and that urbanization causes an increase in sewage discharge. This problem may be enhanced by the complex patterns of oceanic circulation in regions near the coast that alters accumulation, transport and dilution of pollutants (Kennish, 1992). Population densities in the coastal zones have been increasing more pronouncedly than the general human population growth in the world (Valiela *et al.,* 1992; Prates *et al.,* 2012), a situation also verified in the coast of São Paulo State, one of the most populated regions of the world.

Likens (1989), Risser (1991) and Strömberg (1997) highlighted the importance of long-term ecological studies to better access variation in slow processes, rare or episodic events, and highly variable or complex phenomena. Examples that fit well in these definitions include changes in population dynamics, some of which might be related to cases of ecosystem degradation due to anthropogenic impacts. These studies, however, are still rare and scientists should be encouraged to produce data from long term approaches, so that knowledge on some natural phenomena becomes as solid and trustful as possible (Callahan, 1984; Likens, 1989). In the context of long-term ecological studies, we aimed at comparing data on the fish assemblages of the Flamengo Cove, Ubatuba, São Paulo in two different periods (1990 and 2000) through a brief description and analysis of the structure and dynamics of its ichthyofauna.

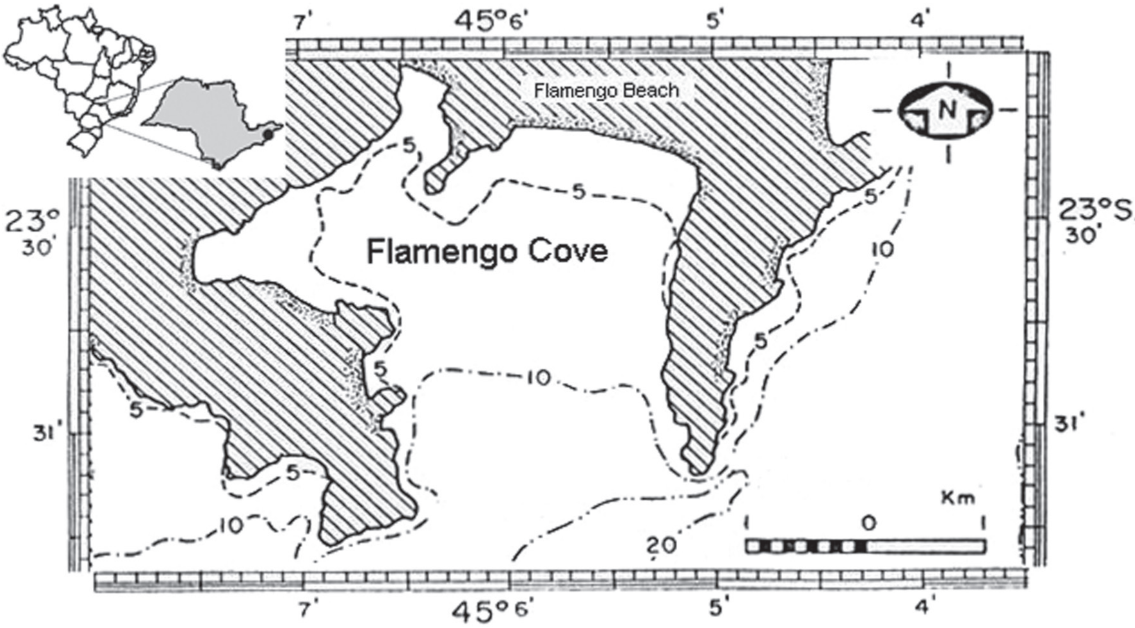

FIGURE 1: Map of the study area showing the Flamengo Cove, Ubatuba, São Paulo, modified from Cunningham (1983).

MATERIAL AND METHODS

Study Area

The Flamengo Cove (23°33'S, 45°05'W) is located in the municipality of Ubatuba, São Paulo State, approximately 12 km south from the center of the city (Fig. 1). The cove is fringed by sandy beaches and rocky shores, being a small calm-water bay with gentle slope beaches (Ab'Saber, 1955; Cruz, 1974). Local temperature ranges from 14.6°C to 27.9°C and the salinity stands around 31.7 to 35.8 (Cunningham, 1983; Mahiques, 1995). In general, the cove is under the seasonal influence of cold, deep and salty subtropical waters (Emílsson, 1961). More specifically, the Flamengo Cove is under seasonal influence of the warmer Coastal Water (CW) and the South Atlantic Central Water (SACW) with colder and salty waters (Cunningham, 1983; Castro Filho *et al.,* 1987). It is under low intensity of waves coming from the East and stronger intensity of waves coming from South and Southwest (FUMEST, 1974). Southeast winds predominate in the area. Sediment is predominantly fine such as sand, silt and clay, with coarser material localized in restricted areas due to the pattern of current inside the cove (*e.g.,* Magliocca & Kutner, 1965; Mahiques, 1995). Depth in the Flamengo Cove reaches from 5 meters along the coastline to nearly 20 meters where the cove empties in the ocean (Sassi & Kutner, 1982).

Fish Samples and Analyses

We included data from two periods set apart by ten years, 1990 and 2000. Data from 1990 were gathered by project Ecologia e Biologia da Ictiofauna de Ubatuba (ECOBIU), a project under the responsibility of one of us (PTMC) whose data were previously unpublished. Data from 2000 were collected for the present study. The same collecting effort and site of sampling were used in both projects, allowing a direct comparison between the two periods. Samples occurred in months of autumn and spring (May and November, respectively), totalizing four units of sample effort. We used an otter trawl (OT) with 25 mm mesh in the sac pulled at 2.5 knots during 10 minutes in each occasion at a depth of approximately 10 meters, operated by vessels from Instituto Oceanográfico da Universidade de São Paulo (IOUSP).

Specimens of cartilaginous fishes were identified with the key of Figueiredo (1977), weighed on board and subsequently released alive. Specimens of teleosts were immediately transported to the laboratory in iceboxes. In the laboratory, they were sorted and identified to the species level with the keys of Figueiredo & Menezes (1978; 1980) and Menezes & Figueiredo (1980; 1985; 2000). Specimens were then counted and weighed with a scale of 0.01 g precision. Some specimens were preserved in formalin, transferred to alcohol and deposited in the ichthyological collection of ECOPEX (Laboratório de Ecologia de Peixes

– IOUSP) as voucher specimens. The list of species follows the systematic order used by Menezes *et al.* (2003) and Nelson (2006). Nomenclature of fish species was updated following Eschmeyer (2013).

The structure of the ichthyofauna was studied through the abundance in number of individuals and in total weight of specimens. To access the dynamic of the fish community between the two periods we calculated the Similarity of Jaccard (J) between samples (1990-2000 in total, autumn-spring in total, autumn-spring of 1990, autumn-spring of 2000), in addition to Margalef Diversity (D_{Mg}) and Simpson Dominance (D), three simple statistic descriptors useful for this kind of study (Magurran, 1996). Both D_{Mg} and D were calculated for each year and each season. Species were classified according to their occurrence in the sampling units, being considered as rare (25%), common (50%), very common (75%) or permanent residents (100%). We also verified the dominant species, in each period, according to the number of individuals and total weight. For each year, the species composing 50% of the total values of abundance (number of individuals and total weigth) were verified by counting in decreased order the number of individual or total weight of the most abundant species, accumulating with the second most abundant species and so forth, until 50% of the total value was reached. We also made a more detailed analysis of the seasonal and temporal variation in total number of individuals and average weight for the most abundant species in number of individuals and biomass.

RESULTS

A total of 782 individuals weighing 18,113.3 g were sampled in the whole period. The fishes belong to 37 species and 19 families (Table 1). Considering the years separately, we sampled 420 individuals weighing 12,792.7 g, representing 26 species in 1990, and 362 individuals weighing 5,320.6 g, representing 25 species in 2000. Diversity of species was greater in autumn 2000 (22 species) and lower in spring 2000 (10 species), with intermediate values for autumn 1990 (15 species) and spring 1990 (19 species). In the seasonal context, autumn collections yielded 227 individuals weighing 8,273.5 g, representing 28 species, and spring collections resulted in 555 individuals weighing 9,839.8 g, comprising 23 species.

The most diverse family in the whole study was the Sciaenidae, with eight species, followed by Haemulidae and Paralichthyidae, each with four species, and Gerreidae, with three species. In the temporal context, the Sciaenidae was the most diverse family in both 1990 and 2000 (eight and seven species, respectively), followed by Paralichthyidae (three species), Carangidae, Serranidae and Haemulidae (two species each) in 1990, and Gerreidae and Paralichthyidae (three species each) in 2000. In the seasonal context, the Sciaenidae was the most diverse family in both autumn and spring (eight and six species, respectively), followed by Gerreidae, Haemulidae and Paralichthyidae (three species each) and Serranidae and Carangidae (two species each) in autumn, and Triglidae, Haemulidae and Paralichthyidae (two species each) in spring (Table 1).

The Similarity of Jaccard was higher when comparing both the faunas of 1990 and 2000 in total, and the faunas of autumn and spring in total (37.84%). Similarity between seasons within the same year was lower, being 30.77% between autumn and spring of 1990 and 28% between autumn and spring of 2000. Diversity of Margalef was similar in 1990 and 2000 (4.13 and 4.07, respectively). In the seasonal context, Diversity of Margalef was slightly higher in autumn (11.46) than in spring (8.02). Simpson Dominance was slightly lower in 1990 than in 2000 (0.16 and 0.25, respectively), and significantly higher in spring than in autumn (0.26 and 0.08, respectively).

Only three species were considered permanent residents occurring in all four samples, the sciaenids *Ctenosciaena gracilicirrhus* (Metzelaar, 1919), *Menticirrhus americanus* (Linnaeus, 1758) and *Paralonchurus brasiliensis* (Steindachner, 1875). Six species were considered very common during the study, occurring in 75% of the samples: *Dactylopterus volitans* (Linnaeus, 1758), *Diplectrum radiale* (Quoy & Gaimard, 1824), *Selene setapinnis* (Mitchill, 1815), *Isopisthus parvipinnis* (Cuvier, 1830), *Larimus breviceps* Cuvier, 1830 and *Etropus crossotus* Jordan & Gilbert, 1882. Eight other species occurred in half of the samples being considered common, and the remaining 20 species were regarded as rare, occurring in only one of the four samples (Table 1).

In 1990, the dominant species (*i.e.,* composing 50% of the total value) in number of individuals were *Paralonchurus brasiliensis* and *Ctenosciaena gracilicirrhus* (Fig. 2A), and those dominant in terms of biomass were *Paralonchurus brasiliensis, Chilomycterus spinosus* (Linnaeus, 1758) and *Menticirrhus americanus* (Fig. 2D). In 2000, the dominant species in number of individuals were *Ctenosciaena gracilicirrhus* and *Etropus crossotus* (Fig. 2B), and in terms of total biomass the most abundant species were *Ctenosciaena gracilicirrhus, Paralonchurus brasiliensis, Etropus crossotus* and *Prionotus nudigula* Ginsburg, 1950

TABLE 1: List of species sampled in the Flamengo Cove, Ubatuba, São Paulo, organized by systematic order of families following Menezes *et al.* (2003). Data presented for each sample unit. Frequency refers to the occurrence of each species in the total four sample units.

Family	Species	1990		2000		Frequency
		Autumn	Spring	Autumn	Spring	
Narcinidae	*Narcine brasiliensis*	—	X	—	—	**25**
Rhinobatidae	*Rhinobatos percellens*	X	—	—	—	**25**
Gymnuridae	*Gymnura altavela*	—	X	—	—	**25**
Muraenidae	*Gymnothorax ocellatus*	—	X	—	—	**25**
Ophichthidae	*Ophichthus gomesii*	—	—	X	—	**25**
Dactylopteridae	*Dactylopterus volitans*	X	X	X	—	**75**
Triglidae	*Prionotus nudigula*	—	—	X	X	**50**
	Prionotus punctatus	—	X	—	—	**25**
Serranidae	*Diplectrum radiale*	X	X	X	—	**75**
	Epinephelus morio	X	—	—	—	**25**
Carangidae	*Selene setapinnis*	—	X	X	X	**75**
	Selene vomer	X	—	—	—	**25**
Gerreidae	*Diapterus rhombeus*	—	—	X	—	**25**
	Eucinostomus argenteus	—	—	X	—	**25**
	Eucinostomus gula	—	—	X	—	**25**
Haemulidae	*Conodon nobilis*	—	—	X	—	**25**
	Haemulon steindachneri	—	—	X	—	**25**
	Haemulopsis corvinaeformis	—	X	—	—	**25**
	Orthopristis ruber	—	X	X	—	**50**
Sciaenidae	*Ctenosciaena gracilicirrhus*	X	X	X	X	**100**
	Cynoscion jamaicensis	X	—	X	—	**50**
	Isopisthus parvipinnis	—	X	X	X	**75**
	Larimus breviceps	X	X	X	—	**75**
	Macrodon atricauda	X	X	—	—	**50**
	Menticirrhus americanus	X	X	X	X	**100**
	Paralonchurus brasiliensis	X	X	X	X	**100**
	Stellifer rastrifer	X	—	X	—	**50**
Mullidae	*Mullus argentinae*	—	—	—	X	**25**
Trichiuridae	*Trichiurus lepturus*	X	—	—	X	**50**
Stromateidae	*Peprilus paru*	—	X	—	—	**25**
Paralichthyidae	*Citharichthys macrops*	—	—	X	—	**25**
	Citharichthys spilopterus	—	X	—	—	**25**
	Etropus crossotus	—	X	X	X	**75**
	Syacium papillosum	X	—	X	—	**50**
Cynoglossidae	*Symphurus tessellatus*	—	—	X	—	**25**
Balistidae	*Balistes capriscus*	—	—	—	X	**25**
Diodontidae	*Chilomycterus spinosus*	X	X	—	—	**50**

(Fig. 2E). In the whole study, the most abundant species in number of individuals were *Ctenosciaena gracilicirrhus* and *Paralonchurus brasiliensis* (Fig. 2C), and in terms of biomass the most abundant species were *Paralonchurus brasiliensis, Chilomycterus spinosus, Ctenosciaena gracilicirrhus* and *Menticirrhus americanus* (Fig. 2F).

A detailed analysis of the two most abundant species in terms of number of individuals (*Ctenosciaena gracilicirrhus*) and biomass (*Paralonchurus brasiliensis*) showed that the number of individuals of *Ctenosciaena gracilicirrhus* was higher in the spring of both years, and slightly higher in 2000 than in 1990 for both seasons (Fig. 3A). On the other hand, the average weight of individuals of this species was larger in autumn than in spring. The biomass of *Ctenosciaena gracilicirrhus* was higher in autumn 2000 than in autumn 1990, but slightly lower in 2000 than in 1990 when the springs of both years are compared. In both years, however, the biomass in autumns was larger than that of spring time, especially in 2000 (Fig. 3B). The number of individuals of *Paralonchurus*

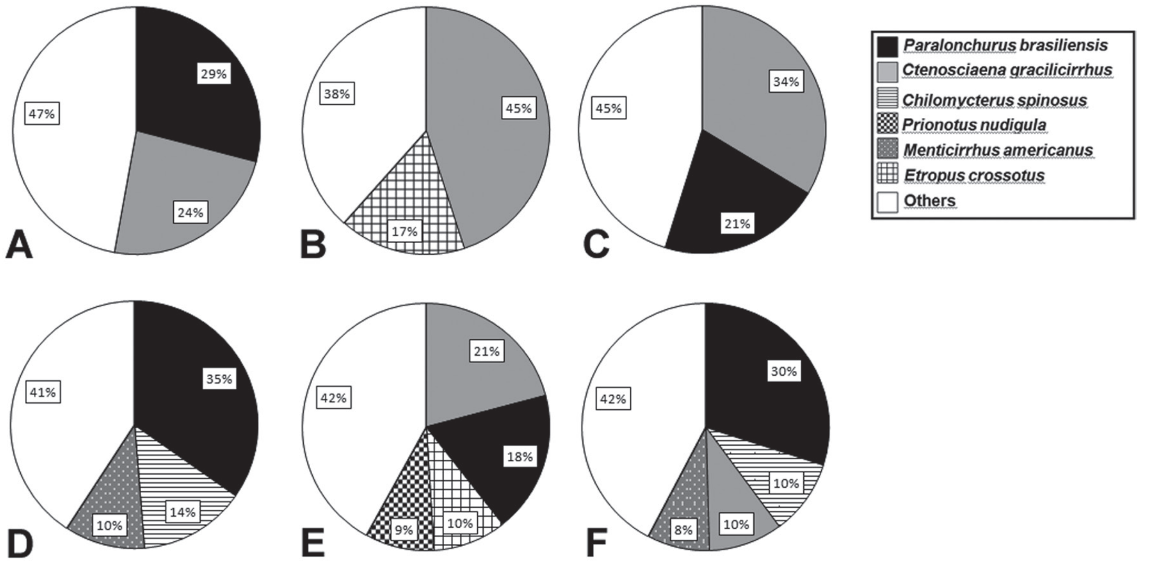

FIGURE 2: Most abundant species composing 50% of the samples in terms of **(A)** number of individuals in 1990, **(B)** number of individuals in 2000, **(C)** number of individuals considering both periods, **(D)** total biomass in 1990, **(E)** total biomass in 2000, **(F)** and total biomass considering both periods, in the Flamengo Cove, Ubatuba, São Paulo.

brasiliensis was also much larger in the spring of both years, but we noticed a lower number of individuals in 2000 than in 1990 (Fig. 4A). The biomass of *Paralonchurus brasiliensis* was clearly higher in autumn 2000 than in autumn 1990, but slightly lower in 2000 than in 1990 when both springs are compared. While the biomass of *Paralonchurus brasiliensis* in 1990 was slightly higher in autumn than in spring, it was conspicuously higher in autumn 2000 than in spring 2000 (Fig. 4B).

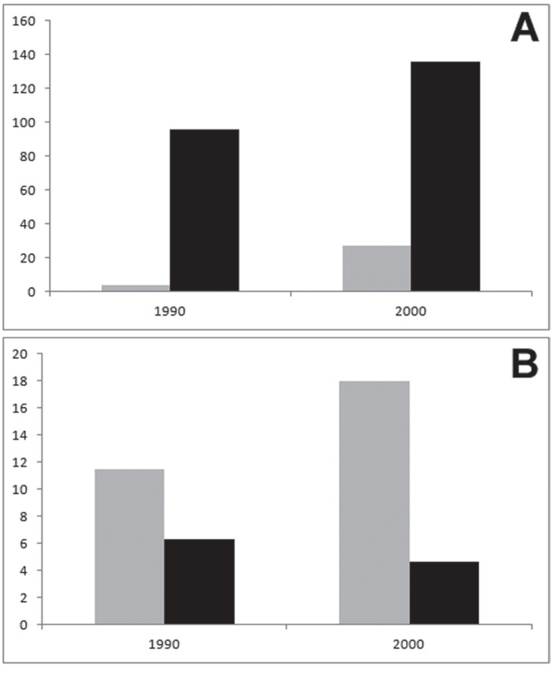

FIGURE 3: Temporal and seasonal variation in **(A)** total number of individuals and **(B)** mean weigth (in grams) for *Ctenosciaena gracilicirrhus* in the Flamengo Cove, Ubatuba, São Paulo. Gray bars represent autumn samples and black bars represent spring samples.

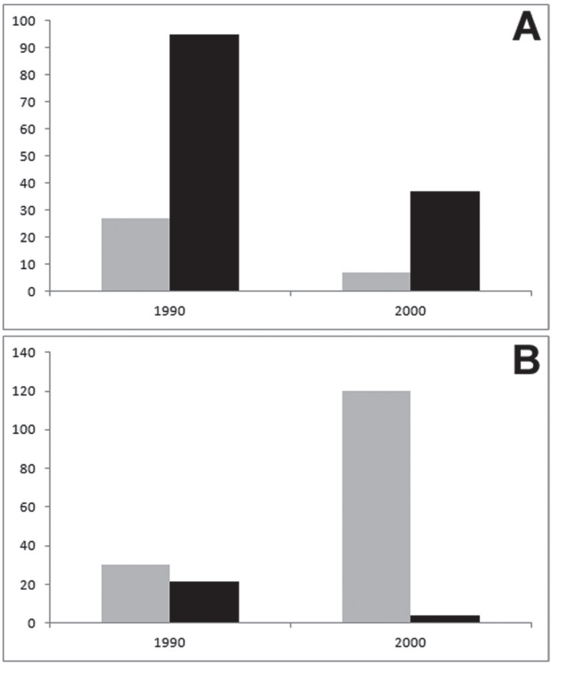

FIGURE 4: Temporal and seasonal variation in **(A)** total number of individuals and **(B)** mean weigth (in grams) for *Paralonchurus brasiliensis* in the Flamengo Cove, Ubatuba, São Paulo. Gray bars represent autumn samples and black bars represent spring samples.

DISCUSSION

The long-term study of the ichthyofauna of Flamengo Cove presented herein showed that the dominant family in the assemblage is the Sciaenidae, both in number of species (Table 1) and in abundance of individuals and biomass. The species *Ctenosciaena gracilicirrhus* and *Paralonchurus brasiliensis,* in special, figured among the most common and dominant species in the study (Fig. 2). This was to be expected, as many authors considered the Sciaenidae as the main family inhabiting near shore soft-bottoms in various parts along the coast of South America. Lowe-McConnell (1962), for instance, mentioned that the type of substrate is one of the main factors affecting the composition of the ichthyofauna of the continental shelf and that in areas with soft-bottoms off the Guyana coast she found 21 species of the Sciaenidae and 13 of the Haemulidae, the two most conspicuous in her study. According to that same author, the most common sciaenids were *Micropogonias furnieri* (Desmarest, 1823), *Macrodon ancylodon* (Bloch & Schneider, 1801), *Cynoscion virescens* (Cuvier, 1830), and species of *Menticirrhus, Equetus* and *Larimus.*

Nonato *et al.* (1983) studied the ichthyofauna off the coast of the islands Anchieta, Couves and Vitória, near the area of the present study, and found that sciaenids and flounders of the Paralichthyidae and Cynoglossidae were the dominant species, along with some rajids. Braga & Goiten (1984) surveyed the same area of the present study and also found sciaenids as the dominant group, including 13 species in total, and highlighted the importance of *Paralonchurus brasiliensis, Cynoscion jamaicensis* (Vaillant & Bocourt, 1883), *Ctenosciaena gracilicirrhus, Isopisthus parvipinnis* and *Stellifer rastrifer* (Jordan, 1889) in the community. Rocha & Rossi-Wongtschowski (1998) also studied the ichthyofauna off the coast of Ubatuba and Caraguatatuba and found similar results, with *Ctenosciaena gracilicirrhus* and *Paralonchurus brasiliensis* as the most abundant species. More recently, Rocha *et al.* (2010) investigated the ichthyofauna of Palmas Bay, off the Anchieta Island, a region close to Flamengo Cove. They reported that five species composed more than 73% of their samples, with *Ctenosciaena gracilicirrhus* as one of the most important in number of individuals in addition to three gerreids and one haemulid.

In other areas off the Brazilian coast, the Sciaenidae was also one of the most important families in several studies, such as in São Cristóvão beach, Areia Branca, Rio Grande do Norte State (Dantas *et al.,* 2012) and in the estuary of Rio Sergipe (Alcântara, 1989) with approximately 70% of the individuals belonging to 15 species of this family with dominance of *Stellifer rastrifer.* The Sciaenidae was also the most diverse and abundant family in the Guanabara Bay, Rio de Janeiro State, especially due to large amounts of *Micropogonias furnieri* in the central area of the study (Rodrigues *et al.,* 2007). In the Sepetiba Bay, Rio de Janeiro State, fish assemblages were not strongly dominated by sciaenids but also included Ariidae and Gerreidae as dominant groups (Araújo *et al.,* 2002), although a spatial repartition was found and *Micropogonias furnieri* was one of the dominant species in the inner zone of the bay while *Ctenosciaena gracilicirrhus* was one of the dominant species in the outer zone (Azevedo *et al.,* 2007). Off the coast of São Sebastião, São Paulo State, Muto *et al.* (2000) registered sciaenids as the most prominent family in number of species, abundance and weight and stated that *Ctenosciaena gracilicirrhus, Paralonchurus brasiliensis* and *Cynoscion jamaicensis* dominated the catches. Godefroid *et al.* (2004) reported the Sciaenidae as the most diverse family off the coast of Paraná State with 18 of the 70 sampled species, and mentioned that four of the seven dominant species belonged to this family (*Larimus breviceps, Paralonchurus brasiliensis, Stellifer brasiliensis* (Schultz, 1945) and *Stellifer rastrifer*). They also highlighted that three of these sciaenids along with *Conodon nobilis* (Linnaeus, 1758) accounted for 70% of the total catch in weigth. At Lagoa dos Patos, Chao *et al.* (1982) found *Micropogonias furnieri* as the dominant species and abundant juveniles of other sciaenids (*Cynoscion striatus* (Cuvier, 1829), *Macrodon atricauda* (Günther, 1880), *Ctenosciaena gracilicirrhus, Umbrina canosai* Berg, 1895 and *Paralonchurus brasiliensis*). Studying a broad area off the coast of Rio Grande do Sul State, Haimovici *et al.* (1996) found similar results, with the Sciaenidae as the most diverse family and constituting more than 80% of the total weight.

Although the diversity in number of families, number of species (Table 1) and Diversity of Margalef showed little difference between the two years sampled, we noticed that only 14 of the 37 species were common to 1990 and 2000. A similar pattern was observed when comparing autumn and spring samples. At the family level, it is worth to highlight that six families occurred exclusively in 1990, including the three Chondrichthyes, while five families occurred exclusively in 2000, including the Gerreidae with three species that did not occur in 1990 (Table 1). In the seasonal context, four families occurred only in autumn samples and six families were exclusive of spring samples, again including the three species of the Gerreidae. This suggests that although the diversity remains practically the same, the structure of the whole community is dynamic and changes both in time and with season, something evidenced by the fact that only three species, all sciaenids, could be considered as permanent residents of the area. This was also partially shown by the values of Similarity of Jaccard, accounting for less than 40% of similarity between the years and between the seasons.

Two patterns were observed in the present study regarding the number of individuals and total weight. In terms of the number of individuals, we noticed that nearly 71% of the total number of individuals was sampled in spring, although the biomasses of both seasons are nearly 50% of the total weight. This shows that there are more individuals relatively smaller in spring than in autumn, which may indicate a possible reproductive season for at least some of the species (*e.g.,* Araújo & Santos, 1999; Bernardes & Dias, 2000; Robert & Chaves, 2001; Castello & Castello, 2003; Godefroid *et al.,* 2004; Lima & Castello, 2007; Bruno & Muelbert, 2009). As for the biomass, approximately 71% of the total weight was sampled in 1990 although the number of individuals did not differ much between the two years.

It is interesting to notice that less species are necessary to make up 50% of the total number of individuals than total weight, indicating that fewer species (always two) are considered dominant in terms of abundance of individuals than in terms of biomass (three to four species) (Fig. 2). Dominance of Simpson was higher in 2000 than in 1990, and much higher in spring than in autumn. This is clearly due to the dominance of *Ctenosciaena gracilicirrhus* both in the samples from 2000, when it made up 45% of the total number of individuals (Fig. 2B), and in the spring samples, where it composed nearly 42% of the total number of individuals. It is worth to highlight the increase in importance of the Pleuronectiformes, both in number of individuals (less pronounced) and in biomass, which almost doubled from 1990 to 2000. This is reflected in the inclusion of *Etropus crossotus* among the dominant species in 2000 both in abundance and in biomass (Figs. 2B and 2E).

Considering the two most important species of this study, *Ctenosciaena gracilicirrhus* in number of species and *Paralonchurus brasiliensis* in biomass, our data show that these species were more abundant in the spring of both years, when the lower values of mean weight were registered for both species (Figs. 3 and 4). This indicates that recruitment is probably occurring right before the spring time for both species. This data partially contrast with what Costa (1977) found for *Ctenosciaena gracilicirrhus* off the coast of Rio Grande do Sul. According to that author, larger specimens approximately 20 cm in length were found in spring samples and the recruitment was established to occur in autumn when the smallest specimens were found. Cunningham (1978), on the other hand, studied the same species along a broad area off the Brazilian southeastern and southern coast and found out that recruitment started during the winter, reached its peak in spring and lasted until summer. The latter author also mentioned a slight migration northward of the species to the spawning areas between latitudes 23°S and 25°S. Araújo *et al.* (2006) described a marked spatial repartition among sciaenid species in the Sepetiba Bay, Rio de Janeiro, and found that *Ctenosciaena gracilicirrhus* was associated with the outer zone of the bay where depth and transparency are higher, factors associated with more pronounced marine influences. A seasonal repartition of *Ctenosciaena gracilicirrhus* was also registered by several authors studying areas near the one covered herein, and the species was interpreted as being associated with warmer waters, being present in great numbers near the shore during summer (Rossi-Wongtschowski & Paes, 1993; Rocha & Rossi-Wongtschowski, 1998; Rocha *et al.,* 2010), in accordance with the high abundance of this species at Flamengo Cove in the spring presented herein.

At last, it is worth mentioning that five of the sampled species are currently considered under threat in the State of São Paulo (Rossi-Wongtschowski *et al.,* 2009): *Rhinobatos percellens* (Walbaum, 1792), *Cynoscion jamaicensis, Macrodon atricauda, Epinephelus morio* (Valenciennes, 1828) and *Balistes capriscus* Gmelin, 1789. *Cynoscion jamaicensis* is one of the five main species landed in the State of São Paulo and was treated as "under threat of overexploitation" (Rossi-Wongtschowski *et al.,* 2009). The other four were considered "under overexploitation" and, in additional to overfishing, other impact that may threaten these species is habitat degradation (Rossi-Wongtschowski *et al.,* 2009). Three of these species (*Macrodon atricauda, Epinephelus morio* and *Balistes capriscus*) are also considered under threat of overexploitation in the federal context (Brasil – MMA, 2004). In addition, *Rhinobatos percellens* and *Epinephelus morio* were included as "near threatened" in IUCN's (2012) Red List. It is evident, therefore, that measures and public policies to ensure the conservation of the fish assemblage at Flamengo Cove are needed.

CONCLUSIONS

The fish community in the Flamengo Cove, Ubatuba, São Paulo varied in terms of its constitution both in the temporal context (between 1990 and 2000) and the seasonal context (between autumn and spring). Although the diversity remained virtually the same in terms of absolute number of species, the structure of the whole community changed significantly in these two contexts as evidenced by the Jaccard Similarity index. The most representative family was the Sciaenidae, with eight species in the whole study, following a similar pattern found by other authors studying either the same area or other areas also constituted by soft-bottom sediments. The most abundant species in number of individuals and in biomass were *Ctenosciaena gracilicirrhus* and *Paralonchurus brasiliensis,* respectively, both representatives of sciaenids. Data on abundance and mean weight of these two species showed that recruitment probably occurred right before spring time. Long-term studies are useful in detecting variations in the structure of the fish community, as shown herein, and more research programs dealing with the long-term variation of fish communities are encouraged to further enlight our knowledge on the ichthyofauna, especially in areas under strong human influence. In this context, the Flamengo Cove represents a good area of study due to its proximity to the facilities and infra-structure of Instituto Oceanográfico da Universidade de São Paulo.

RESUMO

A costa brasileira estende-se por mais de 8.000 km cobrindo cerca de 38 graus de latitude nos climas tropical, subtropical e temperado quente e inclui grande variedade de ambientes marinhos como praias arenosas, estuários, costões rochosos e recifes. Esta heterogeneidade de habitats reflete-se na diversidade de peixes marinhos encontrados em águas brasileiras que somam aproximadamente 1.300 espécies conhecidas. Estima-se que aproximadamente 600 espécies marinhas ocorram na costa do Estado de São Paulo. Estudos de longo prazo são úteis para se acessar a variação na comunidade de peixes devida a processos lentos, eventos raros ou episódicos e fenômenos muito variáveis e complexos. Nosso levantamento dos peixes da Enseada do Flamengo, Ubatuba, São Paulo, incluiu dois períodos distantes 10 anos entre si (1990 e 2000), em que foi amostrada a ictiofauna de fundos não consolidados, com rede de arrasto com portas, no outono e primavera. Coletamos 782 indivíduos pesando 18.113,3 g no total e representando 37 espécies de 19 famílias. Cinco espécies são consideradas ameaçadas de extinção no Estado de São Paulo, três delas consideradas ameaçadas de sobreexploração no contexto federal e duas incluídas na Lista Vermelha da IUCN. A família dominante foi Sciaenidae, com oito espécies nos dois períodos. Evidenciamos uma variação significativa na estrutura da ictiofauna entre 1990 e 2000, e entre outono e primavera, apesar do número de espécies não ter se alterado. As espécies mais importantes em termos de número de indivíduos e em biomassa foram Ctenosciaena gracilicirrhus *e* Paralonchurus brasiliensis, *respectivamente. Dados provenientes dessas duas espécies indicam que o recrutamento ocorreu na primavera quando mais indivíduos de tamanhos pequenos foram amostrados. Mais estudos de longo prazo como este são encorajados visando um melhor entendimento sobre a variação temporal na estrutura da comunidade de peixes em águas marinhas brasileiras.*

Palavras-Chave: Ambiente costeiro; *Ctenosciaena gracilicirrhus;* Peixes marinhos; Substrato não-consolidado; Sciaenidae.

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