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Co-occurrence of fish species on an impacted transitional environment in the Southern coast of Brazil

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Abstract. Biological communities are influenced by interactions among species and their environment, impacting species richness and composition over time. Understanding ecological patterns of species occurrence and distribution is crucial for elucidating the mechanisms driving community assembly. In this study, co-occurrence patterns of fish species in a transitional aquatic environment affected by human activities were investigated to determine if observed patterns differ from random expectations. The fish were collected from Saco dos Limões cove following anthropogenic impacts caused by highway construction. The findings suggest that fish community assembly in the area generally mirrors randomly generated patterns, indicating that competitive interactions may not be the primary drivers of community structure. Instead, abiotic factors such as environmental heterogeneity and resource availability likely play significant roles in shaping fish assemblages. Although some matrices showed deviations from random processes, these findings may be attributed to Type I Error, underscoring the importance of considering environmental characteristics when analyzing species co-occurrence patterns. Overall, the study underscores the resilience of fish assemblages in transitional waters and their ability to maintain functional integrity despite anthropogenic disturbances.

Keywords: s-score, competition, community ecology, ichthyofauna, interspecific interacrions.

Resumo. Coocorrência de espécies de peixes em um ambiente transicional impactado no litoral sul do Brasil. Comunidades biológicas são influenciadas por interações entre espécies e seu ambiente, impactando a riqueza e composição de espécies ao longo do tempo. Entender os padrões ecológicos de ocorrência e distribuição de espécies é crucial para elucidar os mecanismos que impulsionam a montagem da comunidade. Neste estudo,

os padrões de coocorrência de espécies de peixes em um ambiente aquático de transição afetado por atividades humanas foram investigados para determinar se os padrões observados diferem das expectativas aleatórias. Os peixes foram coletados na enseada Saco dos Limões após impactos antropogênicos causados pela construção de rodovias. As descobertas sugerem que a montagem da comunidade de peixes na área geralmente reflete padrões gerados aleatoriamente, indicando que as interações competitivas podem não ser os principais impulsionadores da estrutura da comunidade. Em vez disso, fatores abióticos como heterogeneidade ambiental e disponibilidade de recursos provavelmente desempenham papéis significativos na formação de assembleias de peixes. Embora algumas matrizes tenham mostrado desvios de processos aleatórios, essas descobertas podem ser atribuídas ao Erro Tipo I, ressaltando a importância de considerar as características ambientais ao analisar os padrões de coocorrência de espécies. No geral, o estudo ressalta a resiliência das assembleias de peixes em águas de transição e sua capacidade de manter a integridade funcional apesar das perturbações antropogênicas.

Palavras-chave: *s-core*, competição, ecologia de comunidades, ictiofauna, interações interespecíficas.

Introduction

Biological communities are, by definition, the set of species interacting with each other (Sobral & Cianciaruso, 2012). The study of the interactions between species and the environment allows us to understand which factors affect the species richness and composition of communities along the time (Begon *et al.*, 2006). Thereby, the ecology of communities investigates the patterns of occurrence and distribution of species in space and time (Gotelli 2000, Sánchez-Lizaso *et al.*, 2000), to understand why certain species are never found in a community, why others coexist, and if competitive interactions are ruling the maximum number of species in the community (Gotelli 2000). Since the ecological patterns suggest that the occurrence of species is not random, as communities are made up of a few abundant and many rare species (McGill *et al.*, 2007).

The theme Assembly Rules for structuring communities began with the work of Diamond (1975), when observing that several pairs of bird species never or rarely occurred together on the same island, in the archipelago of New Guinea. The same author concluded that this non-random co-occurrence pattern should be a consequence of competitive exclusion. At the study site, there were no geophysical limitations to dispersal, such as geographical barriers or climatic restrictions, making it possible to observe the ecological processes affecting the structure of bird assemblages, defining patterns in space and time (Diamond 1975, Sobral & Cianciaruso 2012). However, Connor & Simberloff (1979) reanalyzed the data of Diamond (1975) using a null model and found that the distribution pattern did not differ significantly from the expected at random. On the other hand, the proposed null model was criticized for being restrictive and was considered redundant by Gotelli & Graves (1996). Thus, how to identify whether a pattern of co-occurrence is the result of defined processes or simply occurs by chance? In this context, Gotelli & McGill (2006) state that null models are statistical models that, through randomization, make it possible to make inferences about a certain pattern or process observed concerning what is expected by chance.

The study and analysis of the patterns of co-occurrence of fish species in transitional waters is important for understanding how fish assemblages are structured, as having an understanding of how the ichthyofauna is structured and varies is very important, both for sustainable management, as well as for the preservation of local species (Kupschus & Tremain, 2001). Previous studies indicate that the occurrence of marine and estuarine fish species

is directly affected by abiotic variables (*e.g*. salinity, temperature, and depth) of the environment where they are found (Andrade-Tubino *et al.*, 2008, Froeschke *et al.*, 2010, Matich *et al.,* 2017). However, the structure of fish assemblages can also be related to their biological processes such as abundance cycles managed by migrations (long or short) of fish both for feeding and reproduction (Araújo *et al.*, 2002, Azevedo *et al.*, 2006).

Despite this, not all authors agree with the structure of fish assemblages in transitional waters (Ortega *et al.*, 2015), some authors suggest that fish assemblages exhibit random patterns of co-occurrence (Gotelli & McCabe, 2002), while others indicate that these patterns occur segregated (Bhat & Magurran, 2007). However, it is known that not all species carry out competitive interactions with each other, only those that have similar niches (Simberloff & Dayan, 1991).

Furthermore, in transitional waters (e.g. estuaries and bays), the scarcity of resources does not seem to be a determining factor, since these ecotones are known as areas of great biological production and resource availability (Kennish, 2002). Therefore, the distribution of species in these environments does not seem to be the result only of biotic interactions, and factors such as environmental requirements and species' ability to disperse also seem to influence their distribution (Peres-Neto *et al.*, 2001, Mackenzie *et al.*, 2004). Thus, the distribution of fish species in transitional waters is commonly related to abiotic factors such as salinity, temperature, type of substrate, turbidity, and depth (Blaber 2002). For that reason, the study of the co-occurrence of fish species is a crucial point for understanding how communities are assembled, allowing the identification of variations in the abundance, distribution, and behavior of fish fauna on small spatial scales (Auster *et al.*, 2005, Matich *et al.*, 2017).

That said, the present study aimed to identify possible competitive interactions between fish species present in a transitional aquatic environment impacted by human action to verify whether the pattern found in this location differs from that expected for this type of environment., since changes caused in the natural environment may be influencing the biological relationships of the local fish assemblage. To this end, ichthyofauna data from an impacted environment from in Saco dos Limões Cove, South Bay, state of Santa Catarina, Brazil were analyzed. Co-occurrence patterns were tested with the aid of null models, used to verify whether the structure of the local community is determined by environmental and biological factors or is equivalent to models generated by chance (random). According to the null model hypothesis, the observed pattern of co-occurrence should differ from chance if biotic interactions predominate as the driving force in the structuring of the ichthyofauna.

Material and methods

The fish fauna was collected in Saco dos Limões Cove, located on the east bank of South Bay, Santa Catarina, Brazil (Figure 1). The cove is shallow (2-8 m) and has a sandy-muddy bottom with a large amount of biodetritic material (Souza-Conceição & Schwingel, 2011).

The morphology of the Saco dos Limões cove was significantly altered along its eastern edge for the construction of a 15.9 km long landfill, the work removed 8.5 x 106 m3 of sandy sediment from the inlet itself. The total duration of the construction of the highway was from 1995 to 2004, with the dredging and backfilling activities beginning in August 1996 and ending in February 1997 (Veado & Resgalla Jr., 2005). Dredging and landfill resulted in changes in the hydrodynamics of the cove (e.g. decrease in area and increase in average depth), greater circulation of adjacent marine water and increase in the concentration of suspended material in the water column (Veado & Resgalla Jr., 2005).

Sampling of fish was carried out in February, April, June, August, October and December of 1997, 2000, 2001, 2002, 2003, at six sampling sites (1 to 6) (Figure 1). Fish were collected using two identical otter trawls with a length of 4.5 m, 7.5 m headline and 9 m footrope, mesh size of 14 mm in the top and bottom

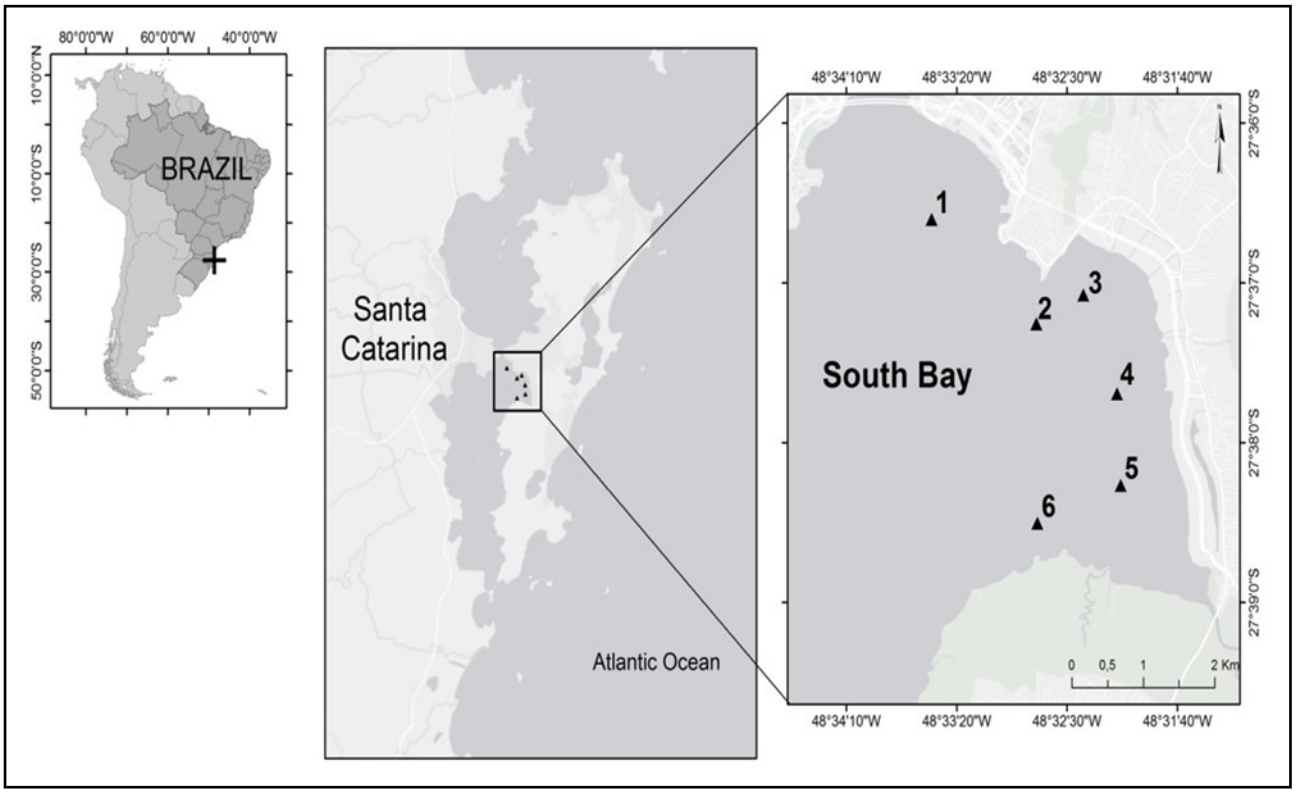

Figure 1. Location of sampling sites (1 to 6) in the Saco dos Limões Cove of South Bay (Santa Catarina, Brazil).

panel and 12 mm in the cod-end, with fishing effort standardized to 10 minutes, operating simultaneously. The material of the two nets was considered a sample. Identification of the caught species was carried out in laboratory using available taxonomic keys and scientific publications.

The data obtained through the sampling of fish fauna were tabulated in matrices, where the lines represent the species and the columns represent the locations or periods sampled. Each cell was assigned the value one (1) for the presence and the value zero (0) for the absence of each species in the sampled locations or periods. The matrices used for the analysis were produced by segregating temporal (month and year) and spatial (collection sites) scales. Because the effect of each type of scale (temporal or spatial) is not independent, so, during the analysis of spatial co-occurrence there is the effect of the temporal scale and vice versa (Ortega *et al.*, 2015). After preparing the matrices, the frequency of occurrence of the species was calculated using the formula: F.O.=(n/N) *100, where n is the number of samples where the species is present and N is the total number of samples. The occurrence was classified into the following categories: Very abundant, representing 81-100%; abundant, representing 61-80%; frequent, representing 41-60%; occasional, representing 21-40%; and rare, representing 1-20%.

Null models are statistical models that, through randomization, make it possible to make inferences about a certain pattern or process observed in relation to what was expected at random (Gotelli & Mcgill 2006). Values greater than those generated by chance indicate that the assemblage presents a segregation pattern, while values smaller than those generated by chance indicate a pattern of aggregated occurrence among species (Gotelli 2000).

To evaluate whether the organization pattern of local ichthyofauna differs from chance, the matrices obtained were subjected to analysis according to Gotelli (2000), carried out using the null model analysis package EcoSim version 1.00 (Gotelli *et al.*, 2015) in computational environment R (R Development Core Team 2022), using 5000 randomizations

(Entsminger, 2014) with a significance value of 0.05 for all analyses.

The chosen index was "C-score" because according to Gotelli (2000), it is less prone to Type I Error (rejecting the null hypothesis when it is true) and Type II Error (accepting the null hypothesis when it is false) and can detect significant patterns, even in noisy data sets. The matrix co-occurrence index (C-score) detects pairs of species that do not co-occur frequently. C-Score was calculated for each of the simulated assemblages and the observed indices were compared to the mean of the simulated indices. For C-score, values higher than those generated at random indicate that the assemblage has a pattern of segregation, while values lower than those generated at random indicate an aggregate occurrence pattern between species (Gotelli 2000, Gotelli & McCabe, 2002).

To construct the null models, three different algorithms were used, where the sum of the rows is always fixed (F) and the sum of the columns varies between fixed (F), proportional (P), and equiprobable (E), as models where the sum of the lines is fixed, they are less likely to incur a type I error (Gotelli 2000). In this way, the following algorithms were tested: (1) Fixed line x fixed column (FxF), where the sum of both the rows and columns of the original matrix remains constant, preserving the differences in the frequencies of occurrence of the species (sum of the rows) and the number of species per location (sum of columns); (2) Fixed line x equiprobable column (FxE), which generates matrices with communities considered equivalent; (3) Fixed line x proportional column (FxP), generating matrices where the distribution of species is proportional to that observed in the columns, allowing variation in column totals as well as in the equiprobable model, however, which may reflect differences between locations as well as in the fixed model.

Results

In the Saco dos Limões cove, 78 fish species were identified; the lowest richness was recorded in December 1997, with 17 species, and the highest in October 2002, with 40 species (Appendix 1). Regarding the frequency of occurrence, 58 species were considered rare, 10 were considered occasional , 5 were considered frequent, 3 were considered abundant, and 2 were considered very abundant (Appendix 1). The most frequent species during the study period, in descending order, were: *Genidens genidens* (Cuvier 1829), *Citharichthys spilopterus* (Günther 1862), *Eucinostomus gula* (Quoy & Gaimard 1824), and *Micropogonias furnieri* (Desmarest 1823).

In general, the results of the analyzed matrices indicated that community assembly resembles randomly generated patterns, not suggesting co-occurrence in the analyzed data. On a temporal scale, when the data was analyzed year by year, only the years 1997 and 2000, in the fixed row-fixed column algorithm, presented results suggesting co-occurrence (Table 1).

Table 1. C-Score values of null co-occurrence models for time scale matrices (comparing species occurrence between months in the years). Significance statistics: p-value <0.05. Significant values in bold. FxF = fixed row vs. fixed column; FxE = fixed row vs. equiprobable column; FxP = fixed row vs. proportional column.

Year	Observed	FxF		FxE		FxP	
		simulated	p-value	simulated	p-value	simulated	p-value
1997	0.765	0.725	**<0.05**	0.812	0.90	0.791	0.76
2000	1.203	1.179	**<0.05**	1.220	0.70	1.196	0.52
2001	0.659	0.660	0.48	0.695	0.87	0.687	0.81
2002	0.591	0.571	0.11	0.826	1	0.788	0.99
2003	0.787	0.771	0.12	0.847	0.94	0.829	0.84

Still in relation to the spatial scale, when testing a single matrix where the columns represented the months and the rows represented the species, all the algorithms (FxF, FxE, and FxP - where the row sum is always fixed (F) and the column sum varies between fixed (F), proportional (P), and equiprobable (E)) suggest the occurrence of co-occurrence (Table 2).

In relation to spatial distributions, co-occurrence patterns were observed by the fixed row-column algorithm in February, August and December 1997, October 2000, February 2001 and 2002 and June 2003 and by the fixed row-equiprobable column algorithm in June 1997 and April 2003 (Table 3).

Table 2. C-Score values of null co-occurrence models for time scale matrix (comparing species occurrence between all the months between 1997, 2000, 2001, 2002, 2003). Significance statistics: p-value <0.05. Significant values in bold. FxF = fixed row vs. fixed column; FxE = fixed row vs. equiprobable column; FxP = fixed row vs. proportional column.

Observed	FxF		FxE		FxP	
	simulated	p-value	simulated	p-value	simulated	p-value
12.18	12.007	**<0.05**	13.448	**<0.05**	0.791	**<0.05**

Discussion

The fish assemblage sampled in Saco dos Limões Cove during the analyzed period, following anthropogenic disturbance, generally showed no evidence of co-occurrence. The community structure did not differ substantially from what would be expected by chance, suggesting that competitive interactions were not the main drivers of assembly. Instead, abiotic factors likely played a greater role. This interpretation is supported by the high productivity of the area, fueled by nutrient inputs from rivers such as the Tavares (McLusky & Elliott, 2004, Souza-Conceição & Schwingel, 2011), by connectivity with adjacent marine habitats (Pasquaud *et al.*, 2015, Vasconcelos *et al.*, 2015), and by habitat diversity, including mangroves. These factors increase environmental heterogeneity and resource availability, creating numerous ecological niches that sustain high biodiversity without the need for intense competitive interactions.

Patterns of fish co-occurrence remain debated. While some studies argue that assemblages follow random patterns (Gotelli & McCabe, 2002), others suggest segregation (Bhat & Magurran, 2007). Competition occurs only among species that exploit resources in similar ways (Simberloff & Dayan 1991), and distributions are also shaped by differences in dispersal capacity and environmental requirements (Peres-Neto *et al.*, 2001, Mackenzie *et al.*, 2004). In transitional waters, as in the present study, fish distribution is primarily influenced by abiotic factors such as temperature, salinity, substrate type, turbidity, and depth (Blaber 2002). Biotic factors, including adaptive capacity, prey–predator dynamics, and habitat segregation, also contribute to community structuring (Gotelli *et al.*, 1997, Cartagena *et al.*, 2011).

The diversity pattern observed in Saco dos Limões Cove is consistent with other estuarine systems, typically characterized by a few dominant species and many rare ones (Magurran & Henderson, 2003). According to assembly rules, if biotic interactions were the dominant force, observed patterns would diverge from randomness. In this study, however, most matrices conformed to random expectations, with only a few exceptions. These deviations may be explained by the dredging activity associated with highway construction between 1995 and 2004 (Porto & Teixeira, 2002), which likely altered species distributions. As the system recovered, negative interspecific interactions appear to have been reduced.

Some deviations from randomness, particularly in FxF models and the overall temporal matrix, may also reflect Type I Error,

Table 3. C-Score values of null co-occurrence models for spatial scale matrices (comparing species occurrence between sampling sites between 1997, 2000, 2001, 2002, 2003). Significance statistics: p-value <0.05. Significant values in bold. FxF = fixed row vs. fixed column; FxE = fixed row vs. equiprobable column; FxP = fixed row vs. proportional column.

Year	Month	Observed	FxF		FxE		FxP	
			simulated	p-value	simulated	p-value	simulated	p-value
1997	February	0.746	0.693	**<0.05**	0.811	0.94	0.786	0.80
	April	1.071	1.046	0.10	1.098	0.70	1.043	0.44
	June	0.974	0.987	0.59	1.354	**<0.05**	1.219	0.96
	August	1.255	1.110	**<0.05**	1.402	0.92	1.240	0.52
	October	0.343	0.356	1	0.382	0.88	0.368	0.88
	December	1.700	1.599	**<0.05**	1.652	0.44	1.551	0.24
2000	February	1.317	1.318	0.48	1.504	0.96	1.354	0.64
	April	0.743	0.741	0.43	1.374	1.00	1.374	0.89
	June	0.989	1.006	0.71	1.060	0.83	1.023	0.69
	August	1.091	1.119	0.87	1.118	0.68	1.083	0.54
	October	0.891	0.761	**<0.05**	1.541	1.00	0.783	0.28
	December	0.830	0.771	0.07	0.965	0.90	0.885	0.70
2001	February	0.879	0.797	**<0.05**	1.284	1.00	1.070	0.93
	April	1.107	1.106	0.42	1.142	0.76	1.114	0.60
	June	0.802	0.815	0.73	0.921	0.94	0.889	0.91
	August	1.091	1.083	0.33	1.096	0.60	1.075	0.47
	October	1.124	1.140	0.73	1.204	0.88	1.163	0.72
	December	1.123	1.152	0.95	1.053	0.16	1.052	0.16
2002	February	1.542	1.474	**<0.05**	1.535	0.55	1.414	0.23
	April	1.011	1.048	0.96	1.342	0.99	1.165	0.90
	June	0.539	0.554	0.63	1.120	1.00	0.903	0.99
	August	1.228	1.220	0.33	1.177	0.26	1.164	0.23
	October	1.085	1.084	0.43	1.164	0.93	1.119	0.73
	December	1.238	1.191	0.09	1.212	0.45	1.155	0.26
2003	February	0.923	0.941	0.83	0.896	0.40	0.888	0.35
	April	0.852	0.846	0.67	1.129	**<0.05**	1.026	0.11
	June	0.963	0.903	**<0.05**	1.166	0.9918	1.068	0.85
	August	1.392	1.347	0.06	1.465	0.514	1.355	0.42
	October	1.027	1.003	0.14	1.355	1.00	1.202	0.93
	December	0.485	0.509	0.90	1.442	1.00	0.757	0.94

since most results aligned with random patterns. When analyzing co-occurrence, it is essential to consider habitat characteristics, as species-specific preferences may generate non-random distributions. Moreover, presence/absence matrices provide limited ecological realism and may lead to misleading inferences (Mackenzie *et al*., 2004).

When data were reorganized into a strictly temporal matrix, all algorithms indicated significant co-occurrence (Table 2). However, this approach masks spatial variation and groups species that do not naturally occur together. The outcome suggests that results from other matrices (Tables 1 and 3) reflect the combined effects of spatial gradients and differences among sampling stations. This pattern is consistent with expectations for transitional environments (Blaber 2002), where spatial segregation along environmental gradients pre-

vents co-occurrence and highlights the dominant role of abiotic factors in structuring fish communities (Azevedo *et al.*, 2006, Bot Neto *et al.*, 2021), even under anthropogenic disturbance.

These findings also indicate that conventional approaches may be insufficient to disentangle the role of biological interactions in estuarine systems. To better assess their influence, future studies should employ models that incorporate species' functional guilds (Gotelli & Graves 1996, Both *et al.*, 2011). Overall, fish community assembly in Saco dos Limões Cove largely reflects random processes, reinforcing the predominance of abiotic factors—such as environmental heterogeneity, resource availability, and connectivity with adjacent ecosystems—in maintaining community integrity. Although some deviations were detected, likely due to Type I Error, the study emphasizes that connectivity supports functional resilience by reducing the risk of function loss, promoting high taxonomic turnover, and sustaining ecological integrity. The tolerance of species to environmental variability, combined with the resilience of transitional assemblages, ensures the maintenance of functional structure even in the face of anthropogenic disturbance, while minimizing interspecific competition.

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Appendix 1. List of occurrences, in alphabetical order, of fish species captured in Baía Sul (Santa Catarina, Brazil) in the months of February, April, June, August, October and December of the years 1997, 2000, 2001, 2002, 2003 and respective percentages of frequency of occurrence relative to the thirty sampling campaigns carried oct. The numbers 1, 2, 3, 4, 5 and 6 represent the number of sampling points in which the species were present.

Species	feb/97	apr/97	jun/97	aug/97	oct/97	dec/97	feb/00	apr/00	jun/00	aug/00	oct/00	dec/00	feb/01	apr/01	jun/01	aug/01	oct/01	dec/01	feb/02	apr/02	jun/02	aug/02	oct/02	dec/02	feb/03	apr/03	jun/03	aug/03	oct/03	dec/03	FO (%)
Achirus declivis	3																														3.3
Achirus lineatus	1																						2				2	2	1		16.7
Anchoa marinii																													1		3.3
Archosargus rhomboidalis		5	3	5	3	2	4	3	5	4	1		2	2	5	5	5	3	5	2	1	5	5	1	3	1	3	1	5	4	93.3
Bairdiella ronchus											1							2													6.7
Caranx latus										1																					3.3
Catathyridium garmani		3	1	3	1			2	3	4			1	2	1	2	2	3		2	2	1	1	1	1						63.3
Centropomus parallelus	1						1	1			1									1			1				1			1	26.7
Centropomus undecimalis																													2		3.3
Cetengraulis edentulus	2	4	6	4	3	3	1	6	1		3	5	1	1	1	2							4				4	3	5	3	66.7
Chaetodipterus faber	1						1	1	1	3			4	2	3	3	2	2	1		1	3	4	1	1	1	1	2	4	1	73.3
Chilomycterus spinosus																												1			3.3
Chirocentrodon bleekerianus			1					1															1				1				13.3
Chloroscombrus chrysurus		1	2	1			3	4	1		1		5	2	2			2	4	5	2	5	1	1	6	6		1		1	70.0
Citharichthys spilopterus	6	5	6	5	3	4	4	5	6	6	3		5	6	6	6	6	6	4	4	6	6	5	5	5	4	5	6	6	3	96.7
Ctenosciaena gracilicirrhus																			1	1	1										10.0
Cynoscion leiarchus	2		4				2	3	3					5						1	1	1	2		5	3	2	3			46.7
Cynoscion microlepidotus		1																													3.3

Appendix 1. Continuation.

Species	feb/97	apr/97	jun/97	aug/97	oct/97	dec/97	feb/00	apr/00	jun/00	aug/00	oct/00	dec/00	feb/01	apr/01	jun/01	Aug/01	oct/01	dec/01	feb/02	apr/02	jun/02	aug/02	oct/02	dec/02	feb/03	apr/03	jun/03	aug/03	oct/03	dec/03	FO (%)
Dactylopterus volitans							1			1																					6.7
Diapterus rhombeus	2	2	2	2	1	4	4		4	1	2			3	4	5	3	3	3	4	1	3	4	1	3	4	2	2	3	3	90.0
Diplectrum radiale	1	2	2	2	1		3	2	3	5	2		4	4	6	5	4	4	2	1	5	4	3		2		1	3	3	1	86.7
Elops saurus															1							1									6.7
Epinephelus marginatus																1															3.3
Etropus crossutus											1		3	3	4	3	2			3	5	4	2		4		1	3	2		46.7
Etropus longimanus						1																									3.3
Eucinostomus argenteus	1	5	3	5	3	5	2	1	5	6	3		1	6	6	5	4	4	3	5	5	4	4	4	3	2	2	3	3		93.3
Eucinostomus gula	6	6	4	6	1	6	5	5	6	4	3	3	4	5	5	6	5	6	2	2	5	5	6	6	6	6	6	3	6	3	100
Eucinostomus melanopterus	1	2	3	2		1	2			4	1	1			2	1		1		1	2	3	1						2		56.7
Genidens barbus	4	2	2	2		4	4	4	2	1	2	3	3	4	1	3	6	6	2	4	2	2	4	3	6	5	4	1	4		93.3
Genidens genidens	4	4	5	4	2	4	5	5	5	4	3	6	6	6	6	6	6	6	5	4	3	6	6	5	6	6	6	5	6	5	100
Gobionellus oceanicus	1		2		1			1				1	2	1					2	1					2						33.3
Gymnura altavela								1																							3.3
Haemulopsis corvinaeformis							1			1					1										1						13.3
Harengula clupeola		2	2	2	2		1	2				1											2				2		1	1	36.7
Hypleurochilus fissicornis									1	1																					6.7
Hyporthodus niveatus																													1		3.3
Isopisthus parvipinnis													5	1	4	3	1			2		1									23.3

Appendix 1. Continuation.

Species	feb/97	apr/97	jun/97	aug/97	oct/97	dec/97	feb/00	apr/00	jun/00	aug/00	oct/00	dec/00	feb/01	apr/01	jun/01	Aug/01	oct/01	dec/01	feb/02	apr/02	jun/02	aug/02	oct/02	dec/02	feb/03	apr/03	jun/03	aug/03	oct/03	dec/03	FO (%)
Laugcephalus laevigatus	4	1	1	1	1	2		4	2		1	6	2	4	4		1	5	1	2			1	3	6	1			3	3	76.7
Lutjanus synagris			1													2							1		1						13.3
Lycengraulis grossidens			2		1	3	1					1											1				1	1			26.7
Menticirrhus littoralis					1				1	1		1																			13.3
Menticirrhus martinicensis			1				1	2					2	1	1	1	2	1					1				1			1	40.0
Micropogonias furnieri	5	4	4	4	3	3	4	5	4	3	2	4	6	6	6	6	6	5	4	6	3	4	6	1	4	3	6	3	4	2	100
Mugil curema		3	3	3				3	1		1			2	2	1			1				1				1		4	1	46.7
Mugil liza		1	1	1											1		2			1		1									23.3
Mycteroperca acutirostris														2	1		2		1	1	1			2				1			26.7
Mycteroperca bonaci																						1									3.3
Mycteroperca microlepis													1	2	2	1	1														16.7
Mycteroperca rubra							1	1	1																						10.0
Oligoplites saliens															5	3		1													10.0
Oligoplites saurus			3		2			2						2	4	3	1			1		2	1	1		1	1		3	1	50.0
Ophichthus gomesii													1										2						1		10.0
Orthopristis rubra	2		2													1		1	1	1		2	3				1		1		33.3
Paralichthys orbignyanus						1																									3.3
Paralonchurus brasiliensis													2	1	2		2						1								16.7
Pellona harroweri			1																												3.3

Appendix 1. Continuation.

Species	feb/97	apr/97	jun/97	aug/97	oct/97	dec/97	feb/00	apr/00	jun/00	aug/00	oct/00	dec/00	feb/01	apr/01	jun/01	Aug/01	oct/01	dec/01	feb/02	apr/02	jun/02	aug/02	oct/02	dec/02	feb/03	apr/03	jun/03	aug/03	oct/03	dec/03	FO (%)
Peprilus paru												1	2												1						10.0
Pogonias courbina		1		1																											6.7
Pomatomus saltatrix					1								1			1					1			1				1	1		23.3
Prionotus punctatus	4	2	5	2	1	3	4	5	4	3	2	3	5	6	6	5	2	5	2	4	4	5	4	3	6	4	4	3	2	2	100
Pseudobatos percellens		1		1					1	1																					13.3
Rypticus randalli													1	2												1				1	13.3
Sardinella brasiliensis																												1			3.3
Selene vomer	1		1		1	1		3	1				4	5	4	4	3	2		3	1	1	3	1	4	2	3	1	2		73.3
Sphoeroides greeleyi	1											5	2			2	3	2				1	6	2	2	1	2	2	3	2	50.0
Sphoeroides pachygaster																	1														3.3
Sphoeroides testudineus	3	4	1	4	2	3		1			2	4		4	5	2	4	3	3	2	1	4	4	1	1	2	1	1	4	2	86.7
Sphoeroides spengleri													3	1	1	1	3	1	1	1	1		1	1							36.7
Sphyraena guachancho								1					1	1						2											13.3
Stellifer brasiliensis																							1								3.3
Stellifer rastrifer			1																				1		1				1		13.3
Stellifer stellifer																													1		3.3
Stephanolepis hispidus										2			1		2	1		1			1	2	1				1	1	2		36.7
Symphurus plagusia		1		1	1		3	3	3	2		1																			26.7
Symphurus tessellatus	3										1	1	3	4	1	1	1			1	2	4	2	3	2	1	2	3	3	1	63.3

Appendix 1. Continuation.

Species	feb/97	apr/97	jun/97	aug/97	oct/97	dec/97	feb/00	apr/00	jun/00	aug/00	oct/00	dec/00	feb/01	apr/01	jun/01	Aug/01	oct/01	dec/01	feb/02	apr/02	jun/02	aug/02	oct/02	dec/02	feb/03	apr/03	jun/03	aug/03	oct/03	dec/03	FO (%)
Synodus foentes	1						3	3	6	6	1	5	1	2	1	2	1	1		2	5	6	4	4	1	3	3	2	1	1	70.0
Trachinotus carolinus															1																3.3
Trichiurus lepturus			1				1	1				1	5	2	1	1	1	1		1	1		2		2	2		2		1	56.7
Total de espécies capturadas	24	23	32	22	21	17	25	30	24	22	21	19	32	32	36	33	28	26	20	31	26	28	40	22	27	21	29	28	33	22	--