Trophic Analysis of the Fish Community Taken as Bycatch of Shrimp Trawls off the Coast of Alvarado, Mexico

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ABSTRACT

In the southern Gulf of Mexico, there is an important shrimp fishery industry with no recent works on the fish assemblage ecology coming from the trawling bycatch. The objective of this work was to seasonally analyze the trophic spectrum and niche parameters of the most important fish coming from the shrimp bycatch. During 1991 to 1994, 21 two hour trawls were done in the southern Gulf of Mexico off Veracruz, Mexico at a mean depth of 20 m. The importance value of the food items, identified to the finest level possible, was used to calculate: the Levins niche breadth for each species; a cluster analysis, and the Rekonen index for niche overlap between species for three seasons. During the dry season, 26 fish species were analyzed which grouped into four clusters based on 24 food items. The highest Rekonen value (> 53%) was for species feeding on benthic or zooplankton items. For the rainy season, 26 species were grouped into three clusters, of which the benthic feeders presented the highest niche overlap (> 47%) and the least number of species. The northerly winds season was the richest in species (43), which were assembled in three groups according to their food items. One group was formed by two anchovies with a high (> 80%) niche overlap. Thirty-six species formed a single group feeding on a variety of items (mainly benthic) with a niche overlap > 50%. The high number of species feeding on similar items during the northerly winds season may be due to a higher productivity in the region produced by the river runoff. In contrast to the other seasons, the amount of food items are restricted, thus diminishing the number of possible prey and increasing the niche overlap between trophic groups.

KEY WORDS: Fish ecology, resource partitioning, shrimp bycatch

Análisis Trófico de la Comunidad de Peces Provenientes de la Pesca Incidental Camaronera de la Costa de Alvarado, México.

El objetivo de este trabajo fue el de analizar estacionalmente el espectro trófico y los parámetros del nicho de las especies de peces más importantes provenientes de la pesca incidental del camarón. Durante 1991 a 1994 se realizaron 21 viajes en el sur del Golfo de México haciendo arrastres de 2 horas a una profundidad media de 20 m. El valor medio de los tipos alimenticios, identificados al nivel más fino posible, fue usado para calcular: el índice de amplitud de nicho de Levins; un análisis de clasificación y el índice de Rekonen para el solapamiento de nicho entre las especies durante las tres temporadas del año. Para la temporada de secas 26 especies fueron analizadas que se agruparon en cuatro grupos de acuerdo a los 24 tipos alimenticios ingeridos. El mayor valor de Rekonen (>53%) fue para las especies que se alimentan de bentos o zooplancton. Para la temporada de lluvias 26 especies fueron analizadas agrupadas en tres grupos, de los cuales las que se alimentaron del bentos presentaron el mayor valor de Rekonen (>47%) y el menor número de especies. La temporada de nortes fue la de mayor riqueza específica (43 especies) quienes se dividieron en solo tres grupos. Uno de los grupos formado por las anchoas y un solapamiento mayor al 80%. Otro de los grupos se formó por 36 especies que se alimentan de una variedad de organismos (principalmente bénticos) con un solapamiento de nicho del 50%. La alimentación de la gran cantidad de especies en la temporada de nortes tan similar puede deberse a una mayor productividad en la región producida por el escurrimiento de los ríos adyacentes. En contraste la cantidad de tipos alimenticios de las otras temporadas es menor disminuyendo el número de presas e incrementando el solapamiento entre los grupos tróficos.

PALABRAS CLAVES: Captura incidental, ecología de peces, repartición de recursos

INTRODUCTION

Demersal fish community structure has been studied in different ways at different locations of the world. For instance, there have been studies dealing with their diversity (Stobutzki et al. 2001), seasonal biomass trends (Blanchard, 2001), and relation to estuarine areas (Yañez-Arancibia et al. 1985). However, along the Mexican coasts, there are few studies relating to the demersal fish community, with the exception of Yañez-Arancibia and Sánchez-Gil (1988), and Franco et al. (in revision). The former work analyzes the effects on demersal fish from shrimp trawling at the Campeche Bank, and Franco et al. (in revision) analyzes the community structure and seasonal trends in biomass and abundance. Considering the importance that the demersal fish community has on the ecology of the ecosystem, in addition to its importance as an exploited resource, the aim of the present work was to analyze the trophic relationship of the most abundant species during three seasons over a four-year period.

METHODS

All biological material was collected on board the research vessel CET-Mar Alvarado within the commercial area for shrimp capture and in front of the opening of the Alvarado Lagoon. The sampling area was located between 18° 45" and 19° 00" N and 95° 40" and 85° 57" W (Figure 1). Twenty-one trips between May 1991 and November 1994 were performed using a Japanese-type trawl 20 m long, mouth opening of 2 m and mesh size of 1.75 inches. The trawl was fished for 2 h at a depth of 25 meters. All the sampling dates were divided into the three seasons occurring in the area; rainy (n = 6), dry (n = 6) and north winds (nortes; n = 9).

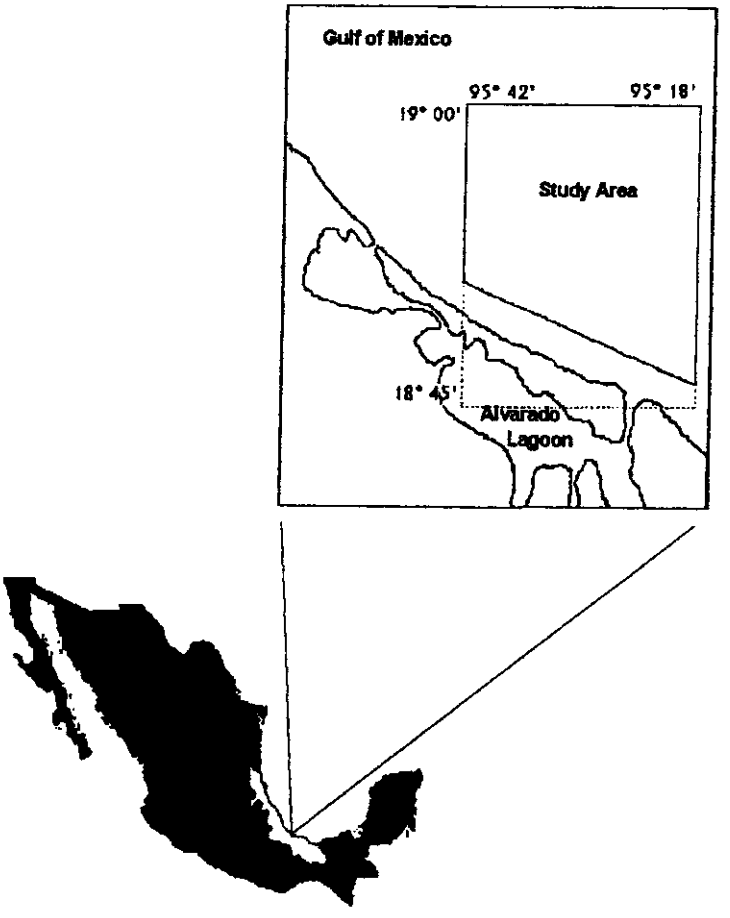

Figure 1. Study area location and its relation with the coastal lagoon of Alvarado and the Gulf of Mexico.

Ten percent of the total fish capture was randomly selected, stored in plastic bags with 10% formaldehyde, and transported to the laboratory. Fishes were identified to species, weighed (g), and measured (standard length; SL; mm). The stomach contents were identified to the highest possible taxonomic level using a stereoscopic microscope. Food items were weighed to the nearest 0.1 mg, and an importance value was assigned to each item, based on the gravimetric and volumetric methods (Bagenal 1978).

Although 159 fish species have been reported for this area (Franco-López et al. in revision), only the species with a biomass greater than 2 kg and an abundance of more than 100 individuals combined for all sampling dates per season were analyzed in this report. The stomach analysis for the fish were pooled for each season. A cluster analysis using Euclidean Distance was performed on the stomach content data in order to identify species guilds for each season. Food niche width was also calculated for each species at each season using the Levins Index (Marshall and Elliot 1997). The trophic niche overlap was computed using the Renkonen Index.

RESULTS

Dry Season

During the dry season, 26 species, representing 3,331 fish containing 24 different food items were analyzed. Trophic niche width, as measured by the Levins Index ranged from 1 to 4.7, with *Micropogonias furnieri*, *Cynoscion arenarius* and *Sphyraena guachancho* presenting values greater than 4, and *Anchoa rostralis* and *Menticirrhus littoralis* values of 1 (Table 1). After the cluster analysis, the dendrogram was divided into four groups according to their food items (Figure 2). The first group, formed by species like *Chloroscombrus chrysurus*, was a guild of species feeding on planktonic organisms. The Levins niche width ranged from 1 to 4.7 with a mean value of 1.74, and presented a mean Rekonen value for niche overlap of 54.17 %. Ten species feeding primarily on benthic items (polychaets, stomatopds, and fish) composed the second trophic guild. The mean Levins niche width was 2.13 (range 1 to 3.9), and the guild was composed of species such as *Haemulos aurolineatum* and *Harengula jaguana*. The Rekonen mean niche overlap for this guild was 53.71 %. Carnivorous species, such as *C. arenarius* and *Synodus foetens*, represented the third group with a mean Levins value of 3.46, (range 2.19 to 4.73) and a mean Rekonen niche overlap of 29.3 %. The last group, represented by six strict carnivorous species feeding on items such as shrimp, crabs, fish, and squid had a mean Levins value of 2.73 (range 1.8 to 3.5) and a mean Rekonen overlap value of 39.4 %.

Rainy Season

During the rainy season, 26 species, representing 3,023 fish were sampled. The Levins niche width index varied between 1 (*Diplectrum bivittatum*, *Saurida brassiliensis* and *Scorphaena plumeri*) and 4.5 (*C. arenarius* and *S. foetens*; Table

2). The dendrogram was divided into three guilds (Figure 3). The first guild contained seven species using 16 different food items such as *A. rostralis*, crabs, and squid, and had a mean Levins index of 3.52 (range 2.5 to 4.5) and a mean Rekonen overlap value of 22.62 %. The second guild represented 11 species feeding on 18 different food items, mainly benthic. The mean Levins index value was 2.5 (range 1 to 3.5), and the mean Rekonen overlap value was 47.7 %. The third guild was composed of five species using planktonic organisms as their main food. Species such as *Harengula clupeola* and *C. chrysurus* were part of this guild, which had a mean Levins value of 2.75 (range 1.9 to 3.9), and a mean Rekonen overlap value of 39.75 %.

Table 1. List of fish species for the dry season and the Levins Index for niche width

Species	Levins Index	Species	Levins Index
Achirus lineatus	3.51	*Lepophidium graellsi*	1.92
Anchoa mitchilli	1.83	*Menticirrhus littoralis*	1.00
Anchovia rostralis	1.00	*Micropogonias furnieri*	4.74
Citharinchthys spilopterus	2.82	*Porichthys porosissimus*	1.89
Chloroscombrus chrysurus	2.00	*Sardinella aurita*	1.88
Conodon nobilis	3.93	*Saurida brassiliensis*	2.63
Cynoscion arenarius	4.73	*Selar crumenophthalmus*	2.34
Cynoscion nothus	2.73	*Selene vomer*	1.36
Diapterus auratus	2.20	*Sphyraena guachancho*	4.22
Engyophrys senta	2.17	*Synodus foetens*	2.25
Haemulon aureolineatum	1.83	*Trachurus lathami*	2.19
Harengula jaguana	1.37	*Trichiurus lepturus*	3.32
Hoplunnis macrura	1.83	*Upeneus parvus*	377

North Winds Season

The highest number of species (43) and individuals (4,378) were captured during the north winds season. The Levins values varied between 1 and 5.9 (Table 3). The resulting dendrogram from the food items analysis was divided into three groups (Figure 4). The first group was composed by two planktivorous species, *Anchoa hepsetus* and *A. mitchilli*, with a mean Levins niche width of 1.38 (ranging from 1 to 5.9), and a mean Rekonen overlap value of 82.7 %. The second group was formed by a carnivorous guild of four species including *Diplectrum formosum* and *S.guachancho*. The mean Levins value for this guild was 1.29 (range 1 to 1.9), and the mean Rekonen overlap value was 69.7 %. The third group had the highest number of species (36), and the greatest number of food items (23), making this group one of the most diverse. The mean Levins width index was 3.04 (range 1 to 5.9), and the mean Rekonen niche overlap value was 53.24 %. This group is a mixture of species feeding on different items, but predominating the benthophagous.

Table 2. List of fish species for the rainy season and the Levins Index for niche width

Species	Levins Index	Species	Levins Index
Cetengraulis edentulus	1.28	*Porichthys porosissimus*	2.62
Chloroscombrus chrysurus	3.92	*Pristipomoides aquilonaris*	3.46
Conodon nobilis	3.70	*Saurida brassiliensis*	1.00
Cyclopsetta chittendeni	3.51	*Scorphaena plumeri*	1.00
Cynoscion arenarius	4.55	*Selene setapinnis*	1.92
Cynoscion nothus	2.53	*Selene spixii*	2.38
Diapterus auratus	2.21	*Sphyraena guachancho*	2.94
Diplectrum bivittatum	1.00	*Stellifer lanceolatus*	4.17
Engyophrys senta	2.06	*Syacium gunteri*	2.94
Haemulon aureolineatum	2.79	*Synodus foetens*	4.44
Harengula clupeola	1.81	*Trinectes maculatus*	1.10
Harengula jaguana	3.09	*Umbrina coroides*	3.63
Micropogonias furnieri	3.08	*Upeneus parvus*	333

Table 3. List of fish species for the north winds season and the Levins Index for niche width

Species	Levins Index	Species	Levins Index
Achirus lineatus	3.58	*Mirophys puntatus*	2.94
Anchoa hepsetus	1.54	*Ophidion welshi*	2.00
Anchoa mitchilli	1.22	*Polydactilus octonemus*	3.41
Caranx hippos	1.00	*Porichthys porosissimus*	4.03
Chloroscombrus chrysurus	3.59	*Prionotus rubio*	2.88
Conodon nobilis	5.88	*Pristipomoides aquilonaris*	2.24
Cyclopsetta chittendeni	1.95	*Sardinella aurita*	1.00
Cynoscion arenarius	2.52	*Scorpaena plumeri*	3.77
Cynoscion nothus	2.99	*Selar crumenophthalmus*	2.00
Diapterus auratus	1.93	*Selene spixii*	2.38
Diapterus rhombeus	1.74	*Sphyraena guachancho*	1.00
Diplectrum bivittatum	1.54	*Stellifer lanceolatus*	3.77
Diplectrum formosun	1.92	*Stenotomus caprinus*	3.43
Egyophyrys senta	2.40	*Syacium gunteri*	3.75
Eucinostomus melanopterus	4.17	*Syacium papillosum*	2.78
Gymnotorax nigromarginatus	2.29	*Symphurus plagiusa*	4.44
Harengula clupeola	4.03	*Synodus foetens*	2.93
Harengula jaguana	5.09	*Trachurus lathami*	1.80
Lepophidium graelisi	2.90	*Trichiurus lepturus*	3.06
Lobotes surinamensis	1.24	*Umbrina coroides*	5.49
Lutjanus campechanus	1.75	*Upeneus parvus*	3.57
Micropogonias furnieri	2.52		

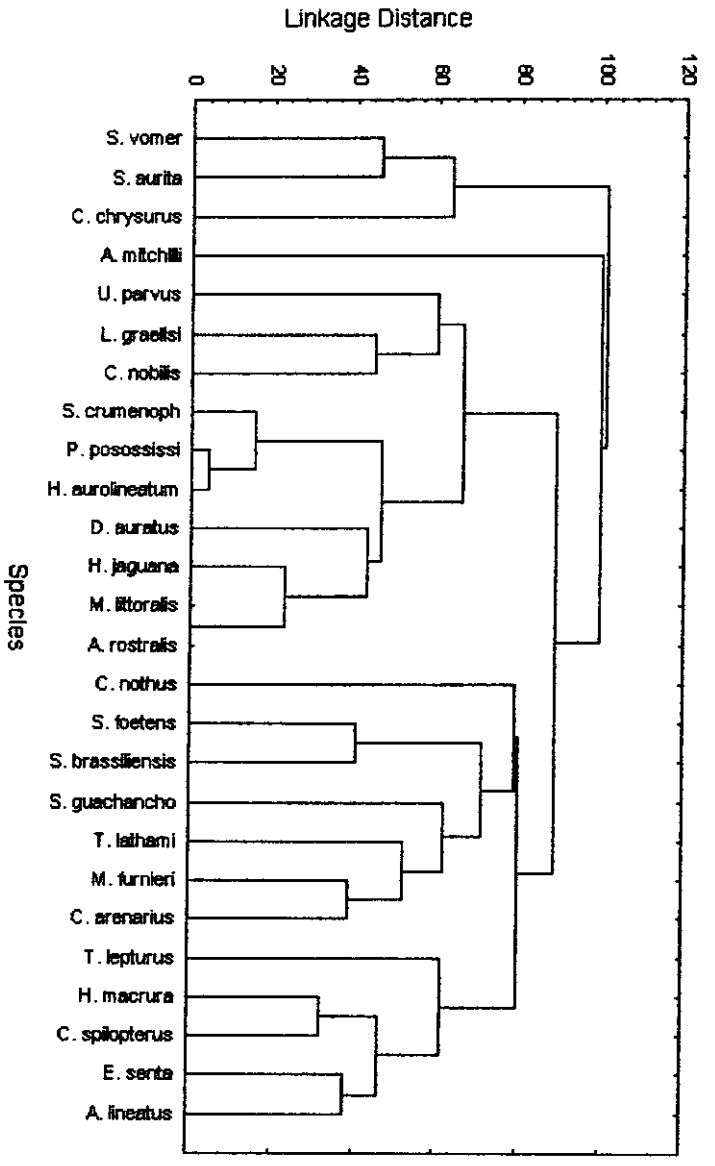

Figure 2. Dendrogram of species according with their food items for the dry season for the area off Alvarado, Veracruz, Mexico.

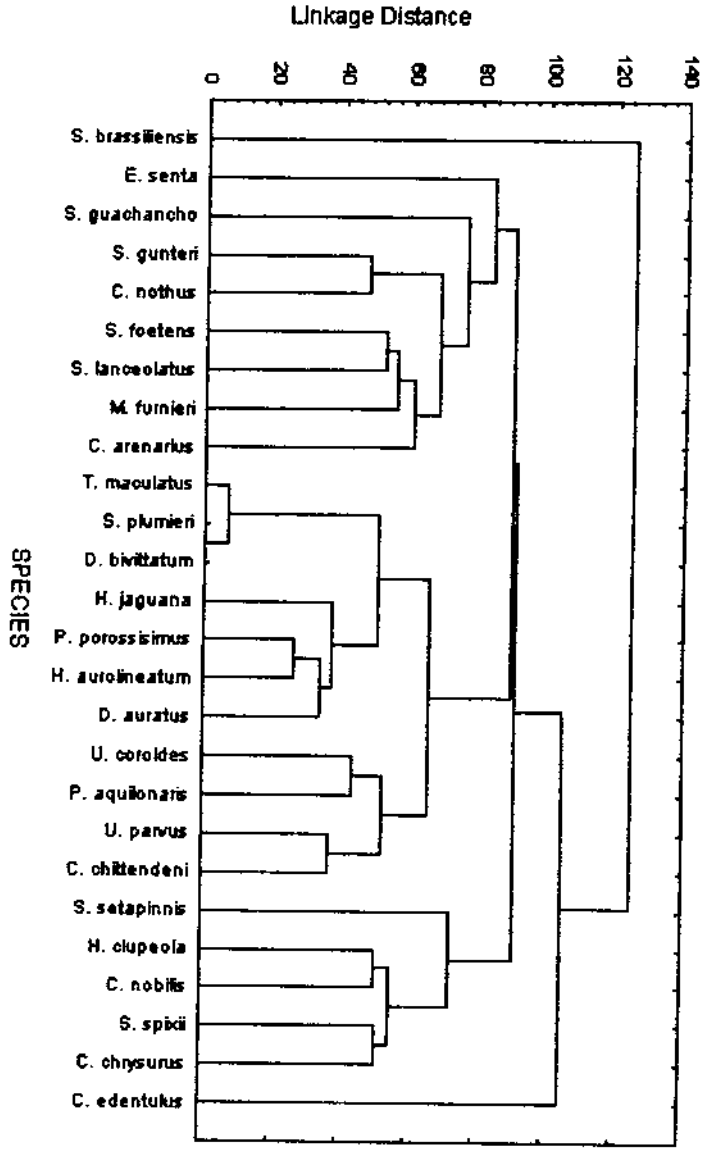

Figure 3. Dendrogram of species according with their food items for the rainy season for the area off Alvarado, Veracruz, Mexico.

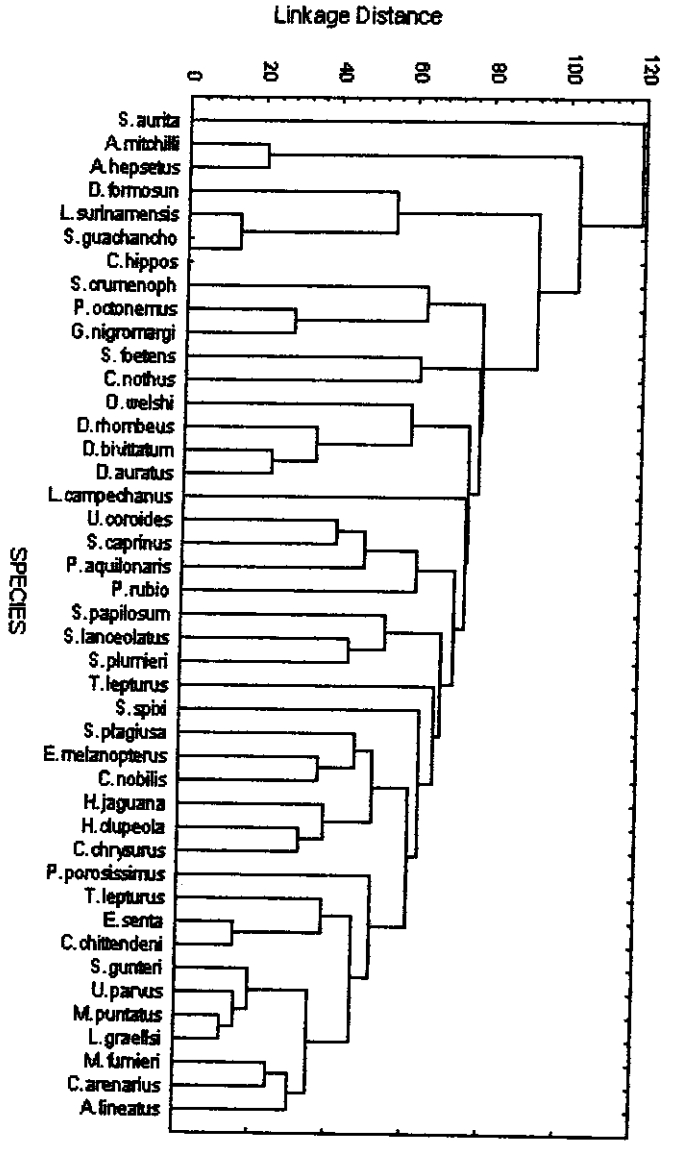

Figure 4. Dendrogram of species according with their food items for the north winds season for the area off Alvarado, Veracruz, Mexico.

DISCUSSION

The number of species found in the area off Alvarado was high (159 species) as expected for a tropical zone (Franco-López, et al. in revision), but lower compared to other similar areas, e.g. Australia (Stobutzki et al. 2001). A tropical system has a high number of species living within its boundaries, meaning that the resources they use, mainly food, have to be shared or partitioned between all of them. The theory in a situation where the resource, e.g. food, is scarce, dictates that competition should appear between species (Odum 1978). However, after a revision of available data, Ross (1986) proposes that the partition of resources between species occurs mainly into three different axes: food, habitat or space, and time. In the case of fish communities, resource partitioning between species is achieved by a high degree of omnivory (Gerking 1994) of the species. One of the characteristics of fishes is their ability to switch food items as the amount them increases or decreases (Sierra et al. 2001, Gerking 1994).

The results of the study revealed a difference of resource partitioning between the fish species between the three different seasons. For the dry and rainy season, with a similar number of species, the number of trophic guilds, and their type is similar. That is, although the species were different for each guild for each season the type of food resource use is the same (e.g. benthophagous, planktivorous). Although the similarity in guilds types the Rekonen overlap measure was different for the same kind of guild between seasons. That is, for the rainy season the planktivorous guild overlap was lower than that for the dry season. This is interesting considering that for the dry season there is one more trophic guild, what can be said of these results is that for the dry season, when the river runoffs are small, the amount of food items is reduced, and fish have to partition more the available preys in order to minimize competition. The opposite occurs in the rainy season when a higher availability of food exist, and fish can share the items with minimal competition.

On the other hand, for the north winds season, with a much high number of species than the previous two seasons, only three trophic guilds from the cluster analysis were found after cutting the dendrogram at the same level as for the former two seasons. One of the guilds was composed by two species of the same genus feeding almost the same items. The biggest of the groups did not present a high niche overlap value as expected considering the high number of species. Considering the relatively low overlap value, the dendrogram was divided further into smaller guilds, producing an increase in the food partitioning between species and a decrease of the niche overlap.

Blanchard (2001) suggests that the biomass variability to be related to the species interactions. In a previous report (Franco-López et al., in revision) it was argued that the biomass oscillations along the four years study might represent a balance of fish species and related to the use of the food resources. The results obtained in this work may support this hypothesis considering that the number of food items found for each season is related to the productivity, and that fish respond to it by increasing their omnivory and opportunism. this two characteristics allow

fish to diminish the competition for food and increase their biomass when the conditions are adequate.

On the other hand, the higher number of species and their resources are also related to the runoff of the adjacent rivers and coastal lagoons during the rainy, dry, or north winds season. A larger runoff produces an adequate environment for a higher productivity, which is used by the benthic and planktonic communities helping the establishment of a certain type of fish communities.

In conclusion, the fish community presented a low degree of food niche overlap within seasons and a marked difference in the number of species during the seasons. The differences between seasons might be related to the amount of food available and the high capacity of fish to share resources between them.

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