Density and biomass variations of micronekton close to fish aggregating devices (FADs) around Martinique.

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ABSTRACT

The numerical and ponderal variations of micronekton around fish aggregating devices (FADs) have been studied in Martinique using day/night sampling from upper 200 m depth with a mesopelagic trawl. The trawl used is an Isaac Kidd type, of 7,13 m² surface to the opening and a grid of 4 mm at the bottom. Forty six samples have been collected between july 2003 and april 2004. A total of 189 taxons of fish, squids and crustaceans covering 86 families were collected. In this article the micronekton's numerical and ponderal variations are discribed using four parameters: the season, the day/night comparaison, the depth and the fishing position. A description of the miconekton composition contingent on the four factors enumerate up is done in order to explain the variations.

KEY WORDS: micronekton, fish aggregating devices (FADs), trawling, Martinique.

Variations de biomasse et de densité du micronecton proche des Dispositifs de concentration de poissons (DCPs) autour de la Martinique.

Les variations numériques et pondérales du micronecton à proximité de DCPs expérimentaux ont été étudiées en Martinique par échantillonnage dans les 200 premiers mètres sous la surface, avec un chalut mésopélagique. Ce chalut est de type Isaac Kidd d'une surface d'ouverture de 7.13 m² et de 4 mm de coté de maille au cul. Quarante six échantillons ont été collectés entre Juillet 2003 et Avril 2004. Un total de 189 taxons de poissons, céphalopodes et crustacés couvrant 86 familles ont été récoltés. Dans cet article les variations numériques et pondérales du micronecton sont décrites en fonction de quatre paramètres : la saison, le cycle nycthéméral, la profondeur et la distance à la côte. La composition des taxons dominants dans les échantillons est mise en évidence afin de comprendre quelle est leur participation au régime alimentaire des thonidés et éventuellement d'expliquer les variations d'abondance de ceux-ci.

MOTS-CLÉS : micronecton, dispositif de concentration de poissons, chalutage, Martinique.

INTRODUCTION

FADs have been introduced in Martinique in order to reduced the pressure applied by the fishing on the shelf resources. Now they have an import social and economic impact in the fishery of Martinique.

Borodulina (1982), Roger and Marchal (1994) and Ménard (2000) reported that *Vinciguerria nimbaria* , a mesopelagic fish of the micronekton, as the most important forage item of skipjack and yellowfin tuna. But Ménard (2000) precised that the opportunistic feeders status of the tuna can explain that this typical mesopelagic species of the Eastern Atlantic Ocean represent an important part of the tuna diet. In the Caribbean region not much is known about the species composition and biomass of the micronekton in general and furthermore close to the FADs.

To describe the moored FADs-macronekton-environment, surveys have been conducted by the IFREMER halieutic resources laboratory from Martinique between May 2003 and April 2004. Three kinds of methods have been used: optical, acoustic and experimental fishing. Only the results of the experimental fishing of micronekton will be discussed in this article.

Using a mesopelagic trawl, 46 samples have been collected close to 4 FADs (Carla, SP20, Vaudreuil and Atlantic) around Martinique. With these samples we tried to elucidate the community structure of the animal groups. This study is a description of the density and biomass distribution of micronekton and its composition close to moored FADs.

MATERIALS AND METHODS

Sampling

Samples were collected by trawling with Beryx ship around 4 FADs (SP 20, Carla, Vaudreuil and Atlantic), between 60°44' W to 61°37' W, and 14°20'N to 14°46' N, from 8 July 2003 to 25 April 2004 (Figure 1). The samples were executed at different depths and in a day/night sampling basis. Micronekton was collected with mesopelagic trawl, Isaac Kidd type, of 7.13 m² surface at the mouth and a grid of 4 mm at the bottom. The trawlings were towed at a speed of 3.7 to 5.5 Km/h. The volume of water filtered was calculated from the mouth size and the riding distance. The 46 trawls are resumed in the table 1.

After each trawl, samples have been gathered by sieving (0.5 mm mesh) and frozen on board. On land, in the laboratory, samples have been sorted into major taxa and fixed in buffered formalin-seawater solution. Then each organism has been identified to the best precision level and weighted. Each fish has been measured, in total length, to the nearest milimeter.

Statistical analysis

Density and biomass by m^3 were calculated for each day and taxonomic group. In order to draw the main parameters affecting the density, a Principal Components Analysis was executed. The density for each taxa, the depth, the longitude, the latitude, the season, the period of the day and the distance to the shoreline were used as variables. The period of the day and the season have been expressed in a binary form.

Among the variables that significantly affecting the density of the taxa, non parametric test have been conducted The significativity of this factors has been tested for discrete range in order to underline the micronekton's repartition around a FAD. The Mann-Whitney test (Cheung and Klotz 1997) has been used to compare the density for variables that could be separate in two groups. A Kruskall-Wallis test (Siegel and Castellan, 1988) based on the density has been performed for variables separate in several discrete range (depth and distance to the shoreline).

To describe the association between the taxa, they have been clustered by dissimilarity using Khi² distance and Ward method (Ward, 1963). The data used were the presence and absence of the different taxa for each trawling.

For a better readability of the data, only the taxa with an occurrence up to 35% for the 46 samples have been analysed by Principal Components Analysis and Hierarchical cluster analysis.

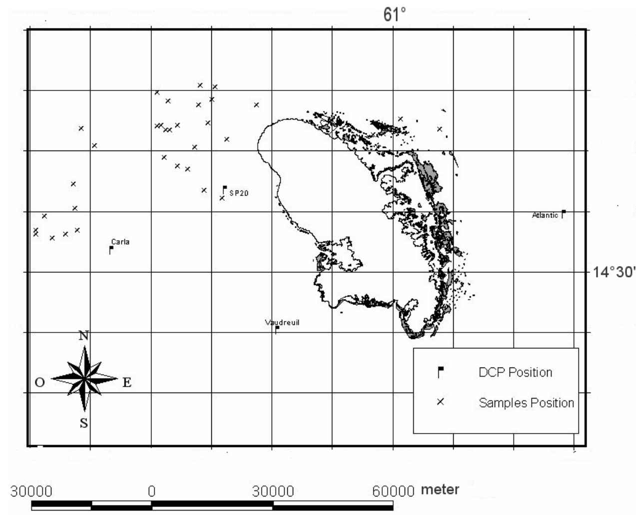

Figure 1. Locations of the FADs and samples during the surveys.

RESULTS

Composition

The trawls analysis brought to identify 189 different taxa, but the level of identification was different between the fishes (osteichthy), the crustaceans (malacostraca) and the molluscs.The micronekton closed to the FADs col-

Table 1. Sampling description.

Campaign	Name	Day	Time	Longitude	Latitude	FAD	Depth (m)	Shoreline distance (Km)
5	D05SP0807030041	08/07/2003	0:41:00	61° 19' 0"	14° 46' 5"	SP20	18	10
5	D05C0807031059	08/07/2003	10:59:00	61° 17' 32"	14° 44' 50"	SP20	21	8
6	D06C0608031953	06/08/2003	19:53:00	61° 33' 41"	14° 34' 39"	Carla	27	43
6	D06C0808030000	08/08/2003	0:00:00	61° 34' 5"	14° 33' 60"	Carla	2	45
7	D07V1009032132	10/09/2003	21:32:00	61° 27' 32"	14° 40' 26"	Vaudreuil	41	28
7	D07V1009032303	10/09/2003	23:03:00	61° 27' 44"	14° 40' 13"	Vaudreuil	65	29
7	D07C1109032341	11/09/2003	21:09:00	61° 34' 45"	14° 33' 33"	Carla	40	46
7	D07C1209032109	11/09/2003	23:41:00	61° 37' 15"	14° 32' 29"	Carla	8	50
8	D08C1210032103	12/10/2003	20:31:00	61° 33' 57"	14° 31' 60"	Carla	11	45
8	D08SP1510031758	15/10/2003	21:03:00	61° 32' 48"	14° 32' 16"	SP20	20	43
8	D08SP1610032015	16/10/2003	17:58:00	61° 17' 19"	14° 42' 34"	SP20	3	11
8	D08SP1610032121	16/10/2003	20:15:00	61° 16' 31"	14° 41' 37"	SP20	3	10
8	D08SP1710030100	17/10/2003	21:21:00	61° 16' 3"	14° 40' 36"	SP20	18	9
8	D09SP0811032031	08/11/2003	1:00:00	61° 18' 27"	14° 42' 27"	SP20	79	13
9	D09SP0911031946	09/11/2003	20:31:00	61° 20' 53"	14° 44' 48"	SP20	51	14
9	D09C1111032108	11/11/2003	19:46:00	61° 19' 22"	14° 44' 34"	Carla	56	12
9	D09C1211032019	12/11/2003	20:19:00	61° 35' 9"	14° 32' 29"	Carla	147	47

lected during this survey is mostly composed of fish's larvae and juveniles, first stages crustaceans, small shrimps and small gastropods.

The fishes were small-sized, the medium size being around 41 mm (maximum = 174 and minimum = 3). For the analysis of the size only 9 taxa (Anguilliformes, *Caranx crysos*, *Caranx sp.*, *Decapterus sp*., Acanthuridae, Lutjanidae, Pleuronectiformes, Gonostomatidae and Myctophidae) have been exploited, the presence of the others being anecdotal. The size of 2737 fishes have been grouped into four classes of size: [0-10], [10-50], [50-100] and ≥ 100 mm. The [10-50] mm class is the most important with 57% of the fishes, the [0-10],[50-100] and ≥ 100 mm repre. The mean size for all fishes seems to be higher in October.

The Hierarchical cluster analysis based on the taxa occurrence sets apart four clusters. There was 15 major taxa retained for this analysis : Stomatopoda, Euphausiacea, Anguilliformes (Chlopsidae, Congridae, Moringuidae, Muraenidae, Nettastomatidae, Ophichthidae, Synaphobranchidae), Cavoliniidae, Brachyura (megalop), Palinura (phyllosoma), Sergestidae, Caridea (Oplophoridae, Processidae, Crangonidae), Stenopodidae (zoea), Myctophidae, Carangidae, Porcellanidae (zoea), Pleuronectiformes, Amphipoda (Hyperidae, Oxycephalidae, Platyscelidae, Phronimidae, Scinidae) and Gonostomatidae. The first cluster is composed of the Myctophidae, Gonostomatidae and Caridea, the second of Pleuronectiformes, the third one

Table 1. Sampling description. Continued.

10	D10SP0212032050	02/12/2003	20:50:00	61° 18' 4"	14° 42' 30"	SP20	16	12
10	D10SP0312031931	03/12/2003	19:31:00	61° 19' 11"	14° 42' 3"	SP20	80	14
10	D10C0612031937	06/12/2003	19:37:00	61° 34' 60"	14° 30' 45"	Carla	22	48
11	D11SP0701042031	07/01/2004	20:31:00	61° 22' 10"	14° 20' 60"	SP20	73	33
11	D11C1101042054	11/01/2004	20:54:00	61° 35' 48"	14° 31' 59"	Carla	50	48
12	D12SP1202042112	12/02/2004	21:12:00	61° 19' 46"	14° 42' 50"	SP20	81	14
12	D12SP1302042058	13/02/2004	20:58:00	61° 19' 4"	14° 42' 49"	SP20	14	14
13	D13C1903042123	19/03/2004	21:23:00	61° 36' 1"	14° 33' 23"	Carla	23	48
14	D14SP1504042037	15/04/2004	20:37:00	61° 18' 30"	14° 41' 45"	SP20	15	13
14	D14SP2304040545	23/04/2004	5:45:00	61° 10' 55"	14° 40' 0"	SP20	11	2
14	D14SP2304040801	23/04/2004	8:01:00	61° 17' 1"	14° 41' 52"	SP20	29	10
14	D14SP2304041009	23/04/2004	10:09:00	61° 15' 37"	14° 38' 51"	SP20	55	10
14	D14SP2304041326	23/04/2004	13:26:00	61° 11' 21"	14° 40' 5"	Carla	20	2
14	D14SP2304041435	23/04/2004	14:35:00	61° 12' 15"	14° 41' 23"	SP20	37	2
14	D14SP2304041545	23/04/2004	15:45:00	61° 11' 36"	14° 39' 59"	Carla	54	3
14	D14C2304041715	23/04/2004	17:15:00	61° 17' 1"	14° 40' 26"	SP20	63	11
14	D14C2304041825	23/04/2004	18:25:00	61° 16' 20"	14° 39' 48"	Carla	52	10
14	D14C2304041936	23/04/2004	19:36:00	61° 17' 28"	14° 41' 19"	SP20	37	11
14	D14C2304042050	23/04/2004	20:50:00	61° 17' 52"	14° 41' 58"	Carla	56	12
14	D14C2304042154	23/04/2004	21:54:00	61° 17' 4"	14° 40' 49"	Carla	40	11
14	D14C2404040357	24/04/2004	3:57:00	61° 16' 56"	14° 41' 41"	Carla	43	10
14	D14C2404040504	24/04/2004	5:04:00	61° 16' 19"	14° 40' 7"	Carla	50	10
14	D14C2404040739	24/04/2004	7:39:00	61° 27' 13"	14° 41' 14"	Carla	4	29
14	D14C2404040842	24/04/2004	8:42:00	61° 28' 46"	14° 40' 56"	Carla	1	31
14	D14C2404040946	24/04/2004	9:46:00	61° 29' 22"	14° 40' 46"	Carla	56	32
14	D14AT2504040250	25/04/2004	2:50:00	60° 48' 58"	14° 40' 40"	ATL	26	7
14	D14AT2504040445	25/04/2004	4:45:00	60° 47' 29"	14° 41' 23"	ATL	37	10
14	D14AT2504040725	25/04/2004	7:25:00	60° 44' 16"	14° 44' 48"	ATL	41	15
14	D14AT2504040852	25/04/2004	8:52:00	60° 44' 20"	14° 43' 47"	ATL	110	14

comprise Carangidae, Amphipoda, Brachyura (zoea), Porcellanidae (zoea) and Stomatopoda,and finally the fourth is constituted by Palinura(Phyllosoma), Euphausiacea, Stenopodidae(zoea), Anguilliformes, Cavoliniidae, and Brachyura(Megalop).

Density and biomass

The following data come from 40 trawls around Carla and SP20 FADs, made between the 8 of July 2003 and the 15 of April 2004 (Figure4).

The mean biomass around Carla FAD is estimated at 2,87 mg m^{-3}. The biomass, contingent to the time, presents its higher values, around 6 mg m^{-3}, from December 2003 to April 2004. The mean density is estimated at 6,25´10^{-2} ind. m^{-3}. The maximum arise in October 2003 (2.36´10^{-1} ind. m^{-3}), and there is an augmentation between January and April 2004. Around the SP20 FAD, the mean biomass and density are respectively estimated at 6,46 mg m^{-3} and 5,66´10^{-2} ind. m^{-3}. They are both peaking in October, reaching the values of 32,6 mg m^{-3} and 2,53´10^{-1} ind. m^{-3}.

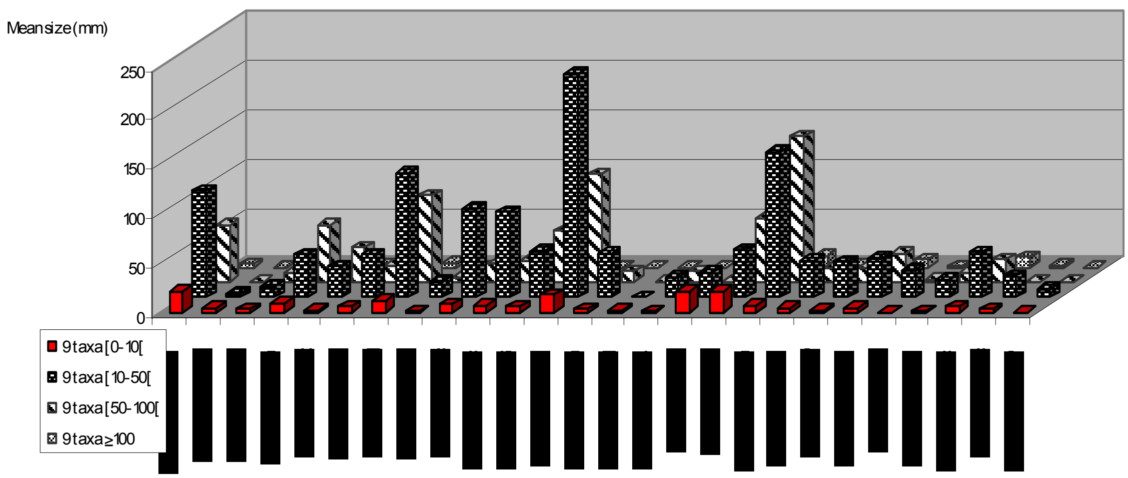

Figure 2. Size class of the groups contingent to the trawls.

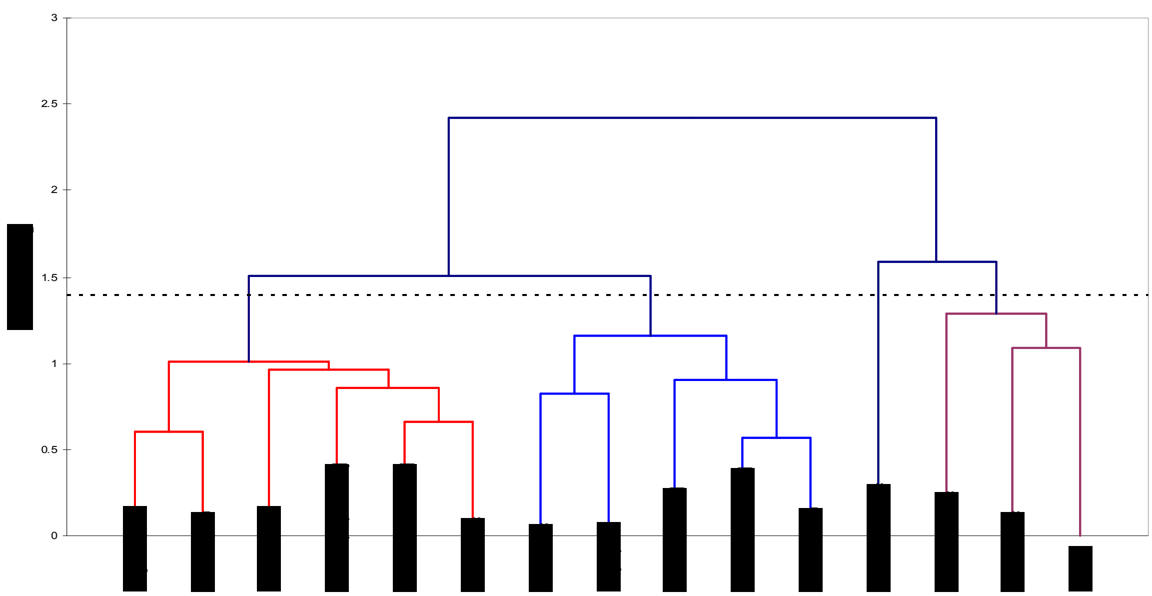

Figure 3. Classification of the taxa based on their occurrence during the prospectings.

The relative density and biomass by FAD for the taxa has benn aggregated in four groups: osteichthy, malacostraca, gastropods and cephalopods (Table 3). Crustaceans constitute the dominant group. The Caridea (essentially Oplophoridae), the Euphausiacea, the Stomatopoda, and the Luciferidae represent 95% of the crustaceans biomass. The Osteichthy are well represented, constituting 35% of the total biomass. This group is at 80% composed of Carangidae, Anguilliformes, Diodontidae, Chauliodontidae, and Myctophidae.

Variations of the density of micronekton

The depth has been separated in four classes [0-10], [10-50],[50-150] and >150 m. For the distance there is three categories : [0-20],[20-40]and >40 Km (table4). The period of the day, the season and the FAD were have been caught the samples were divided in two classes: day (sunrise to sunset according to the freeware appolo 1.3 (Remblain 2002) and night (sunset to sunrise), Wintering (July to December) and Lent (January to June), and Carla or SP20 for the FAD. Among the variables tested, the depth, the period of the day, the season and the distance to the shoreline are significantly correlated to the total density. The micronekton is concentrated around the first fifty meters of the water column. The density is around three times higher in the first ten meters than depth between 50 to 150 m and the difference of density between the first ten meters and the depths comprise between 10 to 50 m is not significant. Micronecton is significantly 2 to 3 times denser for distances upper to 20 km. During the night the number of individuals increase and is about 2.5 times higher than in daytime. The density during Wintering is more than twice the density during Lent.

A Principal Components Analysis based on the density of the 15 same taxa as in the Hierarchical cluster analysis,

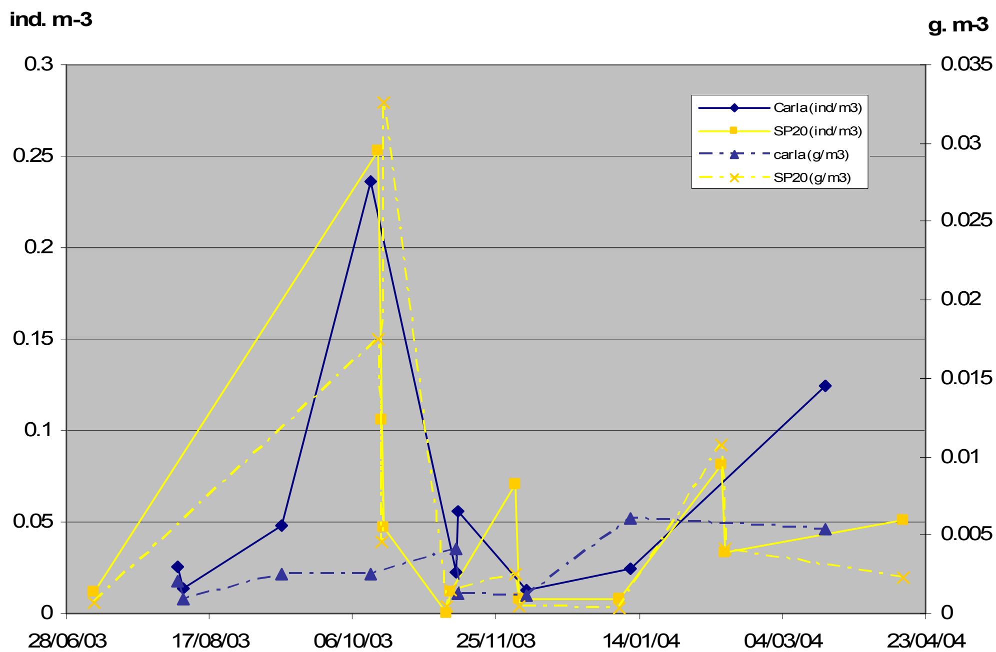

Figure 4. Variations of the micronektonic density and biomass (ind m^{-3} and g m^{-}

Table 3. Mean density and biomass and percentage total of the all survey ( ).

	All FADs	
	Density	Biomass
Crustaceans	0.028 (72)	1.95 (63)
Osteichthy	0.008 (22)	1.05 (35)
Gastropoda	0.002 (6)	0.05 (2)
Cephalopoda	ε	ε

has been processed (Figure 5). Three groups are easily identifiable. The Carids are isolated from the two others and are positively correlated to the distance and the depth, and their densities are inversely proportional to the night. The second group is constituted by the Gonostomatidae, the Sergestidae, the Myctophidae, the Cavoliniidae, the Euphausiacea and the Amphipoda. This group has its density increasing with the distance to the shoreline and the longitude, and declining with the depth. Its density is also higher during the Wintering and at daytime. The last group comprise the Anguilliformes, the Stomatopoda, the Palinura (phyllosoma), the Pleuronectiformes, the Portunidae (zoea), the brachyuran (megalop), the Stenopodidae (zoea) and the Carangidae. In this group the density is positively correlated to the Wintering season and the distance, and decrease with the depth and during the day.

DISCUSSION

The use of a mesopelagic trawl underestimates the micronekton biomass mainly because of the phenomen ovoidance. So the numerical results presented in this article should be taken carefully because of the small numbers of samples.

Composition of the micronekton

Micronekton close to FADs in Martinique is mostly constituted of firsts developmental stages organisms, except for the shrimps (Caridea and Sergestoidea). The most important group, both in density and biomass, is the crustaceans with respectively 72 and 63% of the total density and biomass. The fishes were also abundant, representing 22% of the total density and 35% of the biomass. As said in the introduction it is difficult to compare this results with others due to a lack of informations about micronekton in the region. But others experimentations have been done, in the exclusive economic zone of French Polynesia, by Bertrand et al. (2004). They found an equilibrium between the density of fishes (41%) and crustaceans (42%). After corrections of their raw data they conclude that fishes were the most abundant. The Cephalopods are poorly represented, surely because of their capacity to avoid the trawls (Sund et al, 1981).

Density and biomass

The trawling experimentation helped us to see that micronekton had its density, and by the way its biomass, increasing during the wintering, at the surface, far from the shoreline, and during the night. But due to its complex organisation, the connections between these factors and the different taxa has to be done with complementary informations as biology, ecology and abiotic parameters. Known abiotic factors that affect spatial distribution of planktonic organisms include temperature, salinity, dissolved oxygen, watercurrents and depth.

The season is an explanatory variable of the density variations. espacially for the Anguilliformes, the Stomatopoda, the Pleuronectiformes and the Palinura (phyllosoma). Stomatopoda (occurrence close to 95%), use to be more abundant in October, in the region according to Tavares (2002). Greater density and biomass were found in October. This can be related to the Amazonian water incursions (Doray, 2006) wich append this year in October. During this period the salinity is low for the first forty meters and the dissolved oxygen rate diminish. These water incursions are rich in Chl-a which has repercussions on the food chain. Other explanations exist for this phenomena. Some families of Pleuronectiformes spawn in December (Munroe, 2002), Scophithalmidae see their youngs migrate from the coast to offshore when they grow. Youngs migrate seasonally deeper in autumn and winter when bottom temperatures drop until spring. Spawning almost throughout the year, starting in February until the late autumn, peaking in May.

A part of the Crustaceans (Brachyura (megalop), Stenopodidae (zoea), portunidae (zoea) and the Carangids stay on subsurface. Carangids larvae are known to stay in subsurface, closed to jellyfishes, for depth between 11 and 55 m (Gibbons et al., 1995). Inversely th Carids are more numerous with the depth. The species of Carids found during the surveys are known to be deep shrimps. Sergestids, Euphausiacea, Myctophids, and Gonostomatidae don't seems to be affected in any way by the depth. They are known to do diel vertical migration (deep during the day and close to surface at night), so the effect of the depth on their density is faded (Hartel and Craddock, 2002). In the survey, density and biomass of the micronekton was significantly higher at nightime than at daytime. This is also due to the upturn of the species above cited having diel vertical migration.

An other parameter bearing upon the density and by the way upon the biomass is the distance to the shoreline. Up to 40 Km the concentration of micronekton is significantly higher. The Gonostomatidae, the Sergestidae, the Myctophidae and the Cavoliniidae hve their density growing with the distance and the longitude. Once again this could be due to the contributions of the Amazon and the Orenoque. This is corroborated by the fact that the density grow with the longitude W, meaning the closer from the action zone of the Amazon the micronekton is found, the higher is the density.

The concrete application of this study would be to adapt the fishery to a better exploitation of the resources. The exploitation of some pelagics resources, like the blackfin tuna, could be better at night because of the upturn of the micronekton (Doray, 2006). This could be usefull to reduce the pressure applied on the yellowfin tuna and blue marlin that are caught principally at daytime.

Such studies shows how the study of the micronekton is difficult because of its heterogeneous composition. Further surveys around the region should be usefull to characterize it more precisely.

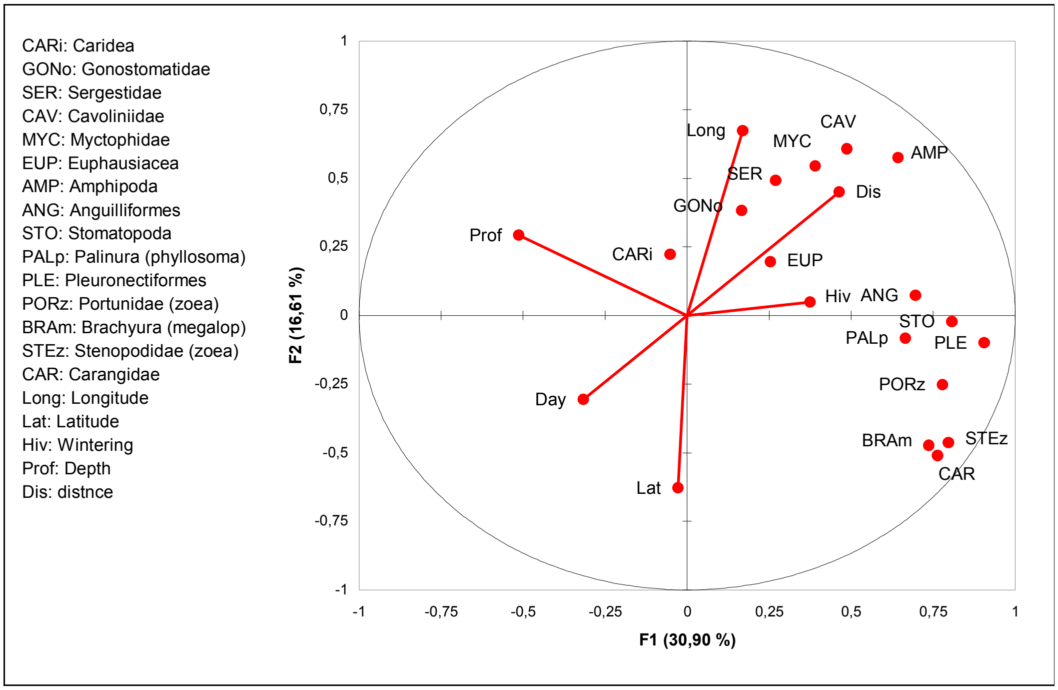

Figure 5. Principal Components Analysis showing 15 taxa and 6 paramaters.

Table 4. Significativity and impact of the depth, distance to the shoreline, nychthemere, the season and the FAD on the total density (NS = non significant, S = significant, * Mann-whitney α = 0.01, ** Kruskall-wallis α = 0.05).

	Depth			**Distance to shoreline**			**Nychthemere**		**Season**		**FAD**	
	0-10	10-50	50-150	0-20	20-40	>40	Nigth	Day	Wintering	Lent	Carla	SP20
Total density average Ind´10 $^{-2}$. m^{-3}	S** d (0-10)> d(10-50) ~ d (50-150) m			S** d (>40) ~ d (20-40) > d (0-20) Km			S* d Night>d Day		S* d Wintering > d Lent		NS*	
	6,80	2,14	1,98	1,64	3,12	5,65	3,31	1,26	4,10	1,73	3,55	2,03

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