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Siphonophora from the coast of Brazil (17°S to 24°S)

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• *Abstract:* This work is based on the analysis of 99 zooplankton samples collected during the Oceanographic Expedition "ESPÍRITO SANTO I", held along the east coast of Brazil, between Cabo Frio and Abrolhos Archipelago, an area characterized by the occurrence of coastal upwelling, from July to September 1984. Zooplankton was collected with vertical plankton net hauls of 250 μm mesh size in the upper 200 meters layer. A total of twenty one species of Siphonophora was observed, two of which were identified as being physonect and the other as calycophorans. Specific diversity close to the shore and at the neighborhood of the Vitória-Trindade Bank System, showed smaller values, in comparison with those in the oceanic regions. Factorial analysis was used in order to access the changes observed in the population of the eleven most abundant species. The first two principal axes represented the influence of the nearshore - offshore gradient and the role of trophic interaction, accounted for 60% of the total variance of the data.

• *Descriptors:* Zooplankton, Community composition, Ecological distribution, Siphonophora, Cnidaria, SW Atlantic, Brazil.

• *Descritores:* Zooplâncton, Composição da comunidade, Distribuição ecológica, Siphonophora, Cnidaria, Atlântico Sul Ocidental, Brasil.

Introduction

Siphonophora are important components in the planktonic ecosystem. In certain regions, these organisms can totally dominate the net catches of macrozooplankton (Pugh, 1977). The impact of the predatory siphonophores fishing is highly significant, since various species feed on a wide range of zooplankters from copepoda nauplii to small fishes (Biggs, 1977).

The study pertinent to the distribution of Siphonophora on the Brazilian coast has been performed on the basis of samples taken from several oceanographic expeditions, such as the "Challenger" (Haeckel, 1888), the "Meteor" (Leloup & Hentschel, 1935) and the "Calypso" (Seguin, 1965). More recently the study of the distribution of these organisms in relation to water masses was done by Alvariño (1968; 1980), Nogueira (1977) and Abreu & Nogueira (1989). The main objective of this work is to contribute with information on the qualitative and quantitative distribution and specific diversity of Siphonophora on the continental shelf in the oceanic waters alongside the east coast of Brazil, between 17°S and 24°S.

Material and methods

Ninety nine oceanographic stations were occupied during the "ESPÍRITO SANTO I" cruise on the R/V "Almirante Saldanha", a ship from the Brazilian Navy, from June to September 1984. Data and information regarding the operation are available, on request, at "Diretoria de Hidrografia e Navegação Data Center, Rio de Janeiro -Brazil".

The stations were arranged in 15 profiles: 12 perpendicular to the shore and 3 situated on the bank system of Vitória-Trindade (Fig.1).

Salinity was measured by means of an inductance salinometer and temperature by means of a bathytermograph and reversing thermometer. Zooplankton was sampled with a cylindric-conical net, of 250 μm mesh and 80 cm mouth diameter equipped with a calibrated flowmeter. The hauls were disposed vertically from 5 m above the bottom to the surface in neritic and from 200 m depth in the oceanic waters.

The biovolume of the zooplankton samples (displacement volume) was measured immediately on board, after the removal of large organisms such as salps,

jellyfishes, fish larvae, etc. The samples were kept in 4% buffered formalin.

In the laboratory siphonophores were identified and counted in subsamples obtained through a Folson plankton splitter. The relative occurrence and frequency for each species were calculated: the occurrence being the ratio between the number of samples where the species occurred and the total number of samples; and frequency being the ratio between the number of organisms in the *species a* and the total number of organisms observed. The Shannon-Weaver index of diversity was used to evaluate the maturity state of population.

In order to access the changes observed by the eleven most abundant species, a factorial analysis was performed. The factorial analysis of correspondence (FAC) is recommended for reduced space ordination of the species abundance data table containing a large number of zeros. The starting point for the FAC consists in the use of the X^2 distance matrix (Legendre & Legendre, 1983). The data input to each analysis consisted of a set of variables representing spatial fluctuations in species abundance.

The water masses of the region were characterized according to Emilsson (1961) and classified into three types: SHELF WATER (SW) - salinity 35,4 to 36,0 SOUTH ATLANTIC CENTRAL WATER (SACW)- salinity 35 - 36 and temperature 10°C to 20°C. TROPICAL WATER (TW) - salinity > 36,0 and temperature > 20°C.

Results

The distribution pattern of the abiotic parameters as presented below is based on values obtained at 10 m depth. Most of the area showed temperature between 23-24°C and the lower temperatures (22°C) were found at coastal stations near São Tomé Cape, Rio de Janeiro.

Salinities between 36, 0-36,8 were found over the continental shelf and the Trindade-Vitória Banks whereas the minimum of 35-35,8 was found on the Rio de Janeiro coast. Beyond the continental shelf salinities range up to 37,1.

The zooplankton biomass varied from 0,01 to 1,70 ml/m^3. The lowest concentration was observed at offshore stations (0,01 -0,09 ml/m^3). The highest zooplankton biomass was measured near the Rio de Janeiro coast, between Cabo Frio and the mouth of Paraíba do Sul river (Fig. 2).

Siphonophora have been collected at all plankton stations. Twenty-one species were found. Two of them were physonectes and the remainder were calycophorans (Table 1).

A much smaller number of species contributes to at least 10% of the density of siphonophores as *Eudoxoides spiralis* (29,5%) *Diphyes bojani* (19%) and *Muggiaea kochi* (15%). The most important species, as judged by the percentage of occurrence in samples were: *E. spiralis* (81%), *D. bojani* (78%), *Bassia bassensis* (60%) and *Lensia subtilis* (53%).

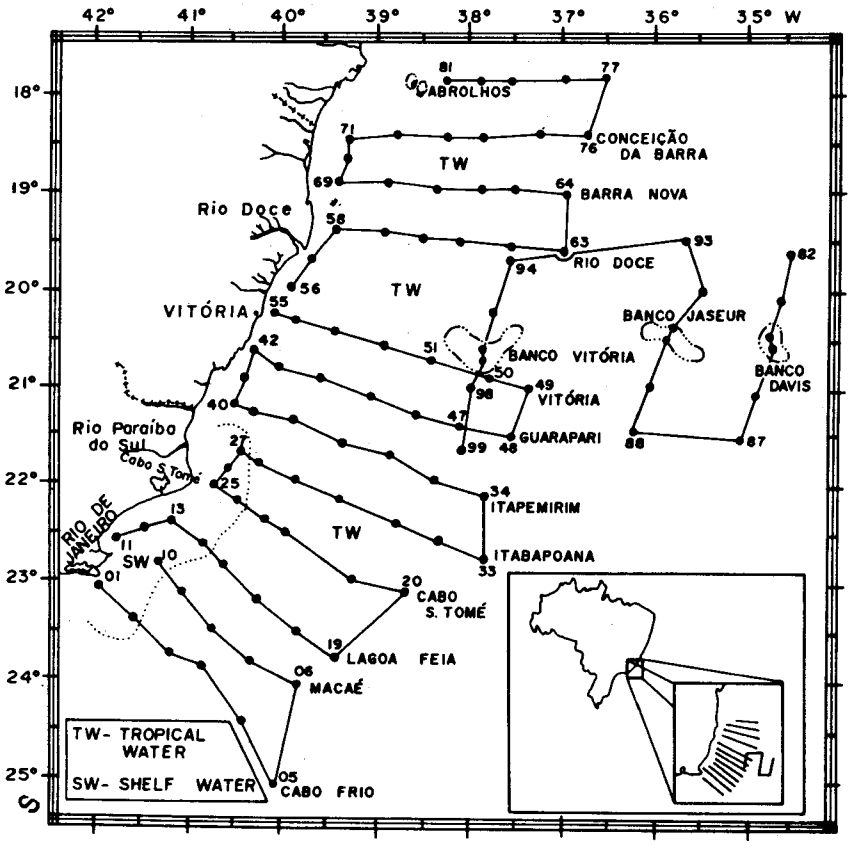

Fig. 1. Stations location and the surface water masses during the "ESPÍRITO SANTO I" cruise. Jul-Sept/1984.

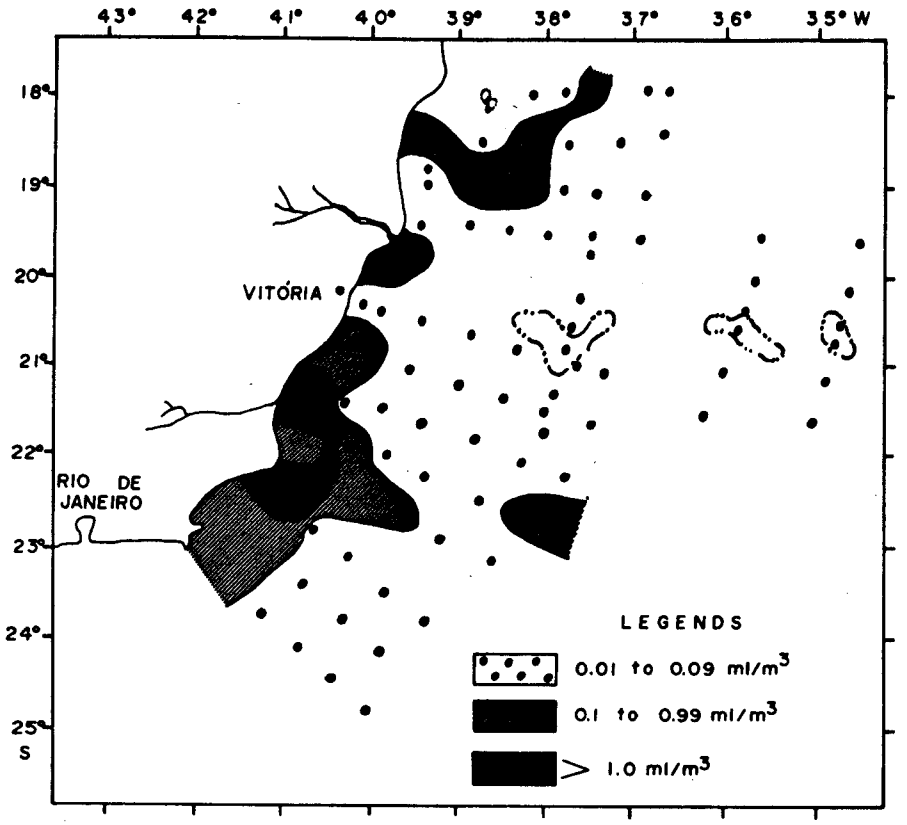

Fig. 2. Zooplankton densities (ml/m^3) during the "ESPÍRITO SANTO I" cruise. Jul-Sept/1984.

Specific diversity of species found close to shore and at the banks showed the lowest values (below 1,5 bits.ind^{-1}). Diversity ranged from 2,5 to 3,0 bits.ind^{-1} at the other stations.

Many common siphonophores were found in all of the hauls although they usually showed some changes in abundance in the profiles, *D. bojani* and *L. subtilis* were more abundant at stations located northerly, showing a progressive increase southward at the coastal stations (Figs 3 and 4). On the other hand, *E. spiralis* and *Chellophyes appendiculata* were abundant in the core of the Brazil Current (Figs 5 and 6).

The distribution of the 99 samples and the 11 species on the planes defined by axes I and II showed that two principal factors were responsible for the variability observed in the population of siphonophores.

AXIS I (Figs 7 and 8) - The first factorial axis was responsible for 40% of the variance of the data. This axis separates the sampling points into two groups: on the positive side were the oceanic stations, and on the negative, the coastal ones. Therefore, this axis represented the variability through the nearshore-offshore gradient. The species of siphonophores were placed on a coordinate system directly related to the components mentionated above. Species positively associated with the first axis were abundant at oceanic stations. *Muggiaea kochi* was placed on the negative side, showing affinity with neritic conditions. *D. bojani, Lensia cossack* and *L. subtilis* can be considered species which are moderately neritic.

AXIS II (Figs 7 and 8) - The second axis accounted for 20% of variability. The high positive values for the axis include most of the shelf stations at more productive waters of Cabo Frio while the bank stations (oligotrophic waters) show high negative values. The distribution of stations on the second axis provides evidence about influence of trophic factors on the distribution of siphonophores. The species positively associated with this axis were: *D. bojani, Eudoxoides mitra* and *Abylopsis tetragona.*

Discussion

The "ESPÍRITO SANTO I" Commission intended to provide information regarding the variation of oceanographic parameters and the occurrence of upwelling at the Vitória-Trindade bank system. Upwelling may occur along the western side of the Brazil Current, in a zone extending from the state of Espírito Santo (20°S) to the State of Paraná (26°S), having a maximum activity in austral summer, from October to March.

The realization of the "ESPÍRITO SANTO I" during the winter season probably in downwelling conditions, favored the influence of tropical water close to the coast. The South Atlantic Central Water, with temperatures below 18°C was found between Cabo Frio and São Tomé Cape, over the continental shelf at 100 m depth, but no siphonophores species upwelling indicator were found.

Table 1. Siphonophora (Ind/100m^3) collected during "ESPÍRITO SANTO I" cruise. Jul-Sept/1984 PF = Polygastric fase; AN = Anterior nectophore; PN = Posterior nectophore; EUD = Complete endoxid; EB = Endoxid bract; EG = Endoxid gonophore

Spp	CODE	PF	AN	PN	EUD	EB	EG	Occur. %	Freq. %
Agalma okeni (Eschscholtz)	AO	-	16,5	-	-	-	-	1	0,06
Halistemma rubrum (Vogt)	HR	-	6,7	-	-	-	-	1	0,03
Hippopodius hippopus (Forskål)	HH	-	71,4	-	-	-	-	13	0,30
Sulculeolaria quadrivalvis (Blainville)	SQ	-	0,9	-	-	-	-	1	0,003
S. chuni (Lens & Van Riemsdijk)	SC	-	6,2	13,5	-	-	-	3	0,07
Diphyes bojani (Eschscholtz)	DB	23,0	2082,2	416,7	1674,5	583,3	379,5	78	19,62
Lensia conoidea (Kefferstein & Ehlers)	LC	-	3,3	-	-	-	-	1	0,01
L. hunter (Totton)	LH	-	3,8	-	-	-	-	1	0,01
L. campanella (Moser)	LCam	-	48,6	-	-	-	12,4	9	0,23
L. cossack (Totton)	LCo	-	75,9	-	-	-	-	15	0,30
L. hotspur (Totton)	LHt	-	13,8	-	-	-	-	3	0,05
L. subtilis (Chun)	LS	52,3	917,7	6,8	88,5	496,5	28,7	53	6,05
L. meteori (Leloup)	LM	-	42,0	-	-	-	-	7	0,16
Mugiaea kocki (Will)	MK	-	1562,9	-	514,5	1023,1	917,3	48	15,48
Chalophyes appendiculata (Eschscholtz)	CH	2,8	136,7	36,5	38,1	87,6	67,8	29	1,40
Eudoxoides mitra (Huxley)	EM	-	2,8	-	115,7	37,2	68,1	24	0,85
E. spiralis (Bigelow)	ES	-	16223,8	-	1018,6	2854,9	2264,6	81	29,52
Ceratocymba leuckartii (Huxley)	CL	2,7	3,3	-	-	-	-	3	0,02
Abylopsis tetragona (Otto)	AT	19,7	243,9	11;7	50,0	135,7	64,7	45	2,01
A. eschscholtzii (Huxley)	AE	-	43,9	17,6	113,0	27,4	66,7	29	1,02
Bassia bassensis (Quoy & Gaimard)	BB	94,5	907,9	225,6	426,4	393,5	498,0	69	9,80

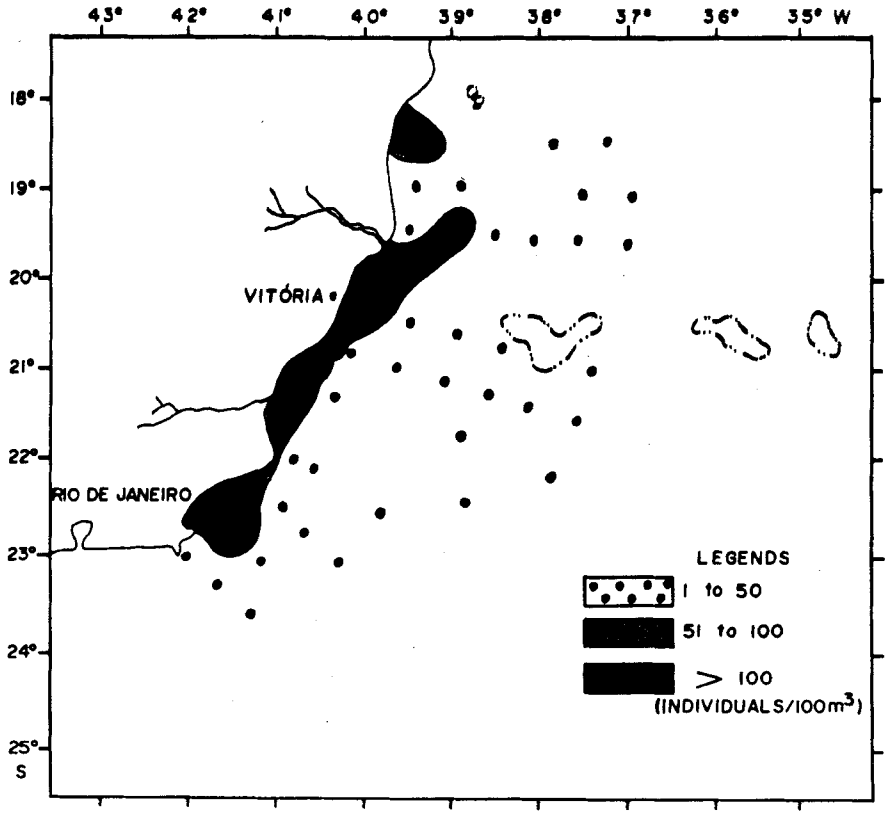

Fig. 3. Geographical distribution of *Diphyes bojani* "ESPÍRITO SANTO I" cruise. Jul-Sept/1984.

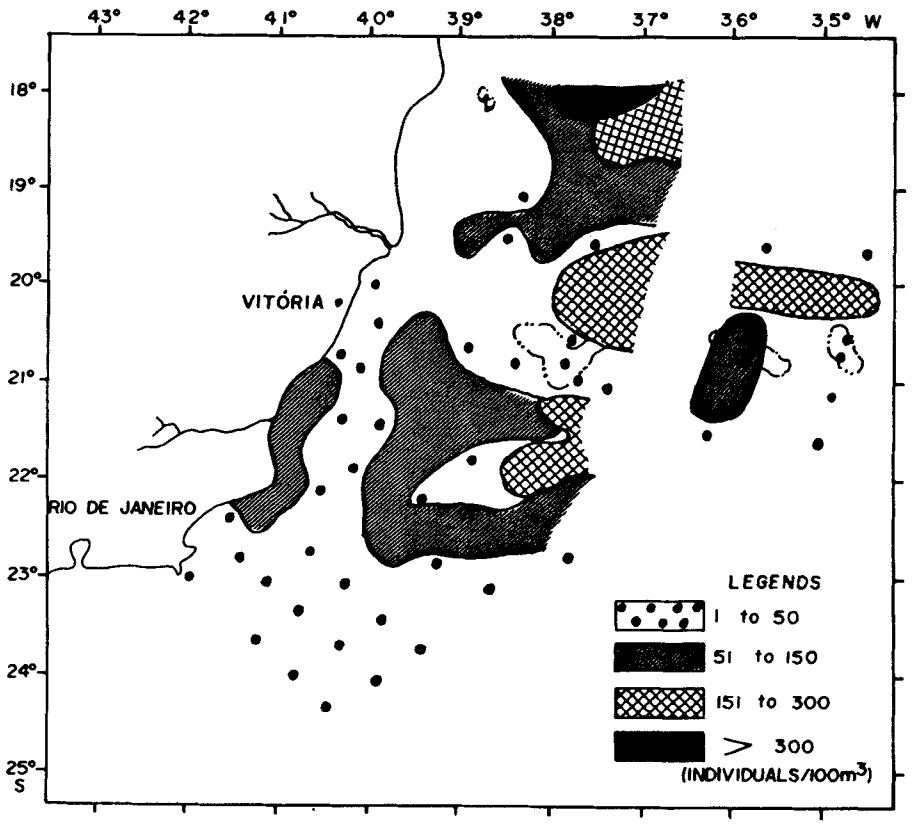

Fig. 4. Geographical distribution of *Diphyes lensia* "ESPÍRITO SANTO I" cruise. Jul-Sept/1984.

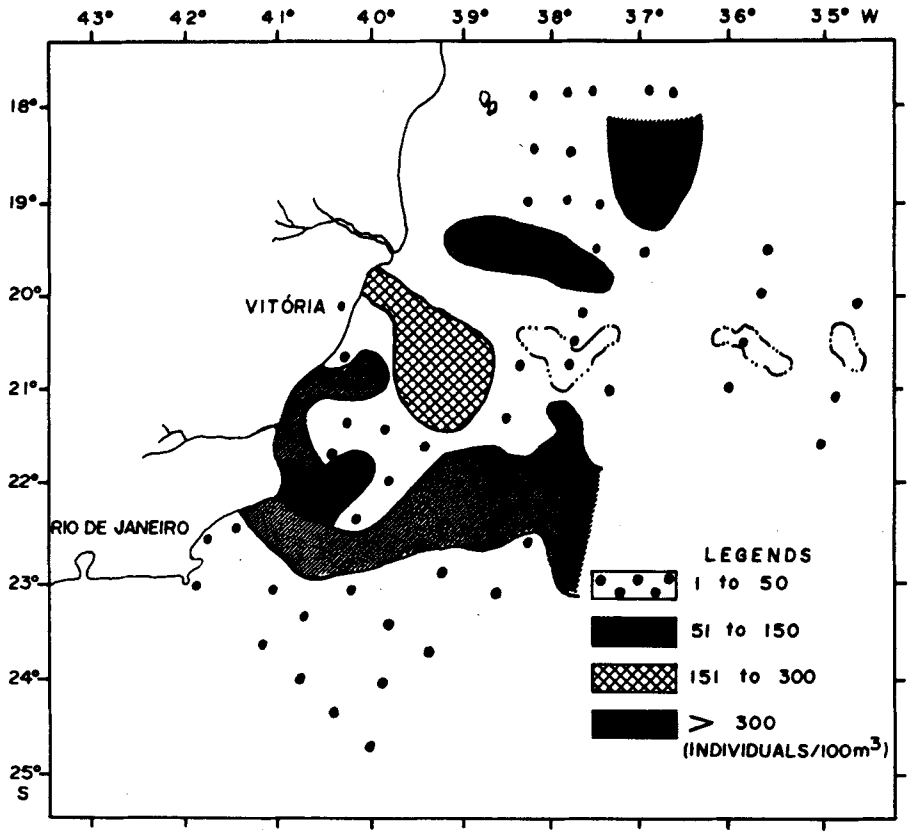

Fig. 5. Geographical distribution of *Muggiaea kochi* "ESPÍRITO SANTO I" cruise. Jul-Sept/1984.

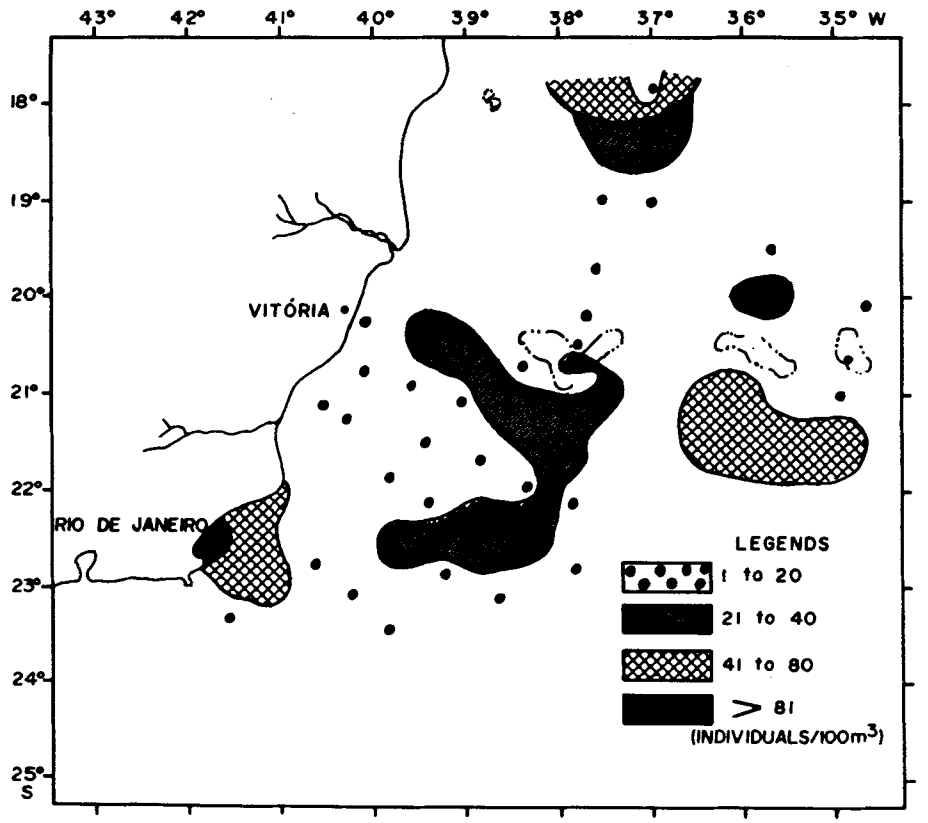

Fig. 6. Geographical distribution of *Eudoxoides spiralis* "ESPÍRITO SANTO I" cruise. Jul-Sept/1984.

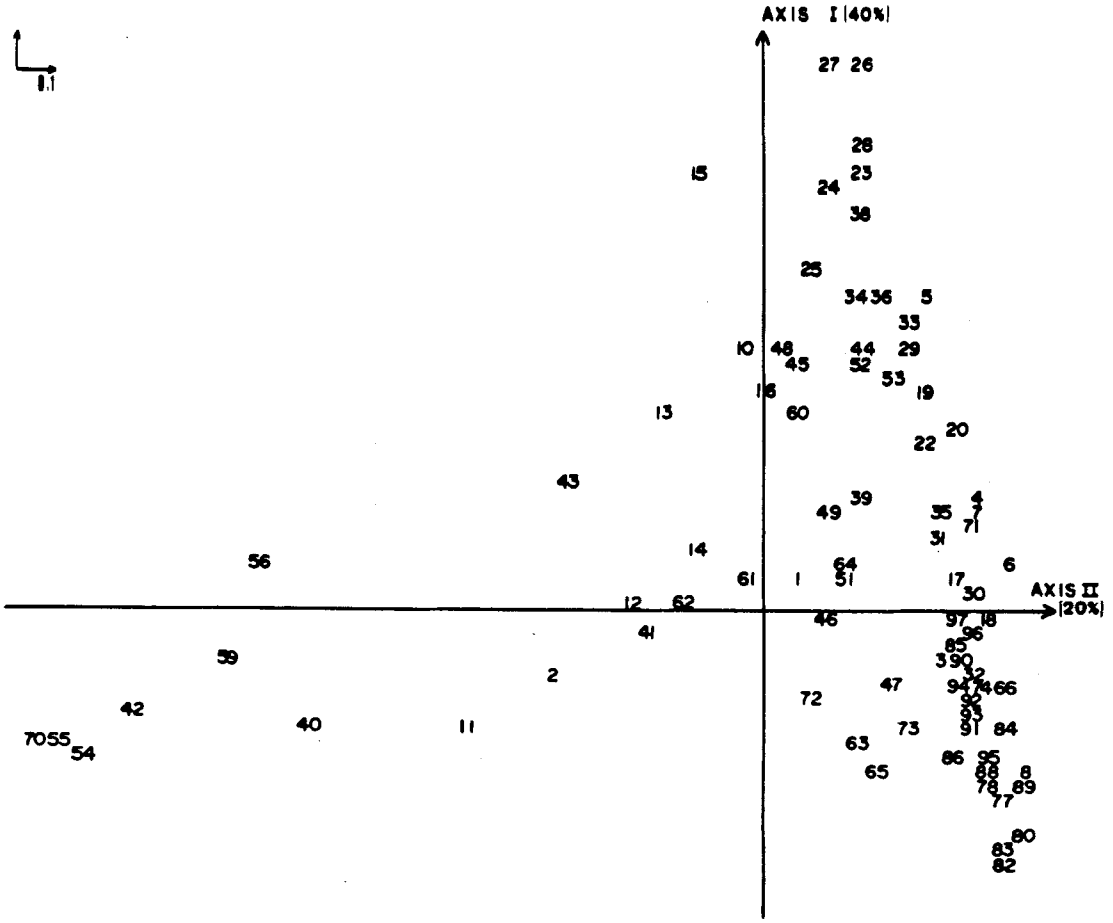

Fig. 7. Correspondence analysis. Projection on factor plan 1-2. Observation points.

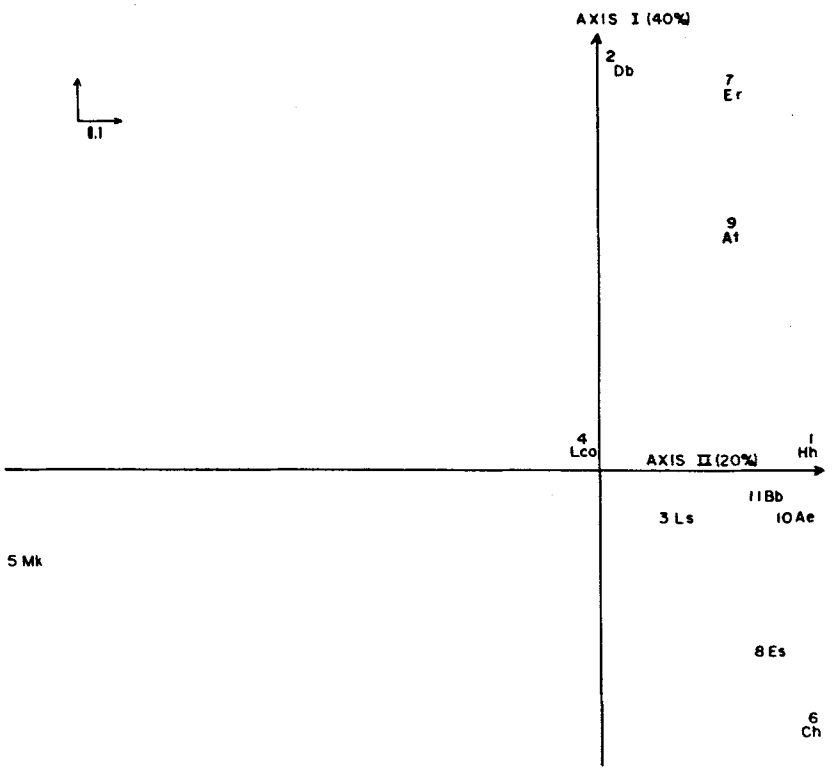

Fig. 8. Correspondence analysis. Projection on factor plan 1-2. Species points (see Table 1 for abbreviations).

Within hydrological homogeneous waters it is interesting to investigate regional differences in distributional patterns of planktonic organisms. The FAC analysis showed that spacial variability of siphonophores in the area was basically determined by hydrobiological factors ; thus most calycophorans species were abundant in the core of the Brazil Current (TW). The distribution of zooplankton biomass appears to be an important factor in the geographic distribution and numerical abundance of neritic species such as *D. bojani, M. kochi* and *L. subtilis*, these results are consistent with the observations of Margulis (1972) and Pugh (1986) in relation to the siphonophores found in the North Atlantic Ocean.

The specific diversity of siphonophores has been little studied though the general tendency is for it to be high in stable oceanic regions in warm water (Pugh, 1986) and low in coastal regions and upwelling areas (Kinzer, 1977).

Unfortunately no data about the siphonophores diversity are available from the Southern Atlantic Ocean. The values obtained within the studied area showed the general trend towards lower biomass and higher diversity (3 bits.ind^{-1}) away from the shore associated with tropical waters. Similar values were observed by Valentin (1984) for the Copepoda diversity from the upwelling area of Cabo Frio (Brazil).

The siphonophores observed from the collection studied here were well known species from temperate and warm water regions of all oceans. As it might be expected most are mainly epipelagic and mesopelagic organisms, with prominence of tropical species, since most of the samples come from surface layer in tropical waters. Species which are dependent on the temperate water as *Hippopodius hippopus, Diphyes dispar* and *Chellophyes appendiculata* were present in low numbers.

Resumo

No período de 26 de julho a 20 de setembro de 1984, na costa leste do Brasil, entre Cabo Frio (RJ) e o Arquipélago dos Abrolhos (BA) realizou-se a Operação ESPÍRITO SANTO I" onde foram realizadas noventa e nove estações oceanográficas com o objetivo de coletar informações representativas de uma situação de inverno e o estudo da ressurgência nos bancos do sistema Vitória - Trindade. O zooplâncton foi coletado com redes de 250 μm de malhas em arrastos verticais de 5 m acima do fundo até a superfície nas estações costeiras, e de 200 m a superfície, nas oceânicas.

Foram identificadas três massas d'água na região: Água Tropical, Água Central do Atlântico Sul e Água de Plataforma, sendo que 88% das estações localizaram-se no núcleo da Corrente do Brasil. Foram encontradas vinte e uma espécies de Siphonophora, sendo duas da sub-ordem Physonectae e as demais da sub-ordem Calycophorae. As espécies com maior percentual de ocorrência nas amostras foram: *Eudoxoides spiralis* (81%), *Diphyes bojani* (78%), *Bassia bassensis* (60%) e *Lensia subtilis* (53%). A diversidade específica mostrou valores baixos, inferiores a 1,5 bits.ind^{-1}, nas estações próximas a costa e aos bancos, e valores maiores entre 2,5 e 3,0 bits.ind^{-1} nas demais estações.

Com o objetivo de analisar as variações observadas na distribuição das onze espécies mais abundantes, os dados foram tratados através de uma análise Fatorial de Correspondência. Os dois primeiros eixos fatoriais representando a influência do gradiente costa-oceano e o papel das relações tróficas contribuíram com 60% da variabilidade observada na distribuição dos organismos.

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