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SEASONAL CHAETOGNATH ABUNDANCE AND DISTRIBUTION IN A TROPICAL ESTUARY (SOUTHEASTERN, BRAZIL).

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ABSTRACT

This study focuses on the seasonal variation of the chaetognath species in the Vitória Bay/Passage Channel estuarine system, Espírito Santo, Brazil, in terms of their abundance and distribution. Specimens of chaetognaths were collected between July 1997 and April 1998 at 10 sampling stations, with a cylindrical-conical plankton net of 200 µm mesh and 30 cm mouth, fitted with a mechanical flowmeter. Five chaetognath species were identified: *Sagitta enflata*, *Sagitta decipiens*, *Sagitta hispida*, *Sagitta friderici* and *Sagitta minima*. Most of them were distributed in areas of high salinity (e.g. at the stations closest to the outer estuary). The dominant species, *S. enflata* and *S. friderici*, were more frequent in the outer estuary where salinities varied from 32 (wet season - summer) to 28 (dry season - winter). *S. friderici* was the only species found right in the middle of the Passage Channel, at a station close to the main freshwater input into the estuary. Results showed that chaetognaths only enter the estuary due to the tidal effect, and that they are not typical residents of this system. This is to be expected because the group normally inhabits only truly marine regions.

RESUMO

Este estudo abordou a abundância e distribuição sazonal das espécies de quetognatos, no sistema estuarino baía de Vitória/Canal da Passagem, Espírito Santo, Brasil. Os organismos foram coletados entre julho de 1997 e abril de 1998 em 10 estações amostrais, utilizando uma rede de plâncton cilíndrico-cônica de 200µm de malha e 30 cm de abertura de boca, dotada de um fluxômetro mecânico. Cinco espécies de quetognatos foram identificadas: *Sagitta enflata*, *Sagitta decipiens*, *Sagitta hispida*, *Sagitta friderici* e *Sagitta minima*. A maioria destas espécies esteve distribuída em áreas com alta salinidade (e.g. estações próximas a saída do estuário). As espécies dominantes *S. enflata* e *S. friderici* foram mais freqüentes na parte externa do estuário onde as salinidades variaram de 32 (verão – estação chuvosa) a 28 (inverno – estação seca). *S. friderici* foi a única espécie encontrada no meio do Canal da Passagem, em uma estação próxima a uma fonte de água doce para o estuário. Os resultados mostram que os quetognatos entram no estuário devido ao efeito da maré, não sendo residentes típicos desse sistema. Isto é esperado visto que este grupo normalmente habita regiões verdadeiramente marinhas.

Descriptors: *Sagitta,* Chaetognatha, Seasonality, Abundance, Distribution, Estuary, Brazil.

Descritores: Sagitta, Chaetognatha, Sazonalidade, Abundância, Distribuição, Estuário, Brasil.

INTRODUCTION

Chaetognaths play an important role in marine food webs, being active predators. Their diet includes a variety of pelagic organisms, consisting mainly of copepods, but they may also prey on fish larvae thus impacting the zooplankton and ictioplankton communities (Casanova, 1999).

These organisms live in various marine habitats from polar to tropical waters and at all depths. Thirty-nine species have so far been reported in the South Atlantic between 0 and 60°S (Casanova, 1999). These species belong to both oceanic and coastal environments, but a few have also been found in estuarine regions. Some chaetognaths are well known as indicators of certain water masses due to their close relationship with the environmental variables (Casanova, 1999); their occurrence and distribution being determined by hydrological conditions (Liang & Vega-Pérez, 1994).

Studies on chaetognaths in southeastern Brazil have concentrated on coastal and oceanic waters where these organisms are abundant (Almeida Prado, 1968; Vega-Pérez & Liang, 1992; Liang & Vega-Pérez, 1995; Liang & Vega-Pérez, 2001; Liang & Vega-Pérez, 2002). However, chaetognaths can also be found in Brazilian estuaries, as reported by Lansac Tôha & Lima (1993) in the estuary of the Una do Prelado river, by Lira & Magalhães (1996) in the Mandaú/Manguaba system in Alagoas, by Lopes (1996) in the estuaries of the Juréia-Itatins ecological station, by Montú (1980) in the Patos Lagoon estuary in Rio Grande and by Paranaguá & Nascimento-Vieira (1984) in the Botafogo river estuary.

The main purpose of this paper was to study chaetognath distribution and abundance in the Vitória Bay/Passage Channel estuarine system, a tropical estuary in Southeastern Brazil, during an annual seasonal cycle.

Material and Methods

Study Area

The Vitória Bay/Passage Channel estuarine system (20º23'S - 40º20'W) is located in the Vitória metropolitan area, Espírito Santo, Brazil. With a mangrove area of 2,051 hectares and an extension of approximately 25 kilometers, this system has a horseshoe shape with two coastal water entrances, one in the Vitória Bay and the other in the Passage Channel (Fig. 1). Local depths vary from 1.5 to 10 meters (outside the main port channel), tidal currents entering the estuary by both entrances. The system is influenced by coastal waters from the Espírito Santo Bay and several rivers that flow into this system (e.g. Aribiri, Marinho, Bubu and Santa Maria rivers – this latter being the main freshwater input). The Passage Channel serves also for drainage as it is narrow and shallow, but the main tidal flow enters the system through the Vitória Bay. Average monthly temperatures range from 21 to 28°C and precipitation from 50 to 200 mm, with the months of December/January being the warmest and wettest and July/August the coldest and dryest.

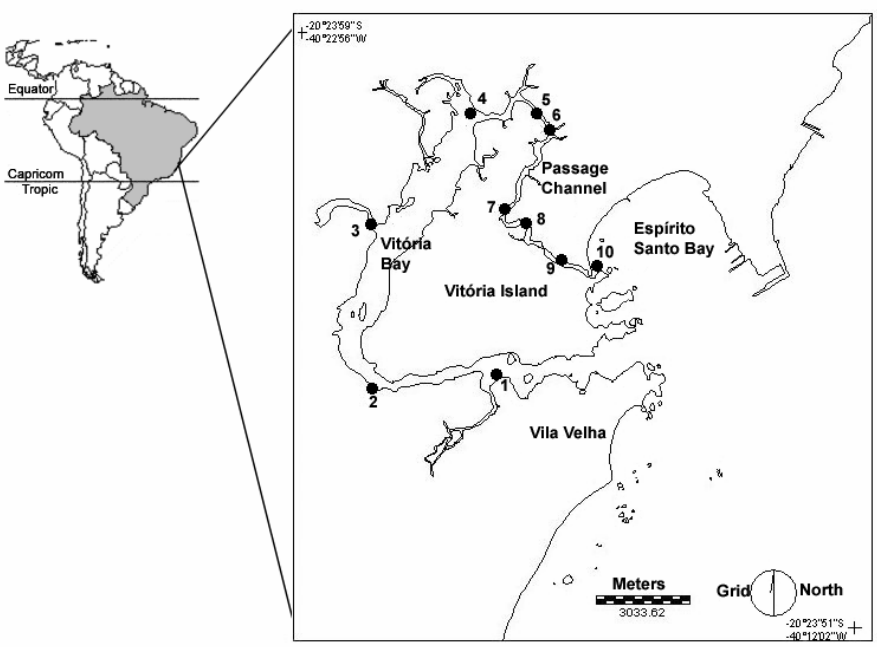

Fig. 1. Map showing the location of ten sampling stations in the Vitória Bay/Passage Channel estuarine system.

Seasonal Sampling and Data Analysis

Sampling of the biological material and environmental parameters was done every three months at ten stations from July 1997 (winter) to April 1998 (fall). No sample was taken at station 2 in July. Zooplankton samples were collected using a cylindrical-conical plankton net with a 30-centimeter mouth opening and 200µm mesh, fitted with a mechanical flowmeter to estimate the amount of water filtered (Omori & Ikeda, 1992). Sub-surface samples were obtained with tows at approximately 1 knot during five-minute periods. The biological material collected was preserved in an aqueous solution of formaldehyde 5%, buffered with sodium tetra-borate. Along with the biological parameters, environmental parameters such as salinity and temperature were measured "in situ" at each sampling station throughout the water column using portable multi-sound equipment (YSI 85). Salinity is expressed in practical salinity units (psu). A total of 39 samples were collected during the sampling period.

Aliquots were taken with a Folsom Plankton splitter and chaetognaths were sorted out of the aliquots, counted under a Leica GZ6 stereoscopic microscope and identified in accordance with the relevant literature (Boltovskoy, 1981; Casanova, 1999; Pierrot-Bults, 1996; Pierrot-Bults & Chidgey, 1988). Copepod abundance was also estimated in each sample for further correlation with chaetognaths. Numbers of organisms were expressed as individuals per cubic meter of filtered seawater.

Multivariate analysis of the environmental variables and copepod abundance related to chaetognath abundance and distribution was performed using the Spearman correlation ($p<0.05$). Group analysis was also made to evaluate the distribution by species.

RESULTS

Over the study period, water temperature varied between 22.0 and 28.8°C, with higher values during summer and fall at the sampling sites in the inner part of the Passage Channel (Fig. 2). Salinity varied between 12 and 38 psu with the highest values occurring during fall and spring, mainly at the sampling stations in the outer estuary region (Fig. 3).

Five species of chaetognaths were identified in the Vitória Bay estuarine system: *Sagitta decipiens* Fowler, 1905, *Sagitta enflata* Grassi, 1881, *Sagitta friderici* Ritter-Záhony, 1910, *Sagitta hispida* Conant, 1895 and *Sagitta minima* Grassi, 1881.

During winter, *S. friderici* was the dominant species at the outer stations with approximately 36 ind.m^{-3}. The same species was also found right in the middle of the estuary (Fig. 4), where salinities were around 14 psu (Fig. 3). *S. enflata* and *S. decipiens* were found in one of the estuary entrances where salinity was higher, the former being the more abundant (36.5 ind. m^{-3}) in this area (Fig. 4). *S. decipiens* was the second species observed in the areas with greater freshwater input in the inner part of the estuary, along with *S. friderici*, both with reduced abundance (2.4 ind.m^{-3} each) (Fig. 4).

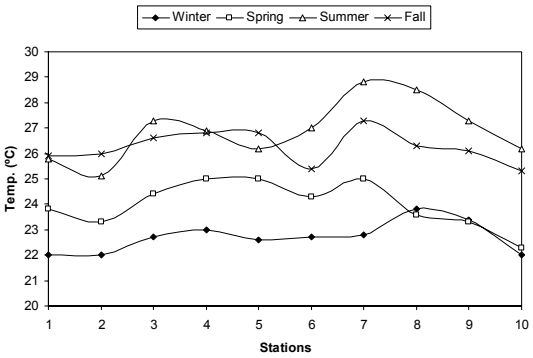

Fig. 2. Temperature (°C) variation for the ten sampling stations between July 1997 and April 1998 in the Vitória Bay estuarine system.

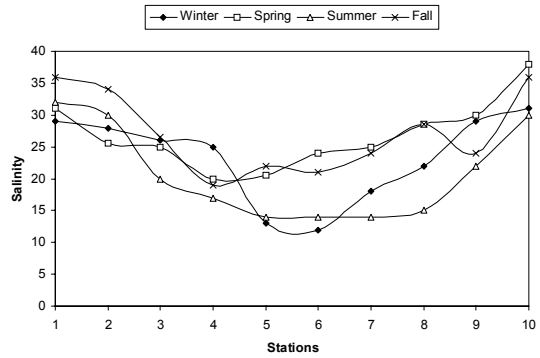

Fig. 3. Salinity (psu) variation for the ten sampling stations between July 1997 and April 1998 in the Vitória Bay estuarine system.

In spring, chaetognaths were also abundant in the outer region of the estuary (Fig. 5). The most abundant species for this season was *S. enflata*, attaining almost 40 ind.m^{-3} (Fig. 5) where salinity values reached their peak in the sampling period (37.5 psu – Fig. 3). Other abundant species were *S. friderici* and *S. decipiens*. *S. minima* had its first and only occurrence (0.4 ind.m^{-3} at St. 2) in the estuary during the entire sampling period. However, hardly any chaetognaths were present in the estuary in the summer. In this period, *S. friderici* was found only in the outer estuary, though in small numbers (max. of 1.9 ind.m^{-3}) (Fig. 6).

In contrast, chaetognaths showed a slight increase in abundance in the fall as compared to the

summer. *Sagitta friderici* was the most numerons species in the system, but with no more than 10.2 ind.m^{-3} at the entrance to Vitória Bay. *Sagitta friderici* was the only chaetognath species found right in the middle of the Passage Channel (Fig. 7), with salinities around 23 (Fig. 3). Other species present during the fall were *S. enflata*, *S. decipiens* and *S. hispida*, with this last occurring, on the first and only occasion, at station 2, though in small numbers (0.4 ind.m^{-3} – Fig. 7).

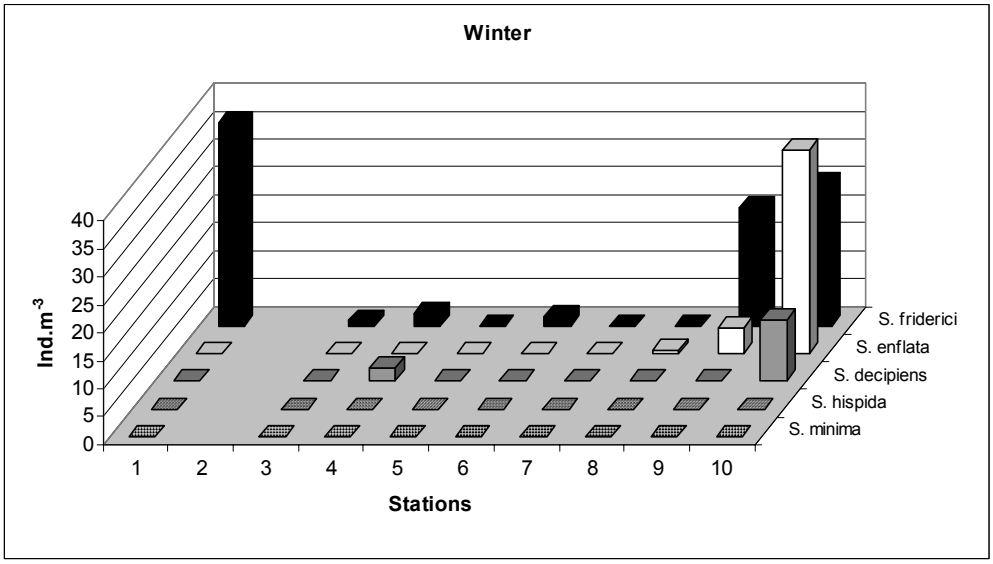

Fig. 4. Winter distribution of chaetognaths in the Vitória Bay/Passage Channel estuarine system (ind. m^{-3}).

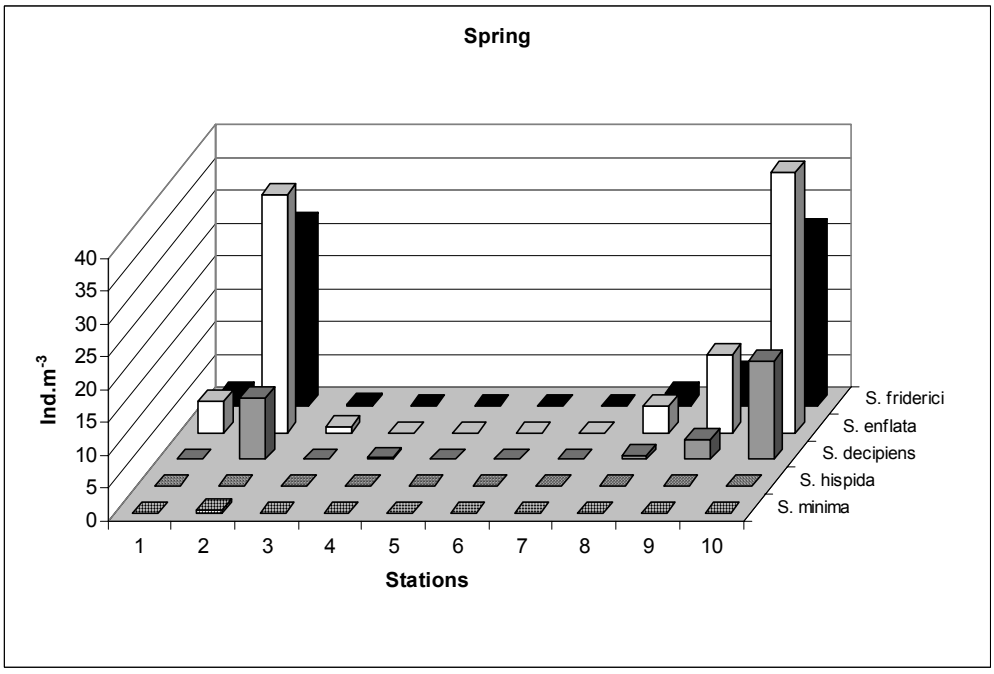

Fig. 5. Spring distribution of chaetognaths in the Vitória Bay/Passage Channel estuarine system (ind. m^{-3}).

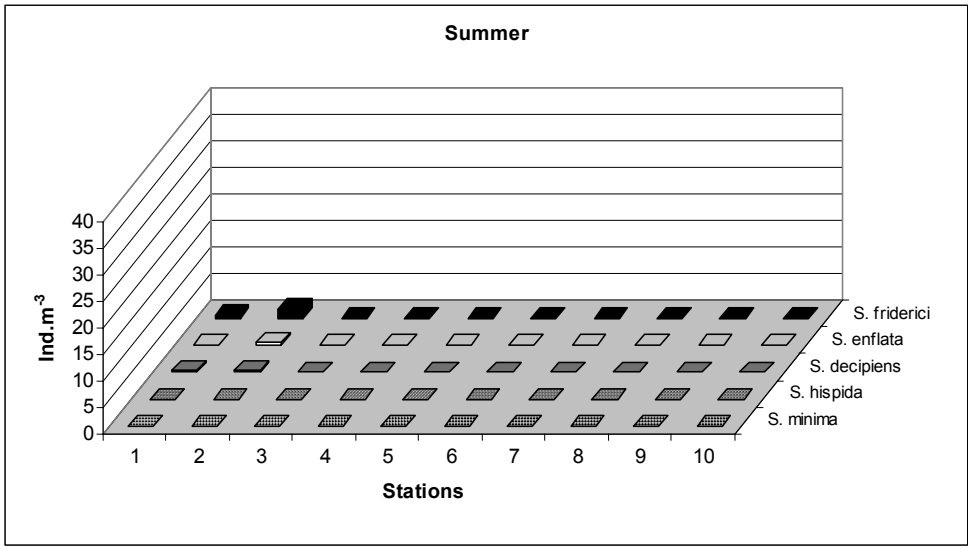

Fig. 6. Summer distribution of chaetognaths in the Vitória Bay/Passage Channel estuarine system (ind. m^{-3})

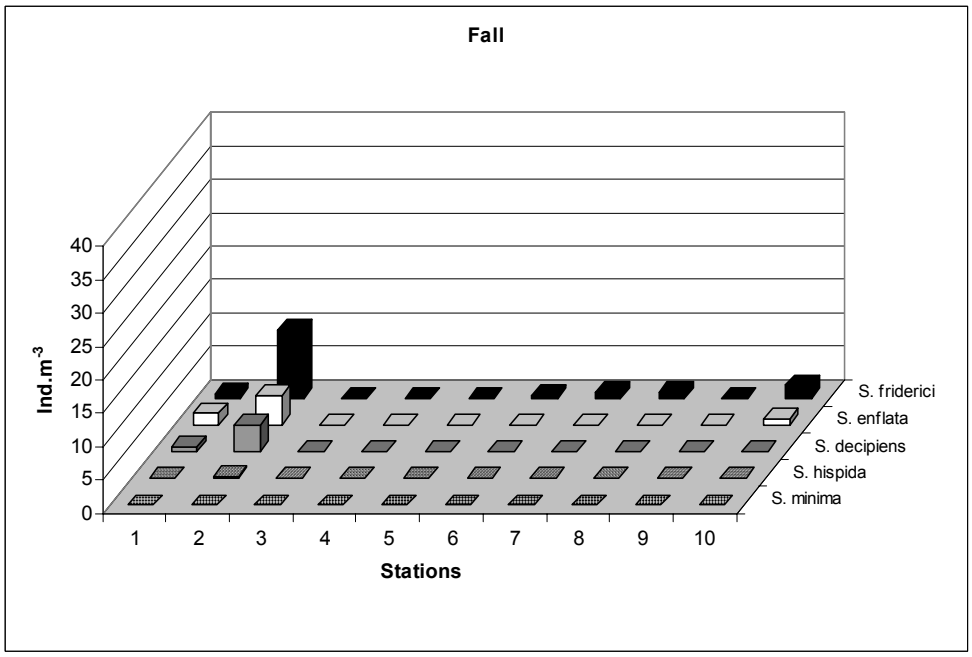

Fig. 7. Fall distribution of chaetognaths in the Vitória Bay/Passage Channel estuarine system (ind. m^{-3}).

Table 1 shows the correlation values obtained by the Spearman test between temperature, salinity and copepod abundance and the chaetognath species. Copepod data were obtained elsewhere. *S. enflata* had a positive correlation with salinity and a tendency to negative correlation with temperature. This same pattern was observed for *S. friderici* and *S. decipiens*, whereas *S. hispida* and *S. minima* did not show any significant correlation with either temperature or salinity. On the other hand, positive

correlation was observed between copepod abundance and *S. enflata*, *S. friderici* and *S. decipiens*.

Table 1. Spearman correlation among the environmental variables, copepod abundance and chaetognath abundance in the Vitória Bay/Passage Channel estuarine system.

Chaetognath Species	Temperature	Salinity	Copepod Abundance
Sagitta enflata	-0.39	0.64	0.43
Sagitta friderici	-0.51	0.66	0.48
Sagitta decipiens	-0.33	0.54	0.42
Sagitta minina	-0.13	0.03	0.21
Sagitta hispida	0.07	0.22	0.10

Cluster analysis (r-mode) for the chaetognath species revealed the existence of two groups: group A consisting of *S. hispida*, *S. minima* and *S. decipiens*, and group B of *S. friderici* and *S. enflata* (Fig. 8).

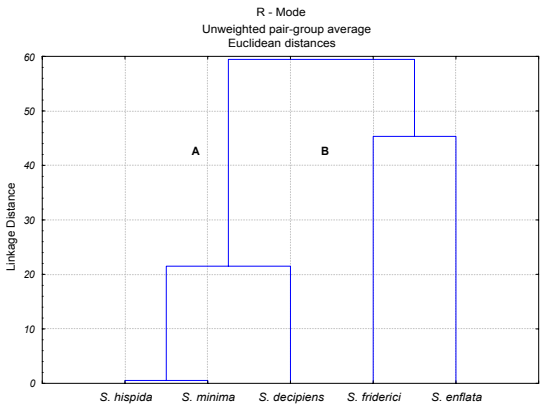

Fig. 8. Cluster analysis of chaetognath species in the Vitória Bay/Passage Channel estuarine system.

DISCUSSION

The results obtained in this study show that most of the species present in the Vitória Bay/Passage Channel estuarine system, such as *S. hispida*, *S. enflata*, *S. decipiens* and *S. minima*, are typical inhabitants of coastal and oceanic waters (Casanova, 1999). The higher abundance observed during winter and spring are in accordance with other studies of Brazilian coastal regions (Liang & Vega-Pérez, 1994).

The first evidence of *S. friderici* in Espírito Santo Bay, adjacent to Vitória Bay, State of Espírito Santo, was recorded by Bonecker *et al*. (1987). In the present study, *S. friderici* was one of the most abundant chaetognath species in the Vitória Bay/Passage Channel estuarine system during the entire year. The occurrence of this species has also been observed in other Brazilian estuarine systems (Montú, 1980; Lansac Tôha & Lima, 1993 and Lopes, 1996). According to Casanova (1999), *S. friderici* is a typical neritic species and can be found off the South American coast, this raising the possibility of its being found in many coastal systems. *S. friderici* is also considered an indicator of colder waters and regions with upwelling (Liang & Vega-Pérez, 2001). In the present study, *S. friderici* and *S. decipiens* were found in the middle of the estuary, where salinities were around 14 during the wet season and near an unusually low 12 psu during the dry season.

The results obtained in the present study show that the chaetognath species found in the Vitória Bay area only enter this estuarine system due to the tidal effect, not being typical residents. This was to be expected especially because this group mainly inhabits coastal and oceanic regions (Casanova, 1999). The presence of *S. friderici* in very low salinities might be explained either by a higher tolerance of this organism to lower salinities or just as a result of the fact that few individuals were trapped in the estuary when the tide started to ebb. *Sagitta enflata*, a cosmopolitan species found in regions where salinities can vary frequently and markedly (Boltovskoy, 1981), has also already been recorded in Brazilian estuaries (Montú, 1980; Lira & Magalhães, 1996: Lopes, 1996). In this study, *S. enflata* was abundant throughout the year at the stations closer to the entrance of the Bay and Channel, where the salinity was higher. Liang & Vega-Pérez (2001) found low densities of *S. enflata* in the coastal region off Vitória, and observed that this species seemed to be limited to the areas of high salinity values (>36) found in the tropical waters of the region, since this is a semi-neritic species (Liang & Vega-Pérez, 2002).

Sagitta hispida, a tropical species whose distribution extends southward with the Brazil Current (Casanova, 1999), is mainly neritic and is distributed in both oceanic and coastal waters (Alvariño, 1965). *S. hispida* has not so far been recorded in estuarine waters in Brazil. However, in this study, a low abundance of *S. hispida* was observed in one sampling station in the Vitória Bay area, probably carried in by a strong tidal current. This species is known to be able to survive in salinities varying from 20 to 45 (Boltovskoy, 1981).

Sagitta minima is a neritic species found in both coastal and oceanic areas (Alvariño, 1965). It has never before been recorded in Brazilian estuaries, this being its first recorded occurrence in this type of system, as also for the State of Espírito Santo. Some authors limit the occurrence of this species to tropical-subtropical waters (Casanova, 1999). The results obtained in this study indicate that *S. minima* is associated with high temperatures (26.0°C), during the fall. The same is true for *S. decipiens*, another oceanic

and costal species distributed from the equator down to 40°S, occurring mainly in subtropical waters (Casanova, 1999).

Liang & Vega-Pérez (1994) mentioned that the distribution and occurrence of chaetognaths are determined by hydrological conditions. In this study, the distribution of the two dominant species *S. friderici* and *S. enflata* was associated with the sampling stations characterized by their elevated salinity values, as can be observed from the Spearman correlation test results (Table 1), indicating the entrance of coastal waters into the estuary.

The occurrence of S. *enflata* e *S. friderici* throughout the year, along with the other species observed in the study area, is likely to be due to the tidal currents that entered the estuary during the sampling period, and were trapped in this system.

Apart from hydrological conditions, food availability also seems to influence chaetognath distribution. Copepods are important food items for chaetognaths (Liang & Vega-Pérez, 1995). Pierrot-Bults (1996) mentioned that approximately 10 to 30% of the copepod biomass is transferred to the chaetognath biomass. The results obtained in this study are in accordance with those observations, since a close correlation of chaetognath occurrence and high copepod densities was observed.

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