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THE CHAETOGNATHA OF THE SOUTHWESTERN GULF OF MEXICO DURING APRIL–MAY, 1986

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ABSTRACT An analysis of the distribution and abundance of Chaetognatha species from the Gulf of Mexico during April–May 1986 is presented. Zooplankton samples were collected at 43 stations from the southwestern and eastern regions of Mexico's Exclusive Economic Zone in the Gulf of Mexico. Species richness and abundance were higher in the southwestern stations located at the platform slope. The rank of Importance Value (IV) shows 3 groups of species; the first group included *Flaccisagitta enflata, Mesosagitta minima, Serratosagitta serratodentata, Krohnitta subtilis, Pterosagitta draco, Sagitta bipunctata,* and *Krohnitta pacifica* which were the most widely distributed species during this period. Density data were classified and analyzed by Morisita's similarity index, depicting 2 large groups of sampling stations along with a third group made up of 5 stations. Two stations were distinct from the others because of the low species richness and because only 2 species with high densities were present. Simpson's dominance index showed low values throughout the study area. Densities of chaetognath species did not differ significantly between day and night samples.

INTRODUCTION

Studies on Chaetognatha are relevant given their importance as predators of zooplankton, including copepods and fish larvae, and also for their role as indicators of particular hydrological conditions of water masses in the oceans (Alvariño 1965, McLelland 1989). Among the studies that focus on chaetognaths in the Gulf of Mexico we highlight those of Owre (1960) and Pierce and Was (1962) in the Florida Current; Pierce (1962) off the coast of Texas; McLelland (1989) in the Mississippi vicinity; and Every (1968) and McLelland and Perry (1989) in the northeastern oceanic zone of the Gulf. There have been studies in Mexico's Economic Exclusive Zone (EEZ), and these have been conducted in local regions: Vega-Rodríguez (1965) off the coast of Veracruz; Rivero-Beltrán (1975) in the Campeche Sound; and Mille-Pagaza et al. (1997) near the Yucatan platform. Since 1986 several oceanographic cruises were conducted in Mexico's EEZ, which comprises the oceanic southern, eastern, and western regions of the Gulf of Mexico in a wide network of stations. Among other results, the distribution of chaetognath species from the southeastern zone of the EEZ has been published by Mille-Pagaza and Carrillo-Laguna (1999). The specific composition, density, and distribution of Chaetognatha is presented herein for the basin and the southern and western regions of the Gulf of Mexico during April–May 1986.

MATERIALS AND METHODS

Samples were collected by the Instituto National de Pesca in April and May 1986 aboard the R/V *Justo Sierra* oceanographic ship (Cruise JS-8601) at 43 sampling stations in the basin, the southern, and western areas of Mexico's EEZ in the Gulf of Mexico (Figure 1). Zooplankton were sampled day and night by oblique tows at depths from 10 to 200 m using a bongo-type net (250 µm mesh). Chaetognaths (9,478) were removed from 10% aliquots for enumeration and identification using the keys and descriptions of McLelland (1989).

Species richness and abundance were calculated as orgs./100 m^3. The Importance Value (IV) (Krebs 1994) and Simpson's dominance Index (Stiling 1999) were obtained using relative abundances and frequencies of the species collected. Similarity between stations was estimated using Morisita's Index (Krebs 1989) and the corresponding dendrogram was derived using the unweighted average procedure (UPGMA). The Mann-Whitney U-test ($\alpha = 0.05$) was used to compare differences between day and night densities of each chaetognath species (Collins and Stender 1989, Zar 1999). A discriminant analysis was performed using surface (10 m) temperature, salinity, dissolved oxygen, and the cluster analysis results to detect which environmental factors influenced chaetognath community composition and density distribution. The relative importance of discriminating variables was judged by the absolute value of standardized coefficients of function. Chi squared ($\alpha = 0.05$) was used as the test statistic (Chester and Thayer 1990, Morrison 1990).

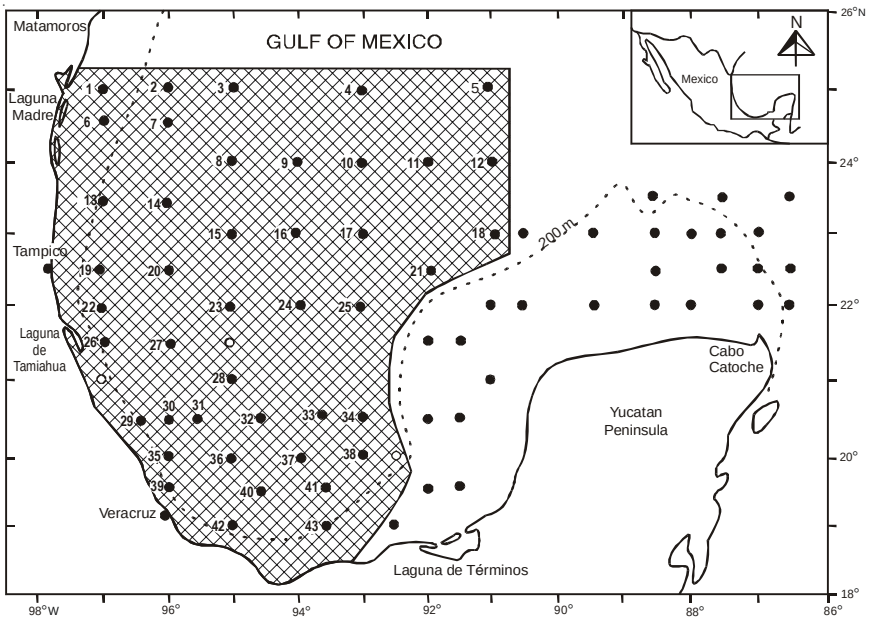

Figure 1. Study area. The hatched area indicates the region of the Gulf of Mexico analyzed in the present study.

RESULTS AND DISCUSSION

A total of 14 Chaetognath species were found ranging from 7 to 12 species per station, although most stations usually had 9 to 10 species. The lowest species numbers occurred in the southern and oceanic regions (Figure 2). There was a tendancy toward increasing species richness at stations near the platform or slope, which is similar to the pattern found at the Campeche Bank (Mille-Pagaza et al. 1997, Mille-Pagaza and Carrillo-Laguna 1999). Species richness in the neritic zone may be attributed to river run-off promoting increases in phytoplankton in coastal areas and thus chaetognath abundance (Alvariño 1965).

The area of highest total density (3,699 orgs./100 m^3) was found at a station close to the coast in the northwestern portion of the study area and consisted mainly of the species *Flaccisagitta enflata* (Grassi, 1881) and *Sagitta tenuis* Conant, 1896 (Figure 3). However, the lowest species number was also recorded at this station. High densities of between 1,101 and 2,980 orgs./100 m^3 were present at several stations in the western and southern

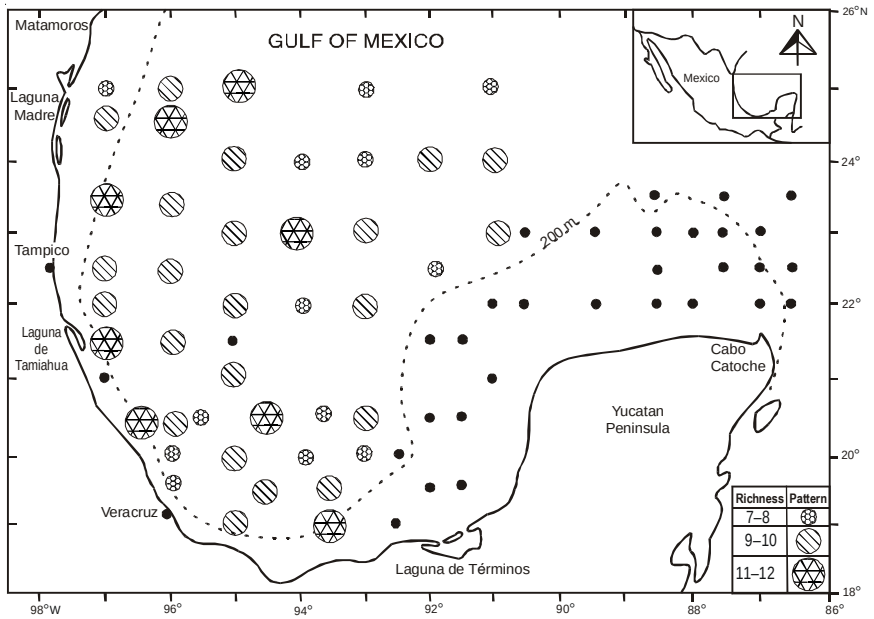

Figure 2. Species richness (number) distribution of chaetognaths in the Gulf of Mexico study area.

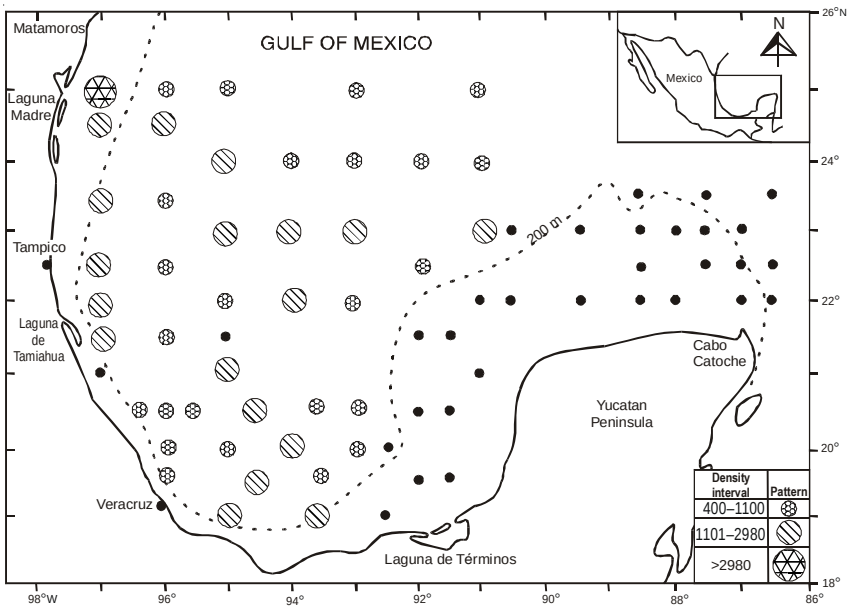

Figure 3. Density distribution of chaetognaths (orgs./100 m^3) in the Gulf of Mexico study area. The scale of the interval is in *e* base.

regions and in the basin where numbers greater than 2,000 orgs./100 m^3 were recorded. In most of the study area, however, abundances ranged from 400 to 1,100 orgs./100 m^3. In the vicinity of a small upwelling zone (Belousov et al. 1966), off the coast of Veracruz (Station 30), less than 500 orgs./100 m^3 were collected. During the present study, Chaetognath density generally was lowest in the southwestern Gulf of Mexico. Values between 1,000 and 5,000 orgs./100 m^3 were recorded at the Campeche Bank during this same period (Mille-Pagaza and Carrillo-Laguna 1999), with peak densities in the Campeche Sound exceeding 5,000 orgs./100 m^3. This confirms the high productivity that has been reported for the area (Bessonov et al. 1971).

Chaetognath species with the lowest densities (< 50 orgs./100 m^3), in decreasing order were: *S. tenuis*, present in the eastern portion of the study area and the most northern station, where found in numbers over 1,000 orgs./100 m^3; *Flaccisagitta lyra* (Krohn, 1853), was found dispersed throughout the area; *Mesosagitta decipiens* (Fowler, 1905) and *Ferosagitta hispida* (Conant, 1895), were found in similar areas at the western and southern stations (the latter also reached a moderate density of 436 orgs./100 m^3 at Station 1); *Mesosagitta sibogae* (Fowler, 1906) was only present at 4 stations in the basin in very low densities; and *Sagitta friderici* Ritter-Zahony, 1911 was collected only at one station in the basin and at another close to the slope off the Tabasco state coast.

Species with the highest abundances were *F. enflata* and *Mesosagitta minima* (Grassi, 1881), both widely distributed in the study area. *Flaccisagitta enflata* was collected in high densities of over 1,000 orgs./100 m^3 at stations near the platform in the western Gulf, but was low in abundance (from 200 to 1,000) in other areas. *Mesosagitta minima* was found in numbers over 200 orgs./100 m^3 in most areas, but at some stations only reached 500 and 1,000 organisms.

Other species distributed throughout the study area included: *Krohnitta pacifica* (Aida, 1897), *K. subtilis* (Grassi, 1881), *Sagitta bipunctata* Quoy and Gaimard, 1827, and *Flaccisagitta hexaptera* (d'Orbigny, 1843). In general, numbers for these species ranged from 4 to 50 orgs./100 m^3, but reached over 200 orgs./100 m^3 at some stations. *Serratosagitta serratodentata* (Krohn, 1853) and *Pterosagitta draco* (Krohn, 1853) were found throughout the study area, with densities between 100 and 500 orgs./100 m^3 in the oceanic zone, but lower densities were seen nearer the platform and slope. This coincides with Owre's (1960) finding for the Florida Current.

Results of the Importance Value (IV) analysis indicated 3 species sets (Table 1). The first set (IV > 10), was headed by *F. enflata* and *M. minima*, followed by *S. serratodentata, K. subtilis, P. draco, S. bipunctata,* and *K. pacifica*. The species *S. tenuis*, *F. hexaptera*, *F. hispida,* and *M. decipiens* were grouped together in the 2nd set (IV = 5–10). Finally, *F. lyra*, *M. sibogae* and *S. friderici* made-up the 3rd set (IV < 5).

TABLE 1

Species Importance Value (IV) of chaetognaths found in the Gulf of Mexico study area during April–May 1986, and their worldwide distribution. *Species reported for the Gulf of Mexico by McLelland 1989.

Species	IV	Worldwide Distribution (Alvariño 1965, 1969)
Set 1		
Flaccisagitta enflata	52.78	Oceanic, epiplanktonic, temperate-tropical.
Mesosagitta minima	32.09	Oceanic, epiplanktonic, tropical-temperate.
Serratosagitta serratodentata	19.45	Oceanic, epiplanktonic, Atlantic-temperate, tropical
Krohnitta subtilis	16.34	Oceanic, epiplanktonic, temperate, tropical
Pterosagitta draco	15.76	Oceanic, epiplanktonic, tropical-temperate
Sagitta bipunctata	14.92	Oceanic, epiplanktonic, tropical-temperate
Krohnitta pacifica	11.88	Oceanic, epiplanktonic, tropical-ecuatorial
Set 2		
Sagitta tenuis	9.49	Neritic, epiplanktonic, Atlantic-tropical-ecuatorial
Flaccisagitta hexaptera	9.27	Oceanic, epiplanktonic, tropical-temperate
Ferosagitta hispida	7.22	Oceanic, epiplanktonic, Atlantic-tropical-ecuatorial
Mesosagitta decipiens	5.55	Oceanic, epimesoplanktonic, tropical-temperate
Set 3		
Flaccisagitta lyra	3.27	Oceanic, epiplanktonic, tropical-temperate
**Mesosagitta sibogae*	1.36	Oceanic, mesoplanktonic, temperate
Sagitta friderici	0.61	Neritic, epiplanktonic, Atlantic-tropical-ecuatorial

The species in the first set, with the exception of *K. pacifica*, were distributed over 90% of the study area. However, some species were present in had very low abundances in some areas which is indicative of their oceanic or neritic nature. The position of *F. enflata* corresponds to that reported for the Campeche Bank (Mille-Pagaza et al. 1997, Mille-Pagaza and Carrillo-Laguna 1999) and agrees with the cosmopolitan species category assigned by several authors (Alvariño 1965, 1969, Michel 1984, McLelland 1989). On the other hand, some species showed inconsistent distribution patterns (e.g., *M. minima)*. Owre (1960) indicated that

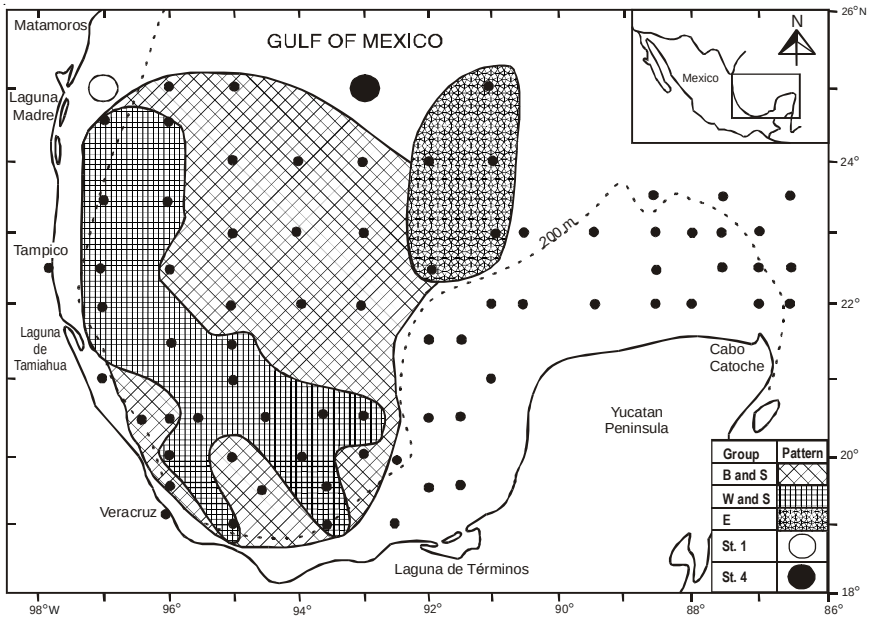

Figure 5. Spatial distribution of the groups obtained with Morisita's similarity index. Basin and South (B and S) West and South (W and S), East (E) and station (St.).

this species was a coastal species found in low abundances in the oceanic zone and was a species characteristic of mixed waters. Alvarino (1968) indicated that it was scarce in the Gulf of Mexico. In this study, *M. minima* it was found distributed throughout the entire area, with moderate to high abundances. Its distribution could be indicative of mixed surface waters from the Gulf stream and coastal waters (Vazquez de la Cerda 1975).

Ferosagitta hispida (2nd set) is considered to be a neritic form by Alvariño (1965) and McLelland (1989) and a possible indicator species of waters from the Gulf of Mexico (Pierce 1951, Owre 1960). In this study, it was restricted to the neritic zone but did occur in some oceanic stations. *Sagitta tenuis,* also a neritic species (Alvariño 1965, McLelland 1989), showed a similar distribution to that of *F. hispida*. *Mesosagitta decipiens*, a mesoplanktonic species, was present over the slope, which may be indicative of a mixture of deep and surface waters given the active hydrodynamics of the Gulf of Mexico (Vazquez de la Cerda 1975, Gasca 1999). This species was also recorded with a low IV value in the Campeche Bank by Mille-Pagaza and Carrillo-Laguna (1999).

Densities of chaetognath species did not differ significantly between night and daytime samplings, reflecting that most of the species collected are cosmopolitan, epiplanktonic, and are broadly distributed in the tropical and subtropical waters of the study area (Alvariño 1969, Michel 1984). This result agrees with those obtained for siphonophores in the Gulf of Mexico southwestern zone (Gasca 1999); however, Collins and Stender (1989) did find differences for mugilids larvae between day and night catches in the southwestern US.

Simpson's dominance index ranged from 0.14 to 0.54. In general, the highest values (> 0.30) were found close to the slope of the western platform and towards the southern zone of the study area. The highest dominance value (0.54) was recorded at Station 41 where *F. enflata* dominated. The lowest dominance values were recorded at the center of the basin where there were no predominant species. This pattern could be attributed to low abundances of chaetognath species as a result of the oligotrophic waters (Gasca 1997).

From the dendrogram constructed, 3 groups of sampling stations and 2 individual stations were defined when an arbitrary break was set at 0.87 (Figure 4). The first large group of 19, were basin and Gulf stations, where several species with relatively high and others with very low densities were collected (Figure 5). No clear dominance was established by any species, which was confirmed by the Simpson's index values (0.14 to 0.29). *Flaccisagitta enflata* and *M. minima* were the dominant species in the 2nd group of 17 stations located

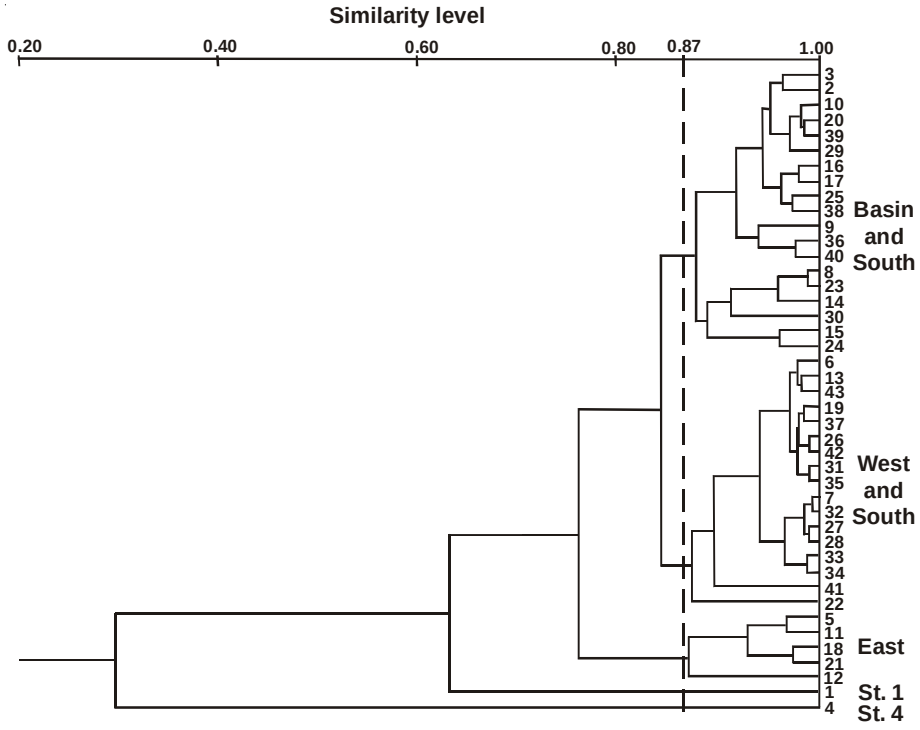

Figure 4. Dendrogram obtained with Morisita's similarity index and UPGMA's grouping method.

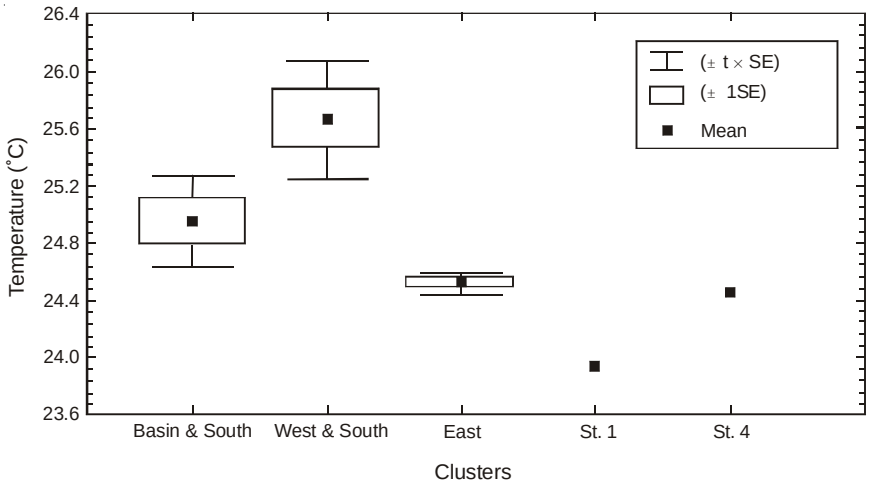

Figure 6. Boxplots of water temperature for each cluster obtained with Morisita's similarity index. t = value from t-distribution table.

in the southern zone and western slope region. The highest dominence index values for this group of stations ranged between 0.30 and 0.54 (Figure 5).

Five stations located in the eastern portion of the study area made-up the 3rd group (Figure 5). The densities of species in this group varied widely with no detectable trend. This group of stations also showed low dominance index values of between 0.16 and 0.26.

Stations 1 and 4 were separated from the other 3 groups by a similarity level value of less than 0.65. In these 2 stations (Figure 5) only 8 and 7 species, respectively, were present. Most species were represented by very low numbers with only 2 species at higher densities. *Sagitta tenuis* and *F. enflata* were found at Station 1 with over 1000 orgs./100 m^3. At Station 4, *M. decipiens* and *M. minima* ranged between 201 and 500 orgs./100 m^3 while *M. sibogae* reached a maximum density of only 30 orgs./100 m^3.

Multiple discriminant analysis applied to abiotic variables showed that species densities and chaetognath community composition were influenced primarily by temperature (Figure 6). The other variables did not differ significantly among station clusters ($P = 0.05$). Gasca (1999) found similar results for siphonophores; moreover, Alvariño (1969) asserted that food resources were a fundamental factor in chaetognath species distribution in other Atlantic regions. More investigation must be done in order to demonstrate the relationship between chaetognath abundance and environmental variables.

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