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DISTRIBUTION AND ABUNDANCE OF CHAETOGNATHA ON THE YUCATAN SHELF DURING MAY, 1986.

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ABSTRACT An analysis of chaetognath species distribution and abundance from the Yucatan Shelf during May 1986 is presented. Zooplankton samples and associated hydrographic data were collected at 21 stations off the northern and northwestern coasts of the peninsula. Density data were classified and analyzed by calculating the Euclidian distance. In addition, the Importance Value of the species was obtained. Highest abundance (1000 to 5000 orgs./100m³) occurred in the northern and northwestern zones off the peninsula, while species richness was higher at oceanic stations farther offshore. The most abundant and frequent species were *Sagitta enflata* and *S. bipunctata*. The classification analysis based on the Euclidian distance showed three zones in the study area with different predominant species: (1) The northeast oceanic region of the Peninsula, with *S. minima*, *S. serratodentata*, *S. enflata* and *S. bipunctata*; (2) the west and northwest neritic region with *S. enflata* and (3) the near northeast and west coastal region with *S. bipunctata*.

INTRODUCTION

Besides being an important oil zone, the Campeche Bank comprises areas of high biological productivity (Bessonov et al., 1971). Most Cuban and Mexican fishing activity is done in these waters. Among the commercial species, one can find the blue fin tuna, *Thunnus thynnus*, fish of the families Pomadasidae, Sparidae, Lutjanidae and Serranidae, as well as crustaceans such as shrimp and lobster. Enhanced exploitation of these resources requires more complete knowledge of the zooplankton community.

Among the studies focused on chaetognaths carried out in the Caribbean zone, we highlight the works of Furnestin (1965) in the Antilles, Suárez-Caabro (1955) on the coasts of Cuba and Michel and Foyo (1976) and Michel (1984) for the entire Caribbean Sea. On the southeast coast of the United States, Owre (1960) and Pierce and Wass (1962) investigated the chaetognaths of the Florida Current. In the northern Gulf of Mexico, Pierce (1962) investigated the chaetognaths on the Texas coast and McLelland (1984, 1989) studied the distribution of coastal and oceanic chaetognaths and prepared a key to their identification. For the southern Gulf of Mexico, Vega-Rodríguez (1965) focused on the coast off Veracruz, Mexico and Rivero-Beltrán (1975) studied the abundance of chaetognaths of the Campeche Bank, Mexico.

At present, the Advanced Investigation Center-I.P.N. Mérida Campus (CINVESTAV-IPN-Mérida) is performing a series of oceanographic cruises over the Campeche Bank which include the collection of zooplankton samples. Meanwhile, the Ecology Laboratory of the National School of Biological Sciences (ENCB-IPN, Mexico City) has

carried out several zooplankton investigations on this community in the same zone since 1979 (Guzmán del Proo et al., 1986; de la Campa et al., 1987). This paper, based on the latter investigations, intends to continue these studies by reporting the Chaetognatha species composition, spatial distribution and density on the Campeche Bank during May 1986.

Study Area

The continental shelf that surrounds the Gulf of Mexico broadens off the coast of Texas, Florida and the Yucatan Peninsula. The Yucatan Shelf, also known as the Campeche Bank, surrounds the Yucatan Peninsula on its north and west sides. It comprises an area with a gentle slope that extends out to depths of 200 m.

The system of currents in the Gulf is dominated by the Yucatan Current (Nowlin 1971, Suárez and Gasca 1989). The movement of this current along the Yucatan Shelf contributes to the upwelling of nutrient-rich water along the northeastern edge of the shelf and the central portion of the Campeche Bank (Gasca and Suárez 1991).

Bessonov et al. (1971) divided the Yucatan Shelf into two regions, the western and eastern zones, according to circulation patterns. They also established two types of circulation. The first occurs when the intensity of the Yucatan Current increases during the rainy season, causing a cyclonic circulation in the eastern zone. The second takes place when the intensity of the Yucatan Current decreases during the dry season. As a consequence, patterns of cyclonic and anticyclonic circulations are developed in the northern and western regions of the shelf from November through March.

MATERIALS AND METHODS

Twenty-one zooplankton samples were collected by the CINVESTAV-IPN Mérida staff in May 1986 aboard the oceanographic ship *Justo Sierra*. Sampling stations were located on the Yucatan Shelf between 19° 25'24"N and 86° 10'93"W (Figure 1, Table 1). At each station, temperature, salinity and dissolved oxygen values were recorded from the surface level (0-50m), and zooplankton sampling was performed by oblique tows using bongo type nets (333 μ m mesh). Settled volume of zooplankton was measured as an estimate of biomass. Afterwards, the chaetognaths were removed from sample aliquots for enumeration and identification.

Chaetognath density was standardized and reported as number of orgs./100m³, and species richness was calculated. The data gathered was then classified and analyzed by the Euclidian distance to detect distribution patterns of the species in the Campeche Bank, according to methods described by Crisci (1983). In addition, the Importance

Value (IV) (Krebs, 1978) was obtained, using only the density and frequency of the species.

RESULTS

Environmental Conditions

Two areas were detected with high surface temperatures (27°C), one off the west side of the Peninsula near the coast, and the second to the far northeast side of the study zone (Figure 2). The lowest records of surface temperature (22°C), were found off the northern part of the Peninsula, over the shelf. In this zone, a westward gradient of 22-25°C was observed. The lowest surface salinity obtained was 36.2‰ off both, the eastern and western sides of the peninsula. The highest value was 37‰ off Campeche. Oxygen in surface waters was highest (5.0 ppm) in the oceanic region to the north and west of the peninsula above the 50 m isobath. For the rest of the study zone, values of 4.7-4.9 ppm were registered.

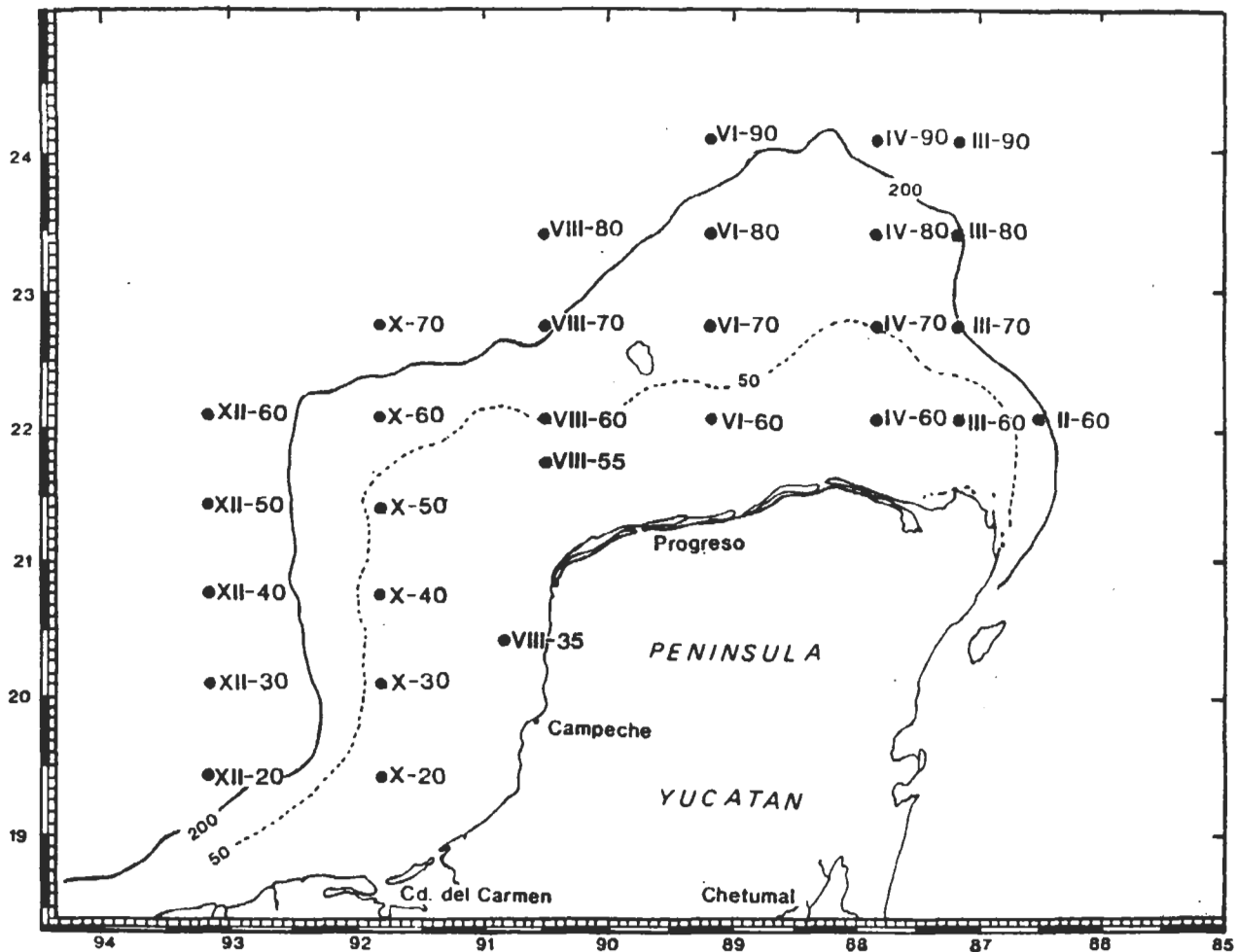


Figure 1. Sampling stations during the Oceanographic Cruise "Yucatan VI" carried out in Yucatan Shelf, Mexico. May 1986.

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TABLE 1

Biomass, abundance and species richness of Chaetognatha in Yucatan shelf, Mexico, May 1986.

Station	Position	Sampling depth (m)	Biomass (ml / 100m ³)	Abundance (org./100 m ³)	Number of species
II-60	22° 05' 86° 30'	99.2	43.5	660	3
III-60	22° 05' 87° 30'	14.7	62.8	1680	4
III-80	23° 25' 87° 10'	101.1	11.0	159	7
III-90	24° 05' 87° 10'	102.2	12.3	266	7
IV-70	22° 45' 87° 50'	30.1	44.7	478	6
IV-80	23° 25' 87° 50'	64.8	11.9	549	7
IV-90	24° 05' 87° 50'	104.3	6.9	414	7
VI-60	22° 04' 89° 10'	35.0	265.3	8000	5
VI-80	23° 24' 89° 09'	92.7	48.2	761	6
VIII-35	20° 25' 90° 50'	4.7	49.4	848	2
VIII-55	21° 15' 90° 28'	9.9	26.2	386	3
VIII-60	22° 05' 90° 30'	25.0	45.6	697	5
VIII-70	22° 45' 90° 29'	110.2	13.4	906	7
VIII-80	23° 25' 90° 30'	106.6	8.3	548	7
X-20	19° 24' 91° 50'	22.0	62.4	3358	5
X-50	21° 25' 91° 50'	29.6	57.8	989	5
X-60	22° 05' 91° 50'	52.9	93.1	1757	4
X-70	24° 45' 91° 49'	108.5	19.0	799	7
XII-30	20° 05' 93° 10'	94.2	23.9	829	7
XII-40	20° 45' 93° 10'	83.5	36.5	652	7
XII-60	22° 05' 93° 10'	97.0	23.2	1091	6

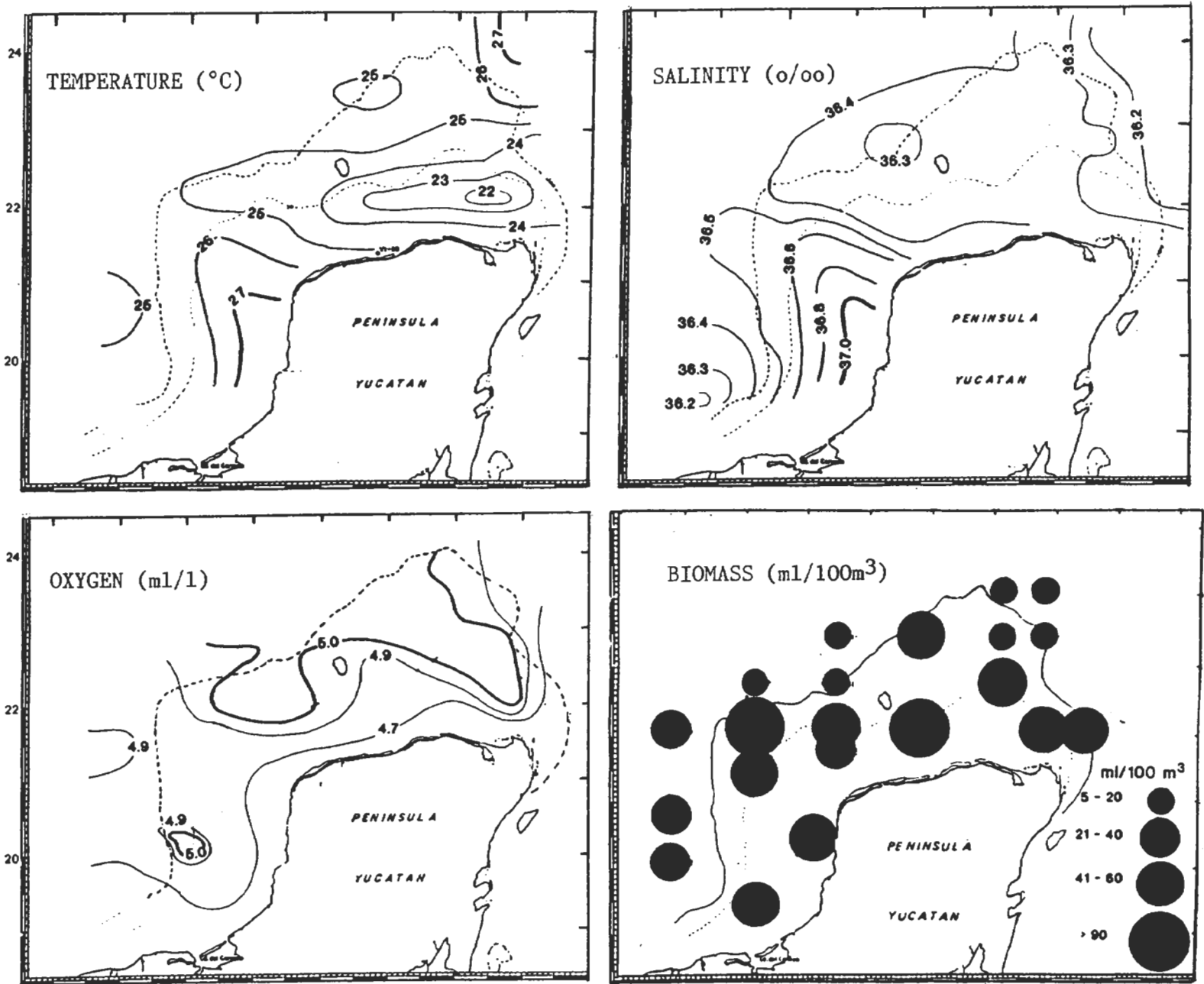


Figure 2. Horizontal distribution of shallow water temperature, salinity, oxygen and total plankton biomass, Yucatan Shelf, Mexico, May 1986.

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Biological Characteristics

The lowest biomass (6.9-36.5 ml/100m³) occurred in the northern oceanic zone and over the slope (200 m isobath). Values on the Yucatan Shelf ranging from 26.2 to 265.3 ml/100m³ (Figure 2, Table 1). Highest abundance (>5000 orgs./100m³) was found in one shallow near-coastal station (VI-60), while values from 1001 to 5000 orgs./100 m³ occurred in the northeastern and northwestern zones off the peninsula. Off the northern peninsula, beyond the 50 m isobath, chaetognath density ranged from 158 to 500 orgs./100m³ (Figure 3, Table 2).

Species richness was higher at oceanic stations (Figure 3, Table 1), with nine species belonging to the genera *Krohnitta*, *Pterosagitta* and *Sagitta*. The rank of importance, calculated from the Importance Value, is as follows:

Species

IV

<i>Sagitta enflata</i> (Grassi, 1881)	145.6
<i>Sagitta bipunctata</i> (Quoy and Gaimard, 1827)	124.2
<i>Sagitta serratodentata</i> (Kronhn, 1853)	89.7
<i>Sagitta minima</i> (Grassi, 1881)	79.7
<i>Pterosagitta draco</i> (Kronhn, 1853)	75.9
<i>Krohnitta subtilis</i> (Grassi, 1881)	68.8
<i>Sagitta hexaptera</i> (d'Orbigny, 1843)	58.4
<i>Krohnitta pacifica</i> (Aida, 1897)	9.6
<i>Sagitta friderici</i> (Ritter-Zahony, 1899)	4.9

Based on these values, three species groups were detected:

First set (IV:> 100). Most abundant and frequent species included *Sagitta enflata* and *S. bipunctata*, which

TABLE 2

Abundance (org./100 m³) of Chaetognaths Species in the Yucatan Shelf, Mexico. May, 1986. (Kp-*Krohnitta pacifica*, Ks-*K. subtilis*, Pd-*Pterosagitta draco*, Sh-*Sagitta hexaptera*, Se-*S. enflata*, Ss-*S. serratodentata*, Sb-*S. bipunctata*, Sm-*S. minima*, Sf-*S. friderici*).

Station	Species									
	Kp	Ks	Pd	Sh	Se	Ss	Sb	Sm	Sf	TOTAL
II-60	0.0	0.0	0.0	0.0	25.3	12.6	622.5	0.0	0.0	660
III-60	0.0	0.0	0.0	0.0	370.4	66.1	780.6	463.1	0.0	1680
III-80	0.0	15.5	28.5	2.5	38.9	46.7	18.1	7.7	0.0	158
III-90	0.0	2.7	96.0	2.7	120.7	35.6	5.4	2.7	0.0	266
IV-70	0.0	7.9	95.1	0.0	137.7	79.2	142.6	0.0	15.8	478
IV-80	0.0	21.8	59.6	7.9	97.4	35.7	137.1	89.4	0.0	549
IV-90	0.0	20.7	55.4	37.1	177.3	20.7	37.4	65.1	0.0	414
VI-60	0.0	326.5	244.8	0.0	3102.0	0.0	3755.1	571.4	0.0	8000
VI-80	22.0	0.0	88.2	0.0	264.8	55.1	44.1	286.8	0.0	761
VIII-35	0.0	0.0	0.0	8.2	0.0	0.0	840	0.0	0.0	848
VIII-55	0.0	13.0	0.0	0.0	229.0	0.0	143.9	0.0	0.0	386
VIII-60	8.2	0.0	0.0	0.0	614.1	24.8	41.4	8.2	0.0	697
VIII-70	0.0	20.2	117.8	30.3	273.1	208.8	138.0	117.8	0.0	906
VIII-80	0.0	25.0	69.5	5.5	164.1	91.8	148.8	43.1	0.0	548
X-20	0.0	0.0	62.4	31.2	3123.7	15.6	124.9	0.0	0.0	3358
X-50	0.0	10.5	0.0	0.0	768.2	10.5	178.9	21.0	0.0	989
X-60	0.0	0.0	16.5	165.7	1158.3	16.5	0.0	0.0	0.0	1757
X-70	0.0	25.4	112.0	15.2	468.5	76.3	61.1	40.7	0.0	799
XII-30	0.0	6.3	19.1	6.3	599.4	89.2	76.5	31.8	0.0	829
XII-40	0.0	38.9	29.2	29.2	321.2	38.9	19.4	175.2	0.0	652
XII-60	0.0	38.1	61.9	0.0	567.2	100.1	95.3	228.8	0.0	1091
TOTAL	30.2	573.0	1156.0	342.0	13021.3	1024.2	7411.2	2152.8	15.8	25830

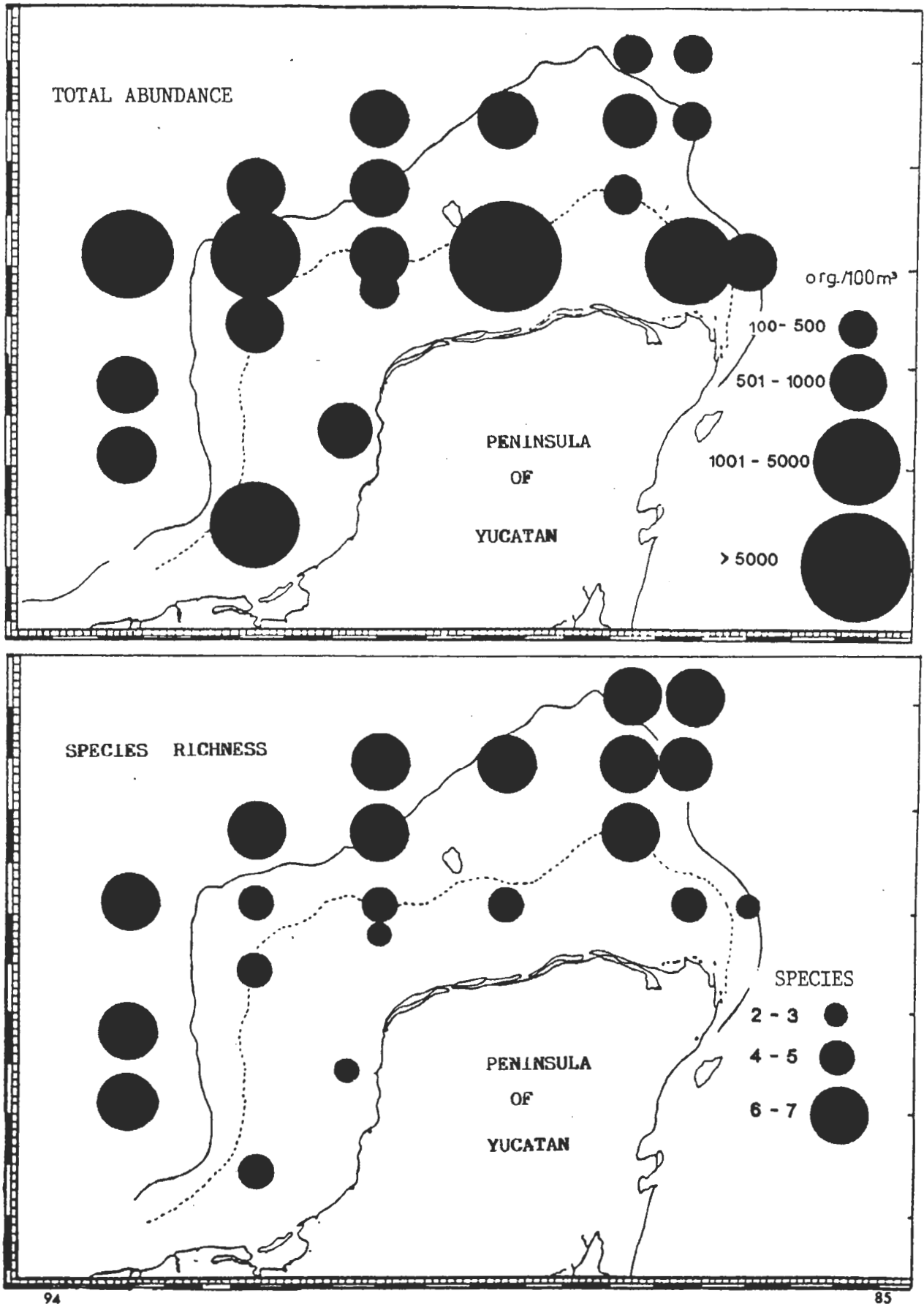


Figure 3. Total abundance and species richness of Chaetognaths. Yucatan Shelf, Mexico, May 1986.

are broadly distributed in the study area. The first was found mostly in the west, while the second was most abundant in the shallow near-coastal zone to the north of the peninsula and off the Campeche coast (Figure 4, Table 2).

Second set (IV: 50-80). Species with regular abundance and frequency included *Sagitta serratodentata*, *S. minima*, *Pterosagitta draco*, *Krohnitta subtilis* and *S. hexaptera*. These were found mainly in the northern part of the study area (Figure 5).

Third set (IV: < 10). Less frequent and abundant species included *Sagitta friderici* and *Krohnitta pacifica*, which were present at only one and two sampling stations, respectively, towards the northern part of the shelf (Table 2).

In the oceanic region, to the northeast and north of the peninsula, there was no evident dominance by a particular species (Figure 6). In this region, *Sagitta bipunctata*, *S. minima*, *S. enflata* and *S. serratodentata* comprised between 26 and 50% of the collected individuals.

From the dendrogram constructed using dissimilarity values obtained with the Euclidian distance Index (Figure 7), three groups of samples are distinguished: (1) most of the samples found off the northern part of the peninsula near the slope; (2) those located over or near the slope west of the peninsula and (3) those found over the shelf near shore, to the northeast and west of the peninsula.

DISCUSSION

Previous investigations in the Gulf of Mexico and the Caribbean Sea coincide in placing the Campeche Bank among the zones with the highest productivity in the Gulf, a fact that is reflected in its high planktonic biomass values (Bogdanov et al. 1968; Jromov 1965, De la Cruz 1971). Bogdanov et al. (1968) also mentioned that this is a zone where upwelling takes place often throughout the year and the highest biomass occurs during the rainy season when upwelling increases.

During May 1986, the highest biomass values were recorded over the Campeche Bank (Figure 2) and towards the western oceanic region, while the values were relatively low in the northern and northeastern oceanic regions. The total chaetognath density (Figure 3) presented a similar distribution to that of biomass, with highest values found mostly over the shelf, a fact also reported by Juárez (1975) for fish eggs and larvae.

The species number was high at oceanic stations beyond the 50 m isobath, but specific abundance was low (Figure 3). This relationship is better observed in the northeast region of the zone. Jromov (1965) pointed out that this relationship between abundance and specific richness appears frequently in tropical waters due to the

stability of oceanographic conditions. Meanwhile, the changing conditions of the shallow near-coastal zone only allows the development of some species.

Most of the identified species in this study have been reported by other authors as common in the Caribbean Sea (Suárez-Caabro 1955; Michel and Foyo 1976). *Sagitta enflata* was prominent in those reports and in this study because of its high abundance. If we consider the current entering the Gulf through the Yucatan Channel to be an extension of Caribbean waters, we should expect to find the same epipelagic species in both regions. The majority of the recorded species in this study are oceanic, epipelagic and cosmopolitan in tropical and subtropical waters. Only *Sagitta friderici* and *S. serratodentata* are reported to be distributed exclusively in the Atlantic Ocean. Because of their epipelagic nature, the identified species are associated with surface tropical water masses (Alvarifio 1969; Michel and Foyo 1976) and can tolerate broad variations in salinity and temperature brought about by evaporation, precipitation and fluvial discharge.

Sagitta enflata (Grassi 1881) is epipelagic, widely distributed and the most abundant in tropical and subtropical regions (Alvarifio 1969; McLelland 1989). *Sagitta enflata* was present throughout the study area with high abundance levels (Figure 4). To the west of the peninsula, it represented a high percentage of all identified organisms (Figure 6) and coincided with high values of temperature and salinity (25-27°C and 36.4-37.0‰).

Sagitta bipunctata (Quoy and Gaimard 1827) is epipelagic in tropical and subtropical regions and is considered oceanic and scarce in the Caribbean Sea and Gulf of Mexico (Michel and Foyo 1976, Rivero-Beltrán 1975). In the present study, *S. bipunctata* had a conspicuously neritic distribution and was the second in abundance throughout the study area (Figure 4). Its relative abundance was low, except for two stations near the coast at the northeast and west side of the peninsula where its abundance ranged between 76 and 99% (Figure 6). Its presence coincided with the highest and lowest salinity and temperature values, suggesting a wide tolerance to variations in these factors.

Sagitta minima (Grassi 1881) is characteristic of mixed waters along continental shelf regions (Alvarifio 1965). Owre (1960) reported *S. minima* as being eurythermic. In this particular case, it was found to be third in abundance. It was present in oceanic and neritic samples (Figure 5) where its high abundance coincided with temperatures of 22-25°C and salinity values of 36.2-36.5‰.

Sagitta serratodentata (Krohn 1853) is oceanic, epipelagic and characteristic of tropical and subtropical Atlantic waters (Alvarifio 1965; McLelland 1989). In the

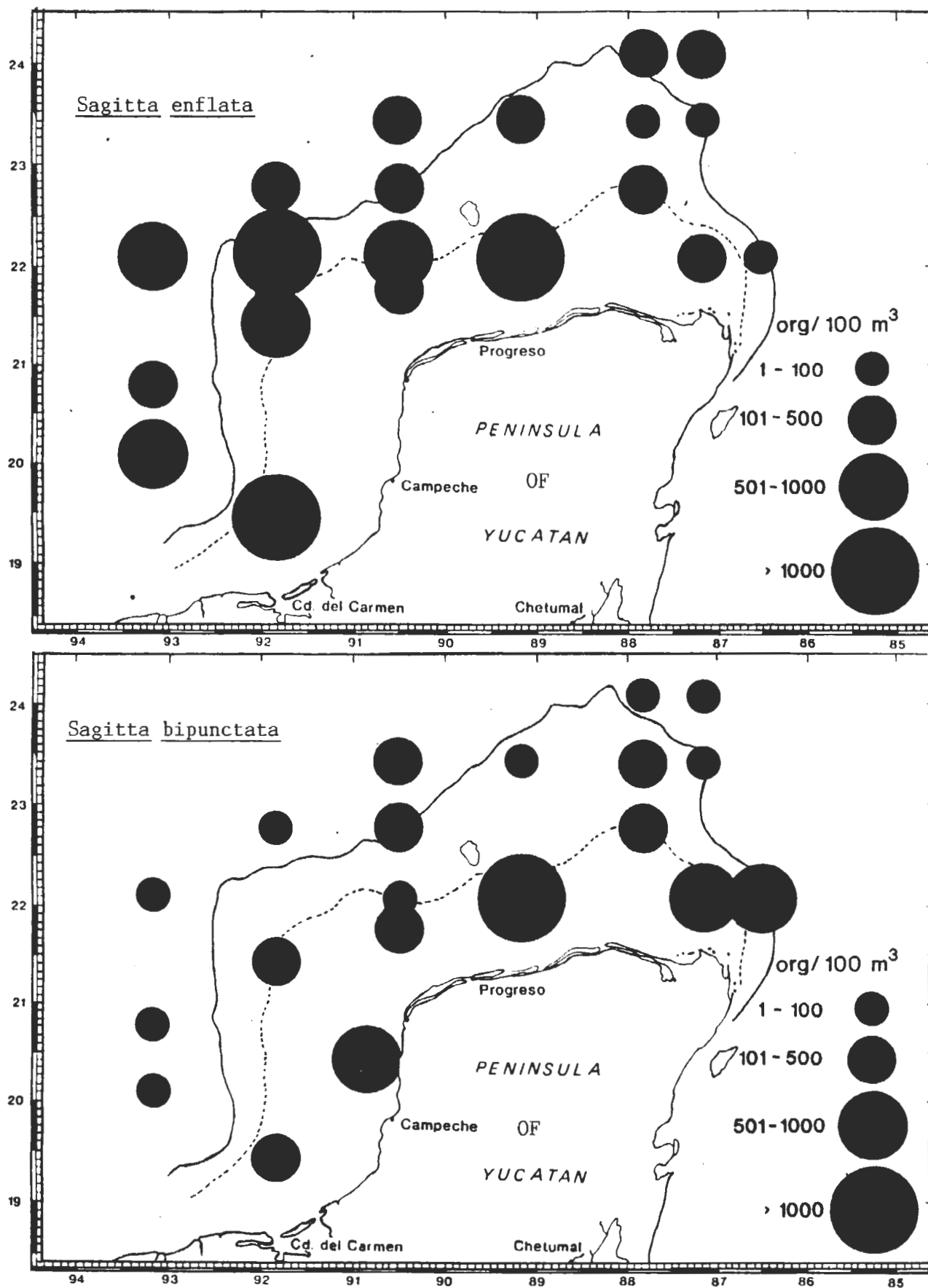
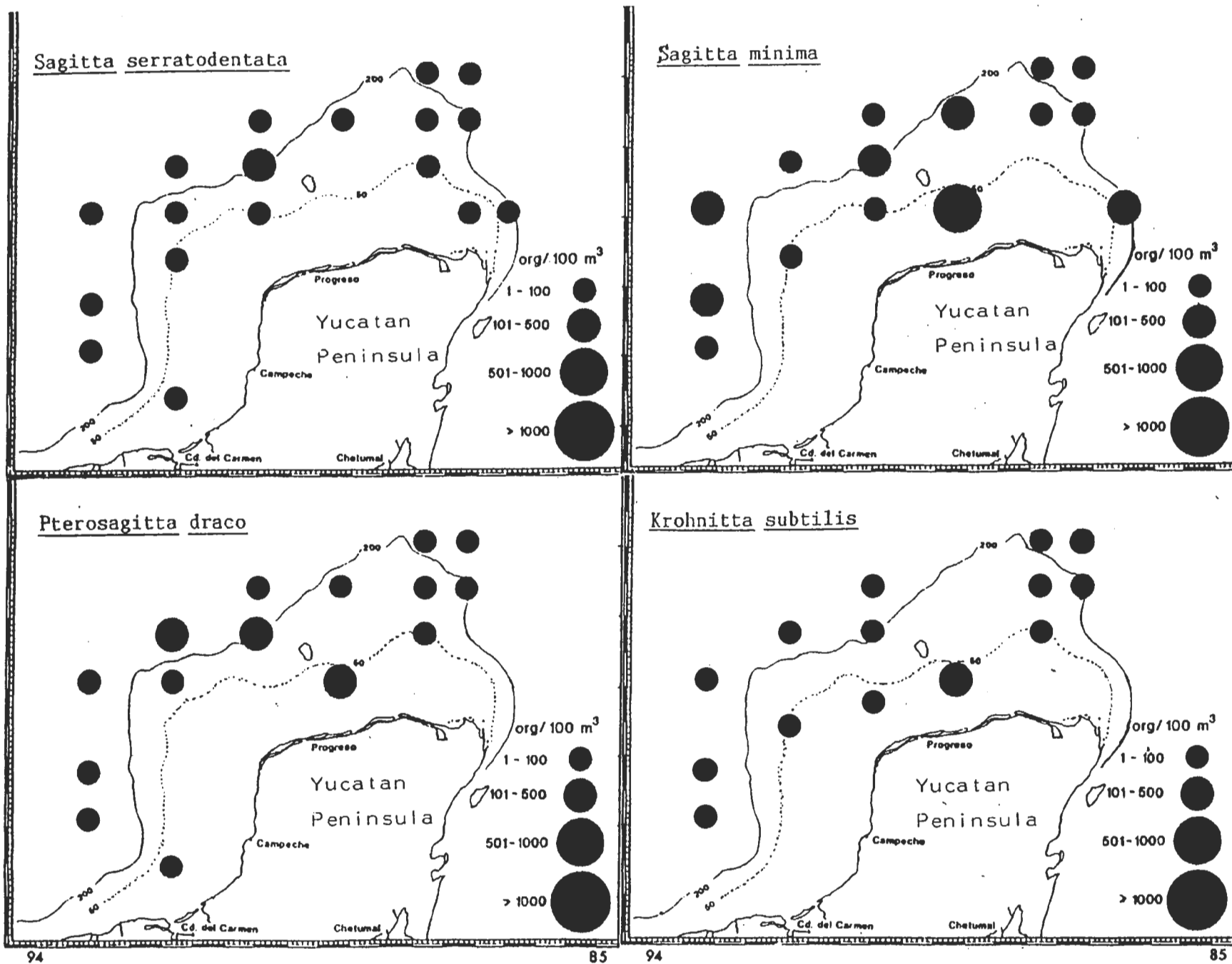


Figure 4. Abundance of *Sagitta enflata* and *S. bipunctata*. Yucatan Shelf, Mexico, May 1986.

Figure 5. Abundance of *Sagitta serratodentata*, *S. minima*, *Pterosagitta draco* and *Krohnitta subtilis*. Yucatan Shelf, Mexico. May 1986.



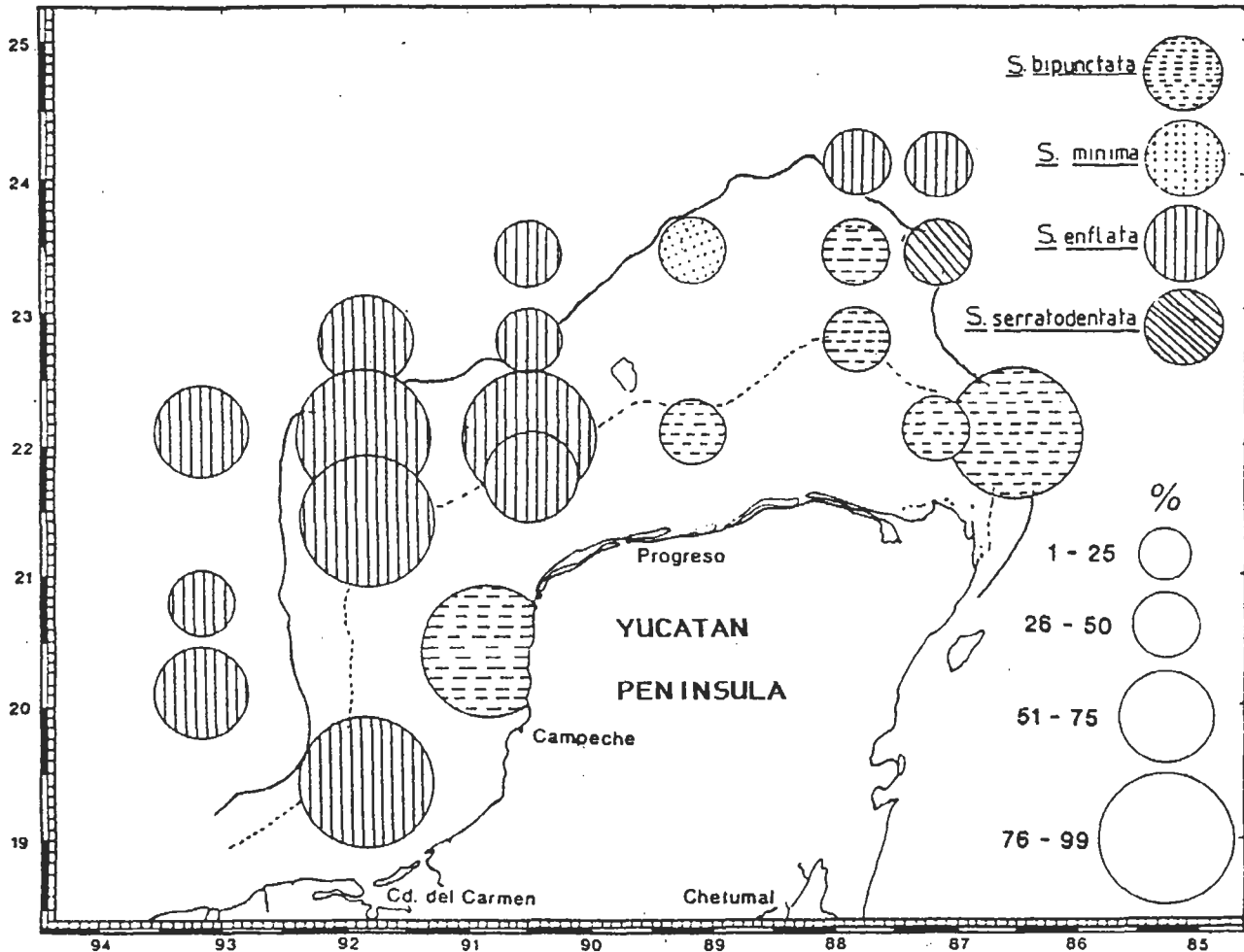


Figure 6. Relative abundance of the most important species at each station. Yucatan Shelf, Mexico. May 1986.

study area, *S. serratodentata* had a middle abundance (1024 orgs./100m³) and was distributed from the 50 m isobath to the oceanic region (Figure 5). However, it has been reported throughout the Gulf of Mexico and the Caribbean Sea as among the most abundant species (Suárez-Caabro 1955; Colman 1959; Owre 1960; Furnestin 1965; Rivero-Beltrán 1975; Michel and Foyo 1976).

Pterosagitta draco (Krohn 1853) is oceanic and lower epipelagic (Suárez-Caabro 1955; Owre 1960; Alvarifio 1965; McLelland 1989). It is reported as abundant north of Cuba and in the Florida Current (Suárez-Caabro 1955; Owre 1960). In this study, *P. draco* showed an affinity for the oceanic environment (Figure 5) and was generally low in abundance (1-100 orgs./100m³).

Krohnitta subtilis (Grassi 1881) is oceanic and cosmopolitan in tropical and subtropical waters (Suárez-Caabro 1955; Owre 1960; Alvarifio 1964, 1965; McLelland 1989). *Krohnitta subtilis* was low in abundance in the study area (1 to 100 orgs./100m³); its distribution corresponded to that reported by these authors (Figure 5).

Sagitta hexaptera (d'Orbigny 1843) oceanic and cosmopolitan in tropical and subtropical waters (Suárez-Caabro 1955; Owre 1960; Alvarifio 1965; McLelland 1989). It was low in abundance in the study area, with a strong oceanic tendency in its distribution.

Sagitta friderici (Ritter-Zahony 1911) is neritic and epipelagic in the Atlantic Ocean and adjacent seas (Faure 1952; Colman 1959; Heydorn 1959; Alvarifio 1965; Michel and Foyo 1976; McLelland 1984, 1989) and associated with coastal lagoons (Laguada-Figueras 1967; Rivero-Beltrán 1975; López-Cano 1987) in the Gulf of Mexico and in the Caribbean Sea, although scarcely represented. *S. friderici* was found at only one station in the study area IV-70, located to the northeast of the peninsula above the 50 m isobath where salinity was 36.3‰ and temperature ranged from 24 to 25°C.

Krohnitta pacifica (Aida 1897) is semi-neritic, epipelagic, cosmopolitan in tropical and subtropical seas (McLelland 1989) and common in areas of mixing water masses. *Krohnitta pacifica* was present at two stations

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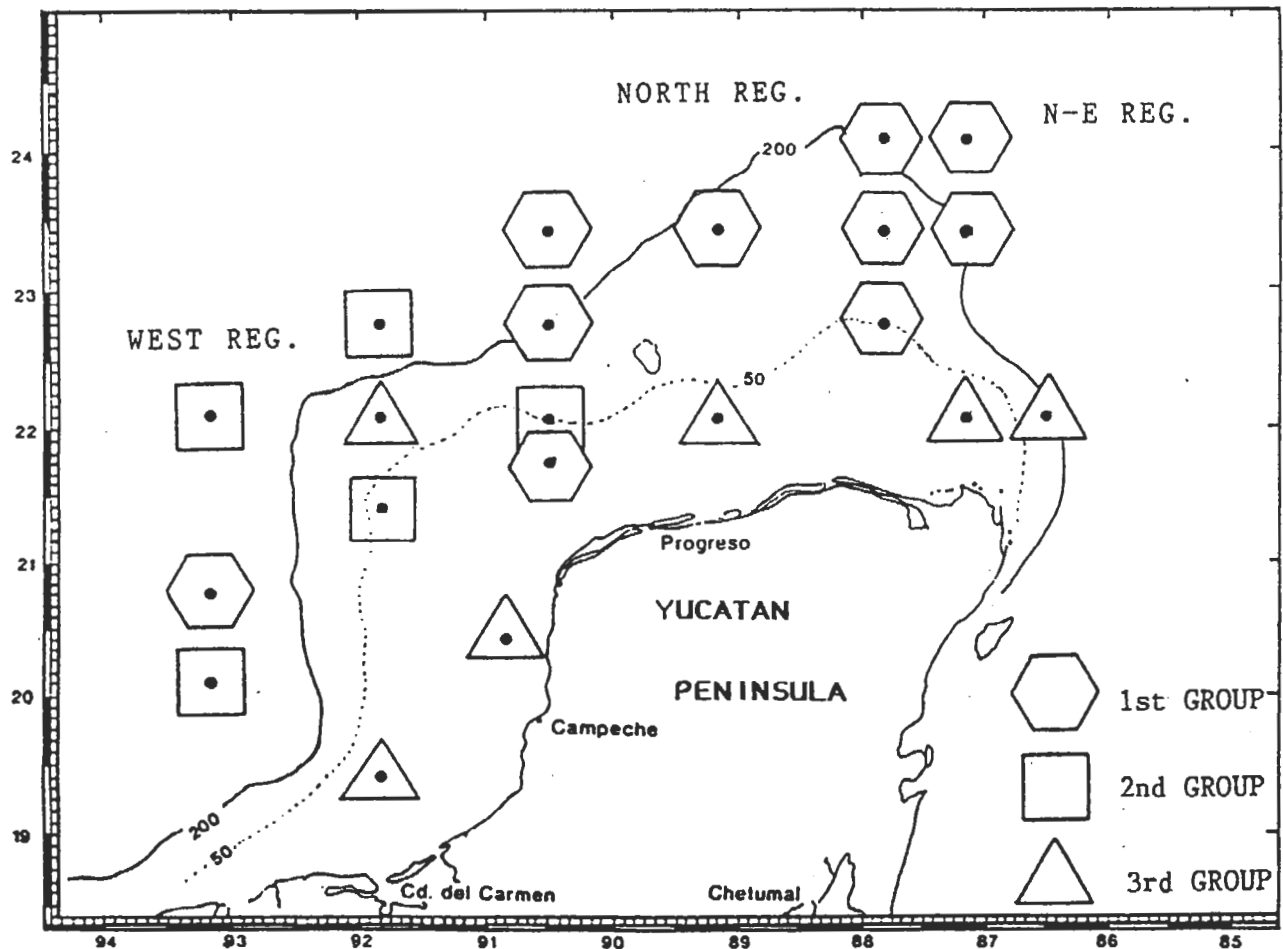
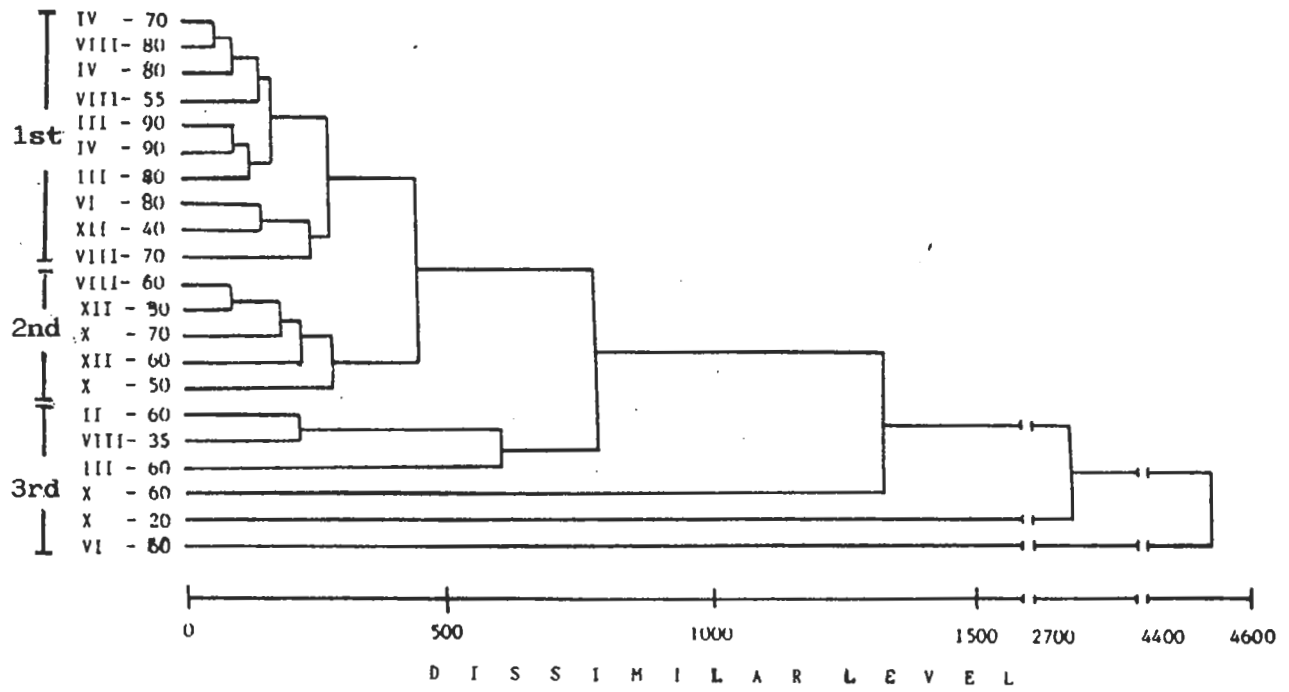


Figure 7. Classification and geographic location of station groups formed according to Euclidian distance. Yucatan Shelf, Mexico. May 1986.

in the northern part of the peninsula near the slope (200 m isobath) where salinity ranged from 36.3 to 36.4 ‰ and temperature was 25°C. These data agree with those reported by Owre (1960) in the strait of Florida, by Pierce and Wass (1962) for the Florida Current and by Michel and Foyo (1976) for the Caribbean Sea.

According to the distribution pattern for these species, three regions can be distinguished (Figure 6): 1) A shallow near-coastal region that surrounds the Peninsula in its northeastern and western side, where *Sagitta bipunctata* predominates. 2) An oceanic province located off the western side of the Peninsula, where *S. enflata* is the dominant species, and 3) An oceanic region located to the northeast of the Peninsula where specific diversity is higher and no particular species was found to be predominant.

This distribution pattern is confirmed, in general terms, by classification and ordination analysis. The Euclidian Distance analysis identified three different groups of species according to their spatial distribution (Figure 7). Those with higher similarity were found in the north and northeast sides of the Peninsula where temperature ranged from 25 to 27°C and salinity was 36.5‰. Here the abundance of chaetognaths was low, the specific richness was high and there was not a dominant species. This group included *Sagitta minima*, *S. serratodentata*, *S. enflata* and *S. bipunctata*. The samples in the second group were located in the northwest and west side of the Peninsula, with high temperature (25°C) and salinity (36.3-36.6‰). In these samples the abundance of chaetognaths was higher

and the predominant species was *S. enflata*. Finally, a third group is formed by two groups of samples showing high abundance: *S. bipunctata* was the dominant species along the shallow waters (<50 m) characterized by variable temperature (22-27°C) and salinity (36.4-37.0‰) values, whereas *S. enflata* was predominant at the west side of the shelf, with salinity of 36.4-36.6‰ and temperature of 25-26°C.

Finally, the groups of samples obtained from classification and ordination analysis coincided, in broad terms, with the three regions based on environmental features: (a) Northeast region, where temperature was high, salinity and abundance were low, and *Sagittaminima*, *S. serratodentata* and *S. bipunctata* predominated; (b) West region, where salinity, temperature and abundance were high and the most important species was *S. enflata*; and (c) North region, characterized by low values of salinity and temperature, high chaetognath abundance and *S. bipunctata* as the predominant species.

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