

CHAPTER II

Patterns of meiofauna (especially nematodes) in physical disturbed Ecuadorian sandy beaches

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ABSTRACT

Meiofauna was studied at two sandy beaches along the Ecuadorian coast between August 1999 and February 2001 (with seasonal intervals), a sheltered beach with high recreational use and an exposed beach with fishing activities. Meiofauna densities ranged between 376 and 2388 ind./10 cm². Despite the La Niña event, no clear seasonal trends could be detected in the meiofauna abundances. Nematodes represented between 22-81% of the total meiofauna at the sheltered beach and 76-95% at the exposed beach, followed by turbellarians and gastrotrichs. A total of 40 genera belonging to 19 families were identified. *Neochromadora*, *Daptonema*, *Metadesmolaimus* and *Omicronema* were the dominant genera at the sheltered beach, while *Metachromadora*, *Rhynchonema*, *Paracyatholaimus*, *Ceramonema* and *Gonionchus* were more dominant at the exposed site. Despite the different genus composition, the general genus diversity was similar in both sites. However, a clear difference was present in the feeding types. Non-selective deposit feeders were dominant (42%) followed by predators/omnivores (26%) and epistrate feeders (24%). Multivariate analysis demonstrated that the meiofauna and nematode communities remain different between the two beaches with regard to the temporal variation as well: so each beach, although only 28 km apart from each other, but clearly different in sediment texture, do have their own meiofauna and nematode composition.

KEY WORDS: Intertidal, composition, diversity, exposed beach, sheltered beach.

INTRODUCTION

Meiofauna plays an important role in pollution research. HEIP (1980) has discussed the possibility of nematodes as tools in monitoring the biological effects of pollution. Some nematode species are resistant to pollution and anaerobiosis, they are often the last metazoans to survive in grossly polluted sediments (VINCX AND HEIP, 1991). They range in reproductive potential from explosive opportunists to conservative survivalists and vary in sensitive to pollutants and environmental disturbance (BONGERS AND FERRIS, 1999). The present study was aimed to examine the effects of meiofauna (especially nematodes) community in two Ecuadorian sandy beaches, under different "disturbance" pressure, such as sediment types, human activities carried out in the surf zone (*i.e.* the penaeids shrimp post-larvae capture in San Pedro de Manglaralto, this was forbidden on 2002 onwards in our coast), by comparing the different seasonal and spatial patterns. The results provide the first data available from the Ecuadorian coast reporting on composition and density range of the meiofauna.

MATERIAL AND METHODS

The sites are located along the Ecuadorian coast in Santa Elena Peninsula (Figure 2.1). The area is characterized by two seasons¹: rainy (January-March) and dry (April-December). 'Salinas' (Chipe bay) is a sheltered beach, characterized by fine grain sand and extensively used by tourists. 'San Pedro de Manglaralto' is an exposed beach, situated in a fishing village; the sediment is composed of fine to medium grain sand.

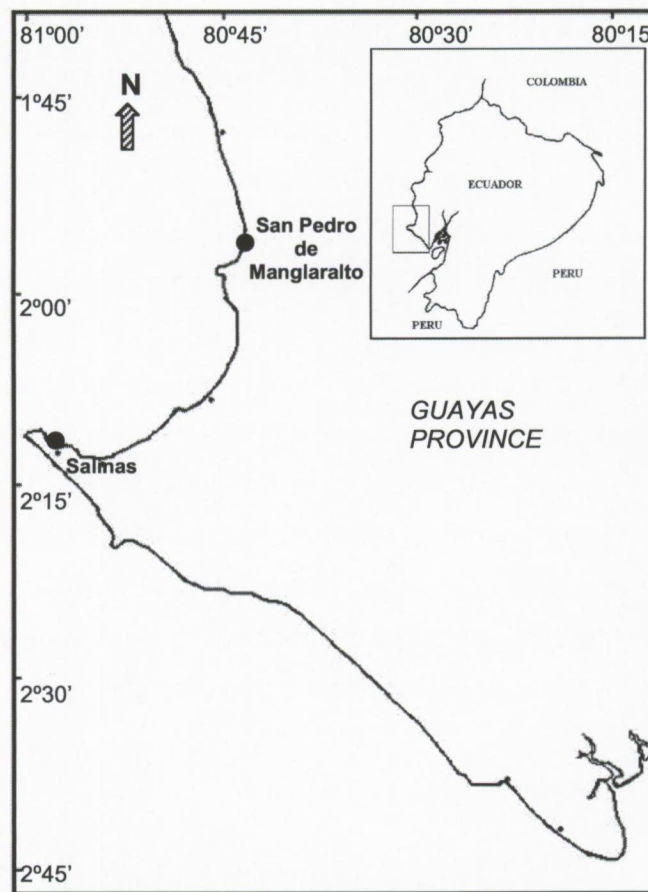


Figure 2.1 Study area.

¹ The dry and rainy season mentioned here corresponded to the data set of the environmental sampling campaigns of the present study.

The sampling was carried quarterly from August 1999 to February 2001 (presence of an anomalous period, “La Niña” cold phase after the 1997-1998 El Niño). Meiofauna samples were collected with cores (3.6 cm diameter), preserved with hot (60 °C) formaldehyde 4%, retained in a 38 µm sieve and extracted by centrifugation with Ludox HS 40 (density 1.18 g/cm³). Higher taxa were counted and sorted under a stereomicroscope and 200 nematodes were picked out in each replicate, prepared in glycerin solution and mounted on slides for further identification at the genus level (PLATT AND WARWICK, 1988). Nematode feeding types according to WIESER (1953): 1A, selective deposit feeders; 1B, non-selective deposit feeders; 2A, epistrate feeders and 2B, predators/omnivores were analyzed¹.

In situ salinity and temperature were measured using a refractometer and a mercury thermometer. Water samples were taken and passed through Whatman GF/C filters for the determination of chlorophyll *a* (*Chl a*) by acetone-methanol extraction², suspended particulate matter (SPM) was measured by weight difference (filters were dried at 60 °C/48h) and particulate organic matter (POM) by subsequently burning filters at 550 °C. Median grain size was analysed by Coulter LS and classified to the Wentworth scale (BUCHANAN, 1984).

Hill's diversity indices were calculated on nematode genera (HILL, 1973). Diversity profiles were visualized by *k*-dominance curves (LAMBSHEAD *et al.*, 1983). Classification was performed by Two Way Indicator Species Analysis (TWINSpan) and Principal Component Analysis (PCA) ordination (McCune AND MEFFORT, 1999), using the higher meiofauna taxa (%) and total nematode³ density (ind./10 cm²). Mann-Whitney U test was used to assess the significance of differences between samples sites (p<0.001-very highly significant, p<0.01-highly significant, p<0.05-significant).

¹ Samples were collected at low tide level and two replicates were used to the data analysis.

² The chlorophyll *a* was measured by spectrophotometer (PARSONS *et al.*, 1984).

³ Genus composition.

RESULTS

Environmental factors

Temperature ranged between 22° and 29 °C. Salinity varied from 34 to 36 PSU. The median grain size ranged between 184-224 μm in Salinas, corresponding to fine sand while in San Pedro de Manglaralto it ranged between 201 and 260 μm (fine to medium sand). The *Chl a* values increased in the rainy season, the concentrations ranged from 0.11 to 3.74 mg/l. SPM concentrations varied from 10.1 to 290.15 mg/l at Salinas and 218.7-1392.4 mg/l at San Pedro de Manglaralto, while POM varied from 3.2 to 53.5 mg/l at Salinas and between 20 and 78.3 mg/l at San Pedro de Manglaralto.

Meiofauna community

Total meiofauna density ranged from 461 ± 101.5 to 1848 ± 7 ind./10 cm^2 at Salinas (sheltered beach) and from 376 ± 21.5 to 2388 ± 161.5 ind./10 cm^2 at San Pedro de Manglaralto (exposed beach). An opposite trend was observed between both stations regarding the temporal variability; at San Pedro de Manglaralto the maximum densities were registered in August 1999 and followed by a subsequent decline until November 2000, while at Salinas, a progressive increase was observed until May 2000, followed by a decline and to increase in February 2001 (Figure 2.2a). However, no significant differences were observed. Nematodes dominated at San Pedro de Manglaralto (76-95%), while in Salinas nematodes represented between 22 and 81% of the total meiofauna density. The temporal variation (Figure 2.2b) was characterized by lower densities (374 ± 61.5 ind./10 cm^2) during dry season at Salinas, while at San Pedro de Manglaralto they were highest (2273 ± 125.5 ind./10 cm^2). Turbellarians represented between 7 and 76% of the total meiofauna density at Salinas and 0.3-13% at San Pedro de Manglaralto. The maximum densities were registered in May 2000 and February 2001, corresponding to warm periods (Figure 2.2c). Gastrotrichs were the third most important taxon, accounting for 6 to 11% of the total meiofauna density (Figure 2d). Other meiofauna groups included rotifers (0.34-1.12%), copepods (0.23-0.32 %), ostracods (0.30%) and polychaetes (0.06-0.24%), while tardigrades, isopods, cnidarians (registered in San Pedro de Manglaralto) and bivalves (registered in San

Pedro de Manglaralto) represented less than 0.05% of the total meiofauna. Spearman rank correlation confirmed the positive relationship between harpacticoids, polychaetes ($p < 0.05$) and rotifers ($p < 0.001$) with median grain size and negative relationship for turbellarians ($p > 0.001$) and isopods ($p < 0.01$).

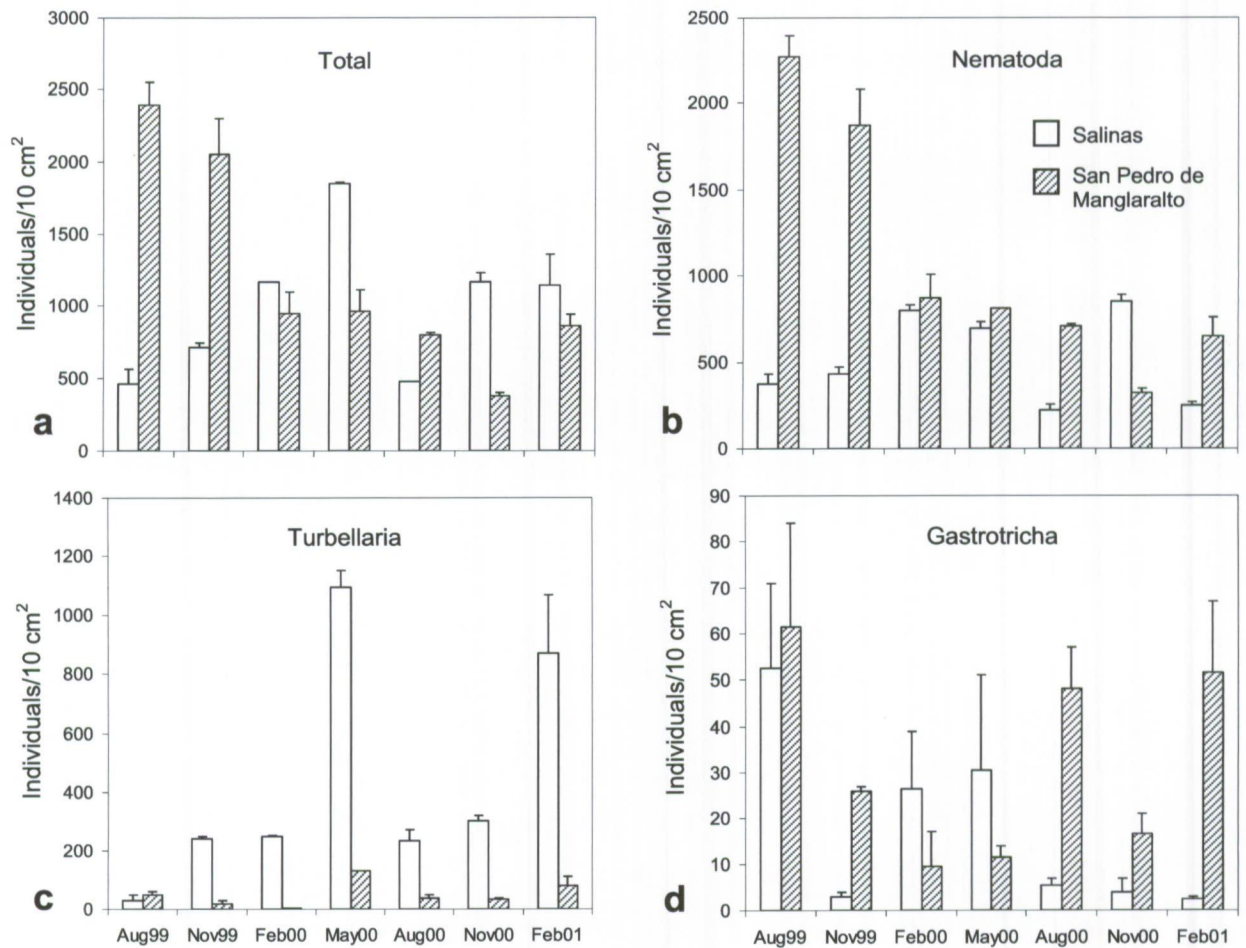


Figure 2.2 Mean density (a) total, (b) nematodes, (c) turbellarians and (d) gastrotrichs from August 1999 until February 2001; mean values and standard error of the mean ($\text{bar} \pm \text{SE}$).

Twinspan showed the separation of meiofauna samples for Salinas and San Pedro de Manglaralto beaches. PCA distinguished the temporal variation of meiofauna into seasonal groups (Figure 2.3). At Salinas: Group 1 (August 1999) influenced by "La Niña" event; Group 2 (November 1999-February 2000 and August-November 2000), characterized by the most tourist month (February) and Group 3 (May 2000, February 2001) where the highest turbellarians density was observed. At San Pedro de Manglaralto two groups were detected, corresponding to the chronological sampling done (August 1999-February 2000 and May 2000-February 2001).

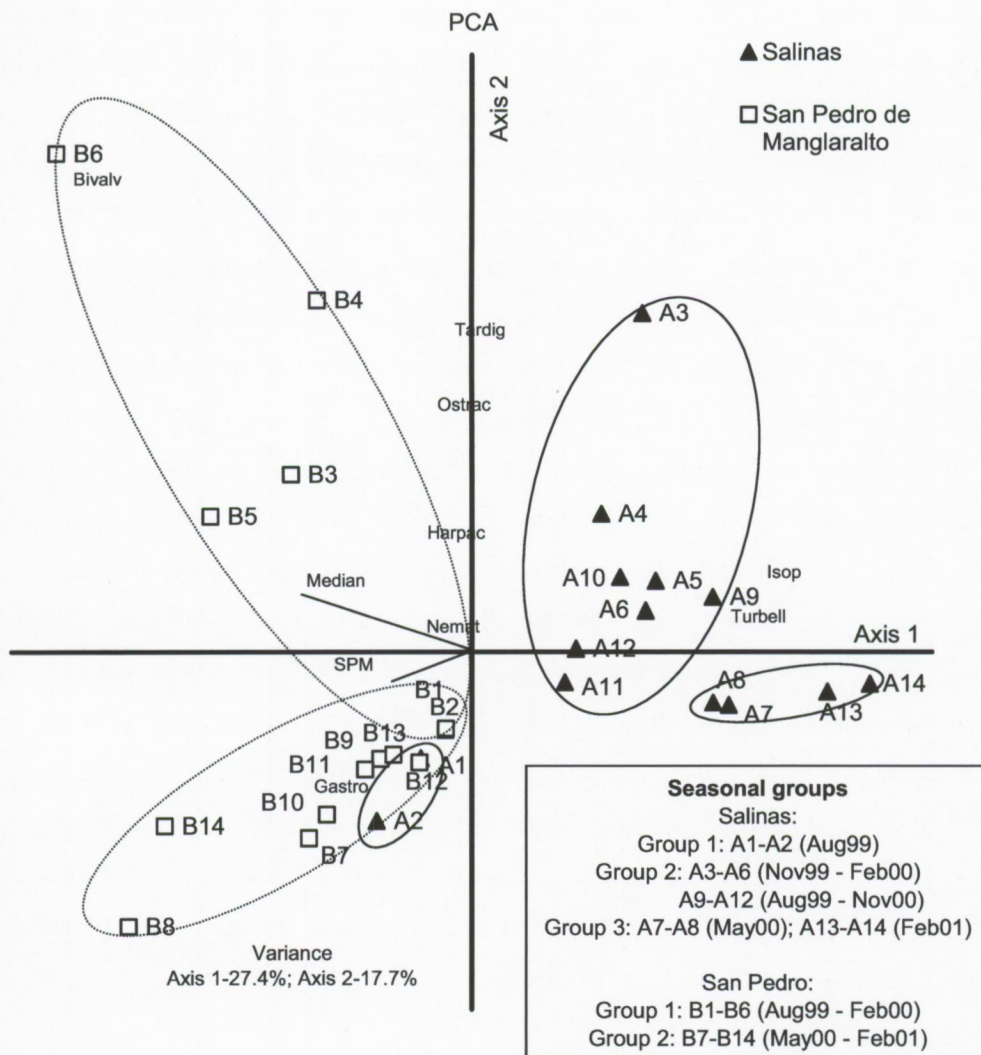


Figure 2.3 Principal Component Ordination of Salinas (▲) and San Pedro de Manglaralto (◻). Nemat= Nematoda, Turbell= Turbellaria, Gastro= Gastrotricha, Harpac= Harpacticoida, Ostrac= Ostracoda, Tardig= Tardigrada, Isop= Isopoda and Bivalv= Bivalvia.

Nematode community

A total of 40 genera belonging to 19 families were identified (See Table 2.1). At Salinas Xyalidae (with the genera *Rhynchonema*, *Daptonema*, *Metadesmolaimus*, *Omicronema*, *Paramonohystera* and *Pseudosteineria*) represented 49% of the nematode community, followed by Chromadoridae (genera: *Dichromadora* and *Neochromadora*) represented 21% and Desmodoridae (17%), while at San Pedro de Manglaralto Xyalidae represented 44%, Desmodoridae (22%) and Cyatholaimidae (13%).

Neochromadora represented 20% of the total nematode density at Salinas and ranged between 3 ± 0.6 (August 2000) and 319 ± 68.3 (November 2000) ind./10 cm². The densities increased from August 1999 until May 2000, after a steep density decline was registered in August 2000 and February 2001; indicating that higher nematode densities were observed during the transitional months (from dry to rainy season or vice versa). At San Pedro de Manglaralto low densities were registered along the sampling period (Figure 2.4a). *Daptonema* represented 19 % at Salinas (from 33 ± 2.1 to 238 ± 11.5 ind./10 cm²) and 10% at San Pedro de Manglaralto (from 8 ± 5.7 to 388 ± 4.2 ind./10 cm²). The temporal patterns showed similar trends during February-August 2000 at both sites (Figure 2.4b). *Metachromadora* represented 17% at Salinas and 22% at San Pedro de Manglaralto. The densities peaked in February 2000 at Salinas (335 ± 70.9 ind./10 cm²) and in November 1999 (649 ± 10.4 ind./10 cm²) at San Pedro. The temporal variation to the subsequent period showed similar fluctuations at both sites (Figure 2.4c). *Metadesmolaimus* ranged between 10 ± 6.1 and 220 ± 68.4 ind./10 cm² (Figure 2.4d). *Rhynchonema* was the second dominant genus at San Pedro de Manglaralto ranging from 32 ± 1.2 to 509 ± 179.9 ind./10 cm², represented 17% of the total density (Figure 2.4e). *Paracyatholaimus* registered the highest density at San Pedro de Manglaralto (410 ± 53.6 ind./10 cm²) (Figure 2.4f). *Ceramonema* represented 11.6% of the total nematode density at San Pedro, while at Salinas scarce individuals were found. The temporal pattern differed along the sampling period with the maximum density in February 2001 (Figure 2.4g).

Family	Genera	Salinas			San Pedro de Manglaralto		
		Mean	Min - Max	%	Mean	Min - Max	%
Thoracostomopsidae	<i>Enoplolaimus</i>	4,1	0 - 13	0,80	1,8	0 - 5	0,16
Anoplostomatidae	<i>Anoplostoma</i>	0,1	0 - 1	0,03			
Anticomidae	<i>Anticoma</i>				1,0	0 - 5	0,10
	<i>Odontanticoma</i>	1,9	0 - 6	0,36	37,5	11 - 65	3,50
Oxystominidae	<i>Halalaimus</i>	1,0	0 - 3	0,19	1,4	0 - 5	0,13
	<i>Nemanema</i>				0,3	0 - 2	0,03
Oncholaimidae	<i>Metoncholaimus</i>	0,2	0 - 2	0,05			
	<i>Oncholaimellus</i>	2,7	0 - 12	0,52			
	<i>Oncholaimus</i>	0,1	0 - 1	0,02			
	<i>Viscosia</i>	26,3	4 - 56	5,08	8,4	2 - 24	0,78
Enchelidiidae	<i>Ditlevsenella</i>				0,4	0 - 3	0,04
	<i>Eurystomina</i>				0,6	0 - 5	0,06
	<i>Pareurystomina</i>				0,1	0 - 1	0,01
	<i>Bathylaimus</i>				16,5	0 - 57	1,54
Chromadoridae	<i>Dichromadora</i>	5,6	0 - 23	1,07	3,2	0 - 18	0,30
	<i>Neochromadora</i>	103,7	3 - 319	20,05	10,1	0 - 63	0,95
Comesomatidae	<i>Sabatieria</i>	5,1	0 - 21	1,00			
Cyatholaimidae	<i>Paracyatholaimus</i>	5,0	0 - 32	0,97	127,3	13 - 410	11,88
	<i>Pomponema</i>	0,5	0 - 4	0,10	7,3	0 - 16	0,68
Selachinematidae	<i>Synonchiella</i>	0,2	0 - 1	0,04			
Desmodoridae	<i>Metachromadora</i>	87,1	2 - 335	16,83	233,3	44 - 649	21,77
	<i>Spirinia</i>	0,1	0 - 1	0,02			
Microilaimidae	<i>Microilaimus</i>				9,9	0 - 28	0,93
Leptolaimidae	<i>Camacolaimus</i>	0,3	0 - 2	0,07	0,3	0 - 2	0,02
	<i>Leptolaimus</i>				0,2	0 - 1	0,02
Ceramonematidae	<i>Ceramonema</i>	0,8	0 - 2	0,16	124,4	55 - 209	11,61
Xyalidae	<i>Cobbia</i>				0,2	0 - 1	0,02
	<i>Daptonema</i>	99,8	33 - 238	19,29	109,3	8 - 388	10,20
	<i>Gonionchus</i>				81,9	12 - 195	7,64
	<i>Metadesmolaimus</i>	62,7	10 - 204	12,12	69,9	12 - 220	6,53
	<i>Omicronema</i>	35,6	9 - 91	6,89	25,0	1 - 56	2,34
	<i>Paramonohystera</i>	28,9	0 - 126	5,58	1,9	0 - 7	0,18
	<i>Pseudosteineria</i>	2,2	0 - 14	0,42			
	<i>Rhynchonema</i>	26,3	2 - 40	5,08	180,6	32 - 509	16,85
	<i>Sphaerolaimus</i>	0,1	0 - 1	0,03			
	<i>Eumorpholaimus</i>	1,6	0 - 10	0,31			
Linhomoeidae	<i>Paralinhomoeus</i>	0,2	0 - 1	0,03			
	<i>Axonolaimus</i>				0,5	0 - 4	0,05
Axonolaimidae	<i>Odontophora</i>	0,1	0 - 1	0,03			
	<i>Parodontophora</i>	14,9	5 - 48	2,89	18,1	0 - 55	1,69

Table 2.1 Nematode genera density (ind./10 cm²) at Salinas and San Pedro.

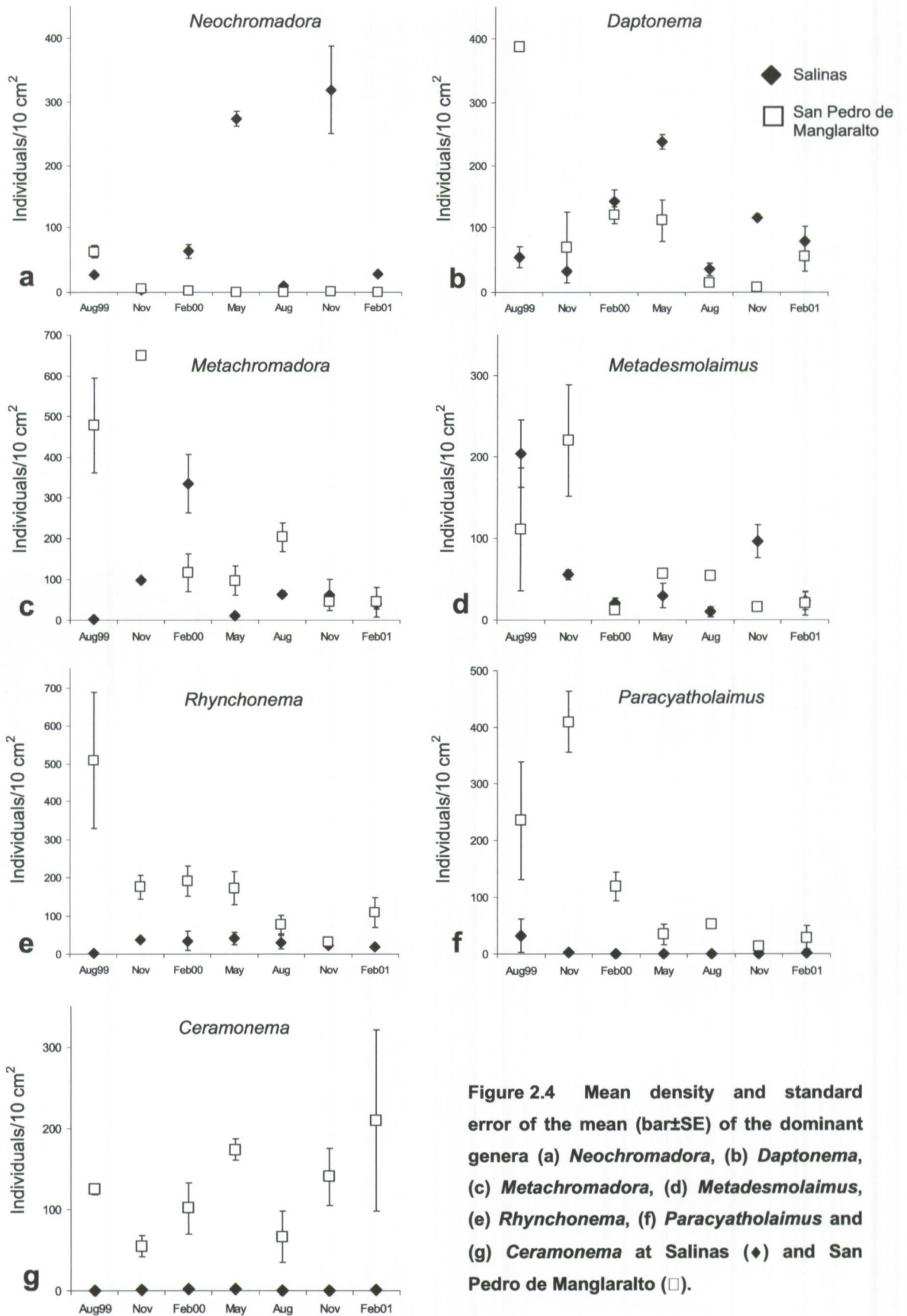


Figure 2.4 Mean density and standard error of the mean (bar \pm SE) of the dominant genera (a) *Neochromadora*, (b) *Daptonema*, (c) *Metachromadora*, (d) *Metadesmolaimus*, (e) *Rhynchonema*, (f) *Paracyatholaimus* and (g) *Ceramonema* at Salinas (♦) and San Pedro de Manglaralto (□).

The diversity was similar at both beaches: lowest in August 1999 and highest in the rainy season (Table 2.2)¹. The *k*-dominance curves (Figure 2.5) also showed similar patterns.

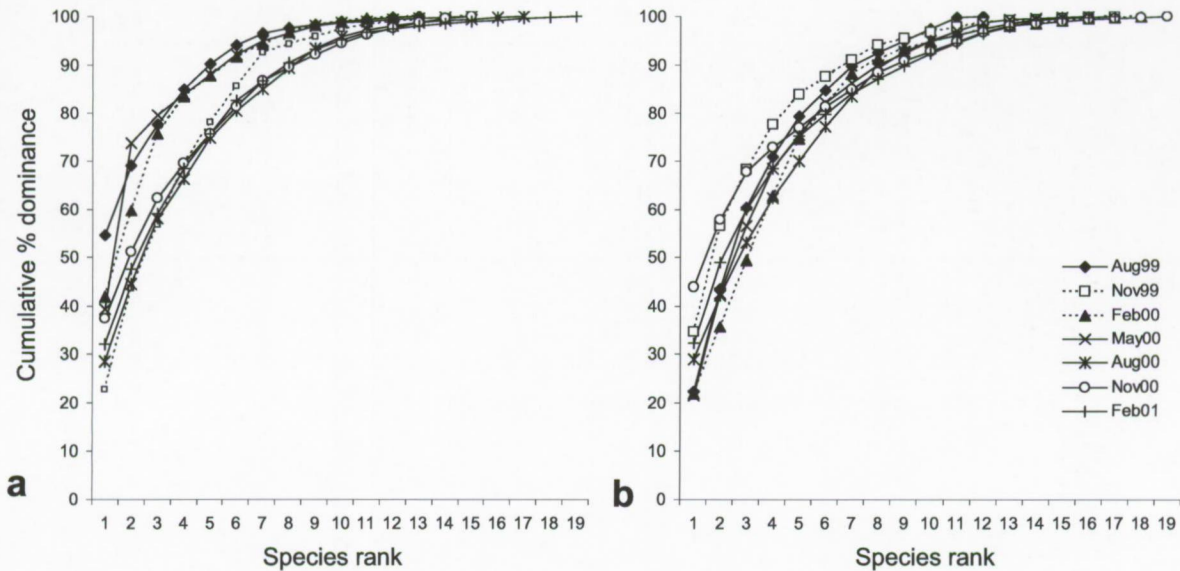


Figure 2.5 *K*-dominance curves of nematode assemblages for Salinas (a) and San Pedro de Manglaralto (b) beaches.

Non-selective deposit feeders predominated: at Salinas represented 51% (*Daptonema*, *Metadesmolaimus* and *Omicronema* contributed with 38%), while at San Pedro de Manglaralto represented 38% (*Rhynchonema* and *Daptonema* contributed with 27%). At Salinas predators/omnivores represented 26% of the trophic structure, followed by epistrate feeders (23%), while the selective deposit feeders were less abundant. At San Pedro de Manglaralto epistrate feeders and predator/omnivores represented 25.2 and 25.1% respectively, followed by selective deposit feeders (12%) where *Ceramonema* contributed with 11.7% (Figure 2.6). PCA results of the Nematoda genera densities showed that the samples formed two groups² (like meiofauna community) but not displayed any seasonal trend.

¹ See Annex 2.1 in this article (page 39).

² See Annex 2.2 in this article (page 40).

Salinas beach	Aug99	Nov99	Feb00	May00	Aug00	Nov00	Feb01
N_0	13	15	13	15	17	15	19
N_1	4.74	8.30	5.86	5.15	9.06	8.10	8.79
N_2	2.97	6.75	4.10	3.54	6.73	5.28	6.13
N_{inf}	1.83	4.40	2.38	2.54	3.52	2.67	3.13
H'	1.56	2.12	1.77	1.64	2.20	2.09	2.17

San Pedro beach	Aug99	Nov99	Feb00	May00	Aug00	Nov00	Feb01
N_0	12	17	18	16	16	19	17
N_1	8.17	7.19	9.63	9.15	9.50	7.48	9.00
N_2	6.70	5.04	7.74	7.20	7.05	4.30	6.13
N_{inf}	4.47	2.89	4.54	4.67	3.47	2.28	3.10
H'	2.10	1.97	2.26	2.21	2.25	2.01	2.20

Table 2.2 Diversity indices (Hill's numbers N_0 , N_1 , N_2 , N_{inf} and Shannon-Wiener index H') of the nematode community at Ecuadorian sandy beaches.

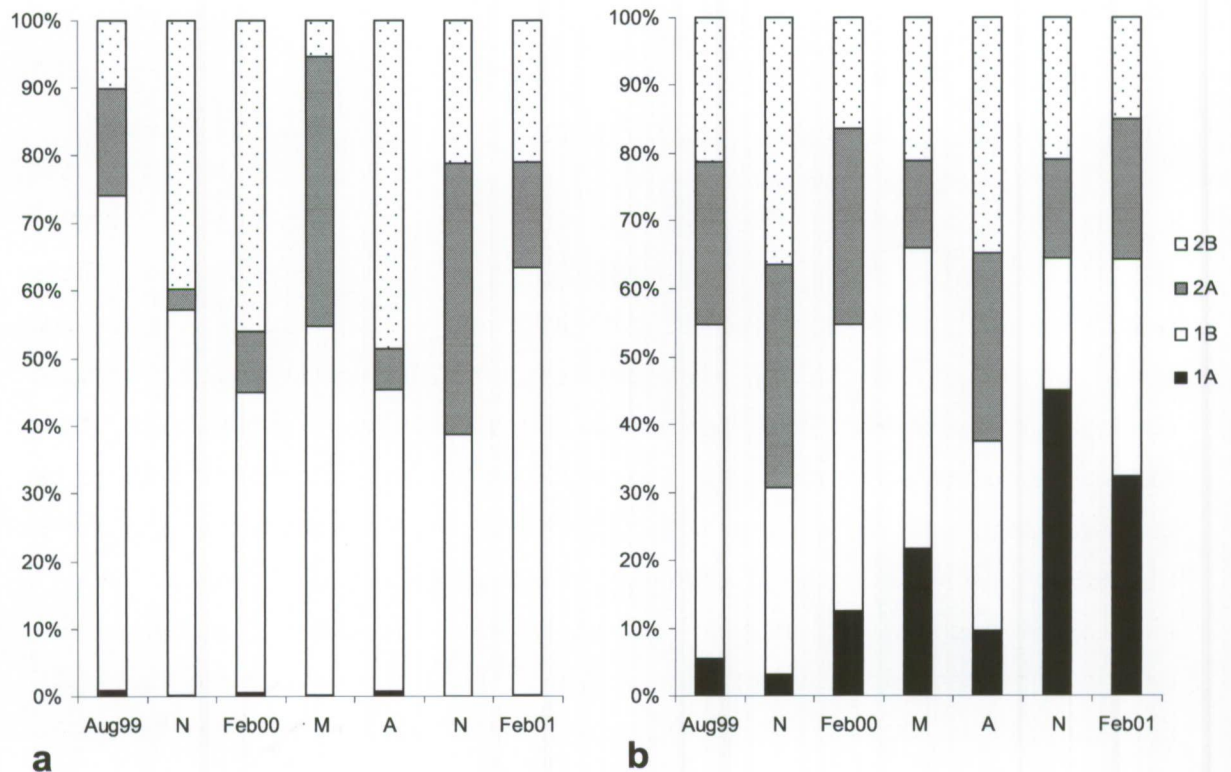


Figure 2.6 Nematode feeding types at Salinas (a) and San Pedro de Manglaralto (b). 1A= selective deposit feeders, 1B= non-selective deposit feeders, 2A= epistrate feeders and 2B= predators/omnivores.

DISCUSSION

The first sampling took place during strong La Niña phase of the El Niño South Oscillation (ENSO) cycle. There is some evidence that ENSO has a substantial influence on meiofauna of sandy beaches (NEIRA *et al.*, 2001). During the anomalous conditions several of the most abundant genera collected, such as *Neochromadora*, *Daptonema* and *Rhynchonema* registered highest densities, especially in San Pedro de Manglaralto; while at Salinas this period attained lowest densities.

The hydrodynamics of each area could influence the infaunal densities by producing differential responses of nematode assemblages to physical disturbance and organic enrichment. In relation to the wave exposure rate, pioneer studies (e.g. MCLACHLAN *et al.*, 1981) suggested that meiofauna in sandy beaches is not negatively affected by the increases in exposure rate and coarser sediments.

The meiofauna composition in the Ecuadorian sandy beaches could be in accordance with the beach characteristics, where the highest meiofauna densities were registered in the exposed beach and the lowest at the sheltered beach. In the Caribbean beaches the nematode generic composition was highly variable at the more wave-exposed locations, but less so at the more sheltered locations (GOURBAULT *et al.*, 1998).

SCHRATZBERGER AND WARWICK (1999) reported that in treatments of physical and biological disturbance, the nematodes show most extreme changes as a result of organic enrichment. In our study the turbellarians were more abundant in Salinas (waste water is deposited directly into the bay) during warm months, turbellarians have been demonstrated being very common in wave-protected areas with little mixing of the sediments (CANNON AND FAUBEL, 1988). On the other hand the organic enrichment caused by intensive fish farming in coastal sediments showed evident changes on meiofaunal densities, which were 50% lower than in a non disturbed site (MAZZOLA *et al.*, 2000).

Non-selective deposit feeders (1B) such as Xyalidae are normally associated with exposed beaches (NICHOLAS AND HODDA, 1999), while the predator/omnivores (2B) such as Oncholaimidae are more associated with water-movement disturbance (NETTO *et al.*, 1999). The dominance of 1B species is associated with lower maturity indexes, which mean the disturbance on nematode fauna (BONGERS *et al.*, 1991). In this study we observed a dominance of Xyalidae, Chromadoridae and Desmodoridae at Salinas (with fine sand), while that Xyalidae, Desmodoridae and Cyatholaimidae dominated at

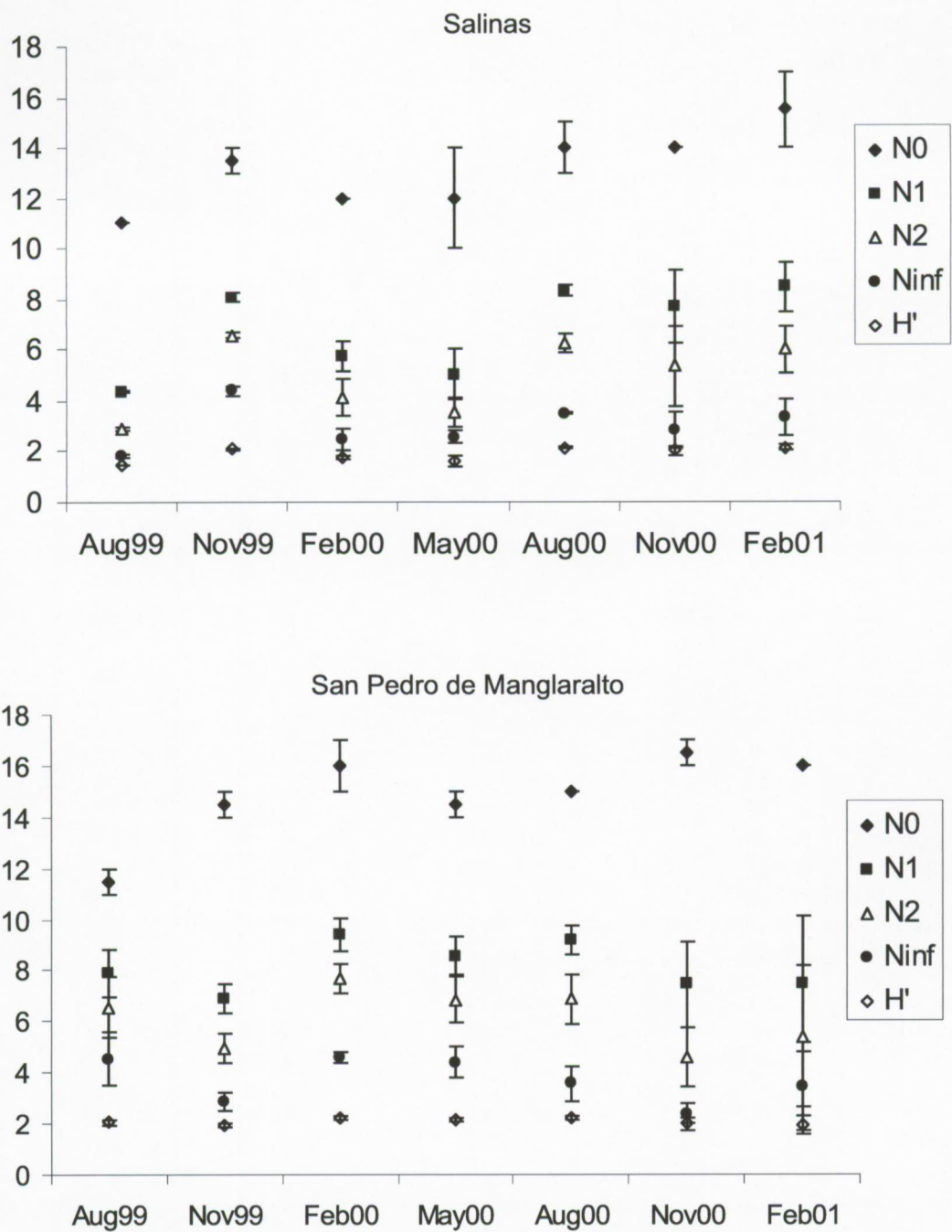
San Pedro de Manglaralto (with fine-medium sand). The proportion of non-selective deposit feeders ranged from 51% (Salinas) to 38% (San Pedro de Manglaralto).

The spatial and seasonal patterns of meiobenthos in the two Ecuadorian sandy beaches showed differences in terms of composition and density but not in diversity. At the higher taxon level, turbellarians were significantly more abundant in the sheltered area compared to the exposed site.

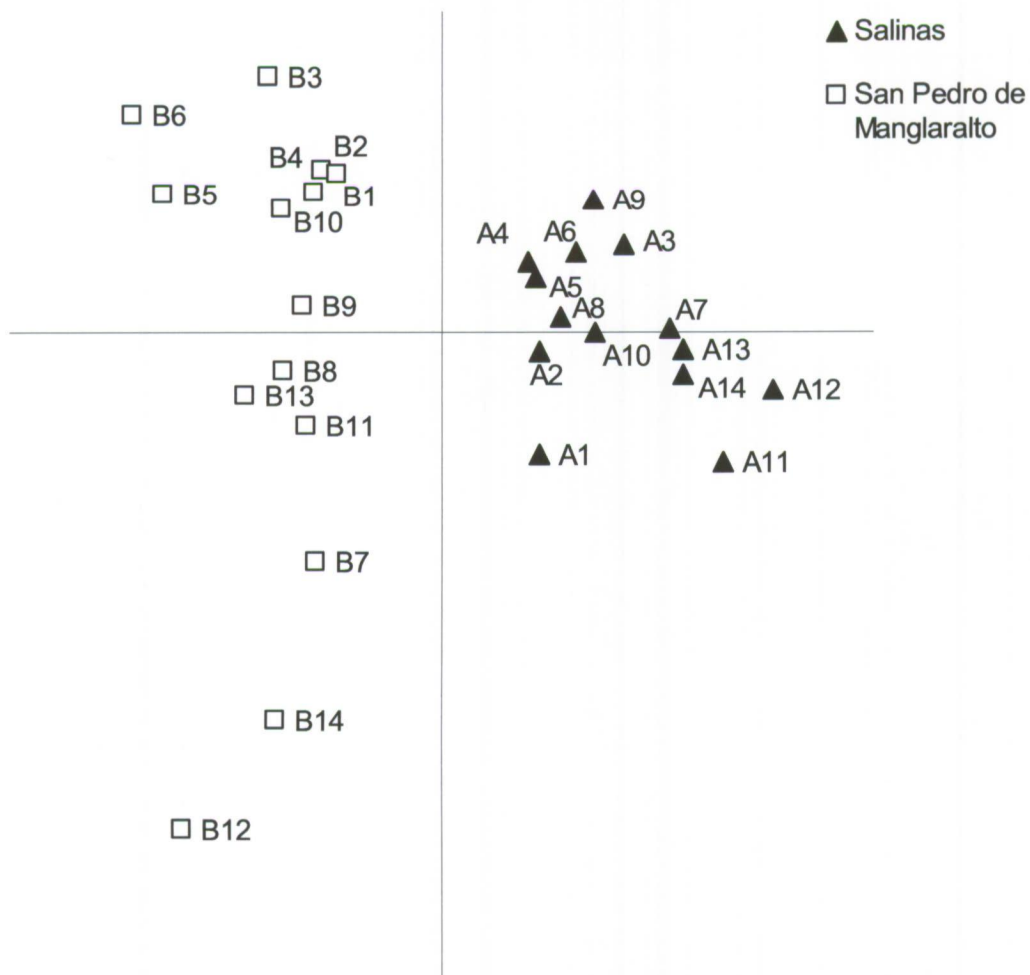
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ANNEX TO THE ARTICLE



Annex 2.1 Mean and standard error of Hill's numbers (N_0 , N_1 , N_2 and N_{inf}) and Shannon-Wiener (H') diversity at Salinas and San Pedro de Manglaralto beaches.



Annex 2.2 Principal Component Ordination of Salinas (▲) and San Pedro de Manglaralto (□) based on Nematoda genera densities.