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Effects of fresh water afflux on polychaetous annelids (Annelida Polychaeta) of the hard bottoms in San Giovanni Li Cuti (Catania, Sicily)

Effets de l'afflux d'eaux pluviales sur les peuplements infralittoraux d'annélides polychètes (Annelida Polychaeta) à San Giovanni Li Cuti (Catane, Sicile)

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ABSTRACT

Mòllica E., 1998 - Effects of fresh water afflux on polychaetous annelids (Annelida Polychaeta) of the hard bottoms in San Giovanni Li Cuti (Catania, Sicily). Mar. Life, ***8*** *(1-2): 11-17.*

The author studied the polychaetes population in a coastal zone of the eastern Sicily (San Giovanni Li Cuti) almost exempt from contamination by urban and industrial pollutants but exposed to significant seasonal variations in salinity due to the afflux of fresh rainwater, with the aim to verify the effects of the drop in salinity on the polychaetes population independently of pollution. Sampling was performed in 23 stations at different depth and distances from the coast, during two different seasons (spring and autumn). The results, compared with those obtained in a previous study performed in an area of similar assemblage, showed that polychaetes react promptly to variations in salinity, that the number of species and individuals is inversely related to the salinity, but also that when salinity decreases some less resistant species migrate towards areas of higher salinity.

RÉSUMÉ

Mòllica E., 1998 - [Effets de l'afflux d'eaux pluviales sur les peuplements infralittoraux d'annélides polychètes (Annelida Polychaeta) à San Giovanni Li Cuti (Catane, Sicile)]. Mar. Life, ***8*** *(1-2) : 11-17.*

L'auteur a étudié les polychètes d'une zone marine côtière de la Sicile orientale (San Giovanni Li Cuti) presque exempte de contamination par les polluants urbains ou industriels mais exposée à une dilution saisonnière importante par l'action des eaux pluviales. Le but était de vérifier l'effet de la chute de salinité sur le peuplement de polychètes en dehors de l'influence de pollution. La récolte des échantillons a été effectuée en 23 stations à différentes profondeurs et distances de la côte, pendant deux saisons (printemps et automne). Les résultats de l'étude, comparés à ceux observés au cours d'une recherche précédente conduite dans une zone de biocénose comparable, démontrent que les polychètes réagissent promptement aux variations de salinité, que le nombre d'espèces et d'exemplaires recueillis est en relation inverse avec la salinité, mais aussi que, lorsque la salinité décroît, quelques espèces moins résistantes émigrent vers des eaux à salinité plus élevée.

INTRODUCTION

Flushing of fresh water into the sea produces significant changes in the benthos, mainly through a drop in salt concentration, and is probably the most important cause of modifications in benthic populations. According to Wolff (1983), benthos exposed to salinity variations undergoes polymorphism and reduction in size, and shows impaired capacity of ionoosmotic regulation.

Many studies have shown peculiarities in population and species distribution as a consequence of variations in salt concentration. These studies however have always been performed on waters of estuaries, river mouths or lagoons (Fauvel, 1938; Cognetti, 1959; Castelli, 1982; Castelli *et al.*, 1982; Wolff, 1983; Curini-Galletti *et al.*, 1985; Gravina, 1985; Gillet, 1986; Lardicci, 1991; Lardicci *et al.*, 1993), i.e. in sites usually contaminated by pollutants which are more likely the real cause of the recorded variations.

In contrast, the focus of the present study is on the seawaters of a coastal area receiving only the unused portion of the groundwater and the rainwater

that are not polluted or scarcely polluted, because they come exclusively from extraurban rural areas; the urban rainfall being canalized in a separate gutter discharging some kilometres away. In areas such as the ones selected for this study the influx of fresh waters, which are colder and hypoosmotic compared to the sea into which they are discharged, produces a drop in temperature and salinity, and therefore these two changes probably represent the only factors responsible for the effects observed in the benthic population.

MATERIALS AND METHODS

San Giovanni Li Cuti is a small fishing village in the middle of the eastern coast of Sicily, now included in the municipality of Catania town. Its environment exhibits some peculiarities that make it ideal for this study. It is a coastal bay of about 30,000 m^2, far from river outfalls and urban waste and only exposed to significant phreatic manifestations. The bottoms of the bay are mainly constituted by the characteristic ancient lavas of the volcano Etna. Twenty three sampling stations situated on rocky bottoms at regular intervals along transects orthogonal to the coast and at depths of -1, -3, and -6 meters were selected. Two additional sampling stations were inside the small harbour, near the fresh water springs (figure 1). Seven transects (numbered 1 to 7 starting from the North) were traced along the bay. The first transect is located at the entrance of the harbour, where the fresh waters pass from the harbour to the sea. The second transect begins near a fresh water spring; the remaining five transects, and particularly the fourth, fifth and sixth, are only occasionally reached by influxes, i.e. when, after heavy rainfall, the rainwater overflows the gutters, percolates through the subsoil and reaches the sea just in these areas. This phenomenon only occurs occasionally, but when it does, it has a strong impact on salinity.

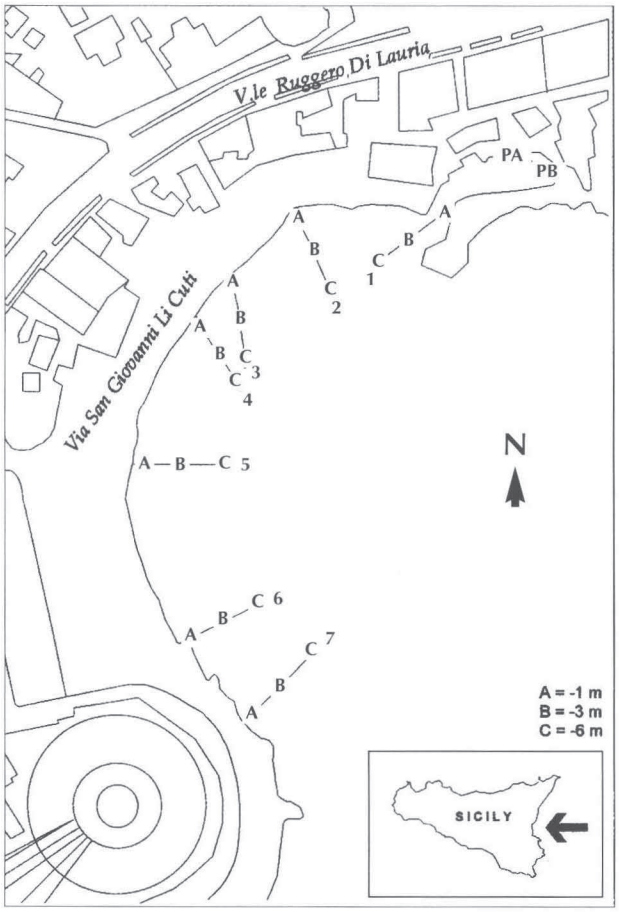

Figure 1 - Localisation of sampling stations in San Giovanni Li Cuti (1:7000). / *Situation des zones de prélèvement à San Giovanni Li Cuti (1:7000).*

The samples were collected during 1992 by scraping standard surfaces of 20x20 cm, according to Bellan-Santini (1970). Two samples were collected from each station, at intervals of six months: one in autumn and another in spring, in order to compare two periods with different regimes of precipitation and two different moments in the life cycle of the benthic population. At each sampling site, surface and bottom values of pH, salinity, redox potential, temperature, dissolved oxygen, and conductivity were also recorded using a multisensor monitoring probe.

All the parameters studied, and particularly salinity, showed a wide variability, so that it was impossible to identify a prevalent condition of the area under study. A series of 4 maps of salinity (bottom values), corresponding to four different phases of the survey (figures 2a to 2d), show highly variable salinity, in apparent relation with the rainfall patterns of the zone. From these maps, it can be observed that the mean salinity of the sea in the area is far below the "normal" salinity of the sea along the Ionic coast of Sicily, which is about 38. This salinity value was only observed in a few stations, and rarely near the coastline. It is particularly important to note that in some stations the salinity varied within a few days from less than 6 to 37.7. This extreme variability strongly supports the role of rainfall in salinity variation patterns.

The values for temperature (varying from 14 to 18°C), as well as those of pH (from 7.93 to 8.20), were within the normal range for the Mediterranean Sea. Conductivity, which is directly related to salinity, varied between 8.121 and 48.700 mMHOS. Disolved oxygen percentage was always within the normal values outside the harbour, and ranged from 4.2 to 5.4 $mlO_2.l^{-1}$ inside, due to the calmness of the harbour waters. Redox potential was between 0.87 and 1.06 volts in the bay, and between 0.34 and 0.71 in the port.

In order to obtain more information, available regional data banks were consulted. Data were recorded by the Department of Ecology, Division of Chemical Services, of the Catania municipality. This office, responsible for monitoring the quality of the sea in bathing establishments, records every two

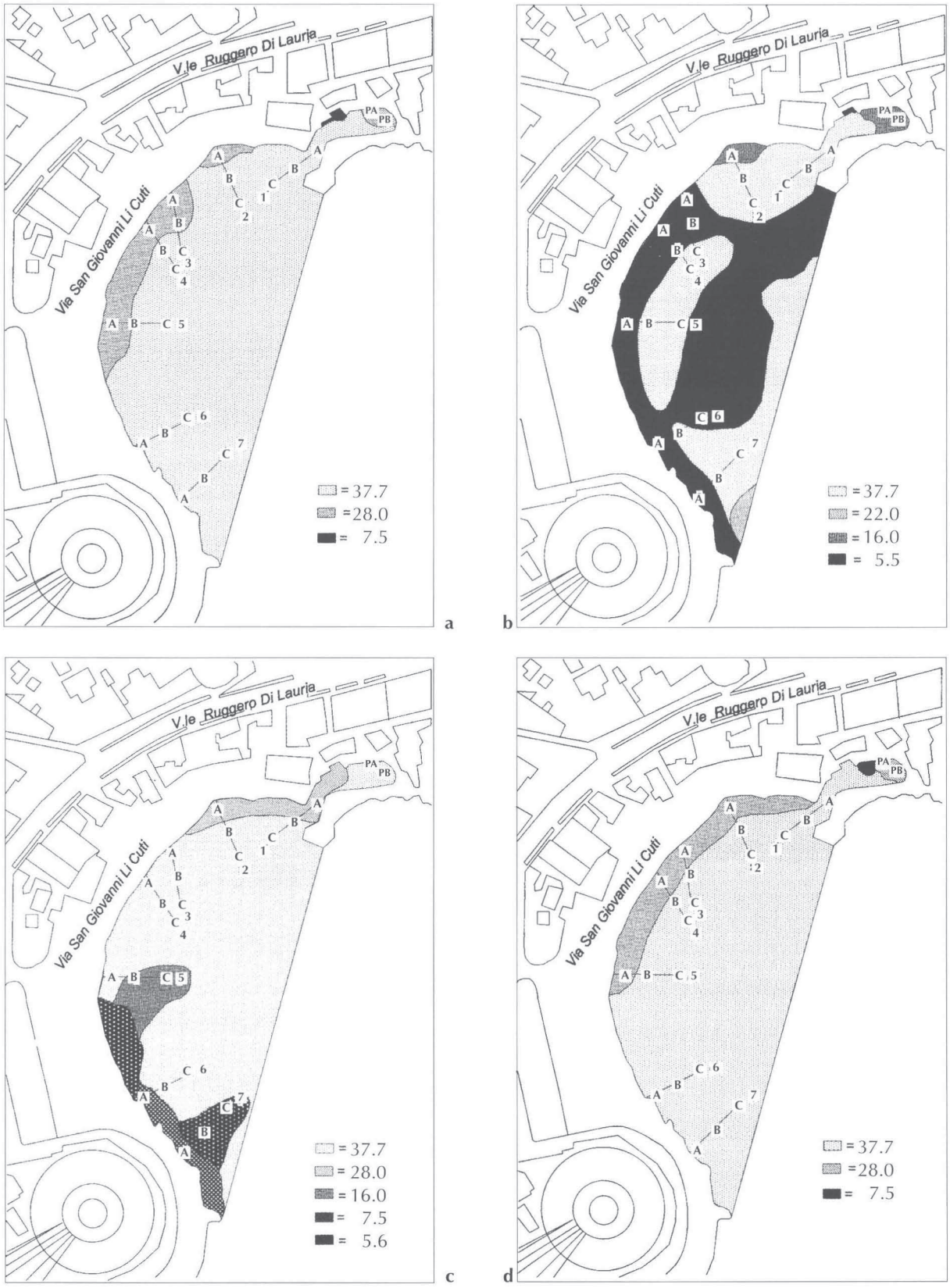

Figure 2 - Bottom salinity of San Giovanni Li Cuti Bay (1:7000). (a): 02/02/1992; (b): 04/02/1992; (c): 19/11/1992; (d): 26/11/1992. / *Salinité dans la baie de San Giovanni Li Cuti (1:7000). (a) : 02/02/1992 ; (b) : 04/02/1992 ; (c) : 19/11/1992 ; (d) : 26/11/1992.*

weeks, throughout the bathing season (June-September), the subsurface values for temperature, pH, D.O., surface-active agents, phenols, conductivity, dissolved oxygen percentage, faecal and total coliforms and streptococci. During the whole of 1992 all this parameters were within the normal range in the bay, and during 1993 there was a discrete presence of coliforms in two samples only; so on the whole the waters of this bay may be considered as chemically and biologically unpolluted.

In order to look for correlation between precipitation and water salinity the data collected by the ISTAT (the Italian Institute of Statistics) concerning the meteorological events from 1982 to 1993, were also consulted. The data are summarized in a table, and show that during the sampling period the frequency and amount of precipitation were within the normal range both for the season and the area (table I).

The peculiarities of the benthic populations were defined by applying the statistical formulas most frequently used in marine ecology, namely:

- Polychaetes pollution index (Bellan, 1984), simplified as follows:

$$IP = \frac{\Sigma \text{ individuals of "indicative of pollution" species}}{\Sigma \text{ individuals of "indicative of clean waters" species}}$$

- Shannon-Weaver diversity index according to Margalef (1957):

$$H' = -\sum_{i=1}^{k} P_i \log_2 P_i$$

- Evenness index of Pielou (1969):

$$E = \frac{H'}{\log_2 \text{ total number of species}}$$

Faunal lists for San Giovanni Li Cuti were also compared with the lists obtained with similar procedures (Fassari, Mòllica, 1989) in Lachea island, in the sea facing Acitrezza (Catania) included since April 1990 among the Italian marine reserves. Lachea island was choosen for comparison for reasons of confidence in the healthy condition of its waters, the proximity of the two areas and the similarity of their fauna. The data of Lachea island were obtained by analysing samples from 8 stations all around the island, collected at -1 and -5 meters in autumn and spring with the same procedure used in the present study.

RESULTS AND DISCUSSION

At first sight the polychaete fauna of San Giovanni Li Cuti looks well developed and varied with a large number of individuals and species in spring as well as in autumn. Nevertheless, a more careful examination shows that there are actually significant differences in comparison with the Mediterranean standards. In fact, while it is usual to observe a wider variety of species and more individuals in spring than in autumn due to the algal blooms and the more propitious conditions for demographic growth in the spring, in San Giovanni Li Cuti the situation is apparently reversed. 4,199 individuals belonging to 128 species were found in the samples collected in autumn, and 3,440 individuals belonging to 106 species in the samples collected during the spring. In the first phase of the study (autumn) only 4 stations presented less than 100 individuals, while in the second phase (spring), there were 11 stations with less than 100 individuals. This difference could come from the influence of the rains. Polychaetes are very sensitive to the effects of winter rains: both the number of species and of individuals decreases during spring and increases in autumn, after the dry summer season. This is supported by the fact that in transects 3, 4, 5, and 6, fresh waters arrive only after heavy precipitation. Looking in detail at the polychaetes fauna collected during the two seasons, it is possible to note that in the autumnal period stations 3A, 5A, and 6A, which are, along their transects, mostly exposed to the impact of fresh water, have a well developed population with as much as 533, 157 and 495 individuals and 26, 16 and 24 species respectively, while in the spring period they become impoverished, with

Table I - Rainfall in the Catania area (1983-1992). / *Pluviosité dans la région de Catane (1983-1992).*

	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	aver.
Jan.	20.6	18.4	260	29.6	39.6	73	129.9	32.8	32.8	56.8	7.4	63.7
Feb.	24.4	59.8	13.8	56.8	32.4	26.8	42	3	32.5	42.6	29.1	33
Mar.	15.6	26.2	54.8	117.4	78.4	25	40.2	0	52.4	30.4	10.9	36.5
Apr.	7.2	42.2	35.6	5	5.6	13	28.8	30.2	13.8	1.3	3.2	16.9
May	11	9.6	20.2	0.6	25.6	5.6	21.8	19	2.2	53.6	7.3	16
Jun.	1.2	0	0	1	0.6	6.4	8.2	0	2.5	19.8	0	3.6
Jul.	7	0	0	5.2	0.4	0	18.2	0	0	0	0	2.8
Aug.	7.8	13.4	0	4.8	0	1.8	1.8	1.4	0	0	0	2.8
Sep.	39.2	25	37.6	153.8	38.4	57	8.2	0.3	28.7	0	n.c.	38.8
Oct.	84.2	55.2	79.2	90.6	8.8	8	34	49.3	42.6	4.6	n.c.	45.7
Nov.	163.8	153.8	39.6	226.3	67.4	89	108.2	31.2	22.6	0.4	n.c.	90.2
Dec.	96.8	282.2	91	38.2	28.6	62.4	69.9	72.5	88.8	109.9	n.c.	94

4.6 = first period of sampling

7.3 = second period of sampling

Table II - San Giovanni Li Cuti biological indexes. / *Indices biologiques de San Giovanni Li Cuti.*

Station	species		specim.		Shannon		Pielou		Bellan	
period	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
PA	23	20	230	148	2.81	3.15	.62	.73	.31	2.79
PB	17	11	137	63	3.32	2.46	.81	.71	.24	5.51
1A	31	32	212	477	3.87	2.81	.78	.56	.11	.03
1B	19	28	106	196	3.24	3.25	.76	.68	.62	.05
1C	13	23	79	93	2.71	3.76	.73	.83	1.13	.59
2A	17	27	188	359	1.49	2.38	.37	.5	.09	1.44
2B	13	26	28	306	3.13	2.93	.85	.62	n.c.	.13
2C	32	29	109	188	4.08	3.66	.82	.75	.04	.15
3A	26	5	533	25	2.68	1.99	.57	.86	.01	2.01
3B	34	29	223	258	4.28	3.43	.84	.71	.09	.12
3C	30	31	208	200	3.71	3.38	.75	.68	.13	.06
4A	4	4	4	21	2	1.64	1	.82	n.c.	4.01
4B	22	14	184	90	3.36	2.69	.75	.71	.03	.14
4C	18	34	127	200	2.78	3.51	.67	.69	.17	.15
5A	16	5	157	41	2.78	1.12	.7	.48	.65	1.01
5B	35	20	322	160	3.53	2.63	.69	.61	.09	.00
5C	23	23	169	173	3.06	3.44	.68	.76	.92	.17
6A	24	7	495	12	3.09	2.45	.67	.87	.37	2.01
6B	29	14	177	63	3.39	2.95	.7	.78	.05	.17
6C	23	17	178	38	3	3.74	.66	.92	.11	.19
7A	9	9	48	154	2.28	1.95	.72	.61	1.06	.88
7B	23	19	124	91	3.26	3.3	.72	.78	.00	.19
7C	21	16	166	84	2.93	2.9	.67	.73	.25	.00

Table III - Lachea island biological indexes. / *Indices biologiques de l'île Lachea.*

Station	species		specim.		Shannon		Pielou		Bellan	
period	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
1A	15	20	58	52	3.18	3.85	.81	.89	.91	.07
1B	15	7	29	9	2.57	2.73	.97	.97	.00	.00
2A	8	19	19	40	2.61	4.01	.87	.94	.07	.22
2B	10	13	17	48	3.06	3.17	.92	.86	.28	.33
3A	17	21	56	118	3.39	3.89	.83	.89	.31	.07
3B	8	16	33	28	2.11	3.75	.70	.94	.57	.33
4A	13	20	39	49	3.31	4.07	.94	.94	.13	.27
4B	12	17	17	34	3.15	3.82	.96	.94	.59	.21

only 25, 41 and 12 individuals and only 3, 5 and 7 species respectively. Only station 4A presents a very low number of individuals and species in both periods (4 individuals belonging to 4 species in autumn, and 21 individuals belonging to 4 species in spring).

Inside the small harbour, in which fresh water coming from the groundwater are persistently present throughout the year, it is possible to see quantitative variations of the fauna linked to the seasonal fluctuations of the flow: station PA exhibits 230 individuals belonging to 23 species in autumn and 148 individuals belonging to 20 species in spring, and station PB has 137 individuals and 17 species in autumn, and 63 individuals and 11 species in spring. In contrast, all the stations of the bay outside the harbour, less exposed to the effects of fresh water, are most enriched in species and individuals during the spring season and depopulated in autumn.

Correspondingly, the Shannon index shifts meanly from 3.08 in autumn to 2.85 in spring, despite the persistence of high values of evenness (0.72 and 0.71 respectively), indicative of a persistently varied and representative presence of species (table II). This does not occur in Lachea island which is unaffected by freshwater (table III).

If we consider the results according to the depth of sampling, it is clear that the largest variation occurs in stations at -1m (-21.6%), followed by stations at -3m (-12.4%) and by those inside the harbour (-8.5%), while in the stations more distant from the coast the Shannon index increases (+8.6%). If we consider stations 3A, 4A, 5A and 6A, which are the nearest to the fresh water influxes, the Shannon index decreases by as much as 31.8%.

The most relevant seasonal variation concerns the species indicative of pollution and those indicative of clean waters (*sensu* Bellan, 1984). On the

whole the latter ones (clean waters) are present with 1,984 individuals in autumn and 1,729 individuals in spring, while the former (polluted waters) are present with 428 individuals in autumn and 449 individuals in spring. Nevertheless, subdividing the stations by depth, it is clear that inside the port and near the coast (stations at -1m) there is a decrease of species indicative of clean waters and an increase of species indicative of pollution; in contrast, there are no significant differences among the stations distant from the coast.

The difference between the two seasons is most evident if we examine the Bellan index: autumnal samples show always values well below the threshold level (< 1), as is the case in the waters of Lachea island (figure 3).

During the spring, after the rainy season, there is a clear inversion of the trend: Bellan index (IP) values meanly increase from 0.30 to 2.49, with the widest variations recorded in the stations near the coast and inside the port, that are most exposed to the impact of the fresh waters. In stations at -1m IP increases from 0.27 to 1.62, and inside the port it increases even more (from 0.12 to 4.15 !). The widest variations were recorded in station 2A (from 0.09 to 1.44), 4A (from only 1 polluted waters individual and no clean waters individuals, to 4.00), 5A (from 0.65 to 1.00), and 6A (from 0.37 to 2.00). The IP values in the other stations were always lower than 1.00. In fact, the widest variations are observed in the spring samples maximally exposed to the impact of the rain (106.9 mm of rainfall in the six months preceding the sampling, *vs* 74.7 mm (i.e. -30.12%) in the six months preceding the autumnal sampling). Moreover, in the three months preceding the autumnal sampling there was no precipitation, while in the six months preceding the spring sampling there were regular rains (table I).

CONCLUSIONS

Some definite conclusions can be drawn on the basis of these results:

- Polychaetes are good "descriptors" of the marine benthic ecosystems.
- Among the parameters considered in this study, salinity is the most important factor that influences the polychaete fauna.
- The number of polychaete species and individuals is inversely correlated with the water salinity.
- When the salinity decreases the least resistant polychaete species migrate towards areas of higher salinity.
- Some polychaetes (belonging to the Syllidae family) are most sensitive to decreases in salinity, but most polychaete species are euryhaline.
- The response of polychaetes to variation of salinity is almost immediate (a few weeks).
- The inverse relationship between salinity and Bellan index supports that this index, originally proposed as an indicator of pollution (Bellan, 1991), could be also used as an indicator of disturbance.

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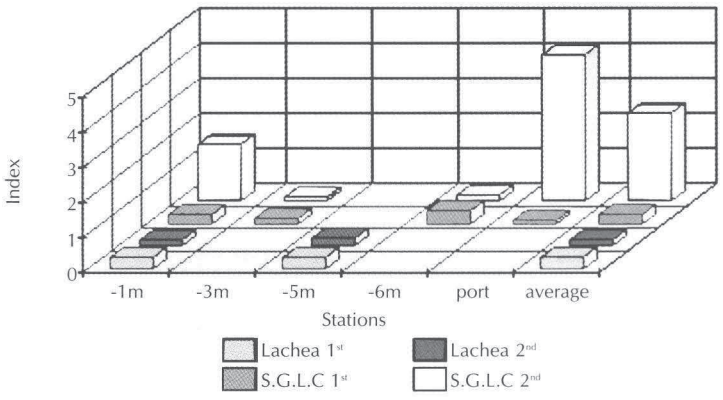

Figure 3 - Bellan index for the two seasons and sites / *Indice de Bellan pour les deux saisons et dans les deux sites.*

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