Peracarida crustacean populations of the artificial hard – substratum in N. Michaniona (N. Aegean)

Baxevanis Athanasios and Chintiroglou Chariton

Department of Zoology, School of Biology, Aristotle University of Thessaloniki, Box 134, 54006, Thessaloniki, Greece.

ABSTRACT. Quantitative samples were taken during summer and winter in two successive years from artificial substrata at one site (N. Michaniona) in Thermaikos Gulf. Sampling was carried out using a specially designed sampler. Data were analyzed with common biocoenotic methods and non-parametric statistical tests. The examination of approximately 10,500 specimens revealed the presence of 17 peracaridan species, the most dominant of which were *Corophium acutum* (41%), *Leptochelia savignyi* (24%), *Corophium sextonae* (14%) and *Elasmopus rapax* (12%). All the species are very common and have been reported in many sites and assemblages in the N. Aegean and W. Mediterranean Sea.

Shannon index, which was calculated separately for each sample, had similar values in the same year (2.04-2.44 in 1994 and 1.30-2.00 in 1995). Comparison of the samples, on the basis of their abundance and their diversity using Kruskal-Wallis test, showed significant differences among them ($p < 0.05$). Mann-Whitney test was used to find out the differences among the samples. Samples were grouped according to their similarity employing Euclidean distances and Ward' s method.

The total of the examined samples demonstrated that the composition of the peracarida fauna in the region of N. Michaniona, was similar to peracarida fauna of photophyllic algae assemblages. The results of this research must be considered essential to the biomonitoring of Thermaikos Gulf.

INTRODUCTION

Even though our knowledge about the structure and function of hard substratum assemblages has been broadened, this does not apply to the assemblages of the artificial hard substratum in increasingly polluted harbors. This should be attributed to the difficulties involved in quantitative sampling and to the complexity of the abiotic factors, which affect the artificial substratum in ports. Furthermore, the functional and constructive diversity of ports seems to cause added difficulty in reaching reliable conclusions.

According to PÉRÈS & PICARD (1964) assemblages in ports (e.g. Marseilles) should be characterized as assemblages of invertebrates in very polluted waters. Bellan-Santini (1969), who also studied the complexity of these biotopes, noted that the diversity of the assemblages increases significantly proportionally to the distance from the center of the ports (e.g. Vieux Port Marseille). Articles concerning the study of biotic and abiotic conditions in ports (ZAVODNIK & ZAVODNIK, 1978; TURSI et al., 1982; HARGRAVE and THIEL, 1983; Leewis and Waardenburg, 1989; LANTZOUNI et al., 1998) have recently revealed some interesting aspects on this matter.

A review of the relevant bibliography revealed the dependence of the hard substratum assemblages from the port's functionality and form (BELLAN-SANTINI, 1981; DESROSIERS et al., 1982; WENNER, 1987). The characteristics of these assemblages are imminently related to the environmental conditions as well as to the degree of the adaptability of the organisms (e.g. changes in the life cycles or feeding patterns, etc.).

Under these circumstances, the major problem in such a study will be whether it is admissible to determine the degree of pollution in a port on the basis of the composition of the hard substratum organismic assemblages. So far, the use of ecological indicators, such as the composition of the peracarida fauna of these substrata, seems to be a satisfactory approach (BELLAN-SANTINI, 1981).

Corresponding author: B. Athanasios, e-mail: thanos75@hotmail.com

The aim of this study is to give the results on the structure of hard substratum peracarida assemblages (Crustacea; Malacostraca; Peracarida) of the port in N. Michaniona (Thermaikos Gulf), setting up the initial base for biomonitoring.

MATERIAL AND METHODS

Habitat description

N. Michaniona is situated 30km south-east of Thessaloniki in the east coast of Thermaikos Gulf (Fig. 1). N. Michaniona's port serves the needs of a great number of fish boats (trawls, purse seines, etc.). Until 1994, there was one large pier in N. Michaiona but in 1995 the works for a second, smaller pier started. The works were terminated in 1995. The samples were taken in the area protected by the piers and from the artificial hard substratum at the land side. The sampling area can be characterized as degraded rather than polluted, because it is not directly affected by the industrial area on the western coast of the Bay. This point is reinforced by the presence of *Arbacia lixula, Paracentrotuts lividus, Anemonia viridis, Actinia equina* which are considered as indicators of non-polluted

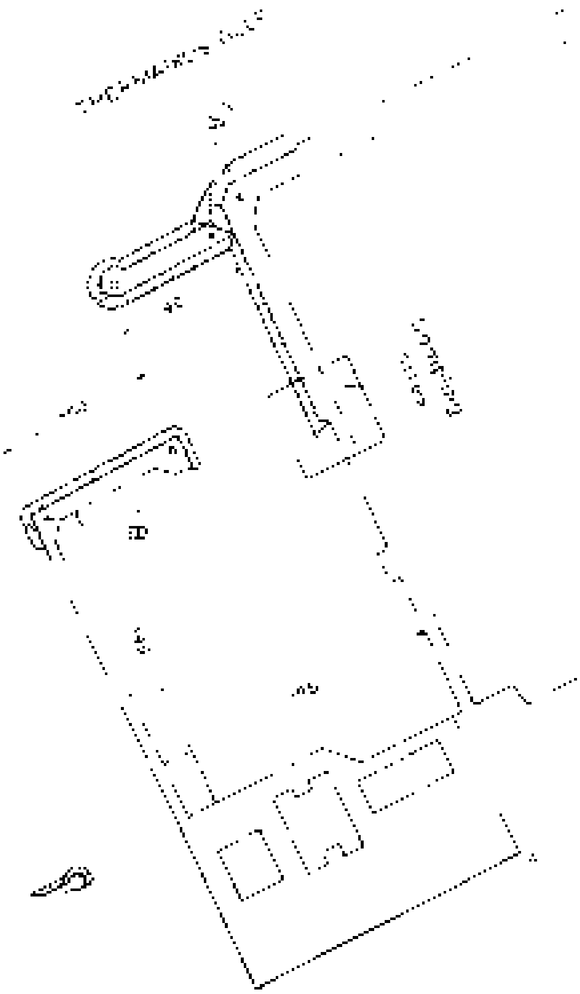

Fig. 1a. – Sampling area in N. Michaniona.

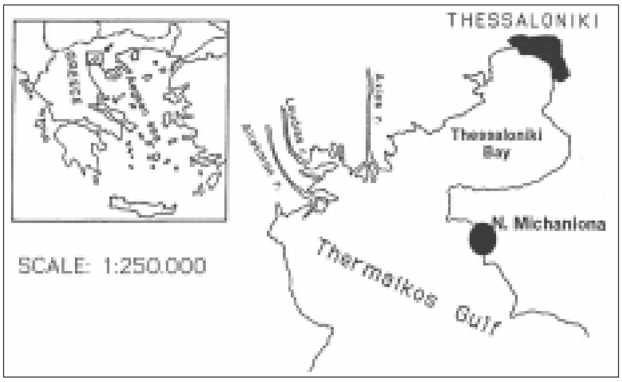

Fig. 1b. – Map of Thermaikos Gulf.

waters (Schmidt, 1972; Harmelin et al., 1981). The surface water temperature varied from 10.5 to 28°C, following a seasonal pattern, with the highest temperatures in July-August and the lowest in January-February (fig. 2). The water salinity was more or less stable (about 37%).

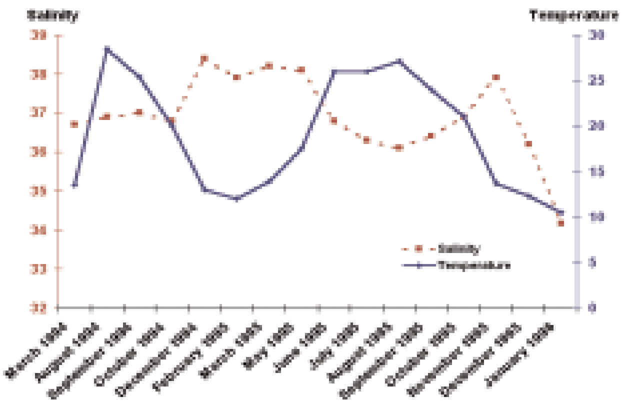

Fig. 2. – Salinity ($^o/_{oo}$) and Temperature (°C) values during the sampling period (1994-1995).

Sampling and statistics

Sampling was carried out on the artificial hard substratum of the pier in N. Michaniona, in summer and winter of two successive years (1994 and 1995). Scuba diving was employed and a special hard substratum sampler described by Chintiroglou & Koukouras (1992) was used. The advantage of this particular sampler, which is similar to others (Stirn, 1981) is that it ensures to a large extent the isolation of the sample and it can be well attached and fixed on the substrate. The area covered by this sampler is 400 cm^2 (20 x 20 cm), which is the minimum necessary quadrat area for the investigation of hard substratum assemblages (Bellan-Santini, 1969; Stirn, 1981). Samples were preserved in 10% formaline solution. In total, 12 samples were taken (3 samples per season). In order to quantify the contribution of the various species, mean abundance and partial mean dominance were calculated (Bellan-Santini, 1981). The Shannon-Wiener information function (H') and the Evenness index (J') were used as diversity indices (Daget, 1979). For the comparison of peracarida diversity between seasons and years, non-parametric tests, such as Kruskal-Wallis test and Mann-Whitney test (SIEGEL, 1956) were employed. Ward's method was used to construct hierarchical classification of peracarida fauna similarities between seasons using Euclidean distances (ALDENDERFER & BLASHFIELD, 1984).

RESULTS

During this study 10,501 peracaridean individuals were identified, which belong to 4 classes (Amphipoda, Isopoda, Tanaidacea and Cumacea) and 17 species (13 Amphipoda, 2 Isopoda, 1 Tanaidacea and 1 Cumacea). Mean abundance and partial mean dominance were calculated (Table 1), as well as the total numbers of species, individuals, Shannon-Wiener index (H') and Evenness index (J'). The most dominant species, by far, was *Corophium acutum* (mA = 360.42, pmD = 41.18); second most was *Leptochelia savignyi* (mA = 207.83, pmD = 23.75) and third *Corophium sextonae* (mA = 125.92, pmD = 14.39). Three other species (*Elasmopus rapax, Ericthonius brasiliensis* and *Jassa marmorata*) showed relatively high abundance in some of the samples.

TABLE 1

Peracarida species in the 4 sampling periods (P: presence, mA: mean abundance, mD: mean dinance)

	Winter 1994			Summer 1994			Winter 1995			Summer 1995		
	P	mA	mD	P	mA	mD	P	mA	mD	P	mA	MD
Corophium acherusicum	3	5.0	0.629	2	2.0	0.185	0	0.0	0.000	0	0.0	0.000
Corophium acutum	3	207.7	26.111	3	267.7	24.780	3	167.0	46.130	3	799.3	57.993
Corophium sextonae	3	107.0	13.453	3	324.3	30.022	3	4.0	1.105	3	68.3	4.958
Elasmopus rapax	3.	91.3	11.484	3	167.3	15.489	3	30.3	8.379	3	142.0	10.302
Ericthonius brasiliensis	3	80	10.059	3	61.31	5,677	1	0.3	0.092	3	22.3	1.623
Jassa marmorata	1	1.3	0.168	1	19.31	1.799	1	0.7	0.184	0	0.0	0.000
Leucothoe serraticarpa	0	0.0	0.000	2	3.01	0.278	0	0.0	0.000	0	0.0	0.000
Leucothoe spinicarpa	1	0.33	0.042	1	0.3	0.031	0	0.0	0.000	0	0.0	0.0001
Liljeborgia dellavallei	0	0.0	0.000	1	0.3	0.031	0	0.0	0.000	0	0.0	0.000
Maera inaequipes	0	0.0	0.000	1	0.7	0.062	0	0.0	0.000	0	0.0	0.000
Stenothoe cavimana	3	8.0	1.006	0	0.0	0.000	3	11.7	3.223	0	0.0	0.000
Stenothoe monoculoides	2	3.0	0.377	1	0.3	0.031	0	0.0	0.000	0	0.0	0.000
Perioculodes aequimanus	0	0.0	0.000	0	0.0	0.000	1	0.3	0.092	1	0.3	0,024
Cymodoce sp.	3	14.0	1.760	3	11.0	1.018	3	7.3	2.026	31	2.0	0.145
Iphinoe sp.	1	0.3	0.042	1	0.3	0.031	2	0.7	0.184	3	9.0	0.653
Leptochelia savignyi	3	277.3	34.870	3	220.0	20.364	3	23.7	6.553	3	310,3	22.512
Paranthura nigropunctata	0	0.0	0.0	1	1.0	0.093	1	1.7	0.460	3	24.7	1.790
Number of individuals	**2386**			**3241**			**743**			**4135**		
Number of species	**12**			**15**			**11**			**9**		
Shannonindex H'	**2.388**			**2.393**			**1.604**			**1.757**		
Evenness index J'	**0.666**			**0.610**			**0.465**			**0.554**		

Shannon index (H'), separately calculated for each season, showed higher values in 1994 (2.388 in winter and 2.393 in summer) than in 1995 (1.604 and 1.757, respectively). The highest value of the evenness index (J') appeared in the winter of 1994 (J' = 0.666) and the lowest in the winter of 1995 (J' = 0.465) (Fig. 3). The value of number of species reached its highest level in the summer of 1994 (16) whereas the lowest value of number of species was in the summer of 1995 (9). The number of species decreased between the two years (Fig. 4). Comparison of the four seasons' samples on the basis of their peracarida fauna diversity by Kruskal-Wallis test, showed significant differences among them (H = 7.9, p = 0.044). Nevertheless, the samples that belong to the same year grouped together. The comparison of the 1994's samples with those of 1995 using the Mann-Whitney test, revealed significant differences between the

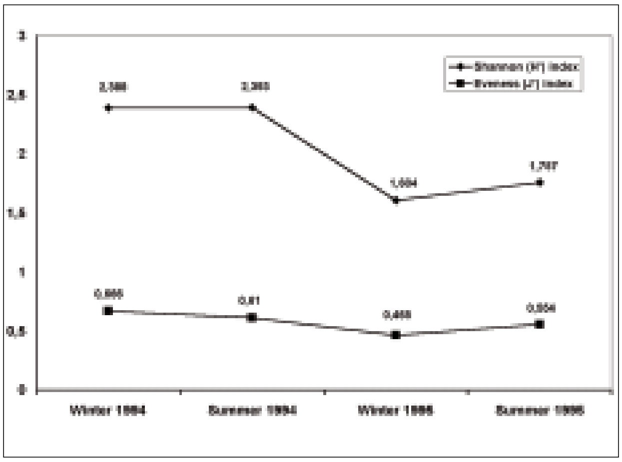

Fig. 3. – Shannon (H') and Evenness (J') indices for the four sampling periods.

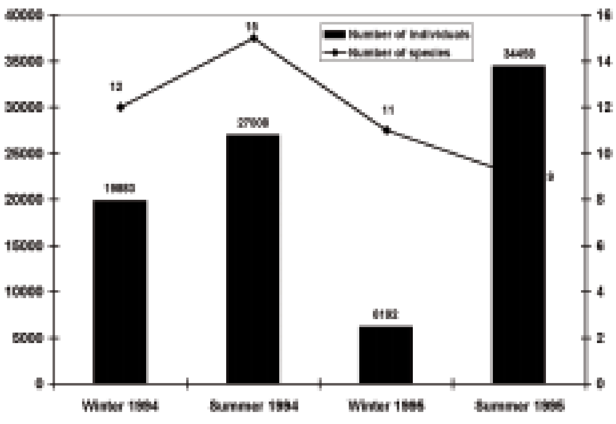

Fig. 4. – Number of individuals and number of species for each sampling period.

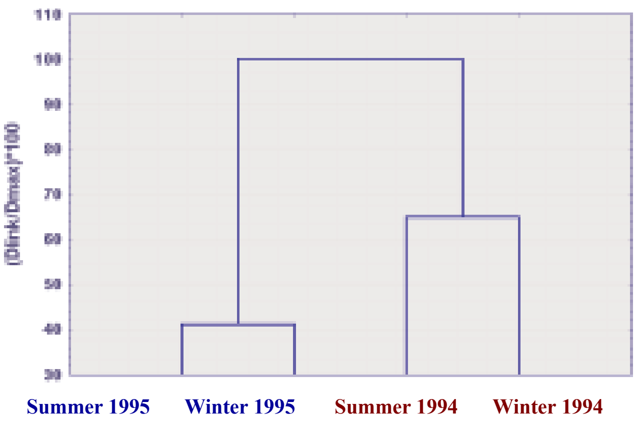

Fig. 6. – Tree diagram for the four sampling periods (Euclidean distances, Ward's method)

two years (Z = 2.9, p = 0.003). As far the differences among the samples are concerned, there were significant differences between the samples of the winter of 1994 and 1995 (Z = 1.96, p = 0.495). Differences were also found between the samples of winter 1994 and summer 1995 and the samples of summer 1994 and winter 1995, as expected. On the contrary, the application of Mann-Whitney test showed that there were no significant differences regarding the samples of winter and summer of 1994 (Z = 0.218, p = 0.827) and the samples of winter and summer of 1995 (Z = 0.218, p = 0.827). In addition, there were no significant differences among the samples of the two summer periods in 1944 and in 1995 (Z = 1.528, p = 0.127).

Samples were grouped according to their similarities (Fig. 5). They are divided into three major clusters; the first cluster includes 2 samples of the summer of 1995 and the second includes the remaining summer samples (1994 and 1995) – plus one 1994 winter sample, which is similar to the summer samples, as the number of individuals and species indicates. The third cluster contains the winter samples (1994 and 1995). On the whole, the samples of the three clusters do not show great differences among them. When the four periods of sampling were grouped

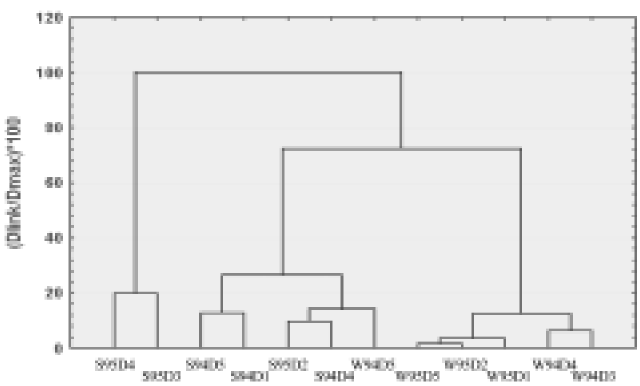

Fig. 5. – Tree diagram for the 12 samples (Euclidean distances, Ward's method)
(W: Winter, S: Summer, 94: 1994, 95: 1995, D1: Number of sample)

with reference to presence/absence data (Fig. 6), the samples of 1995 were grouped together, as were the samples of 1994. According to this tree diagram, the samples were grouped in relation to the sampling year and not to the sampling period (winter or summer)

DISCUSSION

A review of the relevant bibliography showed that the peracarida genera found were almost the same as normally appear in the corresponding hard substrata of other Mediterranean areas (Bellan-Santini, 1981; Tsuchiya and Bellan-Santini, 1989). Furthermore, genera like *Elasmopus, Corophium, Jassa, Stenothoe* are very common in almost all the facies of the photophilic algae biocoenosis (Bellan-Santini, 1969; Bellan-Santini, 1981; Pérès, 1982; Tsuchiya & Bellan-Santini, 1989). Additionally, the genera that were recorded in this study have already been reported in the *Mytilus galoprovincialis* beds from the same area (Lantzouni et al., 1998) and they are very common in the N. Aegean Sea (Stefanidou & Voultsiadou-Koukoura, 1995).

The most dominant species in the studied area were *Corophium acutum*, *Leptochelia savignyi*, *Corophium sextonae* and *Elasmopus rapax*. These species were always present in winter and summer samples. The species of the genus *Corophium* showed a greater abundance when compared with other hard substratum assemblages of the Mediterranean (Bellan-Santini, 1969; Kocatas, 1978; Bellan-Santini, 1981). Besides, *Corophium acutum* is reported for the first time in hard substratum assemblages, while other species of the genus *Corophium* have rarely been found by other authors and only in small proportion (e. g. *Corophium acherusicum* by Kocatas, 1978; Bellan-Santini, 1981). In addition, *Leptochelia savignyi* was reported in hard substratum assemblages and it is considered as an indicator of organic rich waters (Tsuchiya & Bellan-Santini, 1989).

As mentioned above, N. Michaniona is located far from the major industrial area of Thessaloniki. This is the reason N. Michaniona is not under an imminent pollution impact. River runoffs (especially from the river Axios) are considered as pollution sources in the NW of Thermaikos Gulf. The surface currents transfer organic matter and wastes towards N. Michaniona coast (ANAGNOSTOU et al., 1997; KRESTENITIS et al., 1997).

Most of the samples that were collected in the same sampling period (summer or winter) showed a great affinity. Nevertheless, there is a fluctuation that is due to the diversity of the hard substratum microhabitats (BELLAN-SANTINI, 1969). When the samples were examined as a total and their clustering was based on presence/absence data, greater affinity among the samples of the same year (1994 or 1995) was discovered rather than in the samples of the same sampling period (summer or winter). This fact implies that there was no seasonal alteration in the synthesis of the peracaridean community at the examined time and place. However, such seasonal alterations have been observed in amphipod assemblages associated with *M. galloprovinciallis* beds from Thermaikos Gulf (Lantzouni et al., 1998).

Shannon indices for winter and summer of 1994 were found to be similar to those of other photophilic algae assemblages, such as in Marseille region (Bellan-Santini, 1981). In this study, the highest value of H' index was observed in the summer of 1994 (2.393) and the lowest value in winter of 1995 (1.604). The values of the H' index for non-polluted areas ranged from 2.29 to 2.89 and for polluted ones from 0.87 to 1.70 (Bellan-Santini 1981). There was a sharp decrease of Shannon H' index between the summer of 1994 and the winter of 1995 (Fig. 3). In addition, the number of species was smaller in 1994 than the number of species in 1995 (Fig. 4). Furthermore, the great abundance of certain species in 1995, such as *Corophium acutum*, *Leptochelia savignyi* and *Elasmopus rapax*, indicated a disturbed area (GRAY & MIRZA, 1979). Besides, *Corophium acutum* and *Leptochelia savignyi* are tube-dwellers. Particularly *Leptochelia savignyi* is a characteristic species of organic-rich environments (TSUCHIYA & BELLAN-SANTINI, 1989).

The former changes should be attributed to the construction of the pier, marked as B in Fig. 1b, which took place in 1995. The pier, which is part of a major port, comprises an artificial barrier, which changes the physiognomic aspect of the sampling area and also influences the structure of the peracarida assemblages in hard substratum. This pier affected the hydrodynamic of the region by preventing the movement of currents in the port and allowed the accumulation of organic material sediment. Additionally, changes in the composition of the fauna and the flora due to the influence of human disturbances can be detected in a small period of time (Hargrave and Thiel, 1983; Desrosier et al., 1986).

In conclusion, the sampling before, during and after the construction of man-made installations is highly recommended, so that the evolution of the assemblages can be observed. The biomonitoring of the hard substratum fauna, especially the peracaridean one, can eventually produce remarkable results as far as the impacts of the human activities are concerned, since Crustacea are one of the most sensitive groups to environmental changes.

ACKNOWLEDGEMENTS

This study was part of a research project financed by the Ministry of Development, General Secretariat for Research and Technology.

REFERENCES

ALDENDERFER, M. S., and R.K. BLASHFIELD (1984). *Cluster analysis*, Sage University 07-044: 1-88.

ANAGNOSTOU, C., E. GEORGAKOPOULOU-GREGORIADOU, A. ZENETOS, E. KAMBERI, A. KARAGEORGIS, C. KONTOJANNIS, K. PAGOU, P. PANAGIOTIDIS, A. PANCUCCI, I. SIOKOU, N. SYMBOURA, I. CHATJANESTIS & R. PSYLLIDOU-GIURANOVITS (1997). The state of the marine ecosystem of the bay and the Gulf of Thessaloniki – The reaction capacity of the system. *Proceedings 5th Hellenic Symposium Oceanography and Fishery*, 1: 83-86.

BELLAN-SANTINI, D. (1969). Contribution à l'étude des peuplements infralittoraux sur substrat rocheux. Travaux de la Station Marine d'Endoume. *Bulletin*, 31 (47): 1-294 p. (These Univ. Aix-Marseille).

BELLAN-SANTINI, D. (1981). Influence des pollutions sur le peuplement des amphipodes dans la biocénose des algues photophiles. *Tethys*, 10 (2): 185-194.

CHINTIROGLOU, C. & A. KOUKOURAS (1992). A population of the sea anemone *Anemonia viridis* (Forskal, 1775) and its associated flora and fauna, in the north Aegean Sea. *International Revue der Gesamten Hydrobiologie*, 77: 483-495.

DAGET, J. (1979). *Les modèles mathématiques en écologie*. Masson, Paris, 172 pp.

DESROSIERS, G., D. BELLAN-SANTINI & J.-C. BRETHES (1986). Organisation trophique de quatre peuplements de substrats rocheux selon un gradient de pollution industrielle (Golfe de Fos, France). *Marine Biology*, 91: 107- 120.

GRAY, J. & F. MIRZA (1979). A possible method for the detection of pollution-induced disturbance on marine benthic communities. *Marine Pollution Bulletin*, vol. (10), pp. 142-146

HARGRAVE, B.T. & H. THIEL (1983). Assessment of pollution-induced changes in benthic community structure. *Marine Pollution Bulletin*, 14 (2): 41-46.

HARMELIN, J.G., C. BOUCHON & J.S. HONG (1981). Impact de la pollution sur la distribution des échinoderms des substrats durs en Provence (Méditerranée Nord-Occidentale). *Tethys*, 10 (1): 13-36.

HONG, J. S. (1983). Impact of the pollution on the benthic community. *Bulletin of the Korean Fisheries Society*, vol. 16, No 3.

KOCATAS, A. (1978). Contribution à l'étude des peuplements des horizons supérieurs de substrat rocheux du Golfe d'Ismir (Turquie). Ege University, *Fen Faculty Monography Series*, 12: 1-93.

KRESTENITIS, N.Y., S.P. CHRISTOPOULOS, L.A. VALIOULIS & P. HYDER (1997). The study of the region of freshwater influence of Thermaikos Gulf. 5th Hellenic Symposium on Oceanography and Fisheries Kavala, Greece, April 15-18, 47-49.

LANTZOUNI, M., E. VOULTSIADOU & Ch. CHINTIROGLOU (1998). Preliminary observations on amphipod assemblages associated with *Mytilus galloprovincialis* Lam. beds from Thermaikos Gulf (Aegean Sea). XXXVth CIESM Congress, Dubrovnik 1998, 458-459.

LEEWIS, R.J. & H.W. WAARDENBURG (1989). The flora and fauna of the sublittoral part of the artificial rocky shores in the south-west Netherlands. *Progress in Underwater Science*, 14: 109-122.

PÉRÈS, J.M. & J. PICARD (1964). Nouveau manuel de bionomie benthique de la Méditerranée. Rec. Travaux de la Station Marine d' Endoume. *Bulletin*, 31(47): 1-137.

PÉRÈS, J.M. (1982). Major benthic assemblages. *Marine Ecology*, ed. O. Kinne. Wiley, N. Y. 5; part I, pp. 373-522.

SCHMIDT, H. (1972). Prodromus zur einer Monographie der Mediterraneen Aktinien. *Zoologica*, 42: 1-146.

SIEGEL, S. (1956). Nonparametric statistics for the behavioral sciences. McGraw-Hill, Kogakusha LTD, Tokyo, 312 pp.

STEFANIDOU, D. & E. VOULTSIADOU-KOUKOURA (1995). An account of our knowledge of the amphipod fauna of the Aegean sea. *Crustaceana*, 68 (5): 597-615.

STIRN, J. (1981). Manual of methods in aquatic environment research. Part 8. Ecological assessment of pollution effects (Guidelines for the F.A.O. (G.F.C.M.)/U.N.E.P. Joint coordinated project on pollution in Mediterranean). *F.A.O. Fisheries Technical Paper*, 209: 1-190.

TSCUCHIYA, M. & D. BELLAN-SANTINI (1989). Vertical distribution of shallow rocky organisms and community structure of mussel beds (*Mytilus galloprovincialis*) along the coast of Marseille, France. *Mésogée*, 49: 91-110.

TURSI, A., A. MATARRESE, M. SCISCIOLI, R. VACCARELLA & G. CHIEPPA (1982). Biomasse bentoniche nel Mar Piccolo di Taranto e loro rapporto con i banchi naturali di mitili. *Nat. Sicil.*, S.IV, 4, suppl. 2: 263-268.

WENNER, A.M. (1987). Crustacean and other invertebrates as indicators of beach pollution. *Marine Organisms as Indicators*, Ed. by D. F. Soule and G. S. Kleppel, Springer Verlag, Berlin, pp. 199-229.

ZAVODNIK, D. & N. ZAVODNIK (1978). The benthos of Rijeka Bay-Subject to stress of pollution. *IVes Jour. Etud. Pollutions C.I.E.S.M.*, pp. 405-410.