Successional stages of experimental artificial reefs deployed in Vistonikos gulf (N. Aegean Sea, Greece) : Preliminary results

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ABSTRACT. In 1999 an artificial reef system, consisting of a protective zone (240 cubic modules) and a nucleus (9 Italian type and 9 French type artificial reefs), was constructed and deployed at cape Fanari (Vistonikos Gulf, North Aegean Sea) occupying an area of 6 Km2 (25m depth). Samples, (8 cement plates, 35cmx35cm) were collected seasonally with SCUBA-diving from March 2000 till May 2001. Overall 46986 individuals were counted belonging to 13 classes, while 88 species were recorded. Common biocoenotic parameters (numerical abundance, frequency, mean dominance) were calculated. Shannon-Weaver index ranged from 2.509 to 3.741 and evenness from 0.388 to 0.579, both exhibiting a maximum in summertime. The analysis revealed a clear dominance of Serpulids during the first three periods and of Peracarida for the last two. Filter-feeder organisms including *Pomatoceros triqueter*, *Spirobranchus polytrema* and *Corophium sextonae* dominated the samples. Two-way ANOVA indicated significant differences in numerical abundance of each taxon with time. However, no differences were recorded among taxon from the top and the base of the pyramids except for Gastropods,which showed a significant increase in numerical abundance at the top blocks. Cluster analysis provided a dendrogram with 6 groups at a 73% similarity level, 5 of which group together the replicates of each period, except one replicate, from the last period, that forms the 6th cluster. Filter-feeders appeared to be the prevailing organisms in artificial reefs communities.

KEY WORDS : artificial reefs, benthic communities, filter- feeder organisms, Aegean Sea.

INTRODUCTION

The establishment of artificial reefs is a measure of global importance for the management of coastal marine ecosystems (FITZHARDINGE & BAILEY-BROCK, 1989 ; RELINI et al., 1990). During the last ten years, artificial reefs have proved to be a very effective means for fishery enhancement (PICKERING et al., 1998). However, they can play an important role for the coastal zone marine biocoenoses, including protection from the mechanical impact of trawling, habitat restoration, increase of the spatial heterogeneity and variety of substrata on soft seabeds, aquaculture and, recently, tourism (BOMBACE et al., 1994 ; PICKERING et al., 1998). Consequently, the majority of the studies concern the potential and capability of these structures to act as fish attracting and aggregating devices. However, an aspect of artificial reef studies that is often overlooked is their colonization by sessile and other invertebrate organisms, which provide food and shelter for fish and crustaceans (CARTER et al., 1985).

Although artificial reefs have been deployed in Europe since 1960s, their use has increased in the last two decades (SANTOS & MONTEIRO, 1998). In Greece, the first experimental reefs were deployed in July 1998 (SINIS et al., 2000) and the first extensive protective zone with artificial reefs was established in October 1999, primarily in order to increase fish production and protect the existing *Posidonia oceanica* meadows. The aim of this study was to provide preliminary information on the successional stages of benthic invertebrates during the first year of the reef's deployment at cape Fanari (Vistonikos gulf).

MATERIAL AND METHODS

Description of the deployment area

The deployment area, located between Vistonikos Gulf and cape Corosmilou (N Aegean Sea) (Fig.1), included the nucleus of the artificial reefs (3.500 m^2) and the protective zone (6 km^2). The bottom of the study area slopes slightly offshore, forming a flat field at a depth of 20 m, which is covered by a dense, well-developed *Posidonia oceanica* meadow. However, during the last years, repeated mechanical damaging caused mainly by otter- and beam-trawling, resulted to serious regression of these meadows and their associated biota. Thus, the main part of the seabed consists of a completely degraded meadow, which is often replaced by muddy sheets containing organic detritus and characterized by the presence of *Turitella communis* (BELLAN-SANTINI et al., 1994). Only 25% of the area is covered by a well-developed and continuous *Posidonia oceanica* meadow. Seawater samples, at the broader coastal region, were carried out at approximately bimonthly intervals from October 1997 to April 1998, using NISKIN (5L) sampler. Nutrients (phosphate, nitrate, nitrite, silica, and ammonia), organic carbon, chlorophyll-a and phaeopigments concentrations for the critical periods (October and February) are shown in Table 1. The coastal area of Rodopi could be characterized as typically eutrophic, with relatively high primary productivity that, often, favours phytoplankton blooms (Dounas, unpubl. data). Moreover, prevailing currents are easterly and their velocity ranges from 1cm/sec to 24.4 cm/sec, with a mean value of 6.8 cm/sec (Dounas, 1998).

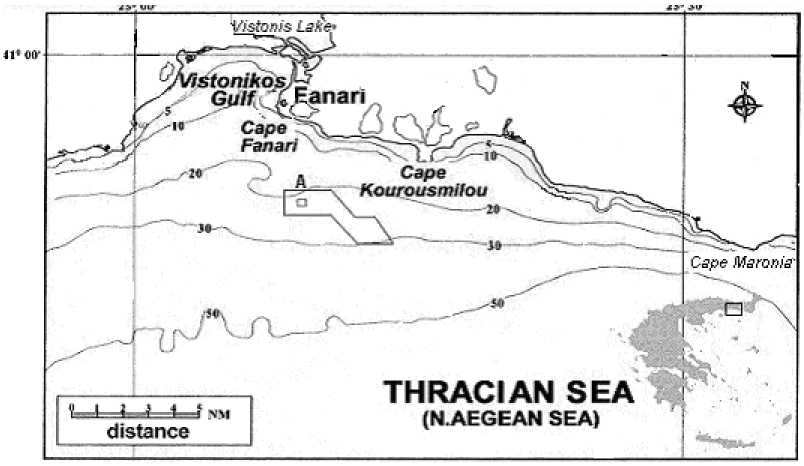

Fig. 1. – Location of the deployment area. Site A represents the protective zone and the nucleus.

TABLE 1

Nutrients, organic carbon (POC), chlorophyll-a and phaeopigments concentrations in Vistonikos Gulf during October 1997 and February 1998 (Mean value, Standard deviation and range).

Parameter	October 1997		February 1998	
	Mean value (SD)	Range	Mean value (SD)	Range
Chlorophyll (μ/L)	0.292 (0.387)	0.096-1.897	0.663 (0.29)	0.213-1.381
Phaeopigments (μ/L)	0.236 (0.386)	0.044-1.828	0.601 (0.252)	0.046-1.113
POC (μ/L)	499.8 (197.69)	308-1053	661 (208.4)	276-1029
Nitrate NO_3 (μM)	2.8 (0.989)	1.41-4.40	1.12 (0.53)	0.38-2.52
Nitrite NO_2 (μM)	0.46 (0.306)	0.14-1.38	0.42 (0.211)	0.11-0.97
Phosphorus PO_4 (μM)	0.056 (0.026)	0.035-0.160	0.115 (0.041)	0.065-0.2
Silica SiO_2 (μM)	2.68 (0.995)	1.12-4.78	3.04 (1.867)	1.26-9.65
Ammonium NH_4 (μM)	0.496 (0.149)	0.256-0.768	0.454 (0.304)	0.16-1.17

Description of the reef

Two groups of artificial reefs, located 25 m apart from each other, formed the nucleus zone of the deployment area. The first group was formed of 9 pyramids (Italian type), which are placed in a three-series arrangement. Each pyramid was made of 5 cubic concrete blocks (2x2x2 m), four at the base and one at the top, placed at about 15 m from each other. At the sides of the blocks holes of different diameter were created, increasing shelter availability (Bombace et al., 1994 ; Ardizzone & Bombace, 1983 ; Bombace, 1977 ; Bombace, ; Relini & Relini, 1989). The second group was consisted of nine more units, each one made of bulky cement-bricks on a cement base.

At the broader protective zone, 240 smaller units of artificial reefs (1,2x1,2x1, 2m), were placed on the seabed at distances ranging from 80 to 250 m. The aim of these units was, mainly, the prevention of the illegal trawling at the nucleus zone, in order to protect fish stocks and the meadow. Moreover, they provided additional hard substrata for benthic fauna thus increasing environmental carrying capacity of the reef.

Data collection

The survey of the colonization process was restricted to the Italian type units. For this purpose, square concrete plates (35x 35 cm) were placed at the 2 upper corners at each side of each block. A total of 5 samplings were carried out from March 2000 till May 2001. The initial sampling took place 5 months after immersion of the reef. At each sampling, 8 plates (3 from the top and 5 from the base block) were collected by divers, while visual monitoring of the reef was carried out using an underwater camera. The plates were transferred to the laboratory where the surface of each plate was scraped, washed through sieve with 0.5 mm mesh size and preserved in a 10% formalin solution. After sorting, all faunal elements were counted and identified to species level.

Data analysis

Common biocoenotic parameters, including numerical abundance (number of individuals/m^2), mean dominance (number of ind. of each species/ total number of ind.), frequency and total species richness were calculated for each period. Species diversity was estimated by using Shannon-Wiener (H') and Pielou's Evenness (J') indices based on $\log_2$ (BAKUS, 1990 ; HONG, 1983). Two-way analysis of variance was applied in order to check for significant differences in each taxon's mean numerical abundance with time and, also, to compare between replicates of each sample from different sites. Fisher's Least Significant Difference (LSD) test was used to compare across all pairs of group means when corresponding ANOVA tests were significant ($p<0.05$). Prior to performing these statistical tests, data were transformed ($\log_{10}$), when necessary, to meet the assumptions of ANOVA. Numerical abundance data were analyzed using multivariate techniques (i.e., cluster analysis and multidimensional scaling), based on the Bray-Curtis similarity, as adopted in the PRIMER package (CLARKE & WARWICK, 1994 ; CLARKE & GREEN, 1988). All data were transformed (log (x+1)) in order to weight the contribution of common and rare species (KLUIJVER, 1997 ; CLARKE & WARWICK, 1994). The significance of the multivariate results was assessed by ANOSIM test.

RESULTS AND DISCUSSION

Overall 46,986 individuals were counted belonging to 13 classes, while 88 species were recorded (Table 2). During the first three sampling periods (March/2000, May/2000, July/2000) the dominant taxon was Polychaetes, mainly Serpulids, followed by Bivalves. During March/2000 and May/2000 the species are dominated by *Spirobranchus polytrema* (27.1% and 54.6% for the first and second period respectively), while in July/2000 this species was replaced by *Pomatoceros triqueter* (18.4%). Concerning Bivalves, *Anomia ephippium* showed the highest mean dominance during March/2000, May/2000 and July/2000, followed by *Hiatella arctica*. During December/2000 Polychaetes and Peracarida exhibited equal values of mean dominance (34.0% and 32.0% respectively) with *Pomatoceros triqueter* constituting on its own 28.7% of the mean dominance followed by *Corophium sextonae* (26.4%). Bivalves were the third dominant taxon (16.0%) represented mainly by *Hiatella arctica* (6.8%). During May 2001, settlement was characterized by the clear dominance of Peracarida (56.0%) with *Corophium sextonae (56.1%)* being the most important species.

TABLE 2

Species found at each sampling period (from March 2000 until May 2001) on the cement blocks immersed in Vistonikos Gulf (F: Frequency, mD: mean Dominance).

Species	Sampling period									
	March 2000		May 2000		July 2000		December 2000		May 2001	
	F	mD	F	mD	F	mD	F	mD	F	mD
Foraminifera	0	0	100	8,01	100	9,84	100	3,70	25	0,02
Calcarea										
Sycon sp.	0	0	0	0	0	0	0	0	87,5	0,22
Polychaeta										
Harmothoe spinifera (Ehlers, 1864)	37,5	0,23	25	0,05	37,5	0,04	87,5	0,24	100	0,25
Chrysopetalum debile (Grube, 1855)	0	0	0	0	0	0	0	0	12,5	0,004
Phyllodoce madeirensis(Langerhans,1880)	12,5	0,03	0	0	0	0	12,5	0,01	87,5	0,10
Kefersteinia cirrata (Keferstein, 1862)	0	0	0	0	0	0	0	0	12,5	0,004
Odontosyllis ctenostoma (Claperede, 1868)	12,5	0,03	0	0	0	0	0	0	0	0
Syllis hyaline (Grube, 1863)	0	0	0	0	0	0	12,5	0,01	100	0,37
Trypanosyllis zebra (Grube, 1860)	0	0	0	0	0	0	0	0	12,5	0,004
Autolytus edwardsii (Saint-Joseph, 1887)	12,5	0,09	0	0	0	0	0	0	0	0
Nereis rava (Ehlers, 1868)	0	0	12,5	0,01	12,5	0,01	62,5	0,35	100	1,13
Platynereis dumerilii (Fauvel, 1916)	12,5	0,03	25	0,03	37,5	0,10	75	0,24	37,5	0,03
Glycera tesselata (Ehlers, 1868)	0	0	0	0	0	0	0	0	25	0,01
Eunice vittata (delle Chiaje, 1929)	0	0	12,5	0,01	0	0	50	0,05	87,5	0,11
Lysidice ninetta (Audiuin & Edwards, 1834)	0	0	0	0	0	0	25	0,02	12,5	0,004
Marphysa fallax (Marion & Bobretzky, 1857)	0	0	0	0	0	0	0	0	12,5	0,01
Scoletoma funchalensis (Kinberg, 1865)	0	0	0	0	0	0	0	0	75	0,06
Terebella lapidaria (Linnaeus, 1767)	0	0	0	0	0	0	0	0	37,5	0,01
Polyophthalmus pictus (Claparede, 1864)	0	0	0	0	0	0	0	0	100	0,29
Nematonereis unicornis (Grube, 1840)	0	0	0	0	0	0	0	0	100	0,50
Branchiomma bombyx (Dalyell, 1853)	0	0	0	0	0	0	0	0	37,5	0,03
Hydroides pseudouncinata (Zibrowius, 1971)	100	2,90	100	1,62	100	1,40	100	0,82	100	0,80
Pomatoceros triquete (Linnaeus, 1865)	100	12,49	100	18,09	100	18,39	100	28,73	100	14,93
Placostegus tridentatus (Fabricius, 1779)	100	0,82	0	0	0	0	0	0	0	0
Serpula vermicularis (Linnaeus, 1767)	100	3,29	100	2,59	100	1,97	100	2,89	100	4,72
Spirobranchus polytrema (Philippi, 1844)	100	54,58	100	27,10	100	14,66	100	1,87	100	1,06
Vermilliopsis infundibulum (Gmelin, 1788)	12,5	0,03	0	0	0	0	0	0	87,5	0,16
Protula sp. (Risso, 1826)	0	0	0	0	0	0	0	0	25	0,01
Bivalvia										
Chlamys varia (Linnaeus, 1758)	0	0	50	0,15	100	0,32	62,5	0,14	50	0,05
Acanthocardia tubercolata (Linnaeus, 1758)	0	0	100	0,56	37,5	0,07	100	0,35	37,5	0,01
Mytilus galloprovincialis (Lamarck, 1819)	12,5	0,06	37,5	0,31	75	0,38	62,5	0,26	87,5	0,13
Musculus subpictus (Cantraine, 1835)	100	2,43	100	1,25	100	3,79	100	1,41	0	0
Modiolus adriaticus (Lamarck, 1819)	100	1,84	100	0,68	100	1,19	100	2,28	87,5	0,85

TABLE 2 (CONT.)

Species found at each sampling period (from March 2000 until May 2001) on the cement blocks immersed in Vistonikos Gulf (F: Frequency, mD: mean Dominance).

Species	Sampling period									
	March 2000		May 2000		July 2000		December 2000		May 2001	
	F	mD	F	mD	F	mD	F	mD	F	mD
Hiatella arctica (Linnaeus, 1767)	100	2,10	100	6,11	100	6,79	100	6,80	87,5	6,19
Anomia ephippium (Linnaeus, 1758)	100	6,32	100	15,50	100	16,16	100	4,31	87,5	4,64
Ostrea edulis (Linnaeus, 1758)	0	0	12,5	0,05	0	0	0	0	62,5	0,03
Chamelea gallina (Linnaeus, 1758)	0	0	0	0	0	0	0	0	12,5	0,01
Arca tetragona (Poli, 1795)	0	0	0	0	0	0	0	0	37,5	0,01
Polyplacophora										
Acanthochitona fascicularis (Risso, 1826)	0	0	0	0	0	0	0	0	12,5	0,004
Gastropoda										
Jujubinus exasperatus (Pennant, 1777)	0	0	0	0	100	0,17	75	0,19	62,5	0,02
Bittium latreillei (Payraudeau, 1826)	0	0	0	0	100	1,44	100	7,14	87,5	2,32
Pusillina radiate (Philippi, 1836)	37,5	0,23	87,5	0,81	100	2,24	100	1,38	87,5	0,05
Odostomia conoidea (Brocchi, 1814)	12,5	0,03	12,5	0,05	0	0	0	0	50	0,05
Raphitoma echinata (Brocchi, 1814)	12,5	0,03	0	0	37,5	0,04	0	0	0	0
Anatoma crispate (Fleming, 1828)	0	0	0	0	0	0	0	0	87,5	0,27
Cerithium vulgatum (Bruguiere, 1792)	0	0	0	0	0	0	0	0	37,5	0,03
Acmaea virginea (Mueller O.F., 1776)	0	0	0	0	0	0	0	0	25	0,01
Nassarius incrassatus (Stroem, 1768)	0	0	0	0	0	0	100	0,33	100	0,13
Turritella communis (Risso, 1826)	0	0	0	0	0	0	0	0	12,5	0,004
Copepoda	100	0,92	100	3,53	100	1,31	75	0,24	12,5	0,01
Cirripedia										
Balanus trigonus (Darwin, 1854)	100	1,51	100	1,82	87,5	0,85	75	0,44	100	0,32
Balanus perforatus (Bruguiere, 1789)	50	1,61	75	1,41	50	0,52	62,5	1,33	37,5	0,87
Verruca stroemia (Mueller O.F., 1776)	0	0	0	0	0	0	0	0	37,5	0,01
Malacostraca										
Microdeutopus anomalus (Rathke, 1843)	100	3,85	100	3,94	100	5,48	100	0,31	75	0,03
Caprella acanthifera (Mayer, 1890)	37,5	0,36	50	0,22	100	0,68	100	0,51	62,5	0,03
Corophium sextonae (Crawford, 1937)	100	2,01	100	2,26	100	6,80	100	26,41	100	56,13
Dexamine spinosa (Montagu, 1813)	25	0,06	75	0,15	100	1,45	37,5	0,05	62,5	0,06
Stenothoe antennulariae (Della Valle, 1893)	75	0,56	25	0,05	50	0,36	0	0	0	0
Stenothoe bosphorana (Sowinsky, 1898)	0	0	87,5	1,07	25	0,12	0	0	75	0,07
Stenothoe monoculoides (Montagu, 1815)	37,5	0,16	87,5	1,98	75	1,79	87,5	0,21	100	0,30
Stenothoen gallensis (Walker, 1904)	0	0	0	0	12,5	0,05	0	0	0	0
Metaphoxus sp. (Bonier, 1890)	0	0	0	0	25	0,02	0	0	0	0
Metaphoxus simplex (Bate, 1857)	0	0	25	0,07	12,5	0,01	12,5	0,01	0	0
Lysianassa caesarea (Ruffo, 1987)	37,5	0,09	37,5	0,07	75	0,14	100	0,91	100	0,11
Phtisica marina (Slabber, 1796)	12,5	0,06	0	0	25	0,02	0	0	0	0
Leucothoe spinicarpa (Abildgaard, 1789)	0	0	0	0	0	0	75	0,32	25	0,01
Liljeborgia dellavallei (Stebbing, 1906)	0	0	0	0	0	0	87,5	0,53	37,5	0,02
Synchelidium longidigitatum (Ruffo, 1947)	0	0	0	0	0	0	25	0,02	0	0
Iphimedia minuta (G.O. Sars, 1882)	0	0	12,5	0,01	0	0	62,5	0,11	25	0,01
Elasmopus rapax (A. Costa, 1853)	12,5	0,13	0	0	0	0	0	0	12,5	0,01
Gnathia vorax (Lucas, 1849)	0	0	12,5	0,01	12,5	0,01	50	0,09	62,5	0,03
Gnathia sp praniza (Leach, 1814)	0	0	37,5	0,05	25	0,03	37,5	0,04	37,5	0,03
Idotea baltica (Audouin, 1827)	0	0	0	0	0	0	0	0	37,5	0,01
Leptochelia savignyi (Kroyer, 1842)	50	0,16	12,5	0,01	100	0,35	87,5	2,21	87,5	0,08
Thorulus cranchii (Leach, 1817)	37,5	0,39	37,5	0,07	75	0,21	100	0,90	87,5	0,15
Athanas nitescens (Leach, 1814)	50	0,26	12,5	0,01	75	0,11	100	0,21	87,5	0,08
Alpheus dentipes (Guérin, 1832)	0	0	0	0	0	0	75	0,17	50	0,03
Galathea intermedia (Lilljeborg, 1851)	0	0	0	0	0	0	0	0	25	0,05
Pisidia longicornis (Linnaeus, 1767)	0	0	0	0	25	0,10	100	0,42	75	0,05
Pilumnus spinifer (Edwards, 1834)	0	0	0	0	50	0,05	100	0,39	100	0,17
Pilumnus hirtellus (Linnaeus, 1761)	0	0	0	0	25	0,02	0	0	0	0
Pycnogonida										
Achelia longipes (Hodge, 1864)	0	0	0	0	0	0	0	0	37,5	0,02
Echinoidea (juveniles)	0	0	0	0	75	0,26	50	0,08204	25	0,01
Ophiuroidea (juveniles)	0	0	0	0	0	0	12,5	0,01	12,5	0,004
Ascidiacae										
Didemnum sp.	0	0	0	0	0	0	12,5	0,01	50	0,01
Styela partita (Stimpson, 1852)	0	0	0	0	12,5	0,02	62,5	0,12	87,5	0,19
Styela plicata (Lesueur, 1823)	12,5	0,06	37,5	0,07	12,5	0,03	75	0,09	0	0
Phallusia mammillata (Cuvier, 1815)	12,5	0,09	12,5	0,01	25	0,02	62,5	0,08	87,5	0,07
Number of individuals		3034		5655		9461		8532		20304
Number of species		36		39		46		50		74
Shannon index (H')		2,6594		3,3801		3,741		3,45028		2,5076
Evenness index (J')		0,4117		0,5233		0,5792		0,53415		0,3882

The performance of two-way ANOVA indicated significant differences among samples for every taxa : Peracarida ($F=36.05$, $p<0.05$), Polychaetes ($F=30.14$, $p<0.05$), Eucarida ($F=12.74$, $p<0.05$), Bivalves ($F=63.06$, $p<0.05$) and Gastropods ($F=16.82$, $p<0.05$). The results of Fisher's Least Significant Difference (LSD) test are shown in Table 3. As regards Peracarida, higher differences were recorded between samples from March/2000 and May/2001, May/2000 and May/2001, March/2000 and December/2000. Polychaetes showed higher significant differences between samples from March/2000 and May/2001, May/2000 and May/2001, December/2000 and May/2001.

TABLE 3

Results of two-way ANOVA (Fisher's LSD) among samples for each taxon. (* denotes a statistically significant difference).

	Polychaeta	Peracarida	Eucarida	Bivalves	Gastropods
March/00-May/00	-67,5	*-0,444	0,446	*-0,567	*-0,901
March/00-July/00	*150,0	*-0,928	-0,039	*-0,851	*-1,03
March/00-December/00	*93,5	*-1,15	*-0,709	*-0,553	*-0,665
March/00-May/01	*344,0	*-1,695	*-0,493	*-0,902	-0,296
May/00-July/00	*82,5	*-0,484	*-0,485	*-0,283	-0,131
May/00-December/00	-26	*-0,706	*-1,154	0,014	0,235
May/00-May/01	*276,5	*-1,251	*-0,939	*-0,334	*0,605
July/00-December/00	56,5	-0,222	*-0,669	*0,297	*0,366
July/00-May/01	*194,0	*-0,767	*-0,454	-0,051	*0,736
December/00-May/01	*250,5	*-0,544	0,215	*-0,349	*0,369

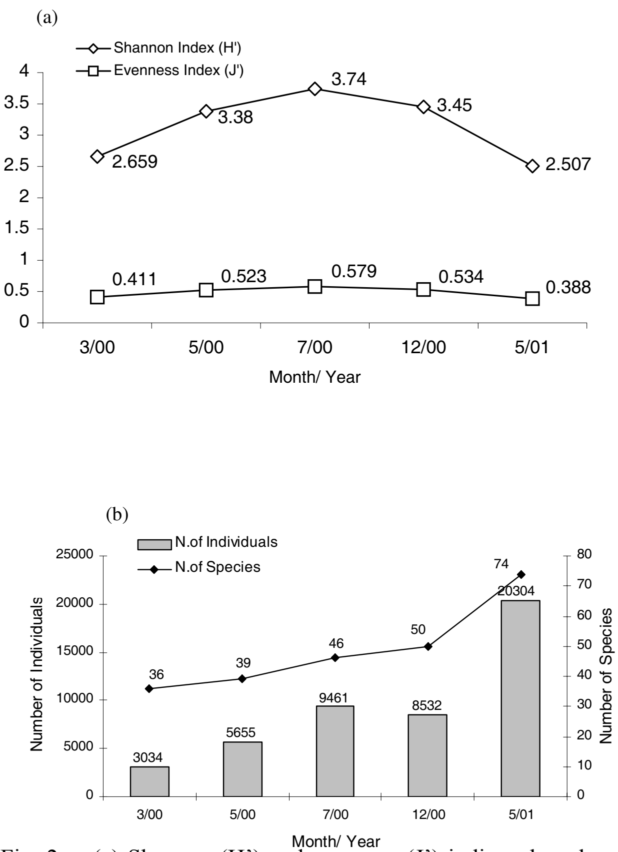

Fig. 2. – (a) Shannon (H') and evenness (J') indices, based on log_2 transformation, and (b) number of individuals and number of species for each sampling period (from March 2000 until May 2001) in Vistonikos Gulf.

Finally, comparing replicates from the top and the base of the pyramids, there were no significant differences for the four taxa except for Gastropods, which showed a significant increase in numerical abundance at the top blocks ($F=37.33$, $p<0.05$). At the top blocks algae exhibited faster growth due to better light conditions which favoured higher productivity. For instance, in July/2000, algal mean wet biomass at the top blocks was 169.8 g m^{-2} and at the base ones was 9.79 g m^{-2}. Consequently, Gastropods, which are mainly grazers, showed higher numbers at the top of the pyramids.

Serpulids, which was the main taxon in the present study, have been reported among the first fouling organisms that settle after the development of the bacterial film (BOUGIS, 1976). Moreover, in our case the dense colonization of Serpulids may be attributed to the eutrophic character of the deployment area of the reefs. Consequently a high occurrence of filter-feeder organisms is expected. Amphipods with the prevailing species *Corophium sextonae* which is also a filter-feeder organism and builds its tubes among Serpulids, using them as a shelter from predators (BARNARD, 1958). The clear dominance of the latter species in May/2001 could be attributed to its rapid maturation and long reproductive periods, lasting, sometimes, for the whole year. Additionally, turbid waters bear organic and mineral particles, which are useful to fouling organisms for tube construction and food (BARNARD, 1958). BOMBACE et al. (1994), studying settlement on artificial substrata of sessile organisms, report that the dominant organisms are always filter-feeders, including serpulids (*Pomatoceros triqueter* and *Serpula vermicularis)* ascidians and some bivalve species *(Hiatella arctica* and *Anomia ephippium)*, that they were present in this study too.

Shannon-Wiener index (H') values ranged from 2.509 to 3.741 and Evenness (J') from 0.388 to 0.579, both showing a maximum in summertime (July 2000) (figure 2 (a)). For both indices, the lowest value was recorded during May/2001 due to the clear dominance of *Corophium sextonae.* The low evenness values revealed that the community has not reached the final climax stage yet (FITZHARDINGE, & BAILEY-BROCK, 1989 ; RELINI et al., 1990 ; RELINI, ; ODUM, 1993). The pattern of total species richness and number of individuals (figure 2(b)) differed from that of species diversity (H') with the highest values recorded during the last period (May/2001), when it rose from 50 to 74 species. Such an increase was mainly attributed to Errantia (Polychaeta) and Gastropods, which were represented more frequently at this period.

The results of cluster analysis and MDS are shown in figure 3. Cluster analysis indicated two main groups at the 49.5% similarity level. The first one consisted of all replicates of the last sampling period (May/2001), due to high total species richness, while the other one comprised the remaining ones. The second group included four main subgroups of clusters at about 60% similarity level, each corresponding to all replicates of the four periods. The results of ANOSIM (R=0.948, p<0.01) indicate discrimination between the groups of samples, so the cluster is confirmed. The results of MDS agreed with those of cluster analysis. The stress value for the two dimensional MDS configuration was 0.09 indicating very good group separation (Clarke & Warwick, 1994).

(a)

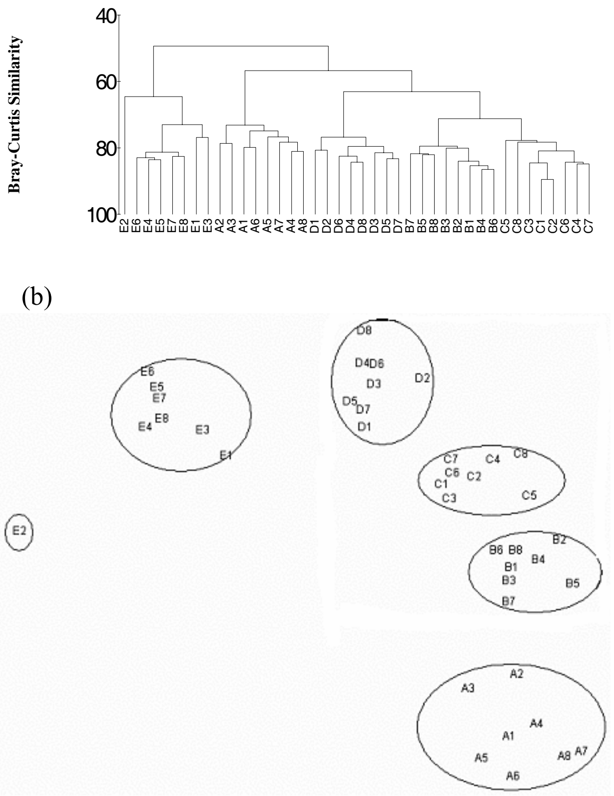

Fig. 3. – Results of (a) cluster and (b) multidimensional scaling (stress value=0.09) based on Bray-Curtis similarity index, of the cement blocks immersed in autumn 1999 (A1-A8 : March 2000, B1-B8 : May 2000, C1-C8 : July 2000, D1-D8 : December 2000, E1-E8 : May 2001).

As mentioned in the introduction, the studies that refer to the colonization of artificial reefs are very few in number. However, Fager (1971) noted that algae and invertebrates usually colonize new reef materials rapidly, although attaining an equilibrium community structure can take several years. A review of the relevant bibliography revealed that filter-feeders appeared to be the prevailing organisms in artificial reefs communities (Bombace et al., 1994 ; Relini et al., 1990). However, initial colonization, successional patterns and the final composition and abundance of benthic organisms can depend on the composition of the substrate, the season the material was deposit and on environmental variables including water temperature, chemistry and current patterns (Bohnsack & Sutherland, 1985). This study reveals that sufficient amount of nutrients is very important for the development of the colonization, as they favour the faster completion of the colonization process. The high abundance of the individuals recorded in this study (about 20.000 ind. / m2 in the last period), are not consistent with the results reported by Antoniadou et al. (2001, and, also, from unpublished data), in a similar study that was conducted in the oligotrophic system of Chalkidiki (N. Aegean Sea). While the dominant taxon in Chalkidiki was Mollusca (herbivore grazers), it is the filter-feeders that prevail in Cape Fanari (Peracarida, Serpulidae). These facts imply that the feeding types of the colonizing fauna depend mainly on the available food supply in the area where the reefs are deployed. Apparently, as Carter et al. (1985) noted, the best areas for reef deployment, in order to achieve the optimum growth of the fishing stock, are those that favour a fast qualitative and quantitative colonization growth.

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