Hydrobiologia (2006) 555:89–98

H. Queiroga, M.R. Cunha, A. Cunha, M.H. Moreira, V. Quintino, A.M. Rodrigues, J. Serôdio & R.M. Warwick (eds),
Marine Biodiversity: Patterns and Processes, Assessment, Threats, Management and Conservation
DOI 10.1007/s10750-005-1108-2

Inter-annual variability of soft bottom macrofaunal communities in two Ionian Sea lagoons

Artemis Nicolaidou[1,]*, Konstantinos Petrou[1], Konstantinos Ar. Kormas[1] & Sofia Reizopoulou[1,2]
[1]*Department of Zoology – Marine Biology, School of Biology, University of Athens, 157 84 Panepistimiopoli, Athens, Greece*
[2]*Hellenic Centre for Marine Research, Institute of Oceanography, PO Box 712, 190 13 Anavissos, Attiki, Greece*
*(*Author for correspondence: Tel.: +30-210-727-4359; Fax: +30-210-727-4359; E-mail: anikol@biol.uoa.gr)*

Key words: Lagoons, benthos, Amvrakikos, Greece, temporal variations

Abstract

Inter-annual variation in the composition of the soft bottom macrobenthic communities of two undisturbed lagoons, in Amvrakikos Gulf, Ionian Sea, Greece, was investigated over three consecutive summers. The environmental parameters that showed the greatest variability were organic carbon of the sediment and salinity. The species found were typical of lagoonal systems, the most common and abundant of which were *Abra ovata*, *Mytilaster minimus* and, in the most enclosed areas, larvae of chironomids. Multivariate analysis registered community changes, which were mostly caused by changes in species dominance. Structural community characteristics such as number of species, number of individuals and diversity did not show significant differences among years except in the stations with least water exchange with the sea.

Introduction

Coastal lagoons in the Mediterranean Sea are usually shallow water bodies receiving variable amounts of fresh water. Due to their geomorphological and hydrological characteristics, environmental conditions in the lagoons undergo frequent fluctuations on a daily and seasonal basis. This instability causes changes in the distribution of benthic species and the structure of communities (Millet & Guelorget, 1994), which are often accentuated by anthropogenic influences. The most common and serious anthropogenic impact is nutrient enrichment, which often instigates a shift from sea-grasses to opportunistic green macroalgae (Valiela et al., 1997) and leads to oxygen depletion known as 'dystrophic crises' (Amanieu et al., 1977; Izzo & Hull, 1991; Sfriso et al., 1992; Viaroli et al., 1996). Temporal variations in benthic communities associated with such eutrophication phenomena have been the subject of numerous studies (e.g., Lardicci et al., 1997; Tagliapietra et al., 1998; Koutsoubas et al., 2000; Mistri et al., 2000, 2001a; Lardicci et al., 2001). Conversely, very little is published concerning yearly changes in undisturbed lagoons (Gravina et al., 1989; Bachelet et al., 2000). Yet, the information on natural temporal variability in lagoons is also very important. Establishing patterns of community change under relatively undisturbed conditions provides some understanding of the functioning of lagoonal communities and allows a better assessment of the extent of anthropogenic disturbances.

The present paper investigates the inter-annual changes in the benthic communities of the lagoonal system of Tsoukalio/Rodia in Amvrakikos Gulf, Ionian Sea over a period of 3 years.

The lagoons are far from any point source of pollution. Kormas et al. (2001) measured monthly the nutrient and chlorophyll concentrations in the lagoons over an annual cycle and attributed the temporal changes they observed to climatic factors and to the geomorphological characteristics of the lagoons.

Materials and methods

Tsoukalio and Rodia lagoons are formed in the common delta of the rivers Arachthos and Louros, on the north coast of Amvrakikos Gulf (Fig. 1). Tsoukalio is separated from the sea by a narrow barrier with eight narrow openings allowing limited water exchange with it. Rodia is connected to Tsoukalio through a very narrow opening approximately 10 m wide and less than 2 m deep. The depth in Tsoukalio ranges from 0.6 to 1.8 m and in Rodia from 1.0 to 3.5 m. The lagoons are used for the extensive culture of various species of mullet and eels, which are trapped as fry and allowed to grow naturally in the lagoon. Small numbers of gilthead (*Sparus aurata*, L.*)* and bass (*Dicentrarchus labrax* L.) are also caught.

Sampling was carried out once in the late summer of three consecutive years (1993–1995) in Tsoukalio and two in Rodia (1994–1995), at four and three stations, respectively.

Temperature, salinity and dissolved oxygen were measured just above the bottom using temperature/salinity and oxygen probes (Yellow Spring Inc.). Five replicate benthic samples were taken at each station with a Ponar grab sampling 0.05 m^2 of the bottom. Samples were sieved through a 1 mm mesh sieve, preserved in 4% formalin, and stained with Rose Bengal. A small amount of sediment was kept for granulometry and analysis of organic carbon.

In the laboratory, the macrofauna was sorted, identified to species level where possible, and counted. Grain size analysis of the sediment was carried out according to the methods described by Buchanan (1984). Samples with high content of sand were dry sieved, while the rest were analysed with the pipette method.

Univariate and multivariate methods were used to statistically analyse the data. Values of environmental parameters were log-transformed and normalized before being subjected to ordination by means of principal component analysis (PCA). The scores of the stations on the first two axes were correlated with environmental parameters using the Spearman Rank correlation. For the macrofauna, univariate measures included number of taxa, abundance, Shannon-Wiener diversity H' ($\log_2$ basis) and Pielou's Evenness J. The significance of the differences of the above indices among the years in each station was tested with analysis of variance (ANOVA) and Tukey's least significant difference (LSD) test. Community changes were described by non-metric multidimentional scaling (MDS). This was based on a similarity matrix constructed using the Bray-Curtis similarity index. The data were first transformed by $Y = \log(x+1)$. The PCA and MDS were performed using the PRIMER v5 software package, developed in the Plymouth Marine Laboratory. The routine BIO-ENV of the above programme was used to identify potential correlation of the environmental variables and the community pattern. For the rank correlation and the ANOVA the STATISTICA software was used.

Results

Environmental parameters

The values of environmental parameters measured are shown in Table 1.Temperatures measured at the times of sampling reached 29 °C with small variation between stations. Dissolved oxygen also showed some variation (4.8–6.6 mg l^{-1}) but never dropped to hypoxic levels. Salinity, on the contrary, was more variable both in space and time. Lower salinity was observed in Rodia, where it ranged from 17 to 19.5 psu. Salinity in Tsoukalio was highest in the summer of 1993 and ranged from 24 to 27 psu and lowest in 1994 when it ranged from 18 to 22 psu. Data from the National Meteorological Service showed that total rainfall was higher by approximately 20% in the year preceding the 1994 sampling.

The sediment granulometry did not change considerably in the 3 years, with the exception of stations T3 and T4. Following limited dredging to maintain the entrance to Rodia, which preceded the 1994 sampling, station T3 changed from muddy sand to sandy mud while the opposite happened in T4, which changed from sandy mud to muddy sand. Muddy sand was also found in station T2, while in the rest of the stations the sediment was sandy mud with varying amount of sand (8.3–45.3%).

The percentage of organic carbon was inversely related to the amount of sand in the sediment, as would be expected, but it varied more with time within each station. It ranged from 5.1% in T3 in 1993 to 1.21% in R3 in 1995.

The variations in the environmental parameters are registered in the PCA (Fig. 2), where high salinity stations in 1993 are located at the lower part of the graph, and low salinity at the higher. For example, salinity at station T2 in 1993 is 27 and at R2 in 1994 is 17. Sandy stations with low organic carbon are found at high scores on Axis 1 and muddy stations with high organic carbon are found at low scores. Correlation of the scores on Axis 1 with organic carbon was highly significant ($r = -0.942$, $p < 0.001$) while the scores on Axis 2 were significantly correlated with salinity ($r = -0.817$, $p < 0.001$).

Together the two axes accounted for 70% of the variability in the environmental data. Thus, variation in the environmental conditions concerned mostly sediment organic carbon and salinity.

The benthic fauna

The number of species, the number of individuals, the diversity and the evenness at each station and year are shown in Table 1, while the abundance of each species is found in the Appendix. A total of 48 species were found over the 3 years; however, a much smaller number was found at each station at any one time. Thus, larger number of species (29) was found in T2 in 1993 while only three species in Station R1 in 1995.

Some species were present in almost all stations and times such as *Abra ovata* (Philippi), *Cyclope neritea* (L.) and *Nephtys hombergi* (Savigny). Some species had a wide distribution and reached extremely high numbers on some occasions such as *Mytilaster minimus* (Poly) with density of 10 812 indiv m^{-2}, while others were characterised by occasional appearance at high densities such as *Erichthonius difformis* Milne-Edwards (622 indiv m^{-2}), *Idothea balthica* (Pallas)(1624 indiv m^{-2}) and Chironomidae (4839 and 1180 indiv m^{-2}). As a result, the dominant species differed with time at each station. For example, in station T2 *C. neritea*, *N. hombergi* and *M. minimus* were almost equally dominant except in 1993 where *M. minimus* numbering 3456 indiv m^{-2} accounted for 55.2% of the individuals. Similarly, in station T4 1993 *C. neritea* and *N. hombergi* had an important contribution but *E. difformis* dominated with 45% of the individuals.

The changes in community composition are reflected in the MDS plot of Figure 3. No clear groups or gradients are formed, however the stations of the more enclosed lagoon Rodia are situated at the left of the diagram. There is also a shift of most 1995 stations to the left of those of the previous low salinity year. Furthermore, there is a tendency of stations with high organic carbon to be located at the upper right part of the graph. The BIOENV results showed only a very weak correlation between the environmental parameters and the pattern produced by the MDS. The highest correlation obtained ($\rho_w = 0.317$) was for the combination of temperature, salinity and % organic carbon in the sediment, while the single most important environmental variable was % organic carbon ($\rho_w = 0.285$).

The high dominance of some species, together with the number of species present, had a pronounced effect on the diversity (Table 1). Thus, lowest diversity (0.79) was observed in station R1 in 1995 with only three species and evenness J' 0.50. In fact, high dominance was responsible for the low diversity in the rest of the Rodia stations in that year. Highest diversity (3.27) was observed in T3 in 1995 with 24 species and J' 0.71.

The availability of five samples per station enabled the testing of the significance of the differences in the diversity H, the number of species S and the number of individuals N with time. The diversity showed no significant changes with time in any of the stations. The number of species differed significantly only in three stations. Station T2 in 1993 had a higher number of species than in the other 2 years ($F = 8.452$, $p < 0.01$), station T6 had a lower number of species in 1993 than in 1994 ($F = 1.939$, $p < 0.05$) and R2 had more species in 1995 than in 1994 ($F = 6.255$, $p < 0.05$). Concerning individuals, station T2 had a higher number in 1993 ($F = 10.398$, $p < 0.01$) and stations R1 and R2

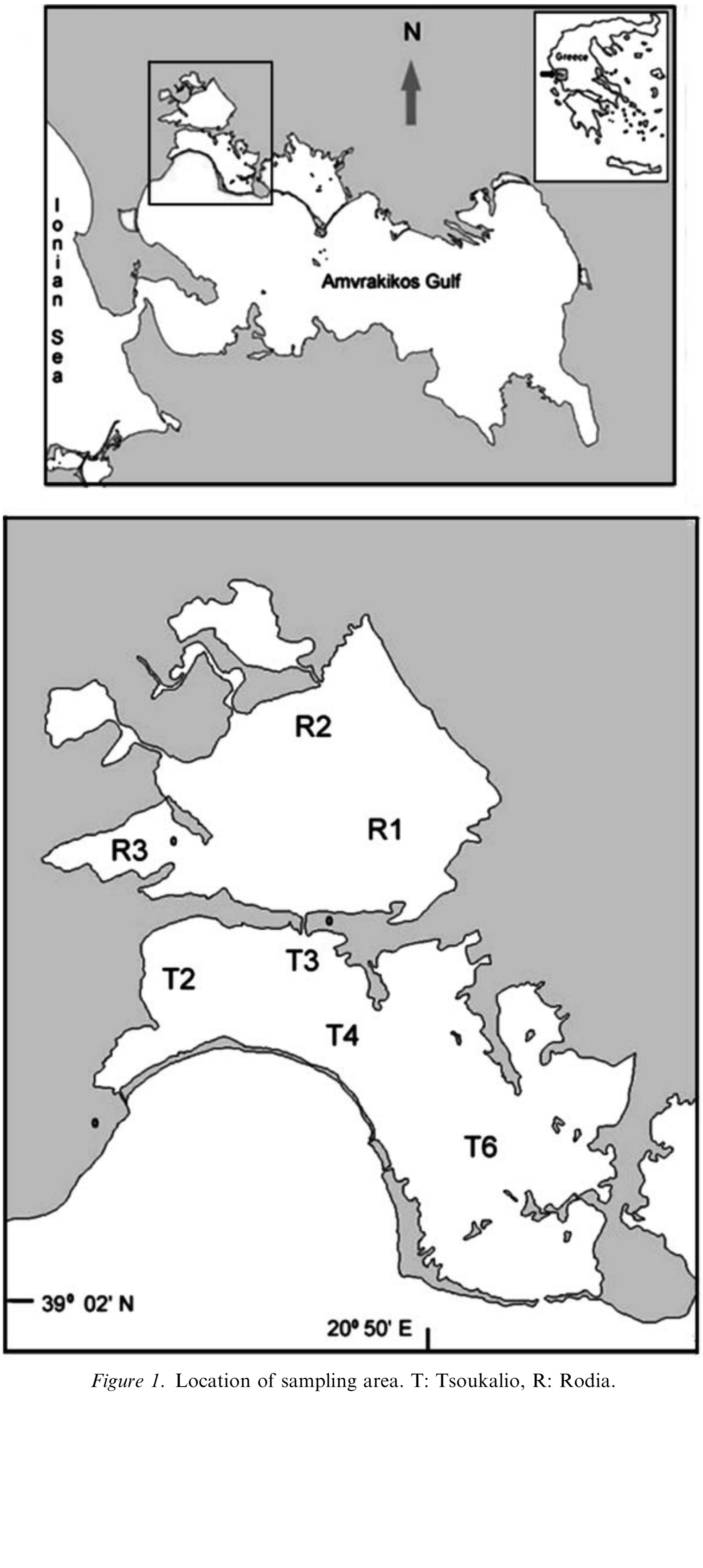

Figure 1. Location of sampling area. T: Tsoukalio, R: Rodia.

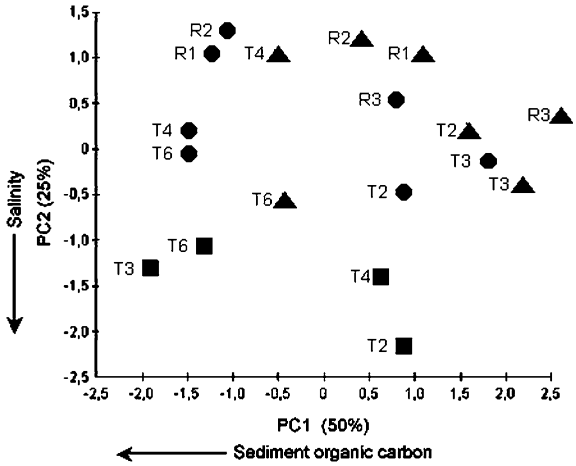

Figure 2. Plot of the first two axes of the PCA ordination on environmental parameters. ■, 1993; ●, 1994; ▲, 1995.

in 1995 ($F=93.453$, $p<0.001$ and $F=118.343$, $p<0.001$, respectively). In the rest of the stations there were no statistically significant changes in any of the ecological indices considered.

Discussion

The species composition in Tsoukalio and Rodia was similar to that of other Mediterranean lagoons (Reizopoulou et al., 1996; Mistri et al., 2001b). According to Lardicci et al. (1997) three main groups of benthic species are found in coastal brackish water lagoons, depending on their hydrologic and trophic status: euryhaline brackish water species, marine species preferring shallow sheltered areas and opportunistic species abundant in organically enriched areas. In the present case, opportunistic species were only occasionally present and then only in small numbers, confirming the undisturbed conditions of the lagoons. The second group was represented by species such as *Loripes lacteus* (L.) and *Nephtys hombergi*. However, the species with the highest abundance were those typical of eurythermal and euryhaline communities such as *Abra ovata*, and *Mytilaster minimus* and, in the most enclosed stations, larvae of Chironomidae. The dominance of these species changed from year to year and the differences in community were registered as shifts of stations in the MDS. Thus, the community pattern was regulated by certain species, as was also observed in other lagoons (Mistri et al., 2001a).

Of the environmental parameters studied, those, which showed the greatest variability, were sediment organic carbon and salinity. However, neither of them appeared directly related with the benthic community pattern of the lagoons. This is not surprising since the environmental measurements represent only an instance in time, while the benthic community reflects the conditions, which prevailed throughout the year prior to sampling. Thus, yearly ranges of environmental factors, were they available, might have shown a better relationship with the benthic fauna. In fact, there was a definite separation of the innermost Rodia stations, in which conditions are expected to be more variable in time due to their seclusion. Guelorget & Perthuisot (1983) introduced the concept of 'confinement' of coastal lagoons, to describe the degree of their isolation and the time required for the renewal of their marine elements. The effect of 'confinement' on benthic communities in coastal lagoons has been documented by many authors (Gravina et al., 1989; Guelorget et al., 1994; Reizopoulou et al., 1998; Koutsoubas et al., 2000). In addition, changes in the regime of freshwater input are known to influence drastically the macrobenthic communities (Stora et al., 1995). According to Mistri et al. (2000) the communities in inner parts of lagoons are physically regulated, while Bachelet et al. (2000) recognized that the higher the water exchange in a lagoon the more stable their benthic communities.

The most enclosed stations were also those, which showed some statistically significant differences in the number of species and individuals from year to year. On the other hand, diversity did not vary significantly with time in any of the stations. This confirms that species diversity is not a sensitive parameter in expressing variations in coastal lagoons. Reizopoulou et al. (1996) found that it was inefficient in distinguishing even between undisturbed and impacted lagoons. Due to their environmental instability and natural enrichment, coastal lagoons can be considered as naturally stressed environments where diversity is maintained at low levels. Nevertheless, a fact, which should not be overlooked, is the patchy distribution of some species, which, in the present case, would have increased the variability among replicate samples.

Table 1. Environmental parameters and ecological indices at each station and year

Station	T2			T3			T4			T6			R1		R2		R3	
Year	93	94	95	93	94	95	93	94	95	93	94	95	94	95	94	95	94	95
Temperature °C	26.5	28.0	21.0	26.5	27.0	19.0	27.0	29.0	21.0	27.0	28.0	20.0	26.5	19.0	27.0	19.0	25.0	18.5
Salinity psu	27.0	20.0	20.0	27.5	18.0	22.0	24.0	21.0	20.0	26.0	22.0	26.0	18.0	19.5	17.0	19.0	18.0	19.0
Dissolved oxygen mg/l	4.8	6.4	5.6	6.2	6.0	6.0	4.8	6.2	5.6	6.2	6.0	6.5	6.4	6.0	6.2	6.3	6.6	6.0
% Sand	66.7	60.3	56.6	18.0	79.0	76.0	60.1	11.7	15.4	13.1	8.3	28.0	23.3	14.2	12.0	25.1	45.3	77.5
% Organic carbon	1.7	2.0	1.6	5.1	1.5	1.6	2.0	4.2	4.0	3.7	4.2	3.8	5.0	1.2	4.1	3.1	2.3	1.2
Number of species (S)	29	6	7	16	22	24	23	13	12	11	9	12	7	3	10	12	16	16
Number of individuals/m2 (N)	6260	96	292	552	1682	1808	1404	380	248	1215	556	564	1900	312	184	1720	5232	16744
Diversity (H')	2.32	2.2	2.2	2.86	3.12	3.27	3.09	2.25	3.09	2.04	1.91	2.42	1.26	0.79	3.05	1.65	2.16	1.35
Evenness (J)	0.48	0.71	0.79	0.72	0.7	0.71	0.68	0.61	0.862	0.59	0.6	0.67	0.45	0.5	0.92	0.46	0.53	0.34

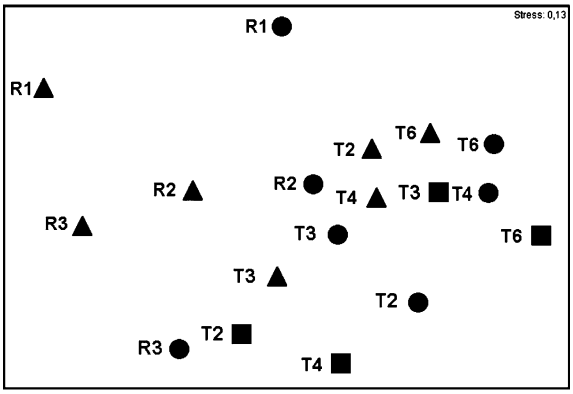

Figure 3. Plot of non-metric MDS ordination of stations based on species abundances. ■, 1993; ●, 1994; ▲, 1995.

Changes in community composition as shown by the MDS and at the same time constancy in ecological indices, suggest that most of the observed variability is caused by changes in the relative abundance of the species. Obviously, the increase in abundance of some species was compensated by the decrease in others. According to Mistri et al. (2001a) compensatory mechanisms in benthic communities in lagoons make them resistant to environmental changes, which generate fluctuations in species abundance.

Changes in the dominance of species could be caused not only by changes in the physical environment, but also by biological interactions such as competition and predation, or they may be related to intrinsic characteristics of the species. For example, interspecific competition between species of amphipods, has been observed by Nicolaidou & Karakiri (1989) in another lagoon of Amvrakikos Gulf. Furthermore, *Abra ovata* is thought to adopt different life strategies depending on environmental characteristics (Nicolaidou & Kostaki-Apostolopoulou, 1988; Sprung, 1994). Clarifying the mechanisms, which produce the changes in dominance of species in coastal lagoons, will contribute towards better understanding of the dynamics of the benthic communities.

Acknowledgements

The authors would like to thank the Tsoukalio–Rodia Lagoons Fishermen Cooperatives for their valuable assistance during sampling. The project was supported financially by the Greek Ministry of Agriculture.

References

Amanieu, M., O. Guerlorguet & P. Michel, 1977. Richesse et diversite de la macrofaune benthique d'une lagune littorale mediterraneenne. Vie Milieu 27: 85–109.

Bachelet, G., X. De Montaudouin, I. Auby & P. Labourg, 2000. Seasonal changes in macrophyte and macrozoobenthos assemblages in three coastal lagoons under varying degrees of eutrophication International Committee for Exploration of the Seas. Journal of Marine Sciences 57: 1495–1506.

Buchannan, J. B., 1984. Sediment analysis. In Holme, N. A. & A. D. McIntyre (eds.) Methods for the study of benthos. Blackwell, Oxford: 41–65.

Gravina, M. F., G. D. Ardizzone, F. Scaletta & C. Chimenz, 1989. Descriptive analysis and classification of benthic communities in some Mediterranean coastal lagoons (Central Italy). Marine Ecology 10: 141–166.

Guelorget, O. & J. P. Perthuisot, 1983. Le domain paralique Expression geologique, biologique du confinement. Travaux du Laboratoire de Geologie, Ecole Normale Superieure de Paris 16, Paris 136 pp.

Guelorget, O., J. P. Perthuisot, N. Lamy & A. Lefebvre, 1994. Structure et organisation de l' Etang de Thau d'apres la faune benthique (macrofaune-meiofaune) Relations avec le confinement. Oceanoligica Acta 17: 105–114.

Izzo, G. & V. Hull, 1991. The anoxic crises in dystrophic processes of coastal lagoons: an energetic explanation. In Rossi, C. & E. Tiezzi (eds.) Ecological physical chemistry. Elsevier, Amsterdam: 559–572.

Kormas, K. A., A. Nicolaidou & S. Reizopoulou, 2001. Temporal variations of nutrients, chlorophyll a and particulate organic matter in three coastal lagoons of Amvrakikos Gulf (Ionian Sea, Greece). Marine Ecology 22: 201–213.

Koutsoubas, D., C. Dounas, C. S. Arvanitidis, S. Kornilios, G. Petihakis, G. Triantafyllou & A. Eleftheriou, 2000. Macrobenthic community structure and disturbance assessment in Gialova Lagoon, Ionian Sea. International Committee for Exploration of the Seas. Journal of Marine Sciences 57: 1472–1480.

Lardicci, C., S. Como, S. Corti & F. Rossi, 2001. Recovery of the macrozoobenthic community after severe dystrophic crises in a Mediterranean coastal lagoon (Orbetello, Italy). Marine Pollution Bulletin 42: 202–214.

Lardicci, C., F. Rossi & A. Castelli, 1997. Analysis of macrozoobenthic community structure after severe dystrophic crises in a Mediterranean coastal lagoon. Marine Pollution Bulletin 34: 536–547.

Millet, B. & O. Guelorget, 1994. Spatial and seasonal variability in the relationships between benthic communities and physical environment in a lagoon ecosystem. Marine Ecology Progress Series 108: 161–174.

Mistri, M., E. A. Fano, G. Rossi, K. Caselli & R. Rossi, 2000. Variability in macrobenthos communities in the Valli di Comacchio, Northern Italy, a hypereutrophized lagoonal ecosystem. Estuarine, Coastal and Shelf Science 51: 599–611.

Mistri, M., E. A. Fano & R. Rossi, 2001a. Redundancy of macrobenthos from lagoonal habitats in the Adriatic Sea. Marine Ecology Progress Series 215: 289–296.

Mistri, M., R. Rossi & E. A. Fano, 2001b. Structure and secondary production of a soft bottom macrobenthic community in a brackish lagoon (Sacca di Goro, north-eastern Italy) Estuarine. Coastal and Shelf Science 52: 605–616.

Nicolaidou, A. & M. Karakiri, 1989. The distribution of Amphipoda in a brackish-water lagoon in Greece. Marine Ecology 10: 131–139.

Nicolaidou, A. & M. Kostaki-Apostolopoulou, 1988. The growth of *Abra ovata* in a brackish water lagoon. Vie Marine 9: 7–10.

Reizopoulou, S., K. A. Kormas & A. Nicolaidou, 1998. Benthic biodiversity in five coastal brackish water lagoons of Amvrakikos Gulf, Hellas. Rapports de Committee Internationale de Mer Mediterranee 35: 580–581.

Reizopoulou, S., M. Thessalou-Legaki & A. Nicolaidou, 1996. Assessment of disturbance in Mediterranean lagoons: An evaluation of methods. Marine Biology 125: 189–197.

Sfriso, A., B. Pavoni, A. Macromini & A. A. Orio, 1992. Macroalgae, nutrient cycles, and pollutants in the lagoon of Venice. Estuaries 15: 517–528.

Sprung, M., 1994. Observations on the life cycle of *Abra ovata* on an intertidal mud flat in Portugal. Journal of the Marine Biological Association of U.K. 74: 919–925.

Stora, G., A. Arnoux & M. Galas, 1995. Time and spatial dynamics of Mediterranean lagoon macrobenthos during an exceptionally prolonged interruption of freshwater inputs. Hydrobiologia 300/301: 123–132.

Tagliapietra, D., M. Pavan & C. Wagner, 1998. Macrobenthic community changes related to eutrophication in Pallude della Rosa (Venetian lagoon, Italy). Estuarine, Coastal and Shelf Science 47: 217–226.

Valiela, I., J. McClelland, J. Hauxwell, P. J. Behr, D. Hersh & K. Foreman, 1997. Macroalgal blooms in shallow estuaries: controls and ecophysiological and ecosystem consequences Limnology and Oceanography 42: 1105–1118.

Viaroli, P., M. Naldi, C. Bondavalli & S. Bencivelli, 1996. Growth of the seaweed *Ulva rigida* C Agardh in relation to biomass densities, internal nutrient pools and external nutrient supply in the Sacca di Goro lagoon (Northern Italy). Hydrobiologia 329: 93–103.

Appendix

Table A1. Species abundance (indiv/m^2), in each station and year

Stations	T2			T3			T4			T6			R1		R2		R3	
Years	93	94	95	93	94	95	93	94	95	93	94	95	94	95	94	95	94	95
Species																		
Polychaeta																		
Capitella capitata (Fabricius, 1780)	68	0	0	16	0	0	0	0	4	0	0	4	0	0	0	0	0	0
Harmothoe spinifera (Ehlers, 1864)	132	4	0	24	64	20	52	4	8	15	0	4	0	0	0	0	8	0
Microspio mecznikovianus (Claparede, 1868)	12	0	0	20	12	0	12	0	0	55	4	0	0	0	0	0	0	0
Naineris laevigata Grube, 1855	1336	0	0	0	8	52	12	0	0	5	0	0	0	0	28	0	8	0
Nephtys hombergi (Savigny, 1820)	140	16	56	164	140	64	84	116	48	270	152	76	40	0	8	0	60	48
Nereiphylla rubiginosa (Saint-Joseph, 1888)	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ophiodromus pallidus (Claparede, 1868)	16	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0
Pectinaria koreni (Malmgren, 1865)	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0
Phyllodoce sp.	48	0	16	8	0	32	4	0	0	0	0	4	0	0	0	20	0	260
Platynereis dumerilii	396	0	0	0	24	328	72	0	0	0	0	0	0	0	0	12	0	0

Continued on p. 97

Table A1. (Continued)

Stations	T2			T3			T4			T6			R1		R2		R3	
Years	93	94	95	93	94	95	93	94	95	93	94	95	94	95	94	95	94	95
Aoudouin & Milne-Edwards, 1834																		
Prionospio malmgreni	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	8	0
Claparede, 1870																		
Protoaricia oerstedi	0	0	0	0	12	0	0	0	0	0	0	0	0	0	12	0	0	0
(Claparede, 1864)																		
Pseudopolydora antennata	0	0	0	4	0	0	0	4	0	25	0	0	0	0	0	0	0	0
(Claparede, 1870)																		
Schistomeringos rudolphi	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
(Delle Chiaje, 1828)																		
Syllis gracilis	32	0	0	0	0	4	36	0	0	0	0	0	0	0	0	0	0	0
Grube, 1840																		
Mollusca																		
Abra ovata	56	0	12	16	308	20	12	16	44	10	20	236	924	0	36	40	600	32
(Philippi, 1836)																		
Bittium reticulatum	0	4	0	0	0	20	0	0	4	0	0	0	0	0	0	8	0	68
(Da Costa, 1788)																		
Cerastoderma glaucum	44	0	16	80	4	12	8	40	12	55	268	84	4	0	4	8	4	0
(Poiret, 1789)																		
Cyclope neritea	36	16	144	160	100	64	40	168	44	90	92	104	8	0	16	68	28	28
(Linnaeus, 1758)																		
Gastropoda juv.	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0
Gibbula adansonii	40	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	4
(Pyraudeau, 1826)																		
Haminea hydatis	0	0	0	0	4	0	0	4	0	0	0	0	0	0	0	0	0	0
(Linnaeus, 1758)																		
Hinia reticulata	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0
(Risso, 1826)																		
Hydrobia sp.	4	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0
Loripes lacteus	156	0	28	24	164	160	20	0	20	0	0	8	904	48	24	40	0	316
(Linnaeus, 1758)																		
Mytilaster minimus	3456	16	20	0	188	576	52	0	12	0	4	0	0	8	36	288	2040	10812
(Poli, 1795)																		
Philine aperta	12	0	0	0	12	0	0	4	0	0	0	0	0	0	0	0	0	4
(Linnaeus, 1767)																		
Retusa truncatula	0	0	0	0	0	4	0	0	8	0	0	0	0	0	0	8	0	0
(Bruguiere, 1792)																		
Rissoa venusta	8	0	0	0	0	20	0	0	0	0	0	4	0	0	0	0	0	8
(Philippi, 1844)																		
Venerupis aurea	12	0	0	4	24	0	0	0	0	0	4	0	0	0	0	0	0	0
(Gmelin, 1791)																		

Continued on p. 98

Table A1. (Continued)

Stations	T2			T3			T4			T6			R1		R2		R3	
Years	93	94	95	93	94	95	93	94	95	93	94	95	94	95	94	95	94	95
Amphipoda																		
Corophium acherusicum (A. Costa, 1853)	4	0	0	0	0	16	8	0	0	0	0	0	0	0	0	0	0	4
Dexamine spinosa Montagu, 1813	28	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0
Ericthonius difformis Milne-Edwards, 1830	0	0	0	0	0	52	632	0	0	10	0	0	0	0	0	0	0	0
Microdeutopus sp.	16	0	0	4	40	12	120	4	0	0	4	0	0	0	12	0	76	4
Oedicerotidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0
Isopoda																		
Idotea balthica (Pallas)	0	0	0	0	0	20	100	0	4	0	0	0	0	0	0	0	1624	0
Sphaeroma ghigii (Arcangeli, 1941)	0	0	0	0	12	12	0	0	0	0	0	0	0	0	0	0	712	4
Tanaidacea																		
Leptochelia savignyi (Kroyer, 1842)	76	0	0	0	0	0	68	0	0	0	0	0	0	0	0	0	0	0
Cumacea																		
Iphinoe serrata (Norman, 1867)	0	0	0	4	0	0	4	4	0	670	0	0	0	0	0	0	4	0
Decapoda																		
Hippolyte sp.	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paguridae	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
Miscellanea																		
Actiniaria	8	40	0	12	536	208	36	8	40	0	0	28	12	0	8	24	8	4
Chironomidae	8	0	0	0	0	4	0	0	0	0	0	0	0	256	0	1180	8	4836
Copepoda	4	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Echinodermata	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0
Nemertea	96	0	0	4	10	100	20	4	0	10	0	0	8	0	0	24	36	312
Phoronis sp.	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
Turbellaria	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0