Original scientific article
Received: 2012-10-29

UDK 597:591.91(262.32)

VERTICAL DISTRIBUTION OF SOFT BOTTOM MACROZOOBENTHOS IN THE GULF OF TRIESTE (NORTHERN ADRIATIC SEA)

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ABSTRACT

The macrozoobenthos is commonly considered to be the main agent of bioturbation in shallow water, and responsible for the enhancement of the interchange of both dissolved and gaseous species between the pore waters and the upper water column. As reported by several authors, this basic phenomenon is usually investigated by describing the vertical distribution of macrobenthic organisms. For this purpose, a site located in the central part of the Gulf of Trieste (depth = 21 m) was selected and, during 1999/2000, 9 core samples were collected in triplicate to a maximum depth of 20 cm. The vertical distribution of the macrozoobenthic communities was described by applying the bioturbation activity index (BA). The vertical distribution of macrofauna showed a clear decrease in both number of taxa and abundance when moving downcore. The BA suggested that surficial, detritus-feeding polychaetes have a pivotal role in the bioturbation of muddy sediments, whereas suspension-feeding molluscs are also important if the only top layer is considered. Taking into account the overall results, it can be stated that the BA index application based on the core sampling technique, could be a useful tool in describing bioturbation in the northern Adriatic soft bottom sediments.

Key words: macrozoobenthos, vertical zonation, bioturbation index, feeding guilds, Gulf of Trieste, Adriatic Sea

DISTRIBUZIONE VERTICALE DEL MACROZOOBENTHOS DI FONDO MOBILE NEL GOLFO DI TRIESTE (ALTO ADRIATICO)

SINTESI

Il macrozoobenthos viene comunemente considerato il maggiore agente dei fenomeni di bioturbazione nelle acque costiere, il quale facilita gli scambi della sostanza disciolta e gassosa tra le acque interstiziali e la sovrastante colonna d'acqua. Per tale motivo, questi fenomeni di scambio possono essere indagati in via preliminare attraverso la descrizione della distribuzione degli organismi bentonici lungo il profilo sedimentario. A tale scopo è stato selezionato un sito di studio nella parte centrale del Golfo di Trieste. Durante il periodo 1999-2000 sono stati condotti 9 campionamenti, considerando un adeguato numero di repliche (3 repliche per campionamento), alla massima profondità di 20 cm nel sedimento. In questi campioni è stata descritta la distribuzione verticale del macrozoobenthos e inoltre è stato applicato un indice di bioturbazione (BA). La distribuzione verticale della macrofauna indica un chiaro decremento degli organismi dagli strati superficiali verso quelli più profondi, sia in termini di taxa presenti che di abbondanza degli individui. L'applicazione dell'indice di bioturbazione ha fatto rilevare che i policheti detritivori di superficie possono assumere un ruolo principale nella bioturbazione dei sedimenti fangosi dell'area centrale del Golfo di Trieste, cui fanno seguito i molluschi sospensivori nei soli strati superficiali. Pertanto l'applicazione di tale indice, anche accoppiato alla tecnica di campionamenti con il carotaggio, potrebbe risultare un utile strumento per descrivere la bioturbazione nei fondi mobili dell'Alto Adriatico.

Parole chiave: macrozoobenthos, zonazione verticale, indice di bioturbazione, categorie trofiche, Golfo di Trieste, Mare Adriatico

INTRODUCTION

One of the main factors affecting the species composition within a macrobenthic community is the nature and quality of the substratum (Gray, 1974). It is well established that when fine sediments prevail, the presence of an interstitial fauna is greatly inhibited due to the high packing of the substratum, poor water circulation and, as a consequence, low oxygen content. Conversely, medium and fine sands are characterised by the presence of an abundant fauna, which shows several adaptive strategies (Gray, 1981). The fauna plays a pivotal role in physical phenomena such as bioturbation through building tubes, constructing burrows, feeding pits, transports sediments, thus enhancing the exchange of dissolved (nutrients, trace element etc.) and gas phases between the sea bed and water column. In addition, some abiotic factors (*e.g.*, sedimentation rates, quality and quantity of organic matter, OM) can influence the trophic structure, abundance and biomass of the macrobenthic community and the pattern of colonisation through the sediment layers (Pearson & Rosenberg, 1978; Gray & Mirza, 1979; Warwick, 1986; Marsh & Tenore, 1990; Dauer & Alden, 1995; Flach & Heip, 1996; Dauer, 1997; Dauwe *et al*., 1998). In particular, the importance of OM becomes evident when it increases and generates more biomass and density of the benthic organisms; under these conditions, dystrophic events – such as hypoxia or anoxia and the strong and prolonged pycnocline of the water column – cause massive reductions and/or elimination of the benthic fauna (Simonini *et al*., 2004) and important changes in both the physical and chemical characteristics of the top sediment layers (Heip *et al*., 1995).

To date, knowledge about bioturbation is mainly related to the consequences and the influence on abiotic factors such as physical-chemical parameters, whereas the role of vertical distribution of macrozoobenthic organisms in the sediment has scarcely been investigated. This work provides a first analysis of the vertical zonation of the macrozoobenthos in the muddy bottom sediments of the Gulf of Trieste, followed by the application of the bioturbation activity index (BA).

MATERIAL AND METHODS

Study area

The Gulf of Trieste is located at the northwestern part of the Adriatic Sea, covers an area of about 600 km^2 and reaches a maximum depth of about 25 m in its central part. As reported in Ogorelec *et al*. (1991), 10 % of the total area has a depth < 10 m. The water circulation system, which is affected by the action of both winds (ENE) and tides (average and spring ranges of 0.5 and 1 m, respectively), is anticlockwise and acts on deep-water layers, which flow permanently at 2–3 cm s^{-1}. Wind-driven superficial currents differentiate the uppermost water mass, down to a depth of about 5 m, flowing anticlockwise with easterly winds and clockwise with westerly winds (Stravisi, 1983). The average salinity ranges between 33 to 38 at the surface and 36 to 38.5 at the bottom (Stravisi, 1983; Cardin & Celio, 1997). The Isonzo River represents the primary freshwater input, with an average annual flow rate estimated at the river mouth (period 1998–2005) of 91.2 m^3 s^{-1} (1.1–665.9 m^3 s^{-1}; Comici & Bussani, 2007). The riverine discharge shows significant seasonal variations with two typical flood events: a relatively long spring maximum (March–May) and a shorter, but more intense, autumn maximum (September–November), when the rate of flow can exceed 2,500 m^3 s^{-1} (RAFVG, 1986). The annual water temperatures range from 8 to 24 °C and from 8 to 20 °C at the surface and bottom, respectively. Tidal amplitude is about 1.5 m, which is the highest of the Mediterranean Sea.

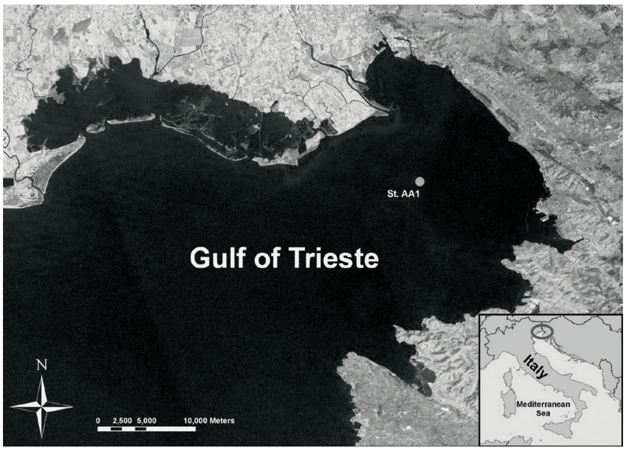

Fig. 1: Gulf of Trieste and sampling station AA1.
Sl. 1: Tržaški zaliv in vzorčevalna postaja AA1.

The sedimentation rate is mainly controlled by river input rather than by marine currents (Brambati & Catani, 1988). Measurements based on ^{210}Pb determinations estimated it to be 1.84–2.1 mm a^{-1} in the mid-Gulf (station AA1, Ogorelec *et al*., 1991; Covelli *et al*., 2001), and up to 2.5 mm a^{-1} adjacent to the river mouth (Ogorelec *et al*., 1991). The soft bottom composition is not homogeneous and varies from sands with patches of beach rocks to mud, predominantly detrital (Brambati *et al*., 1983). The widespread benthic biocoenoses of the Gulf belong to the DC (Détritique Cotier), DE (Détritique Envasé) and VTC (Vases Terrigenes Cotieres) biocoenoses (Orel & Mennea, 1969; Solis-Weiss *et al*., 2004).

Three main natural factors influence the composition, evolution and persistence of marine life in the Gulf of Trieste: strong winds (mainly Bora), stratification of the water column, leading to occasional hypoxia and/or anoxia events, as well as occasional mucilage production (Solis-Weiss *et al*., 2001).

This study was carried out at one station (AA1) located in the middle of the Gulf of Trieste (45° 39′ 48″ N, 13° 35′ 42″ E) at a depth of about 21 m (Fig. 1). The main solid phase and chemistry characteristics of AA1 are reported in Emili *et al*. (2011). The sediment texture consists of clayey silt (< 63 µm, from 87 to 98 %; Hines *et al*., 2000), whereas C_{tot} and C_{org} account for about 5.1 and 1.17 %, respectively. Previous studies reported the occurrence of hypoxia and anoxia events, such as mucilage aggregate deposition at the bottom (Aleffi *et al*., 1992).

Sampling

Benthic samples were collected in 1999 (February, June and August) and 2000 (January, June, July, August, October and December) using a KC Haps bottom corer (KC-Denmark, Silkeborg, Denmark) with a polycarbonate sample tube (i.d. = 13.3 cm; sample area = 127 cm^2). In order to assess the vertical distribution, three replicate samples were randomly collected. After sediment collection, each core was sectioned in slices (0-1, 1-3, 3-5, 5-10 and 10-20 cm). The sediment was sieved through a 0.5 mm mesh and subsequently stored in 4 % formaldehyde following standard methods (Holme & McIntyre, 1984). Faunal samples were sorted and identified at the lowest possible taxonomical level.

Analyses

In order to analyse the structure of the communities, several univariate techniques are commonly employed. Among these the abundance, the number of taxa and the diversity index were previously used (Shannon-Wiener diversity index, H′, on log_2 basis; Shannon & Weaver, 1949). The feeding guild analysis was based on Fauchald & Jumars' (1979), Bachelet's (1981) and Macdonald's *et al*. (2010) definitions.

Bioturbation activity (BA) was estimated by means of the scoring system outlined in Swift (1993) and Grehan *et al*. (1994). Briefly, the scores were assigned to all taxa on the basis of individual feeding mode (0-4), mobility (0-3) and burrowing capability (0-4); the maximum value of 11 represents the species characterised by the greatest potential capacity to cause sediment bioturbation.

Tab. 1: Minimum, maximum and mean value of abundance, number of taxa and H′ of a core.
Tab. 1: Minimalna, maksimalna in povprečna vrednost števila osebkov, števila taksonov in H′ jedra vrtine.

	Abundance	No. Taxa	H′
Min	52	15	3.26
Max	270	50	4.65
Mean	163	32	3.98

RESULTS

A total of 1,471 organisms belonging to 90 taxa were identified in the 27 sampled cores. Table 1 displays minimum, maximum and mean values of abundance, number of taxa and H′ in the cores. The most abundant taxa were polychaetes (57.8 %) followed by molluscs (24.4 %) and crustaceans (13.2 %), thus accounting together for the 95.4 % of the specimens. Other taxa such as

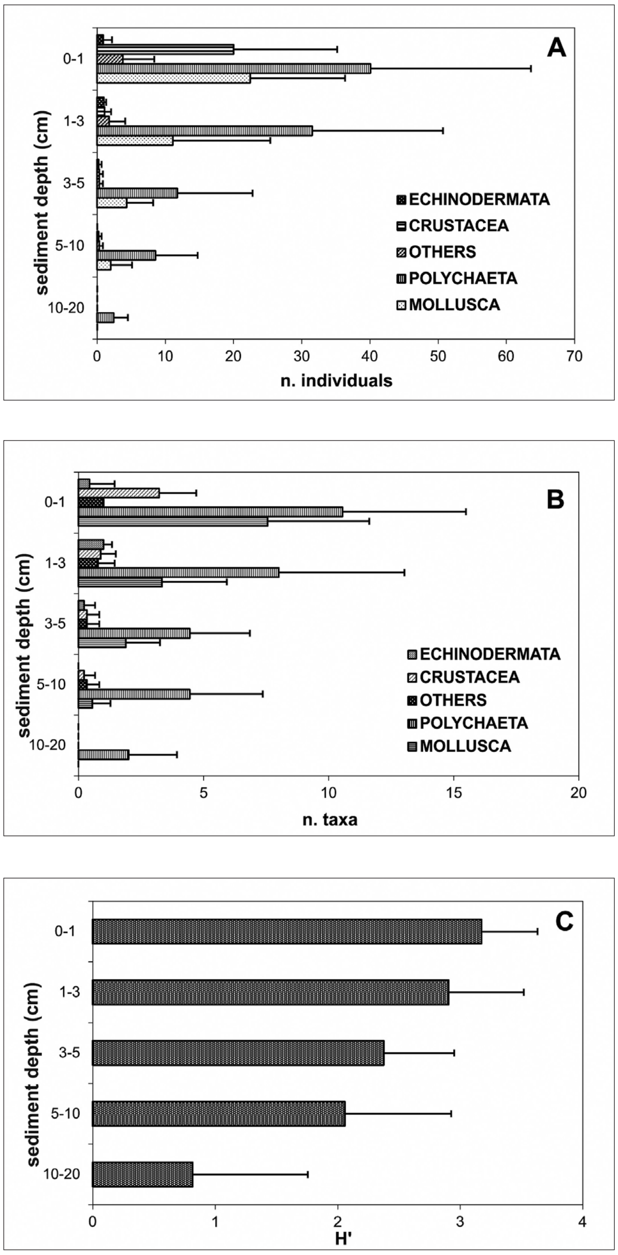

Fig. 2: (A) Average value of abundance, (B) number of main taxa and (C) H′ for each layer of the core.
Sl. 2: (A) Povprečno število osebkov, (B) število najpomembnejših taksonov in (C) H′ za vsak sloj jedra vrtine.

echinoderms, sipunculids, ascidians, anthozoans and nemertines were poorly represented. The polychaetes were also the dominant taxon in term of number of species (44 sp.), followed by molluscs (28 sp.) and crustaceans (11 sp.); together these constituted 91 % of the species.

The vertical distribution of macrofauna showed a clear decrease in both taxa and abundance moving downcore. At the 10-20 cm layer, only polychaetes were found, whereas echinoderms disappeared below 5 cm. H' dropped at the 10-20 cm layer (Fig. 2).

Feeding guilds were mostly represented by suspension and surface deposit feeders, both in terms of abundance and taxa, followed by carnivores, sub-surface deposit feeders and grazers. Suspension feeders were the dominant guild at the top. Surface deposit feeders showed similar abundance in 0-1 and 1-3 cm layers, but dropped in 3-5 cm. Carnivores and sub-surface deposit feeders showed a constant decrease down core, whereas grazers were scarcely represented and disappeared below 10 cm (Fig. 3).

As reported in Table 2, twelve species represented about 50 % of the total abundance. Among these, some suspension feeders such as the bivalves *Corbula gibba* and *Venerupis aurea* and the amphipods *Ampelisca* spp. were mostly abundant at the topmost layers (0-3 cm). *C. gibba* and *Ampelisca spp.* completely disappeared after 3 cm while *V. aurea* was found until 5 cm (Fig. 4). The bivalve *Mysella bidentata* and several surface deposit feeders species such as the polychaetes *Laonice cirrata*, *Prionospio cirrifera* and the sipunculid *Aspidosiphon muelleri muelleri* gradually decreased with depth, until 10 cm. *M. bidentata* and *P. cirrifera* peaked the abundance in 1-3 cm. Taking into consideration the carnivores, the polychaetes *Lumbrineris gracilis* and *Eunice vittata* gradually decreased from the top till 5 and 20 cm respectively, whereas the *Lumbrineris latreilli* distribution did not show any significant trend along the se-

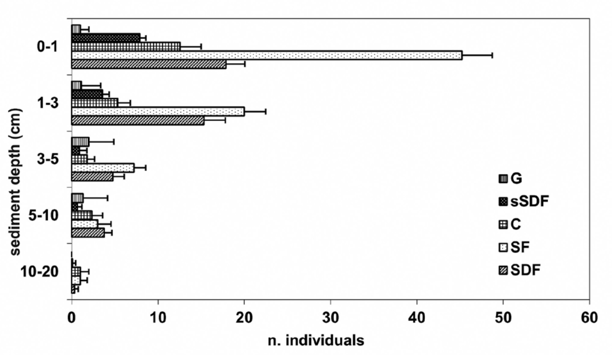

Fig. 3: Average abundance of feeding guilds for each layer of the core.
Sl. 3: Povprečno število osebkov prehranskega ceha za vsak sloj jedra vrtine.

Tab. 2: Total abundance (A), frequency (F), percentage (%) and cumulative percentage (% cum) of the twelve most abundant species. Feeding guilds (F. guilds): SDF = surface deposit feeders, SF = suspension feeders, G = grazers, sSDF = subsurface deposit feeders, C = carnivores. Taxa: Cru = crustaceans, Mol = molluscs, Pol = polychaetes.
Tab. 2: Skupno število osebkov (A), pogostost (F), odstotki (%) in kumulativni odstotki (% cum) dvanajstih vrst z največjim številom osebkov. Prehranski cehi (F. guilds): SDF = površinski detritivori, SF = suspenziofagi, G = strgalci, sSDF = podpovršinski detritivori, C = karnivori. Taksoni: Cru = raki, Mol = mehkužci, Pol = mnogoščetinci.

F. guilds	Taxa	Species	A	F	%	% cum
SDF	Pol	*Prionospio cirrifera*	162	7	11.0	11.0
SF	Cru	*Ampelisca* spp.	135	9	9.2	20.2
SF (SDF)	Mol	*Mysella bidentata*	135	7	9.2	29.4
SF	Mol	*Corbula gibba*	57	9	3.9	33.2
SDF	others	*Aspidosiphon muelleri*	51	7	3.5	36.7
G	Mol	*Hyala vitrea*	44	7	3.0	39.7
SF	Mol	*Venerupis aurea*	36	7	2.4	42.2
sSDF	Pol	*Maldane glebifex*	32	6	2.2	44.3
C	Pol	*Lumbrineris gracilis*	27	4	1.8	46.2
SDF	Pol	*Laonice cirrata*	24	3	1.6	47.8
C	Pol	*Lumbrineris latreilli*	23	5	1.6	49.4
C	Pol	*Eunice vittata*	22	5	1.5	50.9

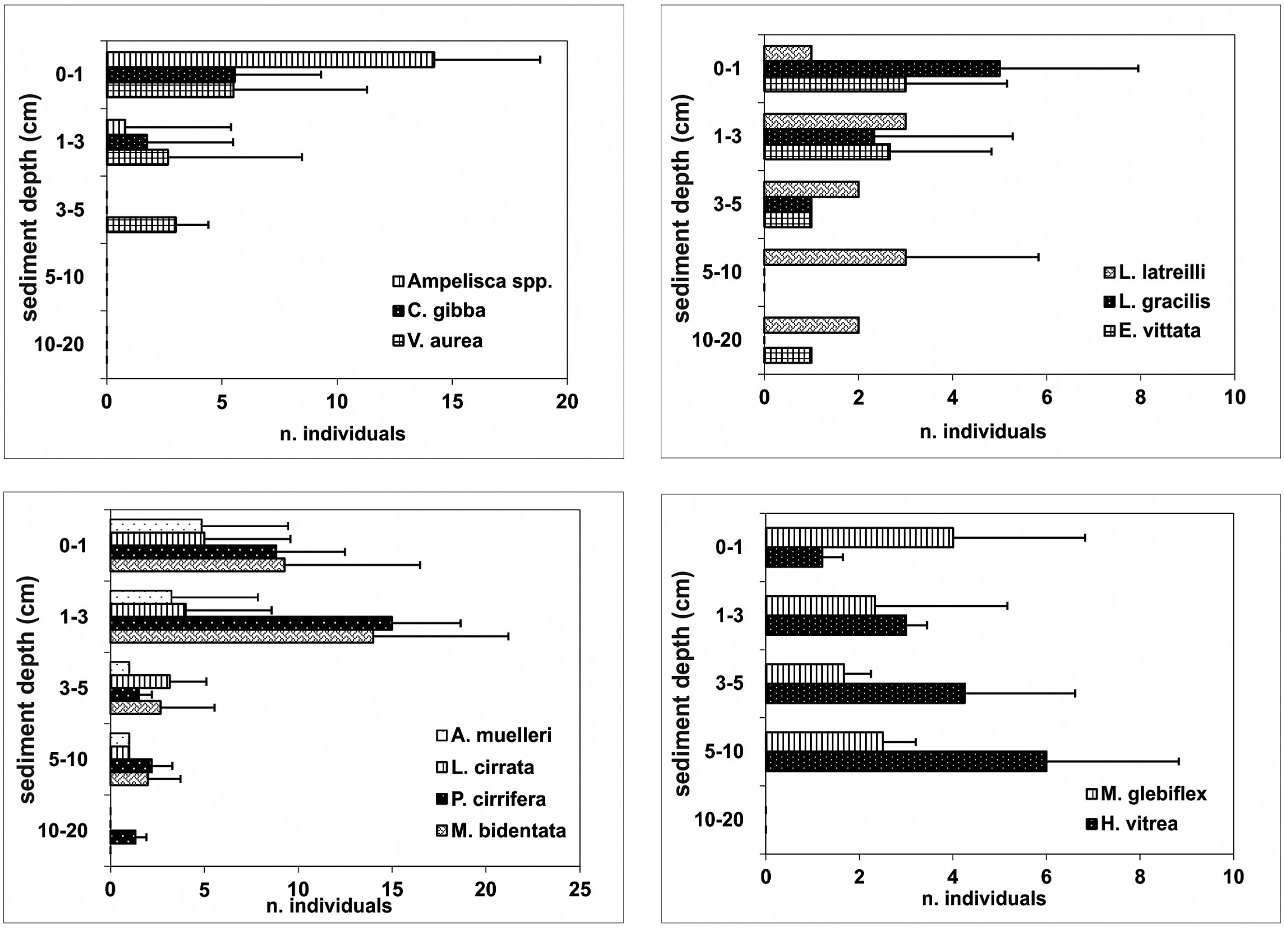

Fig. 4: Average abundance of the dominant species for each layer of the core.
Sl. 4: Povprečno število osebkov prevladujoče vrste za vsak sloj jedra vrtine.

dimentary sequence. The polychaete *Maldane glebifex* mostly represented sub-surface deposit feeders within the upper 10 cm without any clear decreasing gradient. Conversely, the grazer gastropod *Hyala vitrea* showed an increase in abundance from the top until 10 cm, below where it disappeared.

The BA score assigned to each taxon is shown in Table 3. BA estimated for feeding guilds showed a mean of 8 for SSDF, 5 for SDF and 2 for remaining guilds; with regard to main taxa the average was 4 for polychaetes and crustaceans, 3 for echinoderms and others and 2 for molluscs.

The trend of BA downcore showed a significant average decrease for every feeding guild. Moreover, it seems to be clear that SDF represents the most important class, which contributes to the index value in the whole of the layers investigated. Finally, BA calculated on main taxa indicates that polychaets are the main responsible for the bioturbation phenomena, whereas the contribution of molluscs seems to be important only in the upper layer (Fig. 5).

DISCUSSION

The vertical zonation of benthic organisms within the sediment has long attracted the attention of marine biologists. Since macrobenthic and meiobenthic bioturbation is an important phenomenon in surficial marine sediments (Cullen, 1973), even geologists and geochemists have emphasised the necessity for information on patterns of vertical distribution in the marine benthos (Huys *et al.*, 1986).

Several authors have described in the past the different macrozoobenthic communities in the Gulf of Trieste (*e.g.*, Orel & Mennea, 1969; Fedra *et al.*, 1976; Fedra, 1978; Orel et al., 1987), often in connection with anoxia conditions (*e.g.*, Stachowitsch, 1984; Aleffi *et al.*, 1992; Orel *et al.*, 1993; Stachowitsch & Fuchs, 1995). Recently, the status and distribution of macrobenthic communities was discussed through the application of GIS techniques (Solis-Weiss *et al.*, 2001) and a faunistic, biocoenotic and ecological survey on soft bottom macrozoobenthos was conducted in the southern part of the Gulf (Mavrič *et al.*, 2010). Apart from some studies concerning the vertical distribution of meiobenthos in the southern area of the Gulf (Vrišer, 1983-1984), there are very few data regarding the vertical zonation of soft bottom macrozoobenthos.

The development of the macrobenthic community at station AA1 was followed from 1990 to 2001. This area was affected by anoxia in September 1990, when oxygen (O_2) concentrations at the bottom dropped to 0.37 $cm^3\ l^{-1}$. In 1991 a mucilage event occurred during the summer and the lowest value of O_2 was recorded in October (1.28 $cm^3\ l^{-1}$), whereas in 1992 the minimum value was measured in August (3.46 $cm^3\ l^{-1}$). During the period 1999-2001, no O_2 concentration at the bottom below 2.00 $cm^3\ l^{-1}$ was recorded, except in October 2001, when 1.69 $cm^3\ l^{-1}$ was found. In addition, mucilage aggregates occurred in June 2000 (Bettoso *et al*., 2003). A clear difference was revealed between the benthic community of the investigated periods 1990-1993 and 1999-2001 at the same site of the present study. Average H' and J values were 1.89, 0.56 and 2.9, 0.79 in the former and latter period, respectively. A remarkable result during the period 1990-1993 (characterised by frequent hypoxia-anoxia events) was the huge abundance of the suspension feeder bivalve *Corbula gibba*, which is a well-known indicator of environmental instability condition (Aleffi & Bettoso, 2000). From 1999-2001 and in the present study, the environmental conditions were more stable, without any noticeable chemical-physical stress. Accordingly, a notable decrease of the *C. gibba* dominance was detected. Similar trends were revealed for the polychaetes *Maldane glebifex* and *Eunice vittata*, which were found to be dominant together with *C. gibba* in the early 1990s (Aleffi *et al*., 1996). In contrast, several species, never recorded or very scarce, were abundant in 1999-2001. Among these, the gastropod *Aporrhais pespelecani*, the sipunculid *Aspidosiphon muelleri muelleri* and the polychaetes *Sternaspis scutata* and *Sthenolepis yhleni* are the most important. Moreover, the constant presence of *Atrina pectinata* was also remarkable because this large bivalve seems to be very sensitive to low oxygen levels (Bettoso *et al*., 2003). During 1999-2001 the presence of *Ampelisca* spp. was also remarkable. Moodley *et al*. (1998) observed that *C. gibba* abundance may be negatively affected by the presence of large population of *Ampelisca*. The authors consider the two species as suspension feeders that compete for food supply. Moreover, they suggested that dense aggregations of *Ampelisca*, which build tubes in the more superficial layers of sediment, could both occupy space and influence the structure and density of the community down core (Dauvin, 1988; Dauvin & Bellan-Santini, 1990; Massamba N'Siala *et al*., 2008).

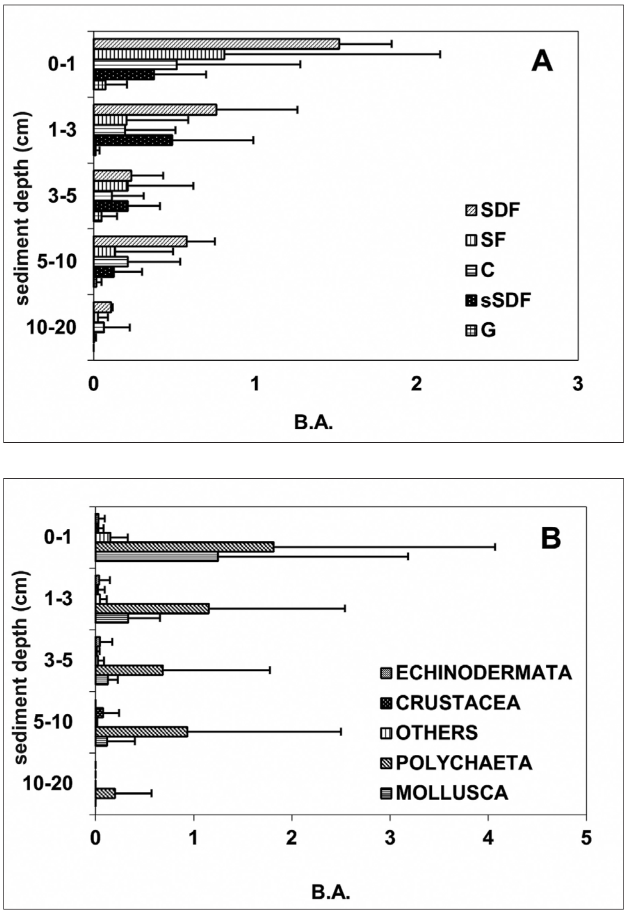

Fig. 5: (A) Average BA for feeding guilds and (B) main taxa in each layer of the core.
Sl. 5: (A) Povprečen indeks BA za vsak prehranski ceh in (B) najpomembnejši taksoni za vsak sloj jedra vrtine.

Despite a low number of species detected with this sampling method, the percentage abundances of the most abundant taxa in the cores were comparable to those recorded by grab sampling (Aleffi *et al*., 1996; Bettoso *et al*., 2003). Unfortunately, no recent data for this sampling station were available, although no stress condition due to oxygen depletion was recorded in the last decade.

The infaunal macrozoobenthos distribution indicates that the colonisation of the sediment occurs at the maximum depth of 20 cm, according to Moodley *et al*. (1998) for the northwestern Adriatic Sea; however, as already observed by Simonini *et al*. (2004) in the area close to the Adige and Po River mouths, it essentially involves the first 5 cm, whereas a sharp decline of macrofauna occurred below 10 cm.

The vertical distribution of feeding guilds followed a well-defined pattern in which the suspension and surface deposit feeders are mostly found in the surface layers, whereas sub-surface deposit feeders and carnivores-omnivores followed below. Among suspension feeders *Ampelisca* spp., *C. gibba* and *Venerupis aurea* were not encountered in deeper layers as also observed by Moodley *et al*. (1998). In contrast, the bivalve *Mysella bidentata* was not confined to a specific layer. These

Tab. 3: Bioturbation activity (BA) assigned to taxa as outlined in Swift (1993) and Grehan** et al. **(1994): M = mobility, F = feeding mode, B = burrowing capability. For explanations (F. guilds, Taxa except Ech = echinoderms) see Table 2.

Tab. 3: Bioturbacija (BA), kot so jo posamičnim taksonom pripisali Swift (1993) ter Grehan** et al. **(1994): M = mobilnost, F = način prehranjevanja, B = zmožnost kopanja rovov. Za razlago (Prehranski cehi, Taksoni razen Ech = iglokožci) glej Tabelo 2.

M	F	B	BA	F. guilds	Taxa	Species
2	1	1	4	C	others	Nemertea indet.
1	0	1	2		Mol	*Nassarius reticulatus*
1	0	1	2		Mol	*Cylichnina umbilicata*
0	0	0	0		Mol	*Akera bullata*
1	0	0	1		Mol	*Scaphander lignarius*
1	4	1	6		Mol	*Antalis inaequicostata*
3	0	2	5		Pol	*Glycera* sp.
0	0	0	0		Pol	*Ophiodromus flexuosus*
0	1	2	3		Pol	*Sigambra tentaculata*
0	0	2	2		Pol	Syllidae indet.
2	0	0	2		Pol	*Nereis lamellosa*
2	0	0	2		Pol	*Nereis rava*
2	0	0	2		Pol	*Nereis* sp.
2	0	2	4		Pol	*Micronephtys* sp.
0	0	0	0		Pol	*Sthenolepis yhleni*
0	0	0	0		Pol	*Nothria conchylega*
0	0	0	0		Pol	*Eunice vittata*
2	0	2	4		Pol	*Lumbrineris gracilis*
2	0	2	4		Pol	*Lumbrineris latreilli*
2	0	2	4		Pol	*Lumbrineris tetraura*
1	2	0	3		Cru	Gammaridae indet.
0	0	0	0		Cru	*Athanas nitescens*
0	0	0	0		Cru	*Eualus cranchii*
0	0	0	0		Cru	*Processa macrophthalma*
1	1	1	3	G	Mol	*Hyala vitrea*
1	0	0	1		Mol	*Calyptraea chinensis*
1	0	0	1		Mol	*Capulus ungaricus*
1	2	0	3	SDF	Mol	*Euspira pulchella*
0	3	1	4		Mol	*Nucula nucleus*
0	3	1	4		Mol	*Nuculana pella*
0	2	1	3		Mol	*Thyasira flexuosa*
1	0	0	1		Mol	*Mysella bidentata*
0	2	1	3		Mol	*Tellina distorta*
0	3	1	4		Mol	*Abra alba*
0	3	1	4		Mol	*Abra prismatica*
1	0	1	2		Mol	*Thracia pubescens*
2	3	0	5		Pol	*Laonice cirrata*
2	3	0	5		Pol	*Polydora flava*
2	3	0	5		Pol	*Prionospio cirrifera*
2	3	0	5		Pol	*Prionospio malmgreni*
2	3	2	7		Pol	*Magelona* sp.
2	3	0	5		Pol	*Poecilochaetus serpens*
3	3	2	8		Pol	*Aricidea* sp.
3	3	2	8		Pol	*Levinsenia gracilis*
3	3	2	8		Pol	*Paradoneis lyra*
3	3	2	8		Pol	*Paraonidae indet.*
1	2	1	4		Pol	*Chaetozone setosa*
1	2	1	4		Pol	*Tharyx killariensis*
1	2	1	4		Pol	Cirratulidae indet.
2	1	2	5		Pol	Opheliidae indet.
0	2	1	3		Pol	*Ampharete acutifrons*
0	2	2	4		Pol	*Melinna palmata*
0	2	0	2		Pol	*Amphitrite variabilis*
0	2	0	2		Pol	Terebellidae indet.
2	1	2	5		Pol	Oligochaeta indet.
0	2	0	2		others	*Aspidosiphon muelleri muelleri*
2	2	2	6		others	*Sipunculus nudus*
3	4	4	11		Cru	Callianassidae indet.
2	2	2	6		Ech	*Amphiura chiajei*
0	2	0	2		Ech	*Amphipholis squamata*
0	0	0	0	SF	others	*Cerianthus membranaceus*
0	0	0	0		Mol	*Anomia ephippium*
1	2	1	4		Mol	*Loripes lacteus*
1	2	1	4		Mol	*Myrtea spinifera*
1	0	0	1		Mol	*Kellia suborbicularis*
0	0	1	1		Mol	*Acanthocardia paucicostata*
0	0	1	1		Mol	*Dosinia lupinus*
0	0	1	1		Mol	*Pitar rudis*
0	0	1	1		Mol	*Venerupis aurea*
1	0	0	1		Mol	*Corbula gibba*
2	3	0	5		Pol	*Polydora* sp.
2	3	0	5		Pol	Spionidae indet.
0	0	0	0		Pol	Sabellidae indet.
0	2	0	2		Pol	*Spiochaetopterus costarum*
1	2	0	3		Cru	Cumacea indet.
0	0	0	0		Cru	*Ampelisca* spp.
3	4	4	11		Cru	*Upogebia tipica*
0	0	1	1		Ech	*Leptopentacta elongata*
2	3	2	7	sSDF	Pol	Capitellidae indet.
2	3	2	7		Pol	*Euclymene* sp.
2	4	2	8		Pol	*Maldane glebifex*
2	4	2	8		Pol	Maldanidae indet.
2	1	2	5		Pol	*Sternaspis scutata*
2	4	3	9		Pol	*Pectinaria auricoma*
2	4	3	9		Pol	*Lagis koreni*
indet.					Mol	Gastropoda indet.
					Mol	Bivalvia indet.
					Cru	Harpacticoida indet.
					Cru	Tanaidacea indet.
					Cru	Amphipoda indet.

species are known to live in association with amphiurids or sipunculids (Hayward & Ryland, 1990), and their numbers are correlated in some areas (Ockelmann & Muus, 1978) but not in others (Rosenberg, 1995). The presence of a large fraction of the *Mysella* population in deeper sediment layers suggests that this bivalve is not restricted to filter feeding but can also feed on deposit particles (Rosenberg, 1995). Most *Hyala vitrea* specimens were deeper than 5 cm and this species could be a predator (Moodley *et al*., 1998, Koulouri *et al*. 2006) and not a grazer, as classified in Macdonald *et al*. (2010). Polychaetes such as *Prionospio cirrifera*, *Eunice vittata* and *Lumbrineris latreilli* were recorded along the whole sediment profile and these species are very common in the sandy and pelitic bottoms of the northern Adriatic Sea (Aleffi *et al*., 2003).

Lee & Schwartz (1980) suggested a scheme of guilds of macrofauna depending on individual modes of feeding, mobility and position in and or the sediment. In this study, the taxa were coded and scored using the scheme of Swift (1993). The sum of the scores for each taxon ranked indicate that the sub-surface deposit feeders *Pectinaria auricoma, Pectinaria koreni* and *M. glebifex* have the greatest bioturbatory effects over the largest depth range, whereas the suspension feeders *C. gibba*, *V. aurea* and *Ampelisca* spp., among the most abundant, have a modest bioturbation in the surface layer.

Considering the relative abundance of each species, BA indicated that SDF polychaetes have a pivotal role in the bioturbatory activity in muddy sediment of the central area of the Gulf of Trieste, followed by SF molluscs if only the top layer is considered.

The results of this work suggest the following final remarks:

(1) The muddy sediment of the investigated area (central Gulf of Trieste) is normally inhabited down to 20 cm depth, with the exception of a sporadic presence of some very large specimens;

(2) The strata analysis of cores successfully investigated and explained the vertical zonation of macrofauna;

(3) The application of BA index to estimate the degree of bioturbation could also be a useful tool when grab-sampling techniques is applied. The availability of a larger dataset and the calculation of BA derived using the grab technique could provide a more detailed depiction of bioturbation for the northern Adriatic soft bottom sediments.

ACKNOWLEDGEMENTS

The authors are very grateful to Dr. Alessandro Acquavita and Francesco Tamberlich for their valuable revision of the manuscript. This study was carried out as a part of the European Community INTERREG II Italy - Slovenia project.

VERTIKALNA DISTRIBUCIJA MAKROBENTOŠKIH ORGANIZMOV MEHKEGA DNA V TRŽAŠKEM ZALIVU (SEVERNO JADRANSKO MORJE)

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POVZETEK

Makrobentoški organizmi običajno veljajo za najpomembnejše povzročitelje bioturbacije v plitvih vodah, spodbujajo pa tudi premešavanje raztopljenih spojin in plinov med porno vodo in zgornjim slojem vodnega stolpca. Kot je omenilo že več avtorjev, se ta temeljni pojav najustrezneje opiše s preučevanjem vertikalne distribucije makrobentoških organizmov. V ta namen smo izbrali lokacijo v osrednjem delu Tržaškega zaliva (globina 21 m) in v letih 1999/2000 vzeli 9 vzorcev jedra vrtine v treh primerkih z največjo globino 20 cm. Pri opisu vertikalne distribucije makrobentoških združb smo upoštevali bioturbacijski indeks (BA). Iz vertikalne distribucije makrofavne je jasno razvidno, da se z upadom globine manjša tako število taksonov kot število osebkov. Indeks BA nakazuje, da imajo ključno vlogo pri bioturbaciji muljastih sedimentov površinski detritivorni mnogoščetinci, medtem ko v zgornjem sloju odigrajo pomembno vlogo suspenzivorni mehkužci. Če vzamemo v obzir vse rezultate, lahko trdimo, da je upoštevanje indeksa BA ob uporabi metode vzorčenja jedra vrtin lahko uporabno orodje pri opisu bioturbacije sedimentov na mehkem dnu severnega Jadrana.

Ključne besede: makrobentoški organizmi, vertikalna conacija, bioturbacijski indeks, prehranski cehi, Tržaški zaliv, Jadransko morje

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