FUNCTIONAL GROUPS TO ESTABLISH THE ECOLOGICAL QUALITY OF SOFT BENTHIC FAUNA WITHIN TUNIS BAY (WESTERN MEDITERRANEAN)

R. Ayari, A. Afli

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*R. AYARI *, A. AFLI*

Laboratoire de Biodiversité et Biotechnologie Marines, Institut National des Sciences et Technologies de la Mer, 28 rue de 2 Mars 1934, 2025 Salammbô, Tunisie
** Corresponding author: Ayari_Rakia@yahoo.fr*

BENTHIC FAUNA
BIOTIC INDEX
TROPHIC GROUPS
ECOLOGICAL GROUPS
TUNIS BAY
WESTERN MEDITERRANEAN

ABSTRACT. – The distribution of the marine biotic index (BI) and the trophic groups is proposed in this paper to assess the impact of environmental factors on the macro-zoobenthic assemblages of Tunis bay. The first approach is based on the subdivision of benthic fauna into five ecological groups. This subdivision is related to the degree of sensitivity to an environmental stress gradient. This enables to characterize the assemblages and the degree of dependence of their health on the disturbances. On the other hand, the spatial distribution of trophic groups gives a general tendency of population evolution. The method of functional groups shows that Tunis bay seems to be in a good state, except some areas which are more affected by disturbances and which could constitute, in the future, a potential threat if the environmental conditions get worse.

INTRODUCTION

The coastal marine zones are subject to an increasing anthropic pressure (urbanization, industry, tourism, over fishing, sea traffic, etc.) and a possible threat due to the climatic change. The consequences can be detected on the general state of the ecosystems, mainly in the littoral fringe which is more sensitive and more exposed. Tunis bay is an example of a coastal zone which can be affected by these multiple aggressions. In this area, a bionomic study carried out by Ayari & Afli (2003) showed that the general state of the macro-zoobenthic communities was satisfying, except the harbour zone of Radès. However, the use of data such as simple numerical values may be insufficient in this respect, and the intrinsic characters of populations should be also considered. Indeed, the use of Shannon's diversity index (H') as a tool for pollution assessment is insufficient if faunistic data are not taken into account to detect opportunistic species abundance (Zenetos & Simboura 2001). A complementary approach based on functional groups aims at better understanding the benthic response to environmental conditions. In this contribution, ecological groups are used to establish the ecological quality of Tunis bay since the ecological study of benthic communities provides information and is essential to understand the general evolution of ecosystems (Borja *et al.* 2000, Solis-Weiss *et al.* 2004). The study of the functional organization also through trophic mechanisms will enable us to follow its temporal variation in order to limit the sources of harmful effect

Description of the study area

The study area is a depression in the South of Tunis gulf, called "the small gulf of Tunis" or Tunis bay. It is limited by Cape Carthage to the West and Cape Fartas to the East (Fig. 1). Its West coast is of alluvial nature and the east coast is sandy. Sedimentation is controlled by the Méliane River inputs and by the littoral currents (Ben Charrada 1997). In the North East, the coast is rocky with many cliffs. In general, sedimentation is controlled mainly by rivers which discharge into the bay (Azouz 1973, Oueslati 1993).

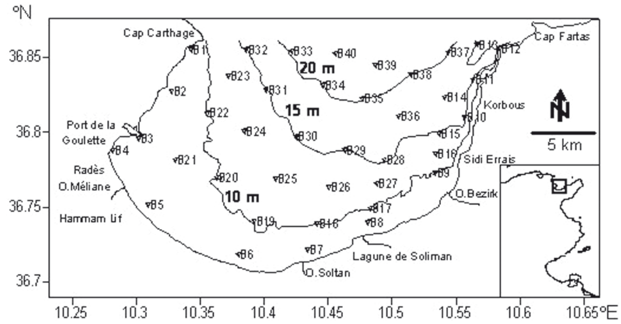

Fig. 1. – Geographic situation, bathymetry and location of sampling stations.

The dominant winds come from the North-Western sector and cause swells during the cold season carrying alluvia to the South and the South-East (Ben Charrada 1997). The average depth of Tunis bay is modest and does not exceed 31 m (Ayari 2003). Water movements are controlled by currents generated by winds. West and North-West winds generate the strongest currents. The currents run parallel to the coast. The range of the tide is not very significant and rarely exceeds 35 cm (Zarrad 2001).

For a few years, the littoral zone of Tunis gulf has been subject to industrial, urban and tourist development. Significant commercial and fishing activities in the Harbour of La Goulette, Radès and Tunis have been noted, as well as the thermal discharges of the Radès power station. The population of Tunis City, of its Northern and Southern suburbs and of Korbous, bordering Tunis bay, was estimated in 2002 approximately at 1,013,830 inhabitants (Anonymous 2002).

The coastal zone close to the urban area, Southern Tunis and Hammam Lif, is the catchments' basin of the most significant source of continental water constituted by the effluents of the Méliane River which discharges directly and permanently into the bay and also by the effluents of the water-treatment plant of "Sud Méliane", with some uncontrolled industrial wastes (Ben Charrada 1997). The coastal area located between Hammam Lif and Sidi Erraïs receives the effluents of three water-treatment plants of the "Office National d'Assainissement Sanitaire (ONAS)" as well as waste water discharges of other coastal agglomerations. On the east coast, small agglomerations like the town of Korbous, discharge their waste water directly into the sea. Also, the presence of the food - processing industry and of the sources of thermal water (Korbous) constitutes potential sources of pollution in the long term.

MATERIAL AND METHODS

Forty stations, distributed in the study area, were prospected in March 2003 (Fig. 1). Twelve of them (B1, B2, B8, B12, B13, B17, B22, B23, B24, B25, B27 and B28) were not the object of fauna sampling because of the difficulties we met (strong winds making it difficult to handle the grab, occurrence of rocky patches or sea grass meadows). The samples, obtained with a 0.1 m^2 Van Veen grab (two grabs per sample), were fixed with a solution of formaldehyde (7%) on board of RV Hannibal. Samples of sediment were taken for particle size and organic matter analysis. At the laboratory, samples for fauna study were also sorted out with water, on a square mesh of 1 mm a side. The animals collected were preserved with diluted alcohol (70%) before being identified, for most of them, up to species level.

In this contribution, we classified organisms on the basis of functional groups. For the trophic groups we used the feeding guilds established by Fauchald & Jumars (1979) and used by Grall & Glémarec (1997), Glémarec & Grall (2000), Afli (1999), Afli & Glémarec (2000):

- Herbivores (H): algae-feeding organisms (e.g. some echinids).

- Scavengers (N): feed on carrions deposited on the bottom (essentially gastropods and decapods).

- Detritus feeders (D): feed on particulate organic matter, essentially vegetable detritus (mainly amphipods and tanaids).

- Carnivores (C): predatory animals (mobile polychaetes, sea-anenomes).

- Micrograzers (μB): feed on benthic microalgae, bacteria and detritus (essentially polyplacophores and gastropods).

- Suspension feeders (S): feed on suspended food in the water column (e.g. most bivalves).

- Surface deposit feeders (SDF): feed on organic particles which settle on the sediment (most sedentary polychaetes).

- Subsurface deposit feeders (SSDF): burrowers which ingest the sediment from which they take their food.

In parallel, the model of biotic index (Hily 1984) was used to assess the health of the communities. It subdivides all the benthic macrofauna into 5 ecological groups according to their reactions to organic disturbances. These groups were classified by Grall and Glémarec (1997), as shown below; the trophic guilds that are presented are the dominant ones:

- Ecological group I: species sensitive to organic enrichment (initial state). They include the specialist carnivores and suspension feeders.

- Ecological group II: species indifferent to organic matter excess (from initial to slight unbalance). They include scavengers.

- Ecological group III: species that are tolerant (slight unbalanced situations), which are stimulated by organic matter excess. They are surface deposit feeders.

- Ecological group IV: second-order opportunistic species (slight to pronounced situations of unbalance). They are subsurface deposit feeders.

- Ecological group V: first-order opportunistic species (pronounced situations of unbalance). There are some deposit feeders.

The respective percentages of the various ecological groups provide a biotic index (BI) or stage of degradation for each case. Its attribution was based on the work of Afli and Chenier (2002). Eight biotic indexes were defined (Table I):

- BI 0: the ecological group I dominate and they are the first to disappear.

- BI 1: characterized by impoverished community, its species richness and its abundance decrease define a first ecotone.

- BI 2: tolerant species (group III) are stimulated and become more abundant.

- BI 3: second ecotone, resulting from a competition between tolerant and opportunistic species, which sometimes favours the proliferation of some indifferent species.

- BI 4: first stage of pollution, characterized by the proliferation of second-order opportunistic species (group IV).

- BI 5: third ecotone, characterized by the competition between first and second-order opportunistic species.

- BI 6: stage of maximum pollution, characterized by the excessive proliferation of individuals of the first-order opportunistic species (e.g. *Capitella capitata* Fabricius, 1780).

- BI 7: ultimate degradation and disappearance of all macrobenthic life.

RESULTS

Fine sands are distributed on the Southern littoral fringe from Radès to the Lagoon of Soliman; muddy sands occupy the central area and are surrounded by

Table I. – Percentages of ecological groups for each stage of degradation or biotic index (according to Afli & Chenier 2002). *: State of transition (ecotone).

Ecological groups (%)	Biotic index							
	BI 6	BI 5*	BI 4	BI 0-4	BI 3*	BI 2	BI 0-2	BI 0
I		< 20	< 20	20-40	< 40	20-40	20-40	> 45
II		> 50			> 30			
III	< 20		20-40	< 40		> 40	20-40	20-40
IV			> 40	20-40		< 20	< 20	< 20
V	> 40							

muddy sediment towards the open sea. Organic matter and silt contents are correlated (R = 0.815), the stations B5, B6, B19, B21, B26, B30, B34 and B38 are most strongly loaded with organic matter (Fig. 2).

The spatial distribution of each main trophic group shows that suspension feeding species dominate along the shallow Southern littoral fringe (Fig. 3). On the other hand, carnivores and deposit feeders are distributed on almost all of the study area. Deposit feeders dominate opposite to the harbour zone of Radès whereas carnivores dominate in the Southern bank of the gulf and off Cape Carthage. Detritus feeders concentrate in the open sea, and also to a lesser extent near the coast, between the Soltan River and the Lagoon of Soliman.

The study of space variability of ecological groups and of species richness (S) and abundance (A) (Fig. 4) shows 5 areas of different levels of degradation (Fig. 5). Characteristic species were related to each state of degradation (Table II). The complete list of all the collected species and their ecological and trophic groups is given in Appendix 1. The first area includes stations B18, B26, B7, B5, B6, B21, B40, B32 and B35. It is characterized by the dominance of the sensitive species of group I, e.g. *Angulus tenuis* (da Costa 1778) and *Pista mirabilis* (McIntosh, 1885) which prompted us to attribute a BI. It corresponds to an area towards the open sea in the North and to another one along the South-East coast limited by the Méliane River in the North and by the Soltan River in the South. The second level of degradation (BI 0-2) concerns stations B10, B15, B11 and B37, located off Korbous. It is the result of the regression of sensitive species in favour of the tolerant species of the group III - *Melinna palmata* Grube, 1870, *Tuberapseudes echinatus* (G.O. Sars, 1882) and *Notomastus profundus* Eisig, 1887. The third level (BI 2) is recorded at stations B31, B36, B34, B38, B3, B33, B4, B39 and B20. It is characterized by the clear dominance of tolerant species and the appearance of two second-order opportunistic species – *Cirratulus cirratus* (O.F. Müller, 1776) and *Chaetozone setosa* Malmgren, 1867. As for the fourth level, it relates to the stations B16, B30, B14, B29 et B19 and corresponds to a situation of transition (ecotone), in which an organization is disappearing in favour of another one. This is a temporary advantage for species indifferent to unbalance like *Scoletoma fragilis* (Malmgren, 1867), *Glycera convoluta* (Keferstein, 1862) and *Nephtys hombergii* Savigny, 1818. BI 3 is due to the simultaneous presence of species of ecological group I – *Maldane glebifex* Grube, 1860, *Ampelisca typica* (Bate, 1856) and *Tellina pulchella* Lamarck, 1818 – and of species of group III, *Scolaricia typica* Eisig, 1914. Thus, the central part of Tunis bay shows degradation levels 2 and 3. The fifth level (BI 0-4) includes a single station (B9) located between the Lagoon of Soliman and the Bezirk River where second-order opportunistic species, like *Heterocirrus* sp. and *Chaetozone setosa*, are becoming more numerous.

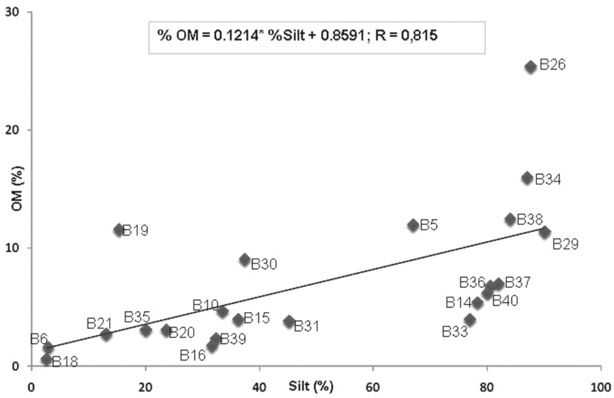

Fig. 2. – Correlation between organic matter and silt contents of sediments at visited stations.

DISCUSSION

In an undisturbed area, the trophic groups share the trophic resources and coexist with slightly different num-

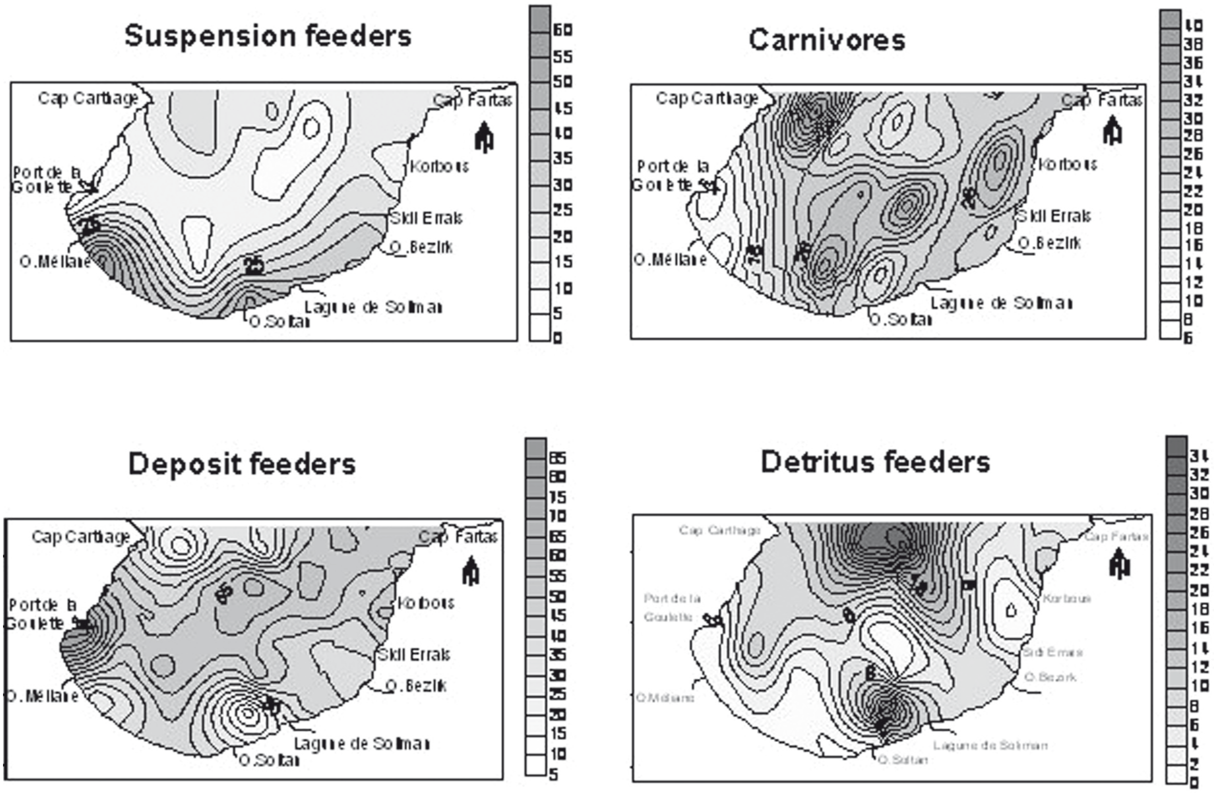

Fig. 3. – Spatial distribution of the main trophic groups (expressed as a percentage).

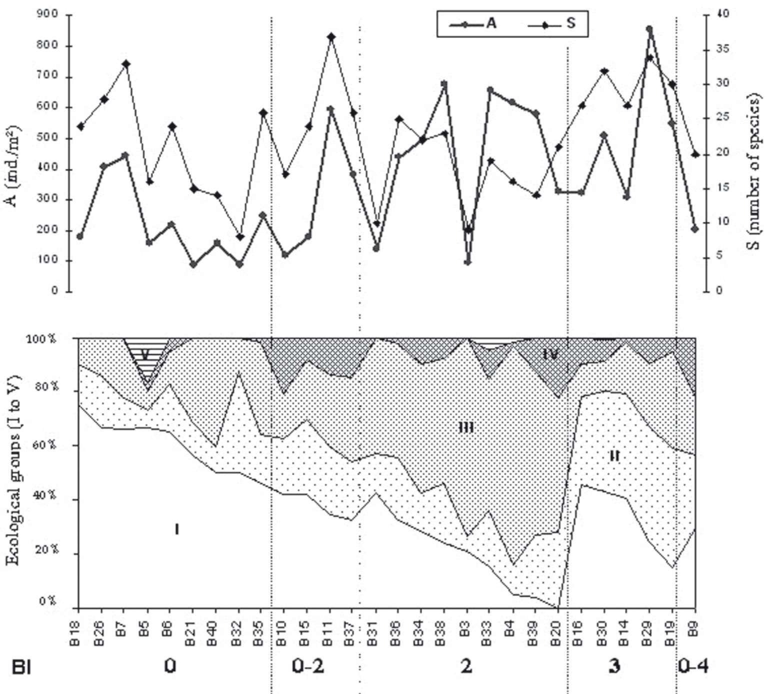

Fig. 4. – Space variability of abundance (A), species richness (S) and of ecological groups.

bers because they do not use the same dimensional category (Hily 1984). In fact, deposit feeders take food particles in the organic-matter-rich surface film or inside the sediment, whereas suspension feeders filter suspended matter in the water column. Detritus feeders are macrophages feeding on crumbs of vegetable matter. On the other hand, carnivores which feed on other animals prevent resources from being monopolized by dominant species by controlling the other populations. In the two undisturbed zones (BI 0) which occupy the south-west littoral fringe and a small area in the open sea, detritus and suspension feeders coexist with carnivores without proliferating, which indicates a trophic balance. But it is necessary to mention that the trophic organisation is not entirely related to the stage of health of the environment. The open sea is apparently saved from the influence of sources of disturbance. The south-west littoral fringe, located between the Méliane River and the Lagoon of Soliman, is probably not affected by the wastes drained by the Méliane River.

The second level of degradation (BI 0-2) concerns the coastal area located off Korbous. This zone is characterized by the presence of indifferent species (ecological group II), like the polychaete *Nephtys hombergii* and of tolerant species (ecological group III), like the surface deposit-feeding polychaete *Melinna palmata*, in about the same proportions. Sensitive species regress slightly. This state of unbalance is clearly due to

Table II. – The main species characterizing each stage of degradation.

Ecological groups	Biotic index				
	BI 0-4	BI 3	BI 2	BI 0-2	**BI 0**
I		*Maldane glebifex* *Ampelisca typica* *Tellina pulchella*			*Angulus tenuis* *Pista mirabilis* *Antalis vulgaris* *Chamelea gallina*
II		*Scoletoma fragilis* *Glycera convoluta* *Nephtys hombergii*		*Nephtys hombergii* *Lumbrineris latreilli*	
III	*Notomastus* sp.	*Scolaricia typica*	*Tuberapseudes echinatus* *Melinna palmata* *Notomastus latericeus*	*Melinna palmata* *Tuberapseudes echinatus* *Notomastus profundus*	
IV	*Heterocirrus* sp. *Chaetozone setosa*		*Cirratulus cirratus* *Chaetozone setosa*		

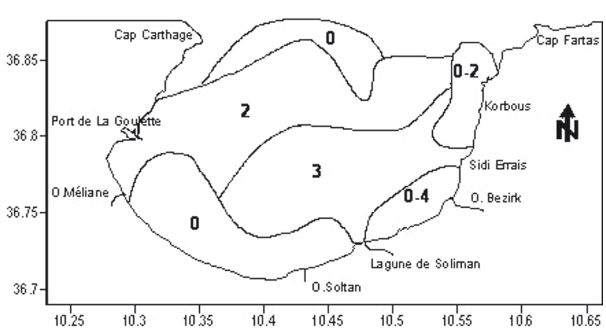

Fig. 5. – Distribution of the degradation states (biotic index) of the macro-zoobenthic communities in Tunis bay.

direct industrial and urban discharges of neighbouring cities (Ben Charrada 1997). In addition, warm water which characterizes the Korbous area (Ayari 2003) has probably a role in the establishment of this unbalanced situation. The central area of Tunis bay shows two levels of degradation. In the area presenting a BI 2, tolerant species of the group III, like the detritus-feeding crustacea *Tuberapseudes echinatus* and *Melinna palmata*, clearly dominate sensitive species, so a situation of unbalance is set up, essentially at stations B3 and B4 (west coast) subject to urban rejections of the La Goulette and Radès agglomerations, and to harbour and industrial activities in this part of the bay.

In the area presenting a BI 3 which reveals a situation of transition (ecotone), indifferent species of the group II, are stimulated and colonize habitats in spite of the other groups. We find especially the carnivorous polychaetes *Glycera convoluta*, *Scoletoma fragilis* and *Nephtys hombergii*. This situation is also characterized by the presence of sensitive species which are in an unstable state and may give place to other more opportunistic populations in terms of the exploitation of resources and which are more resistant to the disturbances (Afli & Glémarec 2000). This situation can be explained by the effects of effluents from water-treatment plants in three neighbouring cities (Menzel Bouzelfa, Grombalia, Soliman), that discharge their waste water into the Lagoon of Soliman. In addition to these factors, the dominance of deposit feeders in this central area can be due to muddy substrate which characterizes this zone. It presents a supplement of food adsorbed on the fine sedimentary particles and whose deposit is favoured by hydrodynamical deceleration.

As for BI 0-4, it characterizes only one station (B9) off the Bezirk River mouth. Second-order opportunistic species of group IV, like the surface deposit feeder *Chaetozone setosa*, are present but without clear dominance. Although sensitive species of group I are always well represented, this area seems most disturbed, probably because of the effluents drained by the Bezirk River and the Lagoon of Soliman.

The trophic organization of benthic fauna in Tunis bay may be broken, if the factors related to the sources of disturbance still persist. The present state shows some geographical segregation between deposit and suspension feeders. Deposit feeders are present everywhere, but dominate in the central zone where they can reach 60% of trophic groups, followed by carnivores (40%), which confirms some ecological unbalance. On the other hand, suspension feeders are present along the Southern littoral fringe of sandy nature. They benefit from the suspended matter drained by the terrigenous input of the Méliane and Soltan Rivers and the Lagoon of Soliman.

It was possible to study the general state of Tunis bay through two approaches based on functional groups, trophic groups and ecological groups. The use of spatial distribution of each trophic group aims at understanding the response of benthic fauna to environmental variations. The study of ecological groups uses species of different sensibility to pollution to give a view of the state of degradation of the bay. Indeed, when a change appears, the system is no longer controlled by the usual factors, essentially the nature of the habitat and the trophic chain. However, there are some opportunistic populations which impose their invasive strategy.

The BI model proposed here to establish the quality of the benthos within Tunis bay takes into account the faunal composition. This method is promising because it integrates the effects of various sources of pollution and it enables us to measure directly their impact on the ecosystems. It complements the methods using mean macrobenthic richness (S), abundance (A), diversity Shannon index (Shannon & Weaver 1963) and Evenness index (Pielou 1969) which are simple numerical values that do not take into account the intrinsic characters of the populations (Zenetos & Simboura 2001).

In general, the situation in Tunis bay does not appear worrying because the state of the benthic fauna is globally good, except in some small well limited areas, but these can constitute a potential threat if the environmental conditions get worse.

The BI model used here is relatively simple and can be applied when attempting to determine the ecological quality of the Tunisian coastlines. The validation of this method shows that the changes due to the sources of disturbance can be detected through the use of the BI which summarizes a considerable amount of ecological data in a single representative value.

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Appendix 1

List of the collected species with their trophic groups (T.G.) and ecological groups (E.G.). N: Scavengers; D: Detritus feeders; C: Carnivores; μB: Micrograzers; S: Suspension feeders; SDF: Surface deposit feeders; SSDF: Subsurface deposit feeders; H: Herbivores.

Species	E.G.	T.G.	Species	E.G.	T.G.	Species	E.G.	T.G.
Polychaeta			*Praxillella gracilis* (M. Sars, 1861)	1	SSDF	*Arca noae* Linnaeus, 1758	1	S
Amage sp.Malmgren, 1866	3	S	*Praxillella* sp. Verrill, 1881	1	SSDF	*Barbatia barbata* (Linné, 1758)	1	S
Amphiglena mediterranea Leydig, 1851	1	S	*Prionospio ehlersi* Fauvel, 1928	4	SDF	*Bolinus brandaris* (Linné, 1758)	2	C
Aonides oxycephala (M.Sars, 1862)	3	SDF	*Prionospio* sp.Malmgren, 1867	4	SDF	*Cardita trapezia* (Linné, 1767)	1	S
Aonides paucibranchiata Southern, 1914	3	SDF	*Prionospio steenstrupi* Malmgren, 1867	4	SDF	*Chamelea gallina* (Linnaeus, 1758)	1	S
Apistobranchus sp. Levinsen, 1883	1	-	*Proclymene* sp. Arwidsson, 1907	1	SSDF	*Chiton* sp. Linnaeus, 1758	1	µB
Aponuphis brementi Fauvel, 1916	2	-	*Pygospio* sp.Claparède, 1863	3	SDF	*Corbula gibba* (Olivi, 1792)	1	SDF
Caulleriella sp. Chamberlin, 1919	4	SDF	*Scolaricia typica* Eisig, 1914	3	SDF	*Cuspidaria cuspidata* (Olivi, 1792)	2	C
Chaetozone setosa Malmgren, 1867	4	SDF	*Scolelepis squamata* (Müller, 1789)	4	SDF	*Cyclope* sp. Risso, 1826	2	N
Chone duneri Malmgren, 1867	1	S	*Scoletoma impatiens* (Claparède, 1868)	2	C	*Devonia perrieri* (Malard, 1904)	1	-
Cirratulus cirratus (O.F. Müller, 1776)	4	SDF	*Scoletoma fragilis* (O.F. Müller, 1776)	2	C	*Donax semistriatus* Poli, 1795	1	S
Cossura soyeri Lucien Laubier 1963	3	SDF	*Spio filicornis* (O.F. Müller, 1766)	3	SDF	*Dosinia lupinus* (Linnaeus, 1758)	1	S
Ciénodrilus serratus (Schmidt, 1857)	4	SDF	*Spio multioculata* (Rioja, 1918)	3	SDF	*Ensis minor* (Chenu, 1843)	1	S
Diopatra neapolitana Delle Chiaje, 1841	3	SDF	*Spiophanes bombyx* (Claparède, 1870)	3	SDF	*Gastrana fragilis* (Linnaeus, 1758)	2	C
Drilonereis filum (Claparède, 1868)	3	D	*Sternaspis scutata* (Renier, 1807)	2	SDF	*Haminoea hydatis* (Linnaeus, 1758)	2	-
Eteone sp.de Savigny, 1822	2	C	*Stylaroides* sp. Delle Chiaje, 1841	1	S	*Hexaplex trunculus* (Linné, 1758)	2	C
Euclymene oerstedii Claparède, 1863	1	SSDF	*Terebellides stroemi* M. Sars, 1835	1	SDF	*Lithophaga lithophaga* (Linnaeus, 1758)	1	S
Euclymene palermitana (Grube, 1840)	1	SSDF	*Vermiliopsis infundibilum* (Philippi, 1844)	1	S	*Loripes lacteus* (Linnaeus, 1758)	1	S
Eunice floridana (Pourtales, 1869)	2	C	**Malacostraca**			*Lutraria angustior* Philippi, 1844	1	S
Eunice pennata (O.F. Müller, 1776)	2	C	*Achaeus cranchii* Leach, 1817	-	-	*Modiola barbata* Linné	1	S
Eunice sp.Savigny in Cuvier, 1817	2	C	*Ampelisca brevicornis* (Costa, 1853)	1	S	*Modiolus adriaticus* (Lamarck, 1819)	1	S
Eupolymnia nebulosa (Montagu, 1818)	3	SDF	*Ampelisca diadema* (Costa, 1853)	1	S	*Modiolus barbatus* (Linnaeus, 1758)	1	S
Glycera sp. de Lamarck, 1818	2	C	*Ampelisca rubella* A. Costa, 1864	1	S	*Neverita* sp. Risso, 1826	1	C
Glycera tesselata Grube, 1863	2	C	*Ampelisca serraticaudata* Chevreux, 1888	1	S	*Nucula turgida* Marshall, 1875	1	SDF
Glycera tridactyla Schmarda, 1861	2	C	*Ampelisca* sp. Kröyer, 1842	1	S	*Nucula nucleus* (Linnaeus, 1758)	1	SDF
Goniada maculata Örsted, 1843	2	C	*Ampelisca tenuicornis* Liljeborg, 1855	1	S	*Nuculana pella* (Linné,1758)	1	SDF
Gyptis sp. Marion & Bobretzky, 1875	1	C	*Ampelisca typica* (Bate, 1856)	1	S	*Pandora inaequivalis* (Linnaeus, 1758)	1	S

Appendix 1 (continued)

Species	E.G.	T.G.	Species	E.G.	T.G.	Species	E.G.	T.G.
Heteromastus filiformis (Claparède, 1864)	4	SSDF	Amphipoda indt.	1	S	*Pharus legumen* (Linnaeus, 1758)	1	S
Heterospio sp. Ehlers, 1874	3	SDF	*Anthura gracilis* (Montagu, 1808)	1	-	*Pitar rudis* (Poli, 1795)	1	S
Hyalinoecia tubicola (O.F. Müller, 1776)	3	SDF	*Aora* sp. Kroyer, 1845	1	SDF	*Spisula ovalis* (J. Sowerby, 1817)	1	S
Laonice cirrata (M. Sars, 1851)	2	S	*Athanas nitescens* (Leach, 1814)	1	D	*Spisula subtruncata* (da Costa, 1778)	1	S
Lepidonotus clava (Montagu, 1808)	2	C	*Cheirocratus* sp. Norman, 1867	1	SDF	*Striarca lactea* (Linnaeus, 1758)	1	S
Lepidonotus squamatus (Linnaeus, 1767)	2	C	*Cirolana cranchii* Leach, 1818	-	-	*Tellina (Moerella) donacina* Linnaeus, 1758	1	SDF
Lumbrinereis latreilli Audouin & M.-Edwards, 1834	2	C	*Colomastix tiahurae* Müller, 1992	1	N	*Tellina pulchella* Lamarck, 1818	1	SDF
Lumbrineris gracilis Ehlers, 1868	2	C	*Cyathura carinata* (Krøyer, 1847)	3	C	*Tellina tenuis* da Costa, 1778	1	S
Lumbrineris sp.Blainville, 1828	2	C	*Diastylis cornuta* (Boeck, 1864)	1	SDF	*Thericium* sp. Bruguière, 1789	2	N
Macroclymene santanderensis (Rioja, 1917)	1	SSDF	*Elasmopus rapax* Costa, 1853	1	S	**Echinodermata**		
Magelona mirabilis (Johnston, 1865)	1	S	*Eriphia verrucosa* (Forskål, 1775)	1	S	*Amphiura chiaje* Forbes, 1843	3	SDF
Maldane glebifex Grube, 1860	1	SSDF	*Eurydice affinis* Hansen, 1905	1	SDF	*Amphiura filiformis* (O.F. Müller, 1776)	1	S
Maldane sarsi Malmgren, 1865	1	SSDF	*Eurydice pulchra* Leach, 1815	1	C	*Asterina gibbosa* (Pennant, 1777)	2	C
Maldane sp.Grube, 1860	1	SSDF	*Gammarus aequicauda* (Martyinov, 1931)	1	D	*Astropecten spinulosus* (Philippi, 1837)	2	C
Marphysa bellii Audouin & M-Edwards 1834	2	C	*Gammarus* sp. Fabricius, 1775	1	D	*Cucumaria* sp. Blainville, 1830	1	D
Marphysa sanguinea (Montagu, 1815)	2	C	*Gnathia maxillaris* (Montagu, 1804)	1	C	*Genocidaris maculata* A. Agassiz, 1869	1	D
Melinna palmata Grube, 1869	3	SDF	*Harpinia* sp. Boeck, 1876	1	D	*Ophioderma longicaudum* (Retzius, 1789)	2	C
Nématonereis unicornis (Grube 1840)	2	C	*Hyale schmidti* Rathke, 1837	1	D	*Ophiomyxa pentagona* (Lamarck, 1816)	2	C
Nephtys hombergii de Savigny, 1818	2	C	*Idotea* sp. Fabricius, 1798	1	D	*Paracentrotus lividus*(de Lamarck, 1816)	1	H
Nephtys sp.Cuvier, 1817	2	C	*Iphinoe trispinosa* (Goodsir, 1843)	1	SDF	*Schizaster canaliferus* (de Lamarck 1816)	1	H
Nereis sp. Linnaeus, 1758	3	D	*Lamprops fasciatus* G.O. Sars, 1863	1	SDF	*Trachythyone elongata* (Düben & Koren, 1846)	1	D
Nicomache sp.Malmgren, 1865	1	SSDF	*Leucothoe* sp. Leach, 1814	1	N	**Cnidaria**		
Nothria conchylega (M. Sars, 1835)	1	C	*Leucothoe spinicarpa* (Abildgaard, 1789)	1	N	*Actinia* sp. (Sebens & Paine 1979)	1	C
Notomastus latericeus M. Sars, 1851	3	SSDF	*Liocarcinus depurateur* (Linnaeus, 1758)	1	C	*Cerianthus* sp. Delle Chiaje, 1830	1	C
Notomastus profundus Eisig, 1887	3	SSDF	*Lysianassa longicornis* (Lucas, 1849)	1	S	*Cladocora cespitosa* (Linnaeus, 1758)	1	S
Notomastus sp. M. Sars, 1850	3	SSDF	*Paguristes oculatus* (Fabricius 1775)	1	C	*Hydrozoa* indt	1	S

Appendix 1 (continued)

Species	E.G.	T.G.	Species	E.G.	T.G.	Species	E.G.	T.G.
Onuphis quadricuspis Mc'Intosh 1910	1	C	*Pagurus* sp. Fabricius, 1775	1	C	**Porifera**		
Pectinaria sp. de Lamarck, 1818	1	SSDF	*Tanais dulongii* (Audouin, 1826)	1	D	*Chondrosia reniformis* Nardo, 1847	1	S
Perinereis sp. Kinberg, 1866	3	D	*Tuberapseudes echinatus* (G.O. Sars, 1882)	3	D	*Ircinia* sp.Nardo, 1833	1	S
Petaloproctus sp.Quatrefages, 1865	1	SSDF	*Vaunthompsonia cristata* Bate, 1858	-	SDF	**Sipunculida**		
Phyllodoce macrophthalma Schmarda, 1861	2	C	**Mollusca**			*Aspidosiphon mulleri* Diesing, 1851	1	SDF
Phyllodoce sp. Lamarck, 1818	2	C	*Abra alba* (Wood 1802)	3	SDF	**Oligochaeta**		
Pista cristata (O.F. Müller, 1776)	1	SDF	*Acanthocardia tuberculata* (Linnaeus, 1758)	1	S	Oligochaeta indt	5	SSDF
Polydora sp. Bosc, 1802	4	SDF	*Antalis panorma* (Chenu, 1843)	1	SSDF	**Nematoda**		
Potamilla reniformis Malmgren 1867	1	S	*Antalis vulgaris* (da Costa, 1778)	1	SSDF	Nematoda indt	5	SSDF
Potamilla torelli Malmgren, 1866	1	S						