

Mollusc assemblages of hard bottom subtidal fringe: a comparison between two coastal typologies

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ABSTRACT

The mollusc assemblages of subtidal fringe from two different coastal typologies are described in their qualitative and quantitative features. The large-scale spatial investigation has been carried out in the lava cliffs of Catania and the conglomerate “beach-rocks” of Capo Peloro (Messina), whose assemblages have been compared by fourteen shallow sampling stations, spaced out hundred/thousand meters apart. The similarity/dissimilarity levels of the two assemblages have been evaluated throughout a set of eighty-six species, exclusive or common between the two areas. Both the assemblages were characteristic of an impoverished and highly variable photophilic taxocoenosis. The area was the main discriminating factor that determined the highest richness and abundance in the rough lava surface. The Catania assemblage was more constant in species composition, with presence of exclusive bivalves, cue of a micro-sedimentary environment. The Messina assemblage was very variable in species composition, and its structure, dominated by motile gastropods, was evidence of a high energy environment. Differences in the structure and micro-topography of the natural substratum from the two areas, besides possible secondary influence of freshwater inputs and wave exposure, were factors mainly responsible for the observed patterns. The whole data set, with dominant and accessory taxa, involves a relevant contribution from the deeper subtidal assemblage; despite of their ephemeral character, these assemblages contribute to maintain the local biodiversity on a broader spatial scale.

KEY WORDS

Biodiversity; Geographical trend; Mediterranean Sea; Molluscs; Rocky shores.

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INTRODUCTION

It is known that species distribution and related biodiversity levels are stressed by the interaction between biotic and abiotic factors, which determine a hierarchy of processes that operate at different spatio-temporal scales (Underwood & Chapman, 1996). Spatial patterns of intertidal hard bottom assemblages have been widely investigated in the past, both on a broad geographic (Blanchette et al., 2008) and local scale (Reichert et al., 2008). In the

Mediterranean basin, despite of the prevalent microtidal regime, the intertidal zone has received much attention (Benedetti-Cecchi, 2001; Fraschetti et al., 2001). By contrast, rocky subtidal assemblages have been investigated to a lesser extent, except for the impacted sessile communities (Fraschetti et al., 2001) and few groups of vagile invertebrates, such as polychaetes (Giangrande, 1988; Giangrande et al., 2003).

The mollusc taxocoene, notwithstanding its relevant diversification and wide geographic and

ecological distribution, has been poorly investigated in its quantitative aspects, and patterns of spatial distribution have been rarely described (Chemello & Milazzo, 2002; Terlizzi et al., 2003). Mollusc spatial patterns and relationships with substratum complexity have been locally investigated, for example in the Aegean Sea (Antoniadou et al., 2005). Within the subtidal zone, the upper level (the fringe) has received a scanty interest in the past, and the associated mollusc assemblages are probably the less known from the Mediterranean phytal zones.

The subtidal fringe, characterized by strong environmental constraints and high levels of environmental disturbance, shows different degrees of substratum complexity which might affect the spatial patterns of flora and fauna (Guichard et al., 2001). Furthermore, the ephemeral character of the algal covering might accentuate the spatial and temporal dynamics of the associated vagile fauna, as proved for shallower as well as deeper subtidal assemblages (Benedetti-Cecchi & Cinelli, 1992). In this respect, the Ionian coasts of Sicily might represent an appropriate case-study, due to rocky cliff typologies that are quite different from the northern coastline (of metamorphic and sedimentary origin) to the central (of mainly volcanic origin) and southern (carbonatic origin) coastlines. In this paper mollusc assemblages of subtidal fringe are investigated from two rocky coasts of different origin, volcanic and sedimentary, respectively located in the Strait of Messina and in the northern side of the Gulf of Catania.

Aims of the present investigation are: i) to describe the mollusc assemblages, which characterise the upper subtidal fringe from two different coastal typologies; ii) to investigate their similarity/dissimilarity at different spatial scales (kilometers, hundreds of kilometers); iii) to highlight the main (a)biotic constraints which may affect the assemblage composition and structure.

MATERIAL AND METHODS

Study areas

The study area, which corresponds to the northern segment of the Ionian coast of Sicily (Fig. 1), has a regular N 30°-trending shoreline, extending for a total length of 107 km from Capo Peloro

(North) to Catania (South). On the basis of geological and morphological characters, two sub-provinces can be distinguished. The northern segment, consisting of the Ionian side of the Peloritani chain from Capo Peloro to the city of Riposto (first 75 km), is characterized by Kabilo-Calabride terraces; the southern segment, made up of the volcanites from the eastern flank of Mt Etna, reaches the city of Catania (Longhitano & Zanini, 2006).

Since it represents a microtidal oceanographic framework, coastal dynamics are mainly influenced by waves that approach the coast obliquely, and by long-shore southward currents, controlled by the complex hydrological dynamics of the Messina Strait. Such hydrodynamics interact with clockwise, offshore circulation of the Ionian Sea.

Wave energy affects the coastline differently, since northwards it is mitigated by the action of the Messina Strait tidal currents, whilst southwards the near shore circulation is often diffracted and inhibited by the great complexity of the volcanic shoreline, marked by small coastal promontories and indentations (Figs. 2, 3). In the Sicily side of the Messina Strait the coastline is almost homogeneous with a mid-Pleistocene conglomerate outcrops, along almost two kilometers of shoreline (Bottari et al., 2005). Such so-called “beach-rock”, which represents the sole hard substratum of natural origin, is frequently connected to artificial breakwaters and other concrete structures (Figs. 4, 5).

Rivers, as the main points of sedimentary input, are localized in the southern part and don't affect the Messina Strait. Freshwater inputs are mostly of phreatic origin in Catania, whilst in Messina stations they are mediated by the Capo Peloro Lagoon, throughout the two canals “Faro” and “Due Torri”.

Sampling and analysis

The sampling strategy has been based on two levels at different spatial scale (Fig. 1). The first level (100 km scale) distinguished the two areas of Messina (Capo Peloro) and Catania (Ognina). At the second level, seven stations per area have been located along 1.9 km (Messina) and 5 km of coast (Catania) respectively, according to the two main substratum typologies (natural vs. artificial), wave exposures (exposed vs. sheltered), slope (vertical vs. horizontal). The presence or absence of freshwater inputs was also considered. In spring 2002

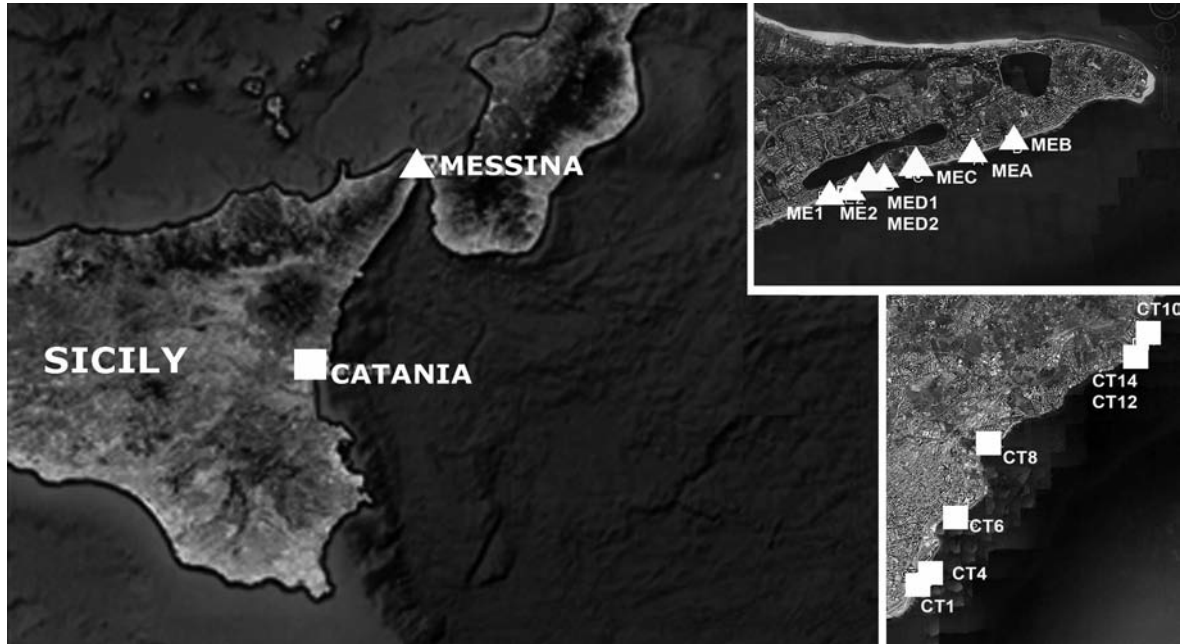


Figure 1. Study area. Messina (upper pane) and Catania (lower pane) coastlines with sampling distribution.



Figures 2-5. Study site. Figs. 2, 3. Messina shoreline with conglomeratic “beach-rocks”.
Figs. 4, 5. Catania shoreline with basaltic rocks.

two random replicates of 25x25 cm scraped surface were carried out for each station, ten meters spaced out (pooled data), in a shallow subtidal fringe from 0 to 0.3 m depth. Substratum typology and algal covering were preliminarily recorded on field. In laboratory, samples were washed throughout a 0.250 mm mesh sieve and the retained macrobenthic fauna was separated from algae throughout a manual centrifuge. Particles smaller than 0.250 mm were considered as "sediment" and their amount evaluated as volume and dry weight (80°C/24 h). Algae were investigated in their structure by dominant taxa, fresh and dried total biomass, total fresh volume and degree of branching, in accordance with Edgar (1983). Besides, the characterising algae were distinguished in the main functional groups of encrusting, thread-like and branched thallii, according to Littre & Arnold (1982).

The macro-zoobenthos (>0.250 mm sieved fraction) has been sorted out under the stereomicroscope at the Phylum/Classis/Ordo levels. Molluscs have been determined at the species level, and respective abundances evaluated. The univariate and multivariate statistical parameters have been elaborated by means of PRIMER 6.0 software package. Main factors potentially affecting assemblage composition and structure were selected a priori and tested by the analysis of similarity procedure (ANOSIM) for one way and two way crossed designs. The selected abiotic factors were the sampling area (two fixed levels), the sampling station (six random levels), the site exposure (two fixed levels), the substratum typology (two fixed levels), slope (two fixed levels), freshwater inputs (two random levels), entrapped sediment (two random levels).

The selected biotic factors were the algal covering (three fixed levels), algal volume (three random levels), dominant algal taxa (seven random levels) and the algal functional groups (three random levels). The similarity percentage analysis (SIMPER) highlighted for those species that were more responsible for dissimilarity between areas.

RESULTS

The whole examined sample set provided a total of 86 species, 46 of which were exclusively collected in Catania and 21 were exclusively recorded in

Messina, while 22 species were common to the two areas (Table 1). Gastropod species were the most numerous, with 63 species, 34 of which were collected only in Catania and 18 only in Messina, plus 11 shared species; half of the 18 bivalve species were exclusively found in Catania, with respect to the two species exclusively recorded in Messina, whilst other 7 species were collected in both areas. Polyplacophora accounted one shared species plus three taxa exclusively found in Catania and one in Messina (Fig. 6).

The number of species found in each station ranged from 7 (MEB) to 24 (MEE1) in Messina with a tendential north-to-south increase; such trend was more irregular in Catania, with 15 species in CT12 up to 37 species in CT6. Likewise the number of species, the abundances per station were higher in Catania (min 244, max 1960 individuals) than in Messina (min 27, max 1349), but they were irregularly distributed and not clearly related to the number of species, except for MEE1 where the peaks of the two parameters matched (Fig. 7).

The trend of Margalef's richness agrees with the number of species. Univariate diversity indexes showed different trends between the two areas. Shannon diversity and species equitability had more remarkable fluctuations in Messina, ranging from 0.52 (MEE1) to 2.04 (MEC) and from 0.16 to 0.89, respectively. Diversity in Catania was meanly 1.5 in most stations, except for values 2.1 and 2.2 in

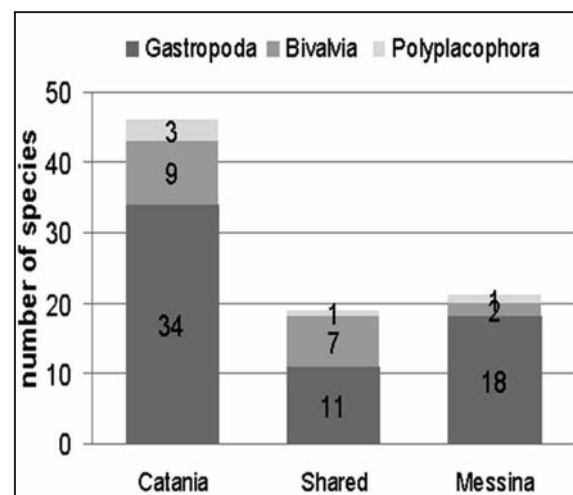


Figure 6. Numbers of Polyplacophora, Bivalvia and Gastropoda species exclusively recorded in Messina or Catania, and shared between the two areas.

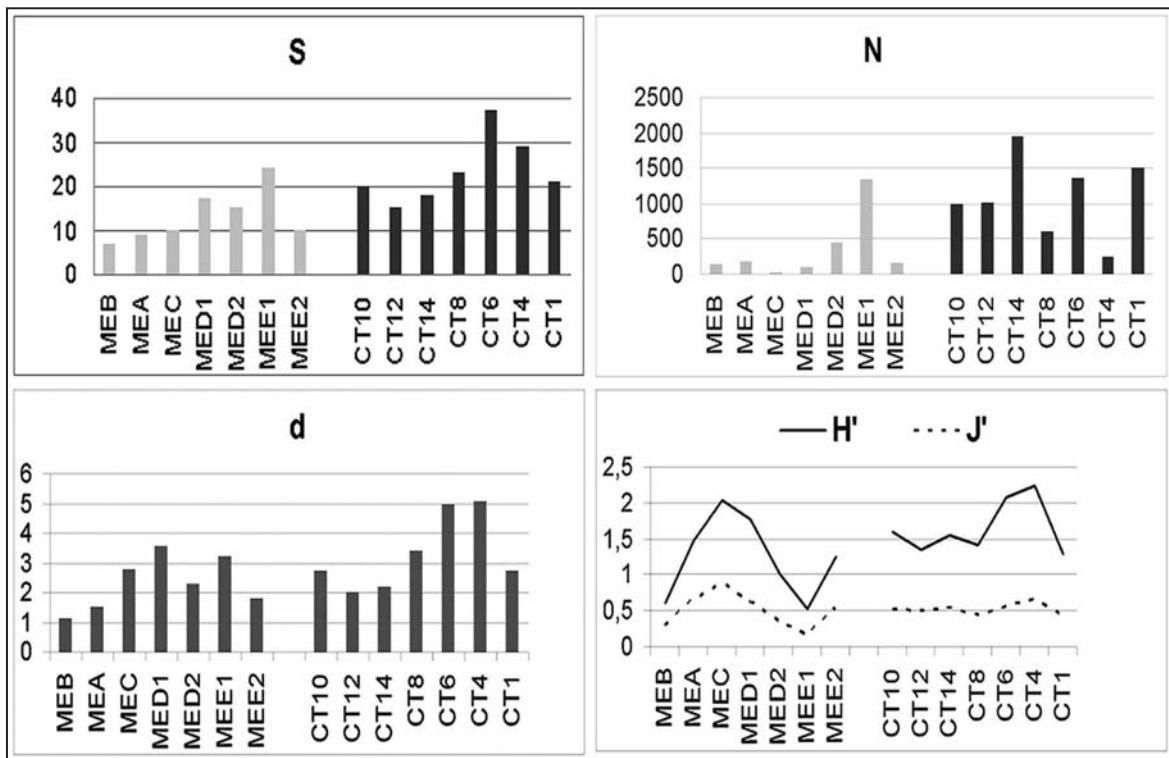


Figure 7. Trends of species number, abundance, Margalef richness, Shannon diversity, Pielou equitability observed in Catania and Messina. For each area, sampling stations are ordered from North (left) to South (right).

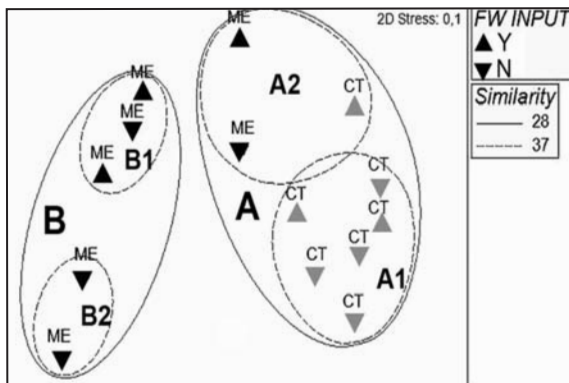


Figure 8. Nm-MDS ordination plot with superimposed cluster classification of Catania and Messina stations. Presence (Y) and absence (N) of freshwater inputs is also showed.

CT6 and CT4 respectively; equitability was meanly low, likewise in Messina, but with a more regular trend (Fig. 7).

The multivariate analysis highlighted further differences in the mollusc assemblages from the two areas. The Bray-Curtis similarity index and the

related cluster analysis (square root transformed data, average linkage) discriminated, at lower 28% level, a first group A of all Catania stations plus two Messina stations, from a second homogeneous group B of five stations of Messina (Fig. 8). At a higher level of 37%, the former group was constituted by a further sub-group A1 of six Catania stations, which were separated from a small sub-group A2 of stations from both areas. Such indication of a different composition/structure of the Messina and Catania mollusc assemblages was supported by the ANOSIM test, which indicated such area-related discrimination as a statistically significant factor (Global E 0.78, p-level 0.1%; number of permuted statistics greater than or equal to Global R: 0). Among the other factors that potentially affected the mollusc taxocoenosis within each area group, the occurrence/absence of freshwater inputs (Fig. 8) and “exposure” (exposed/sheltered), were the most significant.

The ANOSIM test (two way crossed) for differences between areas across all stations with fresh water inputs, also resulted statistically significant,

with a Global R of 0.87 (p-level 0.4%; number of permuted statistics greater than or equal to Global R: 3). A 2D multi-dimensional scaling better clustered the stations submitted or not to such constraint inside the Messina area, with respect to a weaker separation inside the other clusters (Fig. 8).

Similarly, test for differences between the factor “area” across the factor “exposure” provided a Global R of 0.82, but with a lower significance level of 1.3% (number of permuted statistics greater than or equal to Global R: 1). The hypothesis of a possible interaction of the two local affecting factors was less strictly supported by test for differences between “freshwater inputs” across all “exposure”, which provided a Global R of 0.79, but with p-level 4% (number of permuted statistics greater than or equal to Global R:1); in this respect, the general absence of freshwater inputs in the medium and high exposed stations should be noted. All the other abiotic and biotic factors, tested with ANOSIM, did not produce significant differences among the selected levels.

The Messina assemblage, with a lower average similarity of 32.9% (Table 1), was characterized by a small number of species, nine of which accounted

for 91.4% intra-group similarity. Most of similarity (49.1%) was due to two sole species, *Pisinna glabrata* (Megerle von Mühlfeld, 1824) and *Setia amabilis* (Locard, 1886), with 33.7% and 15.4% respectively. The contribution of other species rapidly declined down to 3.1% for *Columbella rustica* (Linnaeus, 1758). A residual 8.6% cumulative similarity was due to 31 rare or occasional species. The Catania assemblage showed a higher 41.5% similarity and was due to a small group of frequent species, eleven of which accounted for 91.2 cumulative percentage. Most of such a cumulative contribution was due to the species *Cardita calyculata* (Linnaeus, 1758), *Pisinna glabrata* and *Barleeia unifasciata* (Montagu, 1803), with an average contribution of 25.7%, 16.6% and 10.8%, respectively. Differently from Messina, the contribution of other species slowly declined, down to a minimum of 1.9% of *Crisilla galvagni* (Aradas et Maggiore, 1844). A consistent group of 54 less common species covered the residual 8.8%.

The same three species that were main responsible for the internal similarity of the Catania area, (*Cardita calyculata*, *Pisinna glabrata*, *Barleeia unifasciata*) had a primary role to determine the

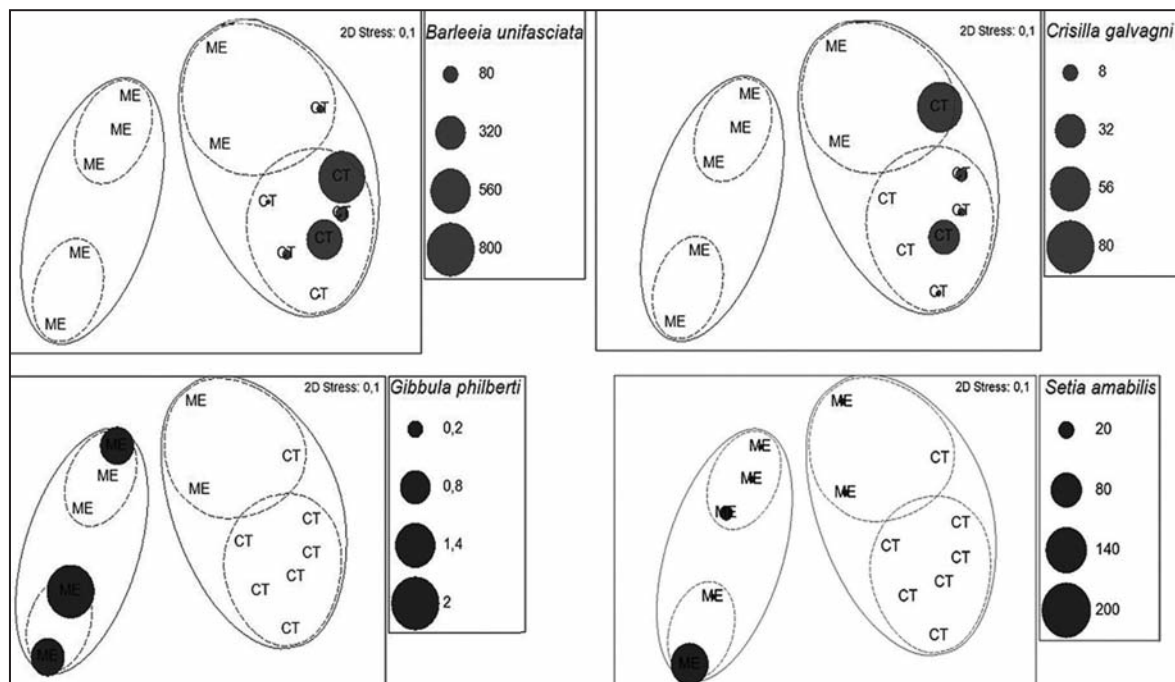


Figure 9. Nm-MDS ordination bubble-plots for some abundant and rare species which characterized the Messina and Catania mollusc taxocoenosis with superimposed cluster classification of the two areas.

inter-group dissimilarity, although at lower extent, accounting respectively for 13.5%, 8.9% and 9.5% of the 79.3% average dissimilarity. Over a total of 86 species, just 40 accounted for 90% cumulative dissimilarity. It is of interest to note that a small group of species, *Setia amabilis*, *Crisilla semistriata* (Montagu, 1808), *Lasaea adansoni* (Gmelin, 1791), that weakly contributed to the intra-group similarity, played a significant role in determining inter-group dissimilarity (Table 1). Such repartition of species per area is well represented in the bubble plots of figure 9, showing the abundances of *Setia amabilis* and *Barleeia unifasciata*, which are highly characterizing species for the Messina and Catania assemblages, respectively. Other two less abundant species, which might be linked to a particular area, were *Crisilla galvagni*, exclusively found in Catania, and *Gibbula philberti* (Récluz, 1843) which characterized the Messina area.

More in general, qualitative differences were recognized in some less frequent taxa that were exclusively or prevalently found in a single area (Table 2). Between the Rissoacea, for example, the genus *Alvania* Risso, 1826 and *Crisilla* Monterosato, 1917 best characterized the area of Catania (with eight and three species respectively) with respect to Messina (with two and none species respectively), whilst the genus *Rissoa* Desmarest, 1814 (two species) and *Setia* Adams H. & A., 1854 (two species) were exclusively found in Messina. Similarly, the genera *Granulina* Jousseaume, 1888 (three exclusive species) and *Gibbula* Risso, 1826 (five exclusive species) best characterised Catania and Messina shorelines, respectively. A possible vicariant distribution between some congeneric species was also noted, such as for *Tricolia deshampsi* Gofas, 1993 and *T. miniata* (Monterosato, 1884) sampled only in Messina, with respect to *T. landinii* Bogi et Campani, 2007 collected exclusively in Catania.

DISCUSSION

In this investigation, which provided the first quantitative data on mollusc assemblages from the Ionian subtidal fringe, a comparison between two areas, Messina and Catania, quite different in the typology of the natural substrata, has been carried out. Their spatial separation (almost 100 Km) and

station distribution (less than 1 km spaced), replicated similar investigations on intertidal communities which have put in evidence a highest grade of variability on a ten meter spatial scales (Kelaher et al., 2001) and even among replicates (Reichert et al., 2008). Such a local variability, in the present investigation has been considered in terms of stochastic patchiness and resolved by replicate pooling. Such procedure allowed a better discrimination of assemblages per stations and areas.

The fringe, as a peculiar aspect of photophilic habitat submitted to high levels of environmental stress (e.g. hydrodynamism, insulation, desiccation, freshwater inputs), was expected to be characterized by impoverished assemblages; in contrast, the total number of recorded species was high, in comparison with deeper subtidal assemblages both from western (Poulicek, 1985), central (Richards, 1983) and eastern Mediterranean (Antoniadou et al., 2005). Number of species and abundance were markedly higher in Catania with respect to Messina, probably due to the rough lavic substratum and a more irregular/uneven shoreline, which increases space availability, habitat complexity and shelter, with respect to the smooth conglomeratic beach-rock and connected concrete blocks.

Although richer in species number and individuals, the lava cliff did not substantially overlie the conglomeratic beach-rock in terms of mollusc diversity, that was moderately high in both substrata typologies. By contrast, equitability was low, thus testifying for a generalised de-structured condition of both the assemblages. In general, the studied mollusc assemblages showed a high grade of stochastic variability, especially in Messina, according to the wide fluctuation of univariate diversity indices and to the low internal similarity of each sample group. Nevertheless, statistically significant differences between the two areas, mainly due to a small number of dominant species (Kelaher et al., 2001) were found. Such differentiation of the two mollusc assemblages was moderately altered by the “intrusion” of two Messina stations in the Catania group, which might be viewed as an evidence of a cenotic affinity, rather than as an ecological transition. In this respect, we note that most of the recorded molluscs are known to be ecologically related to the Mediterranean photophilic algal assemblage complex, with diversified preference in terms of depth, light, exposure.

	ME	sh.	CA		ME	sh.	CA
Polyplacophora				Gastropoda			
<i>Callochiton calcatus</i> Dell'Angelo & Palazzi, 1994	•			<i>Haminoea hydatis</i> (Linnaeus, 1758)			•
<i>Acanthochitona crinita</i> (Pennant, 1777)		•		<i>Haminoea navicula</i> (da Costa, 1778)		•	
<i>Acanthochitona fascicularis</i> (Linnaeus, 1767)			•	<i>Odostomia improbabilis</i> Oberling, 1970			•
<i>Lepidochitona monterosatoi</i> Kaas & Van Belle, 1981			•	<i>Mitra cornicula</i> (Linnaeus, 1758)		•	
<i>Leptochiton cimicoides</i> (di Monterosato, 1879)			•	<i>Naticarius hebraeus</i> (Martyn, 1786)		•	
<u>Gastropoda</u>				<i>Ocinebrina hispidula</i> (Pallary, 1904)		•	
<i>Alvania cancellata</i> (da Costa, 1778)			•	<i>Odostomella doliolum</i> (Philippi, 1844)			•
<i>Alvania cimex</i> (Linnaeus, 1758)			•	<i>Omalogyra atomus</i> (Philippi, 1841)			•
<i>Alvania clathrella</i> (Seguenza L., 1903)			•	<i>Paradoris indecora</i> (Bergh, 1881)		•	
<i>Alvania lanciae</i> (Calcara, 1845)			•	<i>Parthenina clathrata</i> (Jeffreys, 1848)			•
<i>Alvania scabra</i> (Philippi, 1844)			•	<i>Pisinna glabrata</i> (Megerle von Mühlfeld, 1824)			•
<i>Alvania simulans</i> Locard, 1886			•	<i>Phorcus richardi</i> (Payraudeau, 1826)		•	
<i>Alvania subcrenulata</i> (B.D.D., 1884)			•	<i>Pusillina marginata</i> (Michaud, 1830)			•
<i>Alvania zetlandica</i> (Montagu, 1815)			•	<i>Rissoa similis</i> Scacchi, 1836		•	
<i>Ammonicera fischeriana</i> (Monterosato, 1869)			•	<i>Rissoa variabilis</i> (Von Mühlfeldt, 1824)		•	
<i>Aplysia parvula</i> Mörch, 1863		•		<i>Setia amabilis</i> (Locard, 1886)			•
<i>Aplysia fasciata</i> Poiret, 1789			•	<i>Setia scillae</i> (Aradas & Benoit, 1876)			•
<i>Barleeia unifasciata</i> (Montagu, 1803)			•	<i>Sinezona cingulata</i> (O. G. Costa, 1861)			•
<i>Bittium lacteum</i> (Philippi, 1836)			•	<i>Tricolia deschampsii</i> Gofas, 1993			•
<i>Bittium reticulatum</i> (da Costa, 1778)			•	<i>Tricolia miniata</i> (Monterosato, 1884)			•
<i>Bulla striata</i> Bruguière, 1792			•	<i>Tricolia landinii</i> Bogi & Campani, 2007			•
<i>Cerithiopsis nofronii</i> Amati, 1987			•	<i>Vexillum ebenus</i> (Lamarck, 1811)			•
<i>Cerithium vulgatum</i> Bruguière, 1792			•	<i>Vitreolina incurva</i> (B.D.D., 1883)			•
<i>Columbella rustica</i> (Linnaeus, 1758)			•	<i>Vitreolina philippi</i> (de Rayneval & Ponzi, 1854)			•
<i>Conus ventricosus</i> Gmelin, 1791			•	<i>Willamiamia gussoni</i> (Costa O. G., 1829)			•
<i>Crisilla beniamina</i> (Monterosato, 1884)			•	<u>Bivalvia</u>			
<i>Crisilla galvagni</i> (Aradas & Maggiore, 1844)			•	<i>Anomia ephippium</i> Linnaeus, 1758			•
<i>Crisilla semistriata</i> (Montagu, 1808)			•	<i>Arca noae</i> Linnaeus, 1758			•
<i>Eatonina pumila</i> (Monterosato, 1884)			•	<i>Barbatia barbata</i> (Linnaeus, 1758)			•
<i>Epitonium pulchellum</i> (Bivona, 1832)			•	<i>Brachidontes pharaonis</i> (P. Fischer, 1870)			•
<i>Fissurella nubecula</i> (Linnaeus, 1758)			•	<i>Cardita calyculata</i> (Linnaeus, 1758)			•
<i>Fossarus ambiguus</i> (Linnaeus, 1758)			•	<i>Chama gryphoides</i> Linnaeus, 1758			•
<i>Gibberula jansseni</i> van Aartsen et al., 1984			•	<i>Hiatella arctica</i> (Linnaeus, 1767)			•
<i>Gibbula adansonii</i> (Payraudeau, 1826)			•	<i>Hiatella rugosa</i> (Linnaeus, 1767)			•
<i>Gibbula ardens</i> (Salis Marschlin, 1793)			•	<i>Irus irus</i> (Linnaeus, 1758)			•
<i>Gibbula philberti</i> (Récluz, 1843)			•	<i>Lasaea adansonii</i> (Gmelin, 1791)			•
<i>Gibbula racketti</i> (Payraudeau, 1826)			•	<i>Lima lima</i> (Linnaeus, 1758)			•
<i>Gibbula turbinoides</i> (Deshayes, 1835)			•	<i>Musculus costulatus</i> (Risso, 1826)			•
<i>Gibbula umbilicaris</i> (Linnaeus, 1758)			•	<i>Mytilaster minimus</i> (Poli, 1795)			•
<i>Gibbula varia</i> (Linnaeus, 1758)			•	<i>Mytilaster solidus</i> Monterosato, 1883			•
<i>Granulina boucheti</i> Gofas, 1992			•	<i>Mytilus galloprovincialis</i> Lamarck, 1819			•
<i>Granulina marginata</i> (Bivona, 1832)			•	<i>Ostrea edulis</i> Linnaeus, 1758			•
<i>Granulina vanharenii</i> (van Aartsen et al., 1984)			•	<i>Ostrea stentina</i> Payraudeau, 1826			•
<i>Gyroscala lamellosa</i> (Lamarck, 1822)			•	<i>Striarca lactea</i> (Linnaeus, 1758)			•

Table 1. Similarity Percentage analysis for species contribution to Bray-Curtis similarity (S') and dissimilarity (\hat{C}) within each area and between the two areas respectively. Av., average; SD, standard deviation; N, abundance of individuals.

SIMPER within/between Area-Groups	Group ME av. S'	Group ME S'	Group CT av. S'	Group CT S'	av. δ	δ /SD	δ contr. %
	32.92		41.53				
	<u>av. N</u>		<u>av. N</u>				
<i>Cardita calyculata</i>	2.51	2.73*	15.64	10.68*	10.65	1.48	13.47
<i>Barleeia unifasciata</i>	0.00	–	9.96	4.48*	7.53	1.11	9.51
<i>Pisinna glabrata</i>	10.90	11.09*	11.12	6.89*	7.09	1.37	8.96
<i>Ammonicera fischeriana</i>	0.25	–	6.53	3.68*	5.22	0.94	6.59
<i>Acanthochitona crinita</i>	0.29	–	4.53	3.79*	3.29	2.57	4.16
<i>Mytilaster solidus</i>	1.69	0.14	5.24	2.4*	3.21	0.84	4.06
<i>Gibbula turbinoides</i>	3.54	0.15	0.47	–	2.73	0.87	3.45
<i>Setia amabilis</i>	3.23	5.07*	0.00	–	2.71	0.87	3.43
<i>Crisilla semistriata</i>	0.00	–	3.79	–	2.62	0.49	3.32
<i>Lasaea adansoni</i>	0.00	–	2.57	–	2.29	0.46	2.89
<i>Bittium reticulatum</i>	0.34	–	2.62	1.43*	1.93	1.11	2.44
<i>Eatonina pumila</i>	1.05	0.07	3.37	1.35*	1.90	1.07	2.40
<i>Crisilla galvagni</i>	0.00	–	2.71	0.06	1.81	0.97	2.29
<i>Crisilla beniamina</i>	0.00	–	2.30	–	1.80	0.83	2.27
<i>Columbella rustica</i>	1.69	0.04	2.58	1.3*	1.73	1.36	2.19
<i>Sinezona cingulata</i>	0.00	–	1.94	–	1.12	0.51	1.41
<i>Gibbula adansonii</i>	1.11	–	0.40	–	1.03	0.77	1.30
<i>Fissurella nubecula</i>	0.00	–	1.45	–	0.98	1.01	1.24
<i>Musculus costulatus</i>	1.06	0.07	1.68	1.06*	0.93	1.17	1.18
<i>Arca noae</i>	0.74	–	0.98	–	0.90	0.95	1.14
<i>Gibbula ardens</i>	1.10	–	0.00	–	0.81	0.75	1.02
<i>Brachidontes pharaonis</i>	0.14	–	1.10	–	0.77	1.05	0.98
<i>Mytilus galloprovincialis</i>	0.00	–	0.99	–	0.75	0.50	0.95
<i>Aplysia parvula</i>	0.90	0.05	0.00	–	0.68	1.08	0.86
<i>Alvania scabra</i>	0.00	–	1.01	–	0.65	0.68	0.83
<i>Chama gryphoides</i>	0.29	–	0.57	–	0.56	0.74	0.71
<i>Alvania lanciae</i>	0.29	–	0.64	–	0.54	0.70	0.68
<i>Gyroscala lamellosa</i>	0.29	–	0.52	–	0.46	0.84	0.58
<i>Acanthochitona fascicularis</i>	0.00	–	0.69	–	0.45	0.40	0.57
<i>Gibbula philberti</i>	0.49	–	0.00	–	0.44	0.79	0.56
<i>Omalogyra atomus</i>	0.00	–	0.78	–	0.42	0.40	0.53
<i>Aplysia fasciata</i>	0.00	–	0.53	–	0.42	0.40	0.53
<i>Tricolia landinii</i>	0.00	–	0.39	–	0.39	0.58	0.50
<i>Alvania simulans</i>	0.00	–	0.73	–	0.39	0.40	0.50
<i>Irus irus</i>	0.00	–	0.39	–	0.39	0.59	0.49
<i>Gibbula racketti</i>	0.55	–	0.00	–	0.37	0.61	0.47
<i>Ostrea edulis</i>	0.00	–	0.40	–	0.36	0.60	0.45
<i>Tricolia miniata</i>	0.49	–	0.00	–	0.35	0.60	0.44
<i>Alvania cancellata</i>	0.00	–	0.49	–	0.35	0.81	0.44
<i>Granulina vanhareni</i>	0.00	–	0.52	–	0.34	0.60	0.43

Table 2. Distribution of mollusc species in the shallow sublittoral zones of Messina (ME), Catania (CA) and shared (sh.) between the two areas.

Such mélange of species tied to different environmental conditions is explicated in literature as a trapping effect exerted by the branching algae towards the settling larvae and early juveniles (Poulicek, 1985). This supposed “branching effect” did not significantly affect the composition and structure of the mollusc assemblages, which clustered independently from typology and extent of algal covering. Such evidences do not agree with literature data that indicate a significant effect of algal architecture on the mollusc assemblage discrimination (Chemello & Milazzo, 2002; Pitacco et al., 2014; Antoniadou et al., 2005). By contrast, the hypothesis that redundant algal-associated assemblages can play a key role for the maintenance of biodiversity of the broader geographical area (Antoniadou et al., 2005) is here supported. Moreover, contrasting effects of algal covering towards zoobenthic larvae should be considered, since the wave exposed fringe is submitted to a highest sediment/nutrient resuspension that is known to favour spores with respect to benthic larvae in space competition (Richmond & Seed, 1991; Oigman-Pszczol et al., 2004). Once developed, algae might favour larval recruitment and juvenile/adults surviving, providing food and protection from predators and desiccation (Poulicek, 1985; Antoniadou et al., 2005), but limitedly to a short time period, due to their ephemeral character.

Mollusc assemblages that were dominated by small sized species with a short life span reflected such an irregular and transient availability of resources in their high densities and low organization levels. The algal assemblage, in turn, is driven by the substratum type and its (micro)topographic complexity, both of which directly and indirectly affect the settlement and persistence of benthic organisms. In this respect, the geo-lithological structure of the natural substrata and the related texture might be explicative for the observed patterns of diversity among the two areas far apart. The conglomeratic rocks of the Messina Strait is more even and less porous with respect to the basaltic surface of Catania cliffs, which is more irregular and richer in hollows and crevices. The more uneven surface, promoting phyto-benthic colonization, in turn improves shelter and sediment trapping, that is in accordance with the higher richness of the bivalve species observed in the Catania area.

The less fluctuating Shannon H' and equitability of species/abundance of the Catania mollusc assemblage with respect to the Messina area, also support the hypothesis that substratum roughness acts as structuring factor. Other local factors, both related or not with the natural substratum typology, do not play a recognizable role, except for freshwater inputs combined with shelter exposure. The effects of geographical distance, that might be more important than substratum type or roughness in determining assemblage structure (Guarnieri et al., 2009), might be also considered, in reason of the latitudinal gradient between the two areas.

Such a gradient determines a southward temperature increase that near Catania marks the crucial 15°C seawater winter isotherm (Bianchi et al., 2012). In our opinion, the climatic gradient was not directly responsible for the quantitative differences between the two areas, but may partially explicate the different species composition. Some of the forty-six (Catania) and twenty-one (Messina) not shared species have a limited Mediterranean distribution, and some of these species are known from a restricted area, as the recently “rediscovered” *Crisilla galvagni* (Scuderi & Amati, 2012).

CONCLUSIONS

The mollusc assemblages from two subtidal fringes of eastern Sicily configure as an impoverished aspect of the photophilic associated fauna, submitted to some strong environmental constraints that limit the number of characteristic species but allow the transient recruitment of opportunistic and occasional taxa.

The investigated areas, although submitted to similar climatic and edaphic conditions, have differently structured substrata which result more or less favourable to species settlement and survival in accordance with high (Catania) or low (Messina) cliff roughness. The respective assemblages, although characterized by a high local variability, show some common traits that allow to recognize a real taxocoenosis.

Some scarcely known species, mainly localized in the lava cliff, may be preferentially tied to such peculiar environment. The accessory taxa that are partially supplied by other nearby communities

testify for the role of shallow fringe assemblages to maintain the biodiversity at local and at broader geographical scale.

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