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Macrofaunal communities in the Gioia Canyon (Southern Tyrrhenian Sea, Italy)

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Abstract
Submarine canyons play pivotal roles in the physical, biological and ecological processes of coastal areas, especially in closed or semi-closed basins as the Mediterranean Sea, influencing the biodiversity and the abundance of the benthic fauna. On February 2013, during the Tyrrhenian Gravity Flows (TyGraF) campaign, samples have been collected along the Gioia Canyon Basin (Italy) with the aim to describe the taxonomical composition and the abundances of the macrobenthic assemblages, filling the gap of knowledge in this area. A total of 93 taxa were identified, and the Annelida was the phylum with the highest number of specimens and most diversified (46 taxa). The polychaetes *Sternaspis scutata, Prionospio cirrifera* and *Monticellina* sp., the bivalves *Thyasira* sp.1 and *Saccella commutata* and the amphipods belonging to the genera *Ampelisca* and *Harpinia* showed the highest densities in the studied area; however, results suggest low values of the abundances of the macrobenthos if compared with those generally reported for other canyons, both inside and outside the Mediterranean Sea. The marine biotic index (AMBI) highlights that the canyon system and the surrounded area were slightly disturbed and characterized by a high percentage of tolerant taxa. This study is the first baseline for future analyses of the macrobenthic communities of this area.

Keywords: *Mediterranean Sea, macrobenthos, taxonomy, biodiversity, deep sea*

1. Introduction

Most of the oceanic coastal margins are characterized by submarine canyons, deep incisions of the slopes that strongly affect the overall water currents of an area, producing vortexes and vertical fluxes (Klinck 1996; Hickey 1997). These modifications may trigger local upwelling, which pumps nutrients to the euphotic zone regulating the primary production dynamics (Ryan et al. 2005) as well as the entire food web and trophic cascade up to cetaceans (Moors-Murphy 2014). From this point of view, submarine canyons represent a fundamental "two-ways highway" for the transport of sediment, organic matter, larvae, resting stages, nutrients and also pollutants from the shallow waters to the deep sea and conversely (Vetter & Dayton 1998, 1999; Della Tommasa et al. 2004; Boero et al. 2019). The environmental heterogeneity, turbidity currents and internal tides affecting canyons (Shepard 1973; Vetter & Dayton 1998, 1999; Zaniboni et al. 2014), the different seafloor characteristics and the bathymetric profile, were recognized as the major factors able to influence the benthic fauna distribution, abundance and diversity (Rowe et al. 1982; Louzao et al. 2010; McClain & Barry 2010; Vetter et al. 2010; Davies et al. 2014; Zaniboni et al. 2014; Pierdomenico et al. 2016; Grinyó et al. 2018; Covazzi Harriague et al. 2019).

In this contest, the canyon's biodiversity is generally considered strongly related to the habitat structural complexity and it is often represented by the so-called "animal-forests", which contribute to

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enhance the three-dimensionality of the system, improving local biodiversity (Fernandez-Arcaya et al. 2017; Covazzi Harriague et al. 2019), structuring Vulnerable Marine Ecosystems (VMEs). VMEs can shape gardens of Porifera (*Pachastrella monilifera* Schmidt, 1868, *Poecillastra compressa* (Bowerbank, 1866) and *Rhizaxinella pyrifera* (Delle Chiaje, 1828)), Scleractinia (*Lophelia pertusa* (Linnaeus, 1758) and *Madrepora oculata* Linnaeus, 1758), or forests with Pennatulacea (*Funiculina quadrangularis* (Pallas, 1776), Alcyonacea (*Isidella elongata* (Esper, 1788)), Brachiopoda (e.g. *Gryphus vitreus* Borm, 1778) and Echinodermata (e.g. *Leptometra phalangium* (Müller, 1841)) that, hosting in turn rare species and/or species of commercial value, confirm the importance of monitoring and implementing conservation actions toward these ecosystems (Würtz 2012; FAO 2016; Bastari et al. 2018; Grinyó et al. 2018).

Macrobenthos is largely accepted as one of the bioindicators of the marine environmental conditions because able to reallocate nutrients and energy along the trophic levels, extending the trophic-functional heterogeneity (Thrush et al. 2017). Macrobenthos inhabiting canyons is generally characterized by dense populations of deposit-feeders as polychaetes, echiurans and holothuroids (De Leo et al. 2010) and opportunistic species, as the polychaetes *Prionospio* sp., *Paramphinome jeffreysii* and opheliids (Gunton et al. 2015). For instance, a high number of surface deposit feeders, especially polychaetes and crustaceans, were reported in the open slope along the Mediterranean Sea (Mamouridis et al. 2011; Baldrighi et al. 2014); these macrobenthic communities are affected by the terrigenous inputs originating from rivers, by the variation of the quantity and quality of the available food, and in general by the highly variable (in terms of space and time) conditions along the entire Mediterranean basin and in particular in proximity of the canyons (Kröncke et al. 2003; Mamouridis et al. 2011; Baldrighi et al. 2014).

In the Gioia and Petrace Canyons, the available information about the foraminifera and meiofauna assemblages, highlights the presence of several opportunistic taxa with a high rate of turnover so confirming the effect that the environmental features, as high energetic hydrodynamic regime, terrigenous input, and variable organic matter fluxes, have on the benthic compartment (Di Bella et al. 2017). Moreover, fishing activities, as bottom trawling, largely considered a factor that limit the variability and abundance of the benthic assemblages (Romano et al. 2016), has been reported impacting the megafauna living in specific sectors of Gioia canyon (Pierdomenico et al. 2016).

Even though several studies reported data about the assemblages in the Gioia canyon system for the megafauna (Pierdomenico et al. 2016, 2018, 2019), the meiofauna (Gambi et al. 2019) and foraminifera (Di Bella et al. 2017) a gap regarding the macrofaunal compartment is still present. The aim of this study is the description of the macrofaunal assemblages collected inside and outside the Gioia Canyon system (Southern Tyrrhenian Sea) during the Tyrrhenian Gravity Flows cruise (TyGraF) with the purpose of producing a first baseline for future analyses of the communities in this area.

2. Materials and methods

2.1. Study area

The Gioia Canyon is located in the Tyrrhenian Calabrian margin (Italy), oriented SE-NW, near the homonymous locality of Gioia Tauro (Figure 1), one of the most important Italian harbours (Fera & De Paoli 2012). The head of Gioia Canyon begins at 10 m of depth, very close to the coastline, and it is divided into two deep arms that converge in a single central channel at 100 m of depth. This channel runs perpendicular to the coast and it is characterized by bathymetries over 1000 m (Gamberi & Marani 2008). The presence of numerous shelves represents a polyphaser development of the deposition and formation of the canyon (Morelli et al. 2013) that exhibits a V-shaped profile and several morphosedimentary features (Pierdomenico et al. 2016). Near the head of the canyon, several important rivers, locally called *fiumare*, flow into the sea supplying organic matter and accumulating unconsolidated sediments (Masson et al. 2006; Kawamura et al. 2014). All the area is geologically active and has been currently subjected to submarine landslides (Zaniboni et al. 2014). The presence of these delivering freshwater rivers with different hydrodynamic flow is able to affect the sedimentary processes that can evolve in anomalous hyperpycnal flows (Casalborne et al. 2014; Pierdomenico et al. 2016).

2.2. Sampling and analyses

The samples were collected during the cruise "TyGraF" between 20 and 27 February 2013 on board of the R/V Urania (CNR, Italy). In total, 13 samples (Table I) were collected using a Van Veen grab (30 L). The samples 10, 11, 12, 13 were collected in the north arm of the canyon, from 103 m to 146 m depth, while the sample 14 was collected at 200 m depth. The samples 15, 16 and 17 were collected deeper in the central axis of the canyon

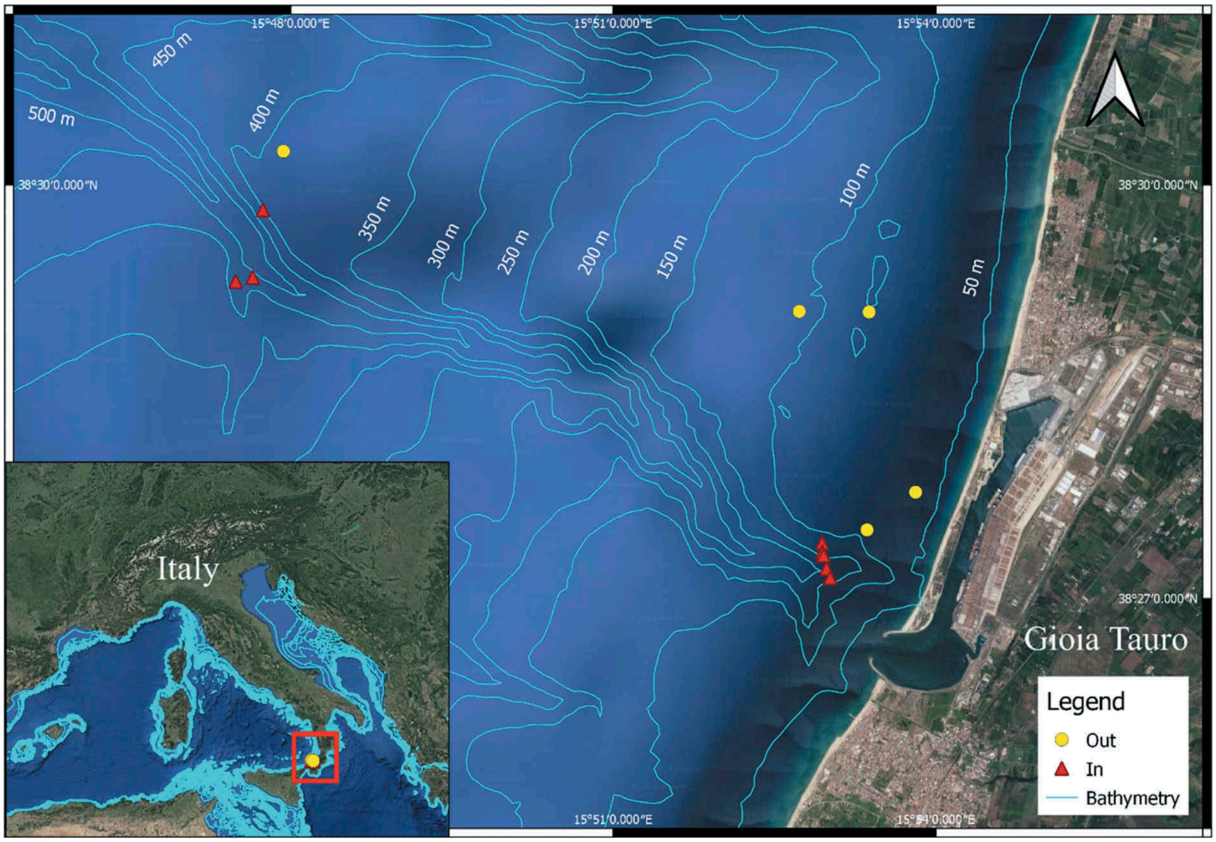

Figure 1. Map of the studied area, with sampling stations (yellow dots and red triangles).

Table I. List of samples collected during TyGraF cruise, with date and location (latitude and longitude).

		Location	
Sample	Date	Latitude	Longitude
BT-10	22 Feb. 2013	38°27′24.25″N	15°52′56.52″E
BT-11	22 Feb. 2013	38°27′20.26″N	15°52′56.68″E
BT-12	22 Feb. 2013	38°27′18.76″N	15°52′57.36″E
BT-13	22 Feb. 2013	38°27′13.10″N	15°52′59.03″E
BT-14	22 Feb. 2013	38°27′9.03″N	15°53′1.04″E
BT-15	26 Feb. 2013	38°29′17.93″N	15°47′29.30″E
BT-16	26 Feb. 2013	38°29′19.72″N	15°47′38.89″E
BT-17	26 Feb. 2013	38°29′49.07″N	15°47′44.50″E
BT-18	26 Feb. 2013	38°30′14.62″N	15°47′55.97″E
BT-19	27 Feb. 2013	38°27′46.36″N	15°53′48.74″E
BT-20	27 Feb. 2013	38°27′29.93″N	15°53′21.64″E
BT-21	27 Feb. 2013	38°29′4.65″N	15°53′22.80″E
BT-22	27 Feb. 2013	38°29′4.92″N	15°52′43.80″E

from a depth of 338 m to 534 m (Table I). The samples 19, 20, 21, 22 were collected outside the canyon, in the northern area of Gioia basin, from 64 to 105 m; while the sample 18 was collected deeper (416 m), outside the canyon (Figure 1).

Onboard, the benthic samples were washed through sieves with 0.5 mm mesh size and then fixed in 4% formaldehyde solution. In laboratory, samples were washed (0.5 mm mesh size) and preserved in ethanol 70°. The macrofauna was sorted according to major taxa under a stereomicroscope, identified, when possible, at the lower taxonomic level (species), and counted.

Results about the abundances are reported as number of individuals and number of taxa per m^2.

To appoint the taxa into the ecological groups, the marine biotic index (AMBI) was used considering the list available in the AMBI program (http://www.azti.es). Although AMBI index is usually conducted for the estuarine and coastal ecosystems (Borja et al. 2000), its suitability is enlarged (Muxica et al. 2005) and includes also deeper water impacted by human activities (Borja et al. 2003).

3. Results

In the analysed samples, we collected 936 specimens belonging to 93 taxa in total. The most diversified phylum was the Annelida (polychaetes 42 taxa and sipunculids 4 taxa), followed by Arthropoda, subphylum Crustacea (Amphipoda 15 taxa, Cumacea 5, Isopoda 2, Tanaidacea 4, Ostracoda 1) and the phyla

Mollusca (Bivalvia 12 taxa, Gastropoda 2 and Caudofoveata 1) and Echinodermata (Holothuroidea 1 taxa, Ophiuroidea 3, Echinoidea 2) (Table SI; Figure 2).

In the canyon system, we recorded 73 taxa in total, with a minimum of 17.6 taxa/m^2 in BT-12 station to a maximum of 54.5 taxa/m^2 in the station BT-16. Outside the canyon, the number of taxa was 61 in total, the lower density of 14.4 taxa/m^2 was detected in the station BT-18, while the maximum was 57.6 taxa/m^2 in BT-20 (Table II). The number of taxa in common between the two areas, inside and outside the canyon, was 41.

The number of organisms inside the canyon varied between 35.2 ind/m^2 (BT-17) to 353.6 ind/m^2 (BT-11). Outside the canyon, it varied between 14.4 ind/m^2 (BT-18) to 260.8 ind/m^2 (BT-20) (Table II).

Overall, the most abundant organisms present in the examined stations belong to the phylum Annelida both inside and outside the canyon (Table II; Figure 2). The most abundant species inside the canyon were *Prionospio cirrifera, Sternaspis scutata* and *Monticellina* sp. with up to 161.6 ind/m^2 (BT-11), 62.4 ind/m^2 (BT-14), 28.8 ind/m^2 (BT-11) respectively. Almost 40% of individuals, in four stations inside the canyon, belonged to the species *S. scutata* (Table II). Another dominant species inside the canyon was *P. cirrifera* with 47.5% in station BT-11. Outside the canyon, the species that showed the highest densities were *P. cirrifera* up to 68.8 ind/m^2 (BT-20), *Chaetozone* sp. up to 40 ind/m^2 (BT-20), *Malacoceros girardii* and *Monticellina* sp. up to 20.8 ind/m^2 (BT-20), and *S. scutata* up to 14.4 ind/m^2 (BT-19). Outside the canyon, the most dominant group is again Annelida; more than 20% of individuals, in two stations belonged to the species *Chaetozone* sp. and *P. cirrifera* (Table II). Some species belonging to the family Eunicidae such as *Eunice vittata* (stations BT-14 and BT-16), *Paucibranchia bellii* (station BT-14) and *Lysidice unicornis* (station BT-17), and also some Capitellidae such as *Leiocapitella* sp. and *Notomastus* sp., were recorded only inside the canyon (Table SI). Sipunculids were collected in both inside and outside the canyon, up to 6.4 ind/m^2 in the station BT-20.

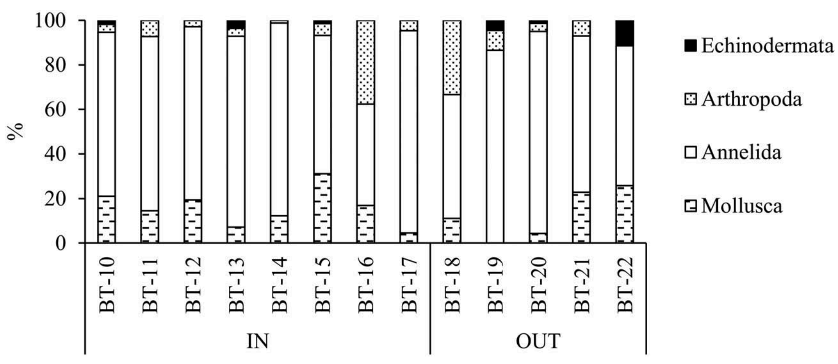

Figure 2. Relative percentage of taxa in the examined stations.

Table II. Density of individuals and of taxa in each station, with depth and position of the stations; the most abundant taxon, with its percentage out of the total number of individuals, was also indicated.

Station	Position	Depth (m)	Abundance (Ind/m^2)	N°taxa/m^2	Most abundant taxa (%)
BT-10	IN	106	91.2	43.2	*Sternaspis scutata* (19.28%)
BT-11	IN	103	353.6	27.2	*Prionospio cirrifera* (45.70%)
BT-12	IN	132	57.6	17.6	*Sternaspis scutata* (50%)
BT-13	IN	146	44.8	20.8	*Sternaspis scutata* (42.85%)
BT-14	IN	200	144	33.6	*Sternaspis scutata* (43.33%)
BT-15	IN	499	118.4	38.4	*Thyasira* sp.1 (18.91%)
BT-16	IN	538	123.2	54.4	*Carangoliopsis spinulosa* (12.98%)
BT-17	IN	338	35.2	22.4	*Onchnesoma steenstrupii steenstrupii* (22.72%)
BT-18	OUT	416	14.4	14.4	*Thyasira* sp. 1, *C. soyeri*, *L. gracilis*, Spionidae ind., *Notomastus* sp. (11.11%)
BT-19	OUT	64	107.2	40	*Chaetozone* sp. (23.88%)
BT-20	OUT	92	260.8	57.6	*Prionospio cirrifera* (26.38%)
BT-21	OUT	105	91.2	33.6	*Thyasira* sp.1 (15.78%)
BT-22	OUT	103	56	33.6	*Thyasira* sp.1 (17.14%)

Table III. AMBI index results. Ecological groups (I = sensitive; II = indifferent; III = tolerant; IV = second-order opportunistic; V = first-order opportunistic).

Area	Sample	%I	%II	%III	%IV	%V	AMBI	BI	Disturbance classification
IN	BT-10	16.5	9.6	8.3	65.1	0.5	3.351	3	Moderately disturbed
	BT-11	7.1	21.4	39.3	32.1	0	2.946	2	Slightly disturbed
	BT-12	5.7	22.9	65.7	5.7	0	2.571	2	Slightly disturbed
	BT-13	3.7	22.2	44.4	18.5	11.1	3.167	2	Slightly disturbed
	BT-14	4.5	20.2	61.8	10.1	3.4	2.815	2	Slightly disturbed
	BT-15	14.7	29.4	44.1	7.4	4.4	2.36	2	Slightly disturbed
	BT-16	44.3	19.7	29.5	6.6	0	1.475	2	Slightly disturbed
	BT-17	38.1	23.8	4.8	33.3	0	2	2	Slightly disturbed
OUT	BT-18	28.6	14.3	42.9	14.3	0	2.143	2	Slightly disturbed
	BT-19	23.1	16.9	18.5	41.5	0	2.677	2	Slightly disturbed
	BT-20	11.2	12.4	14.3	62.1	0	3.41	3	Moderately disturbed
	BT-21	10.7	23.2	26.8	39.3	0	2.92	2	Slightly disturbed
	BT-22	45.5	36.4	6.1	12.1	0	1.273	2	Slightly disturbed

Among Mollusca, the most abundant species was *Thyasira* sp.1, present in the majority of the stations, with the highest densities of 22.4 ind/m^2 inside the canyon (BT-15) and 14.45 ind/m^2 outside the canyon (BT-21) where it represents also the most abundant taxon (Table II). The species *Saccella commutata, Theora lubrica, Nucula* sp., *Cardiomya costellata* and the Caudofoveata were collected in both the areas, while few specimens of other bivalves were collected in some stations inside the canyon, as for *Mendicula ferruginosa* at 499 m depth (BT-15), and *Odostomia improbabilis* at 106 m (BT-10) (Table SI).

Only four taxa of crustaceans were recorded both inside and outside the canyon: the ostracods of the family Trachyleberididae, the amphipods *Harpinia pectinata* and *Ampelisca pseudominimana*, and the cumacean *Diastylis rugosa* (Table SI). In the canyon, the amphipods *Carangoliopsis spinulosa* (up to 16 ind/m^2), recorded in the stations BT-15 and BT-16, and *Harpinia truncata* (up to 8 ind/m^2), collected in BT-11 and BT-15, were the most abundant species. Other species here recorded were the tanaidacean *Araphura brevimanus* (3.2 ind/m^2 in the station BT-16), the isopods *Cleantis prismatica* (1.6 ind/m^2 in the station BT-11) and *Idotea* sp. (1.6 ind/m^2 in the station BT-16). Outside, we detected the presence of the amphipods *Ampelisca brevicornis*, recorded in the station BT-19 (4.8 ind/m^2), *Leucothoe incisa* (up to 1.6 ind/m^2), *Paracentromedon crenulatus* (BT-19, 1.6 ind/m^2) and *Paraphoxus oculatus* (BT-22, 1.6 ind/m^2). Moreover, here other taxa have been detected: Cumacea ind. (up to 3.2 ind/m^2), the tanaidaceans *Heterotanais* sp. (BT-19, 1.6 ind/m^2) and *Chondrochelia savignyi* (BT-21, 1.6 ind/m^2) (Table SI).

Finally, few specimens of the echinoids *Brissopsis lyrifera* (1.6 ind/m^2) were collected in the stations BT-10 and BT-13 inside the canyon, while outside, the ophiuroid *Amphipholis* sp. was present with up to 3.2 ind/m^2 in the stations BT-19 and BT-22.

On the base of the AMBI index (see groups in Table III), both the canyon and the external sampled area result as slightly disturbed ecosystems; in detail, most of the sensitive species were collected in the stations BT-16 (44.3%) and BT-17 (38.1%), inside the canyon, and BT-22 (45.5%) outside the canyon; in the stations BT-10 and BT-20, the percentages of the taxa belonging to the group IV (second-order opportunistic, slight to pronounced unbalanced situation) are higher, 65.1% 62.1%, respectively; the taxa belonging to the V ecological group (first-order opportunistic, pronounced unbalanced situation) were observed only inside the canyon, in the stations BT-13 (11.1%), BT-14 (3.4%) and BT-15 (4.4%). The M-AMBI test revealed an ecological status of high quality (Table IV).

4. Discussion

Although the knowledge about the Gioia Basin and Canyon has been implemented in the recent years, no information is reported for the macrofauna living

Table IV. M-AMBI index results.

Stations	AMBI	Diversity	Richness	X	Y	Z	M-AMBI	Status
IN	2.5857	4.5372	70	−1.1091	1.0665	−5.03E-06	0.9814	High
OUT	2.4844	4.6592	57	−0.94831	0.83565	−7.68E-07	0.93633	High

in this area. With this study, we provide for the first time, data about diversity and abundance of macrofaunal species, which can represent a baseline for future explorations of the Gioia canyon.

Data coming from other studies on the macrofauna living in marine canyon habitats are very heterogeneous and generally not easily comparable; indeed, the sampling methods and a different level of taxonomic identification can be two factors that compromise the comparison of data. To this respect, Cunha et al. (2011) suggested that the lack of taxonomic resolution influences the studies about the biodiversity even if a general view of the systems, as the canyon, can be provided. In this perspective, a possible comparison between our data and what it is reported in literature is possible.

Present data show a high number of taxa if compared with the values reported by Covazzi Harriague et al. (2019) from three different canyons and their adjacent open slopes in the North-Western and Central Mediterranean Sea. These authors signalled up to 43 taxa in the macrofaunal assemblages (Ligurian margin), obtained from a number of samples higher than ours, reporting differences between the inside and the outside of the canyon. Their taxonomic identification was mainly performed at family level for the Annelida, suggesting that a higher level of identification of these organisms could have been resolved in a higher number of taxa, as here reported for the Gioia area. Despite the biodiversity recorded during our study is higher, our results don't show evident differences about the number of taxa inside and outside the canyon (Table II). Moreover, a comparison between our data with those reported outside the Mediterranean Sea, puts in evidence that the biodiversity is considerably greater there, as observed in the Avilés Canyon and the adjacent area (north Iberian shelf) by Louzao et al. (2010) who recorded, in total, 810 macrofaunal taxa, represented mainly by Annelida identified at low taxonomic level, or in three different Portuguese canyons, with 342 taxa, mainly belonging to Annelida, in term of abundance (42.1%), and to Arthropoda, in term of number of species (162) (Cunha et al. 2011).

Considering the macrofaunal density, the abundances recorded in the Gioia system are similar to those reported by Covazzi Harriague et al. (2019) for the Catalan margin (average 91.2 ± 24.1 ind/m^2) and the Ligurian margin (average 141.6 ± 39.2 ind/m^2) but are different respect the higher values of the South Adriatic margin (maximum value in the open slope 2747.3 ± 1066.7 ind/m^2). In general, the densities of the benthic fauna recorded in the present study are relatively low (both inside the canyon and outside) if compared with other studies, including extra-Mediterranean areas. Usually, the abundance is higher inside the canyons and decreases outside, in the surrounding areas; for example, Louzao et al. (2010) found 495.6 ± 43.51 ind/m^2 inside the Nazaré Canyon (Portugal, NE Atlantic Ocean) *vs*. 189.8 ± 22.26 ind/m^2 in the open slope. Stora et al. (1999) found that in the Toulon canyon (North-western Mediterranean Sea) the density of the macrofauna assemblages varied with depth and location from 176 to 1000 specimens/m^2, reporting higher values respect how observed in the present study.

It is known that areas characterized by seismicity, river loads and geological instability of the substrate show low biodiversity level (Di Camillo et al. 2018). As previously reported, the Gioia Canyon is prone to receive unconsolidated sediments and a high rate of phytopigment and organic matter concentrations especially in the canyon's thalwegs (Gambi et al. 2019). In Pierdomenico et al. (2016, 2018) documented in the Gioia basin high level of disturbance due to high sedimentation, turbidite flows and intense bottom trawling effort that resulted in scarce environmental status and low abundances of megabenthic communities. It is largely reported that canyons represent very exploited fishing grounds at global level (Ramirez-Llodra et al. 2011) and that the bottom trawling is cause of strong alterations of biodiversity and functioning in ecosystems, as in the Blanes and La Fonera canyons (North-western Mediterranean Sea), and of negative effects on benthic communities (Pusceddu et al. 2014; Bastari et al. 2016; Lastras et al. 2016; Romano et al. 2016). In the northern coast of Sicily, Romano et al. (2016) reported significant differences between the macrofaunal assemblages from areas where the fishing activity is forbidden and those where the trawling is permitted. In these latter, tolerant families of polychaetes as Cossuridae and Paraonidae were recorded, while the most sensitive species, as the amphipods of the family Ampeliscidae, were observed only in the untrawled sediments. In the present study, a high presence of opportunistic species, usually linked to impacted system, was detected, as highlighted by the AMBI index. For instance, in the samples BT-10 and BT-20, positioned in front of the harbour, we observed an increment of the percentage of taxa, such as Spionidae (surface deposit feeders according to Jumars et al. 2015), belonging to the IV group, related to pronounced unbalanced situation (AMBI index). This evidence is supported also by the low values of abundance and biomass of the meiofauna collected in the Gioia Canyon edge (Gambi et al. 2019), confirming the presence of strong anthropogenic stressors in this area.

According to Pierdomenico et al. (2016), the examined stations inside the canyon are characterized by muddy sand, while those outside the canyon are all characterized by sand with gravel or mud, and hosting many species typical of the VTC (coastal terrigenous muds) biocoenoses (Simboura & Zenetos 2002; Relini & Giaccone 2009), as the polychaetes *Sternaspis scutata*, a subsurface deposit-feeders (Jumars et al. 2015) and the ophiuroid *Amphiura filiformis*. In the Gioia area, Di Bella et al. (2017) reported that the Foraminifera microbenthic community shows differences in species composition and abundances, principally due to the unstable environmental conditions caused by the influence of Mesima River. Also Pierdomenico et al. (2016) reported a relevant effect on the granulometric structure of the seabed in Canyons in front of river estuary where mud and detritic sediments of terrestrial origin, accumulate. In conclusion, beside the already established impact of the bottom trawling in the area, also the already mentioned peculiar environmental characteristics of the area may be responsible of the low diversity as stated in general for the Ionian coast of Calabria (Di Camillo et al. 2018).

Some of the species identified in this study are of interest owing to their rarity, as the case of the holothuroid *Pseudothyone sculponea*, a species that lives on muddy bottom and belongs to the *Tellina* and *Schizaster-Amphiura chiajei* biocoenosis (Tortonese 1965), or because endemic to the Mediterranean Sea, as the polychaetes *Prionospio ehlersi* and *Ophelina modesta* already reported for the bathyal sediments (Langeneck et al. 2019).

The M-AMBI index shows this study area is slightly disturbed, evidencing the habour in proximity of the canyon does not strongly impact the macrobenthic assemblages; nevertheless, an implement of the physical and chemical knowledge of this area is required for a better understanding of the quality status of this habitat.

In recent years, studies on the management and conservation of marine-coastal environments, comprising canyons, are increasingly focusing on the different biological components of the ecosystems and how they are resilient to stress forcing and environmental changes. European legislation, such as the Water Framework Directive, (EEC 60/2000) and the Marine Strategy Framework Directive (EEC 56/2008), pay particular attention to those ecosystem components, important for assessing the state and quality of the environment, and for maintaining or achieving a good state of "health" of the habitat. Constant study of these environments is therefore crucial for the establishment of guidelines to preserve such important and unique marine environments (Grinyó et al. 2018; Danovaro et al. 2020). Additionally, as suggested by Langeneck et al. (2019), an implementation of the surveys and a major effort in the taxonomical identification, considering both morphological and molecular data, are needed. Our results about the macrofaunal communities of the Gioia canyon represent a complement to the biodiversity knowledge of the area, and a reference baseline for future investigations and monitoring.

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Supplementary material

Supplemental data for this article can be accessed here.

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