Article

The Spatial Distribution of Copepod Functional Traits in a Highly Anthropized Mediterranean Coastal Marine Region

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Abstract: Copepods dominate marine zooplankton in abundance and play key roles in pelagic food webs. These small crustaceans show high taxonomic and functional diversity. Although there has been considerable research on their taxonomy, only a few studies have focused on their functional traits. In this study, we analyzed the functional traits of 95 copepod species, considering their body size, trophic regime, feeding behavior, and spawning strategy. Based on samples collected during two surveys (autumn 2020 and summer 2021) located in the coastal waters of three gulfs (Gaeta, Naples, and Salerno) in the highly populated Campania region (the central Tyrrhenian Sea, NW Mediterranean), we identified nine functional groups of copepods with different characteristics. The group that comprised herbivorous copepods with feeding currents and a broadcast strategy was the most abundant in both seasons and all gulfs. This group was dominated by *Acartia clausi*, *Centropages typicus*, *Temora stylifera*, and the *Paracalanus parvus* complex. The other functional groups showed differences in their temporal and spatial distribution. Our study reports the functional diversity of copepods along the Campania coast, thus contributing to advancing our knowledge of the planktonic trophic structure in a region of considerable importance due to its marine resources and services.

Keywords: zooplankton; functional diversity; Tyrrhenian Sea; feeding strategy; spawning strategy

1. Introduction

Zooplanktonic communities play a vital role in marine ecosystems [1]. They are mainly represented by copepods, which are the dominant taxonomic group both in terms of their diversity and abundance of individuals [2] and account for more than 80% of the total abundance of mesozooplankton (0.2–2.0 mm) [3]. Copepods represent the key link within pelagic food webs, as they are the main pathway of energy transfer from primary producers to fish [1,4] and contribute substantially to the functioning of the biological pump [5,6]. Furthermore, copepods also show enormous diversity in functional terms: they can obtain food through ambushing, filter feeding, or cruising behavior and can feed on particles and aggregates [7]. Copepods can select their prey based on size [8,9] and motility [10], as well as mechanical and/or chemical cues [11,12]. Since the role of planktonic copepods in the marine ecosystem is influenced by their diversity and phenotypic characteristics [13], studying the functional traits of these organisms is a fundamental step toward understanding the overall ecosystem functioning [14].

Functional traits, defined as phenotypic attributes that shape the physical form of an organism, delineate species based on their physiological functions and the interactions displayed in the abiotic and biotic environment [15]. Functional traits are characteristics that, at the species or organism level, influence their fitness and have been related to survival, feeding, growth, and reproduction [14,16]. Functional traits are useful for categorizing species that show similar traits into certain functional groups (FGs) [17,18]. The categorization approach based on similarity in functional traits rather than taxonomic classification allows diversity to be summarized in distinct and parsimonious groups. These groups have the potential to improve the representation of zooplankton in ecosystem models, as FGs enrich the description of ecological functionality without introducing additional diversity and taxonomic complexity.

Few studies have been conducted on zooplankton functional diversity in marine and estuarine environments (e.g., [19,20]) and in marine plankton ecology [18,21], and most of them are focused on copepods, given their high abundance, as well as great functional and morphological complexity [22]. Several studies, both at the regional and global scales, have used the study of functional traits to group species with similar traits into FGs [17,18] to describe zooplankton diversity [23,24], with the aim of analyzing community responses to environmental disturbances [21,25] or describing marine food webs with a higher level of detail [26,27].

Although functional trait analyses have been carried out in the Mediterranean Sea [21,28], similar studies are still lacking in the Tyrrhenian Sea, which is considered the most oligotrophic region in the western Mediterranean [29]. The coastal areas of the Tyrrhenian Sea have represented globally crucial ecosystems over the last few decades [30,31], but they are constantly exposed to increasing anthropogenic pressures, which have intensified over time [32,33]. One of the areas overlooking the Tyrrhenian Sea is Campania, a region with three main gulfs, which are, from north to south, the Gulf of Gaeta, the Gulf of Naples, and the Gulf of Salerno (Figure 1). The entire coast of Campania, and particularly the metropolitan area of Naples, is severely exposed to anthropogenic pressure [34] and extensive agriculture, livestock farming, and industrial activities [35]. In addition, coastal waters may also be subject to natural forcings that act at the seasonal or multi-year scale (e.g., periods of drought/rain), as well as short-term episodic disturbances (e.g., floods, storms) [36]. Monitoring these environments is important for understanding the risks imposed by anthropogenic and natural impacts on coastal marine habitats.

In particular, the Gulf of Naples has been extensively studied thanks to the presence of the Long-Term Ecological Research site MareChiara (LTER MC), established in 1984 [37,38] to monitor the physical [39] and chemical [40] characteristics of the water column and the dynamics of plankton [41–43]. In contrast, the Gulf of Gaeta and the Gulf of Salerno have received less attention. Studies in the Gulf of Gaeta have primarily focused on assessing the effects of the Garigliano and Volturno river flows on coastal dynamics [44], while studies on both the physical [44] and biological aspects [45] of the Gulf of Salerno are scant [45].

In this study, we present a complete and detailed overview of copepods' functional traits and of their spatial distribution in the Campania region. Statistical analyses were conducted to define the copepods' FGs, based on specific biological and ecological information obtained during two oceanographic surveys (autumn 2020 and summer 2021) conducted along the Campania coast. We also discuss the spatial distribution of copepod functional traits considering local environmental conditions, such as trophic resource availability, and inputs from the land. This study aims to contribute to a better understanding and trophic characterization of the pelagic system, while providing important background information for future studies.
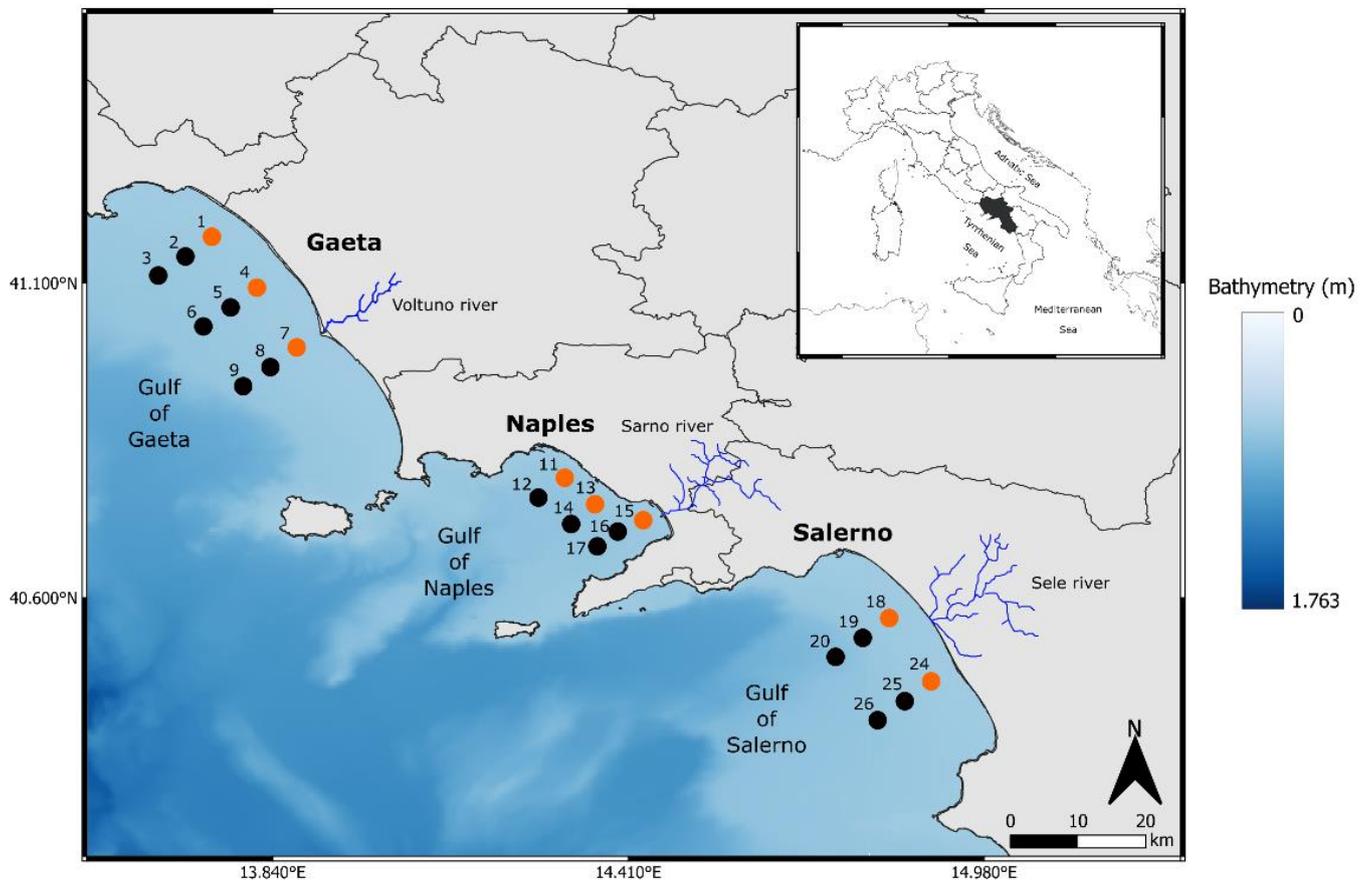
Figure 1. Study area (Campania region) and sampling stations. Orange circles represent inner shelf stations (<20 m depths), and black circles represent mid shelf stations (50–150 m depths).

2. Materials and Methods

2.1. Sampling Area and Environmental Data

We carried out two surveys along the Campania coast (central Tyrrhenian Sea, NW Mediterranean Sea) on board *R/V Vettoria* in the autumn of 2020 (9 September–9 October) and summer 2021 (29 June–15 July). During each survey, we sampled a total of 22 stations among the Gulf of Gaeta (9 stations), the Gulf of Naples (7 stations), and the Gulf of Salerno (6 stations) (Figure 1). The stations were located along transects from the inner (<20 m depth) to mid (50–100 m depth) shelf waters (Table S1).

The three gulfs have different geomorphological characteristics and are influenced by different anthropogenic factors. The Gulf of Gaeta (41°06′ N 13°30′ E) is heavily urbanized, hosts fish and shellfish farms [46,47], and is placed at the mouth of one of the main rivers in southern Italy, i.e., Volturno, which is highly polluted due to discharges from local factories, sewers, and agricultural drains [48]. Volturno River has a seasonal influence on the coasts; in fact, in winter, it manifests a plume oriented more offshore, therefore without interacting with the coastal waters, while in summer, the plume is oriented both north and south of the estuary, influencing the coastal waters [49,50].

The Gulf of Naples (40°44′ N 14°16′ E) is characterized by heavy land runoff from a very densely populated area due to the Sarno River's outflow, though it is also influenced by typical Tyrrhenian oligotrophic waters due to its bottom topography and general physiography [35,51]. The Sarno River is considered the most polluted river in Europe due to heavy metal contamination from industrial activities along its course [52]. From a physical point of view, the Gulf of Naples [53,54] shows a period of stratification in July–August

and a period when the water column is close to completely mixing from December to January, followed by surface re-stratification in February. Similar detailed knowledge about the water stratification processes is not available for the Gulfs of Gaeta or Salerno.

The Gulf of Salerno (40°31′ N 14°42′ E) is characterized by oligotrophic conditions and exposed to the influence of Tyrrhenian waters [45,55]. Here, the Sele River is responsible for transporting pollutants into the sea due to the presence of manufacturing companies from the textile and leather industries and agroindustry along its banks [56,57]. In general, the Gulf of Salerno has been described as a spatially homogeneous system without areas of enrichment, with its coastal influence limited to a restricted inner shelf area [45].

All three gulfs are influenced by upwelling processes, which bring nutrient-rich waters to the surface. Along the Campania coast, these processes occur due to strong winds and the presence, in the Gulf of Gaeta and Naples, of the Cuma Canyon and the Dohrn Canyon, respectively [58,59].

For each sampling site, temperature (°C), salinity (PSU), and turbidity (transmittance) profiles were acquired using a multi-parameter probe (Sea-Bird 911 Plus). In addition, the total chlorophyll *a* was analyzed at selected depths (0, 10, 25, 50, 75, 100 m) using High-Performance Liquid Chromatography analysis (HPLC—Agilent 100, Agilent Technologies, Santa Clara, CA, USA). These environmental values were integrated into the surface layer (0–10 m) and the deep layer (10 m—zooplankton sampling depth) (Table S1).

2.2. Mesozooplankton Sampling and Analysis

Mesozooplankton samples were collected using vertical hauls from 5 m above the bottom to the surface using a double WP2 net (57 cm Ø, 0.25 m² mouth area of each net, 200 μm mesh size) equipped with a flowmeter and towed at 0.7–1 m s⁻¹. One of the two samples was used to estimate the mesozooplankton abundance and taxonomic composition, and the other was used to investigate the gelatinous zooplankton taxonomy. We consider here only the first series of the samples, which were transferred from the cod-end into 500 mL plastic jars, gently concentrated on a gauze (100 μm mesh size), and then fixed in ethanol 96% in 100 mL plastic jars.

In the laboratory, each sample was resuspended in a bowl with distilled water to a final volume of 200 mL. The sample was accurately stirred with a graduated pipette, which was also used to collect two aliquots of 5 mL each that were analyzed for zooplankton identification and enumeration under a stereomicroscope (Leica MZ12.5) in a 10 mL Bogorov counting chamber. The rest of the sample was checked to account for the presence of rare species. The taxonomic identification was performed down to the species level whenever possible, following the proper literature (e.g., [60–63]). The copepods were further identified according to gender and developmental stage (adult females and males, copepodites). To allow for comparison of records collected in water columns of different depths, the abundance was expressed as the number of individuals in a square meter (ind. m⁻²) (Tables S2 and S3).

2.3. Copepod Functional Traits

Functional traits represent various aspects of copepod ecology related to competition and habitat use. In this work, functional traits were attributed to copepod species based on their (i) mean body length (<1 mm, 1–2 mm, >2 mm), (ii) feeding strategy (FS) (ambush feeding, current feeding, cruise feeding), (iii) spawning strategy (SS) (broadcast spawners, egg sacs), and (iv) trophic regime (TR) (carnivore, omnivore, omnivore–detritivore, and omnivore–herbivore). Transitional groups were established to separate species that, while being technically omnivorous, showed a relative preference for herbivory or detritivory [23]. Information on copepod functional traits was obtained from the literature [18,63–66] and from the knowledge of experts in the field. Concerning the feeding strategy, three different categories have been considered: the ambush strategy, in which copepods encounter and intercept prey and capture them with active attacks; current feeding, in which

copepods are able to generate a feeding current and convey prey to their mouth appendages; cruise feeding, in which copepods navigate through the water, catching individual prey [64].

A binary matrix of functional traits was created including all the recorded taxa, assigning 1 when a trait was present in the specific taxon or conversely 0 when a trait was absent. When it was not possible to allocate specific traits to a copepod species owing to little or no information in the literature, the category NA (Not Assigned) was used (Table S4).

2.4. Data Analysis

A dissimilarity matrix (with Jaccard distance) was calculated based on the binary matrix of functional traits, and then agglomerative hierarchical clustering analysis (Ward's method) was used to identify different FGs. For this analysis, only feeding strategy, spawning strategy, and trophic regime were considered as traits. The number of FGs was determined by using the K-means values as a cut-off level, and the "Elbow method" was applied [67] to determine the optimal number of FGs.

To test the significance of seasonal and spatial differences in terms of the abundance of functional groups (data transformed by $\log(x + 1)$) and environmental parameters (data normalized), a two-way permutational multivariate analysis (used Hellinger and Euclidian distances for biological and environmental data, respectively) of variance (PERMANOVA, $p < 0.05$), followed by a pairwise test for significant terms, was performed on three fixed factors: "Season" (two levels: autumn 2020 and summer 2021), "Gulf" (three levels: Gulf of Gaeta, Gulf of Naples, and Gulf of Salerno), and "Distance" (two levels: inner and mid shelf stations). All the analyses were performed and plots generated using the R Studio software v.4.3.2 ('*factoextra*', '*vegan*', '*Rstatix*', and '*tidyverse*' packages) [68].

3. Results

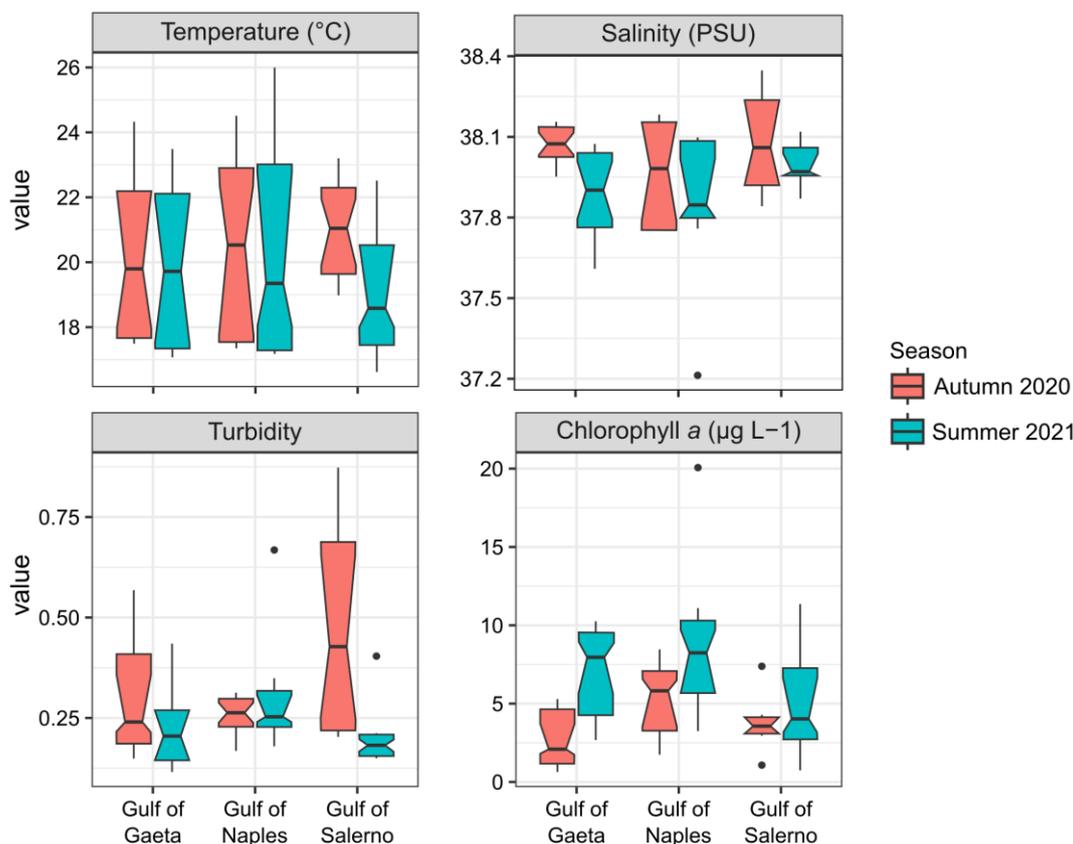*3.1. Environmental Variables*

The environmental conditions, defined by temperature, salinity, turbidity, and chlorophyll *a*, appeared to be significantly different between the inner and mid shelf stations ($p < 0.001$) in both seasons. Only during the summer did significant differences emerge among the three gulfs, particularly between the Gulf of Naples and the Gulf of Salerno ($p < 0.01$).

The overall sea water temperature was not significantly different between the three gulfs (Figure 2). In the Gulf of Salerno, the integrated temperature was significantly higher in autumn as compared to summer, while no significant difference was recorded between seasons in the other gulfs.

The lowest values for depth-integrated temperature were recorded in summer in the Gulfs of Salerno (19.1 °C) and Gaeta (19.8 °C), and the highest values in autumn were recorded in the Gulf of Salerno (21 °C) (Figure 2). In both autumn and summer, the average sea surface temperature was higher in the upper 10 m (24.5 ± 0.98 °C and 25.7 ± 1 °C, respectively) than in deeper waters (19.1 ± 2.6 °C in both seasons) (Table S1). Salinity was consistent across regions, with the highest values recorded in the Gulf of Salerno in autumn and the lowest in the Gulf of Gaeta in summer. The seasonal distributions were not significantly different, except for in the Gulf of Gaeta, where the salinity in autumn was significantly higher than that in summer (Figure 2). Turbidity varied between 0.12 and 0.87, with the highest depth-integrated values in the Gulf of Salerno, where turbidity was significantly higher in the autumn (up to 0.48) as compared to the summer (Figure 2). In summer, the surface turbidity was higher in the Gulf of Naples (0.51) than in Gaeta and Salerno (~0.22), while in the deep layers, it was similar in all three gulfs (~0.25) (Table S1). Chlorophyll *a* peaked in summer (highest concentrations in the Gulf of Naples, 9.1 µg L^{-1}) and was lower in autumn (minimum in the Gulf of Gaeta, 2.9 µg L^{-1}), with significant seasonal differences in the Gulfs of Gaeta and Naples (Figure 2). The chlorophyll *a*

concentration was higher in the Gulf of Naples in both autumn and summer, with surface concentrations of 3.19 µg L⁻¹ in autumn and 6.62 µg L⁻¹ in summer, than in Gaeta and Salerno (<2 µg L⁻¹). Even in the deeper layers, the concentration of chlorophyll *a* was highest in the Gulf of Naples (5.25 µg L⁻¹ in autumn and 9.07 µg L⁻¹ in summer), while in Gaeta and Salerno, it was around 4.7 µg L⁻¹ (Table S1).

Figure 2. Box plots showing the depth-integrated values of environmental variables recorded during the autumn (red) and summer (blue) seasons in the three gulfs of the Campania region. The midline indicates the median value, the vertical line represents the minimum and maximum values, and the black dots indicate the outliers.
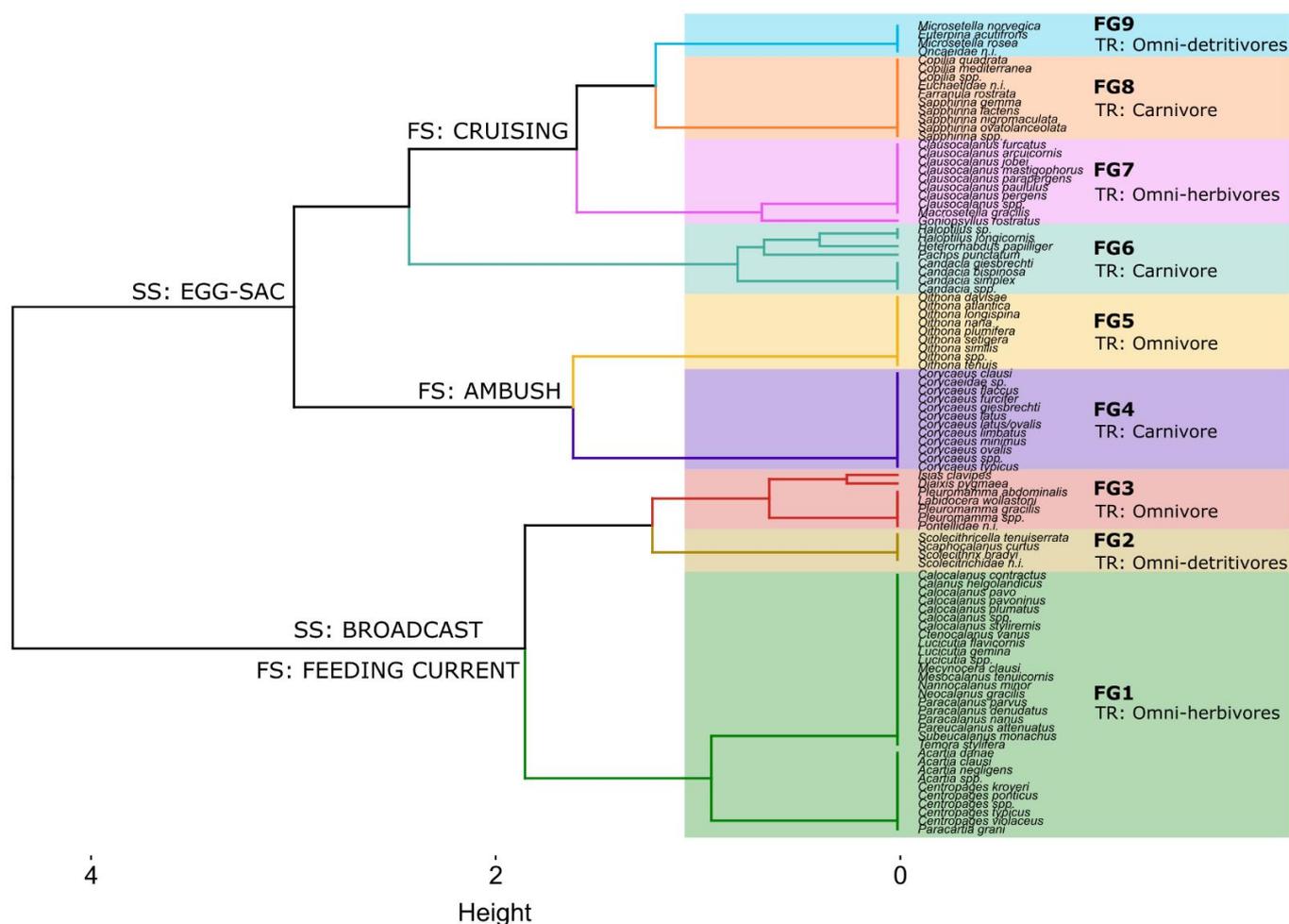
3.2. Copepod Functional Groups

In autumn, the total mesozooplankton abundance was on average 3 × 10⁶ ind. m⁻², 52.6% of which was represented by copepods, followed by cladocerans, which were less represented in the Gulfs of Gaeta and Naples (7%) than in the Gulf of Salerno (19%) (Figure 3). Calanoids were overall the most abundant copepod group (on average, 81% of the total copepod abundance), with *Temora stylifera* being the dominant species, particularly in the Gulf of Naples (3% of total copepod abundance), as opposed to the Gulf of Gaeta and Salerno, where it represented 21% and 13% of the total copepods, respectively. The *Paracalanus parvus* complex, the second dominant copepod taxon, represented 13% of the total copepod abundance in all three gulfs. In summer, the total mesozooplankton abundance was on average 1.62 × 10⁶ ind. m⁻², of which 44.9% was represented by copepods, followed by cladocerans, which, also in this season, were particularly abundant in the Gulf of Salerno (14% of the total zooplankton). In summer, calanoids were the main copepod group (81%) (Figure 3) and were dominated by the *Paracalanus parvus* complex (22.6%) and *Centropages* spp. (11.2%), with both taxa present with a relatively similar abundance in all three gulfs (Tables S2 and S3).
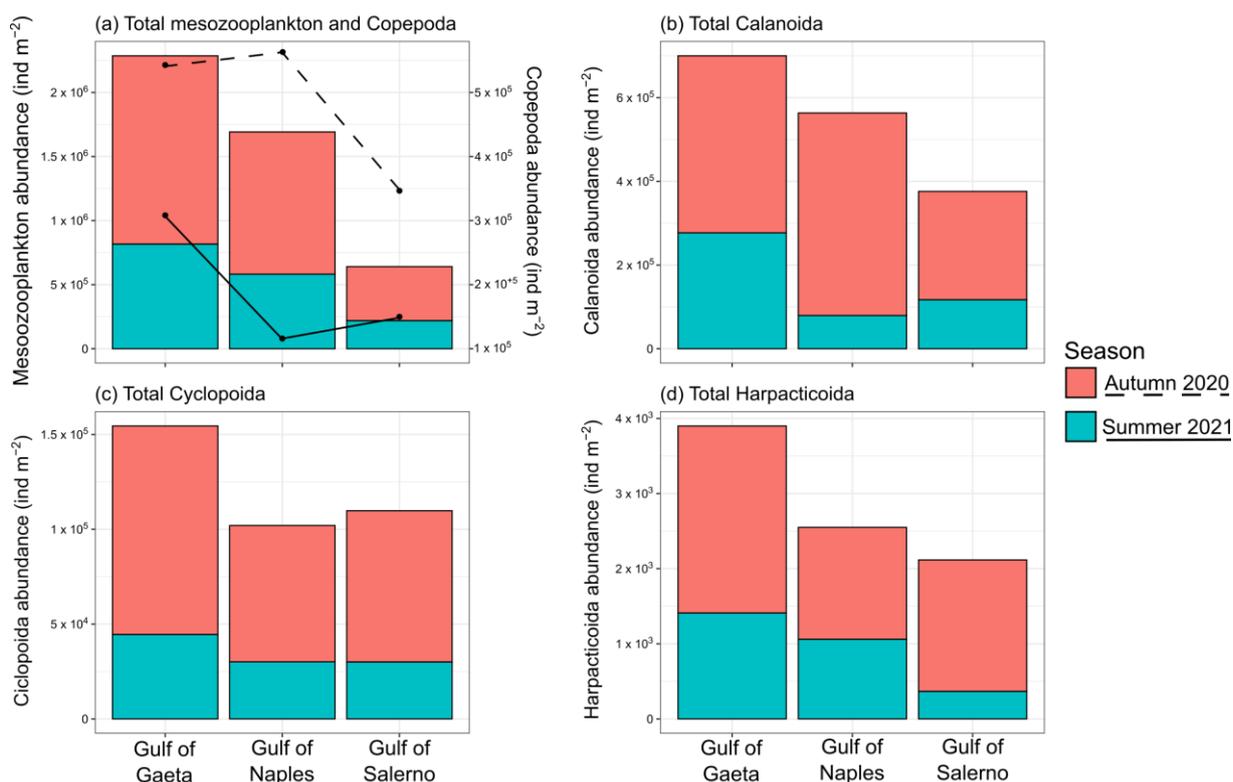
Figure 3. Bar plot showing the total abundance (ind. m⁻²) during autumn (in red) and summer (in blue) of mesozooplankton and copepods (**a**), where the dashed lines refer to the total abundance of copepods in autumn 2020 and the solid lines to summer 2021. (**b**) Total abundance of Calanoida, (**c**) Cyclopoida, and (**d**) Harpacticoida.

We identified nine functional groups (FGs) in the overall copepod assemblage, represented by 95 species (Figure 4). FG1 encompassed the highest number of species and included broadcast, current-feeding taxa, with a tendency toward herbivory. Moreover, this assemblage included different body sizes, among them small (e.g., *Calocalanus* spp. and *Paracalanus* spp.) and medium-sized (*Acartia* spp., *Temora stylifera*) calanoids. FG2 included medium-sized, cruising, broadcasting species (*Scaphocalanus* and Scolecitrichidae). FG3 was represented by small (*Diaixis pygmaea*), medium-sized (*Isias clavipes* and Pontellidae), and large (*Labidocera wollastoni*) omnivorous species, which produce feeding currents and have a broadcasting reproductive strategy. FG4 included the cyclopoid family of Corycaeidae, small–medium-sized carnivore species, ambush feeders, and sac-spawners. FG5 grouped all the *Oithona* species, which are small, omnivorous, ambush-feeding cyclopoids and carry egg sacs. FG6 consisted mainly of large (*Haloptilus* spp., *Heterorhabdus* spp.) to medium-sized (*Candacia* spp.) cruising carnivores with a broadcast reproductive strategy. FG7 grouped small to medium-sized species of the genera *Clausocalanus* and *Macrosetella*, which feed by cruising and carry egg sacs. FG8 consisted mainly of large carnivores (e.g., the genus *Copilia*, members of the family Euchaetidae, and species of the genus *Sapphirina*), with a cruising feeding strategy and a reproductive strategy using egg sacs. FG9 included small cruising detritivores (*Oncaea* spp., *Microsetella* spp.) that use a sac-spawning strategy.

Figure 4. Functional dendrogram obtained from hierarchical clustering using Ward's method, showing nine functional groups (FGs) of the 95 analyzed copepod species (FS: Feeding Strategy; TR: Trophic Regime; SS: Spawning Strategy).

The occurrence of copepod FGs differed significantly ($p < 0.01$) between seasons and between the inner and mid stations. When considering the three gulfs, differences were found in autumn between Gaeta and Salerno ($p < 0.001$), whereas in summer, they were found between Gaeta and Naples ($p < 0.001$) and between Naples and Salerno ($p < 0.01$).

The prevalent group was FG1 (Figure 5a,b), more abundant in summer (69%) than in autumn (54%). In autumn, FG1 was more represented in the Gulfs of Gaeta and Naples (~65% for both) than in Salerno (34%). In summer, FG1 was more represented in the Gulf of Gaeta (83%), while it decreased in the Gulfs of Naples and Salerno (59% and 66%, respectively). In both seasons, FG1 was on average more represented at the inner shelf stations (76%) than at the mid shelf stations (62%). In autumn, the second most represented group was FG7, particularly abundant in the Gulf of Salerno (41%) as compared with Gaeta (15%) and Naples (21%), with an even distribution from the inner shelf to mid shelf stations (~23%). In summer, FG7 was poorly represented (7%). The third group in ranked order of relative abundance was FG5, which showed a similar percentage during both the summer and autumn (~12%) and higher relative abundance at the mid shelf (13%) than at the inner shelf (7%) stations. In autumn, FG5 was more represented in the Gulfs of Gaeta and Naples (16% and 12%, respectively) than in Salerno (7%), whereas in summer, it accounted for similar percentages (~13%) in the three gulfs. The other functional groups (FGs 2, 3, 4, 6, 8, and 9) were poorly represented in the three gulfs in both seasons, as they overall accounted for less than 5% of the total mesozooplankton abundance (Figure 5a,b and Table S5).

(a)

(b)
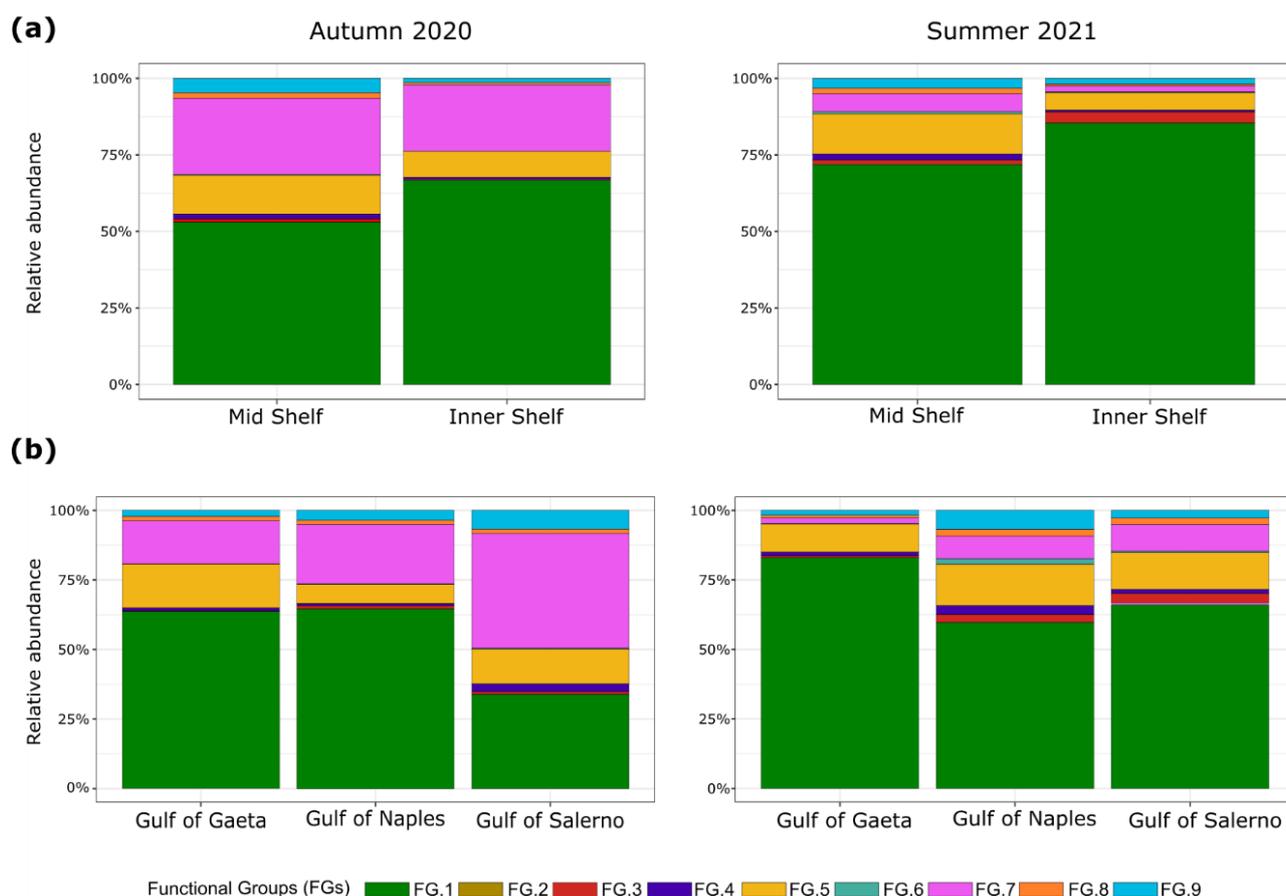
Figure 5. Bar plots of the relative abundance (%) of nine functional groups (FGs) found through cluster analysis, during the autumn and summer seasons at the mid and inner shelf stations (**a**) and in the three gulfs (**b**).

4. Discussion

This study presents the functional traits of copepods along the Campania coast, allowing for a better understanding of the patterns of the variability in and functioning of zooplankton communities in an important Mediterranean region. Our results identified nine different functional groups, which differed in their spawning and feeding strategies and trophic habits. These groups have consistently been found in other studies conducted at both the regional [18,28] and global scales [17,19,65].

Overall, we observed that the spawning strategy, represented by egg sac and broadcast spawners, was the trait distinguishing the two main copepod assemblages characterizing the Campania coast (Figure 2). Carrying egg sacs is considered an energetic strategy that reduces egg mortality, at the expense of individual fecundity and hatching rate, while egg broadcasting is a form of adaptation to protect the eggs [69]. Broadcast spawners are mostly calanoid copepods, while cyclopoids and harpacticoids mainly carry egg sacs, employing cruising and ambush feeding strategies.

Ambush feeding is frequently observed in small copepods, whereas it is less common in larger species, which tend to acquire food while cruising, probably due to differences in metabolic requirements linked to body size [70]. Ambush feeders encounter prey passively and require less energy than cruising predators, who must actively search for prey [7]; this strategy reduces metabolic costs and predation risk, although at the expense of feeding efficiency [64,71].

Our results showed that both summer and autumn were dominated by omni–herbivorous copepods, i.e., FG1. The species in this group represent the main food of many pelagic fish [72,73] and zooplanktonic predators [74,75]. Based on long-term observations, omni–herbivorous copepods, i.e., *Acartia clausi*, *Centropages typicus*, the *Paracalanus parvus*

complex, and *Temora stylifera*, are the most abundant copepods in the Gulf of Naples. These species are present and consistently reproduce all year round [76] but with a succession of their peak of seasonal abundance. For the former three species, the populations begin to increase at the onset of the stratification period and reached peaks during the shallowest stratification period [43]. We observed that FG1 was more abundant under the conditions of a high chlorophyll *a* concentration, which typically characterize inner shelf stations during summer [77,78]. This seasonal preference could be possibly explained by the feeding strategy of the FG1 species, which feed through currents carrying phytoplanktonic cells and tending to reach high abundance along the inner shelf, where rivers provide a greater supply of nutrients. Considering the high concentration of contaminants and potentially toxic compounds accumulated along the Campania coast due to river runoff [34], the success of FG1 in this area could be also explained by the high capacity of some species in this group (such as *Acartia*) to tolerate eutrophicated and polluted areas [79,80].

The mid shelf stations explored in our study host a higher abundance of *Clausocalanus* species (FG7), which constitute an important numerical component of copepod communities throughout the year [81]. *Clausocalanus* in our study dominated the autumn period, when *C. furcatus* largely prevailed over the other congeners, and the autotroph biomass was much lower than in summer. In the Gulf of Naples, this species, which is reported to prefer oligotrophic conditions, where it reproduces better, is mainly found in the upper 40 m of the water column [81].

The presence of small omnivorous copepods, such as the cyclopoids *Oithona* (FG5) and Oncaeidae (FG9), was observed in both summer and autumn in all the gulfs. *Oithona* is considered one of the most abundant genera in the oceans and acts as an important link in the trophic network between the microbial loop and higher trophic levels [82]. *Oithona* spp. can adopt a predatory ambush strategy, preferring mobile prey such as flagellates, ciliates, and dinoflagellates [83,84]. This strategy reduces the risk of predation [85] and metabolic costs [86,87], while increasing tolerance to starvation due to lower energy demands [85]. These adaptations enable the genus *Oithona* to thrive in both oligotrophic and eutrophic environments [85,86], like the Gulf of Naples, which is highly intermittent in terms of the trophic resources originating from the coastline [88].

FG9 comprises detritivorous species, such as *Oncaea*, which mainly consume detritus originating from discharged appendicuralian houses and copepod nauplii [89,90] and use gelatinous zooplankton (e.g., thaliaceans and chaetognaths) as a potential substrate for survival [91], contributing to the recycling of organic matter [92]. Our analyses showed that FG9 was more represented in the Gulf of Salerno in autumn. This is probably due to a rise in turbidity caused by increased river runoff, sediment resuspension, and coastal erosion [93,94] but also by the increase in gelatinous zooplankton (such as thaliaceans and chaetognaths) observed in these area [43]. These conditions may also expose *Oncaea* to pollutants originating from urban areas. In fact, both *Oncaea* and *Oithona* species, thanks to their adaptation strategies, in particular their low metabolic rate and ability to feed on a wide range of prey [86,95], are copepods tolerant or insensitive to pollution [2,96,97].

Two-thirds of the carnivorous copepods appearing during our surveys (FG4 and FG8) were sac-spawners, and only FG6 showed a broadcast spawning strategy. Within these groups, we find species belonging to the families Corycaeidae (FG4), Candaciidae (FG6), and Sapphirinidae (FG8), which have very diversified diets, ranging from the consumption of microalgae [98,99] to small copepods [74,100], meroplankton [101,102], and gelatinous zooplankton, such as thaliaceans, appendicularians, and chaetognaths [102,103]. The low relative abundance of FG4, FG6, and FG8 in the Campania gulfs (Figure 4) is probably due to the use of a sampling method that fails to capture larger zooplanktonic organisms [104,105]. In general, our results show that only in the Gulf of Naples, during the summer, are relatively large carnivores present. This is probably due to an increase in available prey, which may include meroplankton larvae, showing a peak in the early summer [43] likely favored by the abundant presence of microalgae (indicated

by the increase in chlorophyll *a*). The presence of these available prey could also be due to the presence of nutrient-rich water from upwelling processes due to the presence of the Dohrn Canyon [59]. The appearance of typical offshore species (i.e., *Candacia*) is probably due to the surface circulation of the Tyrrhenian Sea, which arrives more regularly within the Gulf of Naples at this time of year [44,106], from oligotrophic Tyrrhenian to coastal waters [76].

5. Conclusions

Our results highlighted the spatial and temporal functional diversity of copepods along the Campania coast, which can be related to local environmental characteristics, thus improving our knowledge of the ecological roles of Mediterranean coastal zooplankton. Herbivorous species dominated in all the three gulfs and in both seasons, detritivorous species were observed most in autumn in the Gulf of Salerno, while carnivorous groups were most represented in summer in the Gulf of Naples. Our study represents a base for successive holistic studies to integrate the information acquired in this work with other biological, physical, and chemical data to increase our understanding of the functional complexity of plankton communities. Our study corroborates the view that functional traits in a community can be used as indicators of environmental characteristics, thus allowing for inference of ecosystem functions, such as energy transfer in the food web and nutrient cycling. Future studies should therefore focus on integrating a wider range of functional traits with multiple environmental factors and ecosystem functions to obtain a more complete and accurate view of the ecological dynamics of planktonic systems.

Conflicts of Interest: The authors declare no conflicts of interest.

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