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Biodiversity of Marine Mollusk Assemblages from Two Contrasted Algal Habitats in the Mediterranean Sea (Tossa de Mar, Costa Brava, NE Spain)

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Abstract: The malacological faunae of two algal habitats with different lighting conditions—a sciophilous wall and a photophilous one—both located in Tossa de Mar (Costa Brava, Girona, NE Spain), have been studied to examine the differences in the malacological communities, their distribution over time, and the role played by micromollusks in these algal habitats. Every two months, for a year, samples were collected via scuba diving and scraping standardized surfaces (20 × 20 cm) of the algal communities. In the laboratory, the samples were washed and filtered using two metal sieves (2 mm for coarse fraction and 513 µm for fine fraction). Mollusks were separated, identified, and later analyzed statistically to assess biodiversity indices and sample grouping. A total of 7913 mollusk specimens from 148 species (112 Gastropoda; 32 Bivalvia and 4 Polyplacophora) were identified across all samples, with 1669 specimens (84 species) from the sciophilous algae and 6244 specimens (133 species) from the photophilous algae. Moreover, 10 species accounted for 76.27% of the total abundance, with each species represented by over 100 specimens in the total samples. The gastropod *Bittium latreillii* was the most abundant species, with 2106 specimens recorded. Regarding the two fractions, 337 specimens (69 species) were found in the coarse fraction, while 7576 specimens (111 species) were found in the fine fraction. Significant differences were obtained between samples with respect to time, habitat type, and size fraction. The Shannon–Wiener biodiversity index values indicated differences between the two communities over time, as well as variations in biodiversity, with the photophilous community exhibiting higher values. It was demonstrated that algal thalli provide a highly suitable substrate for juvenile forms and micromollusks. Our findings, combined with the literature and various online citations, establish Tossa de Mar as the town on the Catalan coast with the best-documented malacological fauna.

Keywords: algal mollusks; diversity; abundance; habitats; Western Mediterranean

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Academic Editors: Marcos Rubal, Puri Veiga and Diego Carreira-Flores

Received: 29 October 2024
Revised: 14 December 2024
Accepted: 18 December 2024
Published: 25 December 2024

Citation: Ballesteros, M.; Silva, A.S.; Villamizar, Ó.F.; Pontes, M.; Oliva, F. Biodiversity of Marine Mollusk Assemblages from Two Contrasted Algal Habitats in the Mediterranean Sea (Tossa de Mar, Costa Brava, NE Spain). *Diversity* **2025**, *17*, 9. https://doi.org/10.3390/d17010009

1. Introduction

In the upper infralittoral zones of all seas and oceans, seaweeds are essential components for the development of animal populations, particularly invertebrates, which find protection, shelter, food, and reproductive sites within these habitats [1–5]. In some cases, they even form true mutualistic symbiotic relationships between algae and animals [6].

In the Mediterranean Sea, many studies emphasize the structural complexity of the various habitats found there, which is why comparisons between different communities and their associated faunae are necessary. Focusing on mollusks in shallow marine environments, Chemello et al. [7] noted that the spatial distribution of the malacological faunae associated with the photophilous algal communities is influenced by factors such as depth and the algal substrate. However, others, like García et al. [8], observed a more homogeneous distribution of gastropod species across all types of algae and habitats, except for certain groups like Sacoglossa gastropods, which are associated with specific species of *Caulerpa* algae, such as *Berthelinia caribbea* Edmunds, 1963.

Avila et al. [9] highlighted that the floristic composition and algal biomass are crucial in determining the distinctiveness of the micromollusk community, as in the intertidal zone of the Azores, where these factors provide protection from waves, high temperatures, and desiccation. The so-called algal architecture is also critical for the settlement and abundance of epibiont marine invertebrate species, particularly mollusks [10,11]. Various sources have also reported behavioral pattern shifts and the advantages of smaller species over larger adults when living among algae fronds. The distribution patterns of mollusk assemblages observed by Terlizzi et al. [12] show that the species within the same genus can exhibit differences in juvenile abundance due to differences in their lifecycles. This is exemplified by *Bittium latreillii* (Payraudeau, 1826) and *Bittium reticulatum* (da Costa, 1778); the former has an 18-month lifecycle with semelparous reproduction, recruiting in October, February, and June, while the latter shows a single recruitment peak in May, as reflected in its abundance throughout the year. On the other hand, smaller species benefit from reduced dispersal capacity [9] and the protection offered by the interstices within algal fronds [8].

It is well known that infralittoral algal communities can be classified according to hydrodynamism (calm or turbulent) and the light they receive (sciophilous or photophilous). In the Mediterranean Sea, typical algal species that characterize sciophilous habitats in the upper infralittoral zone include, among others, *Flabellia petiolata* (Turra) Nizamuddin, 1987, *Halopteris filicina* (Grateloup) Kützing, 1843, *Peyssonnelia rubra* (Greville) J. Agardh, 1851, and *Halimeda tuna* (J. Ellis and Solander) J.V. Lamouroux, 1816. Photophilous habitats are mainly defined by the presence of algae such as *Halopteris scoparia* (Linnaeus) Sauvageau, 1904, *Padina pavonica* (Linnaeus) Thivy, 1960, *Dictyota dichotoma* (Hudson) J.V. Lamouroux, 1809, and *Corallina officinalis* Linnaeus, 1758, with the latter more closely studied in relation to malacological fauna.

In recent decades, several studies on the Mediterranean Sea have explored the relationship between mollusks and different types of algae. For example, studies were conducted on calcareous algae [13,14]; photophilous algae [7,10,15,16]; *Halopteris scoparia* (Linnaeus) Sauvageau, 1904 [17]; *Cystoseira* [18]; and the malacofauna of *Posidonia oceanica* meadows [19], among others.

Tossa de Mar (Girona, NE Spain) is a tourist town on the Spanish Costa Brava that is very popular among scuba divers. From the beach, divers can access rocky and sandy seabeds, caves, and *Posidonia oceanica* meadows, all teeming with marine biodiversity.

The objective of this study is to contribute to the knowledge of the algal-associated marine malacofauna in this locality. Specifically, we aim to determine the role of micromollusks and juvenile forms of larger species in algal communities. We assessed whether significant differences exist in the biodiversity and abundance of mollusk populations between two contrasting algal communities—one photophilous and the other sciophilous—located on two nearby rock walls. We also analyzed potential differences in the trophic categories of the species based on the two types of habitats and fractions studied. Lastly, we examined abundance and diversity patterns in these two contrasting environments over an annual cycle. We aimed to test the theory that differences may exist in the malacofauna between the two environments (photophilous and sciophilous) and that juvenile forms or small species may find the algae to be a highly suitable habitat for their development.

2. Material and Methods

2.1. Study Area

This study was conducted in the town of Tossa de Mar, located in the La Selva region of Girona province, on the southern Costa Brava (NE Spain), approximately 100 km north of Barcelona. The sampling site was at the location known as "Sa Banyera de ses Dones" (Figure 1), situated at the northern end of La Mar Menuda beach. This site features a rocky corridor with a thick sandy bottom flanked by nearly vertical rock walls that are about 10 m apart. The bathymetric levels of these walls range from 2 to 11 m in depth. The southern wall is vertical and faces northwest, giving it distinctly sciophilic characteristics. In contrast, the northern wall has a slope of about 70° and faces southeast, allowing it to receive direct sunlight, which results in a community dominated by photophilous algae (Figure 2).

Figure 1. Location of Tossa de Mar on the Iberian Peninsula, showing La Banyera de ses Dones (1) and the sampling site (2).

2.2. The Studied Communities

At depths between 1.5 and 3 m, the sciophilous wall is dominated by photophilous algae, including *Osmundea pinnatifida*, *Ellisolandia elongata* (J. Ellis and Solander) K.R. Hind and G.W. Saunders, 2013, *Padina pavonica*, and some thalli of *Codium vermilara* (Olivi) Delle Chiaje, 1829. Additionally, the community includes the unicellular green alga *Acetabularia acetabulum* (Linnaeus) P.C. Silva, 1952, cirriped crustaceans of the genus *Semibalanus balanoides* (Linnaeus, 1767), sea urchins (*Arbacia lixula* (Linnaeus, 1758)), and sponges such as *Sarcotragus fasciculatus* (Pallas, 1766). At depths of 3 to 4 m, the wall becomes slightly more sciophilic (Figure 3B) with abundant fronds of *Halopteris scoparia*, the red algae *Peyssonnellia squamaria* (S.G. Gmelin) Decaisne ex J. Agardh, 1842, and the brown algae *Dictyota dichotoma*. Here, red encrusting sponges (*Crambe crambe* Schmidt, 1862) and some *Sarcotragus fasciculatus* are also observed. From 5 to 6 m (Figure 3C), calcareous algae such as *Mesophyllum lichenoides* (J. Ellis) Me. Lemoine, 1928, the red alga *Sphaerococcus coronopifolius* Stackhouse, 1797, as well as hydrozoans of the genus *Eudendrium*, become abundant. Scattered thalli of *Halimeda tuna* (J. Ellis and Solander) J.V. Lamouroux, 1816, the red algae *Halopteris scoparia* and *Peyssonnelia squamaria* (S. G. Gmelin) Decaisne ex J. Agardh, 1842, some thalli of *Codium bursa* (Olivi) C. Agardh, 1817, the sponge *Crambe crambe*, and the zoantharian cnidarian *Parazoanthus axinellae* (Schmidt, 1862) are also present. From depths of 7 to 8 m down to the bottom of the wall (11 m) (Figure 3D), the alga *Flabellia petiolata* predominates, with abundant polychaete spirorbids growing on its fronds. The community also includes encrusting calcareous algae, *Peyssonnelia squamaria*, *Parazoanthus axinellae*, the sponges *Phorbas tenacior* (Topsent, 1925), *Petrosia (Petrosia) ficiformis* (Poiret, 1789), *Chondrosia reniformis* Spikenard, 1847 and *Clathrina clathrus* (Schmidt, 1864), as well as serpulid polychaetes like *Serpula vermicularis* Linnaeus, 1767.

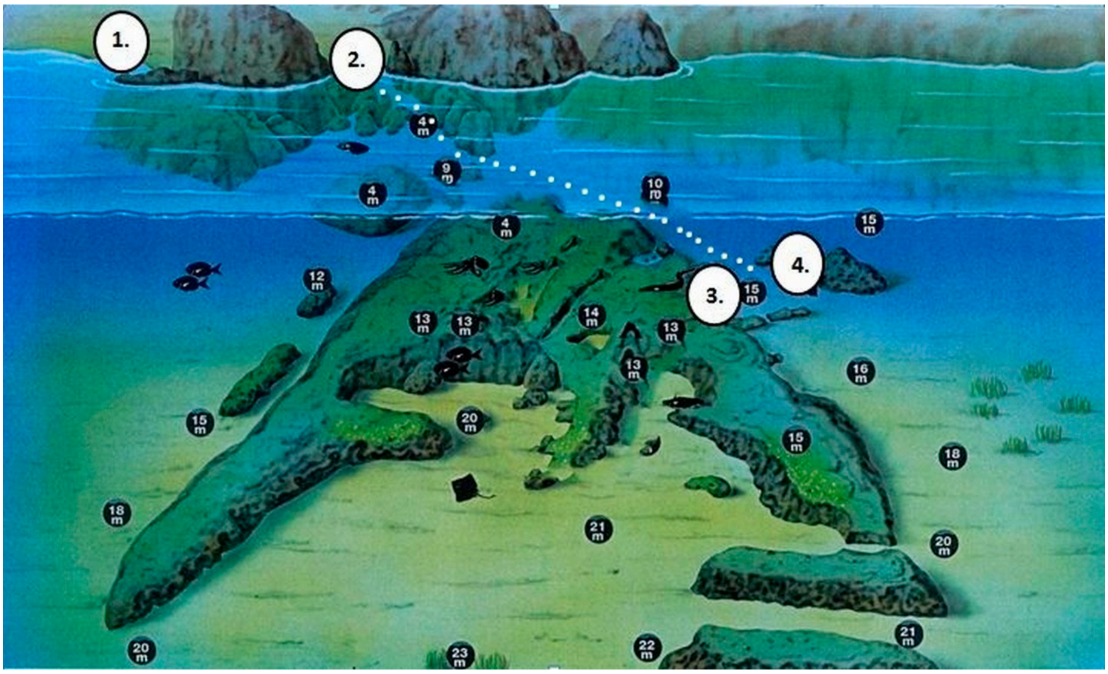

Figure 2. Artistic recreation of the sampling area. 1: Mar Menuda beach; 2: Sa Banyera de ses Dones; 3: sampled sciophilous wall; 4: sampled photophilous wall. Image extracted with permission [20].

The photophilous wall exhibits a fairly homogeneous algal community, with few macroscopic invertebrates observed. At depths between 2 and 4 m, the wall is vertical and dominated by photophilous algae in a wave-beaten mode (Figure 4A), primarily *Osmundea pinnatifida*, *Acetabularia (Acetabularia) acetabulum*, filamentous brown algae, *Corallina elongata*, and *Padina pavonica*. Among these algae, numerous specimens of the cirriped crustacean *Semibalanus balanoides* (Linnaeus, 1767) can be found. From 4 m to the bottom (11 m), the wall becomes slightly inclined and is nearly completely covered by photophilous algae, with abundant thalli of *Padina pavonica* and *Halopteris scoparia* (Figure 4D) and *Acetabularia (Acetabularia) acetabulum* (Figure 4B). Scattered specimens of *Codium bursa*, Dictyota, thalli of *Sphaerococcus coronopifolius*, and encrusting red algae are present beneath the high thallus algal mat. There are also several isolated thalli of *Codium vermilara* (Figure 4C). Among the macroscopic fauna, sea urchins (*Arbacia lixula*), sponges (*Sarcotragus fasciculatus*), and some polychaete spirographs (*Sabella spallanzanii* (Gmelin, 1791)) can be observed. Additionally, there are small sciophilous enclaves featuring *Peyssonnelia squamaria*, the serpulid polychaete *Protula tubularia* (Gmelin, 1791), the sponge *Aplysina aerophoba* (Nardo, 1833), and the echiurid *Bonellia viridis* Rolando, 1822.

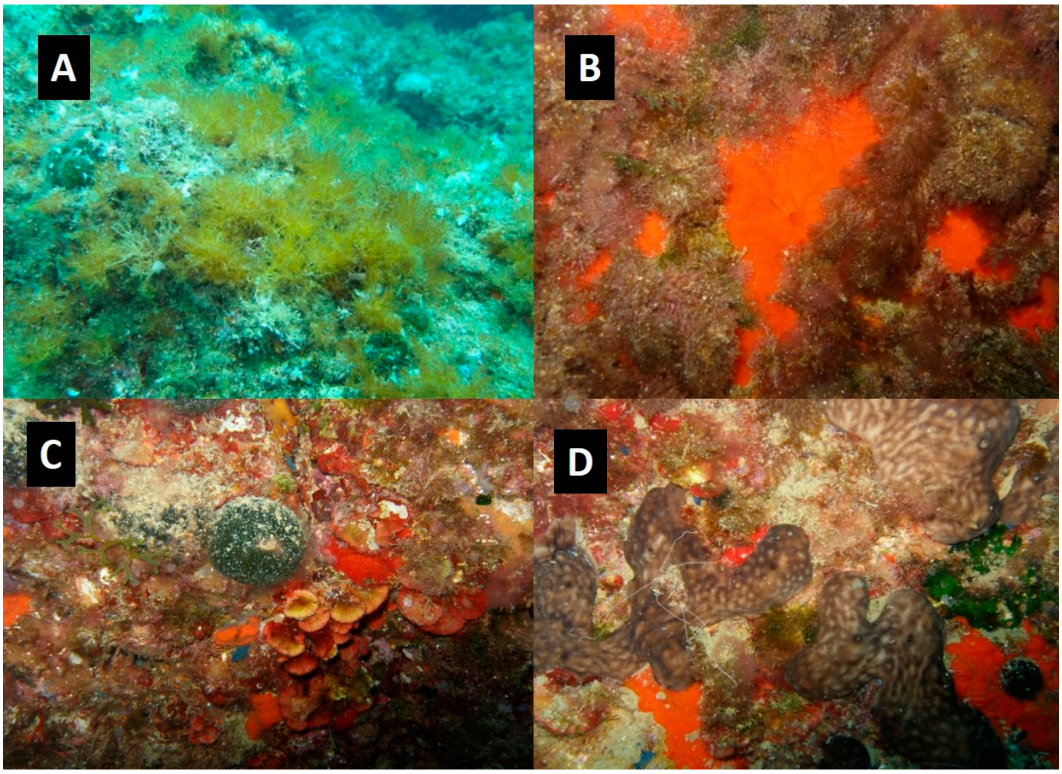

Figure 3. Algal community in the sciophilic wall. (**A**): *Osmundea pinnatifida*; (**B**): *Halopteris scoparia*; (**C**): *Codium bursa* and *Peyssonnellia squamaria*; (**D**): *Chondrosia reniformis*. Photos by M. Ballesteros.

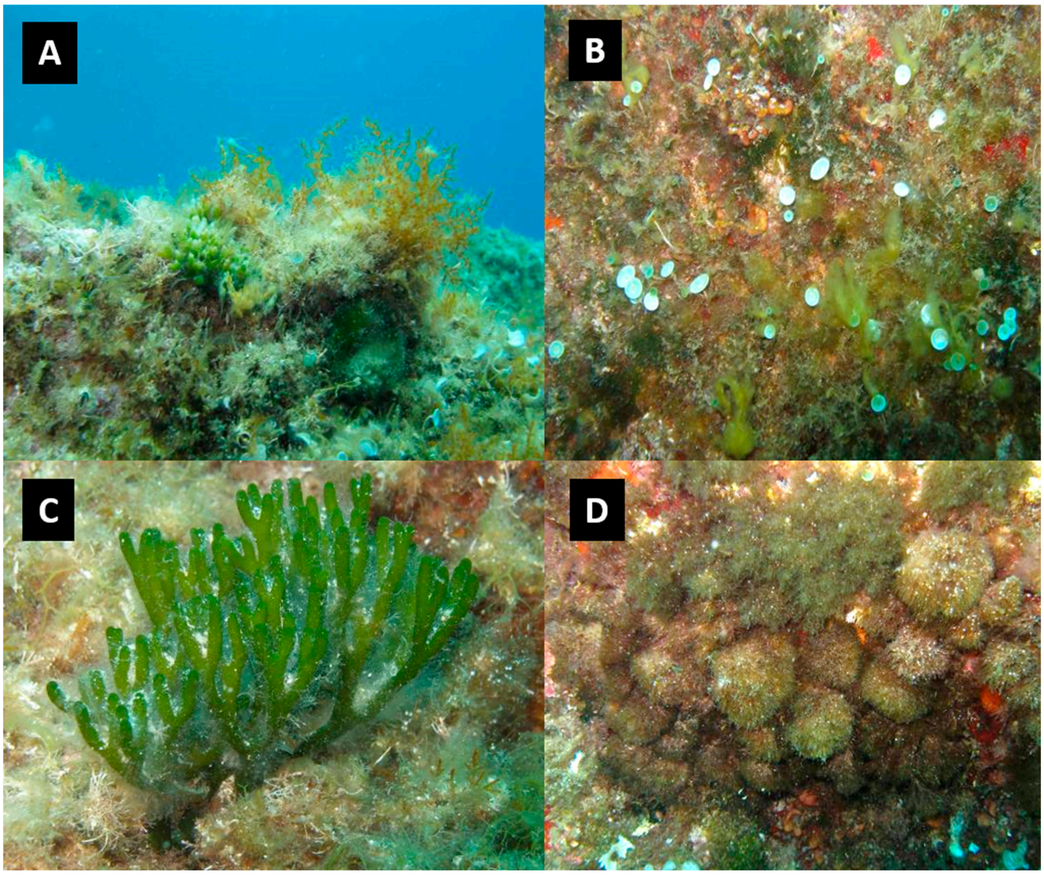

Figure 4. Algal community in the photophilic wall. (**A**): *Osmundea pinnatifida*; (**B**): *Acetabularia (Acetabularia) acetabulum*; (**C**): *Codium vermilara*; (**D**): *Halopteris scoparia*. Photos by M. Ballesteros.

2.3. Sampling Design and Field Work

Sampling was conducted every two months from January to November 2011 by two divers using scuba gear. Underwater photographs of the main communities present on both walls were taken with an Olympus SP-350 camera housed in a waterproof casing.

Algal samples were collected by scraping the existing algal community inside a metal square measuring 20 × 20 cm. During each sampling dive, three replicates were randomly collected from each wall, photophilous and sciophilous. Samples were introduced in plastic bags, in situ. After surfacing and draining most of the water, 70% alcohol was added to each bag. In total, 36 samples were obtained, with 18 corresponding to the photophilous wall (6 samples × 3 replicates) and another 18 to the sciophilous wall (6 samples × 3 replicates).

2.4. Samples Processing

In the laboratory, each sample was washed under running water using two metal filters with mesh sizes of 2 mm and 315 µm. This process enabled the separation of the algal and invertebrate specimens into two fractions: the coarse fraction and the fine fraction, respectively. From these two fractions, the mollusk specimens were separated from the other invertebrates using a Carl Zeiss binocular magnifying glass model GmbH STEMI 2000-C (Zeiss Spain, Barcelona, Spain).

Next, the mollusk specimens from both fractions were sorted by morphotype in plastic classification racks for subsequent counting and taxonomic identification up to the species or higher level. Various general identification guides were employed [21–27] along with specialized literature for identifying juvenile mollusk stages [28]. For the current taxonomy and nomenclature of the species, the recommendations of the World Register of Marine Species [29] were generally followed.

Specimens that posed challenges in their taxonomic determination or that were unusual were photographed and preserved in Eppendorf tubes for identification by specialists. However, some specimens (especially bivalves) were only identified at the class level due to their early development stages.

2.5. Data Analysis and Statistical Methods

Species abundance data were expressed as number of individuals per replicate sample (no. individuals/400 cm^2). Species richness (S), total abundance of individuals (N), Shannon–Wiener diversity index (H′), and Pielou evenness (J′) were calculated for each sampling site. For diversity and evenness, permutation tests (within the PERMANOVA framework) were performed to determine whether there were significant differences between habitats, fractions, and months.

To analyze and compare community composition in relation to habitat, fraction, and seasonal variation, a proximity matrix was constructed using the Bray–Curtis similarity. Prior to this, a fourth root transformation was applied to reduce the influence of extreme values and obtain less asymmetric distributions of abundances. PERMANOVA designs were then used to assess significant differences based on habitat, sediment fraction, and months. Two-dimensional representations using the NMDS technique (Kruskal's algorithm) were created to visualize relationships across habitats, sediment fractions, and months. To identify potential clusters, dendrograms were constructed using the UPGMA method, and significant branches were tested with the SIMPROF test (α = 5%). The clusters identified through this methodology were then represented as ellipsoids on NMDS plots. Finally, species abundance data were grouped by trophic level, and some of the above techniques were reapplied.

All analyses were carried out using PRIMER 7 with PERMANOVA (Plymouth Routines in Multivariate Ecological Research).

3. Results

3.1. General Abundance and Specific Richness

A total of 7913 mollusk specimens, representing 148 different species, were counted across all samples. Of these, 32 belong to the class Bivalvia, 112 to Gastropoda, and 4 to Polyplacophora. Some specimens, due to their small size and immaturity, were identified only to the genus level, higher taxon, or simply as morphotypes. Table 1 lists the species found in the samples, ordered by total abundance, along with their abundance in the two environments (photophilous and sciophilous) and their trophic categories. Table 1 shows the species' abundance according to their presence in the two studied fractions, fine and coarse. Regarding the two habitats, the photophilous environment proved to be the most abundant, with 6244 mollusk specimens (6017 in fine fraction and 227 in coarse fraction), while the sciophilic algae environment contained 1669 specimens (1559 in fine fraction and 110 in the coarse fraction). In terms of specific richness, the photophilous environment again stood out, with 133 different species (105 in the fine fraction and 58 in the coarse fraction), compared to 84 species in the sciophilous environment (62 in the fine fraction and 38 in the coarse fraction). Of the total number of species, 15 were exclusive to the sciophilous environment, 65 were found only in the photophilous environment, and 68 were present in both environments. Of all species, 35 were found only in the coarse fraction, 76 only in the fine fraction, and 37 species were present in both fine and coarse fractions. Among the mollusks of the fine fraction, 57 species were found in both the photophilous and sciophilous samples, 50 species were exclusive to the photophilous environment, and 6 were exclusive to the sciophilous environment. In the coarse fraction, 25 species were present in both sciophilous environments, 33 were found only in the photophilous samples, and 12 species appeared only in sciophilous samples. A total of 72 species were identified in the coarse fraction samples, and 111 in the fine fraction.

Table 1. List of species according to their abundances and trophic categories. "C": carnivore; "EC": ectoparasite; "F": filter feeder; "HE": herbivore; "SC": scavenger; "SDF": surface depot feeder; "UN": unknown. "Sc": sciophilous environment; "Ph": photophilous environment. Note: Some authors classify the species from the Pyramidelloidea group as ectoparasites of echinoderms or other invertebrates, while others consider them micro-carnivores. In this study, they are classified as ectoparasites.

Species	Trophic Categories	Total Abundances	Sc	Ph
Bittium latreillii	HE	2106	55	2051
Musculus costulatus	F	1282	486	796
Pusillina philippi	C	817	272	545
Pusillina radiata	F	546	179	367
Hiatella arctica	HE	404	162	242
Rissoella diaphana	HE	228	0	228
Odostomia striolata	HE	217	50	167
Alvania lineata	HE	176	49	127
Chauvetia mamillata	C	130	22	108
Parvicardium scriptum	F	130	29	101
Triphoridae indet.	C	130	16	114
Bittium reticulatum	HE	96	10	86
Clanculus cruciatus	HE	88	8	80

Table 1. *Cont.*

Species	Trophic Categories	Total Abundances	Sc	Ph
Striarca lactea	F	88	13	75
Tritia incrassata	SC	80	20	60
Ammonicera fischeriana	HE	79	13	66
Modiolula phaseolina	F	67	11	56
Vitreolina perminima	C	65	6	59
Jujubinus ruscurianus	HE	62	13	49
Mytilus galloprovincialis juv.	F	57	11	46
Crisilla semistriata	HE	53	29	24
Cerithium vulgatum	SDF	41	2	39
Parvamussium fenestratum	F	41	22	19
Aplysia punctata juv.	HE	40	10	30
Arca noae	F	40	1	39
Runcina sp.	HE	39	4	35
Aequipecten opercularis	F	36	23	13
Parthenina emaciata	C	36	0	36
Alvania cancellata	HE	35	3	31
Runcina adriatica	C	30	3	27
Cyrillia linearis	C	29	1	28
Cerithiopsis tubercularis	C	25	2	23
Limaria tuberculata	F	24	13	11
Irus irus	F	22	5	17
Mimachlamys varia	F	22	13	8
Scissurella costata	HE	22	1	21
Gibberula turgidula	C	20	0	20
Odostomia plicata	EP	20	11	9
Tricolia sp.	HE	20	3	17
Chauvetia brunnea	C	17	9	8
Cerithiopsis jeffreysi	C	16	0	16
Gregariella semigranata	F	16	8	8
Mitromorpha columbellaria	C	16	5	11
Ocinebrina aciculata	C	16	2	14
Odostomella doliolum	EC	16	1	15
Bulla striata	C	15	3	12
Setia pulcherrima	HE	15	5	10
Haminoea navicula	HE	13	0	13
Petricola lithophaga	F	13	0	13
Chama gryphoides	F	12	8	4
Rissoa lia	HE	11	1	10
Monophorus erythrosoma	C	10	2	8
Alvania nestaresi	HE	9	0	9
Bittium sp.	HE	9	0	9

Table 1. *Cont.*

Species	Trophic Categories	Total Abundances	Sc	Ph
Cerithiopsis sp.	C	9	0	9
Modiolus barbatus	F	9	1	8
Rissoa variabilis	HE	9	1	8
Bivalvia morph. 1	F	8	0	8
Doridina nudibranch	C	8	3	5
Hexaplex trunculus	C	8	4	4
Pusia tricolor	C	8	2	6
Raphitoma echinata	C	8	2	6
Anomia ephippium	F	6	4	2
Diodora graeca	HE	6	2	4
Marshallora adversa	C	6	2	4
Muricopsis cristata	C	6	4	2
Philine sp.	C	6	0	6
Pseudochama gryphina	F	6	3	3
Rhyssoplax corallina	HE	6	3	3
Alvania aspera	HE	5	0	5
Alvania sp.	HE	5	0	5
Gastropoda morph. 1	UN	5	0	5
Gibberula miliaria	C	5	0	5
Mitromorpha olivoidea	C	5	1	4
Tricolia tingitana	HE	5	0	5
Trinchesia genovae	C	5	0	5
Acanthochitona sp.	HE	4	0	4
Chauvetia recondita	C	4	0	4
Nodulus contortus	HE	4	0	4
Smithiela costulata	C	4	1	3
Spiralina alpinoligustica	EC	4	2	2
Acanthochitona fascicularis	HE	3	2	1
Aegires leuckartii	C	3	1	2
Bivalvia morph. 2	F	3	0	3
Gibberula morph. 1	UN	3	0	3
Haliotis tuberculata	HE	3	2	1
Lima lima	F	3	0	3
Limaria hians	F	3	2	1
Pusillina inconspicua	HE	3	0	3
Veneridae indet.	F	3	1	2
Bivalvia morph. 4	F	2	1	1
Brachystomia scalaris	EC	2	0	2
Calliostoma zizyphinum	C	2	0	2
Crisilla simulans	HE	2	0	2
Diodora italica	HE	2	2	0

Table 1. *Cont.*

Species	**Trophic Categories**	**Total Abundances**	**Sc**	**Ph**
Doris ocelligera	C	2	2	0
Emarginula pustula	C	2	1	1
Episcomitra cornicula	C	2	2	0
Folinella excavata	EC	2	0	2
Fusinus rudis	C	2	0	2
Gastropoda morph. 2	UN	2	0	2
Jujubinus exasperatus	HE	2	1	1
Polyplacophoran indet.	HE	2	0	2
Raphitoma laviae	C	2	0	2
Raphitoma morph. 1	C	2	0	2
Rissoa guerinii	HE	2	0	2
Weinkauffia turgidula	C	2	0	2
Alvania cimex	HE	1	1	0
Alvania discors	HE	1	0	1
Aplus dorbignyi	SC	1	0	1
Babelomurex cariniferus	C	1	1	0
Bivalvia morph. 3	F	1	0	1
Caloria elegans	C	1	1	0
Cardiidae morph. 1	F	1	0	1
Cardiidae morph. 2	F	1	0	1
Chauvetia morph. 1	UN	1	0	1
Chauvetia morph. 2	UN	1	0	1
Columbella rustica	HE	1	1	0
Doto sp.	C	1	1	0
Felimare sp.	C	1	0	1
Gari tellinella	F	1	0	1
Gastropoda morph 3	UN	1	1	0
Gibberula morph. 2	UN	1	0	1
Idas sp.	F	1	1	0
Ischnochitonidae indet.	HE	1	0	1
Lithophaga lithophaga	F	1	1	0
Mangelia multilineolata	C	1	0	1
Mangelia morph. 1	UN	1	0	1
Mangelia morph. 2	UN	1	0	1
Mitrella broderipii	C	1	0	1
Muricidae indet.	C	1	0	1
Nodulus spiralis	HE	1	0	1
Otina ovata	UN	1	0	1
Paradoris indecora	C	1	0	1
Patella sp.	HE	1	0	1
Philine intricata	C	1	0	1

Table 1. *Cont.*

Species	Trophic Categories	Total Abundances	Sc	Ph
Phorcus richardi	HE	1	0	1
Pseudomangelia vauquelini	C	1	0	1
Pusia ebenus	C	1	0	1
Raphitoma morph. 2	C	1	0	1
Retilaskeya horrida	C	1	1	0
Retusa mammillata	C	1	0	1
Runcina coronata	HE	1	0	1
Spondylus gaederopus	F	1	1	0
Talochlamys multistriata	F	1	0	1
Tarantinaea lignaria	C	1	0	1
Tectura virginea	HE	1	1	0
Williamia gussoni	HE	1	1	0

Moreover, 76.27% of the total abundance is represented by 10 species: *Bittium latreillii* (Payraudeau, 1826), *Musculus costulatus* (Risso, 1826), *Pusillina philippi* (Aradas and Maggiore, 1844), *Pusillina radiata* (R. A. Philippi, 1836), *Hiatella arctica* (Linnaeus, 1767), *Rissoella diaphana* (Alder, 1848), *Odostomia striolata* Forbes and Hanley, 1850, *Alvania lineata* Risso, 1826, *Parvicardium scriptum* (Bucquoy, Dautzenberg and Dollfus, 1892), and *Chauvetia mamillata* (Risso, 1826), with more than 100 specimens counted across all samples. Notably, a large number of juvenile gastropods from the family Triphoridae (130 specimens) were also recorded but could not be identified at the species or genus level.

Table A1 in Appendix A details the abundances of each species by environment and by their presence in either the fine or coarse fraction. In the sciophilous environment, the most abundant species—those with over 50 observed specimens—were *Musculus costulatus* with 486 specimens (all but two in the fine fraction), *Pusillina philippi* with 272 specimens (all in the fine fraction), *Pusillina radiata* with 179 specimens (all in the fine fraction), *Hiatella arctica* with 162 specimens (153 in the fine fraction and 9 in the coarse fraction), *Bittium latreillii* with 55 specimens (all but one in the fine fraction), and *Odostomia striolata* with 50 specimens (all in the fine fraction).

The samples from the photophilous wall, due to their greater specimen abundance, displayed a higher species diversity, with 16 species exceeding 50 observed specimens. Among those with more than 100 observed specimens, the most abundant by far was *Bittium latreillii* with 2051 specimens (only one in the coarse fraction), followed by the bivalve *Musculus costulatus* with 796 specimens (only 8 in the coarse fraction), *Pusillina philippi* with 545 specimens (all in the fine fraction), *Pusillina radiata* with 367 specimens (all in the fine fraction), *Hiatella arctica* with 242 specimens (only three in the coarse fraction), *Rissoella diaphana* with 228 specimens (all in the fine fraction), *Odostomia striolata* with 167 specimens (all in the fine fraction), *Alvania lineata* with 127 specimens (only 11 in the coarse fraction), *Chauvetia mamillata* with 108 specimens (only 16 of them in the coarse fraction), and *Parvicardium scriptum* with 101 specimens (only one in the coarse fraction). The specimens of the species mentioned above are mostly species under 2 mm, such as *Bittium latreillii*, *Rissoella diaphana*, *Pusillina philippi*, *P. radiata*, and *Odostomia striolata*, while the others are juvenile forms of larger species, although they predominantly appear in the fine fraction.

Regarding the two studied fractions, in the coarse one, the most abundant species was *Tritia incrassata* with 40 specimens (35 in the photophilous environment), followed by *Alvania lineata* with 33 specimens (16 in the photophilous environment and 17 in the sciophilous environment), *Chauvetia mammillata* with 21 specimens (16 in the photophilous environment and 5 in the sciophilous), and *Chauvetia brunnea* with 17 specimens (8 in the photophilous environment and 9 in the sciophilous). In the fine fraction, the highest abundance corresponded to *Bittium latreillii*, with 2104 specimens (2050 in the photophilous environment and 54 in the sciophilous), followed by *Musculus costulatus* with 1272 specimens (788 in the photophilous environment and 484 in the sciophilous), *Pusillina philippi* with 817 specimens (545 in the photophilous environment and 272 in the sciophilous), *Pusillina radiata* with 546 specimens (367 in the photophilous environment and 179 in the sciophilous), and *Hiatella arctica* with 242 specimens (239 in the photophilous environment and only 3 in the sciophilous).

3.2. Species Richness, Abundance, Diversity, and Evenness Throughout the Year

The families Cerithiidae, Mytilidae, and Rissoidae show a clear contrast in terms of abundance compared to the other families in almost all the samples from the two studied environments. Mytilidae were the most abundant in nearly all samples, both photophilous and sciophilous, except in July and September, when Cerithiidae dominated, and in November when Rissoidae dominated both environments. The Rissoidae family exhibited a consistent presence throughout the year in both habitats, with their abundance peaking in the winter months (January and November).

The species found in the photophilous and sciophilous habitats showed different fluctuations over the study period (Figure 5). In the photophilous community, mollusk species richness was the lowest from January to March, while the highest richness was observed from May to September, peaking in July. In the sciophilous environment, species richness was generally lower, but followed a similar pattern, with slight increases from July to September.

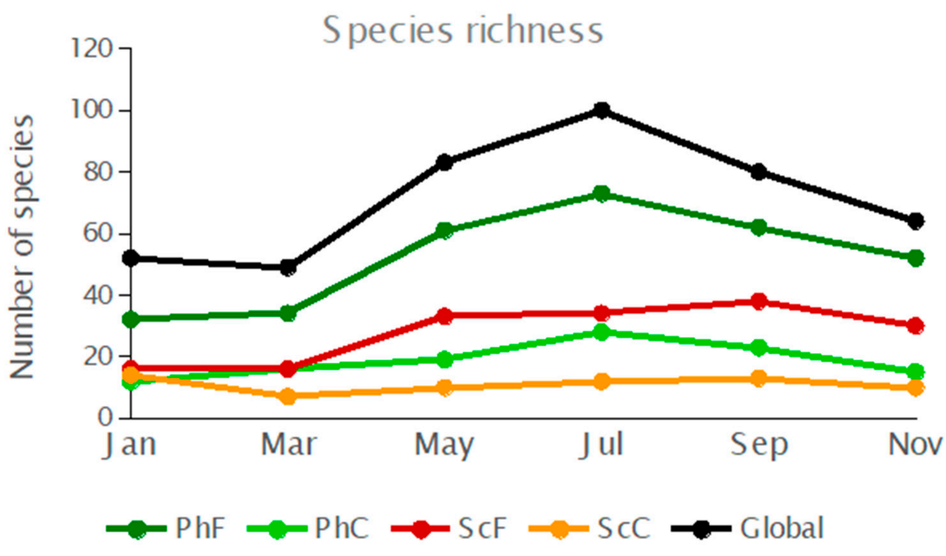

Figure 5. Species richness throughout the year. "Ph" and "Sc" indicate the photophilous and sciophilous communities, respectively, while "F" refers to the fine fraction and "C" to the coarse fraction.

The seasonal abundance (Figure 6) of individuals in the sciophilous habitat remained relatively low throughout the sampling period, with November showing the highest abundance, with almost 500 specimens. The increase in the number of specimens from July to November was primarily driven by the abundance of species from the families Rissoidae and Mytilidae. In the photophilous community, the greatest abundance of individuals occurred in July, mainly due to species from the Cerithiidae family. The peak in specimens in July in the photophilous samples is mainly due to new recruits of *Bittium latreillii* (374, 373, and 552 specimens in the three replicates), *Alvania linata* (20, 24, and 12 specimens), *Clanculus cruciatus* (14, 14, and 10 specimens), *Pusillina philippi* (53, 71, and 83 specimens), *Rissoella diaphana* (72, 52, and 45 specimens) and undetermined juvenile individuals of the Triphoridae family (18, 32, and 26 specimens). All these specimens were found in the fine fraction, which accounted for a total of 2598 specimens across all species in the three replicates. In contrast, the coarse fraction for the same month contained only 48 specimens of all species. Overall, it was observed that for both environments, the peak in species richness and individual abundance occurred during the summer months.

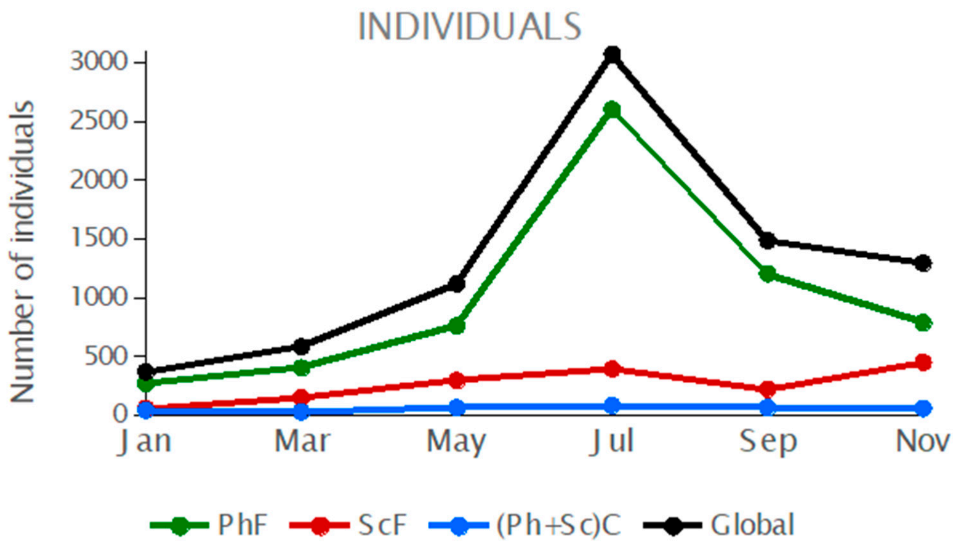

Figure 6. The number of individuals collected throughout the year. "Ph" and "Sc" indicate the photophilous and sciophilous habitats, respectively, while F refers to the fine fraction and C to the coarse fraction. Due to the low number of specimens in the coarse fraction, individuals from both habitats are grouped together.

The Shannon–Wiener diversity index (H′) values (Figure 7A) obtained from the samples (combining the three replicates) are not particularly high, ranging from 1.087 (March) to 2.765 (September) in the sciophilous environment, and from 2.084 (March) to 3.091 (July) in the photophilous environment. A 3-factor PERMANOVA analysis shows significant differences between environments (p = 0.0079) and fractions (p = 0.0266), although the month factor approaches significance (p = 0.0850). No interactions between the factors are detected.

Regarding evenness (the Pielou J′ index) (Figure 7B), the values for the fine fraction range from 0.392 (March) to 0.760 (January and September) in the sciophilous environment, and from 0.540 (July) to 0.714 (May) in the photophilous environment. Evenness is higher in the coarse fraction due to the small number of individuals, which are relatively evenly distributed across several species (Figure 7B). A 3-factor PERMANOVA analysis shows significant differences only between fractions (p = 0.0001).

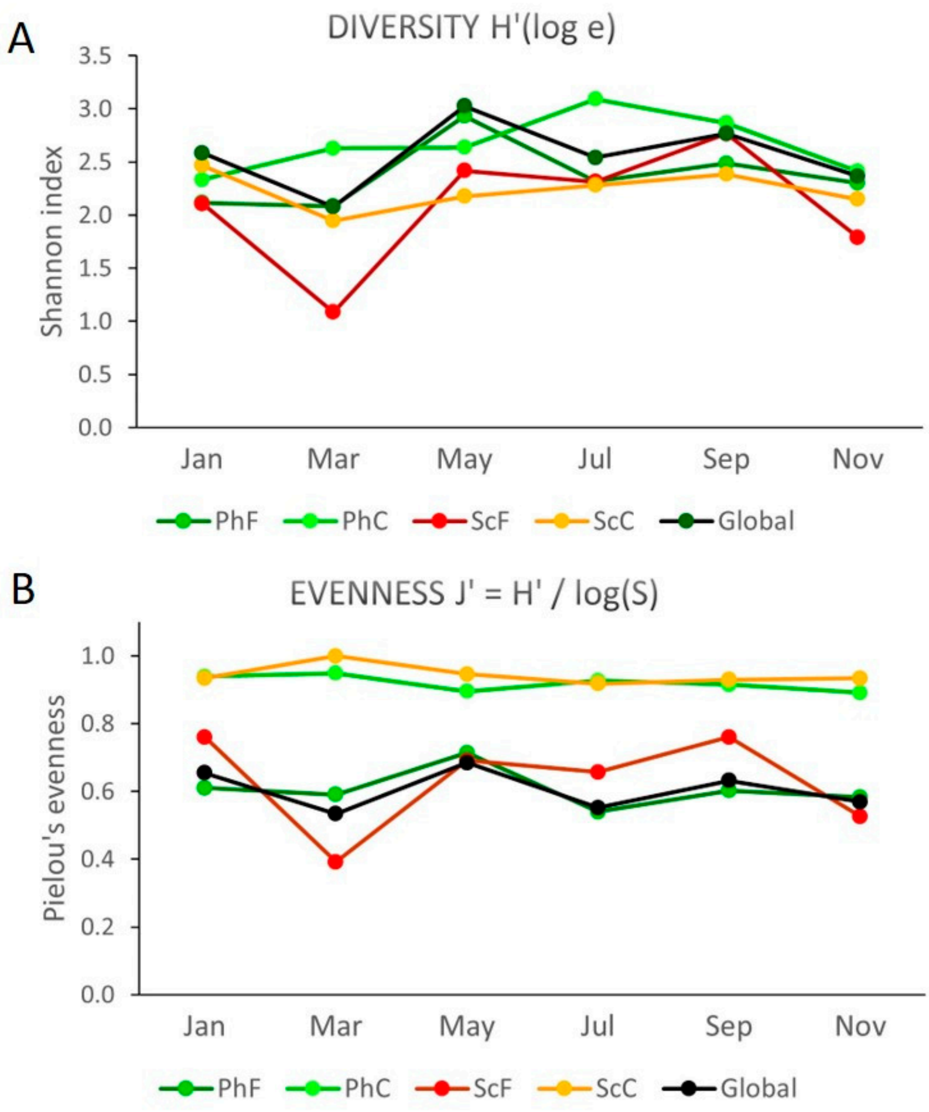

Figure 7. Shannon diversity index (**A**) and Pielou's evenness (**B**) throughout the year. "Ph" and "Sc" refer to the photophilous and sciophilous habitats, respectively, while "F" refers to the fine fraction and "C" to the coarse fraction.

3.3. Community Composition According to Algal Habitat, Fraction, and Changes over the Year

A 3-factor PERMANOVA design (En = environment, Fr = fraction and Mo = month) shows that all main effects and two-way interactions are significant (En, $p = 0.0001$; Fr, $p = 0.0001$; Mo, $p = 0.0001$; En × Fr, $p = 0.0001$; En × Mo, $p = 0.0238$; Fr × Mo, $p = 0.0001$), with only the three-way interaction being non-significant (En × Fr × Mo, $p = 0.2539$). These results indicate that the composition and evolution of the community throughout the year varies depending on the environment and fraction.

Based on these findings, a SIMPER analysis was conducted to examine the En x Fr groups (i.e., PhF, PhC, ScF, and ScC) and months (Tables 2 and A3). The results show clear differences between groups (environments and fractions) and across months.

The NMDS representation (Figure 8) reveals a distinct separation between the fine and coarse fractions, highlighting differences in species composition. Differences between habitats are also observed, although, in the coarse fraction, the separation between September and October and the rest of the year appears to be more pronounced.

Table 2. Results of SIMPER analysis, detailing average similarities (on the diagonal) and average dissimilarities (in red, lower triangle of the matrices) within and between En × Fr groups (i.e., PhF, PhC, ScF, and ScC) or months.

						Jan	Mar	May	Jul	Sep	Nov
	PhF	**ScF**	**PhC**	**ScC**	**Jan**	**34.80**					
PhF	**60.28**				**Mar**	75.92	**29.72**				
ScF	57.05	**49.55**			**May**	67.86	69.63	**46.60**			
PhC	88.50	89.04	**27.62**		**Jul**	71.75	72.44	53.63	**54.60**		
ScC	93.59	89.73	78.87	**28.56**	**Sep**	76.79	70.65	64.71	60.98	**44.42**	
					Nov	77.74	71.65	67.32	71.25	60.51	**41.53**

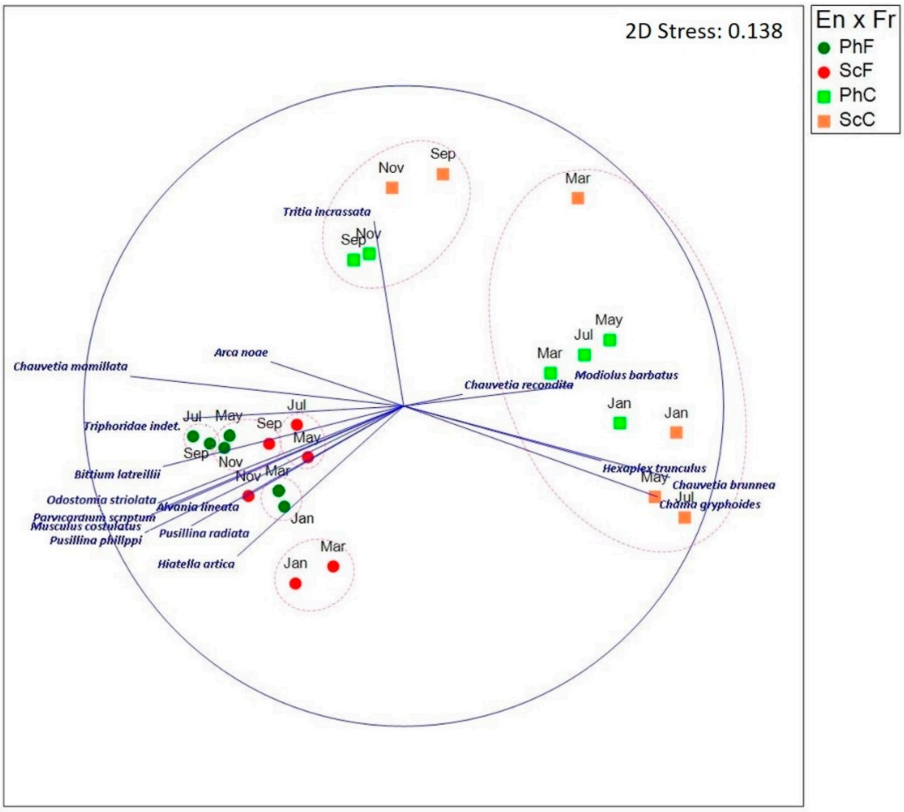

Figure 8. NMDS representation of the sample sites. Clusters are represented by ellipsoids, which were obtained using the UPGMA method, with significant branches verified by the SIMPROF test (α = 5%). "Ph" and "Sc" indicate photophilous and sciophilous habitats, respectively, while "F" refers to the fine fraction and "C" to the coarse fraction. The segments represent the correlation between species and the axes, and the circle delineates the maximum correlation range (−1 to 1). For each habitat, fraction, and month, species contributing at least 5% to the similarity (based on SIMPER analysis) were selected.

The results of the NMDS carried out only with species data from the fine fraction (Figure 9) show a clear separation between the photophilous and sciophilous environments, as well as differences throughout the year. In particular, the months of January and March of the sciophilous environment differ from the rest by the low species richness and the number of individuals. On the other hand, located in the upper part of the graph, the months from May to November of the photophilous environment present the highest species richness and abundance of individuals (especially in July). In this period, the species pointing toward the top of the graph are the most characteristic and abundant in the photophilous habitat.

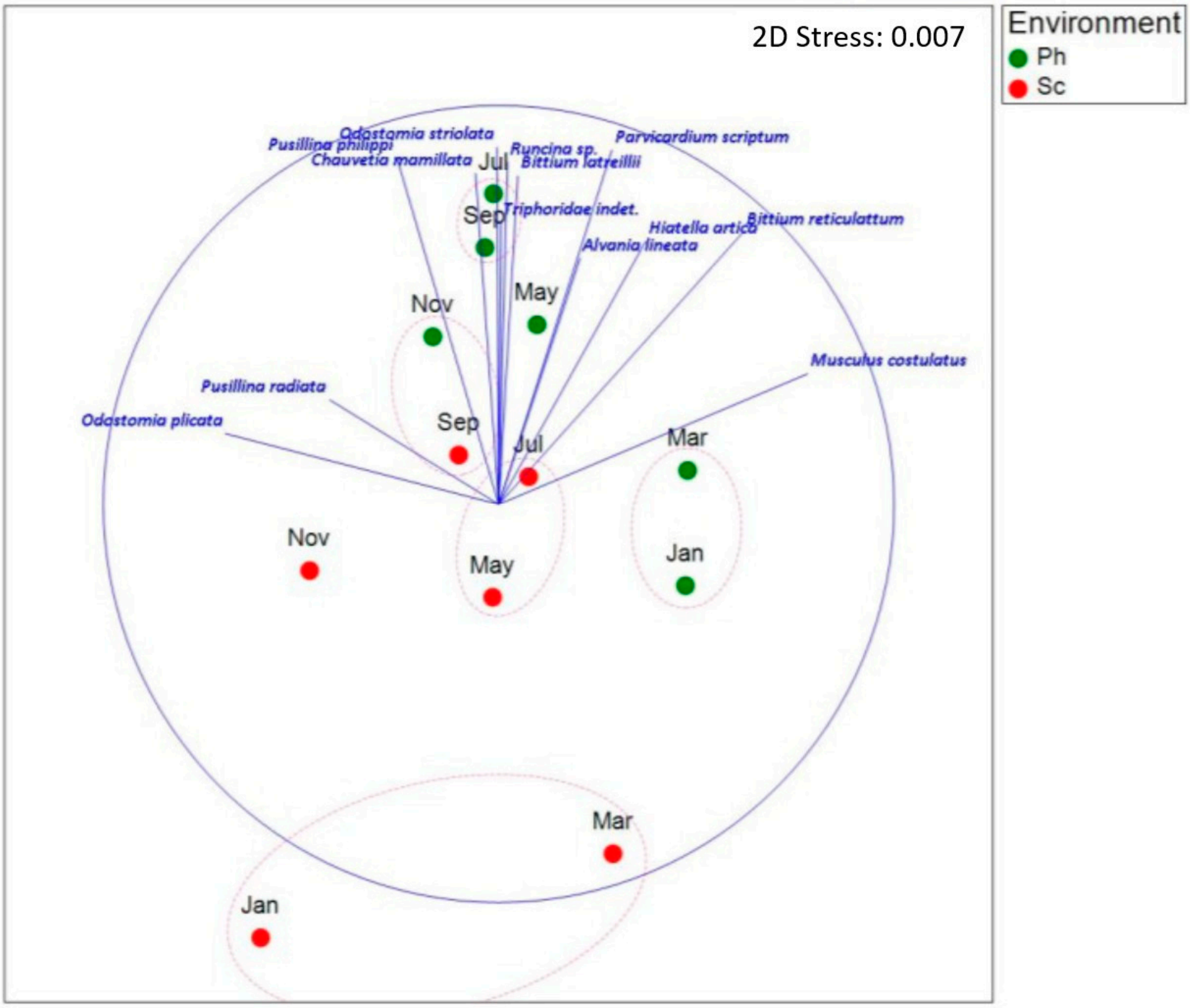

Figure 9. NMDS representation of fine fraction data. Clusters are represented by ellipsoids and have been obtained by applying the UPGMA method and checking significant branches with the SIMPROF test (α = 5%). "Ph" and "Sc" indicate photophilous and sciophilous habitats, respectively. The segments represent the correlation between species and axes, with the circle delimiting the maximum correlation (−1 to 1). For each environment and month, species contributing at least 5% to the similarity (based on SIMPER analysis) were selected.

3.4. Trophic Level According to Environment, Fraction, and Evolution over the Year

For each sampling site and replicate, species abundance data were aggregated according to trophic category. Subsequently, the fourth-root transformation was applied, and a Bray–Curtis similarity matrix was calculated. Running a 3-factor PERMANOVA design (En = environment, Fr = fraction, and Mo = month) showed that all main effects and the En × Fr interaction and the Fr × Mo interaction were significant (En, p = 0.0001; Fr, p = 0.0001; Mo, p = 0.0392; En × Fr, p = 0.0104; Fr × Mo, p = 0.0329). The double interaction En × Mo and the triple interaction were not significant (p = 0.8155 and p = 0.9902, respectively).

The NMDS representation (Figure 10) again shows a clear separation between the fine and coarse fractions. Differences between habitats and months are also evident. The community composition by trophic category is shown in more detail in a bar chart (Figure 11); notice that surface depot feeders (SDFs) and ectoparasites (ECs) were absent in the coarse fraction.

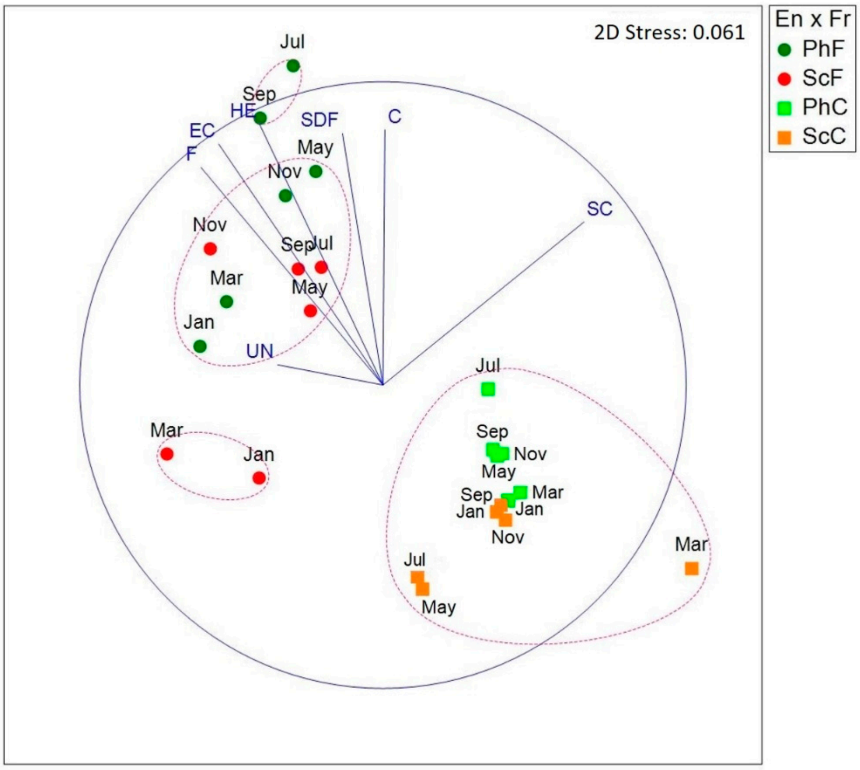

Figure 10. NMDS representation of the sample sites according to trophic categories. Clusters are represented by ellipsoids and were obtained by applying the UPGMA method, with significant branches verified using the SIMPROF test (α = 5%). "Ph" and "Sc" indicate photophilous and sciophilous habitats, respectively, while "F" refers to the fine fraction and "C" to the coarse fraction. The segments represent the correlation between species and axes, and the circle delimits the maximum correlation (−1 to 1). Trophic categories: herbivore (HE), filter feeder (F), surface depot feeder (SDF), carnivore (C), scavenger (SC), ectoparasite (EC), and unknown (UN).

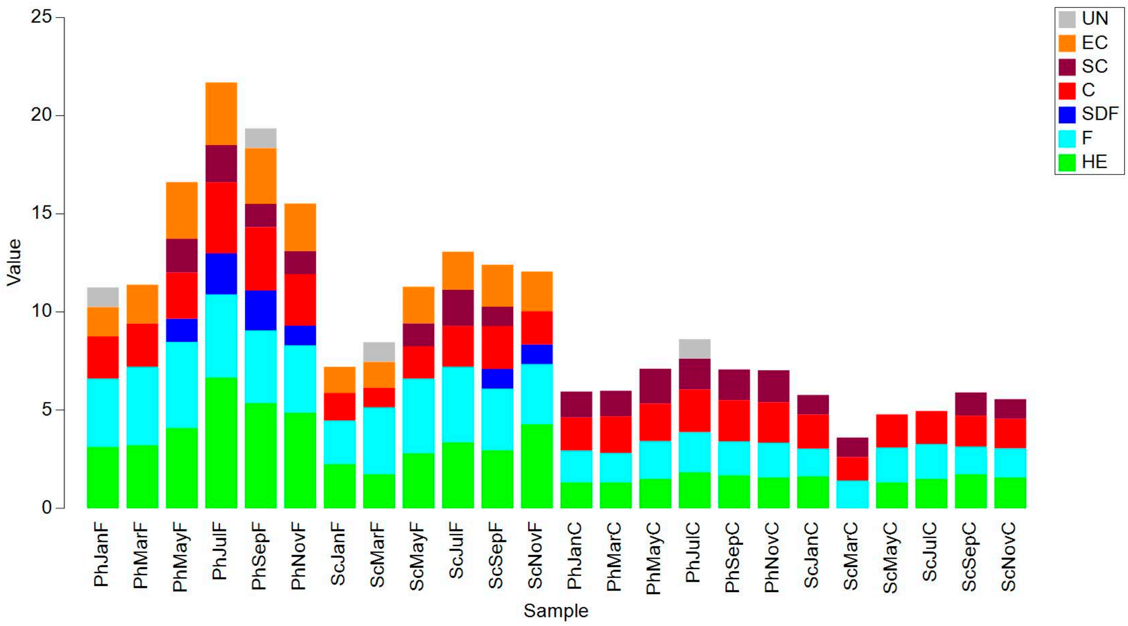

Figure 11. Bar chart of community composition according to trophic categories for each sample site and month. Abundances were previously fourth-root transformed. "Ph" and "Sc" indicate photophilous and sciophilous habitat respectively, while "F" refers to the fine fraction and "C" to the coarse fraction. Trophic categories: herbivore (HE), filter feeder (F), surface depot feeder (SDF), carnivore (C), scavenger (SC), ectoparasite (EC), and unknown (UN).

4. Discussion

This study identified rich malacological populations (148 species) associated with algae, comparable to other studies such as on the Spanish Costa Brava (131 species) [14] and the island of Formentera (118 species) [30]. Studies from other regions also reported similar specific richness associated with certain types of algae, such as La Goulette Bay, Tunisia (93 species) being associated with photophilous algae, with *Corallina officinalis* being the most abundant [31]; Lampedusa Island, Italy (176 species) in the algae community of the genus *Cystoseira* [32]; Algeciras, Spain (98 species) [17] and the Alboran Sea, Spain (193 species) [16] both in algal communities dominated by *Halopteris*; and the Aegean Sea (184 species) [33] associated with photophilous algal turfs. However, these studies are not strictly comparable to ours due to differences in methodology and sampling effort.

Considering previous records from Tossa de Mar [34,35], the observations of amateur naturalists (published with photos on the internet), and our own study, it can be said that the marine mollusks of Tossa de Mar are well-known. The only published work focusing on mollusks observed in Tossa de Mar [34] reported 98 species of gastropods (58 previously classified as "prosobranchs" and 40 as traditional "opisthobranchs") from the area, including the coast and nearby coves. Of these, 73 species were also recorded in our study area. Among the approximately 1300 species of marine mollusk species documented in Catalonia (NE Spain) (MB, personal observation), 296 species are known from Tossa de Mar (Table A2). This means that 22.3% of all known mollusk species from the 580 km of the Catalan coast are found at this single location.

Notably, sea slugs belonging to the marine Heterobranchia group (formerly "Opisthobranchia"), have attracted significant interest over several decades on the Catalan coast, both from scientists and amateur divers. As a result, the Heterobranchia group is particularly well documented in Tossa de Mar, with about 130 species cited, representing around 52% of the total species listed in the Catalan coast's "opisthobranch" catalog [36]. Moreover, two regional Catalan platforms on the internet [37,38] are dedicated to these gastropods. However, only a few species of Polyplacophora and Bivalvia have been recorded, and there are no data available on the observation of species from other mollusk groups in Tossa de Mar.

Regarding specimen abundance, our findings confirm the importance of algal communities for the establishment of mollusk populations. By extrapolating the abundances obtained from the three replicates (surface 20 cm $\times$ 20 cm $\times$ 3 = 1200 cm^2) per month to a surface area of 1 m^2 of the algal community, we found that mollusk abundances in the photophilous habitat range from 2425 specimens/m^2 in January to 22,133 specimens/m^2 in July. In the sciophilous environment, abundance values ranged from 650 specimens/m^2 in January to 3883 specimens/m^2 in November. These data suggest that algal communities provide various resources, including food, shelter, protection, and reproductive support, for a wide variety of medium- and small-sized mollusk species.

The abundances of specimens obtained in our study throughout the year clearly highlight the importance of new recruitments in the studied habitats, particularly in the photophilous habitat. Sampling in July revealed a large number of individuals from several species, with their abundances being much lower than those in other months, especially for small species or juvenile forms, such as *Clanculus cruciatus*, and for other larger species. This significant recruitment of certain species can profoundly alter the structure of the mollusk community on the algal fronds. However, such large recruitment has not been observed in the sciophilous habitat, likely because it is a more stable environment where the algal populations do not fluctuate as much in frond density throughout the year. Additionally, mollusk populations in this habitat have much lower abundances compared to the photophilous habitat. We also believe there is no movement of individuals between the two rock walls, as they are separated by a coarse sand corridor about 5–8 m wide, which lacks algae. The mobility of these small mollusks is likely very limited, restricted to moving between the algal fronds of their own community. The low abundance of specimens in January (296 in the photophilous environment and 78 in the sciophilous one) compared to the other sampling days could be attributed to strong wave action in the days prior to the sampling, which may have negatively impacted the communities of the two rock walls studied.

The abundance values of mollusks per square meter in this study may appear exceedingly high and possibly questionable. However, similarly high abundance figures have been reported in other research studies. For instance, between 2400 and 6300 individuals per square meter in photophilous algae communities dominated by *Cystoseira* species on the island of Ustica (Tyrrhenian Sea, Italy) have been observed, with species richness ranging from 101 to 121 [15]. In Antarctica, up to 7358 small invertebrates per square meter in the intertidal zone of Adelaide Island have been recorded [39]; other authors [40] reported a staggering 130,000 invertebrates per square meter in the intertidal soft substrates of King George Island (South Shetland), while in the same island [41], abundances as high as 100,000 invertebrate per square meter in intertidal algae on a hard substrate have been found, highlighting specific mollusk species such as the Littorinidae *Laevilittorina caliginosa* (3933 specimens per square meter), the bivalve *Mysella subquadrata* (12,250 specimens per square meter), and the littorinid *Eatoniella kerguelenensis* (with an extraordinary count of 42,268 individuals per square meter).

These findings illustrate that small mollusks can thrive in algae fronds, establishing highly dense populations across diverse geographical regions, from the western Mediterranean to the icy waters of Antarctica.

Most of the species identified in this study are well-known in the western Mediterranean and align with findings from similar research. For instance, in a study on the seasonal dynamics of mollusks living among photophilous algae in the Alboran Sea [16], the authors reported several abundant species, including *Musculus costulatus*, *Mytilus galloprovincialis*, *Hiatella arctica*, *Bittium reticulatum*, *Pusillina philippi*, *Chauvetia mamillata*, *Parvicardium scriptum*, and *Tritia incrassata.* These species also frequently appear in our samples. However, species such as *Eatonina fulgida*, *Rissoa guerini*, *Nodulus contortus*, *Setia amabilis*, and *Rissoa similis*, which were abundant in their study, were either absent or present in very low numbers in our findings. The same work also observed that the highest abundances of individuals and species occurred during the summer months, coinciding with the peak growth of photophilous algae thalli—a pattern similarly noted in our study.

The most abundant species identified in this study was *Bittium latreillii*, with 2106 specimens, with the vast majority (2051) found in samples from the photophilous environment. Along with its congener, *B. reticulatum* (96 specimens), these two species account for 27.8% of all mollusks found in our study. Their significant presence, particularly during the summer months, plays a role in determining the seasonal peak in mollusk abundance. Both species of *Bittium* are generalist herbivores distributed throughout the Mediterranean and nearby Atlantic regions, including the North Sea, the Cantabrian Sea, the coasts of Portugal, the Azores, Madeira, the Canary Islands and Mauritania [29,42]. They are often abundant in various algal environments, and our study confirms their preference for photophilous algae-dominated habitats.

The second most abundant species, the mytilid bivalve *Musculus costulatus*, totaled 1282 specimens. Unlike the *Bittium* species, *M. costulatus* was found in photophilous and sciophilous environments, with 486 specimens in the sciophilous and 796 in the photophilous samples, indicating no strong preference for well-lit or darker environments. A characteristic feature of this bivalve genus is its well-developed muscular foot, which facilitates movement and likely contributes to its wide distribution across different algal communities.

Some species identified in this study, although low in abundance, are particularly interesting despite not contributing significantly to the characterization of their respective habitats. For instance, *Otina ovata* (T. Brown, 1827) (Heterobranchia, Eupulmonata, Family Otinidae) and *Williamia gussoni* (O.G. Costa, 1829) (Heterobranchia, Siphonariomorpha, Family Siphonariidae), with only one specimen of each found, belong to groups of mollusks that breathe atmospheric air and are typically found in the intertidal zone of the Mediterranean. They are often found under stones, among algae, and associated with cirriped crustaceans [43,44]. However, in our study, these species were found at depths that do not align with the usual habitat described by most authors.

Species of the Siphonariidae family are generally considered intertidal and air-breathing [45]. However, a study that redescribes *Williamia gussoni* and performs a 3D analysis of its morphology [46], notes that this species typically inhabits subtidal zones and never comes into contact with atmospheric air. He further suggests that its pallial cavity does not function as a lung, making it an anomaly within its family. Based on this, the presence of *W. gussoni* at several meters of depth in our study is not unusual.

As for *Otina ovata*, we speculate that its presence in deeper habitats could be attributed to transport by waves and currents. Interestingly, *O. ovata* had not been recorded previously in Catalonian waters, along the Spanish Levant coast, or the Balearic Islands, according to the marine mollusk census for the Spanish coast [47]. This discovery may represent a new record for this species in these regions.

We found a distinct preference among the algal mollusks of Tossa de Mar for photophilous environments over sciophilous ones, with 6244 specimens and 133 species in the former, compared to 1669 specimens and 84 species in the latter. This suggests that rocky substrates dominated by photophilous algae offer a wider variety of ecological niches, where mollusks and other marine invertebrates can access food resources [48]. The dense fronds and large biomasses in certain months create numerous microhabitats, including small sciophilous enclaves, where diatoms and particulate organic matter accumulate. These deposits serve as food for micromollusks, such as *Rissoa guerini* and other rissoaceans, which “graze” on the periphyton of the algae. The presence of these herbivorous mollusks and invertebrates also influences the abundance of carnivorous mollusk species that feed on them.

Regarding specimen size, we observed a significant abundance of smaller mollusks in the fine fraction than in the coarse fraction. A total of 7576 specimens smaller than 2 mm (fine fraction) were counted, compared to just 337 specimens larger than 2 mm (coarse fraction) (Table A1). This indicates that micromollusks and juvenile forms smaller than 2 mm from larger species find an ideal habitat among algae, both in photophilous environments (6017 specimens, 105 species) and sciophilous environments (1559 specimens, 62 species).

Regarding the statistical analysis of biodiversity, the results indicate significant differences between the two environments (photophilous and sciophilous) and between the two fractions (coarse and fine). Additionally, the sampling month factor is close to reaching statistical significance, as shown in Figure 7.

When analyzing evenness, the coarse fraction exhibits notably higher values compared to the fine fraction. This is likely due to the fact that, although there are fewer specimens in the coarse fraction, they tend to be more evenly distributed among the various species. In other words, no single species dominates the abundance. In contrast, no clear temporal variations were detected across different months, as illustrated in Figure 8.

Regarding the species community composition, a clear distinction emerges between the fine and coarse fractions, as illustrated in the NMDS representation (Figure 9). Notably, the coarse fraction samples from both photophilous and sciophilous environments during September and November occupy a space between the two groups. This positioning may be attributed to the low number of specimens and limited species richness observed in those months. In contrast, samples from the other months in the coarse fraction appear to form a separate group, although some differences between photophilous and sciophilous environments are still evident.

Focusing on the fine fraction, the months of January and March are distinctly separated from the sciophilous environment, indicating a unique composition compared to the other months (Figures 9 and 10). This differentiation is likely due to these months having the fewest total specimens and the lowest species richness. Overall, a clear distinction between environments is apparent, with the months of May to November clustering at the top of the graph (Figure 10), correlating with a higher number of individuals and greater species richness. Specifically, July in the photophilous environment stands out at the top of the graph, reflecting the peak in both species' richness and total specimens during that month.

The analysis of trophic categories reveals noteworthy findings, particularly in terms of the distinct separation between the fractions (Figure 11). This separation is attributed not only to the lower species richness and number of specimens in the coarse fraction but also to the different compositions of the trophic categories. In the bar plot representation (Figure 11), it is evident that the coarse fraction lacks the presence of species feeding on detritus (SDF) or epifaunal consumers (ECs), exhibiting a higher relative proportion of collector (C) and scraper (SC) species. The reduced number of specimens found in the sciophilous environment, along with slight compositional differences between environments, results in a slight differentiation in the graph. March stands out as particularly unique within the sciophilous environment, characterized by a lower number of individuals and species. Notably, no herbivorous (HE) species were detected during this month, a finding that is challenging to explain. This anomaly may stem from undetected sampling issues or complications in the laboratory analysis of the samples.

Based on our data and other studies published in journals and online platforms, we can indicate that the malacofauna of Tossa de Mar is the best documented along the Catalan coast, with a total of 296 species recorded (Table A2). Notably, the sea slugs (in the broad sense) of the subclass Heterobranchia are particularly well-represented, with around 130 species cited in this locality. However, there is still much to be explored in terms of the biodiversity of bivalves, cephalopods, and other minor mollusk groups.

5. Conclusions

The algal communities of the upper infralittoral zone, subjected to different light intensities allow the characterization of two contrasting environments that differ in terms of structure, abundance, and species biodiversity. This has been demonstrated in this study by examining the mollusks in algal populations.

The photophilic algal community exhibits greater spatial heterogeneity compared to poorly lit bottoms, with well-lit areas alternating with small sciophilous microenvironments. This variation enhances habitat diversity. In contrast, the sciophilous wall excludes much of the flora and fauna typically found in photophilous zones. This is confirmed by the significantly higher abundance and species richness of mollusks in samples from the photophilous environment compared to the sciophilous one.

Although both communities are similar at the trophic level, due to the high contribution of herbivores and filter feeders, specific species distinguish the sciophilous community, such as *Musculus costulatus*, *Hiatella arctica*, *Pusillina philippi*, *Alvania lineata*, and *Pusillina* *radiata*. In the photophilous community, species like *Musculus costulatus*, *Bittium latreillii*, *Pusillina philippi*, *Hiatella arctica*, *Chauvetia mamillata*, *Parvicardium scriptum*, *Alvania lineata*, *Bittium reticulatum*, *Odostomia striolata*, and *Pusillina radiata* are predominant.

The results—in terms of abundance and specific richness—indicate that in Tossa de Mar, micromollusks (less than 2 mm) and juvenile individuals of larger species find extremely suitable environments for living and carrying out all their vital functions within both photophilous and sciophilous algal communities.

Finally, this paper describes the mollusk assemblages in two different habitats in Tossa del Mar and also contributes to the knowledge of the biodiversity of the malacofauna at this important site.

Author Contributions: Conceptualization, M.B.; methodology, M.B., A.S.S., Ó.F.V. and F.O.; validation, M.B.; formal analysis. M.B. and F.O.; investigations, all the authors; resources, M.B., A.S.S., Ó.F.V. and M.P.; data curation, M.B., A.S.S., Ó.F.V. and F.O.; writing—original draft preparation, M.B., A.S.S. and Ó.F.V.; writing—review and editing, M.B., F.O. and M.P.; visualization, M.B.; supervision, M.B., F.O. and M.P.; project administration, M.B.; funding acquisition, M.B. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the consolidated research group, Benthic Biology and Ecology (BEB), at the University of Barcelona (project 2009-SGR-484), to which the first three authors belong. It also received partial support from the Banc de Dades de Biodiversitat de Catalunya (BIOCAT) project funded by the Generalitat de Catalunya (Catalonia, Spain) (project FBG-306697).

Data Availability Statement: The data collection for this work is deposited in the laboratory of the Department of Evolutionary Biology, Ecology and Environmental Sciences (BEECA) of the Faculty of Biology of the University of Barcelona.

Acknowledgments: We are grateful to Lluís Toll for his invaluable assistance with the underwater work, as he participated in all the sampling. Anselmo Peñas helped us identify micromollusk species, especially those from the Pyramidelloidea group, while Pepe Templado clarified our doubts regarding juvenile specimens of the *Bittium* genus. We thank Ángel Luque for supervising the trophic categories of all species. We also appreciate Sergi Taboada's advice on the general organization of this work. Vanessa Muñoz assisted us with IT tasks. Finally, we thank the two anonymous referees whose suggestions have improved the quality of this manuscript.

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

Appendix A

Table A1. Species abundance by environment and fraction. Species are listed alphabetically. "Sc": sciophilous environment; "Ph": photophilous environment.

Species	Sciophilous Environment (Sc)			Photophilous Environment (Ph)			Total Sc + Ph
	Coarse	Fine	Total	Coarse	Fine	Total	
Acanthochitona fascicularis	2		2	1		1	3
Acanthochitona sp.					4	4	4
Aegires leuckartii		1	1		2	2	3
Aequipecten opercularis		23	23		13	13	36
Alvania aspera				5		5	5
Alvania cancellata		4	3		31	31	35
Alvania cimex	1		1				1
Alvania discors					1	1	1

Table A1. *Cont.*

Species	Sciophilous Environment (Sc)			Photophilous Environment (Ph)			Total Sc + Ph
	Coarse	Fine	Total	Coarse	Fine	Total	
Alvania lineata	17	32	49	16	111	127	176
Alvania nestaresi				2	7	9	9
Alvania sp.					5	5	5
Ammonicera fischeriana		13	13		66	66	79
Anomia ephippium	1	3	4	1	1	2	6
Aplus dorbignyi					1	1	1
Aplysia punctata juv.		10	10	2	28	30	40
Arca noae		1	1	11	28	39	40
Babelomurex cariniferus	1		1				1
Bittium latreillii	1	54	55	1	2050	2051	2106
Bittium reticulatum		10	10	4	82	86	96
Bittium sp.				2	7	9	9
Bivalvia morph. 1				2	6	8	8
Bivalvia morph. 2				2	1	3	3
Bivalvia morph. 3					1	1	1
Bivalvia morph. 4		1	1		1	1	2
Brachystomia scalaris					2	2	2
Bulla striata		3	3		12	12	15
Calliostoma zizyphinum				2		2	2
Caloria elegans	1		1				1
Cardiidae morph. 1					1	1	1
Cardiidae morph. 2					1	1	1
Cerithiopsis jeffreysi					16	16	16
Cerithiopsis tubercularis		2	2		23	23	25
Cerithiopsis sp.					9	9	9
Cerithium vulgatum		2	2		39	39	41
Chama gryphoides	8		8	4		4	12
Chauvetia brunnea	9		9	8		8	17
Chauvetia mamillata	5	17	22	16	92	108	130
Chauvetia recondita				4		4	4
Chauvetia morph. 1				1		1	1
Chauvetia morph. 2				1		1	1
Clanculus cruciatus	1	7	8	1	79	80	88
Columbella rustica	1		1				1
Crisilla semistriata		29	29		24	24	53
Crisilla simulans					2	2	2
Cyrillia linearis	1		1	10	18	28	29
Diodora graeca		2	2	2	2	4	6
Diodora italica	2		2				2
Doridina nudibranch		3	3		5	5	8
Doris ocelligera		2	2				2

Table A1. *Cont.*

Species	Sciophilous Environment (Sc)			Photophilous Environment (Ph)			Total Sc + Ph
	Coarse	Fine	Total	Coarse	Fine	Total	
Doto sp.		1	1				1
Emarginula pustula		1	1		1	1	2
Episcomitra cornicula	2		2				2
Felimare sp.				1		1	1
Folinella excavata					2	2	2
Fusinus rudis				2		2	2
Gari tellinella				1		1	1
Gastropoda morph. 1				2	3	5	5
Gastropoda morph. 2				1	1	2	2
Gastropoda morph. 3		1	1				1
Gibberula miliaria				5		5	5
Gibberula turgidula				2	18	20	20
Gibberula morph. 1					3	3	3
Gibberula morph. 2					1	1	1
Gregariella semigranata		8	8		8	8	16
Haliotis tuberculata		2	2		1	1	3
Haminoea navicula					13	13	13
Hexaplex trunculus	4		4	4		4	8
Hiatella arctica	9	153	162	3	239	242	404
Idas sp.	1		1				1
Irus irus		5	5		17	17	22
Ischnochitonidae sp.					1	1	1
Jujubinus exasperatus	1		1	1		1	2
Jujubinus ruscurianus	7	6	13	3	46	49	62
Lima lima					3	3	3
Limaria hians	2		2	1		1	3
Limaria tuberculata		13	13	1	10	11	24
Lithophaga lithophaga		1	1				1
Mangelia multilineolata				1		1	1
Mangelia morph. 1					1	1	1
Mangelia morph. 2					1	1	1
Marshallora adversa	2		2		4	4	6
Mimachlamys varia	4	9	13	7	2	8	22
Mitrella broderipii				1		1	1
Mitromorpha columbellaria	1	4	5	2	9	11	16
Mitromorpha olivoidea	1		1	4		4	5
Modiolula phaseolina		11	11	3	53	56	67
Modiolus barbatus	1		1	8		8	9
Monophorus erythrosoma	1	1	2		8	8	10
Muricidae indet.				1		1	1
Muricopsis cristata	4		4	2		2	6

Table A1. *Cont.*

Species	Sciophilous Environment (Sc)			Photophilous Environment (Ph)			Total Sc + Ph
	Coarse	Fine	Total	Coarse	Fine	Total	
Musculus costulatus	2	484	486	8	788	796	1282
Mytilus galloprovincialis juv.	1	10	11		46	46	57
Nodulus contortus					4	4	4
Nodulus spiralis					1	1	1
Ocinebrina aciculata	1	1	2	3	11	14	16
Odostomella doliolum		1	1		15	15	16
Odostomia plicata		11	11		9	8	20
Odostomia striolata		50	50		167	167	217
Otina ovata					1	1	1
Paradoris indecora					1	1	1
Parthenina emaciata					36	36	36
Parvamussium fenestratum		22	22		19	19	41
Parvicardium scriptum	2	27	29	1	100	101	130
Patella sp.					1	1	1
Petricola lithophaga					13	13	13
Philine intricata					1	1	1
Philine sp.					6	6	6
Phorcus richardi				1		1	1
Polyplacophora indet.					2	2	2
Pseudochama gryphina	3		3	3		3	6
Pseudomangelia vauquelini					1	1	1
Pusia ebenus					1	1	1
Pusia tricolor	2		2	4	2	6	8
Pusillina inconspicua					3	3	3
Pusillina philippi		272	272		545	545	817
Pusillina radiata		179	179		367	367	546
Raphitoma echinata		2	2	1	5	6	8
Raphitoma laviae				2		2	2
Raphitoma morph. 1					2	2	2
Raphitoma morph. 2					1	1	1
Retilaskeya horrida	1		1				1
Retusa mammillata					1	1	1
Rhyssoplax corallina	2	1	3		3	3	6
Rissoa guerinii					2	2	2
Rissoa lia		1	1		10	10	11
Rissoa variabilis		1	1	1	7	8	9
Rissoella diaphana					228	228	228
Runcina adriatica		3	3		27	27	30
Runcina coronata					1	1	1
Runcina sp.		4	4		35	35	39
Scissurella costata		1	1		21	21	22

Table A1. *Cont.*

Species	Sciophilous Environment (Sc)			Photophilous Environment (Ph)			Total Sc + Ph
	Coarse	Fine	Total	Coarse	Fine	Total	
Setia pulcherrima		5	5		10	10	15
Smithiella costulata		1	1	1	2	3	4
Spiralina alpinoligustica		2	2		2	2	4
Spondylus gaederopus	1		1				1
Striarca lactea	4	9	13	9	66	75	88
Talochlamys multistriata				1		1	1
Tarantinaea lignaria				1		1	1
Tectura virginea		1	1				1
Tricolia tingitana					5	5	5
Tricolia sp.		3	3		17	17	20
Trinchesia genovae					5	5	5
Triphoridae indet.		16	16	5	109	114	130
Tritia incrassata	5	15	20	35	25	60	80
Veneridae indet.		1	1		2	2	3
Vitreolina perminima		6	6		59	59	65
Weinkauffia turgidula					2	2	2
Williamia gussoni		1	1				1
Total specimens	**110**	**1.559**	**1.669**	**227**	**6.017**	**6.244**	**7.913**
Total species	**38**	**62**	**84**	**58**	**105**	**133**	**148**

Table A2. List of mollusk species recorded in Tossa de Mar (*: present study). Species within each family are listed in alphabetical order.

Class GASTROPODA 257 species
Subclass Caenogastropoda
Order Littorinimorpha
Littorinidae
Melarhaphe neritoides
Skeneopsidae
Skeneopsis planorbis
Naticidae
Notocochlis dillwynii
Rissoidae
**Alvania aspera*
**Alvania cancellata*
**Alvania cimex*
**Alvania discors*
**Alvania lineata*
**Alvania nestaresi*
Alvania subcrenulata
Alvania tenera
**Crisilla semistriata*
**Crisilla simulans*
**Pusillina incospicua*
Pusillina lineolata
**Pusillina philippi*
**Pusillina radiata*
Pisaniidae
**Aplus dorbignyi*
Pisania striata
Conidae
Conus ventricosus
Mangeliidae
**Mangelia multilineolata*
**Pseudomangelia vauquelini*
**Smithiela costulata*
Mitromorphidae
**Mitromorphacolumbellaria*
**Mitromorpha olivoidea*
Raphitomidae
**Cyrillia linearis*
**Raphitoma echinata*
**Raphitoma laviae*
Raphitoma leufroyi
Mitridae
**Episcomitra cornicula*
Isara cornea
Muricidae
**Babelomurex cariniferus*
Coralliophila meyendorffii
**Hexaplex trunculus*
Petalifera petalifera
Phyllaplysia lafonti
Order Cephalaspidea
Aglajidae
Aglaja tricolorata
Camachoaglaja africana
Melanochlamys miqueli
Spinoaglaja wildpretii
Bullidae
**Bulla striata*
Haminoeidae
Haminoea exigua
Haminoea hydatis
**Haminoea navicula*
**Weinkauffia turgidula*
Philinidae
**Philine intricata*
Philine catena
Retusidae
**Retusa mammillata*
Retusa truncatula
Order Ellobiida
Otinidae
**Otina ovata*

Table A2. *Cont.*

Rissoa decorata	_Hirtomurex squamosus_	Order Nudibranchia
*_Rissoa guerini_	*_Muricopsis cristata_	Aegiridae
*_Rissoa lia_	_Pseudofusus rostratus_	*_Aegires leuckartii_
Rissoa splendida	_Ocenebra edwardsii_	_Aegires punctilucens_
*_Rissoa variabilis_	*_Ocinebrina aciculata_	Aeolidiidae
*_Setia pulcherrima_	_Stramonita haemastoma_	_Aeolidiella alderi_
Anabathridae	Cystiscidae	_Berghia coerulescens_
*_Nodulus contortus_	*_Gibberula miliaria_	_Spurilla neapolitana_
*_Nodulus spìralis_	*_Gibberula turgidula_	Arminidae
Cypraeidae	Costellariidae	_Armina tigrina_
Luria lurida	*_Pusia ebenus_	Cadlinidae
Eulimidae	*_Pusia tricolor_	_Aldisa banyulensis_
Vitreolina antiflexa	Order Caenogastropoda _incertae sedis_	Calycidorididae
*_Vitreolina perminima_	Cerithiidae	_Diaphorodoris alba_
Ovulidae	*_Bittium latreillii_	_Diaphorodoris luteocincta_
Simnia spelta	*_Bittium reticulatum_	_Diaphorodoris papillata_
Triviidae	_Cerithium africanum_	Chromodorididae
Trivia monacha	*_Cerithium vulgatum_	_Felimare bilineata_
Vermetidae	Cerithiopsidae	_Felimare fontandraui_
Vermetus triquetrus	*_Cerithiopsis jeffreysi_	_Felimare orsinii_
Order Neogastropoda	*_Cerithiopsis tubercularis_	_Felimare picta_
Chauvetiidae	Newtoniellidae	_Felimare tricolor_
*_Chauvetia brunnea_	*_Retilaskeya horrida_	_Felimare villafranca_
*_Chauvetia mamillata_	Triphoridae	_Felimida binza_
*_Chauvetia recondita_	_Marshallora adversa_	_Felimida krohni_
Columbellidae	*_Monophorus erythrosoma_	_Felimida luteorosea_
*_Columbella rustica_	Turritellidae	_Felimida purpurea_
Mitrella broderipii	_Turritellinella tricarinata_	Coryphellidae
Mitrella scripta	**Subclass Heterobranchia**	_Coryphella lineata_
Fasciolariidae	SuperOrder Acochlidiimorpha	Dendrodorididae
*_Fusinus rudis_	Hedylopsidae	_Dendrodoris grandiflora_
Pseudofusus rostratus	_Hedylopsis spiculifera_	_Dendrodoris limbata_
*_Tarantinaea lignaria_	Order Aplysiida	Discodorididae
Nassariidae	Aplysiidae	_Discodoris rosi_
Tritia corrugata	_Aplysia depilans_	_Discodoris stellifera_
*_Tritia incrassata_	_Aplysia fasciata_	_Geitodoris planata_
Tritia reticulata	*_Aplysia punctata_	_Jorunna tomentosa_
Tritia varicosa	_Candiella striata_	*_Paradoris indecora_
Platydoris argo	_Marionia blainvillea_	_Peltodoris atromaculata_
Rostanga rubra	Order Pleurobranchida	_Puncturella noachina_
Tayuva lilacina	Pleurobranchidae	Haliotidae
Dorididae	_Berthella ocellata_	*_Haliotis tuberculata_
*_Doris ocelligera_	_Pleurehdera stellata_	Scissurellidae
Dotidae	_Pleurobranchus testudinarius_	*_Scissurella costata_
Doto coronata	Order Runcinida	Order Trochida
Doto dunnei	Runcinidae	Phasianellidae
Doto eireana	*_Runcina adriatica_	*_Tricolia tingitana_
Doto floridicola	_Runcina africana_	Calliostomatidae
Doto fragaria	_Runcina bahiensis_	_Calliostoma laugieri_
Doto koenneckeri	*_Runcina coronata_	*_Calliostoma zizyphinum_
Doto paulinae	_Runcina hansbechi_	_Calliostoma conulus_
Doto rosea	Super Order Sacoglossa	Trochidae
Embletoniidae	Hermaeidae	_Clanculus corallinus_
Embletonia pulchra	_Cyerce cristallina_	*_Clanculus cruciatus_
Eubranchidae	_Hermaea bifida_	_Gibbula ardents_
Amphorina farrani	_Hermaea variopicta_	_Gibbula divaricata_
Capellinia doriae	Limapontiidae	_Gibbula drepanensis_

Table A2. *Cont.*

Eubranchus capellinii	*Placida cremoniana*	**Jujubinus exasperatus*
Eubranchus exiguus	*Placida dendritica*	**Jujubinus ruscurianus*
Eubranchus vittatus	*Placida verticilata*	*Jujubinus striatus*
Facelinidae	Plakobranchidae	**Phorcus richardi*
**Caloria elegans*	*Bosellia mimètica*	*Phorcus turbinatus*
Caloria quatrefagesi	*Elysia margaritae*	*Steromphala divaricata*
Cratena peregrina	*Elysia timida*	*Steromphala umbilicalis*
Facelina annulicornis	*Elysia viridis*	Turbinidae
Facelina auriculata	*Thuridilla hopei*	*Bolma rugosa*
Facelina rubrovittata	Order Umbraculida	**Class BIVALVIA 32 species**
Facelinopsis marioni	Tylodinidae	**Subclass Autobranchia**
Favorinus branchialis	*Tylodina perversa*	Order Cardiida
Flabellinidae	Umbraculidae	Cardiidae
Calmella cavolini	*Umbraculum umbraculum*	**Parvicardium scriptum*
Calmella gaditana	Order Siphonariida	Psammobiidae
Edmundsella pedata	Siphonariidae	**Gari tellinella*
Flabellina affinis	**Williamia gussoni*	Order Venerida
Paraflabellina gabinierei	Super family Omalogyroidea	Chamidae
Paraflabellina ischitana	Omalogyridae	**Chama gryphoides*
Goniodorididae	*Ammonicera rota*	**Pseudochama gryphina*
Okenia mediterranea	*Ammonicera fischeriana*	Veneridae
Trapania lineata	Superfamily Pyramidelloidea	*Gouldia minima*
Trapania maculata	Pyramidellidae	**Irus irus*
Hancockiidae	**Brachystomia scalaris*	**Petricola lithophaga*
Hancockia uncinata	**Folinella excavata*	*Venus casina*
Janolidae	**Odostomella doliolum*	*Venus verrucosa*
Antiopella cristata	**Odostomia plicata*	Order Adapedonta
Myrrhinidae	**Odostomia striolata*	Hiatellidae
Nemesignis banyulensis	**Parthenina emaciata*	**Hiatella arctica*
Onchidorididae	*Parthenina monozona*	Super order Anomalodesmata
Atalodoris pictoni	**Spiralina alpinoligustica*	Thraciidae
Atalodoris sparsa	Super family Rissoelloidea	*Thracia phaseolina*
Idaliadoris neapolitana	Rissoellidae	Order Arcoida
Phyllidiidae	**Rissoella diaphana*	Arcidae
Phyllidia flava	**Subclass Patellogastropoda**	**Arca noae*
Piseinotecidae	Super Family Lottioidea	Noetiidae
Piseinotecus soussi	Lotiidae	**Striarca lactea*
Polyceridae	**Tectura virginea*	Order Galeommatida
Crimora papillata	Superfamily Patelloidea	Galiommatidae
Kaloplocamus ramosus	Patellidae	*Galeomma turtoni*
Limacia inesae	*Patella aspera*	Lasaeidae
Polycera elegans	*Patella caerulea*	*Kellia suborbicularis*
Polycera quadrilineata	*Patella rustica*	Order Gastrochaenida
Samlidae	*Patella ulyssiponensis*	Gastrochaenidae
Luisella babai	**Subclass Vetigastropoda**	*Rocellaria dubia*
Trinchesiidae	Order Lepetellida	Order Limida
Rubramoena amoena	Fissurellidae	Limidae
Trinchesia caerulea	*Diodora gibberula*	**Lima lima*
Trinchesia cuanensis	**Diodora graeca*	**Limaria hians*
Trinchesia foliata	**Diodora italica*	**Limaria tuberculata*
**Trinchesia genovae*	*Emarginula huzardii*	Order Mytilida
Trinchesia miniostriata	*Emarginula octaviana*	Mytilidae
Trinchesia morrowae	**Emarginula pustula*	**Gregariella semigranata*
Trinchesia ocellata	*Emarginula sicula*	**Lithophaga lithophaga*
Tritoniidae	*Fissurella nubecula*	**Modiolula phaseolina*
Candiella manicata		**Modiolus barbatus*
Candiella odhneri		**Musculus costulatus*

Table A2. *Cont.*

Order Pectinida	**Mytilus galloprovincialis*
Anomiidae	
**Anomia ephippium*	
Pododesmus patelliformis	
Pectinidae	
**Aequipecten opercularis*	
**Mimachlamys varia*	
**Talochlamys multistriata*	
Propeamussiidae	
**Parvamussium fenestratum*	
Spondylidae	
**Spondylus gaederopus*	
Class POLYPLACOPHORA 7 species	
Subclasse Neoloricata	
Order Chitonida	
Acanthochitonidae	
Acanthochitona crinita	
**Acanthochitona fascicularis*	
Chitonidae	
**Rhyssoplax corallina*	
Rhyssoplax olivacea	
Ischnochiton rissoi	
Lepidochitona caprearum	
Order Lepidopleurida	
Leptochitonidae	
Leptochiton sarsi	

Table A3. Additional results from the SIMPER analysis, detailing the species that contribute to dissimilarities across Environment × Fraction groups (PhF, PhC, ScF and ScC) and the similarities observed within each month. Cut-off thresholds of 80% for similarity and 50% for dissimilarity were applied.

PhF (Photophilous. Fine Fraction)—Average Similarity: 60.28					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Musculus costulatus	2.50	6.53	1.65	10.83	10.83
Bittium latreillii	2.49	4.51	1.91	7.49	18.31
Pusillina philippi	2.09	4.30	2.03	7.13	25.45
Chauvetia mamillata	1.46	3.51	2.42	5.83	31.27
Hiatella arctica	1.71	3.51	1.79	5.82	37.09
Parvicardium scriptum	1.40	2.76	2.14	4.58	41.67
Odostomia striolata	1.43	2.38	1.48	3.95	45.62
Alvania lineata	1.28	2.12	1.21	3.52	49.14
Aplysia punctata	1.00	2.02	1.52	3.36	52.50
Bittium reticulatum	1.17	1.96	0.85	3.26	55.76
Pusillina radiata	1.25	1.87	0.71	3.09	58.85
Alvania cancellata	0.82	1.35	0.94	2.23	61.08
Clanculus cruciatus	1.05	1.31	1.05	2.17	63.25
Striarca lactea	0.87	1.29	0.98	2.14	65.39
Rissoella diaphana	1.04	1.25	0.77	2.07	67.46
Runcina sp.	0.77	1.13	0.81	1.87	69.33

Table A3. *Cont.*

Vitreolina perminima	0.95	1.09	0.79	1.82	71.15
Ammonicera fischeriana	0.84	1.08	0.86	1.79	72.93
Modiolula phaseolina	0.93	1.06	0.82	1.77	74.70
Triphoridae indet.	0.88	0.93	0.76	1.55	76.25
Arca noae	0.77	0.91	0.79	1.51	77.76
Jujubinus ruscurianus	0.60	0.82	0.63	1.37	79.13
Mytilus galloprovincialis	0.74	0.78	0.74	1.30	80.43
ScF (Sciophilous. Fine Fraction)—Average Similarity: 49.55					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Musculus costulatus	2.08	10.77	1.92	21.74	21.74
Hiatella arctica	1.43	6.83	1.52	13.78	35.52
Pusillina philippi	1.48	5.06	1.37	10.21	45.73
Odostomia striolata	1.04	4.14	1.36	8.36	54.08
Alvania lineata	0.81	3.18	0.72	6.42	60.50
Pusillina radiata	0.86	2.73	0.61	5.51	66.01
Chauvetia mamillata	0.61	1.88	0.53	3.78	69.80
Triphoridae indet.	0.51	1.49	0.67	3.00	72.80
Aequipecten opercularis	0.48	1.47	0.67	2.97	75.77
Odostomia plicata	0.47	1.27	0.59	2.57	78.33
Bittium latreillii	0.71	1.22	0.59	2.47	80.80
PhC (Photophilous. Coarse Fraction)—Average Similarity: 27.62					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Tritia incrassata	1.05	9.04	1.50	32.72	32.72
Arca noae	0.52	2.88	0.58	10.43	43.16
Chauvetia mamillata	0.31	2.37	0.43	8.60	51.75
Modiolus barbatus	0.35	1.73	0.51	6.25	58.01
Alvania lineata	0.57	1.48	0.43	5.35	63.36
Alvania aspera	0.23	1.17	0.43	4.24	67.60
Cyrillia linearis	0.33	1.15	0.33	4.17	71.76
Chauvetia recondita	0.13	1.08	0.24	3.90	75.66
Triphoridae indet.	0.23	0.88	0.34	3.20	78.86
Chama gryphoides	0.18	0.75	0.24	2.70	81.56
ScC (Sciophilous. Coarse Fraction)—Average Similarity: 28.56					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Chama gryphoides	0.47	7.68	0.83	26.89	26.89
Alvania lineata	0.63	5.61	0.72	19.66	46.55
Hiatella arctica	0.39	4.23	0.56	14.81	61.36
Chauvetia brunnea	0.33	2.90	0.46	10.15	71.51
Chauvetia mamillata	0.20	1.88	0.25	6.60	78.11
Muricopsis cristata	0.24	1.31	0.25	4.57	82.68

Table A3. *Cont.*

PhF and ScF Average Dissimilarity = 57.05						
Species	**Group PhF Av.Abund**	**Group ScF Av.Abund**	**Av.Diss**	**Diss/SD**	**Contrib%**	**Cum.%**
Bittium latreillii	2.49	0.71	2.92	1.79	5.12	5.12
Bittium reticulatum	1.17	0.35	1.98	1.10	3.46	8.58
Pusillina philippi	2.09	1.48	1.96	1.02	3.44	12.02
Chauvetia mamillata	1.46	0.61	1.65	1.19	2.89	14.91
Parvicardium scriptum	1.40	0.56	1.54	1.14	2.69	17.60
Pusillina radiata	1.25	0.86	1.45	0.91	2.54	20.14
Alvania cancellata	0.82	0.18	1.36	1.13	2.38	22.51
Alvania lineata	1.28	0.81	1.35	1.00	2.37	24.89
Vitreolina perminima	0.95	0.29	1.33	1.07	2.34	27.22
Musculus costulatus	2.50	2.08	1.33	1.00	2.33	29.55
Rissoella diaphana	1.04	0.00	1.30	0.92	2.28	31.84
Modiolula phaseolina	0.93	0.38	1.17	0.91	2.06	33.89
Aplysia punctata	1.00	0.37	1.15	1.05	2.01	35.90
Clanculus cruciatus	1.05	0.25	1.13	1.17	1.99	37.89
Arca noae	0.77	0.06	1.13	1.11	1.98	39.87
Limaria tuberculata	0.47	0.49	1.02	0.87	1.80	41.67
Runcina sp.	0.77	0.22	1.01	1.01	1.77	43.44
Cerithiopsis tubercularis	0.57	0.07	0.95	0.78	1.67	45.10
Parthenina emaciata	0.68	0.00	0.95	0.85	1.66	46.76
Crisilla semistriata	0.45	0.53	0.93	0.66	1.64	48.40
Rissoa lia	0.42	0.06	0.91	0.57	1.59	49.99
Hiatella arctica	1.71	1.43	0.86	0.69	1.51	51.50
PhF and PhC—Average Dissimilarity = 88.50						
Species	**Group Ph Av.Abund**	**Group PhC Av.Abund**	**Av.Diss**	**Diss/SD**	**Contrib%**	**Cum.%**
Musculus costulatus	2.50	0.30	5.26	1.45	5.95	5.95
Bittium latreillii	2.49	0.06	4.28	2.22	4.84	10.79
Pusillina philippi	2.09	0.00	4.27	2.30	4.83	15.62
Hiatella arctica	1.71	0.12	3.21	2.08	3.63	19.25
Parvicardium scriptum	1.40	0.00	2.78	2.36	3.15	22.39
Chauvetia mamillata	1.46	0.31	2.62	1.47	2.96	25.36
Pusillina radiata	1.25	0.00	2.54	0.96	2.87	28.22
Odostomia striolata	1.43	0.00	2.53	1.83	2.86	31.08
Bittium reticulatum	1.17	0.11	2.43	1.19	2.75	33.83
Aplysia punctata	1.00	0.11	1.98	1.44	2.24	36.07
Alvania lineata	1.28	0.57	1.91	1.12	2.16	38.24
Vitreolina perminima	0.95	0.00	1.70	1.19	1.92	40.16
Modiolula phaseolina	0.93	0.12	1.63	1.13	1.85	42.00
Clanculus cruciatus	1.05	0.06	1.62	1.40	1.83	43.83
Rissoella diaphana	1.04	0.00	1.56	0.92	1.77	45.60
Runcina sp.	0.77	0.00	1.47	1.09	1.67	47.26

Table A3. *Cont.*

Alvania cancellata	0.82	0.00	1.47	1.18	1.66	48.92
Tritia incrassata	0.63	1.05	1.46	0.85	1.65	50.57
ScF and PhC—Average Dissimilarity = 89.04						
Species	**Group ScF Av.Abund**	**Group PhC Av.Abund**	**Av.Diss**	**Diss/SD**	**Contrib%**	**Cum.%**
Musculus costulatus	2.08	0.30	7.51	1.61	8.43	8.43
Pusillina philippi	1.48	0.00	5.13	1.57	5.76	14.19
Hiatella arctica	1.43	0.12	5.07	2.05	5.69	19.88
Pusillina radiata	0.86	0.00	3.62	0.87	4.06	23.94
Odostomia striolata	1.04	0.00	3.53	1.48	3.96	27.90
Tritia incrassata	0.27	1.05	3.43	1.33	3.85	31.75
Alvania lineata	0.81	0.57	2.82	0.91	3.16	34.92
Chauvetia mamillata	0.61	0.31	2.71	0.93	3.04	37.96
Bittium latreillii	0.71	0.06	2.13	0.93	2.39	40.35
Aplysia punctata	0.37	0.11	1.93	0.68	2.17	42.52
Arca noae	0.06	0.52	1.91	0.84	2.14	44.66
Parvicardium scriptum	0.56	0.00	1.84	0.81	2.07	46.73
Limaria tuberculata	0.49	0.06	1.79	0.84	2.01	48.75
Crisilla semistriata	0.53	0.00	1.70	0.66	1.91	50.66
PhF and ScC—Average Dissimilarity = 93.59						
Species	**Group PhF Av.Abund**	**Group ScC Av.Abund**	**Av.Diss**	**Diss/SD**	**Contrib%**	**Cum.%**
Musculus costulatus	2.50	0.12	5.99	1.78	6.40	6.40
Pusillina philippi	2.09	0.00	4.54	2.44	4.85	11.25
Bittium latreillii	2.49	0.06	4.53	2.12	4.84	16.09
Hiatella arctica	1.71	0.39	3.11	1.62	3.32	19.41
Parvicardium scriptum	1.40	0.00	2.98	2.34	3.18	22.59
Chauvetia mamillata	1.46	0.20	2.89	1.80	3.09	25.68
Pusillina radiata	1.25	0.00	2.77	0.96	2.96	28.63
Odostomia striolata	1.43	0.00	2.72	1.75	2.90	31.54
Bittium reticulatum	1.17	0.00	2.72	1.33	2.90	34.44
Alvania lineata	1.28	0.63	2.16	1.27	2.31	36.75
Aplysia punctata	1.00	0.00	2.16	1.67	2.31	39.06
Clanculus cruciatus	1.05	0.06	1.92	1.44	2.05	41.10
Modiolula phaseolina	0.93	0.00	1.78	1.18	1.91	43.01
Vitreolina perminima	0.95	0.00	1.78	1.13	1.90	44.91
Alvania cancellata	0.82	0.00	1.61	1.15	1.72	46.63
Rissoella diaphana	1.04	0.00	1.58	0.88	1.69	48.32
Runcina sp.	0.77	0.00	1.54	1.06	1.64	49.96
Arca noae	0.77	0.00	1.47	1.13	1.57	51.54
ScF and ScC—Average Dissimilarity = 89.73						
Species	**Group PhF Av.Abund**	**Group ScC Av.Abund**	**Av.Diss**	**Diss/SD**	**Contrib%**	**Cum.%**
Musculus costulatus	2.50	0.12	5.99	1.78	6.40	6.40

Table A3. *Cont.*

Pusillina philippi	2.09	0.00	4.54	2.44	4.85	11.25
Bittium latreillii	2.49	0.06	4.53	2.12	4.84	16.09
Hiatella arctica	1.71	0.39	3.11	1.62	3.32	19.41
Parvicardium scriptum	1.40	0.00	2.98	2.34	3.18	22.59
Chauvetia mamillata	1.46	0.20	2.89	1.80	3.09	25.68
Pusillina radiata	1.25	0.00	2.77	0.96	2.96	28.63
Odostomia striolata	1.43	0.00	2.72	1.75	2.90	31.54
Bittium reticulatum	1.17	0.00	2.72	1.33	2.90	34.44
Alvania lineata	1.28	0.63	2.16	1.27	2.31	36.75
Aplysia punctata	1.00	0.00	2.16	1.67	2.31	39.06
Clanculus cruciatus	1.05	0.06	1.92	1.44	2.05	41.10
Modiolula phaseolina	0.93	0.00	1.78	1.18	1.91	43.01
Vitreolina perminima	0.95	0.00	1.78	1.13	1.90	44.91
Alvania cancellata	0.82	0.00	1.61	1.15	1.72	46.63
Rissoella diaphana	1.04	0.00	1.58	0.88	1.69	48.32
Runcina sp.	0.77	0.00	1.54	1.06	1.64	49.96
Arca noae	0.77	0.00	1.47	1.13	1.57	51.54
PhC and ScC—Average Dissimilarity = 78.87						
Species	**Group PhC Av.Abund**	**Group ScC Av.Abund**	**Av.Diss**	**Diss/SD**	**Contrib%**	**Cum.%**
Tritia incrassata	1.05	0.29	6.45	1.20	8.17	8.17
Alvania lineata	0.57	0.63	4.64	0.98	5.89	14.06
Arca noae	0.52	0.00	4.15	0.80	5.26	19.32
Hiatella arctica	0.12	0.39	3.57	0.73	4.52	23.85
Striarca lactea	0.36	0.14	2.92	0.77	3.70	27.55
Modiolus barbatus	0.35	0.06	2.60	0.79	3.29	30.84
Chama gryphoides	0.18	0.47	2.48	0.60	3.14	33.98
Musculus costulatus	0.30	0.12	2.40	0.61	3.05	37.03
Muricopsis cristata	0.11	0.24	2.21	0.63	2.80	39.83
Pusia tricolor	0.22	0.12	2.19	0.54	2.78	42.61
Marshallora adversa	0.22	0.12	2.12	0.53	2.69	45.29
Mimachlamys varia	0.25	0.19	2.09	0.51	2.65	47.95
Cyrillia linearis	0.33	0.06	2.08	0.59	2.64	50.58
January—Average Similarity: 34.80						
Species	**Av.Abund**		**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Musculus costulatus	1.05		7.45	0.91	21.40	21.40
Alvania lineata	0.83		7.32	0.97	21.02	42.42
Chama gryphoides	0.43		5.19	0.65	14.92	57.35
Pusillina philippi	0.62		2.60	0.65	7.49	64.83
Chauvetia mamillata	0.48		2.60	0.58	7.47	72.30
Hexaplex trunculus	0.35		2.20	0.43	6.33	78.64
Pusillina radiata	0.46		1.69	0.39	4.86	83.50

Table A3. *Cont.*

March—Average Similarity: 29.72					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Musculus costulatus	1.45	7.26	0.86	24.42	24.42
Hiatella arctica	1.01	5.33	0.84	17.93	42.34
Parvicardium scriptum	0.47	1.75	0.59	5.89	48.23
Bittium latreillii	0.54	1.64	0.55	5.53	53.76
Chauvetia recondita	0.19	1.62	0.29	5.44	59.20
Pusillina philippi	0.52	1.44	0.55	4.86	64.06
Tritia incrassata	0.27	1.25	0.29	4.19	68.25
Chauvetia mamillata	0.41	1.21	0.55	4.06	72.31
Odostomia striolata	0.35	1.20	0.38	4.03	76.34
Alvania lineata	0.51	1.13	0.55	3.81	80.15
May—Average Similarity: 46.60					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Chama gryphoides	0.33	4.73	0.55	10.14	10.14
Hiatella arctica	1.30	4.55	0.83	9.77	19.92
Tritia incrassata	0.82	4.49	0.70	9.64	29.56
Alvania lineata	1.14	4.21	0.84	9.04	38.60
Musculus costulatus	1.38	3.23	0.90	6.92	45.52
Pusillina philippi	0.92	2.31	0.94	4.95	50.47
Odostomia striolata	0.84	2.18	0.93	4.68	55.14
Muricopsis cristata	0.17	1.74	0.29	3.74	58.88
Aequipecten opercularis	0.48	1.25	0.55	2.69	61.57
Bittium latreillii	0.66	1.19	0.67	2.54	64.11
Jujubinus ruscurianus	0.63	1.15	0.67	2.46	66.58
Mimachlamys varia	0.49	1.05	0.55	2.25	68.83
Gregariella semigranata	0.33	0.99	0.55	2.13	70.96
Clanculus cruciatus	0.66	0.96	0.65	2.06	73.01
Chauvetia mamillata	0.55	0.96	0.67	2.05	75.07
Crisilla semistriata	0.57	0.94	0.61	2.02	77.09
Arca noae	0.25	0.87	0.29	1.86	78.95
Mitromorpha olivoidea	0.18	0.87	0.29	1.86	80.80
July—Average Similarity: 54.60					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Hiatella arctica	1.25	6.39	0.98	11.71	11.71
Chauvetia brunnea	0.46	4.47	0.64	8.19	19.90
Musculus costulatus	1.36	2.76	0.82	5.06	24.96
Pusillina philippi	1.24	2.72	0.84	4.98	29.94
Alvania lineata	1.10	2.63	0.67	4.82	34.75
Tritia incrassata	0.80	2.17	0.71	3.98	38.74
Triphoridae indet.	0.90	1.92	0.87	3.51	42.24
Odostomia striolata	0.88	1.87	0.86	3.43	45.68
Modiolus barbatus	0.28	1.87	0.55	3.42	49.10

Table A3. *Cont.*

Mimachlamys varia	0.49	1.86	0.42	3.41	52.50
Alvania aspera	0.27	1.76	0.55	3.22	55.72
Bittium latreillii	1.42	1.65	0.66	3.02	58.74
Ammonicera fischeriana	0.79	1.63	0.88	2.98	61.73
Modiolula phaseolina	0.68	1.60	0.82	2.93	64.65
Chama gryphoides	0.17	1.44	0.29	2.64	67.29
Aequipecten opercularis	0.57	1.30	0.79	2.38	69.67
Striarca lactea	0.64	1.03	0.49	1.89	71.56
Cyrillia linearis	0.52	0.95	0.46	1.74	73.31
Parvicardium scriptum	0.66	0.89	0.63	1.62	74.93
Pusillina radiata	0.63	0.88	0.61	1.61	76.54
Chauvetia mamillata	0.61	0.87	0.61	1.60	78.14
Bittium reticulatum	0.68	0.83	0.60	1.53	79.66
Rissoella diaphana	0.68	0.81	0.55	1.49	81.15
September—Average Similarity: 44.42					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Tritia incrassata	0.77	4.62	0.78	10.40	10.40
Bittium latreillii	1.44	3.10	1.15	6.98	17.38
Musculus costulatus	1.26	2.75	1.08	6.18	23.56
Pusillina philippi	1.12	2.73	1.12	6.14	29.70
Hiatella arctica	0.89	2.63	0.97	5.91	35.61
Triphoridae indet.	0.90	2.51	1.12	5.65	41.26
Odostomia striolata	0.88	2.38	1.08	5.35	46.61
Chauvetia mamillata	0.90	1.95	1.10	4.40	51.01
Runcina sp.	0.67	1.86	1.05	4.18	55.19
Alvania lineata	0.84	1.72	0.48	3.88	59.06
Parvicardium scriptum	0.81	1.49	0.73	3.36	62.42
Jujubinus ruscurianus	0.51	1.34	0.32	3.03	65.45
Arca noae	0.53	1.26	0.58	2.84	68.28
Pusia tricolor	0.27	1.13	0.32	2.54	70.83
Vitreolina perminima	0.62	1.13	0.74	2.53	73.36
Rissoella diaphana	0.51	0.97	0.61	2.18	75.54
Aplysia punctata	0.53	0.97	0.67	2.18	77.72
Modiolula phaseolina	0.55	0.87	0.39	1.95	79.67
Mitromorpha columbellaria	0.36	0.69	0.32	1.56	81.23
November—Average Similarity: 41.53					
Species	**Av.Abund**	**Av.Sim**	**Sim/SD**	**Contrib%**	**Cum.%**
Chauvetia mamillata	0.98	6.89	0.72	16.60	16.60
Pusillina radiata	1.37	3.83	0.92	9.22	25.82
Tritia incrassata	0.48	3.09	0.54	7.43	33.25
Arca noae	0.43	3.08	0.59	7.42	40.67
Musculus costulatus	1.08	2.97	0.91	7.15	47.81
Pusillina philippi	1.03	2.69	0.64	6.48	54.29

Table A3. *Cont.*

Odostomia striolata	0.75	2.55	0.87	6.15	60.44
Hiatella arctica	0.75	2.28	0.90	5.48	65.92
Pseudochama gryphina	0.33	2.20	0.40	5.29	71.21
Odostomia plicata	0.56	1.91	0.87	4.60	75.81
Bittium latreillii	0.77	1.54	0.54	3.71	79.52
Striarca lactea	0.78	1.17	0.66	2.83	82.34

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