universität wien

MASTERARBEIT / MASTER'S THESIS

Titel der Masterarbeit / Title of the Master's Thesis

„The molluscan biocoenoses of a *Posidonia* meadow in southern Crete "

verfasst von / submitted by

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angestrebter akademischer Grad / in partial fulfilment of the requirements for the degree of

Master of Science (MSc)

Wien, 2020 / Vienna, 2020

Studienkennzahl lt. Studienblatt / degree programme code as it appears on the student record sheet:	UA 066 833
Studienrichtung lt. Studienblatt / degree programme as it appears on the student record sheet:	Ecology and Ecosystems UG2002
Betreut von / Supervisor:	Univ.-Prof. Mag. Dr. Martin Zuschin
Mitbetreut von / Co-Supervisor:	Dr. Paolo Giulio Albano

Acknowledgment

I want to thank the University of Vienna for the support of my field work with the KWA – Kurzfristige Auslandstipendien. Further, I want to thank my supervisor Univ.-Prof. Mag. Dr. Martin Zuschin for his guidance throughout the whole project. Big support was provided by the Mare Mundi and Dive2gether Marine Field Station at the south coast of Crete. Without their provision of facilities this project would have not been possible. I thank the Natural History Museum of Vienna for the provision of Ethanol. Another vital support came from Dr. Paolo G. Albano by his help identifying the collected Mollusca and his patience until the thesis was finished. Further I want to thank Nadja Loferer and Denny Morchner for their dedication during the long hours sieving and sorting the samples in the field. Last but not least I want to thank Stefan Duijvestijn and my partner Michael Holzknecht for their support during the underwater sampling.

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Introduction

Seagrass, an important ecosystem

Seagrasses make up less than 0.02% of the angiosperm species (Hemminga and Duarte, 2001). Worldwide 60 species are distributed along the coastlines, whose species richness decreases with increasing latitude (**Fig. 1**). The ability of some species to form extensive meadows, makes these costal habitat one of the most valuable on Earth (Hemminga and Duarte, 2001). Seagrasses evolved to a life fully submerged in the marine environment. So far no other angiosperm species was able to do so (Den Hartog, 1970; Waycott et al., 2002). They belong to the order Alismatales with four families. These are Posidoniacea, Zosteraceae, Hydrocharitaceae and Cymodoceaceae, which originated in the Cretaceous period (Den Hartog, 1970). The family Posidoniacea comprises the single genus *Posidonia* and is the earliest marine angiosperm (Den Hartog, 1970).

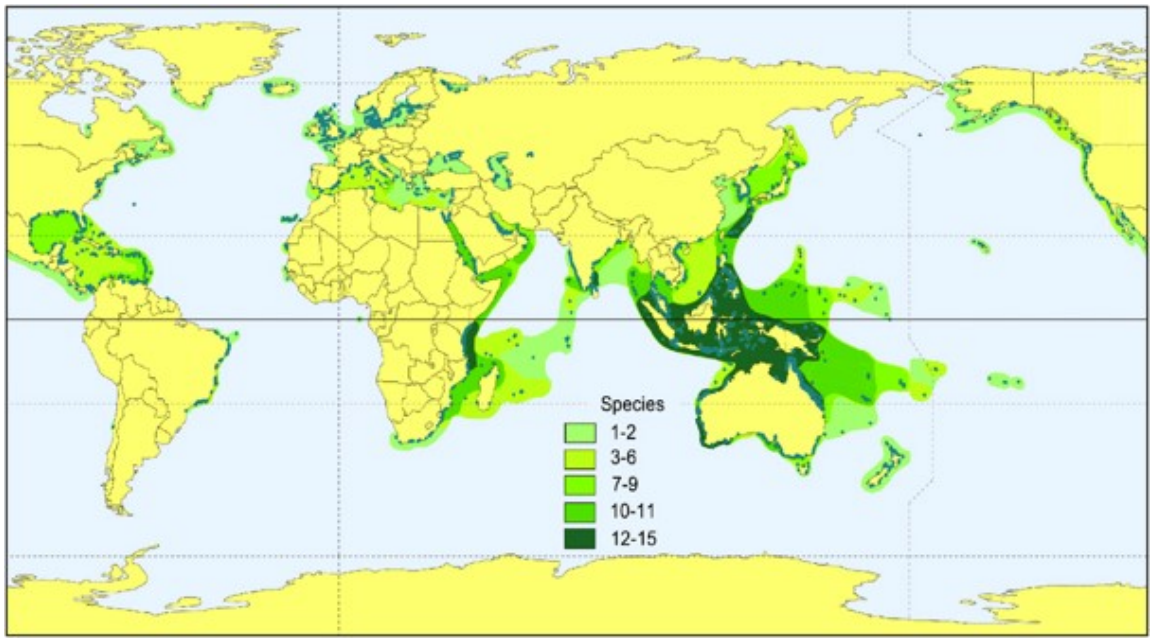

Fig. 1 Global seagrass diversity and distribution. Shades of green indicate numbers of species reported for an area; blue points and polygons indicate documented reports of seagrass occurrence (from 2005 UNEP-WCMC, Short et. al. 2007).

According to Aires and colleagues (2011) this genus split in two lineages more than 60 million years ago. Seven species are distributed around Australia and one is endemic to the Mediterranean Sea (Campey et al., 2000).

Six more species of seagrasses occur in the Mediterranean Sea. These are *Cymodocea nodosa*, *Ruppia cirrhosa*, *R. maritima*, *Zostera marina*, *Z. noltii*, which are native in this area and the non-native species *Halophila stipulacea,* which entered the Mediterranean Sea after the opening of the Suez Canal in 1869. It was recorded for the first time in 1894 off Rhodes, Greece (Lipkin, 1975).

The endemic species *Posidonia oceanica* (Linnaeus, 1813) covers about 2% of the Mediterranean sea floor (Larkum et al., 2006). It forms dense “Mattes” consisting of a

web constructed by plagiotropic (horizontal) and orthotropic (vertical) rhizomes, roots and sediment. The types of rhizomes are responsible for colonization and the avoidance of burial respectively (Larkum et al., 2006). At the apex of each rhizome is the so-called shoot with the basal meristem, allowing the leaf growth (**Fig. 2**).

Posidonia oceanica is a very slow growing, long-living species, characterized as a K strategist. A study by Marba and colleagues (1996) showed an elongation of the rhizome by 1-6 cm yr^{-1} with a maximum shoot age of 6-30 years in Spanish meadows. Some meadows have been dated to an age older than 6000 years (Picard, 1965). Decomposition of rhizomes is a very slow process, therefore structures can persist over millennia (Boudouresque et al., 1980). *Posidonia oceanica* forms monospecific meadows with varying connectivity, from continuous to patchy (Borg et al., 2005).

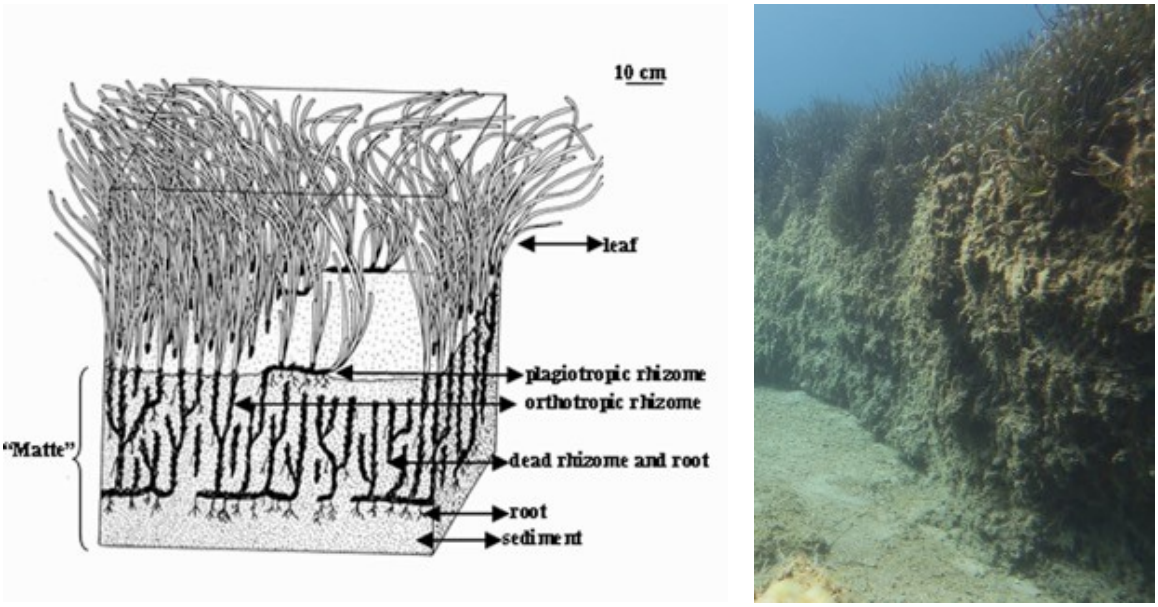

Fig. 2 (left) Schematic illustration of the rhizomes, roots, leaves, and 'matte' in a *P. oceanica* meadow (Boudouresque and Meinesz, 1982 redrawn by Larkum et al., 2006). (right) Rhizome 'matte' in Souda Bay, Crete (Photo by Martina Stockinger, 2016).

Depth is a limiting factor due to the decrease of light intensity and temperature. Those factors are, amongst others, the reason that density of *P. oceanica* meadows decreases with depth, ranging from 1200 shoots in shallow areas to fewer than 100 shoots at depths around 30 m (Larkum et al., 2006). Due to the slow growth the number of shoots, in a determined area, is more or less constant over the period of a year (Pergent-Martini and Pergent, 1994). The density (shoots m^{-2}) of a *Posidonia oceanica* meadow is a widely used indicator for the state of the meadow (Pergent-Martini et al., 2005).

The "mattes" are remarkable biological structures (**Fig. 2**), which together with the leaf layer provide a variety of ecosystem functions and services, making seagrass meadows comparable to tropical coral reefs and kelp-forests. Campagne and colleagues (2014) identified 25 ecosystem services of *P. oceanica*, which states the importance of this species for the human well-being in the Mediterranean Sea. Its presence increases the heterogeneity of the environment. The structure provides living and nursery space, modifies food webs and produces organic material. This carbon source is not only utilized

by direct grazing but also exported into other habitats at considerable distance (Matéo et al., 1997). The amount of carbon sequestration of this seagrass species can exceed most other ecosystems (Laffoley and Grimsditch, 2009). The estimation of the economic value of *P. oceanica* ranges from 284 to 514€ ha $year^{-1}$ depending on the state of the meadow (Campagne et al., 2014).

Alarmingly seagrass meadows worldwide are under threat. Natural processes and especially anthropogenic impacts lead to a rapid decline of this important habitat. Overall, an area of 27 km^2 yr^{-1} was lost from 1879 to 2006. Furthermore, the rate of decline increased between 2001 and 2009 (Short et al., 2011; Waycott et al., 2009). These numbers can be an underestimation since the exact numbers of existing surface area and losses are rough estimates. For some areas of the world, data is completely lacking, and precise figures on well-studied areas are few.

These uncertainties are also true for the endemic species *Posidonia oceanica*, especially in the southern parts and the eastern basin of the Mediterranean Sea (Boudouresque et al., 2009; Telesca et al., 2015). A study revealed the total known area of *Posidonia oceanica* to be 1,224,707 ha of which 713,992 ha exist in the eastern Mediterranean Sea. *Posidonia* is widely present along the coastline of Greece including its islands, covering 44,939 ha. **Figure 3** shows that only a fraction of these meadows have been mapped by 2015 (Telesca et al., 2015). This demonstrates how little we know about the distribution and state of *Posidonia oceanica* meadows.

In the last two decades *P. oceanica* has become one of the main targets of the protection and management of the Mediterranean marine environment (Boudouresque et al., 2012). The European Union's Habitat Directive (92/43/CEE) includes *P. oceanica* beds among priority habitats (Habitat Type 1120: *P. oceanica beds – Posidonion oceanicae*). Furthermore, The Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean of the Barcelona Convention considers this plant as endangered and a habitat of priority for conservation. It is recognized within the 1120* "*Posidonia* beds" of the Directive 92/43/CE "Habitat", and therefore sites hosting *Posidonia oceanica* can be studied for inclusion in the Natura 2000 network (European Commission - DG Environment, 2013). More recently, the Marine Strategy Framework Directive (MSFD) (2008/56/EC) has established a framework according to which all member states shall take the necessary measures to achieve or maintain "Good Environmental Status" in the marine environment. This includes the monitoring and mapping of special habitat types recognized in the Habitats Directive, which includes *Posidonia oceanica* beds.

It is vital to gather more information about its present state and distribution, especially in the less explored eastern Mediterranean Sea, which is under the siege of numerous Lessepsian non-native species.

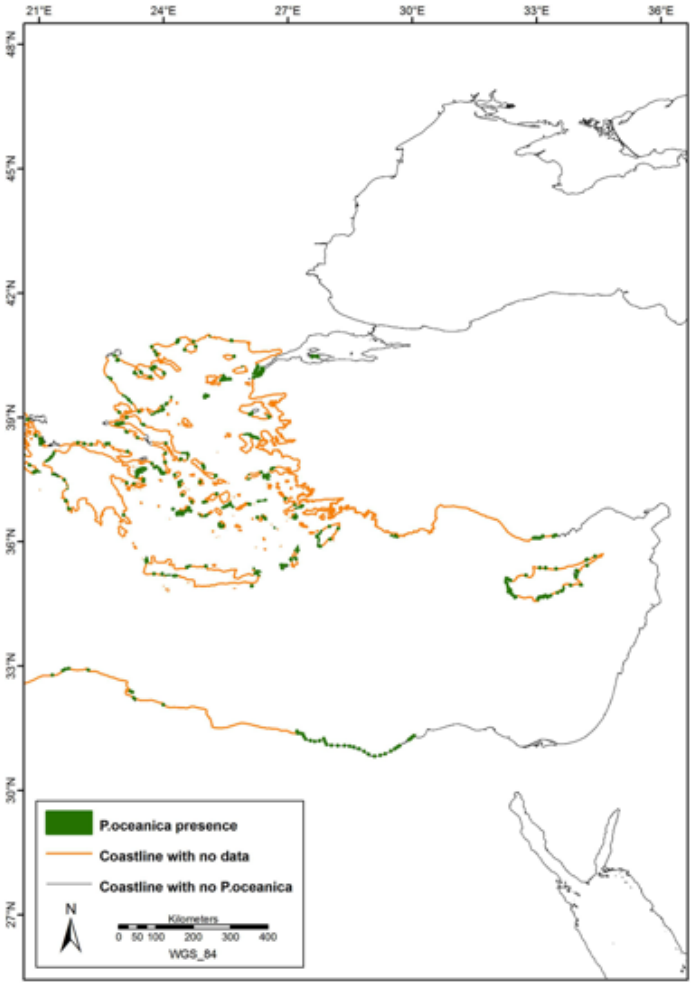

Figure 3. Detail of the current distribution of *Posidonia oceanica* meadows in the eastern Mediterranean Sea (Telesca *et al.*, 2015).

The Mediterranean Sea and Crete

The Mediterranean Sea is the largest (2,969,000 km^2) and deepest (5,267 m) semi enclosed sea on earth (Coll et al., 2010). It is connected via the Strait of Gibraltar to the Atlantic Ocean, to the Black Sea through the Bosporus Strait and via the Suez Canal, an artificial construction, to the Red Sea. The western and the eastern Mediterranean basin are separated by the Strait of Sicily (**Fig. 4**).

It is an oligotrophic sea and characterized by a west to east gradient of increasing temperature, salinity and oligotrophy. The eastern Mediterranean basin has only a third of the productivity that can be measured in the western basin (Turley, 1999). The western Mediterranean Sea is characterized by water temperatures fluctuating between 12 and 22°C. Its salinity is similar to the Atlantic with 35 PSU (Practical Salinity Unit). The eastern basin's water temperature ranges between 15 and 31 °C and a salinity between 38 and 39 PSU, making it a subtropical body of water (Rilov and Galil, 2009).

Since the end of the 90's, biodiversity was widely accepted as an important indication for the environmental health and function of an ecosystem (Aarts and Nienhuis, 1999; Worm

et al., 2006). A summary by Bianchi and Morri (2000) stated a rough estimate of 8500 macroscopic marine organisms in the Mediterranean Sea, which is 4-18% of the world's marine species. This number was updated by Coll and colleagues (2010) to 17,000 species, about 7% of the world's biodiversity, with a high richness of endemic species. Of these 17,000 species, about 26% are bacteria, archaea and eukaryotic marine microbes. Within the Animalia Kingdom the greater proportion of species belong to the subphylum Crustacea (13.2%) and Mollusca (12.4%). The species richness is surprisingly high, taking into account that the Mediterranean Sea represents less than 0.8% of the world's ocean surface area and less than 0.3 % of its volume (Boudouresque, 2004).

Figure 4 Main biogeographic regions, basins and administrative divisions of the Mediterranean Sea. **1)** Alboran Sea, **2)** Balearic Sea, **3)** Gulf of Lions, **4)** Ligurian Sea, **5)** Algeria and Tunisian waters, **6)** Tyrrhenian Sea, **7)** North Adriatic Sea, **8)** Central Adriatic Sea, **9)** South Adriatic Sea, **10)** Ionian Sea, **11)** North Aegean Sea, **12)** South Aegean Sea, **13)** Levant Sea, **14)** Gulf of Gabés. Modified after (Coll et al. 2010)

This high biodiversity can be explained by the turbulent history of the Mediterranean Sea. It is a relic of the Tethys Ocean, which was a biogeographical province during the Mesozoic and at that time filled with tropical biota. At the end of the Miocene (ca. 10 million years ago) the connection to the Indo-Pacific closed and it slowly lost its tropical characteristics (Rilov and Galil, 2009). One extreme event was the isolation from the global ocean. During the Messinian crisis, about 5.9 million years ago, the basin nearly dried out and went through drastic changes in temperature and salinity (Garcia-Castellanos et al., 2009). This led to an extinction of the prevalent fauna and flora with a few species surviving in refuge areas. After the re-establishment of the connection to the Atlantic Ocean, about 5 million years ago, the Mediterranean Sea was refilled with water and biota. Changing climate from ice ages to interglacial conditions, during the Quaternary, resulted in waves of migration of Atlantic species of boreal and subtropical origin (Bianchi and Morri, 2000). In addition, the heterogeneity in topography, sea water temperature and salinity supported the evolution of a high biodiversity in the basin.

The eastern Mediterranean Sea diversity is lower compared to the western basin and other subtropical bodies of water. This unique sea is under enormous anthropogenic pressures. These can be of direct or indirect impact on biodiversity. The most important threats are habitat loss, degradation and pollution, overexploitation of marine resources, invasion of species and climate change (Coll et al., 2010; Lejeusne et al., 2010). The continuous increase of human population, especially along the coastline, led to a progressive alteration of marine habitats due to destructive fishing methods, pollution and costal constructions. Hardly any region in the Mediterranean Sea seems spared of disturbance caused by humankind (Goffredo and Dubinsky, 2014). Especially the eastern Mediterranean Sea is impacted by climate change and the invasion of non-native species. Raitsos and colleagues (2010) found a positive correlation between the warming of the Aegean and eastern Ionian Sea and the settlement of non-native species in this region.
The island of Crete is situated at the southern border of the Aegean Sea. It is surrounded by the water masses of the Cretan Sea in the north, the Libyan Sea in the south-east and the Ionian Sea in the south-west. It is the fifth largest island in the Mediterranean Sea and the largest island of Greece. It is located approximately 160 km south of the Greek mainland and has a coastline of about 1,300 km length (Alexandrakis et al., 2015). The water masses surrounding the island of Crete are oligotrophic, due to low primary production and chlorophyll a concentration (Psarra et al., 2000). Together with the deep trenches surrounding the island and the high evaporation rates, the coastal waters of Crete are unique in their characteristics. Surprisingly its marine fauna is one of the least studied in this area (Crocetta et al., 2015). Studies regarding the coastal marine environment focus mostly on the north coast of Crete (Karakassis and Eleftheriou, 1998; Katsanevakis and Thessalou-Legaki, 2009). This might be because of the higher economical interest in the north coast due to more tourism (Alexandrakis et al., 2015), leaving the southern coastal area of Crete nearly unexplored. Information on the distribution and state of important habitats, like seagrass meadows (e.g. *Posidonia oceanica*) are hardly available. Also records and monitoring of non-native species are scarce, with a few exceptions (Steger et al., 2018). It is vital to collect scientifically important information of these neglected areas, especially considering the rapid changes and destruction of the marine environment.

Non-native species in the eastern Mediterranean Sea

Non-native or non-indigenous species (NIS) are organisms introduced in an area outside their past or present natural range and dispersal potential (Falk-Petersen et al., 2006). These species are introduced intentionally or unintentionally by human activity. Among the introduction factors, there are shipping, either as biofouling on the hull or in ballast water, aquaculture, aquarium trade and the construction of the Suez Canal (Katsanevakis et al., 2014). Globalization and increasing transportation of goods accelerate the introduction rates of marine biological invasion (Katsanevakis et al. 2013).

NIS can threaten biodiversity in various ways, from reducing genetic variation by depleting the gene pool, they cause the extinction of endemic species and alter the food web. Depletion of the gene pool can happen by hybridization of non-indigenous with native species, resulting in an infertile offspring or eventually hybrids replace the native species (Hulme, 2007). Some non-native species can be a serious threat to the human health and economy (Galil et al., 2014; Katsanevakis et al., 2014). This possible threat is also recognized by the European Union Marine Strategy Framework Directive (MSFD) and Biodiversity Strategy (EC, 2010; European Union, 2011). The Suez Canal (**Fig. 4**), is the major vector of bioinvasion to the Mediterranean Sea (Galil and Zenetos, 2002). The Canal opened 1869 with a length of 163 km, depth of 8 m and a bottom width of 22 m. Named after one of the first engineers of the Suez Canal, Ferdinand Marie de Lesseps, the process of species entering the Mediterranean Sea from the Red Sea and the Indo-Pacific region is called Lessepsian invasion (Por, 1978). This term has been revised by Galil (2000) to the Erythrean invasion. An extreme increase of so-called Erythrean species has been recorded since the mid-1960s. This acceleration can, at least partly, be related to the enlargement of the Suez Canal, which was finished in 2016. As consequence of the long-lasting extensions important natural barriers were slowly removed. The tidal current towards the Mediterranean Sea increased, which caused a decrease of the salinity of the "Great Bitter Lakes".

The invasion of non-native species into the Mediterranean Sea follows a certain general pattern: first a population establishes in the southern Levantine basin. Individuals spread with the anticlockwise surface current (**Fig. 5**) reaching the coastline of south Turkey and then the Islands of the south-east Aegean Sea in the west. The journey continues into the northern Aegean Sea and into the Ionian Sea, until they reach the western Mediterranean basin (Katsanevakis et al., 2013).

In 2014, a total of 955 non-native species were known. Most of them were introduced to the eastern Mediterranean (Rilov and Galil, 2009), fewer to the western basin and the Central Mediterranean and very few to the Adriatic Sea. These numbers are most likely underestimates, since knowledge about unicellular organism is still insufficient (Goffredo and Dubinsky, 2014; Rilov and Galil, 2009). Furthermore, species numbers change from publication to publication. Zenetos and colleagues (2012) identified already 986 marine non-indigenous species, but the general distribution in the different basins of the Mediterranean Sea remained the same.

Figure 5 A schematic summary of the major current and gyre systems of the Mediterranean Sea and their seasonal variability. Thick line = winter circulation; thin line = summer circulation. **A**: Algerian current and eddies; **B**: Branches of the Ionian stream; **C**: Tyrrhenian cyclonic current; **D**: summer anticyclone in the eastern Tyrrhenian Sea; **E**: Ligurian-Provencal current; **F**: Lions gyre; **G**: Syrte anticyclone; **H**: mid-Mediterranean jet; **I**: Shikmona and Mersa-Matruth gyres system; **J**: Cilician and Asia Minor current; **K**: Rhodes gyre; **L**: Iera-Petra gyre; **M**: western Cretan gyre; **N**: Pelops gyre; **O**: Ionian cyclonic current; **P**: southern Adriatic gyre; **Q**: eastern Adriatic coastal current; **R**: western Adriatic coastal current; **S**: western Ionian gyre. Modified after Pinardi & Masetti (2000)

The phylum with the highest number of non-native species is the Mollusca, with 215 species, most of them recorded in the eastern basin (Zenetos et al., 2012).

The geographic position of Crete makes it an important area to study the westward migration of non-native species. The observations and records of these species might give us a better understanding of migration routes and time scales of the invasion. An inventory of marine alien species in Greek seas by Zenetos et al. (2011) reported 237 species of which 33 are macrophytes, 131 invertebrates, 42 vertebrates, 2 bacteria, and 29 protozoans. The majority of alien species (47) belong to the phylum Mollusca, which makes 19.8% of all alien species in Greek waters. Several marine non-native species have been reported from the coastal waters of Crete. A list of these species is given in **Table 1**.

Table 1 Records of non-indigenous marine species in the coastal waters of Crete, Greece. A hyphen (-) at the "Frist records" indicates that the cited literature presents a record, but not the first record of a species.

Phylum	Species	First record	Literature
Rhodophyta	*Asparagopsis taxiformis* (Delile) Trevisan de Saint-Léon, 1845	-	Zenetos et al. (2015)
	Hypnea spinella (C.Agardh) Kützing, 1847	2013	Tsiamis and Panayotidis, (2015)
Chlorophyta	*Caulerpa cylindracea* Sonder, 1845	-	Zenetos et al. (2015)
Ochrophyta	*Stypopodium schimperi* (Kützing) Verlaque & Boudouresque, 1991	2013	Tsiamis and Panayotidis, (2015)
	Scytosiphon cf. dotyi M.J.Wynne, 1969	2013	Tsiamis and Panayotidis, (2015)
Tracheophyta	*Halophila stipulacea* (Forsskål) Ascherson, 1867	-	Zenetos et al. (2015)
Foraminifera	*Amphistegina lessonii* d'Orbigny in Guérin-Méneville, 1832	1969	Blanc-Vernet (1969)
	Coscinospira hemprichii Ehrenberg, 1839	1997	Hollaus & Hottinger (1997)
Myzozoa	*Gambierdiscus* sp.	2003	Aligizaki & Nikolaidis (2008)
	Sinophysis canaliculata J.-P.Quod, L.Ten-Hage, J.Turquet, G.Mascarell & Couté, 1999	2003	Aligizaki &Nikolaidis (2008)
Annelida	*Neopseudocapitella brasiliensis* Rullier & Amoureux, 1979	1991	Simboura (1996)
	Chaetozone corona Berkeley & Berkeley, 1941	1996	Simboura (1996)
Echinodermata	*Synaptula reciprocans* (Forsskål, 1775)	2010	Zenetos et al. (2011)
	Diadema setosum (Leske, 1778)	2016	(Mytilineou et al., 2016)
Mollusca	*Clementia papyracea (Gmelin, 1791)*	1985	Crocetta et al. (2016)
	Ventomnestia girardi (Audouin, 1826)	1994	Cosenza & Fasulo (1997)
	Trochus erithreus Brocchi, 1821	1997	Cosenza & Fasulo (1997)
	Pinctada imbricata radiata (Leach, 1814)	2003	Zenetos et al. (2008)
	Goniobranchus annulatus (Eliot, 1904)	2004	Daskos & Zenetos (2007)
	Bursatella leachii Blainville, 1817	2004	Daskos & Zenetos (2007)
	Aplysia dactylomeda Rang, 1828	2006	Andersson (2006)
	Conomurex persicus (Swainson, 1821)	2007	Katsanevakis et al. (2008)
	Ergalatax junionae Houart, 2008	2007	Zenetos et al. (2008)
	Haminoea cyanomarginata Heller & Thompson, 1983	2007	Crocetta et al. (2017)

Table 1 continued

Phylum	Species	First record	Literature
Mollusca	*Dendostrea frons* (Linnaeus, 1758)	2010	Zenetos et al. (2011)
	Septifer cumingii Récluz, 1849	2010	Zenetos et al. (2011)
	Brachidontes pharaonis (P. Fischer, 1870)	2010	Zenetos et al. (2011)
	Melibe viridis (Kelaart, 1858)	2011	Crocetta et al. (2017)
	Flabellina rubrolineata (O' Donoghue, 1929)	2013	Crocetta et al. (2017)
	Rhinoclavis kochi (Philippi, 1848)	2016	Lipej et al. (2017)
Crustacea	*Erugosquilla massavensis (Kossmann, 1880)*	1963	Dounas and Steudel (1994)
Chordata	*Sargocentron rubrum* (Forsskål, 1775)	-	Zenetos et al. (2015)
	Fistularia commersonii Rüppell, 1838	-	Zenetos et al. (2015)
	Stephanolepis diaspros Fraser-Brunner, 1940	2002	Golani et al. (2002)
	Siganus luridus (Rüppell, 1829)	2003	Tingilis et al. (2003)
	Siganus rivulatus Forsskål & Niebuhr, 1775	2003	Tingilis et al. (2003)
	Lagocephalus sceleratus (Gmelin, 1789)	2005	Kasapidis et al. (2007a)
	Upeneus moluccensis (Bleeker, 1855)	2006	Peristeraki et al. (2006)
	Etrumeus teres (DeKay, 1842)	2007	Kasapidis et al. (2007b)
	Lagocephalus suezensis Clark & Gohar, 1953	2009	Koulouri et al. (2015)
	Upeneus pori Ben-Tuvia & Golani, 1989	2009	Koulouri et al. (2015)
	Torquigener flavimaculosus Hardy & Randall, 1983	2009	Koulouri et al. (2015)
	Pteragogus pelycus (Randall, 1981)	2012	Thessalou-Legaki et al. (2012)
	Pterois miles (Bennett, 1828)	2015	Marmara et al. (2017)
	Sousa plumbea (G. Cuvier, 1829)	2017	Frantzis (2018)

The importance of mollusc assemblages and the biotic resistance hypothesis

About 46 000 species of recent marine molluscs are known in 2016. It is estimated that in total there should be 200 000 species, which leaves 150 000 species to be discovered and described (Bouchet et al., 2016). Not only is this group one of the most diverse in the marine environment but it also covers a wide ecological spectrum. They are very important in the food chain and can be found at different trophic levels. In terms of feeding guild, they span from detritivores to herbivores, omnivores and carnivores (Levinton, 1995). Therefore, mollusc communities are a good proxy to study benthic communities and to analyse the status of an ecosystem. This phylum has been used by various authors to describe ecosystems such as seagrass meadows (Albano and Sabelli, 2012; Creed and Kinupp, 2011).

The Malacofauna of the Mediterranean Sea, with its approximately 2000 species, is the best known in the world. Nevertheless especially the eastern Mediterranean basin lacks data on spatial distribution of most species (Oliverio, 2003).

All marine ecosystems are exposed to anthropogenic activities. Most of them are a threat to the biodiversity of these ecosystems (Pawar, 2016; Sechrest and Brooks, 2002). In general, marine communities respond to environmental stress with three main changes: (1) lowering diversity; (2) regression to a poorly diverse community dominated by few opportunist species; and (3) reduction in mean size of the dominant species (Pearson and Rosenberg, 1978). One major stressor is the introduction of non-native species. Today, the relationship between biodiversity and invasibility of ecosystems is intensely discussed (Stachowicz et al., 2002). One hypothesis is the “Biotic resistance hypothesis”. It states that ecosystems with a high biodiversity are more resistant to invaders than ecosystems with a low biodiversity. This hypothesis has also been called the “Vacant niche hypothesis”. The biotic resistance hypothesis has its beginning with Charles Elton (1958). Considerations behind this hypothesis are (1) diverse and relatively undisturbed systems have fewer vacant niches than less diverse and more disturbed systems; and (2) systems with few vacant niches offer few opportunities for introduced species to establish, whereas systems with many vacant niches offer many such opportunities (Jeschke and Genovesi, 2011). This has been tested in multiple settings in terrestrial ecosystems. According to this hypothesis, native and non-indigenous species richness should be negatively correlated (Jeschke, 2014). In general, this has hardly been studied in marine ecosystems (Jeschke, 2014). Confusingly, many contrasting results between observational and experimental studies can be found in the literature (Cobián-Rojas et al., 2018; Jeschke and Genovesi, 2011; McKinney, 2002).

Aim/Hypothesis

Given the importance of Seagrass ecosystems world-wide and especially the endemic species *Posidonia oceanica* in the Mediterranean Sea, the lack of knowledge in neglected areas like the south coast of Crete, the increasing number of Lessepsian non-native species in the eastern Mediterranean basin, controversial results regarding the

biotic resistance hypothesis, this study aims to describe a molluscan assemblage in a *Posidonia* meadow at the south-west coast of Crete with the focus on Lessepsian non-native species. I will present novel data about the state of this meadow and its molluscan community. The number of native species will reflect the state of the *Posidonia oceanica* meadow, assessed by the shoot density. Based on the differences between the leaf- and rhizome layer, in their structure and predominant abiotic factors (e.g. light intensity), I hypothesize that the number of species and their abundance differs significantly between those two layers. Further, I will test the hypothesis that the mollusc assemblage will change over depth, due to different environmental factors like light intensity, strength of water movement and temperature. Further the assemblage will be different between spring and autumn explained by a later recruitment phase and higher water temperature. Regarding the number of non-native species found in the coastal habitat of the island Crete, I hypothesize that Lessepsian molluscs will be present. In accordance with the biotic resistance hypothesis the number of native species will be negatively correlated with the number of non-native species.

Materials and Methods

Study area

The study was carried out in the bay of Plakias, on the south-western coast of Crete, (35.1796° N, 24.3957° E, **Fig. 6**). The bay is 1.5 km long and extends from NNW to SSE. Its southern border is a long rock wall, called "Paligremnos wall", which extends to the south-west into the sea for approximately 800 m. At the bottom of this wall, a sandy substrate stretches over the entire bay partly covered with the seagrass *Posidonia oceanica*. The meadows are mostly found parallel to the wall, starting patchily at just 30 centimetres water depth, and then growing into a continuous meadow at a depth of 5 metres and extending deeper than 30 metres (**Fig. 7**). In this bay the sea surface temperature ranges from a minimum of 15 °C in March to a maximum of 27 °C in August. Samples were taken from this *P. oceanica* meadow, at four different depths (5 m, 10 m, 15 m, 20 m). Sampling was carried out in May and in September 2017 to capture intra-annual variation (**Tab. 2**).

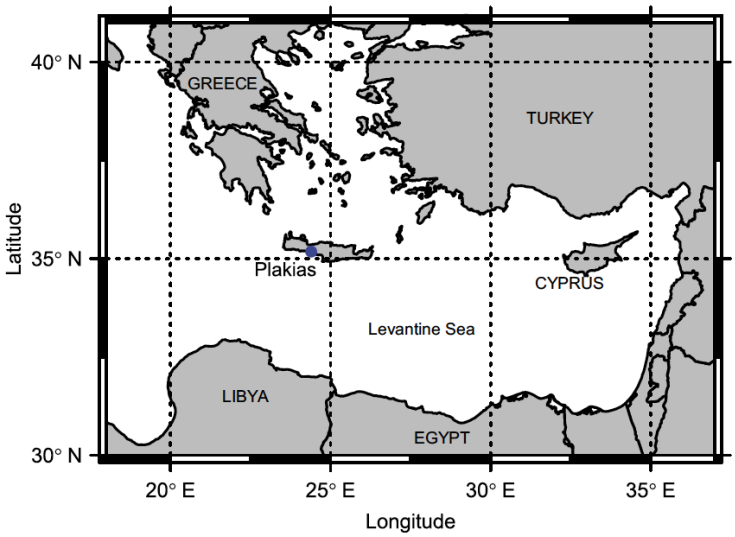

Figure 6 Geographic location of the study site Plakias, southwestern Crete, in the eastern Mediterranean Sea.

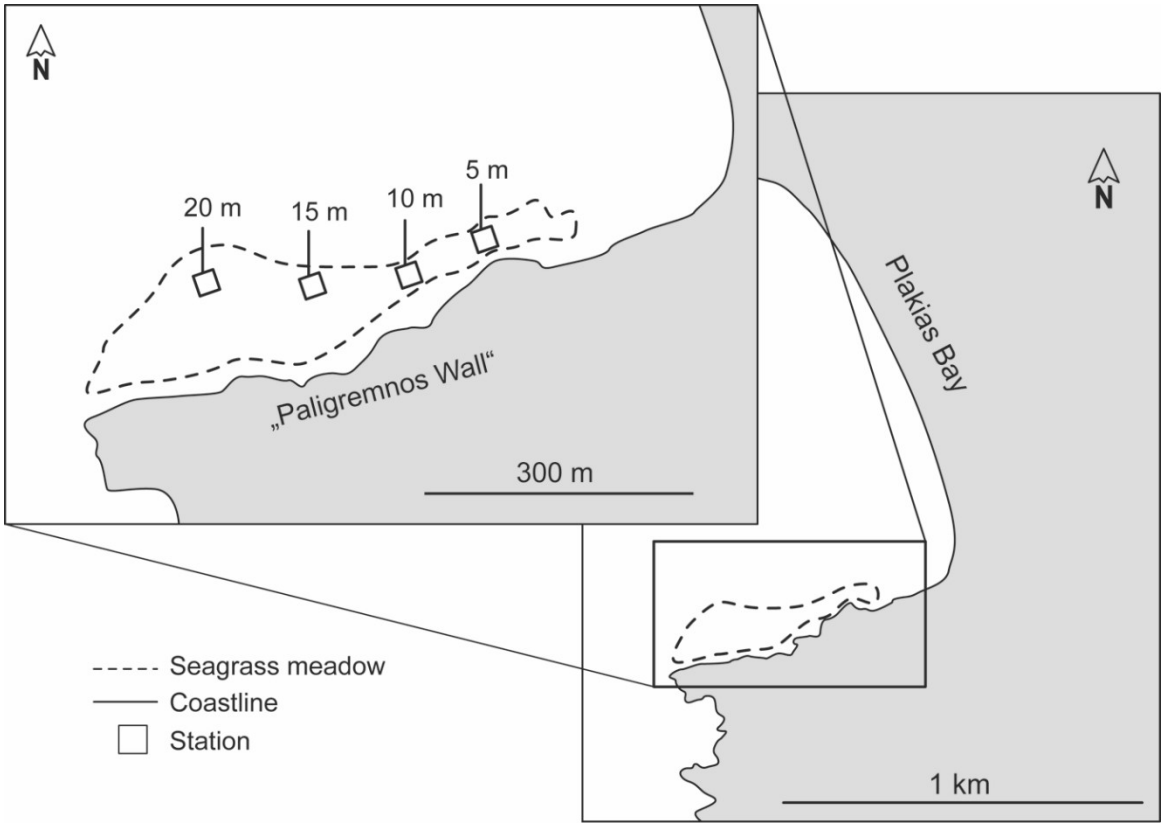

Figure 7 The sampling area Plakias Bay, southwestern Crete. Dashed lines indicate the *Posidonia oceanica* meadow. Squares mark the four different stations (5 m, 10 m, 15 m, 20 m).

Sampling methods

I sampled both, the leaf and the rhizome layer of the meadow. For the leaf layer, samples were collected using a hand-operated net by SCUBA diving according to the technique described by Ledoyer (1962), modified and standardized by Russo et al. (1985). The hand net consists of a metal frame (40 x 20 cm) and a net of 500 µm mesh size. A net stroke starts at the base of the leaves; it is then pulled upwards to collect the mobile fauna crawling on the leaves. At every depth replicates with 60-strokes were performed (two in May and four in September).

The rhizome layer was sampled with an air-lift suction sampler. This device consists of a PVC tube on which a net with a mesh size of 500 µm was mounted on one end. A SCUBA tank was attached to the pipe to supply air for the suction force. Sampling was carried out on 1 m^2 quadrats after defoliation to improve sampling efficacy. Standardization of sampling intensity was performed by using 100 bar of a 12-litre steel tank for each replicate.

At each replicate, shoot density on a 40 x 40 cm sub-quadrat in the 1 m^2 quadrat was counted (Panayotidis at al. 1981). Water temperature was measured at each station with the dive computer SUB GEAR XP10.

Back at the field lab, the nets were washed with saltwater in order to keep the organisms alive. Afterwards the material was sieved into three size fractions (large > 5 mm, small 1-5 mm and fine 0.5-1 mm). The fine fraction was immediately fixed in 96% ethanol, whereas the large and small fractions were sorted to pick living organisms. Using binoculars microscopes, the living organisms were further divided into Polychaeta, fixed in 4% formol, Mollusca and other taxa (e.g. Crustacea, Echinodermata), fixed in 95% ethanol. The residue was sun dried and stored in plastic bags. Ethanol was changed two times during the storage period to enhance the preservation of live-collected organisms.

Table 2 List of collecting stations in Plakias, southwestern Crete. The station code contains the depth in meters and the season (SP = spring, AU= autumn).

Station	Sampling date	Longitude	Latitude	Temperature (°C)	Sampling method
05 SP	08.05.2017	35°10.818’	24°23.850’	18.7	Hand net, Suction sampler
05 AU	24.09.2017	35°10.818’	24°23.850’	24.0	Hand net, Suction sampler
10 SP	15.05.2017	35°10.762’	24°23.697’	17.9	Hand net, Suction sampler
10 AU	17.09.2017	35°10.762’	24°23.697’	24.0	Hand net, Suction sampler
15 SP	11.05.2017	35°10.749’	24°23.639’	18.4	Hand net, Suction sampler
15 AU	21.09.2017	35°10.749’	24°23.639’	24.5	Hand net, Suction sampler
20 SP	17.05.2017	35°10.749’	24°23.563’	18.0	Hand net, Suction sampler
20 AU	14.09.2017	35°10.749’	24°23.563’	24.4	Hand net, Suction sampler

Data analysis

At the University of Vienna, the Mollusca were sorted, counted and identified to species level. Data of the large and small fraction of the leaf and rhizome stratum were pooled per replicate for further analysis. For the leaf layer this results in two replicates of 60 net strokes for the spring season and 4 replicates of 60 net strokes for the autumn season for each depth. For the rhizome layer, 3 replicates for each season and depth were sampled. Data analysis was done in the R statistical environment. Diversity indices like the number of specimens (N) and the number of species (S) were calculated. I used the VEGAN package to calculate the Shannon (H’) index with the diversity() function and for multivariate analysis. Data was standardized by the total number of specimens per species and square root transformed to avoid an excessive influence of the most common species since the assemblages were rich and diverse. Ordination was performed with a non-metric multi-dimensional scaling plot. I tested for differences between groups (e.g., seasons, depths) with PERMANOVA (Anderson, 2001). For the pairwise comparison between the different depths of the rhizome layer, I used the pairwise.adonis() function of the VEGAN package. Furthermore, the dominance (%D) for each species in each replicate was calculated. I used the package iNext to compute coverage curves (Hsieh et al., 2016). Endemism was assessed using the documented distribution of the World Register of Marine Species (WoRMS). Since all the first authors of the species are listed in the faunistic tables (**Tab. 5 and 7**), I will not mention them in the text.

Results

Posidonia oceanica bed structure

The maximum shoot density was at the 5-meter station, with a mean density of 741 ± 186 shoots m^{-2}. The density decreased to a minimum of 491 ± 53 shoots m^{-2} at the 20-meter station (**Table 3**). The standard deviation is highest at the shallowest station with 186 shoots m^{-2} and lowest at the 10-meter station with 37 shoots m^{-2}.

Table 3 Shoot density of the *Posidonia oceanica* meadow at Plakias, south-west coast of Crete. Shoot density is given in shoots m^{-2} for each replicate over the four different sampling stations. Mean and standard deviation were calculated.

Replicate	5m-station	10m-station	15m-station	20m-station
1	487	631	681	506
2	975	662	587	537
3	681	631	681	493
4	693	706	581	431
5	943	612	500	550
6	662	687	593	425
Mean ± SD	740±185	655±36	604±68	490±52

The molluscan assemblage and non-native species

In total 9344 specimens were collected, belonging to 110 species. Of these 27 (24.5%) species are endemic to the Mediterranean Sea. From all collected species, 76 (69.1%) belong to the Class Gastropoda, 30 (27.3%) to the Bivalvia and 4 (3.6%) to the Polyplacophora. I observed the samples with the greatest abundance at the 20 m station in spring. At this station, the rhizome layer contained 1458 specimens and the leaf layer 424 specimens. The station with the most species-rich assemblage was the 5-meter station in autumn for the rhizome layer with 63 species. It also shows the highest Shannon index (H') of 2.9 ± 0.1. In the leaf layer, most species (12) were found at the 20-meter station in autumn (**Table 4**). A complete species list for every replicate in the leaf and rhizome layer is given in the Annex (**Table A1, A2**).

Four species of Lessepsian non-native species were identified. These are *Septifer cumingii*, *Pinctada imbricata radiata*, *Viriola bayani* and *Isognomon* sp. (**Fig. 8**). In total 98 specimens of non-native species were present, 51 individuals of *S. cumingii,* 44 of *P. imbricata radiata*, 2 specimens of *V. bayani* and 1 of *Isognomon* sp.. All, but one were present in the rhizome layer and only one specimen of *P. imbricata radiata* was collected from the leaves. Most non-native specimens (35) were found at the 5-meter station, 8 in spring, representing 1.9% of all individuals found at that station and 27 in autumn, which are 2.7% of all individuals found there (**Table 4**). All specimens of *S. cumingii*, *P. imbricata radiata* and *Isognomon* sp. were juveniles (**Figure 8**). The two specimens of *Viriola bayani* were adult size.

Table 4 List of biodiversity indices (H‘), total number of specimens (N), total number of non-native specimens, total number of species (S) and total number of non-native species, for each station. The station number indicates the depth in m, separated in spring (SP) and autumn (AU) for the rhizome and leaf layer. The dominance index %D (in brackets) for the number of non-native specimens and species.

Rhizome Layer	05 SP	05 AU	10 SP	10 AU	15 SP	15 AU	20 SP	20 AU
N, number of specimens	423	1000	1100	1058	743	1309	1458	839
Number of non-native specimens	8 (1.9%)	27 (2.7%)	4 (0.4%)	10 (0.9%)	15 (2%)	8 (0.6%)	15 (1%)	10 (1.2%)
S, number of species	30	63	48	50	38	51	54	46
Number of non-native species	2 (6.7%)	2 (3.2%)	1 (2.1%)	3 (6%)	2 (5.3%)	2 (3.9%)	2 (3.7%)	3 (6.5%)
H‘, Shannon index	2.2 ± 0.3	2.9 ±0.1	2.2 ± 0.1	2.2 ± 0.1	2.1 ± 0.1	2.1 ± 0.3	2.1 ± 0.1	2.1 ± 0.4
Leaf Layer	05 SP	05 AU	10 SP	10 AU	15 SP	15 AU	20 SP	20 AU
N, number of specimens	288	164	183	131	56	38	424	130
Number of non-native specimens	-	-	-	-	-	-	1 (0.2%)	-
S, number of species	8	10	10	8	8	8	11	12
Number of non-native species	-	-	-	-	-	-	1 (9.1%)	-
H‘, Shannon index	1.5 ± 0.1	1.1 ± 0.3	1.6 ± 0.2	0.8 ± 0.1	1.4	0.9 ± 0.5	1.1 ± 0.1	1.3 ± 0.5

The highest abundance of *P. imbricata radiata* was found at the 20-meter station. The number of individuals of this species seems to increase with water depth. While most specimens of *S. cumingii* were present at the 5-meter station and show decreasing numbers of specimens with increasing depth (**Fig. 9**). Although trends for depth preferences are observable, the collected number of non-native specimens is too low for significant statistical results. Most non-native specimens were found in autumn.

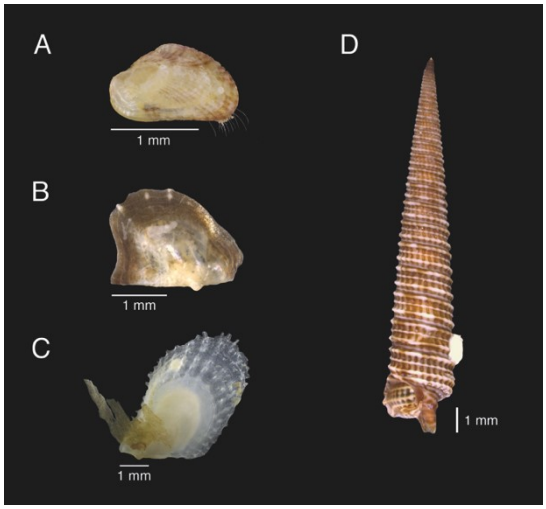

Figure 8 The four non-native species found in the *P. oceanica* meadow at Plakias, south-west coast of Crete. A) *Septifer cumingii* Récluz, 1848; B) *Pinctada imbricata radiata* (Leach, 1814); C) *Isognomon* sp.; D) *Viriola bayani* Jousseaume, 1884.

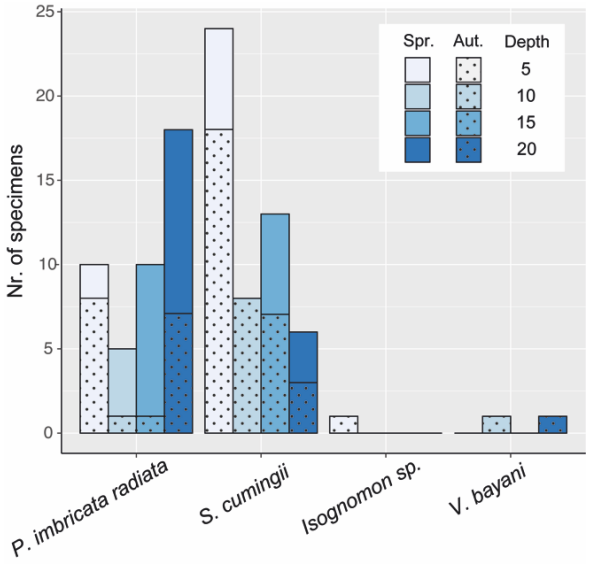

Figure 9 Depth distribution of non-native species. Areas with plain colors show number of specimens found in spring (Spr.) and dotted areas show number of specimens found in autumn (Aut.). The different colors indicate the depth in which the specimens were found. Divergent trends of depth preference in non-native species.

The mollusc assemblage in the leaf layer

In the leaf layer a total of 1414 specimens belonging to 19 species were collected. The endemic species are represented by 82 (5.8%) individuals. A detailed list, of species per depth, season and their dominance, is given in **Table 5**. Nearly all collected specimens belong to the group of Gastropoda, except two individuals of Bivalvia: one specimen of *Barbatia barbata* found in the 15-m station in autumn and a specimen of *Pinctada imbricata radiata*. The latter was found at the 20-m station in spring and is the only non-native specimen found in this layer. Two more species, *Muricopsis cristata* and *Aplysia parvula*, were represented by only one individual each. Sample coverage was 100% at all depths and seasons, suggesting that the results are very robust (**Fig. 10**).

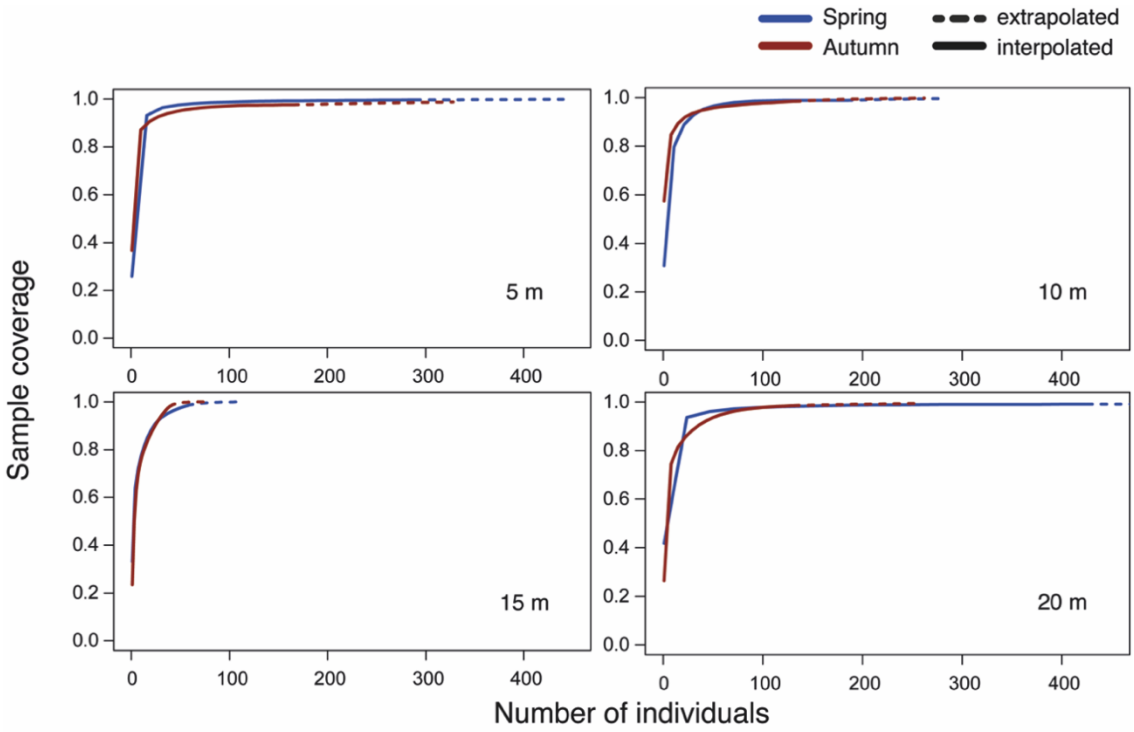

Figure 10 Coverage plot for the samples taken in the leaf layer. Dotted line shows the extrapolated data and solid line shows the interpolated data. The blue line represents the samples taken in spring and the red line stands for the samples taken in autumn. Sampling coverage was 100% at all depths and seasons.

The rank abundance curve visualizes a low evenness of this stratum (**Fig. 11**). Three species, *Jujubinus exasperatus*, *Bittium latreillii* and *Bittium reticulatum* are represented by more than 100 specimens each. The species *Rissoa angustior*, *Pusillina radiata*, *Tricolia pullus*, *Smaragdia viridis*, *Tricolia speciosa* are present with more than 10 individuals. The only species, which was found in the leaf layer and not in the rhizome layer is *Rissoa violacea*. It was present in the 15-m station in autumn (3 specimens) and in the 20-m station in spring (1 specimen) and autumn (3 specimens). The species *Jujubinus exasperatus*, *Tricolia speciosa*, *Bittium latreillii* and *Rissoa angustior* were found at every station in both seasons (**Table 5**)

Table 5 Molluscs found in the *P. oceanica* leaf layer with quantitative data. The total number of individuals for each station and season and the dominance index %D (in brackets) are shown. Endemic species (WoRMS) are marked in **bold** and alien species are marked with an asterisk (*).

	05 SP	05 AU	10 SP	10 AU	15 SP	15 AU	20 SP	20 AU
Jujubinus exasperatus (Pennant, 1777)	59 (20.5%)	85 (51.8%)	95 (51.9%)	98 (74.8%)	31 (55.4%)	16 (42.1%)	31 (7.3%)	56 (43.1%)
Calliostoma laugieri (Payraudeau, 1826)	2 (0.7%)	1 (0.6%)	-	1 (0.8%)	-	-	-	-
Tricolia speciosa (Megerle von Mühlfeld, 1824)	9 (3.1%)	3 (1.8%)	1 (0.6%)	1 (0.8%)	2 (3.6%)	2 (5.3%)	3 (0.7%)	3 (2.3%)
Tricolia pullus (Linnaeus, 1758)	-	11 (6.7%)	6 (3.3%)	8 (6.1%)	2 (3.6%)	-	-	7 (5.4%)
Smaragdia viridis (Linnaeus, 1758)	5 (1.7%)	1 (0.6%)	7 (3.8%)	-	6 (10.7%)	2 (5.3%)	5 (1.2%)	-
Bittium latreillii (Payraudeau, 1826)	105 (36.5%)	51 (31.1%)	9 (4.9%)	15 (11.5%)	6 (10.7%)	3 (7.9%)	248 (58.5%)	8 (6.2%)
Bittium reticulatum (da Costa, 1778)	79 (27.4%)	4 (2.4%)	28 (15.3%)	2 (1.5%)	-	-	112 (26.4%)	3 (2.3%)
***Alvania mamillata* Risso, 1826**	**-**	**-**	**-**	**-**	**-**	**-**	**1 (0.2%)**	**1 (0.8%)**
Pusillina philippi (Aradas & Maggiore, 1844)	-	1 (0.6%)	-	-	-	-	-	6 (4.6%)
***Pusillina radiata* (Philippi, 1836)**	**1 (0.4%)**	**-**	**16 (8.7%)**	**2 (1.5%)**	**3 (5.4%)**	**2 (5.3%)**	**15 (3.5%)**	**35 (26.9%)**
Alvania lineata Risso, 1826	-	1 (0.6%)	-	-	-	-	-	1 (0.8%)
Rissoa angustior (Monterosato, 1917)	28 (9.7%)	6 (3.7%)	15 (8.2%)	4 (3.1%)	5 (8.9%)	9 (23.7%)	6 (1.4%)	4 (3.1%)
Rissoa violacea Desmarest, 1814	-	-	-	-	-	3 (7.9%)	1 (0.2%)	4 (3.1%)
***Granulina marginata* (Bivona, 1832)**	**-**	**-**	**5 (2.7%)**	**-**	**-**	**-**	**-**	**-**
Muricopsis cristata (Brocchi, 1814)	-	-	-	-	1 (1.8%)	-	-	-
Ocinebrina aciculata (Lamarck, 1822)	-	-	1 (0.6%)	-	-	-	-	2 (1.5%)
Aplysia parvula Mörch, 1863	-	-	-	-	-	-	1 (0.2%)	-
***Barbatia barbata* (Linnaeus, 1758)**	**-**	**-**	**-**	**-**	**-**	**1 (2.6%)**	**-**	**-**
**Pinctada imbricata radiata* (Leach, 1814)	-	-	-	-	-	-	1 (0.2%)	-

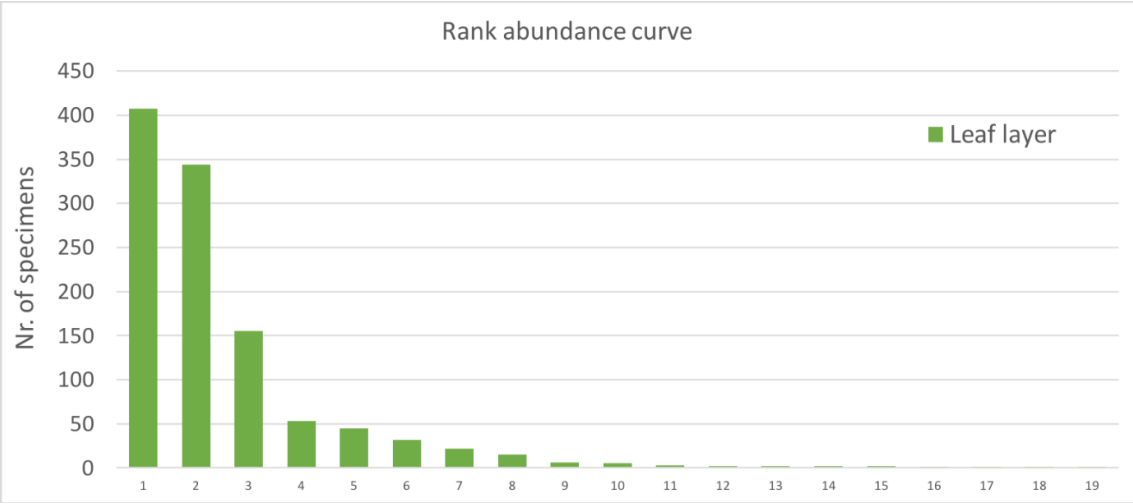

Figure 11 Rank abundance curve of all the molluscs found in the leaf layer of the *Posidonia oceanica* meadow at the south-west coast of Crete, Greece.

The lowest number of individuals was collected at the 15-m station. The non-metric multi-dimensional scaling (NMDS) plot shows no obvious difference in the mollusc assemblage over the stations (**Fig. 12**). This was tested with a PERMANOVA, which supports the NMDS with no significant differences in the assemblage among depths (Fd = 1.396, R^2= 0.059, p = 0.238).

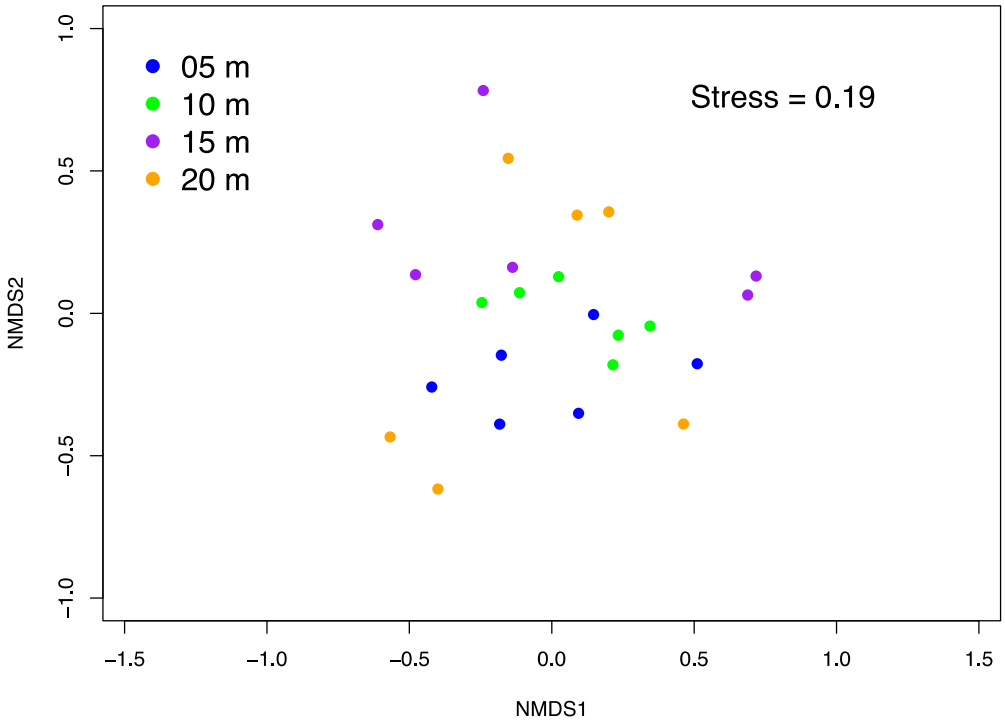

Figure 12 Non-metric multi-dimensional scaling plot representing replication of the different sampling stations of the leaf layer. No visual difference between the depths is obvious.

The mollusc assemblage in the rhizome layer

In total 7930 individuals belonging to 109 species were collected in the rhizome layer. Of these individuals 1496 (18.87%) specimens of endemic species were found. A detailed list, of species per depth, season and their dominance, is given in **Table 6**. Sample coverage was 100% at all depths and seasons, suggesting that the results are very robust (**Fig. 12**).

Among the 10 most abundant species seven belong to Gastropoda and three to Bivalvia. The Gastropoda species in decreasing abundance are *Bittium latreillii, Alvania mamillata, Bittium reticulatum, Jujubinus exasperatus, Tricolia pullus, Alvania discors and Tricolia speciosa*. The Bivalvia are *Glans trapezia, Thyasira* sp. and *Musculus costulatus* (**Fig. 13**).

Figure 14 shows a rank abundance curve, visualizing the low evenness of the sampled seagrass meadow. Four species are very abundant with more than 1000 individuals each and a lot of species with less than 500 individuals. In total 29 species were represented by only one specimen.

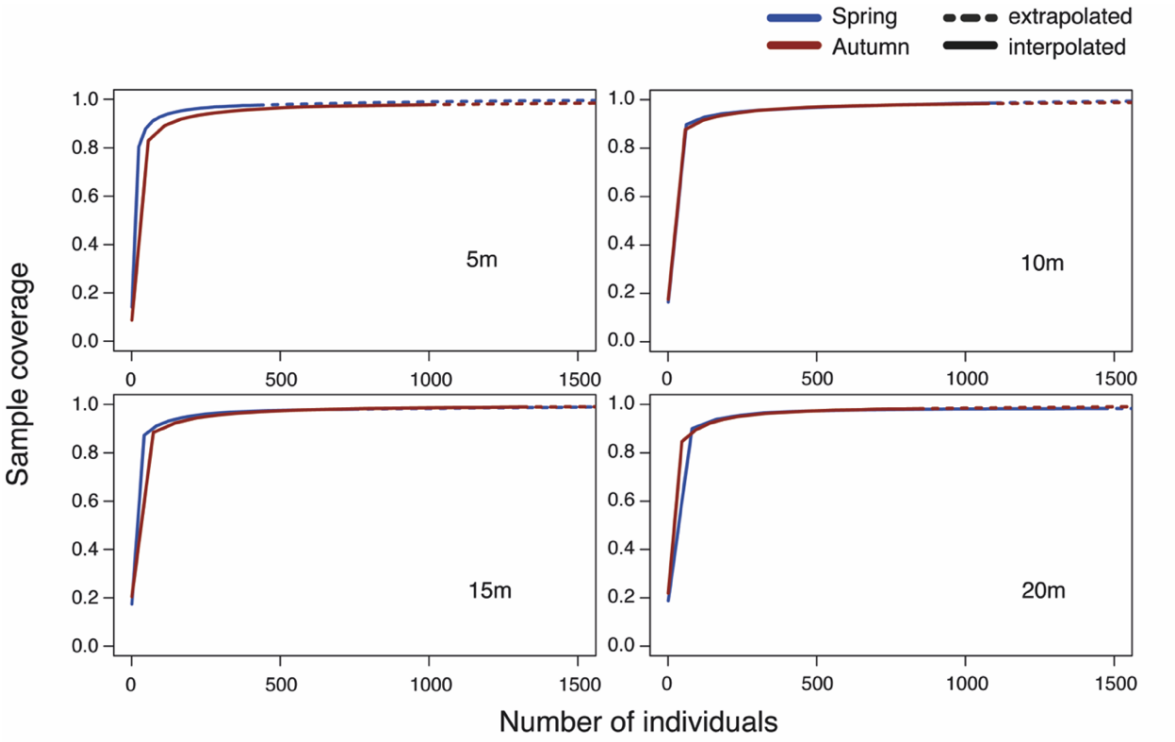

Figure 12 Coverage plot for the samples taken in the rhizome layer. The solid line shows the observed, the dashed line the extrapolated values. The blue and the red lines represent the samples taken in spring and autumn, respectively. Sample coverage was a 100% at all depths.

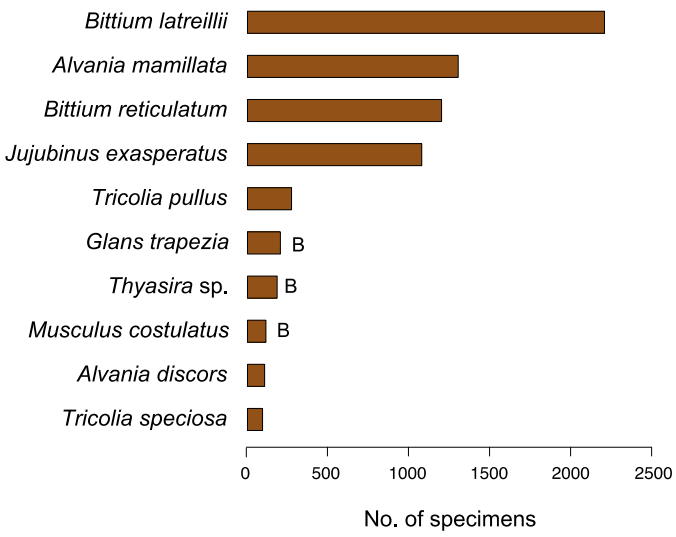

Figure 13 Total number of specimens for the 10 most abundant Mollusca species in the rhizome layer of a *P. oceanica* meadow at the south-west coast of Crete. The B's mark the Bivalvia species.

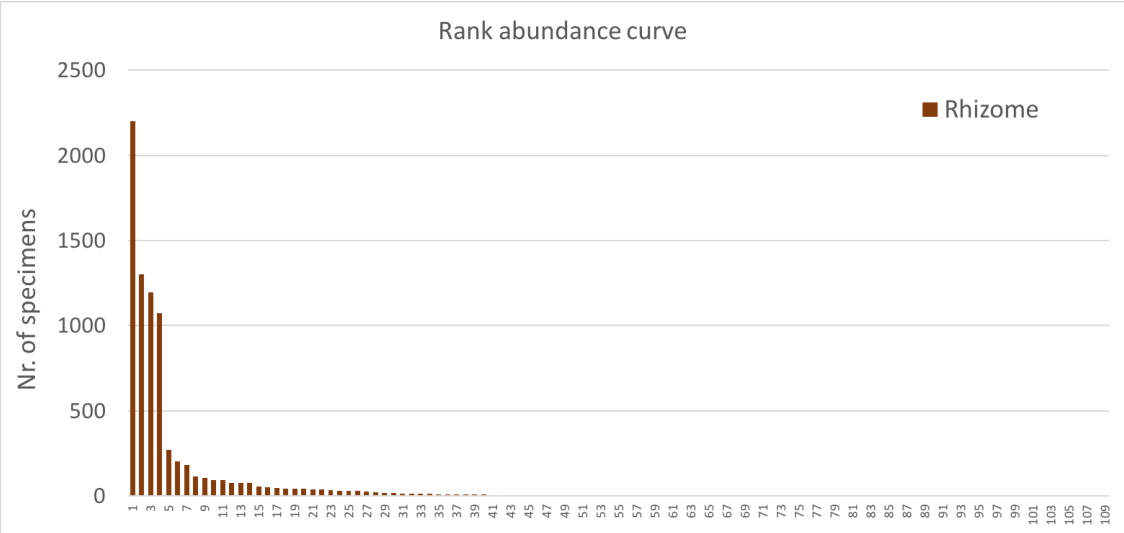

Figure 14 Rank abundance curve of all the molluscs found in the rhizome layer of the *Posidonia oceanica* meadow at the SW coast of Crete, Greece.

Table 6 Molluscs found in the *P. oceanica* rhizome with quantitative data. The total number of individuals for each station, season and the dominance index %D (in brackets) are shown. Endemic species (according to WoRMS) are marked in **bold,** alien species are marked with an asterisk.

	05 SP	05 AU	10 SP	10 AU	15 SP	15 AU	20 SP	20 AU
Acanthochitona fascicularis (Linnaeus, 1767)	-	2 (0.2%)	1 (0.1%)	5 (0.5%)	2 (0.3%)	3 (0.2%)	8 (0.5%)	10 (1.2%)
Leptochiton bedullii Dell'Angelo & Palazzi, 1986	-	4 (0.4%)	-	2 (0.2%)	-	4 (0.3%)	7 (0.5%)	-
Callochiton septemvalvis (Montagu, 1803)	-	1 (0.1%)	-	-	-	2 (0.2%)	1 (0.1%)	-
Chiton olivaceus Spengler, 1797	-	-	-	-	1 (0.1%)	1 (0.1%)	1 (0.1%)	-
Patella sp.	-	-	-	-	1 (0.1%)	-	-	-
Emarginula sicula J.E. Gray, 1825	-	-	1 (0.1%)	1 (0.1%)	-	1 (0.1%)	-	-
Scissurella costata d'Orbigny, 1824	8 (1.9%)	5 (0.5%)	26 (2.4%)	-	16 (2.2%)	3 (0.2%)	17 (1.2%)	-
Clanculus cruciatus (Linnaeus, 1758)	-	-	-	-	-	-	1 (0.1%)	-
***Gibbula ardens* (Salis Marschlins, 1793)**	**-**	**-**	**1 (0.1%)**	**-**	**-**	**-**	**-**	**-**
Jujubinus exasperatus (Pennant, 1777)	40 (9.5%)	47 (4.7%)	184 (16.7%)	113 (10.7%)	99 (13.3%)	200 (15.3%)	287 (19.7%)	105 (12.5%)
Jujubinus striatus (Linnaeus, 1758)	-	-	2 (0.2%)	1 (0.1%)	-	3 (0.2%)	-	2 (0.2%)
Steromphala varia (Linnaeus, 1758)	-	1 (0.1%)	-	-	-	-	-	-
Calliostoma laugieri (Payraudeau, 1826)	1 (0.2%)	24 (2.4%)	2 (0.2%)	2 (0.2%)	1 (0.1%)	-	-	-
Homalopoma sanguineum (Linnaeus, 1758)	-	-	-	-	-	-	-	1 (0.1%)
Tricolia pullus (Linnaeus, 1758)	40 (9.5%)	69 (6.9%)	42 (3.8%)	24 (2.3%)	28 (3.8%)	21 (1.6%)	27 (1.9%)	21 (2.5%)
Tricolia speciosa (Megerle von Mühlfeld, 1824)	3 (0.7%)	8 (0.8%)	31 (2.8%)	8 (0.8%)	12 (1.6%)	12 (0.9%)	14 (1%)	5 (0.6%)
Tricolia tenuis (Michaud, 1829)	-	4 (0.4%)	-	-	-	-	-	-
Bolma rugosa (Linnaeus, 1767)	-	1 (0.1%)	-	2 (0.2%)	-	1 (0.1%)	1 (0.1%)	6 (0.7%)
Smaragdia viridis (Linnaeus, 1758)	14 (3.3%)	27 (2.7%)	14 (1.3%)	9 (0.9%)	5 (0.7%)	12 (0.9%)	3 (0.2%)	8 (1%)
Bittium latreillii (Payraudeau, 1826)	99 (23.4%)	142 (14.2%)	190 (17.3%)	269 (25.4%)	214 (28.8%)	471 (36%)	464 (31.8%)	353 (42.1%)
Bittium reticulatum (da Costa, 1778)	103 (24.3%)	42 (4.2%)	317 (28.8%)	119 (11.2%)	169 (22.7%)	96 (7.3%)	291 (20%)	60 (7.2%)

Table 6 continued

	05 SP	05 AU	10 SP	10 AU	15 SP	15 AU	20 SP	20 AU
Cerithium sp.	-	1 (0.1%)	-	-	-	-	1 (0.1%)	1 (0.1%)
Turritella turbona Monterosato, 1877	-	-	-	-	-	2 (0.2%)	-	-
***Notocochlis dillwynii* (Payraudeau, 1826)**	**1 (0.2%)**	**-**	**1 (0.1%)**	**-**	**1 (0.1%)**	**-**	**2 (0.1%)**	**-**
Marshallora adversa (Montagu, 1803)	-	1 (0.1%)	1 (0.1%)	-	-	1 (0.1%)	1 (0.1%)	-
Monophorus erythrosoma (Bouchet & Guillemot, 1978)	-	-	-	-	-	-	1 (0.1%)	-
Monophorus perversus (Linnaeus, 1758)	-	1 (0.1%)	-	-	-	-	-	-
Similiphora similior (Bouchet & Guillemot, 1978)	-	1 (0.1%)	1 (0.1%)	-	1 (0.1%)	-	-	-
**Viriola bayani* Jousseaume, 1884	-	-	-	1 (0.1%)	-	-	-	1 (0.1%)
Cerithiopsis tubercularis (Montagu, 1803)	-	4 (0.4%)	-	-	1 (0.1%)	-	-	-
***Alvania bozcaadensis* Tisselli & Giunchi, 2013**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**3 (0.4%)**
***Alvania clarae* Nofroni & Pizzini, 1991**	**-**	**2 (0.2%)**	**-**	**-**	**-**	**-**	**-**	**-**
Alvania discors (Allan, 1818)	14 (3.3%)	57 (5.7%)	8 (0.7%)	2 (0.2%)	-	-	15 (1%)	10 (1.2%)
Alvania lineata Risso, 1826	5 (1.2%)	7 (0.7%)	-	-	-	-	-	-
***Alvania mamillata* Risso, 1826**	**29 (6.9%)**	**196 (19.6%)**	**152 (13.8%)**	**306 (28.9%)**	**104 (14%)**	**279 (21.3%)**	**119 (8.2%)**	**115 (13.7%)**
Pusillina philippi (Aradas & Maggiore, 1844)	-	-	-	1 (0.1%)	1 (0.1%)	-	1 (0.1%)	-
***Pusillina radiata* (Philippi, 1836)**	**-**	**1 (0.1%)**	**10 (0.9%)**	**3 (0.3%)**	**5 (0.7%)**	**11 (0.8%)**	**8 (0.5%)**	**11 (1.3%)**
Rissoa angustior (Monterosato, 1917)	20 (4.7%)	6 (0.6%)	3 (0.3%)	4 (0.4%)	2 (0.3%)	1 (0.1%)	1 (0.1%)	3 (0.4%)
***Rissoina bruguieri* (Payraudeau, 1826)**	**-**	**3 (0.3%)**	**-**	**-**	**-**	**-**	**-**	**-**
Caecum auriculatum De Folin, 1868	-	1 (0.1%)	-	-	-	-	1 (0.1%)	1 (0.1%)
Caecum clarkii Carpenter, 1859	-	-	-	-	-	1 (0.1%)	-	-
Campylorhaphion famelicum (Watson, 1883)	-	2 (0.2%)	2 (0.2%)	-	-	-	-	-
Melanella lubrica (Monterosato, 1890)	-	2 (0.2%)	-	-	-	-	-	1 (0.1%)

Table 6 continued

	05 SP	05 AU	10 SP	10 AU	15 SP	15 AU	20 SP	20 AU
Vitreolina philippi (de Rayneval & Ponzi, 1854)	-	2 (0.2%)	-	-	-	-	-	-
Lamellaria perspicua (Linnaeus, 1758)	-	-	-	-	-	-	1 (0.1%)	-
Gibberula philippii (Monterosato, 1878)	-	-	-	-	-	5 (0.4%)	-	-
***Granulina marginata* (Bivona, 1832)**	**-**	**-**	**2 (0.2%)**	**11 (1%)**	**-**	**1 (0.1%)**	**-**	**-**
***Volvarina mitrella* (Risso, 1826)**	**-**	**1 (0.1%)**	**-**	**-**	**-**	**-**	**-**	**-**
***Chauvetia turritellata* (Deshayes, 1835)**	**-**	**2 (0.2%)**	**2 (0.2%)**	**3 (0.3%)**	**-**	**-**	**-**	**-**
Euthria cornea (Linnaeus, 1758)	-	2 (0.2%)	-	1 (0.1%)	-	-	-	-
***Aegeofusinus rolani* (Buzzurro & Ovalis, 2005)**	**1 (0.2%)**	**3 (0.3%)**	**-**	**1 (0.1%)**	**-**	**2 (0.2%)**	**-**	**2 (0.2%)**
***Aptyxis syracusana* (Linnaeus, 1758)**	**-**	**1 (0.1%)**	**-**	**-**	**-**	**-**	**-**	**-**
Hexaplex trunculus (Linnaeus, 1758)	-	7 (0.7%)	2 (0.2%)	1 (0.1%)	1 (0.1%)	1 (0.1%)	1 (0.1%)	2 (0.2%)
Muricopsis cristata (Brocchi, 1814)	1 (0.2%)	4 (0.4%)	3 (0.3%)	10 (0.9%)	1 (0.1%)	12 (0.9%)	1 (0.1%)	2 (0.2%)
Ocinebrina aciculata (Lamarck, 1822)	-	-	1 (0.1%)	2 (0.2%)	-	4 (0.3%)	-	-
***Ocinebrina aegeensis* Aissaoui, Barco & Oliverio, 2017**	**-**	**-**	**-**	**-**	**-**	**-**	**1 (0.1%)**	**-**
Typhinellus labiatus (de Cristofori & Jan, 1832)	-	-	2 (0.2%)	1 (0.1%)	1 (0.1%)	-	-	1 (0.1%)
Haedropleura aff *secalina* (Crete) (Philippi, 1844)	-	-	-	3 (0.3%)	-	6 (0.46%)	1 (0.1%)	1 (0.1%)
Mangelia sp.	-	-	1 (0.1%)	-	-	-	-	-
***Clathromangelia granum* (Philippi, 1844)**	**-**	**1 (0.1%)**	**-**	**-**	**-**	**2 (0.2%)**	**-**	**1 (0.1%)**
***Clathromangelia loiselieri* Oberling, 1970**	**-**	**-**	**-**	**2 (0.2%)**	**-**	**4 (0.3%)**	**2 (0.1%)**	**4 (0.5%)**
Raphitoma sp.	-	-	-	1 (0.1%)	-	-	-	-
Retusa truncatula (Bruguière, 1792)	5 (1.2%)	-	11 (1%)	-	5 (0.7%)	-	8 (0.5%)	-
Atys macandrewii E.A. Smith, 1872	-	-	-	-	1 (0.1%)	-	-	-
Philine catena (Montagu, 1803)	2 (0.5%)	-	1 (0.1%)	-	-	-	1 (0.1%)	-

Table 6 continued

	05 SP	05 AU	10 SP	10 AU	15 SP	15 AU	20 SP	20 AU
Aplysia depilans Gmelin, 1791	-	-	-	-	-	-	1 (0.1%)	-
Aplysia parvula Mörch, 1863	-	-	1 (0.1%)	-	-	-	3 (0.2%)	-
Ascobulla fragilis (Jeffreys, 1856)	-	-	-	1 (0.1%)	-	-	-	-
Williamia gussoni (Costa O.G., 1829)	3 (0.7%)	-	4 (0.4%)	-	6 (0.8%)	-	14 (1%)	-
Eulimella acicula (Philippi, 1836)	-	-	-	-	-	-	1 (0.1%)	-
Odostomia acuta Jeffreys, 1848	-	-	1 (0.1%)	1 (0.1%)	-	-	-	-
Odostomia sicula Philippi, 1851	-	1 (0.1%)	2 (0.2%)	1 (0.1%)	-	-	-	-
Odostomia turriculata Monterosato, 1869	-	-	-	-	-	-	1 (0.1%)	-
Ondina vitrea (Brusina, 1866)	-	-	-	5 (0.5%)	-	1 (0.1%)	-	-
Parthenina interstincta (J. Adams, 1797)	-	1 (0.1%)	1 (0.1%)	-	-	-	-	-
***Parthenina monterosatii* (Clessin, 1900)**	**-**	**1 (0.1%)**	**-**	**-**	**-**	**-**	**-**	**-**
Parthenina terebellum (Philippi, 1844)	-	1 (0.1%)	-	-	-	-	-	-
Pyrgostylus striatulus (Linnaeus, 1758)	-	5 (0.5%)	4 (0.4%)	6 (0.6%)	-	1 (0.1%)	-	8 (1%)
Notodiaphana atlantica Ortea, Moro & Espinosa, 2013	-	1 (0.1%)	-	-	-	-	-	-
Nucula nitidosa Winckworth, 1930	-	20 (2%)	2 (0.2%)	3 (0.3%)	1 (0.1%)	5 (0.4%)	7 (0.5%)	3 (0.4%)
Crenella arenaria Monterosato, 1875 ex H. Martin, ms.	1 (0.2%)	16 (1.6%)	-	3 (0.3%)	2 (0.3%)	9 (0.7%)	17 (1.2%)	6 (0.7%)
Gregariella semigranata (Reeve, 1858)	-	-	-	1 (0.1%)	-	1 (0.1%)	1 (0.1%)	-
Modiolula phaseolina (Philippi, 1844)	-	-	-	1 (0.1%)	-	-	-	-
Musculus costulatus (Risso, 1826)	11 (2.6%)	59 (5.9%)	7 (0.6%)	6 (0.6%)	15 (2%)	10 (0.8%)	5 (0.3%)	1 (0.1%)
**Septifer cumingii* Récluz, 1848	6 (1.4%)	18 (1.8%)	-	8 (0.8%)	6 (0.8%)	7 (0.5%)	3 (0.2%)	3 (0.4%)
***Barbatia barbata* (Linnaeus, 1758)**	**3 (0.7%)**	**12 (1.2%)**	**3 (0.3%)**	**4 (0.4%)**	**4 (0.5%)**	**7 (0.5%)**	**2 (0.1%)**	**4 (0.5%)**
Arca noae Linnaeus, 1758	1 (0.2%)	4 (0.4%)	2 (0.2%)	-	1 (0.1%)	-	1 (0.1%)	1 (0.1%)

Table 6 continued

	05 SP	05 AU	10 SP	10 AU	15 SP	15 AU	20 SP	20 AU
Striarca lactea (Linnaeus, 1758)	4 (0.9%)	7 (0.7%)	7 (0.6%)	16 (1.5%)	8 (1.1%)	14 (1.1%)	10 (0.7%)	12 (1.4%)
**Isognomon* sp.	-	1 (0.1%)	-	-	-	-	-	-
**Pinctada imbricata radiata* (Leach, 1814)	2 (0,5%)	8 (0.8%)	4 (0.4%)	1 (0.1%)	9 (1.2%)	1 (0.1%)	12 (0.8%)	6 (0.7%)
***Pinna nobilis* Linnaeus, 1758**	**1 (0.2%)**	**-**	**2 (0.2%)**	**-**	**3 (0.4%)**	**-**	**1 (0.1%)**	**-**
***Flexopecten hyalinus* (Poli, 1795)**	**1 (0.2%)**	**5 (0.5%)**	**2 (0.2%)**	**-**	**-**	**4 (0.3%)**	**3 (0.2%)**	**3 (0.4%)**
Lima lima (Linnaeus, 1758)	-	-	1 (0.1%)	-	-	2 (0.2%)	1 (0.1%)	1 (0.1%)
Limatula subauriculata (Montagu, 1808)	-	13 (1.3%)	2 (0.2%)	6 (0.6%)	2 (0.3%)	25 (1.9%)	21 (1.4%)	7 (0.8%)
Ctena decussata (O.G. Costa, 1829)	-	7 (0.7%)	-	11 (1%)	-	6 (0.5)	8 (0.5%)	11 (1.3%)
***Loripinus fragilis* (Philippi, 1836)**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1 (0.1%)**
***Megaxinus unguiculinus* Pallary, 1904**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1 (0.1%)**
Myrtea spinifera (Montagu, 1803)	-	-	-	-	-	1 (0.1%)	-	-
Thyasira sp.	1 (0.2%)	25 (2.5%)	37 (3.4%)	34 (3.2%)	7 (0.9%)	25 (1.9%)	40 (2.7%)	14 (1.7%)
Cardita calyculata (Linnaeus, 1758)	-	-	-	1 (0.1%)	-	3 (0.3%)	-	-
***Cardites antiquatus* (Linnaeus, 1758)**	**-**	**-**	**-**	**-**	**-**	**7 (0.5%)**	**1 (0.1%)**	**1 (0.1%)**
Glans trapezia (Linnaeus, 1767)	2 (0.5%)	102 (10.2%)	3 (0.3%)	38 (3.6%)	5 (0.7%)	14 (1.1%)	16 (1.1%)	23 (2.7%)
***Parvicardium trapezium* Cecalupo & Quadri, 1996**	**-**	**4 (0.4%)**	**-**	**-**	**1 (0.1%)**	**-**	**-**	**-**
Arcopella balaustina (Linnaeus, 1758)	-	1 (0.1%)	-	1 (0.1%)	-	2 (0.2%)	1 (0.1%)	1 (0.1%)
***Donax semistriatus* Poli, 1795**	**1 (0.2%)**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Abra alba (W. Wood, 1802)	-	1 (0.1%)	-	2 (0.2%)	-	-	-	-
Gouldia minima (Montagu, 1803)	-	-	1 (0.1%)	-	1 (0.1%)	1 (0.1%)	-	2 (0.2%)
***Lajonkairia lajonkairii* (Payraudeau, 1826)**	**-**	**1 (0.1%)**	**-**	**-**	**-**	**1 (0.1%)**	**-**	**-**
Hiatella arctica (Linnaeus, 1767)	-	1 (0.1%)	-	-	-	-	-	-

The non-metric multi-dimensional scaling plot shows hardly any difference between the four sampling stations, regarding the mollusc assemblage (**Fig. 15**). Nevertheless, a PERMANOVA revealed a significant difference between the depths (Fd = 3.706, R^2 = 0.144, p = 0.001). It must be pointed out, that this difference is only explained by 14.4 % of the variation in the data. A pairwise comparison post hoc test shows that the 5-m station is significantly different from all the other stations (**Table 7**). The significant difference can be explained by roughly one fourth of the variation in the data.

Table 7 Results of the pairwise comparison of the Mollusca assemblage of different stations. The p adjusted values are calculated with the Bonferroni correction.

Stations	Fd	R^2	p adjusted
5 m vs. 10 m	2.952	0.228	**0.048**
5 m vs. 15 m	3.480	0.258	**0.024**
5 m vs. 20 m	3.744	0.272	**0.018**
10 m vs. 15 m	1.316	0.116	1.000
10 m vs. 20 m	1.786	0.152	0.396
15 m vs. 20 m	1.327	0.117	0.972

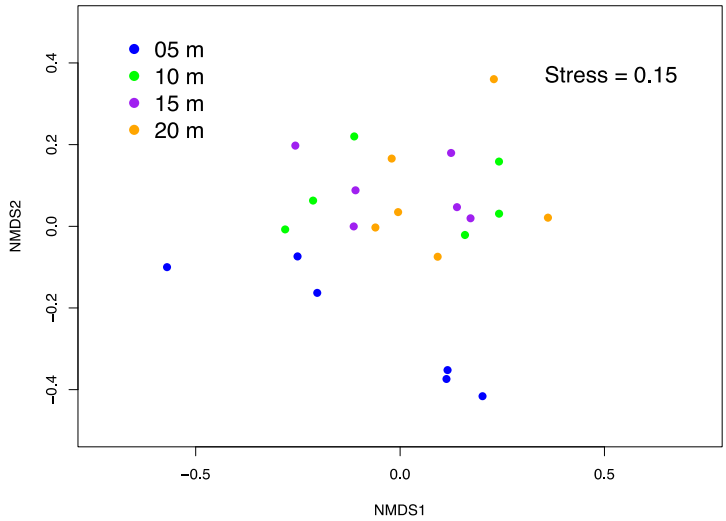

Figure 15 Non-metric multi-dimensional scaling plot representing replication of the different sampling stations. The 5 m replicates seem to be slightly different to the rest of the samples.

Comparing the Shannon index of the different stations and seasons with a pairwise t-test, shows that only the 5-m station in autumn is significantly different from the 10-m station in autumn and the 15- and 20-m station in both seasons (**Table 8**).

Table 8 Adjusted p-values (Bonferroni correction) of the pairwise t-test comparing the Shannon indexes over the four different sampling stations (05, 10, 15, 20) and the two different sampling seasons (SP= spring, AU= autumn) in the rhizome layer. Significant values are in bold.

	05 AU	05 SP	10 AU	10 SP	15 AU	15 SP	20 AU
05 SP	0.072	-	-	-	-	-	-
10 AU	**0.048**	1	-	-	-	-	-
10 SP	0.050	1	1	-	-	-	-
15 AU	**0.019**	1	1	1	-	-	-
15 SP	**0.012**	1	1	1	1	-	-
20 AU	**0.032**	1	1	1	1	1	-
20 SP	**0.015**	1	1	1	1	1	1

Differences in the Mollusca assemblage between seasons

The difference in the mollusc assemblage between spring and autumn is not as prominent in the leaf layer as in the rhizome layer (**Fig. 16 A; B)**. However, PERMANOVA indicates significant differences between the two seasons for both layers (leaf layer: Fd = 5.18, R^2 = 0.19, p = 0.001; rhizome layer: Fd = 6.23, R^2 = 0.22, p = 0.001). In the leaf layer, four species were exclusively found in spring and three species solely in autumn. In spring, 5 specimens of *Granulina marginata* were found at the 10-m station, one specimen of *Muricopsis cristata* at the 15-m station, and one specimen each of *Aplysia parvula* and of *Pinctada imbricata radiata* at the 20-m station. In autumn, *Pusillina philippi* is represented by one specimen in the 5-m station and six individuals at the 20-m station. *Alvania lineata* was present with two specimens, one at the 5-m station and one at the 20-m station, and one individual of *Barbatia barbata* was sampled at the 15-m station.

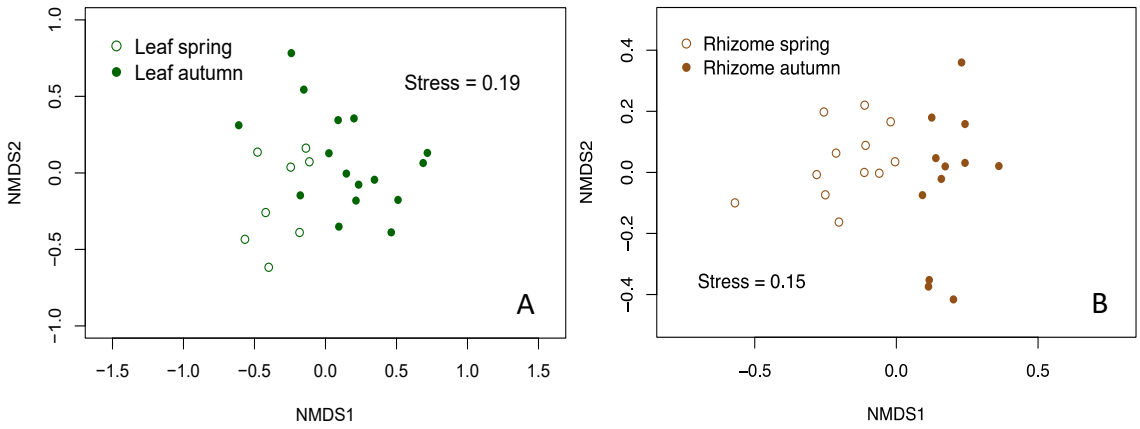

Fig. 16 Non-metric multi-dimensional scaling plots representing replication of the different sampling seasons of the leaf layer (A) and the rhizome layer (B). Empty circles represent samples taken in spring and solid circles samples taken in autumn. The samples of the different seasons are visually apart from each other.

In the rhizome layer six species were only present in spring and another six species were exclusively found in autumn. The species and number of specimens per sampling station are given in **Table 9**.

Table 9 Species found in the rhizome layer, which were exclusively present in spring (SP) or in autumn (AU). The distribution shows endemic (E), native (N) and alien (A) species. Singletons and species only present in one depth are excluded from the list.

	05 SP	10 SP	15 SP	20 SP	Distribution
Notocochlis dillwynii (Payraudeau, 1826)	1 (0.2%)	1 (0.1%)	1 (0.1%)	2 (0.1%)	E
Retusa truncatula (Bruguière, 1792)	5 (1.2%)	11 (1%)	5 (0.7%)	8 (0.5%)	N
Philine catena (Montagu, 1803)	2 (0.5%)	1 (0.1%)	-	1 (0.1%)	N
Aplysia parvula Mörch, 1863	-	1 (0.1%)	-	3 (0.2%)	N
Williamia gussonii (Costa O.G., 1829)	3 (0.7%)	4 (0.4%)	6 (0.8%)	14 (1%)	N
Pinna nobilis Linnaeus, 1758	1 (0.2%)	2 (0.2%)	3 (0.4%)	1 (0.1%)	E
Total	12	20	15	29	
	05 AU	10 AU	15 AU	20 AU	Distribution
Viriola bayani Jousseaume, 1884	-	1 (0.1%)	-	1 (0.1%)	A

Table 9 continued

	05 AU	10 AU	15 AU	20 AU	Distribution
Melanella lubrica (Monterosato, 1890)	2 (0.2%)	-	-	1 (0.1%)	N
Euthria cornea (Linnaeus, 1758)	2 (0.2%)	1 (0.1%)	-	-	N
Clathromangelia granum (Philippi, 1844)	1 (0.1%)	-	2 (0.2%)	1 (0.1%)	E
Ondina vitrea (Brusina, 1866)	-	5 (0.5%)	1 (0.1%)	-	N
Abra alba (W. Wood, 1802)	1 (0.1%)	2 (0.2%)	-	-	N
Total	6	9	3	3	

Comparison of the leaf and rhizome layer

The rhizome layer is richer in mollusc species and hosts a much higher number of individuals per species (**Fig. 17**). This is particularly evident in the group of Bivalvia: whereas only two species were found in the leaf layer, 30 species were found in the rhizome layer. The four species of Polyplacophora were solely present in the rhizome layer.

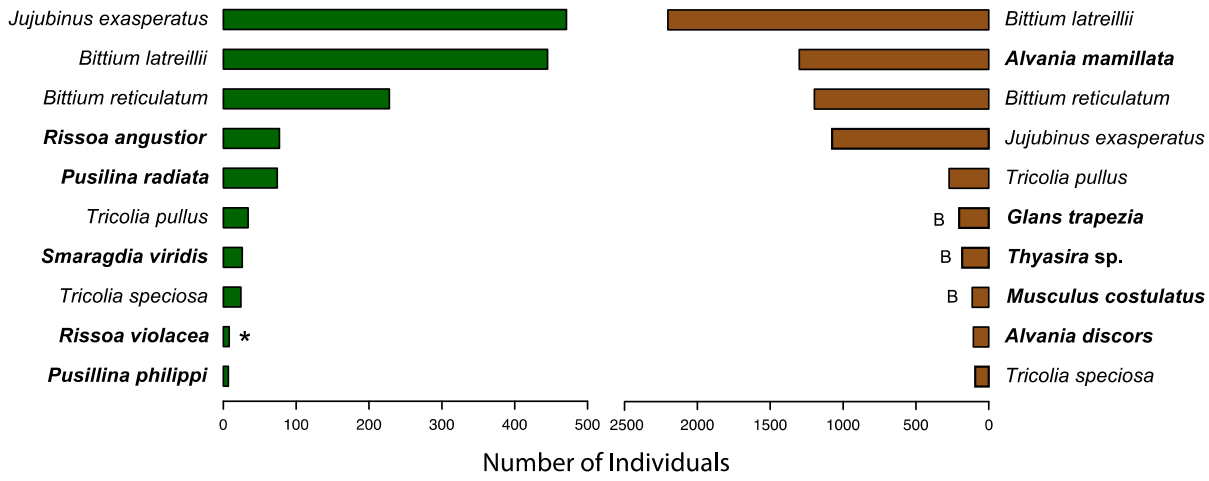

Figure 17 Comparison of the ten most abundant species in the leaf layer (left) and in the rhizome layer (right). The asterisk marks the species only found in the leaf layer. The B marks all species belonging to the Bivalvia. The species in bold are only in one of the layers within the ten most abundant species. The abundance of most species is much higher in the rhizome layer than in the leaf layer.

Gastropods were the most abundant molluscs at all stations. The comparison of the ten most abundant species in the two layers shows that five species were present in both layers with high abundances but with different ranking. Whereas *Jujubinus exasperatus* is the most abundant species in the leaf layer, it ranks only fourth in the rhizome layer. Still the number of individuals found in the rhizome layer is more than twice the number found in the leaf stratum. This is also true for all the other species these two layers have in common (**Fig. 17**). The non-metric multi-dimensional scaling plot shows that the two layers are distinct (**Fig. 18**). Indeed, such assemblages are significantly different (PERMANOVA, Fd=29.83, R^2=0.39, p=0.001).

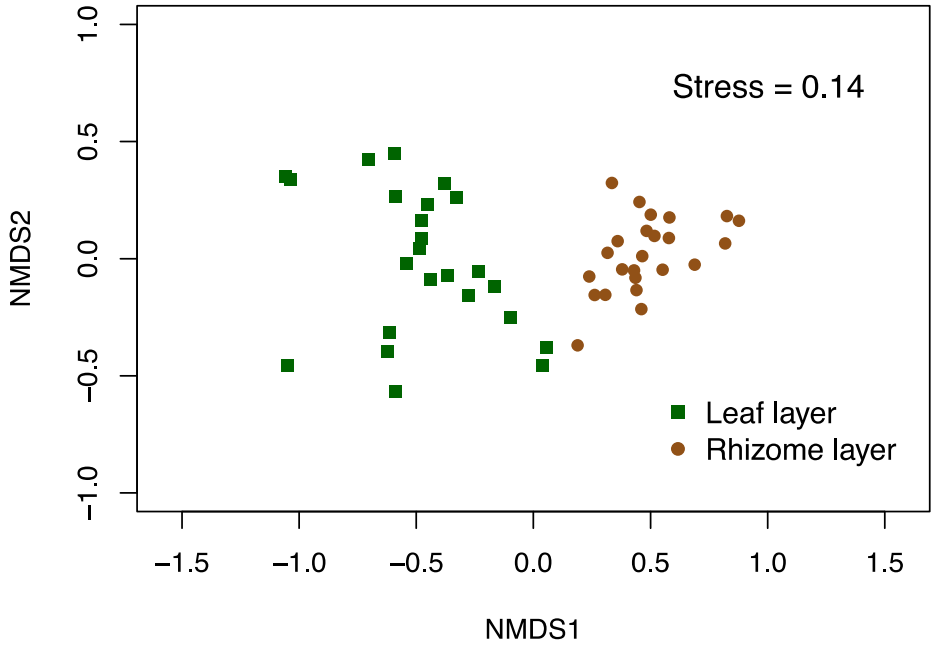

Figure 18 Non-metric multi-dimensional scaling plots representing the two different layers. The mollusc assemblage differs clearly between the two layers.

Discussion

The state of the samples *P. oceanica* meadow

The shoot density of the sampled *Posidonia oceanica* meadow declines with depth (**Fig. 19**). This is caused by an adaption to lower light conditions at depth (Olesen et al., 2002). The monitoring program of the UNEP/MAP-RAC/SPA, (2011) suggests ranges of shoots per square meter over different depths for five states, "high", "good," "moderate", "poor" and "bad" (**Table 10**). Comparing those numbers indicates that the *P. oceanica* meadow at Plakias Bay at the 5-meter station is in a good to moderate condition. While all the other stations are in a high to good state (**Table 10**).

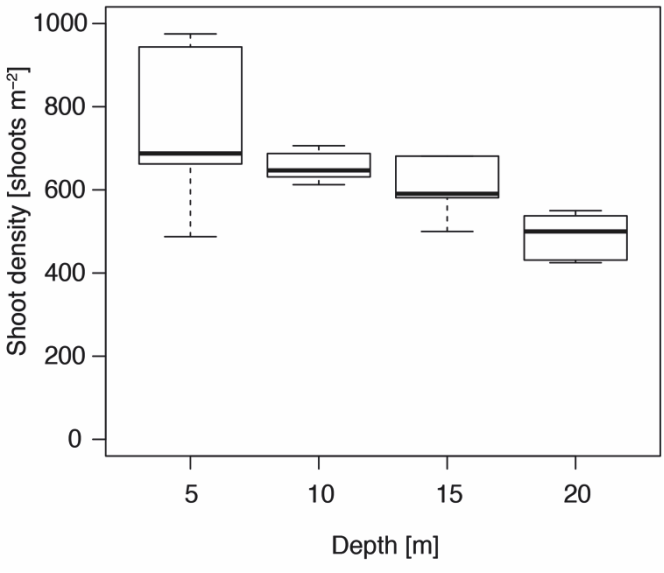

Figure 19 Shoot density (shoots per m^2) of the four sampling depths of a *Posidonia oceanica* meadow in Plakias at the SW coast of Crete.

Table 10 Comparison of shoot density between this study and the suggested numbers of shoots for five different states (High, Good, Moderate, Poor, Bad) of a *Posidonia oceanica* meadow. Numbers used from UNEP/MAP-RAC/SPA, (2011). Bold numbers indicate the ranges of shoot density and status of the observed seagrass meadow.

		Shoots per m^2				
Depth (m)	Present study	High	Good	Moderate	Poor	Bad
5	740.63 ± 185.5	>892	**892 to 709**	**709 to 526**	526 to 343	<343
10	655.21 ± 36.5	**>662**	**662 to 513**	513 to 364	364 to 214	<214
15	604.17 ± 68.8	**>492**	492 to 372	372 to 253	253 to 134	<134
20	490.63 ± 52.6	**>365**	365 to 271	271 to 177	177 to 83	<83

Pergent-Martini and Pergent (1994) studied seagrass meadows at seven sites in four countries. All of their sampled meadows showed a lower shoot density at depths comparable to the one sampled in the present study. A study at the Pagassitikos Gulf (a semi-enclosed area of the western Aegean Sea) sampled a *P. oceanica* meadow at two different depths (3 m, 10 m). They observed a very low shoot density at the 10 m site: 163 ± 38 (Amoutzopoulou-Schina and Haritonidis, 2005).

The much higher standard deviation of shoot density at the 5-m station compared to the others, could be an indicator of disturbance. One explanation could be a higher hydrodynamic movement at the shallow station. Amoutzopoulou-Schina and Haritonidis (2005) also observed more homogenous shoot density at deeper areas.

Regarding the shoot density, the *Posidonia oceanica* meadow in Plakias Bay, is in a "healthy" condition compared to other seagrass meadows in the Mediterranean Sea.

The mollusc assemblage

The Malacofauna in *P. oceanica* meadows have been thoroughly studied in the western Mediterranean Sea (Albano and Sabelli, 2012; Como et al., 2008; Idato et al., 1983; Russo et al., 1991; Urra et al., 2013). Hardly anything is known about the mollusc assemblage of *Posidonia oceanica* in the eastern Mediterranean basin, the chronical understudied area of the Mediterranean Sea. This study provides novel data about this very diverse habitat and its highly abundant Malacofauna.

A study sampling exclusively at 2 m depth at the north-western Alboran Sea, during four different seasons (April, July, November and January) found 17416 specimens belonging to 171 species. In total 40 different replicates were collected (Urra et al., 2013). Like in the present study the most abundant and species-rich taxon were the Gastropoda with 115 (67.25%) species, followed by Bivalvia with 52 (30.4%) species and Polyplacophora with 4 (2.33%) species. In the present study, 76 (69.1%) species belong to the Gastropoda, 30 (27.3%) to the Bivalvia and 4 (3.6%) to the Polyplacophora.

The characteristic gastropod species found in the seagrass meadow in Plakias Bay belong to the family Cerithiidae (*Bittium latreillii* and *B. reticulatum)*, Trochidae (*Jujubinus exasperatus)* and Rissoidae (*Alvania mamillata).* Those taxa account for 74.1% of all the specimens found. All four species are typically found in a seagrass meadows. (Donnarumma et al., 2018a; Russo et al., 1991; Urra et al., 2013; Vetere et al., 2006). The four dominant bivalve species found belong to the families Carditidae (*Glans trapezia*), Mytilidae (*Musculus costulatus*) and Noetiidae (*Striaca lactea*), Thyasiridae (*Thyasira sp.*). These taxa account for 57.2% of all found Bivalvia. The first three are typical species in the studied habitat and are suspension feeders (Donnarumma et al., 2018b). The described species reflect a typical, rich and "healthy" assemblage of a *Posidonia oceanica* meadow.

A study comparing the molluscan assemblage of seagrass habitats with sand habitats along Florida's Gulf Coast, found a much higher alpha diversity at the seagrass sites (Hyman et al., 2019). The authors further concluded that seagrass meadows host a distinct composition an elevated biodiversity. The high number of collected mollusc specimens and the resulting species rich assemblage in the present study confirms the conclusion of Hyman et al. (2019).

The mollusc assemblage of the leaf layer

A *Posidonia oceanica* meadow cannot be considered as a single biocoenosis but should be separated in two layers. The leaf layer, which is well-lit and more exposed to hydrodynamic changes, and the rhizome layer, a dark and highly heterogenous environment (Pérès and Picard, 1964). This is supported by the significant difference found between the leaf and rhizome layer in this study. The difference is driven by the higher biodiversity of the rhizome layer reflected by the Shannon index of 2.24 ± 0.30 in the rhizome layer compared to that (1.16 ± 0.38) in the leaf layer.

The observed species in the leaf stratum are typical for *Posidonia oceanica* meadows. Similar species compositions are described in various studies investigating the invertebrate fauna of this habitat (Albano and Sabelli, 2012; Donnarumma et al., 2018a; Takada et al., 1999; Vetere et al., 2006).The molluscan community of the leaf layer showed no significant differences over the four depth (5 m, 10 m, 15 m, 20 m). This contradicts the findings of Idato et al. (1983). He and his colleagues studied the leaf Malacofauna along a depth gradient from 1 to 30 metres at the Gulf of Naples. They described four coenotic entities. Similar results were found by Russo et al. (1991) in the area of Sardinia. He and his colleagues describe a shallow water (1 to 5 m of depth) and a deep water (15 to 25 m of depth) community. Both studies observed water movement as the main driver. The lack of such a difference in the present study might be due to a different sampled depth range. For shallower stations the sampled *Posidonia oceanica* meadow was too patchy for comparable results. Deeper samples were not feasible within the scope of this study. Another reason could be the clear water due to oligotrophic conditions of the waters surrounding the SW coast of Crete. This might allow the same epiphyte growth on the leaves of the *P. oceanica* meadow from 5 – 20 m. If so, these epiphytic algae would also support the appearance of the same leaf dwelling gastropods. To clarify this, further studies are needed.

The Malacofauna of the rhizome layer

While most studies of the molluscan assemblage of *Posidonia oceanica* focus on the leaf stratum, few studies have investigated the rhizome layer.

The molluscan assemblage of the rhizome layer showed a significant difference between the four depths. A post hoc test revealed that only the 5-m station was different to all the other stations. Comparing the Shannon indexes over the different stations and season shows, that only the 5-m station in autumn might be responsible for the significant difference (**Fig. 20**). The Shannon index of the 5-m station is much higher in autumn than in spring (**Table 4**). The here presented difference is very weak and it must be considered that a sampling bias or a very patchy distribution of the sampled taxa might be responsible. Nevertheless many studies report differences in abundance and species richness between sampling seasons and depths (Belgacem et al., 2013; Martini et al., 2001; Russo

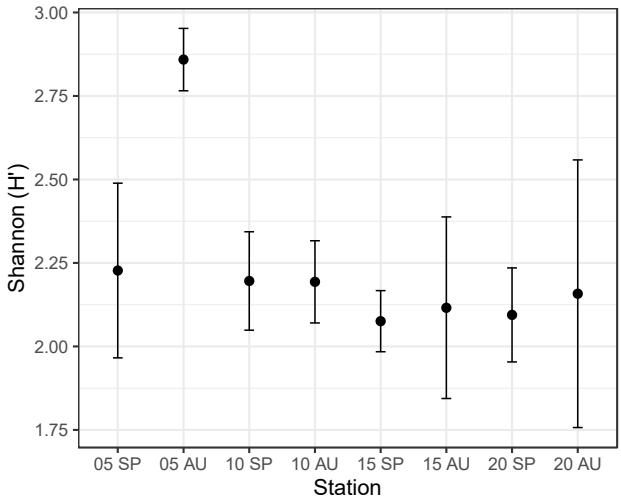

Figure 20 Comparison of the Shannon index (H') over the four different sampling stations (5 m, 10 m, 15 m, 20 m) and two different seasons (SP = spring; AU= autumn), with the standard deviation, in the rhizome layer.

et al., 1991; Urra et al., 2013). A study in Tunisia also found a higher Shannon diversity at their 3 m samples compared to the 10 m samples (Belgacem et al., 2013).
The seasonal difference in the present study is more pronounced than the difference over depth (**Fig. 16**). The reason is that mollusc communities are influenced by seasonal change in water movement (Russo et al., 1991), in nutrients and epiphytic growth on the leaf stratum of seagrass meadows (Gambi et al., 1992). The here demonstrated higher number of species in autumn for the 5-, 10- and 15-m station (**Table 4**), and the appearance and disappearance of species in the two seasons (**Table 8**), demonstrates the role of life history (e.g. spawning time) of some species. This has also been observed by Gambi et al., (1992) and Vetere et al. (2006).

Alien species and the biotic resistance hypothesis

The number of non-native species in the Mediterranean Sea is increasing. For Greece 145 non-indigenous species have been recorded with established populations. Most of these species have their natural distribution in the Indo-Pacific (including the Red Sea). This ranks Greece the country with the 6th highest number of non-native species among Mediterranean countries (Galil et al., 2018). The surprisingly low numbers of those species and their abundance in the current study contrasts with the reported higher number of non-native species for Crete and their established populations (**Table 1**). Of the four alien species collected, only *Viriola bayani* was present in an adult stage. The specimens collected within the scope of this study were reported as the first sightings of live specimens of this species in coastal waters of Greece (Steger et al., 2018). Nevertheless, two individuals are too few for speculations about the population status in the sampled habitat. The species *Septifer cumingii*, *Pinctada imbricata radiata* and *Isognomon* sp. were only present as juvenile individuals of a few millimetres in size. The bivalve *S. cumingii* is the most abundant non-native species collected at the seagrass meadow at Plakias Bay. The abundance suggests an established population in this area. The first record in the Mediterranean Sea was in the Iskenderun Bay, Turkey, under the synonym: *Septifer bilocularis* (Linnaeus, 1758) (Albayrak and Çeviker, 2001). In 2010 the first specimens in Greek waters were recorded in the southern Aegean under the synonym of *Septifer forskali* Dunker, 1855. In the same year this species was observed for the first time on the north coast of Crete (Zenetos et al., 2011). All studies report *S. cumingii* attached to a hard substrate like rocks or other bivalves. The current study presents the first observation of this species in a seagrass meadow in Plakias Bay at the SW coast of Crete.
The bivalve *Pinctada imbricata radiata* (Leach, 1814) was one of the first non-native species, which reached the Mediterranean Sea via the Suez Canal (Monterosato, 1878). By now it has established populations all over the eastern Mediterranean basin and reached as far as Linosa Island in Italy (Lodola et al., 2013) and the southern Adriatic Sea (Petović and Mačić, 2017). This species has been extensively studied in Tunisia. Although mainly found on rocky substrate, it has also been reported attached to the root system of *Posidonia oceanica* and other seagrass species (Lassoued et al., 2018; Tlig-Zouari et

al., 2009), suggesting this habitat as suitable. However, considering the presence of only juvenile specimens, the ability of this non-native species to reach an adult stage in the sampled seagrass meadow is questionable. To answer this question further observations are needed. The fourth and last non-native species found is one specimen of *Isognomon* sp., which could not be further identified due to its juvenile state.

All observed alien specimens comprise only 1.05% of all collected molluscs in the sampling area. This raises the question of the invasibility of the *Posidonia oceanica* meadow on the SW coast of Crete. According to the biotic resistance hypothesis the invasibility of an ecosystem or habitat is increasing with decreasing biodiversity. This has also been shown by experimental studies, which found that species-rich environments are more resistant against invasive species (Stachowicz et al., 1999; Stachowicz and Byrnes, 2006). The argumentation for a species-rich habitat to be more resistant against invasion is that it hosts fewer empty niches, for example in the form of space or nutrients. Another important biotic factor in highly diverse communities is the presence of suitable predators to prey upon the newly introduced species, as shown by a study of Hunt and Behrens Yamada (2003). In contrast to the experimental studies, observational studies often find no proof of the biotic resistance hypothesis or even observed an increase in non-native species with increasing native communities (Lonsdale, 1999; Stohlgren et al., 1999). Stachowicz and Byrnes (2006) argue that these contradicting results arise due to different questions answered in the observational compared to experimental settings. Observational studies often compare sites and find, that sites with a higher biodiversity also host more non-native species than sites with low biodiversity. That can be explained by the characteristics of a habitat: those that support a high native diversity are also able to support a high diversity of non-native species (Davies et al., 2005). In contrast, experimental studies often address the question of the invasibility of a habitat, when native species are lost. This loss due to anthropogenic activity should increase the invasion success of non-native species (Shea and Chesson, 2002).

I observed a *Posidonia oceanica* meadow in Plakias Bay with a very high shoot density compared to other meadows in the Mediterranean Sea. This density naturally declines with depth and does not show signs of anthropogenic impact. I found a rich and abundant mollusc community typical of the Mediterranean Sea and these results agree with other authors' reports that *P. oceanica* meadows are able to host a high diversity (Boudouresque et al., 2016; Kalogirou et al., 2010). This suggests that the sampled seagrass meadow was at an almost pristine state during the sampling period in 2017. Its high native biodiversity and marginal presence of alien species supports the biotic resistant hypothesis.

Conclusion

This study presents novel data of a well-preserved *Posidonia oceanica* meadow and it's Malacofauna on the south-west coast of Crete. The shoot density and the rich and abundant native mollusc fauna reveals an almost pristine ecosystem in an area, where no data has been collected so far. The presented results are a baseline of the status of the sampled *Posidonia oceanica* meadow and distribution data on native and non-native mollusc species. The low presence of Lessepsian non-native species is in accordance with the biotic resistance hypothesis. Further studies are needed to compare other habitats, like rocky substrate and other seagrass meadows in the same area for more insights on the important topic of non-native species in the eastern Mediterranean Sea. I want to stress the importance of a seasonal sampling design, when attempting the assessment of a complete assemblage of short-lived species. Especially when the influence of non-native species is taken into account.

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Abstract

The marine environment is vital for the human well-being. It performs a variety of ecosystem functions and services. A very important ecosystem in the Mediterranean Sea is formed by the endemic seagrass species *Posidonia oceanica*. This habitat and its functions are threatened by anthropogenic impacts, like climate change, pollution, exploitation and the introduction of non-native species. These species are able to alter ecosystem functions by reducing native biodiversity and the destruction of food webs. Since the opening of the Suez Canal in 1869 an increasing number of non-native species has entered the eastern Mediterranean basin. Most of them belong to the Mollusca, which is not surprising considering the high diversity of this phylum. The presented study provides novel data of a Mollusca community in a *Posidonia oceanica* meadow on the SW coast of Crete. Samples were collected in May and September 2017. The leaf and the rhizome layer of the seagrass meadow were inspected at four depths (5 m, 10 m, 15 m, 20 m). The state of the meadow was assessed using the number of shoots per square meter as a proxy. The shoot density ranged from 740 ± 185 shoots m^{-1} at 5 m depth to 490 ± 52 shoots m^{-1} at 20 m depth. The count at 5 m depth indicates a “good to moderate” and at 20 m depth a “high” state, according to the monitoring guidelines of marine magnoliophyte in the Mediterranean Sea of the United Nations Environment Program (UNEP). A total of 9344 specimens, belonging to 110 species were collected in the sampled *Posidonia oceanica* meadow. The majority of the collected species are native and endemic species. In total 98 specimens of non-native species were present, belonging to only 4 species, *Septifer cumingii, Pinctada imbricate radiata*, *Viriola bayani* and *Isognomon sp.*. The biotic resistance hypothesis states, that ecosystems with a high native biodiversity are more resistant to the establishment of non-native species, than ecosystems with a low biodiversity. The low number of non-native species in this healthy *Posidonia oceanica* meadow at the SW coast of Crete and the high abundance and number of native species, agrees with this hypothesis.

Zusammenfassung

Das Ökosystem Meer spielt eine sehr wichtige Rolle für den Menschen, indem es eine Vielzahl von wichtigen Funktionen und Diensten bereitstellt. Ein wichtiges Habitat im Mittelmeer ist die Seegrasart *Posidonia oceanica*. So wie viele andere, ist auch dieses Habitat durch anthropogene Einflüsse, wie den Klimawandel, Verschmutzung, Ausbeutung und die Einbringung von gebietsfremden Arten bedroht. Diese Arten können die Funktionen dieses Habitats negativ beeinflussen, indem sie die heimische Artenvielfalt verringern und somit das Nahrungsnetz stören. Seit der Öffnung des Suez Kanals im Jahre 1869 steigt die Anzahl der eingeschleppten Arten im östlichen Mittelmeer dramatisch. Die meisten dieser Arten gehören zu den Mollusken, was nicht überraschend ist, da dieses Phylum sehr divers ist. Die vorliegende Arbeit präsentiert neue Erkenntnisse über eine Molluskengemeinschaft in einer Wiese von *Posidonia oceanica* an der SW Küste Kretas. Die Proben wurden im Mai und September 2017 gesammelt. Die Blatt- und Rhizomschicht wurde in vier verschieden Tiefen beprobt (5 m, 10 m, 15 m, 20 m). Zusätzlich wurde der Status der Seegraswiese erhoben, idem die Sprossen pro Quadratmeter als Maßstab herangezogen wurden. Die so genannte Sprossendichte variierte von 750 ± 185 Sprossen m^{-1} in 5 m Tiefe zu 490 ± 52 Sprossen m^{-1} in 20 m Tiefe. Nach den Monitoring Richtlinien von marinen Magnoliophyta im Mittelmeer des United Nations Environment Program (UNEP), ist diese Sprossendichte ein Indikator für einen „guten bis moderaten“ Zustand in 5 m Tiefe und einen „sehr guten“ Zustand der Seegraswiese in 20 m Tiefe. Insgesamt wurden 9344 Mollusken gesammelt, welche 110 verschiedenen Arten zugeordnet werden konnten. Die meisten der gesammelten Arten sind heimische oder endemische Arten für das Mittelmeer. Insgesamt wurden 98 nicht heimische Mollusken gefunden, welche zu 4 verschiedenen Arten gehören, *Septifer cumingii, Pinctada imbricata radiata*, *Viriola bayani* und *Isognomon* sp..

Die “Biotic Resistance Hypothesis” besagt, dass Ökosysteme mit einer hohen Diversität heimischer Arten besser vor dem Eindringen gebietsfremder Arten geschützt sind, als Ökosysteme mit einer niedrigen heimischen Diversität. Die niedrige Anzahl eingeschleppter und die hohe Anzahl heimischer Arten, die in der beprobten *P. oceanica* Wiese gefunden wurden, unterstützt diese Hypothese.

Annex

Table A1 Molluscs found in *P. oceanica* leaf layer with quantitative data. The number of individuals for each station, replicate, season and the dominance index %D (in brackets).

		Spring			Autumn		
Familiy	Species	05_1	05_2	05_3	05_4	05_5	05_6
Trochidae	*Jujubinus exasperatus* (Pennant, 1777)	51 (19.3)	8 (33.3)	8 (72.7)	15 (44.1)	26 (37.1)	36 (73.5)
Calliostomatidae	*Calliostoma laugieri* (Payraudeau, 1826)	2 (0.8)	-	-	-	1 (1.4)	-
Phasianellidae	*Tricolia pullus* (Linnaeus, 1758)	-	-	2 (18.2)	5 (14.7)	3 (4.3)	1 (2.0)
	Tricolia speciosa (Megerle von Mühlfeld, 1824)	7 (2.7)	2 (8.3)	-	-	1 (1.4)	2 (4.1)
Neritidae	*Smaragdia viridis* (Linnaeus, 1758)	4 (1.5)	1 (4.2)	-	1 (2.9)	-	-
Cerithiidae	*Bittium latreillii* (Payraudeau, 1826)	98 (37.1)	7 (29.2)	-	11 (32.4)	31 (44.3)	9 (18.4)
	Bittium reticulatum (da Costa, 1778)	73 (27.7)	6 (25.0)	1 (9.1)	-	3 (4.3)	-
Rissoidae	*Alvania lineata* Risso, 1826	-	-	-	1 (2.9)	-	-
	Pusillina philippi (Aradas & Maggiore, 1844)	-	-	-	1 (2.9)	-	-
	Pusillina radiata (Philippi, 1836)	1 (0.4)	-	-	-	-	-
	Rissoa angustior (Monterosato, 1917)	28 (10.6)	-	-	-	5 (7.1)	1 (2.0)
		10_1	10_2	10_3	10_4	10_5	10_6
Trochidae	*Jujubinus exasperatus* (Pennant, 1777)	80 (54.8)	15 (40.5)	5 (62.5)	38 (74.5)	28 (77.8)	27 (75.0)
Calliostomatidae	*Calliostoma laugieri* (Payraudeau, 1826)	-	-	-	-	-	1 (2.8)
Phasianellidae	*Tricolia pullus* (Linnaeus, 1758)	5 (3.4)	1 (2.7)	1 (12.5)	2 (3.9)	4 (11.1)	1 (2.8)
	Tricolia speciosa (Megerle von Mühlfeld, 1824)	-	1 (2.7)	-	-	-	1 (2.8)
Neritidae	*Smaragdia viridis* (Linnaeus, 1758)	5 (3.4)	2 (5.4)	-	-	-	-
Cerithiidae	*Bittium latreillii* (Payraudeau, 1826)	6 (4.1)	3 (8.1)	2 (25.0)	3 (5.9)	4 (11.1)	6 (16.7)
	Bittium reticulatum (da Costa, 1778)	21 (14.4)	7 (18.9)	-	2 (3.9)	-	-
Rissoidae	*Pusillina radiata* (Philippi, 1836)	14 (9.6)	2 (5.4)	-	2 (3.9)	-	-
	Rissoa angustior (Monterosato, 1917)	10 (6.8)	5 (13.5)	-	4 (7.8)	-	-
Marginellidae	*Granulina marginata* (Bivona, 1832)	5 (3.4)	-	-	-	-	-
Muricidae	*Ocinebrina aciculata* (Lamarck, 1822)	-	1 (2.7)	-	-	-	-
		SP			AU		
Familiy	Species	15_1	15_2	15_3	15_4	15_5	15_6
Trochidae	*Jujubinus exasperatus* (Pennant, 1777)	30 (57.7)	3 (33.3)	4 (80.0)	4 (30.8)	4 (33.3)	2 (66.7)
Phasianellidae	*Tricolia pullus* (Linnaeus, 1758)	2 (3.8)	-	-	-	-	-

Table A1 continued

		SP			AU		
Familiy	Species	15_1	15_2	15_3	15_4	15_5	15_6
	Tricolia speciosa (Megerle von Mühlfeld, 1824)	1 (1.9)	1 (11.1)	1 (20.0)	-	-	1 (33.3)
Neritidae	*Smaragdia viridis* (Linnaeus, 1758)	5 (9.6)	3 (33.3)	-	-	-	-
Cerithiidae	*Bittium latreillii* (Payraudeau, 1826)	6 (11.5)	1 (11.1)	-	-	2 (16.7)	-
Rissoidae	*Pusillina radiata* (Philippi, 1836)	3 (5.8)	-	-	2 (15.4)	-	-
	Rissoa angustior (Monterosato, 1917)	4 (7.7)	1 (11.1)	-	7 (53.8)	2 (16.7)	-
	Rissoa violacea Desmarest, 1814	-	-	-	-	3 (25.0)	-
Muricidae	*Muricopsis cristata* (Brocchi, 1814)	1 (1.9)	-	-	-	-	-
Arcidae	*Barbatia barbata* (Linnaeus, 1758)	-	-	-	-	1 (8.3)	-
		20_1	20_2	20_3	20_4	20_5	20_6
Trochidae	*Jujubinus exasperatus* (Pennant, 1777)	26 (6.8)	5 (12.2)	3 (75.0)	25 (54.3)	15 (51.7)	13 (25.5)
Phasianellidae	*Tricolia pullus* (Linnaeus, 1758)	-	-	-	4 (8.7)	1 (3.4)	2 (3.9)
	Tricolia speciosa (Megerle von Mühlfeld, 1824)	3 (0.8)	-	-	-	1 (3.4)	2 (3.9)
Neritidae	*Smaragdia viridis* (Linnaeus, 1758)	5 (1.3)	-	-	-	-	-
Cerithiidae	*Bittium latreillii* (Payraudeau, 1826)	222 (58.0)	26 (63.4)	-	3 (6.5)	2 (6.9)	3 (5.9)
	Bittium reticulatum (da Costa, 1778)	104 (27.2)	8 (19.5)	1 (25.0)	1 (2.2)	1 (3.4)	-
Rissoidae	*Alvania lineata* Risso, 1826	-	-	-	1 (2.2)	-	-
	Alvania mamillata Risso, 1826	-	1 (2.4)	-	1 (2.2)	-	-
	Pusillina philippi (Aradas & Maggiore, 1844)	-	-	-	1 (2.2)	1 (3.4)	4 (7.8)
	Pusillina radiata (Philippi, 1836)	14 (3.6)	1 (2.4)	-	9 (19.6)	6 (20.7)	20 (39.2)
	Rissoa angustior (Monterosato, 1917)	6 (1.6)	-	-	-	-	4 (7.8)
	Rissoa violacea Desmarest, 1814	1 (0.3)	-	-	1 (2.2)	1 (3.4)	2 (3.9)
Muricidae	*Ocinebrina aciculata* (Lamarck, 1822)	-	-	-	-	1 (3.4)	1 (2.0)
Aplysiidae	*Aplysia parvula* Mörch, 1863	1 (0.3)	-	-	-	-	-
Pteriidae	*Pinctada imbricata radiata* (Leach, 1814)	1 (0.3)	-	-	-	-	-

Table A2 Molluscs found in *P. oceanica* rhizome layer with quantitative data. The number of individuals for each station, replicate, season and the dominance index %D (in brackets).

		Spring			Autumn		
Family	Species	05_1	05_2	05_3	05_4	05_5	05_6
Acanthochitonidae	*Acanthochitona fascicularis* (Linnaeus, 1767)	-	-	-	-	1 (0.3)	1 (0.3)
Leptochitonidae	*Leptochiton bedullii* Dell'Angelo & Palazzi, 1986	-	-	-	1 (0.3)	1 (0.3)	2 (0.7)
Callochitonidae	*Callochiton septemvalvis* (Montagu, 1803)	-	-	-	-	1 (0.3)	-
Scissurellidae	*Scissurella costata* d'Orbigny, 1824	2 (1.5)	6 (3.2)	-	2 (0.6)	2 (0.5)	1 (0.3)
Trochidae	*Jujubinus exasperatus* (Pennant, 1777)	16 (12.0)	15 (8.1)	9 (8.7)	13 (3.9)	16 (4.4)	18 (6.0)
	Steromphala varia (Linnaeus, 1758)	-	-	-	-	-	1 (0.3)
Calliostomatidae	*Calliostoma laugieri* (Payraudeau, 1826)	-	-	1 (1.0)	6 (1.8)	8 (2.2)	10 (3.3)
Phasianellidae	*Tricolia speciosa* (Megerle von Mühlfeld, 1824)	1 (0.8)	1 (0.5)	1 (1.0)	3 (0.9)	2 (0.5)	3 (1.0)
	Tricolia pullus (Linnaeus, 1758)	10 (7.5)	21 (11.3)	9 (8.7)	17 (5.1)	36 (9.8)	16 (5.3)
	Tricolia tenuis (Michaud, 1829)	-	-	-	4 (1.2)	-	-
Turbinidae	*Bolma rugosa* (Linnaeus, 1767)	-	-	-	-	-	1 (0.3)
Neritidae	*Smaragdia viridis* (Linnaeus, 1758)	4 (3.0)	3 (1.6)	7 (6.7)	10 (3.0)	8 (2.2)	9 (3.0)
Cerithiidae	*Bittium latreillii* (Payraudeau, 1826)	38 (28.6)	36 (19.4)	25 (24.0)	47 (14.2)	35 (9.5)	60 (19.9)
	Bittium reticulatum (da Costa, 1778)	32 (24.1)	35 (18.8)	36 (34.6)	16 (4.8)	22 (6.0)	4 (1.3)
	Cerithium sp.	-	-	-	-	1 (0.3)	-
Naticidae	*Notocochlis dillwynii* (Payraudeau, 1826)	-	-	1 (1.0)	-	-	-
Triphoridae	*Monophorus perversus* (Linnaeus, 1758)	-	-	-	-	1 (0.3)	-
	Marshallora adversa (Montagu, 1803)	-	-	-	-	1 (0.3)	-
	Similiphora similior (Bouchet & Guillemot, 1978)	-	-	-	1 (0.3)	-	-
Cerithiopsidae	*Cerithiopsis tubercularis* (Montagu, 1803)	-	-	-	1 (0.3)	1 (0.3)	2 (0.7)
Rissoidae	*Alvania mamillata* Risso, 1826	9 (6.7)	19 (10.2)	1 (1.0)	81 (24.4)	70 (19.1)	45 (15.0)
	Alvania discors (Allan, 1818)	5 (3.8)	7 (3.8)	2 (2.0)	17 (5.1)	22 (6.0)	18 (6.0)
	Alvania lineata Risso, 1826	1 (0.8)	4 (2.2)	-	2 (0.6)	3 (0.8)	2 (0.7)
	Alvania clarae Nofroni & Pizzini, 1991	-	-	-	2 (0.6)	-	-
	Rissoa angustior (Monterosato, 1917)	5 (3.8)	12 (6.5)	3 (2.9)	1 (0.3)	1 (0.3)	4 (1.3)
Rissoidae	*Pusillina radiata* (Philippi, 1836)	-	-	-	-	1 (0.3)	-
Rissoinidae	*Rissoina bruguieri* (Payraudeau, 1826)	-	-	-	1 (0.3)	2 (0.5)	-
Caecidae	*Caecum auriculatum* De Folin, 1868	-	-	-	-	-	1 (0.3)
Eulimidae	*Vitreolina philippi* (de Rayneval & Ponzi, 1854)	-	-	-	-	2 (0.5)	-
	Campylorhaphion famelicum (Watson, 1883)	-	-	-	1 (0.3)	1 (0.3)	-

Table A2 continued

Family	Species	Spring			Autumn		
		05_1	05_2	05_3	05_4	05_5	05_6
	Melanella lubrica (Monterosato, 1890)	-	-	-	-	2 (0.5)	-
Marginellidae	*Volvarina mitrella* (Risso, 1826)	-	-	-	-	-	1 (0.3)
Buccinidae	*Euthria cornea* (Linnaeus, 1758)	-	-	-	-	2 (0.5)	-
	Chauvetia turritellata (Deshayes, 1835)	-	-	-	-	2 (0.5)	-
Fasciolariidae	*Aegeofusinus rolani* (Buzzurro & Ovalis, 2005)	-	-	1 (1.0)	-	3 (0.8)	-
	Aptyxis syracusana (Linnaeus, 1758)	-	-	-	-	-	1 (0.3)
Muricidae	*Hexaplex trunculus* (Linnaeus, 1758)	-	-	-	3 (0.9)	-	4 (1.3)
	Muricopsis cristata (Brocchi, 1814)	-	1 (0.5)	-	1 (0.3)	2 (0.5)	1 (0.3)
Raphitomidae	*Clathromangelia granum* (Philippi, 1844)	-	-	-	-	1 (0.3)	-
Retusidae	*Retusa truncatula* (Bruguière, 1792)	2 (1.5)	3 (1.6)	-	-	-	-
Philinidae	*Philine catena* (Montagu, 1803)	-	-	2 (2.0)	-	-	-
Siphonariidae	*Williamia gussoni* (Costa O.G., 1829)	1 (0.8)	-	2 (2.0)	-	-	-
Pyramidellidae	*Parthenina interstincta* (J. Adams, 1797)	-	-	-	-	1 (0.3)	-
	Parthenina monterosatii (Clessin, 1900)	-	-	-	1 (0.3)	-	-
	Parthenina terebellum (Philippi, 1844)	-	-	-	-	-	1 (0.3)
	Odostomia sicula Philippi, 1851	-	-	-	-	1 (0.3)	-
	Pyrgostylus striatulus (Linnaeus, 1758)	-	-	-	2 (0.6)	-	3 (1.0)
Notodiaphanidae	*Notodiaphana atlantica* Ortea, Moro & Espinosa, 2013	-	-	-	-	1 (0.3)	-
Nuculidae	*Nucula nitidosa* Winckworth, 1930	-	-	-	5 (1.5)	10 (2.7)	5 (1.7)
Mytilidae	*Musculus costulatus* (Risso, 1826)	1 (0.8)	6 (3.2)	4 (3.8)	20 (6.0)	18 (4.9)	21 (7.0)
	Septifer cumingii Récluz, 1848	1 (0.8)	5 (2.7)	-	5 (1.5)	9 (2.5)	4 (1.3)
	Crenella arenaria Monterosato, 1875 ex H. Martin, ms.	1 (0.8)	-	-	9 (2.7)	5 (1.4)	2 (0.7)
Arcidae	*Arca noae* Linnaeus, 1758	-	1 (0.5)	-	2 (0.6)	-	2 (0.7)
Arcidae	*Barbatia barbata* (Linnaeus, 1758)	1 (0.8)	2 (1.1)	-	2 (0.6)	7 (1.9)	3 (1.0)
Noetiidae	*Striarca lactea* (Linnaeus, 1758)	1 (0.8)	3 (1.6)	-	2 (0.6)	1 (0.3)	4 (1.3)
Pteriidae	*Pinctada imbricata radiata* (Leach, 1814)	1 (0.8)	1 (0.5)	-	2 (0.6)	4 (1.1)	2 (0.7)
	Isognomon sp.	-	-	-	1 (0.3)	-	-
Pinnidae	*Pinna nobilis* Linnaeus, 1758	-	1 (0.5)	-	-	-	-
Pectinidae	*Flexopecten hyalinus* (Poli, 1795)	-	1 (0.5)	-	3 (0.9)	1 (0.3)	1 (0.3)
Limidae	*Limatula subauriculata* (Montagu, 1808)	-	-	-	8 (2.4)	3 (0.8)	2 (0.7)
Lucinidae	*Ctena decussata* (O.G. Costa, 1829)	-	-	-	3 (0.9)	1 (0.3)	3 (1.0)

Table A2 continued

		Spring			Autumn		
Family	Species	05_1	05_2	05_3	05_4	05_5	05_6
Thyasiridae	*Thyasira* sp.	-	1 (0.5)	-	3 (0.9)	18 (4.9)	4 (1.3)
Carditidae	*Glans trapezia* (Linnaeus, 1767)	-	2 (1.1)	-	32 (9.6)	34 (9.3)	36 (12.0)
Cardiidae	*Parvicardium trapezium* Cecalupo & Quadri, 1996	-	-	-	2 (0.6)	-	2 (0.7)
Tellinidae	*Arcopella balaustina* (Linnaeus, 1758)	-	-	-	-	1 (0.3)	-
Donacidae	*Donax semistriatus* Poli, 1795	1 (0.8)	-	-	-	-	-
Semelidae	*Abra alba* (W. Wood, 1802)	-	-	-	-	1 (0.3)	-
Veneridae	*Lajonkairia lajonkairii* (Payraudeau, 1826)	-	-	-	-	1 (0.3)	-
Hiatellidae	*Hiatella arctica* (Linnaeus, 1767)	-	-	-	-	-	1 (0.3)
Family	Species	10_1	10_2	10_3	10_4	10_5	10_6
Acanthochitonidae	*Acanthochitona fascicularis* (Linnaeus, 1767)	-	-	1 (0.2)	2 (0.6)	3 (0.7)	-
Leptochitonidae	*Leptochiton bedullii* Dell'Angelo & Palazzi, 1986	-	-	-	-	-	2 (0.8)
Fissurellidae	*Emarginula sicula* J.E. Gray, 1825	-	-	1 (0.2)	-	1 (0.2)	-
Scissurellidae	*Scissurella costata* d'Orbigny, 1824	1 (0.5)	10 (2.4)	15 (3.1)	-	-	-
Trochidae	*Jujubinus exasperatus* (Pennant, 1777)	32 (16.4)	85 (20.0)	67 (13.9)	33 (9.1)	52 (11.3)	28 (11.8)
	Jujubinus striatus (Linnaeus, 1758)	1 (0.5)	1 (0.2)	-	-	1 (0.2)	-
	Gibbula ardens (Salis Marschlins, 1793)	-	1 (0.2)	-	-	-	-
Calliostomatidae	*Calliostoma laugieri* (Payraudeau, 1826)	-	1 (0.2)	1 (0.2)	1 (0.3)	-	1 (0.4)
Phasianellidae	*Tricolia speciosa* (Megerle von Mühlfeld, 1824)	12 (6.2)	7 (1.7)	12 (2.5)	1 (0.3)	6 (1.3)	1 (0.4)
	Tricolia pullus (Linnaeus, 1758)	13 (6.7)	17 (4.0)	12 (2.5)	9 (2.5)	9 (2.0)	6 (2.5)
Turbinidae	*Bolma rugosa* (Linnaeus, 1767)	-	-	-	-	2 (0.4)	-
Neritidae	*Smaragdia viridis* (Linnaeus, 1758)	8 (4.1)	4 (0.9)	2 (0.4)	-	9 (2.0)	-
Cerithiidae	*Bittium latreillii* (Payraudeau, 1826)	41 (21.0)	58 (13.7)	91 (18.9)	94 (26.0)	117 (25.4)	58 (24.5)
	Bittium reticulatum (da Costa, 1778)	44 (22.6)	151 (35.6)	122 (25.4)	29 (8.0)	58 (12.6)	32 (13.5)
Naticidae	*Notocochlis dillwynii* (Payraudeau, 1826)	1 (0.5)	-	-	-	-	-
Triphoridae	*Marshallora adversa* (Montagu, 1803)	-	-	1 (0.2)	-	-	-
	Similiphora similior (Bouchet & Guillemot, 1978)	1 (0.5)	-	-	-	-	-
	Viriola bayani Jousseaume, 1884	-	-	-	1 (0.3)	-	-
Rissoidae	*Alvania mamillata* Risso, 1826	6 (3.1)	32 (7.5)	114 (23.7)	125 (34.5)	114 (24.8)	67 (28.3)
	Alvania discors (Allan, 1818)	7 (3.6)	1 (0.2)	-	-	2 (0.4)	-
	Rissoa angustior (Monterosato, 1917)	2 (1.0)	1 (0.2)	-	1 (0.3)	1 (0.2)	2 (0.8)
	Pusillina philippi (Aradas & Maggiore, 1844)	-	-	-	-	1 (0.2)	-

Table A2 continued

			Spring			Autumn	
Family	Species	10_1	10_2	10_3	10_4	10_5	10_6
	Pusillina radiata (Philippi, 1836)	6 (3.1)	3 (0.7)	1 (0.2)	2 (0.6)	-	1 (0.4)
Eulimidae	*Campylorhaphion famelicum* (Watson, 1883)	-	1 (0.2)	1 (0.2)	-	-	-
Marginellidae	*Granulina marginata* (Bivona, 1832)	-	1 (0.2)	1 (0.2)	4 (1.1)	4 (0.9)	3 (1.3)
Buccinidae	*Euthria cornea* (Linnaeus, 1758)	-	-	-	-	-	1 (0.4)
	Chauvetia turritellata (Deshayes, 1835)	-	-	2 (0.4)	-	1 (0.2)	2 (0.8)
Fasciolariidae	*Aegeofusinus rolani* (Buzzurro & Ovalis, 2005)	-	-	-	-	1 (0.2)	-
Muricidae	*Hexaplex trunculus* (Linnaeus, 1758)	-	2 (0.5)	-	-	-	1 (0.4)
	Muricopsis cristata (Brocchi, 1814)	-	1 (0.2)	2 (0.4)	-	5 (1.1)	5 (2.1)
	Ocinebrina aciculata (Lamarck, 1822)	1 (0.5)	-	-	-	2 (0.4)	-
	Typhinellus labiatus (de Cristofori & Jan, 1832)	-	2 (0.5)	-	1 (0.3)	-	-
Horaiclavidae	*Haedropleura* aff *secalina* (Philippi, 1844)	-	-	-	-	3 (0.7)	-
Mangeliidae	*Mangelia* sp.	-	1 (0.2)	-	-	-	-
Raphitomidae	*Raphitoma* sp.	-	-	-	-	-	1 (0.4)
Raphitomidae	*Clathromangelia loiselieri* Oberling, 1970	-	-	-	-	2 (0.4)	-
Retusidae	*Retusa truncatula* (Bruguière, 1792)	1 (0.5)	3 (0.7)	7 (1.5)	-	-	-
Philinidae	*Philine catena* (Montagu, 1803)	-	-	1 (0.2)	-	-	-
Aplysiidae	*Aplysia parvula* Mörch, 1863	-	-	1 (0.2)	-	-	-
Volvatellidae	*Ascobulla fragilis* (Jeffreys, 1856)	-	-	-	1 (0.3)	-	-
Siphonariidae	*Williamia gussoni* (Costa O.G., 1829)	-	3 (0.7)	1 (0.2)	-	-	-
Pyramidellidae	*Parthenina interstincta* (J. Adams, 1797)	-	-	1 (0.2)	-	-	-
	Odostomia acuta Jeffreys, 1848	-	1 (0.2)	-	-	1 (0.2)	-
	Odostomia sicula Philippi, 1851	-	-	2 (0.4)	-	1 (0.2)	-
	Ondina vitrea (Brusina, 1866)	-	-	-	3 (0.8)	2 (0.4)	-
	Pyrgostylus striatulus (Linnaeus, 1758)	-	3 (0.7)	1 (0.2)	2 (0.6)	1 (0.2)	3 (1.3)
Nuculidae	*Nucula nitidosa* Winckworth, 1930	1 (0.5)	1 (0.2)	-	1 (0.3)	1 (0.2)	1 (0.4)
Mytilidae	*Musculus costulatus* (Risso, 1826)	1 (0.5)	3 (0.7)	3 (0.6)	2 (0.6)	4 (0.9)	-
	Septifer cumingii Récluz, 1848	-	-	-	5 (1.4)	3 (0.7)	-
	Gregariella semigranata (Reeve, 1858)	-	-	-	-	-	1 (0.4)
	Modiolula phaseolina (Philippi, 1844)	-	-	-	1 (0.3)	-	-
	Crenella arenaria Monterosato, 1875 ex H. Martin, ms.	-	-	-	1 (0.3)	2 (0.4)	-
Arcidae	*Arca noae* Linnaeus, 1758	-	1 (0.2)	1 (0.2)	-	-	-

Table A2 continued

			Spring			Autumn	
Family	Species	10_1	10_2	10_3	10_4	10_5	10_6
	Barbatia barbata (Linnaeus, 1758)	-	1 (0.2)	2 (0.4)	2 (0.6)	-	2 (0.8)
Noetiidae	*Striarca lactea* (Linnaeus, 1758)	2 (1.0)	2 (0.5)	3 (0.6)	8 (2.2)	3 (0.7)	5 (2.1)
Pteriidae	*Pinctada imbricata radiata* (Leach, 1814)	3 (1.5)	1 (0.2)	-	-	1 (0.2)	-
Pinnidae	*Pinna nobilis* Linnaeus, 1758	2 (1.0)	-	-	-	-	-
Pectinidae	*Flexopecten hyalinus* (Poli, 1795)	-	2 (0.5)	-	-	-	-
Limidae	*Limatula subauriculata* (Montagu, 1808)	2 (1.0)	-	-	3 (0.8)	3 (0.7)	-
	Lima lima (Linnaeus, 1758)	-	-	1 (0.2)	-	-	-
Lucinidae	*Ctena decussata* (O.G. Costa, 1829)	-	-	-	1 (0.3)	9 (2.0)	1 (0.4)
Thyasiridae	*Thyasira* sp.	7 (3.6)	22 (5.2)	8 (1.7)	14 (3.9)	16 (3.5)	4 (1.7)
Carditidae	*Glans trapezia* (Linnaeus, 1767)	-	1 (0.2)	2 (0.4)	13 (3.6)	17 (3.7)	8 (3.4)
	Cardita calyculata (Linnaeus, 1758)	-	-	-	-	-	1 (0.4)
Tellinidae	*Arcopella balaustina* (Linnaeus, 1758)	-	-	-	1 (0.3)	-	-
Semelidae	*Abra alba* (W. Wood, 1802)	-	-	-	1 (0.3)	1 (0.2)	-
Veneridae	*Gouldia minima* (Montagu, 1803)	-	-	1 (0.2)	-	1 (0.2)	-
Family	Species	15_1	15_2	15_3	15_4	15_5	15_6
Acanthochitonidae	*Acanthochitona fascicularis* (Linnaeus, 1767)	-	-	2 (0.9)	1 (0.3)	1 (0.2)	1 (0.2)
Leptochitonidae	*Leptochiton bedullii* Dell'Angelo & Palazzi, 1986	-	-	-	2 (0.5)	2 (0.4)	-
Callochitonidae	*Callochiton septemvalvis* (Montagu, 1803)	-	-	-	2 (0.5)	-	-
Chitonidae	*Chiton olivaceus* Spengler, 1797	-	-	1 (0.4)	-	-	1 (0.2)
Patellidae	*Patella* sp.	1 (0.6)	-	-	-	-	-
Fissurellidae	*Emarginula sicula* J.E. Gray, 1825	-	-	-	-	-	1 (0.2)
Scissurellidae	*Scissurella costata* d'Orbigny, 1824	6 (3.8)	8 (2.2)	2 (0.9)	1 (0.3)	1 (0.2)	1 (0.2)
Trochidae	*Jujubinus exasperatus* (Pennant, 1777)	21 (13.4)	44 (12.2)	34 (15.0)	78 (21.0)	76 (14.3)	46 (11.3)
	Jujubinus striatus (Linnaeus, 1758)	-	-	-	-	3 (0.6)	-
Calliostomatidae	*Calliostoma laugieri* (Payraudeau, 1826)	1 (0.6)	-	-	-	-	-
Phasianellidae	*Tricolia speciosa* (Megerle von Mühlfeld, 1824)	6 (3.8)	5 (1.4)	1 (0.4)	2 (0.5)	8 (1.5)	2 (0.5)
	Tricolia pullus (Linnaeus, 1758)	4 (2.5)	12 (3.3)	12 (5.3)	8 (2.2)	7 (1.3)	6 (1.5)
Turbinidae	*Bolma rugosa* (Linnaeus, 1767)	-	-	-	1 (0.3)	-	-
Neritidae	*Smaragdia viridis* (Linnaeus, 1758)	1 (0.6)	4 (1.1)	-	4 (1.1)	6 (1.1)	2 (0.5)
Cerithiidae	*Bittium latreillii* (Payraudeau, 1826)	64 (40.8)	82 (22.8)	68 (30.1)	97 (26.1)	186 (35.0)	188 (46.2)
	Bittium reticulatum (da Costa, 1778)	27 (17.2)	87 (24.2)	55 (24.3)	30 (8.1)	35 (6.6)	31 (7.6)

Table A2 continued

Family	Species	Spring			Autumn		
		15_1	15_2	15_3	15_4	15_5	15_6
Turritellidae	*Turritella turbona* Monterosato, 1877	-	-	-	2 (0.5)	-	-
Naticidae	*Notocochlis dillwynii* (Payraudeau, 1826)	-	1 (0.3)	-	-	-	-
Triphoridae	*Marshallora adversa* (Montagu, 1803)	-	-	-	1 (0.3)	-	-
	Similiphora similior (Bouchet & Guillemot, 1978)	-	-	1 (0.4)	-	-	-
Cerithiopsidae	*Cerithiopsis tubercularis* (Montagu, 1803)	-	1 (0.3)	-	-	-	-
Rissoidae	*Alvania mamillata* Risso, 1826	7 (4.5)	74 (20.6)	23 (10.2)	66 (17.8)	130 (24.5)	83 (20.4)
	Rissoa angustior (Monterosato, 1917)	-	2 (0.6)	-	-	1 (0.2)	-
	Pusillina philippi (Aradas & Maggiore, 1844)	-	1 (0.3)	-	-	-	-
	Pusillina radiata (Philippi, 1836)	2 (1.3)	-	3 (1.3)	4 (1.1)	6 (1.1)	1 (0.2)
Caecidae	*Caecum clarkii* Carpenter, 1859	-	-	-	1 (0.3)	-	-
Cystiscidae	*Gibberula philippii* (Monterosato, 1878)	-	-	-	-	2 (0.4)	3 (0.7)
Marginellidae	*Granulina marginata* (Bivona, 1832)	-	-	-	-	-	1 (0.2)
Fasciolariidae	*Aegeofusinus rolani* (Buzzurro & Ovalis, 2005)	-	-	-	1 (0.3)	1 (0.2)	-
Muricidae	*Hexaplex trunculus* (Linnaeus, 1758)	-	1 (0.3)	-	-	1 (0.2)	-
	Muricopsis cristata (Brocchi, 1814)	1 (0.6)	-	-	5 (1.3)	1 (0.2)	6 (1.5)
	Ocinebrina aciculata (Lamarck, 1822)	-	-	-	-	3 (0.6)	1 (0.2)
	Typhinellus labiatus (de Cristofori & Jan, 1832)	-	1 (0.3)	-	-	-	-
Horaiclavidae	*Haedropleura* aff *secalina* (Philippi, 1844)	-	-	-	4 (1.1)	1 (0.2)	1 (0.2)
Raphitomidae	*Clathromangelia loiselieri* Oberling, 1970	-	-	-	1 (0.3)	1 (0.2)	2 (0.5)
	Clathromangelia granum (Philippi, 1844)	-	-	-	-	-	2 (0.5)
Retusidae	*Retusa truncatula* (Bruguière, 1792)	1 (0.6)	4 (1.1)	-	-	-	-
Haminoeidae	*Atys macandrewii* E.A. Smith, 1872	-	-	1 (0.4)	-	-	-
Siphonariidae	*Williamia gussoni* (Costa O.G., 1829)	-	4 (1.1)	2 (0.9)	-	-	-
Pyramidellidae	*Ondina vitrea* (Brusina, 1866)	-	-	-	1 (0.3)	-	-
	Pyrgostylus striatulus (Linnaeus, 1758)	-	-	-	-	1 (0.2)	-
Nuculidae	*Nucula nitidosa* Winckworth, 1930	-	-	1 (0.4)	2 (0.5)	3 (0.6)	-
Mytilidae	*Musculus costulatus* (Risso, 1826)	6 (3.8)	5 (1.4)	4 (1.8)	2 (0.5)	3 (0.6)	5 (1.2)
	Septifer cumingii Récluz, 1848	1 (0.6)	1 (0.3)	4 (1.8)	2 (0.5)	2 (0.4)	3 (0.7)
	Gregariella semigranata (Reeve, 1858)	-	-	-	-	1 (0.2)	-
	Crenella arenaria Monterosato, 1875 ex H. Martin, ms.	-	1 (0.3)	1 (0.4)	5 (1.3)	3 (0.6)	1 (0.2)
Arcidae	*Arca noae* Linnaeus, 1758	-	-	1 (0.4)	-	-	-

Table A2 continued

			Spring			Autumn	
Family	Species	15_1	15_2	15_3	15_4	15_5	15_6
Arcidae	*Barbatia barbata* (Linnaeus, 1758)	-	2 (0.6)	2 (0.9)	4 (1.1)	2 (0.4)	1 (0.2)
Noetiidae	*Striarca lactea* (Linnaeus, 1758)	4 (2.5)	2 (0.6)	2 (0.9)	6 (1.6)	4 (0.8)	4 (1.0)
Pteriidae	*Pinctada imbricata radiata* (Leach, 1814)	4 (2.5)	2 (0.6)	3 (1.3)	1 (0.3)	-	-
Pinnidae	*Pinna nobilis* Linnaeus, 1758	-	3 (0.8)	-	-	-	-
Pectinidae	*Flexopecten hyalinus* (Poli, 1795)	-	-	-	-	4 (0.8)	-
Limidae	*Limatula subauriculata* (Montagu, 1808)	-	2 (0.6)	-	11 (3.0)	11 (2.0)	3 (0.7)
	Lima lima (Linnaeus, 1758)	-	-	-	-	1 (0.2)	1 (0.2)
Lucinidae	*Ctena decussata* (O.G. Costa, 1829)	-	-	-	2 (0.5)	4 (0.8)	-
	Myrtea spinifera (Montagu, 1803)	-	-	-	-	1 (0.2)	-
Thyasiridae	*Thyasira* sp.	-	6 (1.7)	1 (0.4)	12 (3.2)	8 (1.5)	5 (1.2)
Carditidae	*Glans trapezia* (Linnaeus, 1767)	-	4 (1.1)	1 (0.4)	6 (1.6)	6 (1.1)	2 (0.5)
	Cardites antiquatus (Linnaeus, 1758)	-	-	-	3 (0.8)	4 (0.8)	-
	Cardita calyculata (Linnaeus, 1758)	-	-	-	1 (0.3)	-	2 (0.5)
	Parvicardium trapezium Cecalupo & Quadri, 1996	-	-	1 (0.4)	-	-	-
Tellinidae	*Arcopella balaustina* (Linnaeus, 1758)	-	-	-	1 (0.3)	-	1 (0.2)
Veneridae	*Gouldia minima* (Montagu, 1803)	-	1 (0.3)	-	-	1 (0.2)	-
	Lajonkairia lajonkairii (Payraudeau, 1826)	-	-	-	1 (0.3)	-	-
Family	Species	20_1	20_2	20_3	20_4	20_5	20_6
Acanthochitonidae	*Acanthochitona fascicularis* (Linnaeus, 1767)	1 (0.4)	6 (0.8)	1 (0.2)	2 (0.7)	3 (1.8)	5 (1.3)
Leptochitonidae	*Leptochiton bedullii* Dell'Angelo & Palazzi, 1986	1 (0.4)	6 (0.8)	-	-	-	-
Callochitonidae	*Callochiton septemvalvis* (Montagu, 1803)	-	1 (0.1)	-	-	-	-
Chitonidae	*Chiton olivaceus* Spengler, 1797	-	1 (0.1)	-	-	-	-
Scissurellidae	*Scissurella costata* d'Orbigny, 1824	5 (1.8)	7 (0.9)	5 (1.2)	-	-	-
Trochidae	*Jujubinus exasperatus* (Pennant, 1777)	37 (13.0)	130 (17.0)	120 (29.3)	44 (16.4)	37 (21.6)	24 (6.0)
	Jujubinus striatus (Linnaeus, 1758)	-	-	-	1 (0.4)	1 (0.6)	-
	Clanculus cruciatus (Linnaeus, 1758)	-	1 (0.1)	-	-	-	-
Colloniidae	*Homalopoma sanguineum* (Linnaeus, 1758)	-	-	-	-	1 (0.6)	-
Phasianellidae	*Tricolia speciosa* (Megerle von Mühlfeld, 1824)	1 (0.4)	7 (0.9)	6 (1.5)	3 (1.1)	-	2 (0.5)
Phasianellidae	*Tricolia pullus* (Linnaeus, 1758)	8 (2.8)	16 (2.1)	3 (0.7)	14 (5.2)	3 (1.8)	4 (1.0)
Turbinidae	*Bolma rugosa* (Linnaeus, 1767)	-	-	1 (0.2)	1 (0.4)	1 (0.6)	4 (1.0)
Neritidae	*Smaragdia viridis* (Linnaeus, 1758)	-	2 (0.3)	1 (0.2)	7 (2.6)	-	1 (0.3)

Table A2 continued

		Spring			Autumn		
Family	Species	20_1	20_2	20_3	20_4	20_5	20_6
Cerithiidae	*Bittium latreillii* (Payraudeau, 1826)	134 (47.2)	225 (29.5)	105 (25.6)	75 (28.0)	42 (24.6)	236 (59.0)
	Bittium reticulatum (da Costa, 1778)	43 (15.1)	173 (22.6)	75 (18.3)	25 (9.3)	14 (8.2)	21 (5.3)
	Cerithium sp.	-	1 (0.1)	-	-	-	1 (0.3)
Naticidae	*Notocochlis dillwynii* (Payraudeau, 1826)	-	-	2 (0.5)	-	-	-
Triphoridae	*Monophorus erythrosoma* (Bouchet & Guillemot, 1978)	-	1 (0.1)	-	-	-	-
	Marshallora adversa (Montagu, 1803)	-	-	1 (0.2)	-	-	-
	Viriola bayani Jousseaume, 1884	-	-	-	-	-	1 (0.3)
Rissoidae	*Alvania mamillata* Risso, 1826	17 (6.0)	89 (11.6)	13 (3.2)	35 (13.1)	34 (19.9)	46 (11.5)
	Alvania discors (Allan, 1818)	3 (1.1)	9 (1.2)	3 (0.7)	8 (3.0)	-	2 (0.5)
	Alvania lineata Risso, 1826	-	-	-	-	-	-
	Alvania bozcaadensis Tisselli & Giunchi, 2013	-	-	-	2 (0.7)	-	1 (0.3)
	Rissoa angustior (Monterosato, 1917)	1 (0.4)	-	-	1 (0.4)	2 (1.2)	-
	Pusillina philippi (Aradas & Maggiore, 1844)	-	1 (0.1)	-	-	-	-
	Pusillina radiata (Philippi, 1836)	2 (0.7)	4 (0.5)	2 (0.5)	3 (1.1)	5 (2.9)	3 (0.8)
Caecidae	*Caecum auriculatum* De Folin, 1868	-	1 (0.1)	-	-	-	1 (0.3)
Eulimidae	*Melanella lubrica* (Monterosato, 1890)	-	-	-	-	-	1 (0.3)
Velutinidae	*Lamellaria perspicua* (Linnaeus, 1758)	1 (0.4)	-	-	-	-	-
Fasciolariidae	*Aegeofusinus rolani* (Buzzurro & Ovalis, 2005)	-	-	-	1 (0.4)	1 (0.6)	-
Muricidae	*Hexaplex trunculus* (Linnaeus, 1758)	-	-	1 (0.2)	1 (0.4)	1 (0.6)	-
	Muricopsis cristata (Brocchi, 1814)	-	1 (0.1)	-	1 (0.4)	1 (0.6)	-
	Ocinebrina aegeensis Aissaoui, Barco & Oliverio, 2017	-	-	1 (0.2)	-	-	-
	Typhinellus labiatus (de Cristofori & Jan, 1832)	-	-	-	1 (0.4)	-	-
Horaiclavidae	*Haedropleura* aff *secalina* (Philippi, 1844)	-	1 (0.1)	-	1 (0.4)	-	-
Raphitomidae	*Clathromangelia loiselieri* Oberling, 1970	1 (0.4)	1 (0.1)	-	-	3 (1.8)	1 (0.3)
Raphitomidae	*Clathromangelia granum* (Philippi, 1844)	-	-	-	1 (0.4)	-	-
Retusidae	*Retusa truncatula* (Bruguière, 1792)	2 (0.7)	3 (0.4)	3 (0.7)	-	-	-
Philinidae	*Philine catena* (Montagu, 1803)	1 (0.4)	-	-	-	-	-
Aplysiidae	*Aplysia parvula* Mörch, 1863	1 (0.4)	1 (0.1)	1 (0.2)	-	-	-
	Aplysia depilans Gmelin, 1791	1 (0.4)	-	-	-	-	-
Siphonariidae	*Williamia gussoni* (Costa O.G., 1829)	-	4 (0.5)	10 (2.4)	-	-	-
Pyramidellidae	*Eulimella acicula* (Philippi, 1836)	-	-	1 (0.2)	-	-	-

Table A2 continued

Family	Species	Spring			Autumn		
		20_1	20_2	20_3	20_4	20_5	20_6
	Pyrgostylus striatulus (Linnaeus, 1758)	-	-	-	2 (0.7)	2 (1.2)	4 (1.0)
	Odostomia turriculata Monterosato, 1869	-	1 (0.1)	-	-	-	-
Nuculidae	*Nucula nitidosa* Winckworth, 1930	2 (0.7)	3 (0.4)	2 (0.5)	1 (0.4)	-	2 (0.5)
Mytilidae	*Musculus costulatus* (Risso, 1826)	-	1 (0.1)	4 (1.0)	1 (0.4)	-	-
	Septifer cumingii Récluz, 1848	-	2 (0.3)	1 (0.2)	1 (0.4)	1 (0.6)	1 (0.3)
	Gregariella semigranata (Reeve, 1858)	-	1 (0.1)	-	-	-	-
	Crenella arenaria Monterosato, 1875 ex H. Martin, ms.	2 (0.7)	9 (1.2)	6 (1.5)	-	3 (1.8)	3 0.75
Arcidae	*Arca noae* Linnaeus, 1758	-	1 (0.1)	-	-	1 (0.6)	-
	Barbatia barbata (Linnaeus, 1758)	1 (0.4)	-	1 (0.2)	3 (1.1)	-	1 (0.3)
Noetiidae	*Striarca lactea* (Linnaeus, 1758)	3 (1.1)	4 (0.5)	3 (0.7)	3 (1.1)	7 (4.1)	2 (0.5)
Pteriidae	*Pinctada imbricata radiata* (Leach, 1814)	3 (1.1)	6 (0.8)	3 (0.7)	4 (1.5)	1 (0.6)	1 (0.3)
Pinnidae	*Pinna nobilis* Linnaeus, 1758	-	1 (0.1)	-	-	-	-
Pectinidae	*Flexopecten hyalinus* (Poli, 1795)	-	1 (0.1)	2 (0.5)	3 (1.1)	-	-
Limidae	*Limatula subauriculata* (Montagu, 1808)	3 (1.1)	8 (1.0)	10 (2.4)	6 (2.2)	-	1 (0.3)
	Lima lima (Linnaeus, 1758)	1 (0.4)	-	-	1 (0.4)	-	-
Lucinidae	*Loripinus fragilis* (Philippi, 1836)	-	-	-	-	-	1 (0.3)
	Ctena decussata (O.G. Costa, 1829)	-	4 (0.5)	4 (1.0)	1 (0.4)	6 (3.5)	4 (1.0)
	Megaxinus unguiculinus Pallary, 1904	-	-	-	-	-	1 (0.3)
Thyasiridae	*Thyasira* sp.	6 (2.1)	24 (3.1)	10 (2.4)	3 (1.1)	-	11 (2.8)
Carditidae	*Glans trapezia* (Linnaeus, 1767)	2 (0.7)	6 (0.8)	8 (2.0)	10 (3.7)	-	13 (3.3)
Carditidae	*Cardites antiquatus* (Linnaeus, 1758)	-	-	1 (0.2)	1 (0.4)	-	-
Tellinidae	*Arcopella balaustina* (Linnaeus, 1758)	1 (0.4)	-	-	1 (0.4)	-	-
Veneridae	*Gouldia minima* (Montagu, 1803)	-	-	-	-	1 (0.6)	1 (0.3)