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„Changes to *Posidonia oceanica* Assemblages triggered by biological Invasions in Crete"

verfasst von / submitted by

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Finally, I want to thank my **mother** and **father** for always fostering and believing in me. Thank you very much!

Content

1. Introduction

1.1 History of the Suez Canal

Since the early days, mankind has affected its environment by shaping it for personal benefits, e.g., agriculture and infrastructure. These influences may have long-term negative effects on the environment, but ultimately also for the human beings themselves. The Suez Canal is a representative example for such a case. Constructed by the Suez Canal Company between 1859 and 1869, it has since then been one of the most important trading routes by sea. The mentioned canal connects the Red Sea and the Mediterranean Sea (marked red in fig.1), and above all, it offers the most direct sea route between the North Atlantic and the Northern Indian Ocean. Illustrating the enormous advantages of the shortcut, e.g., it saves up to 8,900km on a sea travel between Mumbai and London see fig.1 (World Shipping Council, 2018).
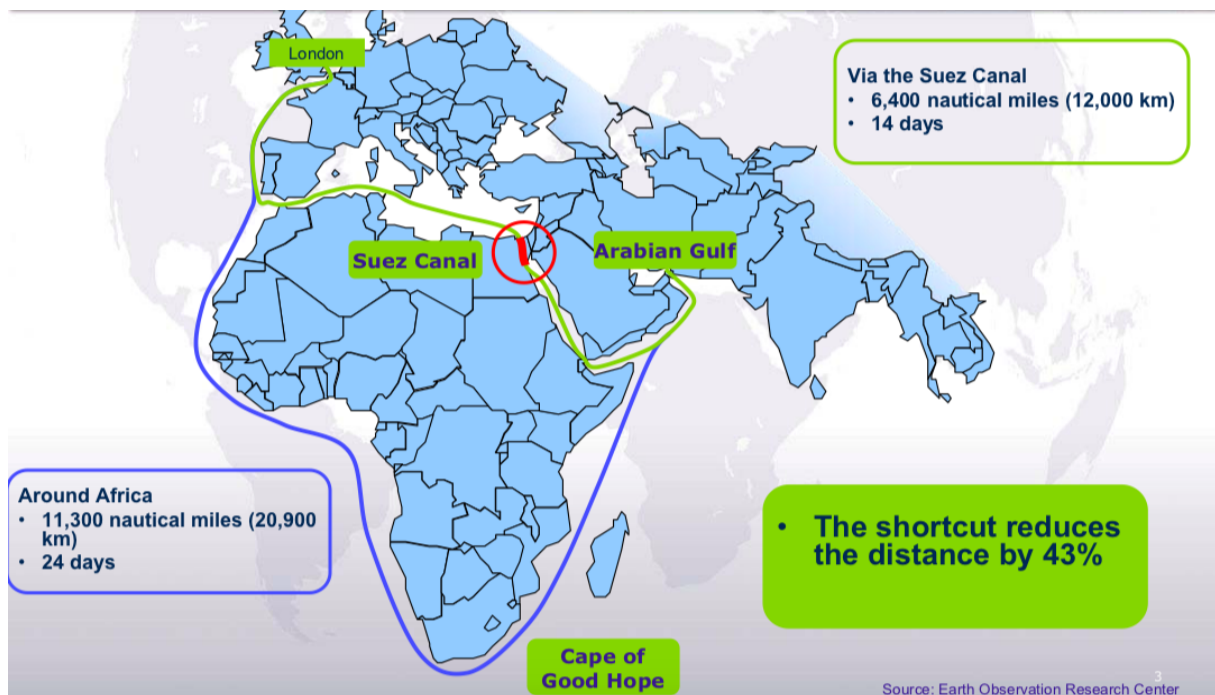
Fig.1: Trading route from Mumbai to London before 1869 (blue) around the Cape of Good Hope and the trading route since 1869 (green) through the Red and Mediterranean Sea. (https://history.stackexchange.com/questions/51958/approximately-how-much-travel-time-was-saved-by-the-opening-of-the-Suez-Canal-in)

The Suez Canal has a length of about 193km and stretches from the northern end of Port Said to the southern end of Port Tawfik near the city of Suez, from which the canal

inherits its name. When the artificial river opened on 17 November 1869, it was 60m to 90m wide on the surface, 22m wide at the bottom and approximately 7.5m deep. Immediately after the opening, passing bays were built, in this way ships could pass by each other. In 1870, around 486 ships were counted to traverse the canal, which could have been 1 to 2 ships per day. The seaway was steadily deepened and widened to allow bigger vessels to traverse it. In 2012, 17,255 vessels traversed the canal, which makes an average of 47 vessels per day, by this time it had reached a width of 400m and a depth of 25m. Two years later, the Suez Canal Area Development Project was launched by the Egyptian president Abdel Fattah el-Sisi, which led to a further widening and deepening of the Suez Canal. As a result, even larger vessels like the world's largest container ship, the 400-meter long OOCL Hong Kong, could traverse the canal. The most recent construction work added up a new side channel with a length of 72km in 2016. The canal expansion raised the annual passage rate from 47 vessels per day to 97, because the new expansion allows vessels to traverse in both directions at the same time see fig.2 (Galil, 2006; caironews.net, 2014; ESA, 2000-2021).

Fig.2: Satellite photograph of the Suez Canal before (left) and after (right) the Suez Canal Area Development Project. (https://upload.wikimedia.org/wikipedia/commons/4/4a/New_Suez_Canal.jpeg)

1.1.1 The Impact of the Suez Canal on the Marine Ecosystem

Having no artificial barrier like a lock-system (Hugo, 1925) but a difference in sea level during half of the year between the south end Port Tawfik and the northern end Port Said, sea water and Red Sea species mostly flow from the Red to the Mediterranean Sea. To be precise, Port Said has a higher sea level from July to December with a maximum of 10.5cm (Eid et al., 1997), for the rest of the year, Port Tawfik's sea level is higher with a maximum of 31.5cm (Eid et al., 1997).

Invasion from the Red to the Mediterranean Sea is more often seen than the other way around. The specific invasion of the Red Sea species into the Mediterranean Sea is called "Lessepsian Invasion" after Ferdinand de Lesseps, who also formed the Suez Canal Company in 1858. Invasion in the opposite way, i.e., from the Mediterranean Sea to the Red Sea, is called "Anti-Lessepsian-Invasion." Another reason for the Lessepsian Invasion could be the higher salinity in the Red Sea (4.2%) in comparison to the Mediterranean Sea (3.8%). Hence, Red Sea species may be more tolerant to harsh environments, and so have another advantage compared to Mediterranean species. Moreover, another dominant factor for this specific invasion is time, as species can be introduced several times through the canal (Por, 2012).

Examples for Red Sea migrants from major marine taxa, especially fish like the seabream *Pagellus bellottii* (Steindachner, 1882) and the pufferfish *Lagocephalus suezensis* (Clark & Gohar, 1953), are recent representatives, which have already established in several areas in the Mediterranean Sea (www.ciesm.org). Other large marine groups like molluscs and polychaetes use the canal as well and invade the Mediterranean Sea through ships or free-swimming larvae. Polychaetes, e.g., *Hydroides dianthus* (Mörch, 1863) and *Hydroides diramphus* (Verrill, 1873), were the first recorded aliens in the Mediterranean Sea (1865, 1870) (Galil, 2008). These species were followed by *Pinctada radiata* (Leach, 1814) and *Cerithium scabridum* (Philippi, 1848), which are two representatives of the molluscs recorded in 1874 and 1883. As a matter of fact, it makes them good historical indicator species for invasion and alien species establishment.

The only natural barrier ever existing was the Bitter Lakes, which are hypersaline lakes and were dry salt valleys before the canal was built. Nowadays they are used by vessels to change their position in line or turn around. This natural barrier has probably

slowed down the invasion in both ways for many decades, but over the years, the Bitter Lakes' salinity equalized with the Red Sea.

Despite having a powerful effect on the ecological health, and thus on the local Mediterranean fishery, the Lessepsian invasion has allowed scientists to study an invasive event on a large scale in a relatively short period of time (Golani, 1998). An example for a negative effect on Mediterranean fishery and local human health is the species *Lagocephalus sceleratus*, which is a strongly poisonous pufferfish and it appears in large numbers in fishers' static nets and longlines (EastMed, F.A.O., 2010). Another Red Sea species, which entails heavy ecological damage, is the rabbit fish. They are grazers which feed intensively on lush brown algae, sometimes leaving whole stretches of algal carpets barren, consequently altering habitats. On the other hand, species like *Siganus spp.* and *Saurida undosquamis* were successfully introduced on local markets and hold high commercial value (EastMed, F.A.O., 2010). Therefore, it is still a topic of high interest and surveillance for the conditions of various Mediterranean marine communities.

1.2 Molluscs as Historical Indicator

Turning now to the class molluscs, which is very vast and diverse with an estimated Recent species range from 50,000 to over 200,000 (Paul Bunje, 2003). They can be found in terrestrial, freshwater, and marine ecosystems. Besides, molluscs are a very old group of animals, reaching back to the lower Cambrian (500 mya) or even the Precambrian period (4.6 bya to about 541 mya) (Nordsieck, 1991-2011), which makes them a significant historical indicator for impacts on their environment. Another helpful advantage is their shell, which consists of mostly aragonite or also calcite ($CaCO_3$), which can stay intact for hundreds to thousands of years and can become fossilized. If the shell is preserved well, it enables identification at the species level and makes them important assets of especially live-dead comparisons (see 1.5 and 1.6)

1.3 Location

Due to the existing cooperation with the diving school "Dive2gether," a suitable seagrass meadow of *Posidonia oceanica* was chosen nearby the school's location as sampling ground. *Posidonia oceanica* create unique habitats, hold a high number of

different species and assemblages, are important oxygen producers and thus hold a high ecological value. By virtue of their ecological importance, they have long been subject to several studies, e.g. Mateo & Romeo,1997, Duarte, 2002, Borum J. et al., 2004, Waycott & Duarte, 2009, Albano & Sabelli, 2012 and were therefore chosen as sampling habitat for this thesis (further information will be provided in 1.4 and 1.4.1). The diving school is situated along the southern coast of Crete in a little fisherman's village called Plakias, which has not been chosen for studies as such so far. Therefore, by now no data on molluscan assemblages are available from this coastal area in particular.

Fig.3: Satellite-image of Crete; Plakias pinned; Coordinates: 35°11'20.7"N 24°23'52.9"E. (Google maps)

Taking a quick glance on the island itself: Crete is mountainous and the fifth largest island in the Mediterranean Sea (fig.3), the most southern of the Aegean Sea and marks the border with the Libyan Sea. Geographically, Crete's location is in between two climate zones, the dominant Mediterranean and the North African one. The island's coast consists mostly of rocky shores and sandy beaches, one of those is found in Plakias. (fig.4).
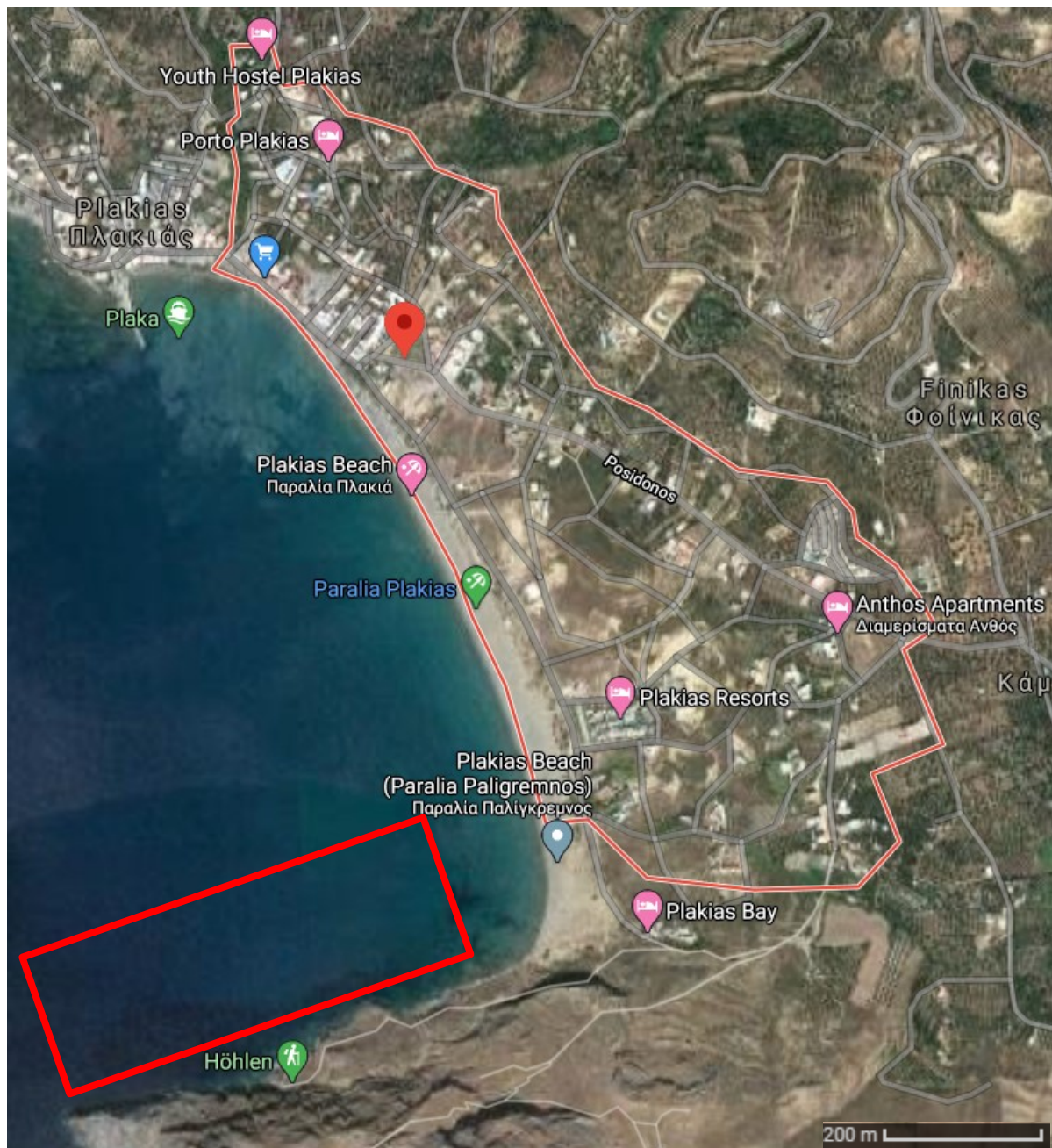
Fig.4: Satellite image of Plakias with its surroundings and the marked sampling area (red rectangle). (Google maps)

Plakias is surrounded by mountains in the north and the Libyan Sea in the south. The village is built on an alluvial fan of material, which was washed down by the river in the Kotsifou gorge, which is found in the north of the village (Cretetravel.com, 2019). This material has formed into a 1,300meter-long fine sand beach along the sea's edge, which extends very gradually out into the bay, making it safe for swimming and hence, for family holidays. While most of the other touristic towns with attractive beaches like Balos and Elafonisi are more focused on tourism, Plakias has not received much notice by tourists for a long time. Due to its calm, family friendly environment, convenient

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access to a lot of beaches and beautiful regional scenery, Plakias's importance as a tourist resort has risen over the last decades. Those circumstances and the fact that there are few studies to Posidonia meadows and assemblages in southern Crete make Plakias a point of interest for novel studies and ultimately for this thesis.

1.4 *Posidonia oceanica* as an Endemic Plant and Important Death Assemblage Holder

As mentioned before, a very important seagrass species, endemic to the Mediterranean, is a native plant species in the marine flora of Plakias named *Posidonia oceanica* (fig.5)*. Posidonia oceanica* is considered a key species of the Mediterranean ecosystem, where it plays a big role in the oxygenation of sea water, primary production, and production of leaf epiphytes (Albano & Sabelli, 2012).
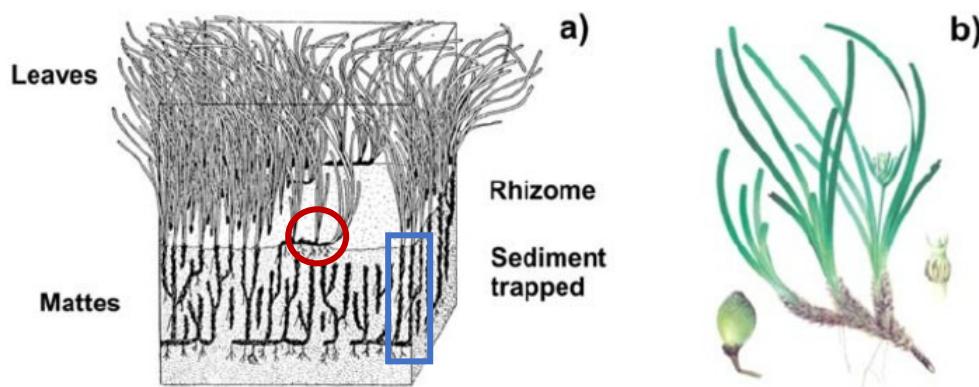
Fig.5: On the left: basic organisation of *Posidonia oceanica* meadow with orthotrophic growth (below the sediment and in vertical direction - see blue rectangle) and plagiothropic growth (above the sediment and in horizontal direction – see (red circle). On the right: the plant with leaves, rhizome, and buds (Cavallaro et al, 2010).

In fact, this plant species hosts a rich and diversified community with many species endemic to *Posidonia oceanica* only and also functions as a nursery for several other marine animals like fish (Albano & Sabelli, 2012). Examples in this respect are common residents like *Gobius spp.* (living on rhizomes), *Sarpa salpa*, *Coris julis*, and *Chromis chromis*, but also strongly specialized species like *Opeatogenys gracilis* and *Syngnathus typhle*, which live in the leaf canopy. Moreover, *Posidonia oceanica*

provides habitat for several calcifying organisms, such as coralline algae, molluscs and foraminifera. A lot of these ephiphytic communities provide a food source for sea slugs like *Aplysia fasciata*, which also use the leaves as a deposit for their eggs. Among the numerous molluscs that reside in *Posidonia oceanica* meadows, the sea snail *Smaragdia viridis* is one of the species, which is well adapted and specialized to this seagrass, and after all makes it very unique by showing the rich diversity of *P. oceanica*.

Regarding the distribution, *Posidonia oceanica* grows quite evenly throughout the Mediterranean Sea except for the parts reaching far west near Gibraltar and far east close to Egypt, and in a depth range from a few meters up to 40m (Albano & Sabelli, 2012). The seagrass meadows of *Posidonia oceanica* are under high anthropogenic pressure, especially by urban and industrial development, followed by heavy decrease in seagrass meadows not only in the Mediterranean Sea, but, in general, in several seagrass species around the globe (Duarte, 2002). In a comprehensive global assessment of Waycott and Duarte, seagrass meadows had been disappearing at a speed of 110km² per year and implied an acceleration from a median of 0.9%yr^{-1} between 1879, where seagrass areas where initially recorded, and 1940 to 7%yr^{-1}. Since 1990 seagrass meadows have been put among the most threatened ecosystems on earth besides mangroves, tropical rainforests, and coral reefs (Waycott & Duarte, 2009). Another fact why *Posidonia oceanica* is not only of high conservational interest, but also holds a high preservative value, lies in the advantage of its rhizome mats, which can reach a thickness of 3 to 4m and are able to keep, e.g., molluscan assemblages consisting of shells with ages up to several thousand years (Mateo & Romeo,1997).

1.4.1 The Fauna Living Around *Posidonia oceanica*

The fauna living on *Posidonia oceanica* can be divided into the leaf epifauna, the rhizome epifauna, the root-associated sediment infauna, and the vagile fauna (Albano & Sabelli, 2012). Building a complex three-dimensional rhizome structure, *Posidonia oceanica* spreads plagiotropically or orthotropically (fig.5). Having a significant sediment component, which includes both autochthonous (residuals of organisms living in the meadow like shells) and allochthonous (sand grains) as well as a hard component, i.e., the rhizomes themselves and their epibiotic species (Albano & Sabelli,

2012). *Posidonia oceanica* is unique in the Mediterranean building such a complex structure (Borum J. et al., 2004). The meadows can host species common on hard as well as soft bottom substrate, and therefore establish a unique habitat with a very diverse and endemic community (Albano & Sabelli, 2012).

1.5 What Is a Death Assemblage and a Living Assemblage?

The living assemblage (LA) consists of the living specimens of a community in a certain habitat or area, which gives a snapshot of the community composition at present. Whereas the death assemblage (DA) is a set of taxonomically identifiable, dead or discarded organic remains present on the surficial mixed layer of a landscape or seafloor (Kidwell, 2013). The DA reflects input from past generations of organisms that lived in the area, temporarily or permanently, and is time-averaged to a certain degree. Time-averaging is a term used when organic remains from different time periods are preserved together (Kidwell, 1997; Walker & Bambach, 1971). This phenomenon is caused by revamping of the sediment where organic remains are mixed by physical reworking and bioturbation. During the process the organic remains are repeatedly buried and exhumated, and by doing so mix several centimetres to a few meters in the sediment column.

Apart from time-averaging, DAs are influenced or can be even dominated by transported remains (post-mortem transport). These two factors, of course, make it hard to make a statement on a specific patch, but through spatial coarsening, bio-information on the surrounding area can be acquired and provides a bigger picture on past generations of communities. So, DAs correctly identify spatial variation. Aside from that it is a fact, studies like Kindle, 1916, Parker, 1956 and Ladd et al., 1957 found that post-mortem transport does not homogenize macrobenthic species occurrences across seafloors and landscapes.

Molluscs as a major group in DAs are used widely in the literature for a live-dead comparison. The DAs of molluscs are the taxonomical identifiable empty shells that are collected from a standardized area or volume. Therefore, these dead individuals are the direct empirical evidence of the former communities on a spatial scale and within a time frame. Live-dead comparisons can be especially useful to recognize recent anthropogenic change in the natural ecological baseline of a system by observing discordance in the diversity, species composition and distribution of living

communities and co-occurring time-averaged DAs. Accordingly, in response to a changing LA, DAs change on a sub annual-to-decadal timescale (Cummins et al., 1986; Perry, 1996; Ferguson and Miller, 2007; Western and Behrensmeyer, 2009).

The composition of the DA lags behind these shifts and volatility in the way the composition of the LAs contribute to it, because the DA is a summed record of many preceding LAs (Kidwell, 2013). Shells surviving the perilous initial post-mortem phase will persist over long periods of time and by that defining the total range of time-averaging in that setting.

The LA is constantly providing the DA with new shells and as a consequence showing species which currently dominate the LA. The dominance of recently deceased shells explains why the DA can reflect the species composition in the LA so well. Older specimens also contribute to the DA, but in a much lower number as they are regionally present, but rarely encountered alive (Kidwell, 2002; Tomasovych and Kidwell, 2011; Olszewski, 2012; Tomasovych et al., 2012). Therefore, as some studies with repeat sampling show, the DA is also able to change according to the changes in the LA on a sub annual-to-decadal timescale (Cummins et al., 1986, Perry, 1996, Ferguson and Miller, 2007, Western and Behrensmeyer, 2009).

1.6 How Does a Live-Dead Comparison Work?

Live-Dead comparisons are the most common method of quantifying the fidelity (faithfulness) of the fossilization of ecological information (Kidwell, 2013). They are considered useful for evaluating modern, mixed-layer DAs as decadal to millennial-scale archives of present-day ecosystems (Kidwell, 2013). The comparisons are always made at a specific scale (Kidwell, 2013), e.g., seagrass meadows and for specific groups of animals, e.g., molluscs. Many statistics which apply for living communities can be used to describe DAs, for example, species richness, evenness, and abundance ranking (Kidwell, 2013). Furthermore, metrics used to compare two samples of living organisms, like Jaccard index of taxonomic similarity or the coefficient of rank correlation in species abundance, can also be used for a live-dead agreement. Consequently, multivariate methods like PERMANOVA are also applicable. A live-dead agreement, thus, cannot be reduced to a single value but is rather an assemblage of different approaches and results, which show different points of view of the comparison (Kidwell 2001, 2002a, 2013; Kowalewski and Hoffmeister 2003). This is

an automatic consequence because so many biological attributes can be considered. The live-dead agreement also varies among major groups of animals owing the differences in intrinsic post-mortem durability and depending on the collecting method. Calcifying molluscs as one of the major groups dominate the LA as well as the DA based on the biomass (Schopf 1978; Staff et al.1986; Staff and Powell 1988, 1999). Using a one-time sampling of the DA and LA in order to generate data yields non-averaged temporally high-resolution data on LA species richness composition and relative abundance (Kidwell, 2013).

1.7 Hypothesis and Resulting Questions

The initiated project on Crete by Martina Stockinger fostered my interest in *Posidonia oceanica* meadows and the communities living inside it. My curiosity was further deepened by my supervisor Dr. Paolo G. Albano, who introduced me to past and present community comparison via live-dead comparison.

As a matter of course, my master thesis focuses on how a community in a specific habitat in the Mediterranean Sea is affected by the Lessepsian Invasion. The aim of the thesis concentrates on the community living in the seagrass meadow of *Posidonia oceanica* in two different microhabitats, on the one hand, the mats formed by the rhizome network of the seagrass, and on the other hand, the leaves. Also, we took samples in two different seasons, May and September. Both living and death assemblages of molluscs of these two microhabitats were collected and identified.

As a pristine state of the community is considered at the chosen location (see 1.3), a high taxonomic similarity in species in accordance with their relative abundance in both, living and death assemblage is assumed regarding several studies by, e.g., Albano et al., 2011, 2016 and Kidwell, 2002, 2007, 2009, 2013.

On the ground of this, the initial hypothesis for my thesis is to do a live-dead comparison between the living assemblage of molluscs found on the leaves and in the rhizome mats, and dead molluscan remains (shells) found in the mats only.

The life and death assemblages are compared in two different seasons (spring and autumn) in order to prove the insignificance for the DA and maybe a significant difference in the LA, see 1.5 above. Change in season should not influence the DA, since it holds a large amount of shells and can be influenced strongly by time-averaging

which works over decades up to millennia. The LA, in contrary, might be dominated by species with short life spans, which could be present in one and absent in the other season. Nevertheless, this should not bias the accordance in the live-dead comparison too much, because the statistical tools use relative abundances rather than total abundances.

One main question resulting from the master thesis' objective is: Is there a difference in community composition between live and death assemblage? And if yes, what is the cause? Are there taphonomic and/or anthropogenic influences? Does the LA change in season? And what about the impact of alien species?

2. Material and Methods

2.1 Location

The sampling took place in a seagrass meadow along the 1,300m Plakias beach coastal environment in the south of Crete (fig.3). On the eastern side the bay is bordered by a far stretched mountain, the Paligremnos Wall. The entire bay ground is covered with a sandy layer, which is partly occupied by seagrass meadows of *Posidonia oceanica*. In the bay area, the meadows can stretch from approximately 0.3m up to 40m in depth and can reach a width up to 20m. The meadows grow from a very shallow level, because of almost no tides. Below 40m the light intensity is insufficient for the meadows' photosynthesis. Within a depth of 0.3m to 5m the growth of the seagrass is rather patchy, but at a depth of 5m it starts to grow into a homogeneous meadow (see fig.6).

Fig.6: Patchy growth of *P. oceanica* meadow in shallow water approx. 0.5 to 1m (sampling area).

The high continuity and coverage of the mats in width and several meters in depth determining the bay's coastal environment and its seagrass meadows met the requirements for this thesis. Furthermore, few signs of destruction or stress by anthropogenic factors such as gouges and bare patches can be seen in the meadow due to the prohibition of anchoring in the entire bay area, except the harbor. Another positive effect is the minimal fishery, which only exists on a private basis. These circumstances allow the assumption of a quasi-pristine meadow and made the location even more favorable for this research.

Further observations detected some areas at the edges of the meadow which displayed traces of erosion and minor empty patches (fig.7), which could be an early sign of disturbance (Kirkman, 1996).
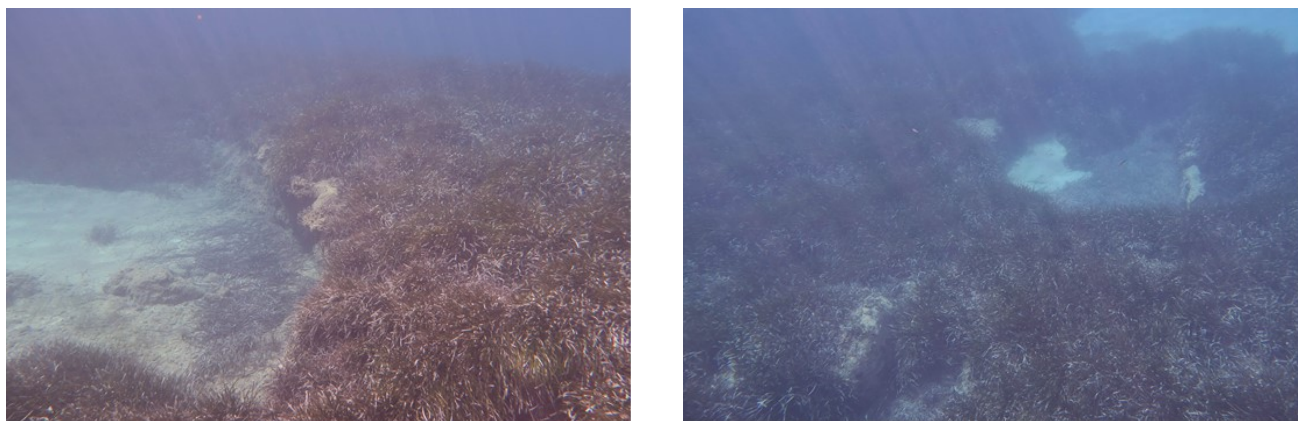
Fig.7: The seagrass meadow shown with eroded edges (left) and empty patches (right).

The measured sea surface temperature in the bay ranged between roughly 18°C in May to a maximum of 24,5°C in September (see tab.1). Samples from the seagrass meadow of *Posidonia oceanica* were taken along a depth gradient at four different depth levels (5m, 10m, 15m, 20m) with three replicates each. The organization of the sampling and sorting was schemed as follows: one day for sampling, two days for sorting. The whole procedure was repeated four times, in total twelve days. The daily schedule consisted of 10 to 16 working hours. For the entire stay a buffer of four days was included. The sampling was conducted twice in 2017 on the following days: May 8, May 10, May 15, May 17, and on September 14, September 17, September 21, September 24 (for reference see tab.1)

Station	Sampling Date	Longitude	Latitude	Temperature (°C)
05m SPR	08.05.2017	35°10.818	24°23.850	18.7
10m SPR	15.05.2017	35°10.762	24°23.697	17.9
15m SPR	11.05.2017	35°10.749	24°23.639	18.4
20m SPR	17.05.2017	35°10.749	24°23.563	18.0
05m AUT	24.09.2017	35°10.818	24°23.850	24.0
10m AUT	17.09.2017	35°10.762	24°23.697	24.0
15m AUT	21.09.2017	35°10.749	24°23.639	24.5
20m AUT	14.09.2017	35°10.749	24°23.563	24.4

Tab.1: List of sample stations in Plakias, Crete. The station code stands for the depth in meters (5,10,15,20) and the season (SPR = spring, AUT = autumn). Temperature was measured on the water surface.

2.2 Preparation before Sampling

At first, a continuous seagrass meadow with at least 8m width and a depth range from at least 5m to 20m was sought, and each depth transect was marked with 3 buoys resembling the 3 replicates for each depth (fig. 8). Regarding the thesis, each replicate is defined by the size of 1m². Coordinates and water surface temperature for all replicates can be extracted from tab.1.

Fig.8: Buoy marking a replicate in a depth transect of our sampling area.

As a matter of fact, the sampling required professional diving skills. Fortunately, my fellow student, Martina Stockinger, already worked for a diving school on Crete, so this project could be initiated.

All necessary dives were carried out by two professional divers of the diving school Dive2gether, including my fellow student.

Generously, the diving school provided their vessel incl. Crew members, lead-weights, SCUBA tanks, a car for transportation, and their in-built laboratory with stereomicroscopes and common laboratory equipment for our research work.

As a next step, the day before sampling the sieving station was set-up (fig.9). Essential materials for sieving like bowls, labels, air-pumps, brushes, and sieves were prepared. For sieving, a triple sieve was created, i.e., three containers with mesh bottoms were

stacked one upon the other. The mesh size decreased from top to bottom by the sizes of 5mm (referred to as large fraction), 1mm (referred to as medium fraction) and 0.5mm (referred to as fine fraction).

For a detailed list see sampling protocol in the appendix.

Fig.9: Sieving station:

1. Rain barrel which was filled with seawater,

2. Hose connected to the rain barrel,

3. Sample net held upside down and flushed with seawater to wash out organisms and sediment,

4. Box for removal of seagrass leaves and bigger debris which could hinder the process of sieving,

5. Box for sieving: the remaining content of the previous box was sieved and washed with fresh seawater.

2.3 Sampling and Sorting

Two segments of the seagrass meadow were targeted for sampling, the leaf area, and the rhizome layer. The leaf area contains living organisms only. The rhizome layer contains living organisms, which form the LA together with the organisms of the leaf area. On the other hand, the rhizome layer contains inorganic remains of dead organisms, which form the DA.

The sampling took place on the vessel provided by Dive2gether. Two divers were sent down to the marked replicate buoys at the target depth with sampling equipment (see sampling protocol in appendix). First, a 0.4x0.4m frame was used to measure shoot density at each depth.
In order to sample the leaf layer, the replicate was framed with a 1m²-frame (fig.10).
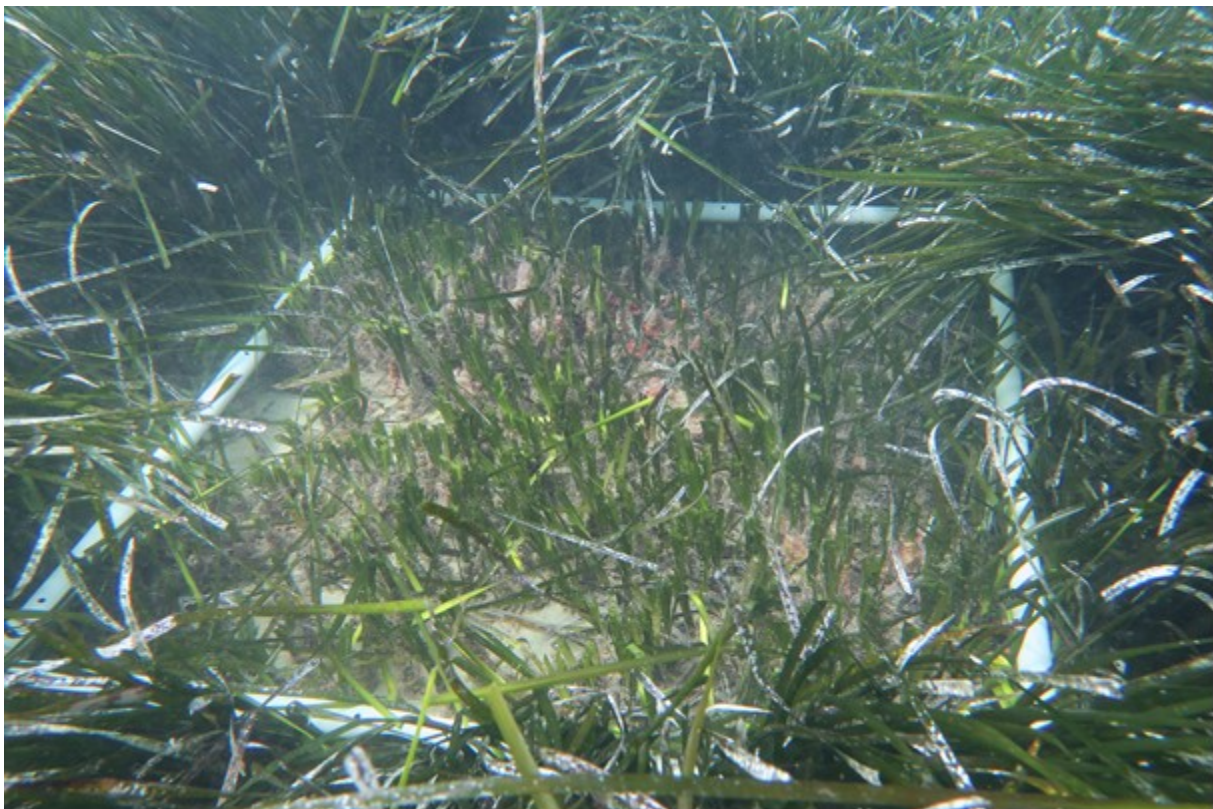
Fig.10: 1m² frame with the seagrass shoots. Seagrass leaves were cut off.

Then, the divers were using hand towed nets while SCUBA diving. Striking the leaves with the frame starting from the bottom and pulling upwards to the top, they collected vagile fauna according to the technique described by Ledoyer (1962), modified and standardized by Russo et al. (1985). The hand nets consisted of a metal frame (0.4x0.2m) mounted with a net (500µm mesh size). Moreover, a control sample was

taken at every depth with one replicate in May and three replicates in September. Control samples were taken by randomly striking the area around the three replicates 60 times. Thereby the procedure was conducted in the same way as explained above. Concerning the rhizome layer sampling, the leaves of the seagrass within the 1m² replicates were cut off. Now, that the rhizome was exposed, the air lift suction sampler (Holme, 1971) was prepared and directed at the rhizome mat and positioned as close as possible to increase the yield of sediment from the rhizome mats without damaging the shoots and the rhizome network.

After the sampling procedure the samples were stored in boxes, and air pumps were installed to ensure that the living fauna stays alive for at least several hours. Immediately after sampling, the nets were emptied in a box and the seagrass was first stripped of possible living fauna, by taking the seagrass between two fingers and moving them along starting from the bottom to the top of the leaf. The remains (sediment and organisms) were sieved with the three sieves mentioned above while pouring water from a hose connected to a barrel filled with seawater. The seawater was taken from the surface of the sea at Plakias Beach to minimize the flush of debris and other organisms. The sieved remains in each sieve size were put in different bowls and labelled. The nets and sieves were cleaned thoroughly to prevent bias between replicates as well as to maximize yield of the samples.

In the following two days, the samples were divided into DA and LA in the diving school's lab. First, the material in the bowls was portioned by using petri-dishes. Then, living organisms were picked under the stereomicroscope and categorized into molluscs, crustaceans, worms, and others. The categorized organisms were directly transferred and stored in tubes with 95% ethanol, and 4% formol for worms.

Living organisms were determined as organisms which were still moving, organisms which were still complete, but died during the sampling, sieving process or through the possible insufficient amount of air and circulation in the boxes. Shells of molluscs without a sign of movement were held up to a light source in order to check if the animal was still inside.

The shells identified as non-living, sediment, and other organic remains were labeled as DA, put in boxes as a protection from wind and exposed to the sun for drying.

Further hard-bodied organisms like Bryozoa or Brachiopods were stored for future research projects but were not analyzed in the context of the current thesis.

Finally, the dried DA's were stored in plastic bags with zips, labeled and immediately after sampling taken to the University of Vienna, Department of Paleontology. Ethanol and formol were changed when samples started to turn yellow due to leaking of body fluids.

After the arrival of the living samples, all living organisms of the entire number of replicates from every depth station were identified and counted by my fellow student Martina Stockinger. At the same time, the DAs were portioned on trays. All shells belonging to molluscs with 50% or more of their shell remaining were picked out, sorted into capsules and small plastic containers, and identified at species level. A minimum of 1,000 shells per sample in the DA was determined if possible. Due to the fact that most of the samples achieved a count of over 1,000 individuals (see tab.2) the samples had to be halved or quartered. Only one replicate of each depth station and for each season was chosen for identification to represent the DA since the shell numbers were available in a high amount.

The remaining non-molluscan debris and molluscan shells, which were too damaged (less than 50% remaining) or unidentifiable through weathering, were put pack into the plastic bags and stored at the Department of Paleontology, University of Vienna.

For further traceability, the partitioning of the sample replicates for DA and LA will be explained in the following section. For the DA, one of three replicates of each depth station (5m, 10m, 15m, 20m) was used. All sample replicates are divided into large (L), medium (M) and fine (F) fractions depending on the mesh size of the sieves (L= >5mm, M= 5mm-1mm, F= 1mm-0.5mm). As the fine fraction was too large in number and much harder to identify on species level, because most of the molluscan individuals are juveniles, it could not be included in this project. Referring to the time schedule explained in material and methods, the fine fraction surpasses the given timetable and would go beyond the work of a master thesis. The medium fraction was identified and pooled with the large fraction, since the number of individuals was marginal compared to the medium fraction. In the LA, each replicate concerning each depth station was used and the assemblage from the leaves were pooled with the assemblage from the

rhizome mats. In total there were 16 samples, respectively 4 from DA in spring and autumn and 4 from LA in spring and autumn.

2.4 Statistical Approach and Analyzes

The raw data of the living and death assemblages was analyzed by displaying abundance distribution, species richness distribution, live-dead metrics (Jaccard-Chao – Spearman and delta PIE – delta S), non-metric multidimensional scaling analyzes, which were carried out using Bray-Curtis similarity coefficient and afterwards tested with a PERMANOVA. All analyzes, tests and plots were performed with the statistical programming environment R studios, version 3.2.2 (R Development Core Team, 2016) using the "vegan" package (Oksanen et al., 2013). As a first step, the LA and the DA were simply plotted against each other to obtain an overview of the abundance, the species-richness distribution and sample size difference. As a matter of fact, the metrics and the nMDS (non-metric multidimensional scaling) were applied following the same procedure as in Albano et al. (2016), whose paper is used as a guideline to explain the following steps of the data analysis: A mismatch in taxonomic composition is based on, first, Chao et al.'s (2005) abundance-based Jaccard index to compensate differences in (live and dead) sample sizes. This index ranges from 0 (no shared species) to 1 (all species occur, both alive and dead). Secondly, on rank-order agreement of relative abundance in species, by using the correlation coefficient *rho* of the non-parametric Spearman rank-order test, the rank-order agreement in species relative abundance was assessed (removal of species not present in both samples). Thirdly, on species richness, which was measured by computing the difference between logarithmic (base 10) values of species richness rarefied to the LA sample size, and S stands for species richness: $\Delta S = \log_{10}(\text{dead S}) - \log_{10}(\text{live S})$ (Olszewski & Kidwell, 2007). Once this was calculated, fourthly, evenness based on the Probability of Interspecific Encounter (PIE = $(N/(N - 1)) (1 - \sum_{i=1}^{s} p_i^2)$), N is abundance and p_i the proportion of species i (Olszewski & Kidwell, 2007), was assessed. The PIE is not biased by sample size allowing direct comparison of live and dead evenness without the need for sample size correction (Gotelli & Graves, 1996). Evenness in live-dead differences were measured as the difference between the values of dead and live PIE: $\Delta PIE = PIE_{DA} - PIE_{LA}$.

These four metrics are helpful by comparing them to previous results with live-dead comparisons in pristine and impacted settings (Kidwell, 2007, 2009). A nMDS plot

(Kruskal & Wish, 1978) was applied to visualize differences between groups, using Bray-Curtis dissimilarities on square-root transformed proportional abundances. Regarding the nMDS plot's reliability, stress was calculated and plotted. Permutational multivariate analysis of variance (PERMANOVA, McArdle & Anderson 2001, Anderson 2001) was applied to evaluate and test the difference in composition between LAs and DAs and in LA-spring and autumn in order to answer our research question (see 1.7).

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3. Results

3.1. Abundance Distribution and Species Richness Distribution

In total 17,377.75 individuals representing 218 species were found and identified throughout all samples. The DA contained 9,406.75 individuals of 193 species. For the LA a total of 7,971 specimens with 106 species were counted. The LA holds about 48.6% of the total species richness, while the DA holds 88.5%. Out of the 218 species 144 are Gastropoda, 66 are Bivalves, 7 are Polyplacophora and one is a Scaphopoda only found in the DA. In the DA all species of Polyplacophora are present, 63 species of bivalves and 122 gastropods. The LA contains approximately half of the gastropod species with 73 species and 43% of the total of bivalve species (29), and 4 of the 7 Polyplacophora (tab.2 in appendix).

In spring, the DA had a total of 3,722.75 individuals, and in autumn 5,684.5 individuals. As for the LA, a total of 3,842 individuals in spring and 4,129 individuals were observed in autumn (tab.2).

Assemblage/season	Individuals	Total
DA_05m_spring	257.125	
DA_10m_spring	958.5	
DA_15m_spring	1124.375	
DA_20m_**spring**	1382.25	**3722.25**
DA_05m_autumn	1216.375	
DA_10m_autumn	1546.25	
DA_15m_autumn	1518	
DA_20m_**autumn**	1403.875	**5684.5**
LA_05m_spring	447	
LA_10m_spring	1137	
LA_15m_spring	759	
LA_20m_**spring**	1499	**3842**
LA_05m_autumn	985	
LA_10m_autumn	1037	
LA_15m_autumn	1303	
LA_20m_**autumn**	804	**4129**

Tab.2: This table shows all used replicates divided in DA, LA and season, with their respective individual count and the total of individuals for each season.

The four most abundant species in both, LA and DA, were in total: *Bittium latreillii* with 18%, followed by *Alvania mamillata* (16%), *Bittium reticulatum* (13%), and *Jujubinus exasperatus* (11%).

Firstly, there is a high similarity of species composition in all season assemblages among LA and DA (tab.3), which resembles the results by Tomasovych and Kidwell, 2011 (see 1.5). In other words, the DA reflects which species dominate the current LA, thus they are also frequently dominated by them.

Family	Species (DA_spring)	count	%	Family	Species (DA_autumn)	count	%
Cerithiidae	*Bittium reticulatum*	363	9.8	Rissoidae	*Alvania mamillata*	1234	21.7
Cerithiidae	*Bittium latreillii*	340	9.1	Cerithiidae	*Bittium reticulatum*	643	11.3
Rissoidae	*Alvania mamillata*	334	9.0	Cerithiidae	*Bittium latreillii*	593	10.4
Trochidae	*Jujubinus exasperatus*	294	7.9	Trochidae	*Jujubinus exasperatus*	475	8.4
Rissoidae	*Alvania geryonia*	266	7.1	Phasianellidae	*Tricolia pullus*	460	8.1
Phasianellidae	*Tricolia pullus*	222	6.0	Thyasiridae	Thyasira Crete-sp.1	361.5	6.4
Family	**Species (LA_spring)**	**count**	**%**	**Family**	**Species (LA_autumn)**	**count**	**%**
Cerithiidae	*Bittium latreillii*	1004	26.1	Cerithiidae	*Bittium latreillii*	1224	29.6
Cerithiidae	*Bittium reticulatum*	901	23.5	Rissoidae	*Alvania mamillata*	881	21.3
Trochidae	*Jujubinus exasperatus*	648	16.9	Trochidae	*Jujubinus exasperatus*	472	11.4
Rissoidae	*Alvania mamillata*	405	10.5	Cerithiidae	*Bittium reticulatum*	305	7.4
Phasianellidae	*Tricolia pullus*	138	3.6	Carditidae	*Glans trapezia*	172	4.2
Thyasiridae	Thyasira Crete-sp.1	85	2.2	Phasianellidae	*Tricolia pullus*	133	3.2

Tab.3 In this table the six most abundant species in each season assemblage with their individual count and percentage in the respective season are shown.

Dividing our findings into the assemblage, we can state the following: In the DA, the dominant species were *Bittium reticulatum* (9.8%) in spring and *Alvania mamillata* (21.7%) in autumn. Additionally, it can be said that the percentage of the six most abundant species in the spring DA assemblage is relatively homogenous compared to autumn. The individual count of all species also seems to increase drastically from spring to autumn.

In both seasons in which the LA was examined, *Bittium latreillii* was the most dominant species (26.1% in spring, 29.6% in autumn). It is also noticeable that there is an increase of *Alvania mamillata* from LA_spring to LA_autumn, and respectively the decrease of *Bittium reticulatum*. *Alvania mamillata*, in general, is more abundant in autumn in both, DA and LA.

Altogether, the six most abundant species account for approximately 50% of the total abundance in the DA, to a greater degree emphasized by the higher species richness seen in fig.12. In comparison, the six most abundant species in the LA account for apparently 75-80% of the total abundance in the LA. The majority of the most abundant species belong to short-life cycle families of either micro-grazers or filter-feeders. Detailed information on molluscs' diet and life span are scarce, therefore it was not possible to find information on all most abundant species. The overall abundance in both assemblages was higher in autumn compared to spring, in particular, the increase was much stronger in the DA (fig.11). For further information see the live-dead

abundance tables (tab.3 and tab.4 in the appendix), with all species names, codes and corresponding abundances in the different sample replicates of living and death assemblage.

Abundance Distribution
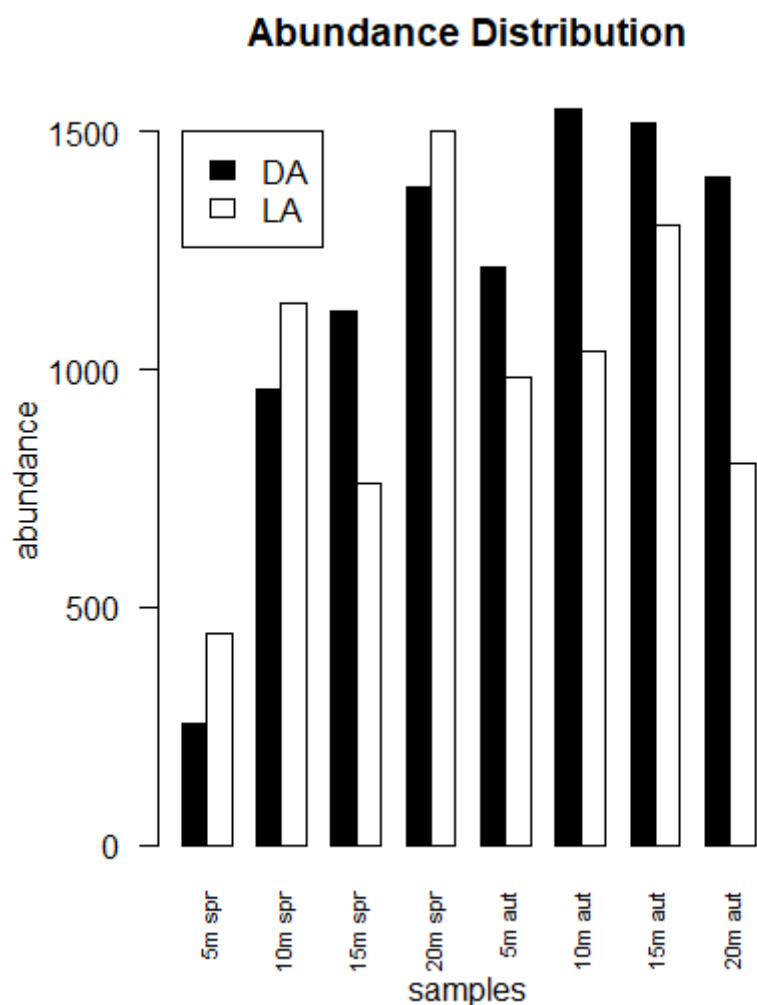
Fig.11: Overall abundance of all individuals throughout all depth stations and seasons
(spr=spring; aut=autumn) in LA and DA. Measured abundance in individuals on y-axis and
depth stations (in meters) with the corresponding season on the x-axis.

Throughout all samples, the DA had a higher species richness than the LA (fig.12). A trend in the DA seems to be the increase in species richness with water depth, only the 5m sample in autumn is an exception. No trend in species richness or distribution with changing depth can be noticed in the LA.
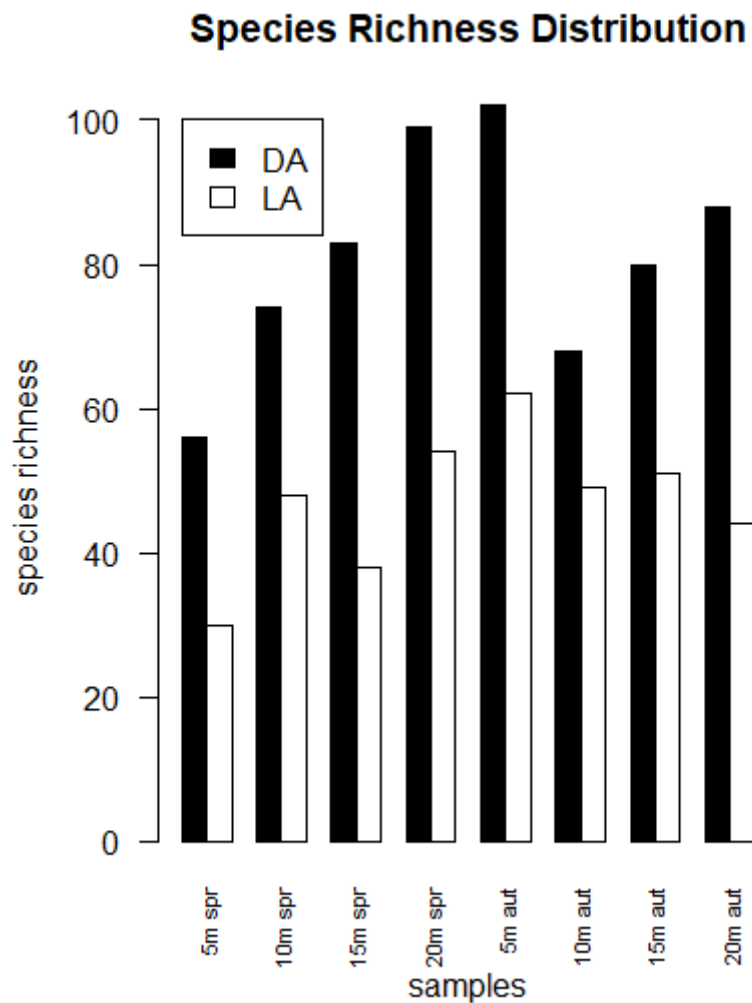
Fig. 12: Species richness distribution in all samples with respective season (spr=spring; aut=autumn). Species richness measured in species per sample is displayed on the y-axis. Samples are displayed on the x-axis.

3.2. Live-Dead Agreement at All Stations

The agreement in taxonomic similarity between LA and DA turned out greater than 0.6 (lowest value 0.66, see 10m sample (spring) in appendix tab.1) with most of the stations were above 0.8 (fig.13, appendix tab.1). However, the difference in taxonomic similarity was higher in spring, ranging from 0.66 to 0.97. The autumn samples showed a much closer similarity (values from 0.89 to 0.92).

As can be seen, rank order of species abundances stretches from 0.23 to 0.33 in spring and the range in the autumn samples reaches from 0.18 to 0.35. Overall, the agreement is quite similar in both seasons even though it is below 0.5.
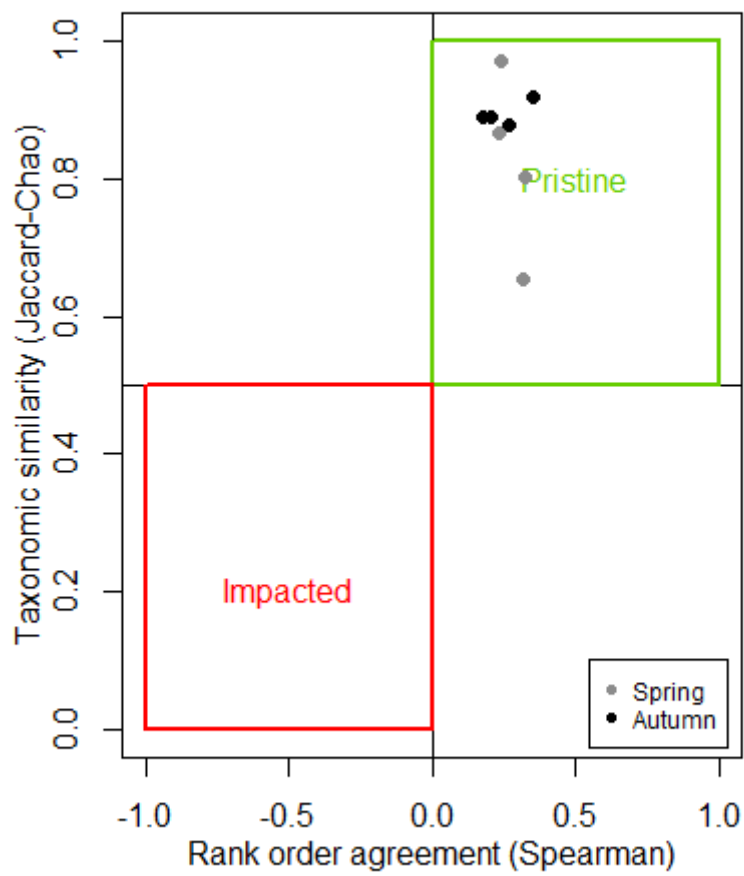
Fig.13: Agreement in LA and DA samples in respect of seasons (spring and autumn). On the y-axis, the Jaccard-Chao taxonomic similarity is displayed (range from 0 (no shared species) to 1 (all species shared). On the x-axis the Spearman rank order agreement is displayed, ranging from -1 (completely dissimilar rank order of species) to 1 (completely shared rank order of species).
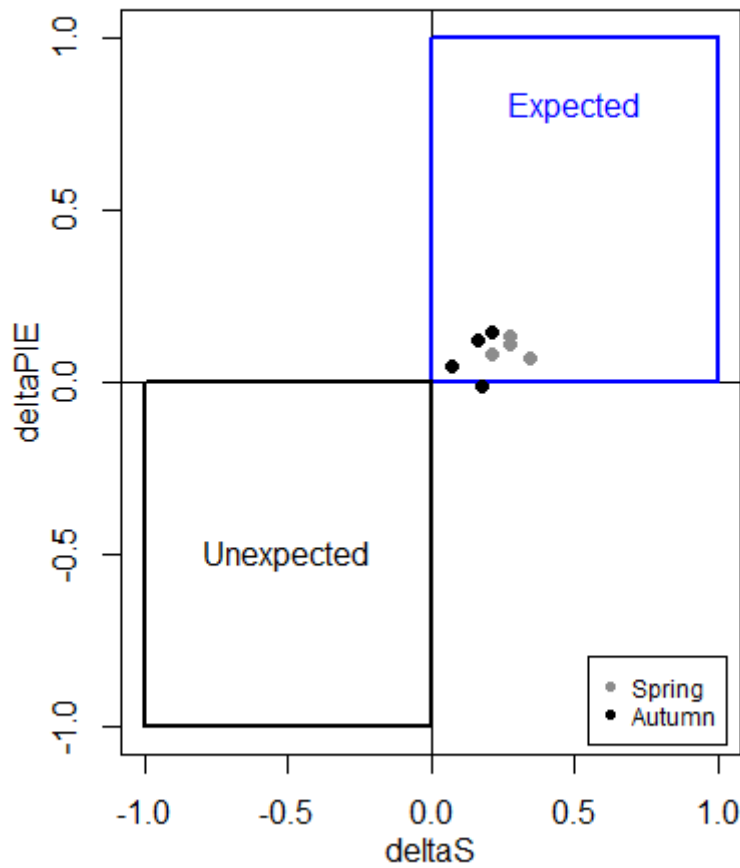
Fig.14: LA and DA samples were plotted in respect of the seasons to assess expectancy of the values, where deltaPIE is displayed on the y-axis and deltaS on the x-axis. DeltaS is used to display the difference in species richness in the samples, ranging from -1 (100% difference in species richness) and 1 (no difference in species richness). Delta PIE shows evenness regarding interspecific encounter, ranging from -1 (completely uneven) to 1 (completely even).

ΔPIE and ΔS only had small fluctuations throughout both seasons as well as all depth stations and show an overlay with the similarity in taxonomy and evenness (fig.14). Only the 5m sample in autumn was detected as an outlier and presents a negative ΔPIE value. Principally, all depth stations have values close to zero in ΔPIE (-0.012 to 0.142) and ΔS (0.072 to 0.345) (tab.1 in appendix)

3.3 NMDS

The data of LA and DA were formed into one abundance matrix, which was then analyzed with non-parametrical multivariate methods. Moreover, the data was

standardized, transformed with square-root, and then subjected to nonmetric MDS (nMDS).
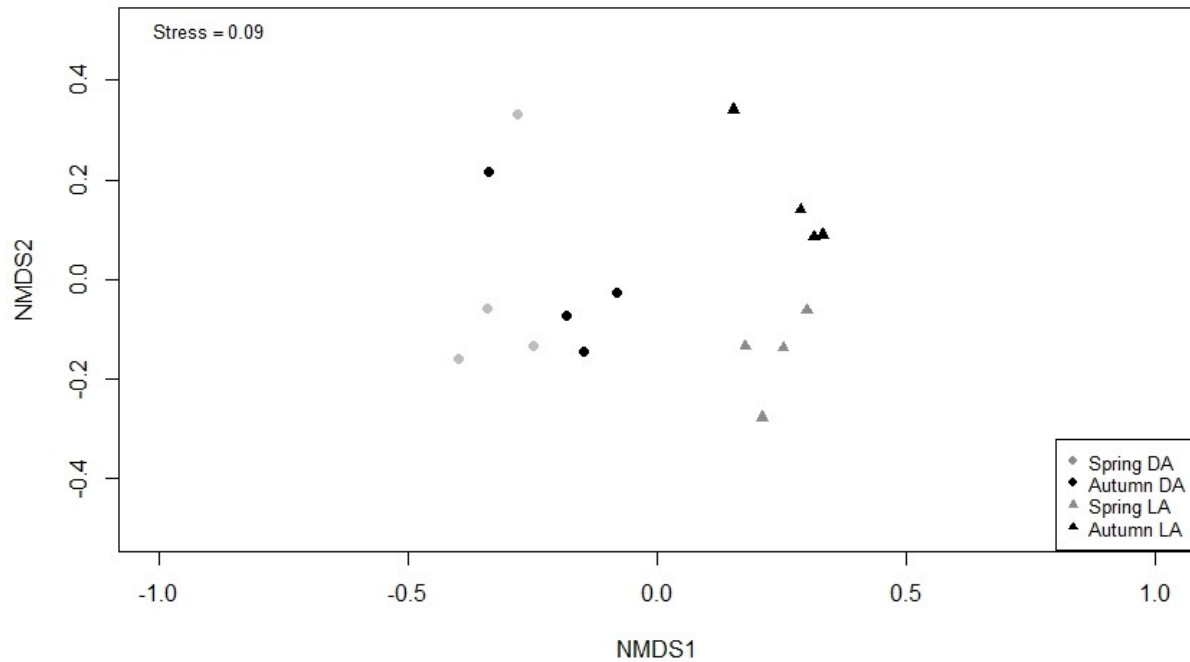
Fig.15: Non-metric multidimensional scaling plot of LAs and DAs in spring and autumn.

The nMDS plot shows a dissimilarity between DA and LA as well as a seasonal difference in the LAs. The DA samples form a cluster except for two sample points, one in spring and a second one in autumn, which disperse from the rest. On the whole, no clear difference among the season is found in the DA.

The samples of LA form two clusters, the spring and the autumn samples. There is a significant difference between the groups (LA and DA as well as spring and autumn in the LA). The difference between those groups is further emphasized by the PERMANOVA results (DA/LA: R^2=0.33; DA/LA-Spring/Autumn: R^2=0.51, see fig.1 and 2 in appendix), both findings show that there is a significant difference in each case even though explained variation between the groups is low in both cases. A main reason for in-between group variation in both tests can be temporal and spatial averaging, and interspecific difference in preservation rates in species in the DAs. A group-difference between DA and LA was expected up to a certain degree, since the

species richness is much higher in the DA. The stress value of the nMDS resulted in 0.09 (<0.05 very good fit, <0.1 good fit, >0.3 poor fit).

The final results of the calculated degrees of freedom in live-dead assemblages for between-group variation is 1, and 14 regarding within-group variation. The degrees of freedom for the seasonal comparison (spring and autumn) between-group variation are 3, and 12 for the within-group variation.

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4. Discussion

4.1 Species Richness and Abundance Distribution

Against the expectations, the overall abundance in the LAs was higher or equalled the abundance in the DAs in spring, except for the 15m depth sample (fig.11). Commonly, the DA holds a much higher amount of shells than the LA (Olszewski & Kidwell, 2007). As a matter of fact, the DA is a culmination of remains of mollusc shells which assembled over years up to centuries in a certain location compared to the LA, which only holds the present living organisms. The very likely reason for this result lays in the methods used for the comparison. As a rule for this research, only one of three replicates concerning each DA sample was sorted and identified. However, all replicates of each LA sample were used (rhizome and leaf samples) to create comparable numbers for the live-dead comparison. Another possible explication which might lead to these data could be a bias in sampling by not always holding the air lift suction sampler close enough to the floor of the seagrass mats as described in material and methods. The air lift suction sampler is known for its ascending force, and thus makes it hard to press it close to the ground.

Moreover, differences in abundance between common and rare species is corrected in the statistical analysis with square-root transformation. Through statistical tools like PIE which is not biased by sample size, but rather uses relative abundances, difference in abundance is countered.

The results in species richness (fig.12) were expected as accumulation of shells and species in the DA happens over a long period of time than in the LA, which only shows present species. The most dominant species in the samples (*Bittium latreillii*, *Bittium*

reticulatum, *Alvania mamillata*, *Jujubinus exasperatus*) are overall very abundant Mediterranean species, which are micro grazers, and thus can be found in a variety of habitats like soft-bottoms and hard-bottoms throughout the Mediterranean Sea. Evaluating these facts, the examined meadow is in a healthy state. Consequently, the near lack of alien species shows that this assemblage is pristine (tab.4). This result stands in contrast to studies like Galil et al. 2018, which indicates the presence of a lot of marine alien species around Greece.

It is empirically proven (Byers, 2002; Albano et al., 2018) that habitats which are already under great anthropogenic stress are more easily invaded than habitats which hold up a still intact species community. Mainly, non-indigenous species should not have a competitive advantage in a novel environment against indigenous species which have been shaped over thousands of years to fit in this environment. In Byers (2002) it is described, that the association between biological invasion and anthropogenically disturbed habitats leads to a successful competition of non-indigenous species over indigenous species. Resulting from the vast literature on this topic, there are three major explanations for this phenomenon: (1) Disturbances create new microhabitats and niches for alien species (Parker et al., 1993; Carlton, 1996, 2000). (2) Disturbances influence population size negatively by creating mismatches between traits of indigenous species and their environment in a very short time, removing possible predators and competitors, and lift the chance that invading species might be better adapted (D'Antonio, 1993; Moyle and Light, 1996; Kotanen, 1997; Stylinski and Allen, 1999; Davis et al., 2000). (3) Through anthropogenic travel and transport propagules, larvae etc. could be introduced, sometimes frequently, to areas that they were not capable of reaching on their own (Usher, 1988; Lonsdale, 1999).

Based on those explanations and the results from tab.4, we can assume that alien species have already been introduced via transport to the seagrass meadow offshore Crete but could not yet gain predominance in competition with local species.

Nevertheless, how shall we comprehend the few present alien molluscs found in the meadows? According to tab.4 *Pinctada imbricata radiata* is present in both assemblages, but *Laternula anatina* seem to only appear in the DA, which could indicate a past migration which was not successful. However, numbers are too low to further interpret these results. Additionally, as already mentioned in 1.1.1 the

Mediterranean has numerous alien species from all kinds of taxa especially fish, worms and molluscs. In this thesis, we only looked at molluscs because molluscs are also alien pioneers (see 1.1.1), but only because mollusc aliens are not as numerous does not exclude a greater presence of aliens from other taxa. Despite this, and strengthened by the results in tab.4, it is clear that there are few alien species, and this habitat has not been dominated by one or more of them. Since invasive alien species from the Red Sea pose a threat to numerous habitats in the Mediterranean Sea, the preservation of especially endangered habitats like seagrass meadows could play a key role in the protection of species endemic to the Mediterranean Sea.

Alien Species	Overall Abundance (%)	Abundance LA (%)	Abundance DA (%)
Pinctada imbricata radiata	0.4	0.4	0.4
Laternula anatina	0.003	0	0.005
Total Abundance	**17377.75**		
Total Species Richness	**218**		
Total Abundance of Aliens	**0.40%**		
Total Species Richness of Aliens	**0.90%**		

Tab.4: Alien Species detected in the samples of DA and LA (for reference see species list) with their respective abundance. Total abundance as well as total species richness in % was calculated accordingly.

4.2 Live-Dead Agreement

This pristine state of the meadow is further validated by the high taxonomic similarity of all single sample replicates as well as a positive match in rank order agreement between DA and LA (fig.13). Under such conditions, samples consistently fall in the upper right square of high taxonomic similarity and rank-order agreement; most species are common to both lists (similarity >0.5). Species that are dominant in one list tend to dominate the other (rank order > 0) (Kidwell, 2013). In fact, impacted data sets would overlap with pristine data sets, but range to a much lower live-dead agreement (left and downwards in the species richness and rank order metrics), and strongly impacted data sets range into even poorer levels.

After sample size standardization, the species richness (ΔS) and evenness (ΔPIE) were both positive, i.e., both of those values were higher in the DA. The result demonstrates a pristine setting (fig.13) as was empirically proved by Olszewski &

Kidwell, 2007. In pristine settings, most of the live-dead differences in molluscan assemblages can be explained largely by time-averaging (Tomasovych and Kidwell, 2009a, b, 2010a, b, 2011). That leaves almost no need to invoke post-mortem bias from destruction (e.g., dissolution and bioerosion) and post-mortem transport, since factor 4, stated in Kidwell, 2013, proposes that the natural within-habitat variability in the composition of LAs is mostly sufficient, especially, in large habitats (Kidwell, 2013). Nonetheless, an outlier in taxonomic similarity in fig.13 shows a noticeably lower agreement and refers to the 10m sample in spring. Additionally, to the overall relatively depressed species richness and evenness two outliers in fig.14 were detected: The 10m sample in autumn, which has a very low value in ΔS and the 5m sample in autumn, which shows a negative ΔPIE, meaning a low evenness in this specific sample. A reason for the low deltaS and deltaPIE in the DA could be incomplete ergodic mixing which occurs when within-habitat spatial mixing does not result in homogenization of dead remains like shells, because of erratic transportation (Olszewski & Kidwell, 2007, Albano & Sabelli, 2011). A likely explanation for this could be the low water hydrodynamc in the rhizome layer of the *Posidonia oceanica* meadow due to the canopy, which increases with greater depth (Gambi et al, 1989). Shells trapped in the vast and thick rhizome network (see 1.4) of the meadows collect only a fraction of the species living in them, and consequently the DA becomes poorer in species richness. The same can be said for all the LA samples, which concentrate around the same values as the DA.

4.3 NMDS

Particular attention should be paid to fig.15 which summarizes both hypotheses (difference between DA and LA and difference between seasons), showing the seasonal comparison as well as the dead-live comparison on a two-dimensional scale clumped together. The data of the nMDS plot (fig.15) are in good accordance with other published results e.g., Albano et al., 2016 and Albano & Sabelli, 2011 from benthic samples around oil platforms and a comparison between an off-shore reef and a *Posidonia oceanica* biocoenoses.

A significant difference between DA and LA could be provided as well as a difference in the seasons of the LA. As stated in Kidwell, 2013, seasonal change is out shadowed by taphonomic processes like time-averaging and the fact that only a very small

fraction of shells is added to the enormous amount of shells which are already held in the DA, each season. It should be noted that the LA does not hold such a great number of shells compared to the DA, and thus the LA is more vulnerable to small changes in individual counts. Moreover, it seems that even though five of the most abundant species present in DA and LA are alike, their relative abundance is causing the difference.

As a matter of fact, species with a short life cycle like specimens of the family Rissoidae, Cerithiidae, and Trochidae which are very abundant throughout all samples, e.g., *Alvania mamillata*, *Bittium latreilii* and *Bitium reticulatum* could greatly influence the seasonal change if alive or not, as seen in Albano & Sabelli (2011). Long-living mollusc species like most predators could come more into the limelight, because of the absence of short-life cycle micro grazers. On the contrary, our samples only seem to hold short living ones of the most abundant species throughout all season assemblages (tab.3). Examining the depth stations individually did not change this fact (tab.5). So, the difference between the LA seasons is probably due to the change of relative abundance between, e.g., *Alvania mamillata* and *Bittium reticulatum* shown in 3.1 and the composition of the less abundant species.

Sample	Family	Species	Count	%	Total
DA_05m_spring	Rissoidae	*Alvania mamillata*	51	19.8	257.125
DA_10m_spring	Rissoidae	*Alvania geryonia*	197	20.6	958.5
DA_15m_spring	Rissoidae	*Alvania mamillata*	135	12.0	1124.375
DA_20m_spring	Cerithiidae	*Bittium latreillii*	168	12.2	1382.25
DA_05m_autumn	Rissoidae	*Alvania mamillata*	300	24.7	1216.375
DA_10m_autumn	Rissoidae	*Alvania mamillata*	443	28.6	1546.25
DA_15m_autumn	Rissoidae	*Alvania mamillata*	291	19.2	1518
DA_20m_autumn	Cerithiidae	*Bittium latreillii*	231	16.5	1403.875
LA_05m_spring	Cerithiidae	*Bittium reticulatum*	109	24.4	447
LA_10m_spring	Cerithiidae	*Bittium reticulatum*	324	28.5	1137
LA_15m_spring	Cerithiidae	*Bittium latreillii*	215	28.3	759
LA_20m_spring	Cerithiidae	*Bittium latreillii*	490	32.7	1499
LA_05m_autumn	Rissoidae	*Alvania mamillata*	194	19.7	985
LA_10m_autumn	Rissoidae	*Alvania mamillata*	295	28.4	1037
LA_15m_autumn	Cerithiidae	*Bittium latreillii*	470	36.1	1303
LA_20m_autumn	Cerithiidae	*Bittium latreillii*	349	43.4	804

Tab.5 All season samples with the respective species dominating them. Count means the number of specimens of the target species found in the samples, % is percentage of abundance in the sample, and total stands for the total number of individuals in the respective sample.

4.4. Conclusion

Taking a closer look at the meta-analysis by Kidwell (2007), we find a strong live-dead mismatch between taxonomic composition and species' rank abundance, which could be caused by anthropogenetic modification of the ecosystem, specifically anthropogenic eutrophication (Kidwell, 2013). By comparing the data of this meta-analysis with the results of fig.13 and 14, significant evidence for the current pristine state of the meadow can be provided. However, a difference between LA and DA does exist (fig.15) but can be explained mostly by time-averaging in the DA and short-lived molluscs in the LA, as explained in 4.3. This leads to further evidence that anthropogenic influence cannot be proven or at least not with this method. Furthermore, the meadow does not show any strong damages so far, which is another indicator for good health of the meadow and few alien species (as explained in 4.1).

Although being pristine these results are only a snapshot of the present and do not provide future prospects. To protect the meadow and its endemic community as well as to ensure tourism, in future, additional long-term observation and conservation of this meadow and seagrass meadows throughout the Mediterranean and globally should be carried out. Despite our research, the biggest future achievement would

mean a preservation of the meadow's current state, so all upcoming generations can indulge the beauty of this unique habitat.

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6. APPENDIX

6.1 Abstract

To evaluate the effect of a large-scale anthropogenic impact on the community of a pristine seagrass meadow, a molluscan live-dead (LD) comparison has been performed.

Samples were taken every 5m over transects from 5m to 20m water depth on one *Posidonia oceanica* seagrass meadow in Crete. The leaves were sampled using nets and the rhizome was sampled using an airlift suction sampler. Samples were then sieved, and species of molluscs sorted and identified. Subsequently, the living and dead data were compared using metrics to measure taxonomic similarity and rank order agreement by Jaccard-Chao's similarity index and Spearman's rank correlation coefficient. Furthermore, delta PIE and Delta S were used to check species evenness. To estimate significant live-dead and seasonal differences the samples were also compared in an ordination (nMDS plot).

As expected, species richness was higher in the death assemblage (DA) than in the living assemblage (LA). The LD-analysis yields fairly high agreement in species richness and rank order, while deltaPIE and deltaS were rather low, which suggests

uneven mixing in the rhizome mats. A significant difference in the nMDS plot between DA and LA and between seasons in the LA was indicated.

Concludingly, it can be said that the meadow seems to be doing well regarding anthropogenic stress and that differences between LA and DA are mostly due to taphonomic factors such as time-averaging. Alien species do not have a big role yet since only two alien species were found, which contribute less than 1% to the overall shell abundance.

Key words: Death Assemblage, Living Assemblage, Taphonomy, Molluscs, *Posidonia oceanica*

6.2 Zusammenfassung

Um die Auswirkungen eines großflächigen anthropogenen Einflusses auf die Lebensgemeinschaft einer unberührten Seegraswiese zu untersuchen, wurde ein Lebend-Tot-(LD) Vergleich mit Mollusken durchgeführt.

Auf einer Seegraswiese von *Posidonia oceanica* auf Kreta wurden alle 5 m über Transekte von 5m bis 20 m Wassertiefe Proben genommen. Die Blätter wurden mit Netzen und das Rhizom mit einem Lufthebesauger beprobt. Die Proben wurden dann gesiebt, die Arten sortiert und identifiziert. Anschließend wurden die lebenden und toten Daten mit Hilfe von Kennzahlen zur Bestimmung der taxonomischen Ähnlichkeit (Jaccard-Chao Index) und der Rangordnungsübereinstimmung (Spearmans Koeffizient) verglichen. Außerdem wurden Delta PIE und Delta S ermittelt, um die Ausgeglichenheit der Artenzusammensetzung zu überprüfen. Um signifikante Lebend-Tot- und saisonale Unterschiede abzuschätzen, wurden die Proben auch in einer Ordination (nMDS-Plot) verglichen.

Wie erwartet war der Artenreichtum in der Todes-Vergesellschaftung (DA) höher als in dem Lebend-Vergesellschaftung (LA). Die LD-Analyse ergab ziemlich hohe Übereinstimmung bei Artenreichtum und in der Rangordnung, während deltaPIE und deltaS eher niedrig waren, was eine ungleichmäßige Durchmischung in den Rhizom-Matten nahelegt. Im nMDS-Plot zeigte sich ein signifikanter Unterschied zwischen DA und LA sowie zwischen den Jahreszeiten in LA.

Zusammenfassend kann gesagt werden, dass die anthropogene Belastung der Seegraswiese gering ist und Unterschiede zwischen LA und DA vor allem auf taphonomische Faktoren wie time-averaging zurückzuführen sind. Abschließend kann gesagt werden, dass der Einfluss von invasiven Arten keine große Rolle zu spielen scheint, da nur zwei invasive Arten gefunden wurden, die mit weniger als 1% zur Gesamtschalenabundanz beitragen.

Schlagwörter: Todes-Vergesellschaftung, Lebend-Vergesellschaftung, Taphonomie, Mollusken, *Posidonia oceanica*

6.3 Picture Copyright Declaration

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6.4 Sampling Protocol

_____

Sampling protocol project (Martina Stockinger, 2017)

Preparation before underwater sampling:

- Find ideal seagrass meadow at least **8 meters wide?** Depth ranges from 5 meter to 20 meter (can be separated meadows but same area)

- Fix depth lines at the specific depth and mark spots to place the frames to save time for the actual sampling

- Write numbers on the sampling nets, hand nets = H1, H2, H3 ……. Air-lift suctionsampler = A1, A2, A3, …..

- On sampling day fill barrel and buckets with saltwater to make sure we have enough saltwater for the sieving. Prepare sieving station with material like sieves, bowls labels, air pumps etc…

- Sampling label code: D5R1L/L = Depth 5m, Replicate 1, Leaves, Large

Needed Material on the Beach for underwater sampling:

- Diving gear + spare material + first aid + oxygen

- 8 x 12 litre tanks + 3x15 litres tanks for Airlift sampler

- Camera for documentation

- 1 x Airlift sampler + 3 nets + 1 spare net

- 1x 1m^2 frame

- 1x 0,40x0,40 cm frame

- 2x Netframe + 4 nets + 1 spare net

- 2x Underwater slates

- 2x Scissors

- 2 -3 Transport boxes for the samples

- 1 or 2 lifting bags + carabiner

- **How to secure material underwater? Sometimes strong wind/waves!!!**

Underwater sampling:

- 4 Stations, 3 replicates per station

- 60 Net strokes per station (in the surrounding Area)

- 20 Net strokes per replicate (inside 1x1m^2 frame)

- 80 bar/15 litre tanke air lift suction sampler per replicate (inside 1x1m^2 frame)

- Shoot counts per replicate in 40x40cm frame (inside 1x1m^2 frame)

Underwater sampling sequence (who does what?)

- Find a secure place for the equipment

- Person B places 1 m^2 frame at the mark

- Person A starts with 60 net strokes at the surrounding area, make sure you stay at the specific depth. Before you start write down on your slate the number of the net (can also be done above water)

- B does 20 net stroke inside the 1 m^2

- When B is finished place 40x40 frame inside the 1x1 frame and start counting shoots

- While B counts shoots A can start to exfoliates inside the 1x1 m^2

- After exfoliating A and B together use the Air-Liftsuctionsampler (ALS-sampler). While A holds the tube and B holds a tank and make sure only 80 bar (15 litre tank) are used

- While A changes the nets on Air lift suction sampler and hand nets B moves the 1x1 m^2 Frame to next mark. A start with 20 net strokes in 2nd replicate (write down on slate which net for what station and replicate)

- When A is finished B places 40x40 square and starts counting shoots while A starts exfoliating the leaves.

- After exfoliation A and B use ALS-sampler like before

  - **REPEATE for 3rd replicate**

- **One day sampling = one station?**

- **Should the sampling be at the same time of the day?**

Samples (nets) will be stored in Boxes full of saltwater for the transport!

At the diving school:

- Denny takes care of the samples, make sure all but one are in a container were air is pumped through. Martina is taking care of the gear and equipment.

- Samples must be sieved through 5mm, 1mm and 0.5mm – sieve one sample at a time.

- Empty one net into a container full of saltwater and first get rid of the sea grass leaves. Before you throw the leaves away glide over them to get all the organisms stuck on them.

- After sieving keep section >5 mm (L), 5-1mm (M) in a bowl ready to sort. Section 1mm – 0,5mm will be preserved unsorted in a glass jar with the double amount of ethanol and a label in and on the glass jar. The glass jar will be closed as followed. Before you put the lid on put plastic foil over it and then screw the lid on.

- <0.5 mm discard (?)

- Before the next sample is sieved sort the section L and M as follow.

Prepare for Sorting

- Stereomicroscope, tweezers, petri dishes, little spoon, spray bottle with ethanol, funnel, lamps, spray bottle with salt water.

- Labels and 3 Jars (per sample fraction) already with a label (2 with ethanol, 1 with formaldehyde)

- 1 Jar for molluscs, 1 for worms (formaldehyde), 1 for the rest of the living animals (Porifera, Echinodermata, etc…)

If possible take a photo of the Porifera (color)

6.5 Tables and Figures

Sample-name	Spearman_rho	Spearman_p-value	Jaccard-Chao	deltaS	deltaPIE
05m_spring	0.232	0.067	0.866	0.345	0.069
10m_spring	0.319	0.003	0.655	0.192	0.079
15m_spring	0.327	0.001	0.801	0.275	0.109
20m_spring	0.239	0.01	0.97	0.278	0.136
05m_ autumn	0.18	0.051	0.889	0.169	-0.012
10m_autumn	0.353	0.001	0.918	0.072	0.045
15m_ autumn	0.265	0.009	0.878	0.165	0.119
20m_ autumn	0.208	0.038	0.888	0.212	0.142

Tab.1: Samples with their respective values shown in the metrics fig. 14 (Spearman_rho plotted against Jaccard-Chao) and fig.15 (deltaS plotted against deltaPIE).

	LA	DA	Total
Gastropoda	73	122	144
Bivalvia	29	63	66
Polyplacophora	4	7	7
Scaphopoda	0	1	1

Tab.2: The four mollusc groups found in the samples with their respective

number of species in the assemblages.

```
Permutation: free
Number of permutations: 999

Terms added sequentially (first to last)

          Df SumsOfSqs MeanSqs F.Model      R2 Pr(>F)
factor_LD  1   0.41171 0.41171  7.0354 0.33446  0.001 ***
Residuals 14   0.81928 0.05852          0.66554
Total     15   1.23099                  1.00000
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Fig.1: PERMANOVA results between the groups LA and DA.

```
Permutation: free
Number of permutations: 999

Terms added sequentially (first to last)

            Df SumsOfSqs MeanSqs F.Model      R2 Pr(>F)
factor_site  3   0.62835 0.20945  4.1706 0.51044  0.001 ***
Residuals   12   0.60264 0.05022         0.48956
Total       15   1.23099                 1.00000
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Fig.2: PERMANOVA results between the groups DA spring, DA autumn and LA spring, LA autumn.

LA Species Abundance Table

Taxon_ID	Family	Genus	Species	Author	Species_Code	LA_05_spr	LA_10_spr	LA_15_spr	LA_20_spr	LA_05_aut	LA_10_aut	LA_15_aut	LA_20_aut
3	Patellidae	Patella	rustica	(Linnaeus, 1758)	G178	0	0	0	0	0	0	0	0
3	Patellidae	Patella	ulyssiponensis	(Gmelin, 1791)	G179	0	0	0	0	0	0	0	0
3	Patellidae	Patella	sp.		G233	0	0	1	0	0	0	0	0
3	Patellidae	Patella	sp. 1		G244	0	0	0	0	0	0	0	0
3	Patellidae	Patella	caerula	(Linnaeus, 1758)	G451	0	0	0	0	0	0	0	0
32	Fissurellidae	Emarginula	octaviana	(Coen, 1939)	G177	0	0	0	0	0	0	32	0
32	Fissurellidae	Emarginula	sicula	(Gray, 1825)	G367	0	1	0	0	0	1	1	0
32	Fissurellidae	Diodora	graeca	(Linnaeus, 1758)	G439	0	0	0	0	0	0	32	0
32	Fissurellidae	Emarginula	huzardii	(Payraudeau, 1826)	G563	0	0	0	0	0	0	32	0
33	Haliotidae	Haliotis	tuberculata lamellosa	(Lamarck, 1822)	G191	0	0	0	0	0	0	0	0
36	Scissurellidae	Scissurella	costata	(d'Orbigny, 1824)	G169	8	26	16	17	5	0	3	0
39	Trochidae	Jujubinus	exasperatus	(Pennant, 1777)	G044	48	199	109	292	54	114	203	101
39	Trochidae	Jujubinus	striatus	(Linnaeus, 1758)	G180	0	2	0	0	0	1	3	2
39	Trochidae	Clanculus	corallinus	(Gmelin, 1791)	G200	0	0	0	0	0	0	0	0
39	Trochidae	Steromphala	varia	(Linnaeus, 1758)	G202	0	0	0	0	1	0	0	0
39	Trochidae	Gibbula	turbinoides	(Deshayes, 1835)	G207	0	0	0	0	0	0	0	0
39	Trochidae	Clanculus	cruciatus	(Linnaeus, 1758)	G208	0	0	0	1	0	0	0	0
39	Trochidae	Gibbula	ardens	(Salis Marschlins, 1793)	G339	0	1	0	0	0	0	0	0
39	Trochidae	Gibbula	fanulum	(Gmelin, 1791)	G424	0	0	0	0	0	0	0	0
42	Calliostomatidae	Calliostoma	laugieri	(Payraudeau, 1826)	G289	1	2	1	0	23	1	0	0
46	Margaritidae	Pinctada	imbricata radiata	(Leach, 1814)	B078	2	4	9	12	5	1	1	1
47	Phasianellidae	Tricolia	speciosa	(Megerle von Mühlfeld, 1824)	G155	5	32	13	14	8	8	13	5
47	Phasianellidae	Tricolia	pullus	(Linnaeus, 1758)	G194	40	43	28	27	66	25	21	21
47	Phasianellidae	Tricolia	tenuis	(Michaud, 1829)	G219	0	0	0	0	4	0	0	0
51	Turbinidae	Bolma	rugosa	(Linnaeus, 1767)	G345	0	0	0	1	1	2	1	6
75	Cerithiidae	Bittium	latreillii	(Payraudeau, 1826)	G017	106	193	215	490	137	268	470	349
75	Cerithiidae	Bittium	reticulatum	(da Costa, 1778)	G026	109	324	169	299	41	116	94	54
75	Cerithiidae	Cerithium	sp. Crete_1		G159	0	0	0	1	1	0	0	1
75	Cerithiidae	Cerithium	sp. Crete_2		G160	0	0	0	0	0	0	0	0
93	Turritellidae	Turritella	turbona	(Monterosato, 1877)	G154	0	0	0	0	0	0	2	0
103	Conidae	Conus	ventricosus	(Gmelin, 1791)	G048	0	0	0	0	0	0	03	0
109	Naticidae	Naticidae	sp. Crete_1		G161	0	0	0	0	0	0	09	0
109	Naticidae	Notocochlis	dillwynii	(Payraudeau, 1826)	G295	1	1	1	2	0	0	0	0
109	Naticidae	Euspira	intricata	(Donovan, 1804)	G492	0	0	0	0	0	0	09	0
111	Atlantidae	Atlanta	sp. Crete_1		G348	0	0	0	0	0	0	10	0
113	Triphoridae	Monophorus	perversus	(Linnaeus, 1758)	G140	0	0	0	0	1	0	0	0
113	Triphoridae	Marshallora	adversa	(Montagu, 1803)	G216	0	1	0	1	1	0	1	0
113	Triphoridae	Similiphora	similior	(Bouchet & Guillemot, 1978)	G287	0	1	1	0	2	0	0	0
113	Triphoridae	Monophorus	erythrosoma	(Bouchet & Guillemot, 1978)	G340	0	0	0	1	0	0	0	0
113	Triphoridae	Viriola	bayani	(Jousseaume, 1884)	G352	0	0	0	0	0	1	0	1
114	Cerithiopsidae	Cerithiopsis	tubercularis	(Montagu, 1803)	G112	0	0	1	0	4	0	0	0
114	Cerithiopsidae	Dizoniopsis	coppolae	(Aradas, 1870)	G167	0	0	0	0	0	0	0	0
114	Cerithiopsidae	Cerithiopsis	Crete_1		G182	0	0	0	0	0	0	0	0
114	Cerithiopsidae	Cerithiopsis	sp. Crete		G453	0	0	0	0	0	0	0	0
117	Rissoidae	Alvania	mamillata	(Risso, 1826)	G046	29	152	104	120	194	295	277	115
117	Rissoidae	Pusillina	cf. philippi	(Aradas & Maggiore, 1844)	G050	0	0	1	1	0	1	0	0
117	Rissoidae	Rissoa	similis	(Scacchi, 1836)	G097	0	0	0	0	0	0	0	0
117	Rissoidae	Alvania	scabra	(Philippi, 1844)	G171	0	0	0	0	0	0	0	0
117	Rissoidae	Alvania	discors	(Allan, 1818)	G172	14	8	0	15	56	2	0	10
117	Rissoidae	Alvania	lineata	(Risso, 1826)	G173	5	0	0	0	7	0	0	0
117	Rissoidae	Rissoa	angustior	(Monterosato, 1917)	G174	20	8	3	1	6	4	1	3

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117	Rissoidae	Alvania	amatii	(Oliverio, 1986)	G175	0	0	0	0	0	0	0	0
117	Rissoidae	Rissoa	variabilis	(Megerle von Mühlfeld, 1824)	G176	0	0	0	0	0	0	0	0
117	Rissoidae	Rissoa	ventricosa	(Desmarest, 1814)	G181	0	0	0	0	0	0	0	0
117	Rissoidae	Rissoa	violacea	(Desmarest, 1814)	G185	0	0	0	0	0	0	0	0
117	Rissoidae	Pusillina	radiata	(Philippi, 1836)	G188	0	12	5	9	1	1	11	10
117	Rissoidae	Alvania	sp. Crete-1		G282	0	0	0	0	0	0	0	0
117	Rissoidae	Alvania	sp. Crete-2		G283	0	0	0	0	0	0	0	0
117	Rissoidae	Alvania	fractospira	(Oberling, 1970)	G284	0	0	0	0	0	0	0	0
117	Rissoidae	Alvania	geryonia	(Nardo, 1847)	G285	0	0	0	0	0	0	0	0
117	Rissoidae	Alvania	clarae	(Nofroni & Pizzini, 1991)	G288	0	0	0	0	2	0	0	0
117	Rissoidae	Rissoa	auriformis	(Pallary, 1904)	G346	0	0	0	0	0	0	0	0
117	Rissoidae	Rissoa	scurra	(Monterosato, 1917)	G448	0	0	0	0	0	0	0	0
117	Rissoidae	Alvania	aspera	(Philippi, 1844)	G449	0	0	0	0	0	0	0	0
118	Barleeiidae	Barleeia	gougeti	(Michaud, 1830)	G450	0	0	0	0	0	0	0	0
120	Myidae	Sphenia	binghami	(Turton, 1822)	B061	0	0	0	0	0	0	0	0
121	Rissoinidae	Rissoina	bruguieri	(Payraudeau, 1826)	G047	0	0	0	0	3	0	0	0
129	Caecidae	Caecum	auriculatum	(De Folin, 1868)	G215	0	0	0	1	1	0	0	1
129	Caecidae	Caecum	clarkii	(Carpenter, 1859)	G360	0	0	0	0	0	0	1	0
150	Eulimidae	Eulima	glabra	(da Costa, 1778)	G036	0	0	0	0	0	0	0	0
150	Eulimidae	Melanella	polita	(Linnaeus, 1758)	G189	0	0	0	0	0	0	0	0
150	Eulimidae	Vitreolina	philippi	(de Rayneval & Ponzi, 1854)	G255	0	0	0	0	2	0	0	0
150	Eulimidae	Campylorhaphion	famelicum	(Watson, 1883)	G291	0	2	0	0	2	0	0	0
150	Eulimidae	Melanella	lubrica	(Monterosato, 1890)	G351	0	0	0	0	2	0	0	1
151	Calyptraeidae	Crepidula	unguiformis	(Lamarck, 1822)	G198	0	0	0	0	0	0	0	0
152	Cypraeidae	Naria	spurca	(Linnaeus, 1758)	G551	0	0	0	0	0	0	0	0
174	Cystiscidae	Gibberula	philippii	(Monterosato, 1878)	G422	0	0	0	0	0	0	5	0
176	Marginellidae	Volvarina	mitrella	(Risso, 1826)	G199	0	0	0	0	0	0	0	0
180	Buccinidae	Chauvetia	mamillata	(Risso, 1826)	G166	0	0	0	0	0	0	0	0
180	Buccinidae	Euthria	cornea	(Linnaeus, 1758)	G332	0	0	0	0	2	1	0	0
180	Buccinidae	Chauvetia	turritellata	(Deshayes, 1835)	G364	0	2	0	0	2	3	0	0
183	Columbellidae	Columbella	rustica	(Linnaeus, 1758)	G139	0	0	0	0	0	0	0	0
184	Fasciolariidae	Aegeofusinus	rolani	(Buzzurro & Ovalis, 2005)	G158	1	0	0	0	3	1	2	2
184	Fasciolariidae	Aptyxis	syracusana	(Linnaeus, 1758)	G350	0	0	0	0	1	0	0	0
186	Nassariidae	Tritia	mutabilis	(Linnaeus, 1758)	G341	0	0	0	0	0	0	0	0
187	Pisaniidae	Pollia	scacchiana	(Philippi, 1844)	G119	0	0	0	0	0	0	0	0
187	Pisaniidae	Enginella	leucozona	(Philippi, 1844)	G212	0	0	0	0	0	0	0	0
188	Muricidae	Hexaplex	trunculus	(Linnaeus, 1758)	G100	0	2	1	1	7	1	1	1
188	Muricidae	Muricopsis	cristata	(Brocchi, 1814)	G197	1	3	1	1	4	10	12	2
188	Muricidae	Murexsul	aradasii	(Monterosato in Poirier, 1883)	G213	0	0	0	0	0	0	0	0
188	Muricidae	Ocinebrina	aegeensis	(Aissaoui, Barco & Oliverio, 2017)	G294	0	0	0	1	0	0	0	0
188	Muricidae	Typhinellus	labiatus	(de Cristofori & Jan, 1832)	G363	0	2	1	0	0	1	0	0
188	Muricidae	Ocinebrina	aciculata	(Lamarck, 1822)	G445	0	2	0	0	0	2	4	0
190	Costellariidae	Vexillum	granum	(Forbes, 1844)	G452	0	0	0	0	0	0	0	0
190	Costellariidae	Pusia	tricolor	(Gmelin, 1791)	G465	0	0	0	0	0	0	0	0
194	Mitridae	Episcomitra	cornicula	(Linnaeus, 1758)	G519	0	0	0	0	0	0	0	0
210	Horaiclavidae	Haedropleura	sp.		G305	0	0	0	1	0	3	6	1
211	Mangeliidae	Mangelia	taeniata	(Deshayes, 1835)	G163	0	0	0	0	0	0	0	0
211	Mangeliidae	Mangelia	sp. Crete_1		G196	0	1	0	0	0	0	0	0
212	Mitromorphidae	Mitromorpha	columbellaria	(Scacchi, 1836)	G447	0	0	0	0	0	0	0	0
214	Raphitomidae	Raphitoma	sp. Crete_1		G164	0	0	0	0	0	0	0	0
214	Raphitomidae	Raphitoma	sp. Crete_2		G190	0	0	0	0	0	1	0	0
214	Raphitomidae	Raphitoma	sp. Crete_3		G195	0	0	0	0	0	0	0	0
214	Raphitomidae	Clathromangelia	loiselieri	(Oberling, 1970)	G304	0	0	0	2	0	2	4	4

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214	Raphitomidae	Clathromangelia	sp. 1		G326	0	0	0	0	0	0	0	0
214	Raphitomidae	Clathromangelia	sp. 2		G327	0	0	0	0	0	0	0	0
214	Raphitomidae	Clathromangelia	granum	(Philippi, 1844)	G353	0	0	0	0	1	0	2	1
214	Raphitomidae	Raphitoma	linearis	(Montagu, 1803)	G462	0	0	0	0	0	0	0	0
214	Raphitomidae	Raphitoma	contigua	(Monterosato, 1884)	G562	0	0	0	0	0	0	0	0
234	Pleurobranchidae	Berthella	aff. plumula	(Montagu, 1803)	G358	0	0	0	0	0	0	34	0
264	Fustiariidae	Fustiaria	rubescens	(Deshayes, 1825)	S006	0	0	0	0	0	0	64	0
294	Retusidae	Retusa	truncatula	(Bruguière, 1792)	G168	5	11	5	8	0	0	90	0
295	Rhizoridae	Volvulella	acuminata	(Bruguière, 1792)	G105	0	0	0	0	0	0	95	0
297	Neritidae	Smaragdia	viridis	(Linnaeus, 1758)	G152	15	16	8	3	27	9	12	8
301	Cliidae	Clio	pyramidata	(Linnaeus, 1767)	G156	0	0	0	0	0	0	0	0
302	Haminoeidae	Haminoea	sp. 1		G151	0	0	0	0	0	0	02	0
302	Haminoeidae	Weinkauffia	turgidula	(Forbes, 1844)	G192	0	0	0	0	0	0	02	0
302	Haminoeidae	Atys	macandrewii	(Smith, 1872)	G342	0	0	1	0	0	0	02	0
302	Haminoeidae	Atys	angustatus	(Smith, 1872)	G343	0	0	0	0	0	0	02	0
304	Philinidae	Philine	catena	(Montagu, 1803)	G165	2	1	0	1	0	0	04	0
315	Colloniidae	Homalopoma	sanguineum	(Linnaeus, 1758)	G170	0	0	0	0	0	0	0	1
315	Aplysiidae	Aplysia	sp. Crete_1	(Mörch, 1863)	G201	0	1	0	3	0	0	0	0
315	"Aplysiidae"	"Aplysia"	sp. Crete-1		G286	0	0	0	0	0	0	0	0
315	Aplysiidae	Aplysia	depilans	(Gmelin, 1791)	G446	0	0	0	1	0	0	0	0
318	Creseidae	Creseis	clava	(Rang, 1828)	G056	0	0	0	0	0	0	02	0
318	Creseidae	Creseis	conica	(Eschscholtz, 1829)	G072	0	0	0	0	0	0	02	0
318	Creseidae	Styliola	subula	(Quoy & Gaimard, 1827)	G228	0	0	0	0	0	0	02	0
321	Peraclidae	Peracle	reticulata	(d'Orbigny, 1834)	G157	0	0	0	0	0	0	02	0
328	Velutinidae	Lamellaria	perspicua	(Linnaeus, 1758)	G183	0	0	0	1	0	0	02	0
329	Granulinidae	Granulina	marginata	(Bivona, 1832)	G184	0	2	0	0	0	11	1	0
331	Volvatellidae	Ascobulla	fragilis	(Jeffreys, 1856)	G362	0	0	0	0	0	1	02	0
338	Siphonariidae	Williamia	gussoni	(Costa O.G., 1829)	G153	3	4	6	14	0	0	0	0
339	Pyramidellidae	Parthenina	interstincta	(Adams, 1797)	G010	0	1	0	0	1	0	0	0
339	Pyramidellidae	Eulimella	acicula	(Philippi, 1836)	G021	0	0	0	1	0	0	0	0
339	Pyramidellidae	Odostomia	cf. acuta	(Jeffreys, 1848)	G022	0	1	0	0	0	1	0	0
339	Pyramidellidae	Megastomia	conoidea	(Brocchi, 1814)	G027	0	0	0	0	0	0	0	0
339	Pyramidellidae	Folinella	excavata	(Phillippi, 1836)	G030	0	0	0	0	0	0	0	0
339	Pyramidellidae	Ondina	vitrea	(Brusina, 1866)	G037	0	0	0	0	0	3	1	0
339	Pyramidellidae	Turbonilla	lactea	(Linnaeus, 1758)	G186	0	0	0	0	0	0	0	0
339	Pyramidellidae	Pyrgostylus	striatulus	(Linnaeus, 1758)	G187	0	4	0	0	5	5	1	7
339	Pyramidellidae	Parthenina	monterosatii	(Clessin, 1900)	G290	0	0	0	0	1	0	0	0
339	Pyramidellidae	Odostomia	sicula	(Philippi, 1851)	G347	0	2	0	0	1	0	0	0
339	Pyramidellidae	Parthenina	terebellum	(Philippi, 1844)	G349	0	0	0	0	1	0	0	0
339	Pyramidellidae	Odostomia	acuta	(Jeffreys, 1848)	G357	0	0	0	0	0	0	0	0
339	Pyramidellidae	Auristomia	fusulus	(Monterosato, 1878)	G365	0	0	0	1	0	0	0	0
339	Pyramidellidae	Euparthenia	humboldti	(Risso, 1826)	G560	0	0	0	0	0	0	0	0
350	Acanthochitonidae	Acanthochitona	fascicularis	(Linnaeus, 1767)	P001	0	1	2	8	2	5	3	10
351	Leptochitonidae	Leptochiton	bedullii	(Dell'Angelo & Palazzi, 1986)	P002	0	0	0	7	4	2	2	0
351	Leptochitonidae	Lepidopleurus	cajetanus	(Poli, 1791)	P007	0	0	0	0	0	0	02	0
352	Callochitonidae	Callochiton	septemvalvis	(Montagu, 1803)	P003	0	0	0	1	1	0	2	0
394	Chitonidae	Chiton	olivaceus	(Spengler, 1797)	P004	0	0	1	1	0	0	1	0
426	Bivalvia	Bivalvia	Crete-sp. 2		B174	0	0	0	0	0	0	02	0
481	Nuculidae	Nucula	nitidosa	(Winckworth, 1930)	B018	0	2	1	7	20	3	5	3
485	Nuculanidae	Lembulus	pella	(Linnaeus, 1758)	B016	0	0	0	0	0	0	05	0
485	Nuculanidae	Saccella	commutata	(Philippi, 1844)	B017	0	0	0	0	0	0	05	0
493	Mytilidae	Gregariella	semigranata	(Reeve, 1858)	B060	0	0	0	1	1	1	1	0
493	Mytilidae	Musculus	costulatus	(Risso, 1826)	B125	11	7	15	5	59	6	9	1

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493	Mytilidae	Septifer	cumingii	(Récluz, 1848)	B132	6	0	6	3	16	7	6	2
493	Mytilidae	Modiolula	phaseolina	(Philippi, 1844)	B141	0	0	0	0	0	1	0	0
493	Mytilidae	Crenella	arenaria	(Monterosato, 1875 ex H. Martin, ms.)	B142	1	0	2	17	16	3	9	5
493	Mytilidae	Septifer	bilocularis	(Linnaeus, 1758)	B151	0	0	0	0	1	0	0	0
493	Mytilidae	Modiolus	barbatus	(Linnaeus, 1758)	B262	0	0	0	0	0	0	0	0
494	Arcidae	Arca	noae	(Linnaeus, 1758)	B138	1	2	1	1	3	0	0	1
494	Arcidae	Barbatia	barbata	(Linnaeus, 1758)	B139	3	3	4	2	12	4	7	3
497	Noetiidae	Striarca	lactea	(Linnaeus, 1758)	B055	4	7	8	10	7	16	13	10
504	Pinnidae	Pinna	nobilis	(Linnaeus, 1758)	B181	1	2	3	1	0	0	0	0
507	Anomiidae	Anomia	sp. 1		B035	0	0	0	0	0	0	0	0
507	Anomiidae	Anomia	ephippium	(Linnaeus, 1758)	B269	0	0	0	0	0	0	0	0
510	Pectinidae	Genus	sp. 1		B042	0	0	0	0	0	0	0	0
510	Pectinidae	Flexopecten	hyalinus	(Poli, 1795)	B143	1	2	0	3	4	0	4	3
510	Pectinidae	Talochlamys	multistriata	(Poli, 1795)	B153	0	0	0	0	0	0	0	0
515	Limidae	Limatula	subauriculata	(Montagu, 1808)	B144	0	2	2	21	13	6	25	7
515	Limidae	Lima	lima	(Linnaeus, 1758)	B152	0	1	0	1	0	0	2	1
515	Limidae	Limaria	hians	(Gmelin, 1791)	B154	0	0	0	0	0	0	0	0
515	Limidae	Limaria	tuberculata	(Olivi, 1792)	B184	0	0	0	0	0	0	0	0
523	Lucinidae	Loripes	orbiculatus	(Poli, 1791)	B020	0	0	0	0	0	0	0	0
523	Lucinidae	Lucinella	divaricata	(Linnaeus, 1758)	B023	0	0	0	0	0	0	0	0
523	Lucinidae	Loripinus	fragilis	(Philippi, 1836)	B068	0	0	0	0	0	0	0	1
523	Lucinidae	Ctena	decussata	(Costa, 1829)	B088	0	0	0	8	7	11	6	11
523	Lucinidae	Lucinidae	sp. 1		B167	0	0	0	0	0	0	0	1
523	Lucinidae	Myrtea	spinifera	(Montagu, 1803)	B247	0	0	0	0	0	0	1	0
524	Thyasiridae	Thyasira	Crete-sp. 1		B140	1	37	7	40	25	34	25	13
524	Thyasiridae	Thyasira	Crete-sp. 2		B162	0	0	0	0	0	0	0	0
526	Carditidae	Glans	trapezia	(Linnaeus, 1767)	B049	2	3	5	16	100	38	14	20
526	Carditidae	Cardites	antiquatus	(Linnaeus, 1758)	B147	0	0	0	1	0	0	7	1
526	Carditidae	Cardita	calyculata	(Linnaeus, 1758)	B161	0	0	0	0	0	1	3	0
529	Astartidae	Goodallia	sp.		B189	0	0	0	0	0	0	0	0
533	Cardiidae	Papillicardium	papillosum	(Poli, 1791)	B074	0	0	0	0	0	0	0	0
533	Cardiidae	Parvicardium	cf. scabrum	(Philippi, 1844)	B105	0	0	0	0	0	0	0	0
533	Cardiidae	Parvicardium	scriptum	(Bucquoy, Dautzenberg & Dollfus, 1892)	B123	0	0	0	0	0	0	0	0
533	Cardiidae	Parvicardium	trapezium	(Cecalupo & Quadri, 1996)	B150	0	0	1	0	4	0	0	0
533	Cardiidae	Laevicardium	crassum	(Gmelin, 1791)	B249	0	0	0	0	0	0	0	0
534	Chamidae	Pseudochama	gryphina	(Lamarck, 1819)	B065	0	0	0	0	0	0	0	0
534	Chamidae	Chama	gryphoides	(Linnaeus, 1758)	B066	0	0	0	0	0	0	0	0
545	Lasaeidae	Tellimya	ferruginosa	(Montagu, 1808)	B014	0	0	0	0	0	0	0	0
545	Lasaeidae	Kurtiella	bidentata	(Montagu, 1803)	B032	0	0	0	0	0	0	0	0
545	Lasaeidae	Scacchia	oblonga	(Philippi, 1836)	B085	0	0	0	0	0	0	0	0
554	Tellinidae	Moerella	donacina	(Linnaeus, 1758)	B052	0	0	0	0	0	0	0	0
554	Tellinidae	Tellina	sp. 7		B100	0	0	0	0	0	0	0	0
554	Tellinidae	Fabulina	fabula	(Gmelin, 1791)	B121	0	0	0	0	0	0	0	0
554	Tellinidae	Arcopella	balaustina	(Linnaeus, 1758)	B148	0	0	0	1	1	1	2	1
554	Tellinidae	Macomangulus	tenuis	(da Costa, 1778)	B283	0	0	0	0	0	0	0	0
555	Donacidae	Donax	semistriatus	(Poli, 1795)	B158	1	0	0	0	0	0	0	0
557	Semelidae	Abra	alba	(Wood, 1802)	B005	0	0	0	0	1	2	0	0
557	Semelidae	Abra	Crete-sp. 1		B155	0	0	0	0	0	0	0	0
560	Veneridae	Venus	verrucosa	(Linnaeus, 1758)	B019	0	0	0	0	0	0	0	0
560	Veneridae	Gouldia	minima	(Montagu, 1803)	B045	0	1	1	0	0	0	1	2
560	Veneridae	Irus	irus	(Linnaeus, 1758)	B176	0	0	0	0	0	0	0	0
560	Veneridae	Lajonkairia	lajonkairii	(Payraudeau, 1826)	B188	0	0	0	0	1	0	1	0
567	Hiatellidae	Hiatella	arctica	(Linnaeus, 1767)	B200	0	0	0	0	1	0	0	0

Taxon_ID	Family	Genus	Species	Author	Species_Code	LA_05_spr	LA_10_spr	LA_15_spr	LA_20_spr	LA_05_aut	LA_10_aut	LA_15_aut	LA_20_aut
576	Lyonsiidae	Lyonsia	norwegica	(Gmelin, 1791)	B115	0	0	0	0	0	0	0	0
579	Thraciidae	Thracia	Crete-sp. 2		B146	0	0	0	0	0	0	0	0
579	Thraciidae	Thracia	distorta	(Montagu, 1803)	B260	0	0	0	0	0	0	0	0
580	Laternulidae	Laternula	anatina	(Linnaeus, 1758)	B230	0	0	0	0	0	0	0	0
719	Tonicellidae	Lepidochitona	furtiva	(Monterosato, 1879)	P006	0	0	0	0	0	0	0	0
817	Ischnochitonidae	Ischnochiton	rissoi	(Payraudeau, 1826)	P008	0	0	0	0	0	0	0	0
834	Solemyidae	Solemya	togata	(Poli, 1791)	B284	0	0	0	0	0	0	0	0
865	Mnestiidae	Mnestia	girardi	(Audouin, 1826)	G543	0	0	0	0	0	0	0	0

Tab.3: All species with their respective abundance in each depth station (05m, 10m, 15m, 20m) and each season (spr=spring, aut=autmn) of the LA. Single valves of bivalves were counted as 0.5 and in the same matter single valves polyplacophora were counted as 0.125.

DA Species Abundance Table

Taxon_ID	Family	Genus	Species	Author	Species_Code	DA_05m_spr	DA_10m_spr	DA_15m_spr	DA_20_spr	DA_05m_aut	DA_10m_aut	DA_15m_aut	DA_20m_aut
3	Patellidae	Patella	rustica	(Linnaeus, 1758)	G178	2	0	0	2	3	0	0	0
3	Patellidae	Patella	ulyssiponensis	(Gmelin, 1791)	G179	1	0	0	1	1	0	0	4
3	Patellidae	Patella	sp.		G233	0	0	0	0	0	0	0	0
3	Patellidae	Patella	sp. 1		G244	0	0	0	0	1	0	0	0
3	Patellidae	Patella	caerula	(Linnaeus, 1758)	G451	0	0	0	1	0	0	0	0
32	Fissurellidae	Emarginula	octaviana	(Coen, 1939)	G177	2	1	0	5	4	0	0	0
32	Fissurellidae	Emarginula	sicula	(Gray, 1825)	G367	0	0	0	0	0	2	0	3
32	Fissurellidae	Diodora	graeca	(Linnaeus, 1758)	G439	2	0	0	0	3	1	0	1
32	Fissurellidae	Emarginula	huzardii	(Payraudeau, 1826)	G563	0	0	0	0	0	0	0	1
33	Haliotidae	Haliotis	tuberculata lamellosa	(Lamarck, 1822)	G191	1	4	1	4	1	2	2	2
36	Scissurellidae	Scissurella	costata	(d'Orbigny, 1824)	G169	6	16	13	11	13	6	20	7
39	Trochidae	Jujubinus	exasperatus	(Pennant, 1777)	G044	7	50	127	110	35	108	170	162
39	Trochidae	Jujubinus	striatus	(Linnaeus, 1758)	G180	0	6	11	14	0	1	13	0
39	Trochidae	Clanculus	corallinus	(Gmelin, 1791)	G200	1	0	0	6	8	0	0	4
39	Trochidae	Steromphala	varia	(Linnaeus, 1758)	G202	0	1	0	0	4	1	1	0
39	Trochidae	Gibbula	turbinoides	(Deshayes, 1835)	G207	0	0	1	0	0	0	0	0
39	Trochidae	Clanculus	cruciatus	(Linnaeus, 1758)	G208	0	0	0	0	0	0	0	0
39	Trochidae	Gibbula	ardens	(Salis Marschlins, 1793)	G339	0	0	1	1	0	0	1	2
39	Trochidae	Gibbula	fanulum	(Gmelin, 1791)	G424	0	0	0	0	0	0	0	1
42	Calliostomatidae	Calliostoma	laugieri	(Payraudeau, 1826)	G289	0	0	0	0	1	0	1	0
46	Margaritidae	Pinctada	imbricata radiata	(Leach, 1814)	B078	1	3	2.5	12.5	1.5	6.5	7.5	3.5
47	Phasianellidae	Tricolia	speciosa	(Megerle von Mühlfeld, 1824)	G155	3	53	83	62	17	36	107	55
47	Phasianellidae	Tricolia	pullus	(Linnaeus, 1758)	G194	12	54	91	65	138	158	96	68
47	Phasianellidae	Tricolia	tenuis	(Michaud, 1829)	G219	1	0	0	0	0	0	0	0
51	Turbinidae	Bolma	rugosa	(Linnaeus, 1767)	G345	2	0	2	4	4	2	1	3
75	Cerithiidae	Bittium	latreillii	(Payraudeau, 1826)	G017	13	82	77	168	66	156	140	231
75	Cerithiidae	Bittium	reticulatum	(da Costa, 1778)	G026	32	73	103	155	137	177	137	192
75	Cerithiidae	Cerithium	sp. Crete_1		G159	0	0	3	3	1	0	0	4
75	Cerithiidae	Cerithium	sp. Crete_2		G160	2	0	0	4	8	0	0	0
93	Turritellidae	Turritella	turbona	(Monterosato, 1877)	G154	0	0	6	8	0	0	5	3
103	Conidae	Conus	ventricosus	(Gmelin, 1791)	G048	0	0	0	2	1	0	0	0
109	Naticidae	Naticidae	sp. Crete_1		G161	0	6	11	8	2	4	14	5
109	Naticidae	Notocochlis	dillwynii	(Payraudeau, 1826)	G295	0	0	0	0	0	0	0	0
109	Naticidae	Euspira	intricata	(Donovan, 1804)	G492	0	0	0	0	0	0	1	0
111	Atlantidae	Atlanta	sp. Crete_1		G348	0	0	1	0	0	0	1	2
113	Triphoridae	Monophorus	perversus	(Linnaeus, 1758)	G140	0	0	0	3	0	0	0	0
113	Triphoridae	Marshallora	adversa	(Montagu, 1803)	G216	0	0	1	0	3	1	1	0
113	Triphoridae	Similiphora	similior	(Bouchet & Guillemot, 1978)	G287	0	0	0	0	0	1	0	0
113	Triphoridae	Monophorus	erythrosoma	(Bouchet & Guillemot, 1978)	G340	0	0	1	0	0	0	0	0
113	Triphoridae	Viriola	bayani	(Jousseaume, 1884)	G352	0	0	0	0	0	0	0	0
114	Cerithiopsidae	Cerithiopsis	tubercularis	(Montagu, 1803)	G112	0	0	1	0	0	0	0	0
114	Cerithiopsidae	Dizoniopsis	coppolae	(Aradas, 1870)	G167	0	0	0	2	1	0	0	0
114	Cerithiopsidae	Cerithiopsis	Crete_1		G182	0	0	0	2	0	0	0	0
114	Cerithiopsidae	Cerithiopsis	sp. Crete		G453	0	0	0	1	0	0	0	0
117	Rissoidae	Alvania	mamillata	(Risso, 1826)	G046	51	14	135	134	300	443	291	200
117	Rissoidae	Pusillina	cf. philippi	(Aradas & Maggiore, 1844)	G050	0	0	0	0	6	9	13	7
117	Rissoidae	Rissoa	similis	(Scacchi, 1836)	G097	0	0	0	0	4	0	0	0
117	Rissoidae	Alvania	scabra	(Philippi, 1844)	G171	0	0	0	2	0	0	1	5
117	Rissoidae	Alvania	discors	(Allan, 1818)	G172	7	23	7	11	75	36	0	0
117	Rissoidae	Alvania	lineata	(Risso, 1826)	G173	0	4	1	12	6	0	0	11
117	Rissoidae	Rissoa	angustior	(Monterosato, 1917)	G174	1	10	7	14	15	7	10	6

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117	Rissoidae	Alvania	amatii	(Oliverio, 1986)	G175	3	0	0	10	10	1	0	7
117	Rissoidae	Rissoa	variabilis	(Megerle von Mühlfeld, 1824)	G176	1	0	1	4	5	0	0	0
117	Rissoidae	Rissoa	ventricosa	(Desmarest, 1814)	G181	0	0	0	2	0	0	0	0
117	Rissoidae	Rissoa	violacea	(Desmarest, 1814)	G185	0	1	1	1	0	1	4	4
117	Rissoidae	Pusillina	radiata	(Philippi, 1836)	G188	0	6	25	17	0	2	5	5
117	Rissoidae	Alvania	sp. Crete-1		G282	0	47	49	35	2	35	41	35
117	Rissoidae	Alvania	sp. Crete-2		G283	0	1	0	0	0	0	0	0
117	Rissoidae	Alvania	fractospira	(Oberling, 1970)	G284	0	1	0	0	0	0	0	0
117	Rissoidae	Alvania	geryonia	(Nardo, 1847)	G285	0	197	36	33	0	0	0	0
117	Rissoidae	Alvania	clarae	(Nofroni & Pizzini, 1991)	G288	0	0	0	2	2	0	0	0
117	Rissoidae	Rissoa	auriformis	(Pallary, 1904)	G346	0	0	3	0	0	0	5	0
117	Rissoidae	Rissoa	scurra	(Monterosato, 1917)	G448	1	0	0	0	1	0	0	1
117	Rissoidae	Alvania	aspera	(Philippi, 1844)	G449	0	0	0	6	0	0	0	6
118	Barleeiidae	Barleeia	gougeti	(Michaud, 1830)	G450	0	0	0	1	3	0	0	2
120	Myidae	Sphenia	binghami	(Turton, 1822)	B061	0	0	0	0.5	0	0	0	0
121	Rissoinidae	Rissoina	bruguieri	(Payraudeau, 1826)	G047	0	0	0	0	2	0	0	0
129	Caecidae	Caecum	auriculatum	(De Folin, 1868)	G215	0	0	0	0	0	0	0	0
129	Caecidae	Caecum	clarkii	(Carpenter, 1859)	G360	0	0	0	0	0	0	0	0
150	Eulimidae	Eulima	glabra	(da Costa, 1778)	G036	0	0	0	1	0	0	0	0
150	Eulimidae	Melanella	polita	(Linnaeus, 1758)	G189	0	2	2	0	1	0	1	0
150	Eulimidae	Vitreolina	philippi	(de Rayneval & Ponzi, 1854)	G255	0	0	0	0	0	0	0	0
150	Eulimidae	Campylorhaphion	famelicum	(Watson, 1883)	G291	0	0	0	0	0	0	0	0
150	Eulimidae	Melanella	lubrica	(Monterosato, 1890)	G351	0	0	0	0	0	0	0	0
151	Calyptraeidae	Crepidula	unguiformis	(Lamarck, 1822)	G198	0	4	3	2	1	0	0	0
152	Cypraeidae	Naria	spurca	(Linnaeus, 1758)	G551	0	0	0	0	0	0	1	0
174	Cystiscidae	Gibberula	philippii	(Monterosato, 1878)	G422	0	0	0	0	0	0	2	0
176	Marginellidae	Volvarina	mitrella	(Risso, 1826)	G199	0	1	0	0	1	0	0	0
180	Buccinidae	Chauvetia	mamillata	(Risso, 1826)	G166	0	0	1	3	0	0	0	0
180	Buccinidae	Euthria	cornea	(Linnaeus, 1758)	G332	0	0	0	0	0	0	0	0
180	Buccinidae	Chauvetia	turritellata	(Deshayes, 1835)	G364	2	0	0	0	1	1	0	0
183	Columbellidae	Columbella	rustica	(Linnaeus, 1758)	G139	0	0	0	2	9	0	1	5
184	Fasciolariidae	Aegeofusinus	rolani	(Buzzurro & Ovalis, 2005)	G158	0	0	1	6	0	0	1	0
184	Fasciolariidae	Aptyxis	syracusana	(Linnaeus, 1758)	G350	0	0	0	0	0	0	0	0
186	Nassariidae	Tritia	mutabilis	(Linnaeus, 1758)	G341	0	0	1	0	0	0	0	0
187	Pisaniidae	Pollia	scacchiana	(Philippi, 1844)	G119	0	0	0	0	2	0	0	1
187	Pisaniidae	Enginella	leucozona	(Philippi, 1844)	G212	0	0	0	0	0	0	1	0
188	Muricidae	Hexaplex	trunculus	(Linnaeus, 1758)	G100	0	0	0	0	2	0	0	0
188	Muricidae	Muricopsis	cristata	(Brocchi, 1814)	G197	1	1	0	0	1	2	1	0
188	Muricidae	Murexsul	aradasii	(Monterosato in Poirier, 1883)	G213	0	0	1	0	0	0	0	0
188	Muricidae	Ocinebrina	aegeensis	(Aissaoui, Barco & Oliverio, 2017)	G294	0	0	0	0	0	2	0	0
188	Muricidae	Typhinellus	labiatus	(de Cristofori & Jan, 1832)	G363	0	0	0	0	0	0	0	0
188	Muricidae	Ocinebrina	aciculata	(Lamarck, 1822)	G445	0	0	0	0	0	0	0	0
190	Costellariidae	Vexillum	granum	(Forbes, 1844)	G452	0	0	0	1	0	0	0	0
190	Costellariidae	Pusia	tricolor	(Gmelin, 1791)	G465	0	0	0	0	0	0	0	1
194	Mitridae	Episcomitra	cornicula	(Linnaeus, 1758)	G519	0	0	0	0	1	0	0	0
210	Horaiclavidae	Haedropleura	sp.		G305	0	0	0	1	0	0	0	1
211	Mangeliidae	Mangelia	taeniata	(Deshayes, 1835)	G163	1	3	1	1	4	0	0	1
211	Mangeliidae	Mangelia	sp. Crete_1		G196	1	1	2	2	1	0	1	1
212	Mitromorphidae	Mitromorpha	columbellaria	(Scacchi, 1836)	G447	1	0	0	0	0	0	1	2
214	Raphitomidae	Raphitoma	sp. Crete_1		G164	0	0	0	1	0	0	0	1
214	Raphitomidae	Raphitoma	sp. Crete_2		G190	0	0	0	0	0	1	1	0
214	Raphitomidae	Raphitoma	sp. Crete_3		G195	0	2	0	2	0	0	1	5
214	Raphitomidae	Clathromangelia	loiselieri	(Oberling, 1970)	G304	0	0	4	0	0	3	0	0

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214	Raphitomidae	Clathromangelia	sp. 1		G326	0	0	0	0	0	0	1	0
214	Raphitomidae	Clathromangelia	sp. 2		G327	0	0	0	0	0	0	0	1
214	Raphitomidae	Clathromangelia	granum	(Philippi, 1844)	G353	0	0	0	0	0	0	0	0
214	Raphitomidae	Raphitoma	linearis	(Montagu, 1803)	G462	0	0	0	0	0	0	0	1
214	Raphitomidae	Raphitoma	contigua	(Monterosato, 1884)	G562	0	0	0	0	0	0	0	1
234	Pleurobranchidae	Berthella	aff. plumula	(Montagu, 1803)	G358	0	0	0	0	0	1	0	0
264	Fustiariidae	Fustiaria	rubescens	(Deshayes, 1825)	S006	0	1	1	1	0	0	0	0
294	Retusidae	Retusa	truncatula	(Bruguière, 1792)	G168	1	18	17	19	9	12	14	13
295	Rhizoridae	Volvulella	acuminata	(Bruguière, 1792)	G105	0	0	0	0	1	0	0	0
297	Neritidae	Smaragdia	viridis	(Linnaeus, 1758)	G152	2	28	50	45	23	71	72	45
301	Cliidae	Clio	pyramidata	(Linnaeus, 1767)	G156	0	0	0	1	0	1	0	0
302	Haminoeidae	Haminoea	sp. 1		G151	0	0	0	0	1	0	0	0
302	Haminoeidae	Weinkauffia	turgidula	(Forbes, 1844)	G192	0	1	0	0	0	0	0	0
302	Haminoeidae	Atys	macandrewii	(Smith, 1872)	G342	0	0	0	0	0	0	0	0
302	Haminoeidae	Atys	angustatus	(Smith, 1872)	G343	0	0	0	0	0	0	1	0
304	Philinidae	Philine	catena	(Montagu, 1803)	G165	0	2	3	4	1	1	2	2
315	Colloniidae	Homalopoma	sanguineum	(Linnaeus, 1758)	G170	0	0	0	3	0	0	3	0
315	Aplysiidae	Aplysia	sp. Crete_1	(Mörch, 1863)	G201	1	2	2	2	1	0	0	0
315	"Aplysiidae"	"Aplysia"	sp. Crete-1		G286	0	5	3	8	2	2	0	1
315	Aplysiidae	Aplysia	depilans	(Gmelin, 1791)	G446	0	0	0	0	0	0	0	0
318	Creseidae	Creseis	clava	(Rang, 1828)	G056	0	0	0	0	0	0	1	0
318	Creseidae	Creseis	conica	(Eschscholtz, 1829)	G072	0	0	0	0	0	0	2	0
318	Creseidae	Styliola	subula	(Quoy & Gaimard, 1827)	G228	0	0	0	0	0	0	0	2
321	Peraclidae	Peracle	reticulata	(d'Orbigny, 1834)	G157	0	0	0	1	0	0	0	0
328	Velutinidae	Lamellaria	perspicua	(Linnaeus, 1758)	G183	0	1	0	0	0	0	0	0
329	Granulinidae	Granulina	marginata	(Bivona, 1832)	G184	1	12	0	13	4	7	3	4
331	Volvatellidae	Ascobulla	fragilis	(Jeffreys, 1856)	G362	0	0	0	0	0	0	0	0
338	Siphonariidae	Williamia	gussoni	(Costa O.G., 1829)	G153	1	12	23	45	21	36	58	30
339	Pyramidellidae	Parthenina	interstincta	(Adams, 1797)	G010	0	0	0	0	1	0	0	0
339	Pyramidellidae	Eulimella	acicula	(Philippi, 1836)	G021	0	0	0	0	0	0	0	0
339	Pyramidellidae	Odostomia	cf. acuta	(Jeffreys, 1848)	G022	0	0	0	0	0	0	0	0
339	Pyramidellidae	Megastomia	conoidea	(Brocchi, 1814)	G027	0	3	0	0	0	0	0	0
339	Pyramidellidae	Folinella	excavata	(Phillippi, 1836)	G030	0	1	0	0	0	0	0	0
339	Pyramidellidae	Ondina	vitrea	(Brusina, 1866)	G037	0	2	2	2	1	2	1	0
339	Pyramidellidae	Turbonilla	lactea	(Linnaeus, 1758)	G186	0	1	0	0	0	0	0	0
339	Pyramidellidae	Pyrgostylus	striatulus	(Linnaeus, 1758)	G187	0	3	1	3	1	2	0	4
339	Pyramidellidae	Parthenina	monterosatii	(Clessin, 1900)	G290	0	0	0	0	0	0	0	0
339	Pyramidellidae	Odostomia	sicula	(Philippi, 1851)	G347	0	0	1	0	1	1	0	0
339	Pyramidellidae	Parthenina	terebellum	(Philippi, 1844)	G349	0	0	0	0	0	0	0	0
339	Pyramidellidae	Odostomia	acuta	(Jeffreys, 1848)	G357	0	0	0	0	1	1	0	0
339	Pyramidellidae	Auristomia	fusulus	(Monterosato, 1878)	G365	0	0	0	0	0	0	0	0
339	Pyramidellidae	Euparthenia	humboldti	(Risso, 1826)	G560	0	0	0	0	0	0	1	2
350	Acanthochitonidae	Acanthochitona	fascicularis	(Linnaeus, 1767)	P001	0.125	0.25	0.625	1	0.5	0.25	1.125	0.625
351	Leptochitonidae	Leptochiton	bedullii	(Dell'Angelo & Palazzi, 1986)	P002	0	0.25	0.25	0.375	0.125	0	0	0.5
351	Leptochitonidae	Lepidopleurus	cajetanus	(Poli, 1791)	P007	0	0	0	0	0.25	0	0.25	0
352	Callochitonidae	Callochiton	septemvalvis	(Montagu, 1803)	P003	0	0	0	0	0.25	0	0	0
394	Chitonidae	Chiton	olivaceus	(Spengler, 1797)	P004	0	0	0	0.25	1.125	0	0.125	0.25
426	Bivalvia	Bivalvia	Crete-sp. 2		B174	0	0.5	0	0	0	0	0	0
481	Nuculidae	Nucula	nitidosa	(Winckworth, 1930)	B018	2.5	6	3	11	12	3.5	6.5	8
485	Nuculanidae	Lembulus	pella	(Linnaeus, 1758)	B016	0	0	0	0	0	0	0.5	0
485	Nuculanidae	Saccella	commutata	(Philippi, 1844)	B017	0	0	0	1	0	0	0	0
493	Mytilidae	Gregariella	semigranata	(Reeve, 1858)	B060	0	0	0.5	0.5	0	0	0	0
493	Mytilidae	Musculus	costulatus	(Risso, 1826)	B125	21.5	19	30.5	27.5	42.5	21.5	26	21

Taxon_ID	Family	Genus	Species	Author	Species_Code	DA_05m_spr	DA_10m_spr	DA_15m_spr	DA_20_spr	DA_05m_aut	DA_10m_aut	DA_15m_aut	DA_20m_aut
493	Mytilidae	Septifer	cumingii	(Récluz, 1848)	B132	0	0	0	0	0	2.5	3.5	1.5
493	Mytilidae	Modiolula	phaseolina	(Philippi, 1844)	B141	0	0	0.5	0	0	0	0	0
493	Mytilidae	Crenella	arenaria	(Monterosato, 1875 ex H. Martin, ms.)	B142	0.5	2	1.5	1.5	0	0.5	1	0.5
493	Mytilidae	Septifer	bilocularis	(Linnaeus, 1758)	B151	3.5	0	2	2	7	0	0	0
493	Mytilidae	Modiolus	barbatus	(Linnaeus, 1758)	B262	0	0	0	0	0.5	0	0	0
494	Arcidae	Arca	noae	(Linnaeus, 1758)	B138	1	1.5	3.5	3	2.5	0.5	4.5	1
494	Arcidae	Barbatia	barbata	(Linnaeus, 1758)	B139	5	4.5	4	12.5	24	6	9.5	12.5
497	Noetiidae	Striarca	lactea	(Linnaeus, 1758)	B055	2	2	6.5	5	5.5	6	7.5	3
504	Pinnidae	Pinna	nobilis	(Linnaeus, 1758)	B181	1	0	3	0	0	0	0	1.5
507	Anomiidae	Anomia	sp. 1		B035	0	0	1	0	0	0	0	0
507	Anomiidae	Anomia	ephippium	(Linnaeus, 1758)	B269	0	0	0	0	0	0	1	0.5
510	Pectinidae	Genus	sp. 1		B042	0	0	0	0	2	0	0	0
510	Pectinidae	Flexopecten	hyalinus	(Poli, 1795)	B143	1.5	1	6.5	24.5	5	6.5	11	32
510	Pectinidae	Talochlamys	multistriata	(Poli, 1795)	B153	0	0.5	0	0	0	0.5	0	0.5
515	Limidae	Limatula	subauriculata	(Montagu, 1808)	B144	0.5	3.5	8	14.5	3	2	7.5	8
515	Limidae	Lima	lima	(Linnaeus, 1758)	B152	1.5	1	2	2.5	3	1.5	1	4
515	Limidae	Limaria	hians	(Gmelin, 1791)	B154	2	0.5	0.5	0	0.5	0.5	0	0.5
515	Limidae	Limaria	tuberculata	(Olivi, 1792)	B184	0	0	0	0	1	0	0	0
523	Lucinidae	Loripes	orbiculatus	(Poli, 1791)	B020	2	1.5	0.5	0.5	5.5	0.5	1	1
523	Lucinidae	Lucinella	divaricata	(Linnaeus, 1758)	B023	0	0.5	0	0	1.5	0	0	0
523	Lucinidae	Loripinus	fragilis	(Philippi, 1836)	B068	0	1.5	4.5	2	2	2.5	1	0.5
523	Lucinidae	Ctena	decussata	(Costa, 1829)	B088	9	11.5	11	27.5	21	6.5	15.5	14
523	Lucinidae	Lucinidae	sp. 1		B167	0	0	0	0	0	0	0	0
523	Lucinidae	Myrtea	spinifera	(Montagu, 1803)	B247	0	0	0	1	0	0	0	0
524	Thyasiridae	Thyasira	Crete-sp. 1		B140	12.5	107.5	67	90	41.5	117	123	80
524	Thyasiridae	Thyasira	Crete-sp. 2		B162	0	0	0.5	0	0	0	0	0
526	Carditidae	Glans	trapezia	(Linnaeus, 1767)	B049	13.5	15.5	11.5	15	27.5	12.5	9.5	14
526	Carditidae	Cardites	antiquatus	(Linnaeus, 1758)	B147	0	0	2.5	1.5	0	0	0	0.5
526	Carditidae	Cardita	calyculata	(Linnaeus, 1758)	B161	0.5	1	0	0.5	2.5	0	0	0
529	Astartidae	Goodallia	sp.		B189	0	0	0	0	0.5	0	0	0
533	Cardiidae	Papillicardium	papillosum	(Poli, 1791)	B074	0.5	1	7	6	0.5	2.5	3.5	9.5
533	Cardiidae	Parvicardium	cf. scabrum	(Philippi, 1844)	B105	0	0	0	1	0	1	0	0
533	Cardiidae	Parvicardium	scriptum	(Bucquoy, Dautzenberg & Dollfus, 1892)	B123	1.5	1.5	2.5	1.5	7	1	3.5	1.5
533	Cardiidae	Parvicardium	trapezium	(Cecalupo & Quadri, 1996)	B150	7.5	6	7.5	4	8	0	6	2.5
533	Cardiidae	Laevicardium	crassum	(Gmelin, 1791)	B249	0	0	0	0.5	0	0	0	0.5
534	Chamidae	Pseudochama	gryphina	(Lamarck, 1819)	B065	0	1	0	0	0	0	0	0
534	Chamidae	Chama	gryphoides	(Linnaeus, 1758)	B066	0	0	0	0	1	0	0	0
545	Lasaeidae	Tellimya	ferruginosa	(Montagu, 1808)	B014	0	1	0	0	0	0	0	0.5
545	Lasaeidae	Kurtiella	bidentata	(Montagu, 1803)	B032	0	0	0	0	0.5	0	0	0
545	Lasaeidae	Scacchia	oblonga	(Philippi, 1836)	B085	0	2	0.5	0	0	0	1.5	0.5
554	Tellinidae	Moerella	donacina	(Linnaeus, 1758)	B052	0	0	0	0	0.5	0	0	0
554	Tellinidae	Tellina	sp. 7		B100	1	0	1	0	0	0	0	0
554	Tellinidae	Fabulina	fabula	(Gmelin, 1791)	B121	0	0	0	0	0	0.5	0	0
554	Tellinidae	Arcopella	balaustina	(Linnaeus, 1758)	B148	0	1	4.5	7	2.5	4	5.5	6
554	Tellinidae	Macomangulus	tenuis	(da Costa, 1778)	B283	0	0	0	0	0.5	0	0	0
555	Donacidae	Donax	semistriatus	(Poli, 1795)	B158	0	0	0	0	0	0	0	0
557	Semelidae	Abra	alba	(Wood, 1802)	B005	0	0	0	0	0	0	0	0
557	Semelidae	Abra	Crete-sp. 1		B155	2	3.5	5	5	1	2.5	3.5	5.5
560	Veneridae	Venus	verrucosa	(Linnaeus, 1758)	B019	0	0	0	0	0	0	0.5	0
560	Veneridae	Gouldia	minima	(Montagu, 1803)	B045	0	0	1.5	1	0	0.5	0	3
560	Veneridae	Irus	irus	(Linnaeus, 1758)	B176	0	0	1.5	0	1.5	0	0	0
560	Veneridae	Lajonkairia	lajonkairii	(Payraudeau, 1826)	B188	0.5	0	0.5	0.5	0.5	0	0	0
567	Hiatellidae	Hiatella	arctica	(Linnaeus, 1767)	B200	0	0	0	0	0.5	0.5	0.5	0

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576	Lyonsiidae	Lyonsia	norwegica	(Gmelin, 1791)	B115	0	0	0	0	0	0	0.5	0
579	Thraciidae	Thracia	Crete-sp. 2		B146	0	1	1	2.5	0	0	0	0
579	Thraciidae	Thracia	distorta	(Montagu, 1803)	B260	0	0	0	0	0.5	0.5	1.5	0.5
580	Laternulidae	Laternula	anatina	(Linnaeus, 1758)	B230	0	0	0	0	0	0	0	0.5
719	Tonicellidae	Lepidochitona	furtiva	(Monterosato, 1879)	P006	0	0	0	0.125	0	0	0	0
817	Ischnochitonidae	Ischnochiton	rissoi	(Payraudeau, 1826)	P008	0	0	0	0	0.125	0	0	0
834	Solemyidae	Solemya	togata	(Poli, 1791)	B284	0	0	0	0	2.5	0	0	0
865	Mnestiidae	Mnestia	girardi	(Audouin, 1826)	G543	0	0	0	0	0	0	1	1

Tab.4: All species with their respective abundance in each depth station (05m, 10m, 15m, 20m) and each season (spr=spring, aut=autmn) of the DA. Single valves of bivalves were counted as 0.5 and in the same matter single valves polyplacophora were counted as 0.125.