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MASTERARBEIT

Titel der Masterarbeit

Long-term environmental shifts as deduced from molluscan death assemblages in a sediment core (northern Adriatic Sea, Piran)

verfasst von

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Inhaltsverzeichnis

Zusammenfassung

Um langfristige Veränderungen in der Faunenzusammensetzung der Mollusken in der Nordadria zu finden, habe ich paläobiologische Methoden verwendet, die Teil des relativ neuen Forschungsfeldes namens "Conservation Paleobiology", sind. Dabei werden Organismen und deren Ökologie der letzten tausend bis millionen Jahre untersucht, um biologische Daten in großen Zeitskalen zu bekommen, die mit lebenden Tieren alleine unmöglich zu ermitteln wären.

Ein Bohrkern mit einer Länge von 152cm, wurde vom Meeresboden in der Nähe von Piran, Slovenien, genommen, in Teilproben geschnitten und die Artenzusammensetzung, Häufigkeit, Diversität, Ernährungsweise und Substratbeziehung der enthaltenen Mollusken untersucht. Am Sediment wurden die Korngröße, Umweltschadstoffe, Schwermetalle und das Alter ermittelt. Veränderungen wurden in allen untersuchten Bereichen durch den Kern beobachtet. Die Anzahl an gefundenen Individuen nimmt nach oben hin steil zu und geht in den obersten Schichten wieder zurück. Die Diversität bleibt durch den gesamten Kern ungefähr gleich, hat aber ein besonders starkes Tief im Intervall von 8-10cm, das mit einem Höchstpunkt in fast allen Umweltschadstoffen (Hg, Pb, Zn, PCB und Kohlenstoff gesamt) zusammenfällt. Dieser Anstieg an Umweltschadstoffen, könnte den Rückgang in der Diversität verursacht haben und vom Menschen ausgelöst sein. Das Sediment wurde bei 18cm auf 112 Jahre datiert bei einer Sedimentstionsrate von ca. 1,6mm/Jahr. Eine Cluster-Analyse resultierte in Gruppen bei der Artenzusammensetzung, Ernährungsweise und Substratbeziehung, die nach der Tiefe im Sedimentkern angeordnet sind. Es gibt einen Wechsel von infaunalen Detritusfressern und Filtrieren in siltigen, zu epifaunalen Filtrieren und Herbivoren in sandigen Sedimenten. Die Häufigkeit von Umweltschadstoffen und Arten scheint von der Korngröße abhängig zu sein. Die zunehmende Anzahl an Schalen wird als primäre autogene Sukzession interpretiert, in der die Zunahme an Hartteilen zu einer Verfestigung des Sediments führt und dadurch ein besseres Substrat für Epifauna bildet, wodurch der Anteil an Sand immer größer wird. Der Anstieg an Herbivoren ist auch damit verbunden, da ein stabileres Sediment besser für Seegras und Algen ist, die wiederum Nahrungsquelle für herbivore Arten dar-

stellen. Die jüngste Entwicklung zurück zu mehr infaunalen Arten wird auf anthropogene Störungen zurückgeführt.

Abstract

To detect long-term shifts in the mollucsan faunal composition of the northern Adriatic Sea, I used paleobiological methods, that are part of a relatively new field of research, called Conservation Paleobiology. It studies organisms of the last thousands to millions of years and their ecology to obtain data on a large temporal scale that are impossible to gain based on living organisms alone.

A core of 152 cm length was taken from the sea bottom of the northern Adriatic Sea approximately 4km from the harbour of Piran, Slovenia, sliced into subsamples and studied regarding down-core changes in molluscan species composition, abundance, diversity, feeding modes and substrate relation. Sediment analyses included grain size, pollutants, heavy metals and age of the sediment.

Changes were found concerning all of the studied aspects. The number of individuals increased steeply towards the top, but then decreased in the youngest samples. Diversity stayed approximately the same through the core, with one major minimum at 8-10 cm, which coincides with a distinct peak in almost all studied pollutants. Rarefied species richness is correlated negatively to some pollutants (Hg, Pb, Zn, PCB and total carbon). The age of the sediments was determined to be 112 years at a depth of 18 cm, at a sedimentation rate of approximately 1.6 mm/year. A cluster analysis yielded distinct down-core groups for species composition, feeding types and substrate relation, which indicate a shift from infaunal deposit- and filter feeders in silty sediments, at the bottom and oldest sediments, to epifaunal herbivores and filter feeders in sediments dominated by sand at the top of the core. The abundance of species and pollutants apparently depends on sediment grain size. The increasing number of shells is interpreted to be responsible for a primary autogenic succession, in which an increasing number of hard parts leads to more stable substrate, which is a better environment for epifauna. Accordingly the amount of sand in the sediment increases continually. The increase in herbivores is also related to this succession, since more stable substrate might provide a better environment for algae and seagrass, which in turn, provide more food for herbivores. The youngest development back to more infaunal species is attributed to anthropogenic disturbances.

1 Introduction

For my thesis I have counted and determined 9018 gastropods, 22,418 bivalves, 305 scaphopods and 207 plates of polyplacophorans. I had each shell in my hands at least three times. First to take them out of the sediment, second to sort them and third to determine the species and count them. Why would anybody bother to do that? Spend hours and hours sitting at the binocular microscope, looking at mollusks? The answer to that question is quite simple: because we hope to get some very good data. The species I am working with, are recent, but I am analyzing them using a paleobiological approach. Why? One problem with ecological studies is, that they usually include only a few generations, because obtaining data for more generations would take too long. This tends to yield very "short sighted" results. The paleobiological approach, however, makes it possible to get a long-term overview of ecological shifts, species composition and species distribution (Dietl & Flessa, 2011). We can look back a few thousand to millions of years and see how species evolved. We can try to understand which characteristics made them survive under which circumstances, and which features made them prone to extinction. We can determine which environmental factors are good for which species and which factors are making species disappear. The next question is: Why do we need to know these things? When we are dealing with a specific snail, for instance, and we want to preserve it, we need to find out under which ecological conditions it manages to reproduce and survive, or becomes extinct. Then we can support those beneficial conditions in areas where we want to protect the species.

My thesis is about the northern Adriatic Sea and how the molluscan community changed at a specific site (Piran) during the last hundreds to thousands of years. The taxonomic data is then correlated to ecological data that were sampled for the same spot to understand why the community developed the way it did. A further goal is to examine the human impact during the studied time-interval. My thesis is part of the research project "Historical ecology of the Northern Adriatic Sea", which is funded by the Austrian Science Fund FWF (project P24901). The aim of this project is to find major ecological shifts in the younger history of the northern Adriatic Sea under con-

sideration of two main aspects: Differences between the living community found on the sea bottom and the dead assemblage in the sediment. First they can show the impacts of bottom trawling (DeGroot, 1984; Thrush & Dayton, 2002) and eutrophication on the species composition. Second they can show the change from mostly epibenthic to more infaunal dominated communities and the ecological factors that shaped them (Zuschin & Stachowitsch, 2009). Bottom trawls can penetrate down to 30 mm into the substrate and therefore affect the benthic organisms. Not all species, however, are affected to the same extent, whereby a long-term shift in species community and numbers can be expected (DeGroot, 1984). Kaiser et al. (2000) compared abundance/biomass curves in areas with high and low fishing disturbances and found that large-bodied organisms are removed with frequent bottom dredging or trawling and smaller organisms that are less sensitive to physical disturbances become more dominant. The most powerful impact is on sessile soft corals, sea urchins, long-lived bivalves and gastropods (Kaiser et al., 2000). After direct contact with bottom-fishing gear, gastropods are more prone to die from starfish predation (Ramsay & Kaiser, 1998) and their eggs are very vulnerable to bottom trawling. In areas with high fishing intensities, benthic communities therefore tend to be dominated by animals that are more robust and not as sensitive to physical disturbance as sea stars, crabs, small polychaetes and small bivalves (Kaiser et al., 2000). Another side-effect is that scavengers aggregate in areas of recent disturbance (Kaiser & Ramsay, 1997; Ramsay et al., 1997). Furthermore scavengers tend to become very dominant in areas where dredging disturbance is high, and the abundance of scavengers can be used as an indicator of high levels of physical disturbance (Collie et al., 1997). Samples were taken along three transects at seven sampling stations: In Italy two stations were at the Po Delta, one at Venice and one at Panzano. In Slovenia, two sites were studied at Piran, and in Croatia one site was studied at Brijuni islands National Park (Fig.1). Per sampling station, 5 cores were taken: one for sediment dating with ^{210}Pb, one to analyse pollutants, one to study the molluscan assemblage, one will be studied regarding the high-biomass epifauna and one is left as a reserve. The different sampling stations were chosen to represent the main sediment types of the area (Fig. 2), different nutrient conditions and different degrees of protection. Sediment types have been found to correspond closely to the benthic assemblages (Zuschin & Stachowitsch, 2009), which is why I paid close attention to the sediment composition of my core and its relationship to the faunal composition. Surface samples were taken by divers, and sediment core samples using a Piston corer. This thesis deals with the first three cores that were taken at station, Piran 2, including the molluscan death assemblage that was

found in the core PIR2M53. Moreover the pollutants and heavy metals were measured and the sediment age determined. Piran is a small port, with an average of 450 vessels (6228.6 net tonnage) between the years of 2009 to 2013 (Kožuh, 2014).

Figure 1: Transects and sampling stations in the northern Adriatic Sea

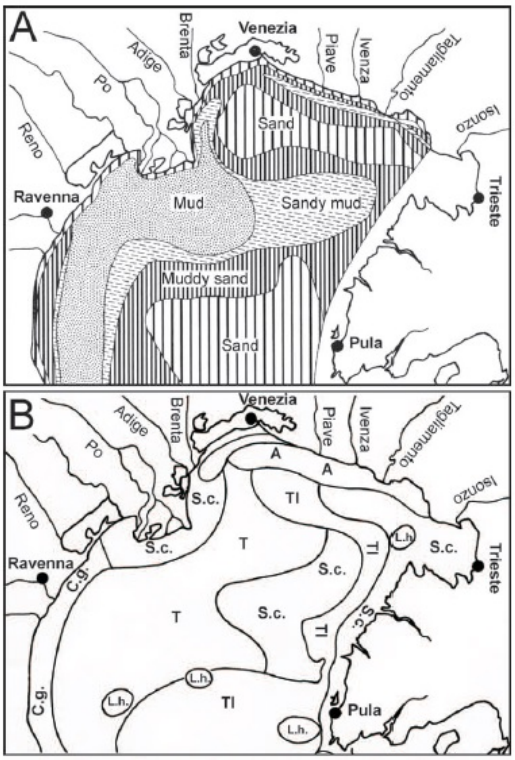

Figure 2: A) Sediments types and B) benthic assemblages in the northern Adriatic Sea (from (Zuschin & Stachowitsch, 2009)

2 Material and Methods

2.1 Study area

The Adriatic Sea is a semi-enclosed water-body that extends from northwest to southeast and connects to the Mediterranean through the Otranto strait. The amount of water that leaves the Adriatic Sea through the strait is larger than the amount that enters. This is mainly because of influx from rivers into the Adriatic Sea (McKinney, 2007). The East Adriatic Current enters at the strait of Otranto and flows north on the eastern side of the Adriatic Sea until the Istrian peninsula, where it turns into the West Adriatic current and returns south along the Italian coast. There are also three re-circulation cells in the southern, central and lower northern subbasin (Fig.3) (Poulin, 2001). During the summer a thermal stratification is present, because the factors that promote circulation are not as strong or absent. Therefore the water exchange with the open sea ceases. In the winter when storms become stronger and more common and insulation is weaker, the water body mixes again (Artegiani et al., 1997; McKinney, 2007)

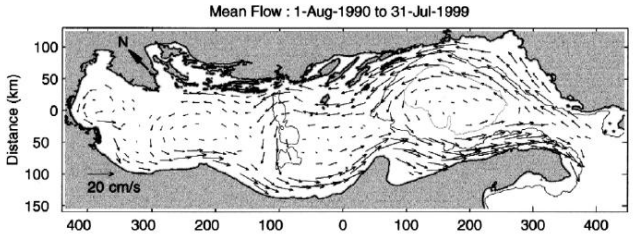

Figure 3: East Adriatic Current and West Adriatic Current in (McKinney, 2007)

The northern Adriatic Sea is defined as the area north of the line from the southern border of Emilia Romagna, an administrative region of northern Italy, to the most southern extension of the Istrian peninsula in Croatia. It has a surface of 18 900 km^2, a volume of 635 km^3 and a mean depth of 33.5 m (Degobbis & Gilmartin, 1990), which

makes it a very shallow sea. It has been populated by humans already for a very long time. 10 000 years ago the first hunter-fisher-gatherer communities lived along the Adriatic coast and farming started in southern Italy in 6200 BC (Kovačević, 2002). From the nineteenth century on, cities were growing fast in parallel with a strong increase in industrialization. This process also applied to fishing methods, which became more industrial and spread from inshore to offshore after World War 2 (Tudela, 2004). In the last century, intensive bottom trawling and dredging, which is a major anthropogenic impact, took place in the northern Adriatic Sea (DeGroot, 1984; Thrush & Dayton, 2002).

Another characteristic of the northern Adriatic Sea is its high primary production, which is among the highest in the Mediterranean (Turley, 1999). Most of the nutrient input comes from the Po River and is mainly transported south along the western side of the northern Adriatic Sea. Additionally to the nutrient input through freshwater, approximately the same amount of nutrients is regenerated through biological cycles. Another path of nutrient loss, beyond transportation, is denitrification of nitrogen and burial of phosphorus and silicon in the sediment (Degobbis & Gilmartin, 1990).

2.2 Sampling and counting

The core sample (code PIR2 M53) was taken in the northern Adriatic Sea close to the Slovenian city Piran at a depth of 22.7 m, approximately 4 km from the coast (Fig.4).

Figure 4: Sampling station (N45°33.793′ E13°32.229′) and Piran, Slovenia, from google earth (16 December 2014)

A "piston corer" was used to take a sediment core with a length of 152cm and a diameter of 15 cm (Fig. 5). It was then sliced into 37 subsamples: from the top 20 cm, slices of 2 cm and from the remainder slices of 5 cm were taken. Afterwards the subsamples were sieved under flowing water with a mesh size of 1mm, dried and all molluscs were picked from the sediment using a stereomicroscope (Motic K-500P). In the next step the specimens were separated according to morphological features and determined to genus level. Next they were determined to species level and counted per subsample. Bivalves were divided into three categories: right valve, left valve and complete specimens. This helped to avoid counting one individual twice if its right and left valve are found in the same sample. By adding the number of more abundantly represented valves to the number of complete specimens, the number of individuals from each family per subsample was calculated. For instance in the 0-2 cm section in the case of *Nucula cf. nucleus* 8 right valves, 11 left valves and 1 complete specimen were found. Therefore we added 11 left valves to 1 complete specimen and calculated 12 individuals for this section. Due to the high numbers of individuals, the samples from 10 cm to 35 cm were split in four parts and only one split was counted. For statistical analysis those data were multiplied by four. Similarly, the samples from 35 cm to 45 cm were divided in half and then multiplied by two. Species abundance and richness were also calculated with always two intervals from 0-20 cm, in order to obtain intervals of 4 cm, which are more similar to the 5cm intervals in the rest of the core. Microsoft Excel XP, Microsoft Excel 2007 and R (R core team 2013) were used to generate diagrams.

2.3 Statistical analysis

To compare the diversity of the samples after accounting for the different sample sizes, the data were entered in Past 2.17 (Hammer et al., 2001) and an individual rarefaction was performed for each sample, which calculates the diversity at the same sample size. This is done because a larger sample is expected to contain more species. A rarefaction analysis eliminates the bias that arises when analyzing only the raw data. Cluster analysis and nonmetric-multidimensional scaling (nMDS) with the software package Primer (Clarke & Gorley, 2006) using square-root transformed abundances to downsize the dominant species were performed on species abundance, feeding modes, and substrate relations. To find the most abundant species in each group that was determined by the cluster analysis, I calculated the abundance and percentage of each species in each subsample. From these percentages, I calculated the mean abundance of each species

per cluster. The same was done for substrate and feeding guilds. A correlation analysis was done with Past 2.17 (Hammer et al., 2001) to correlate the feeding guilds, substrate types, species richness and abundance and the most abundant species with grain size and pollutants. Results with a correlation coefficient r higher than 0.6 and a significance of less than 0.05 were considered as significant.

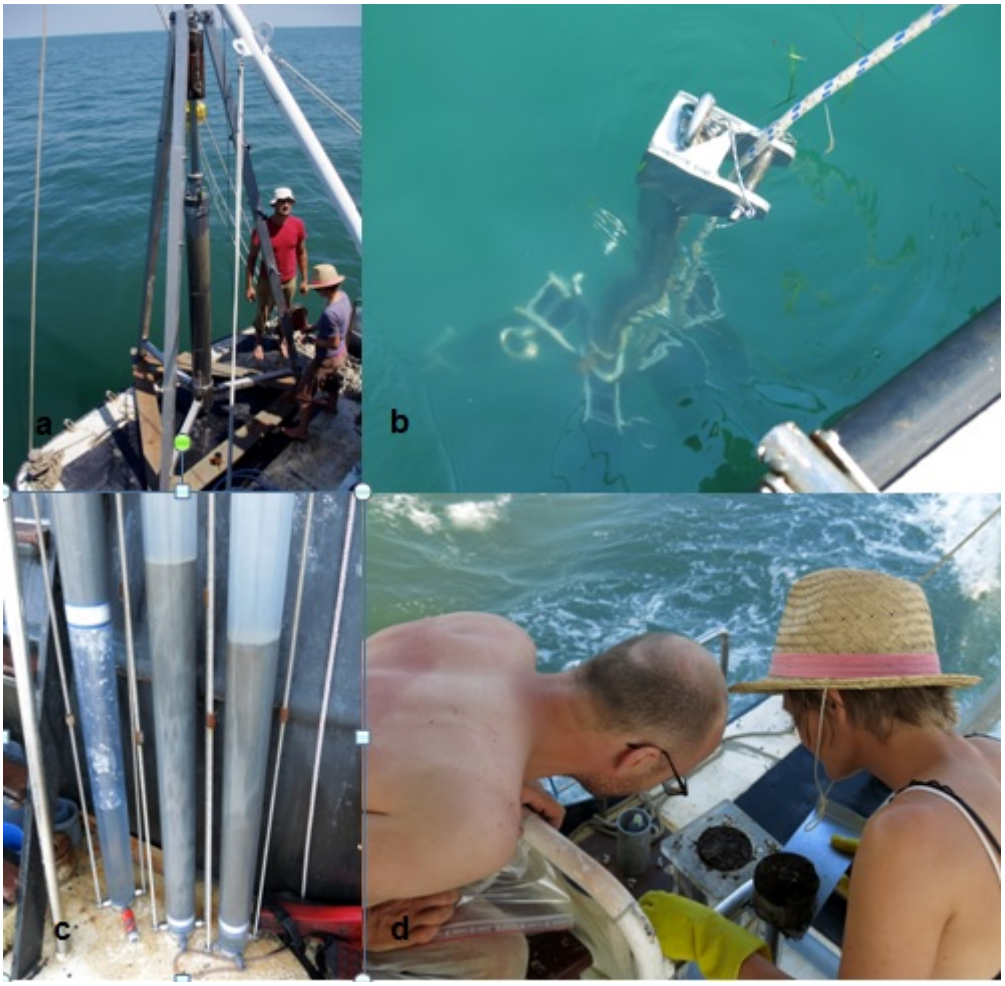

Figure 5: a) Sampling equipment on the boat; b) corer in the water; c) cores after sampling; d) slicing of the cores on the boat

Heavy metals and pollutants were measured by the ISMAR Institute in Venice. On this core, x-ray radiographs were taken to find differences in sediment structure and density variations in order to to distinguish depth intervals for subsamples (Fig. 6). The different colours represent different density of the sediment, with the highest density in red and the lowest density in blue. At certain intervals (0-2 cm, 4-6 cm, 8-10 cm, 20-22 cm, 42-44 cm, 54-56 cm, 76-78 cm, 83-85 cm, 118-120 cm and 136-138 cm) the content of mercury, chrome, copper, nickel, lead, arsenic, cadmium, lithium, zinc, manganese, phosphorus, iron and aluminium was measured in mg/kg, the content of polycyclic aromatic hydrocarbons (PAH) and polychlorinated biphenyls (PCB) in ng/gr, and the percentage of carbon, organic carbon and nitrogen in the percentage of dry weight (%dw).

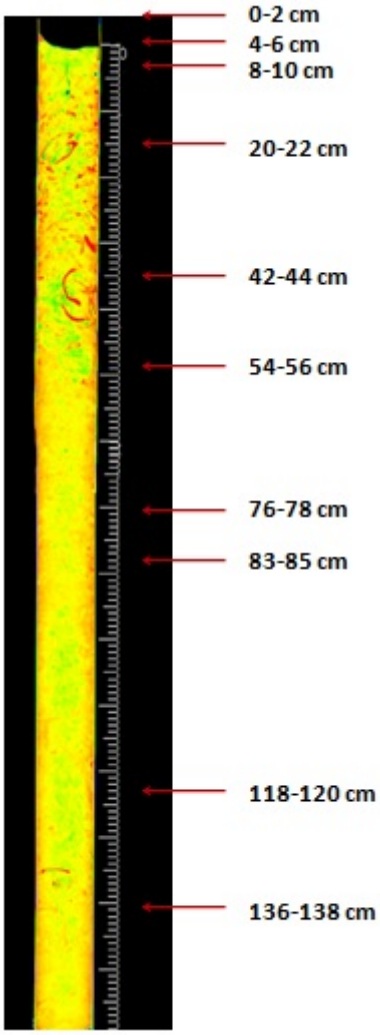

Figure 6: X-ray radiograph of the core PIR2M52 with intervals for analysis by the ISMAR institute.

2.4 Geochronology

Sediment dating with ^{210}Pb was done by the Low Level Counting Labor Arsenal, University of Natural Resources and Life Sciences, Vienna. ^{210}Pb dating is based on unsupported ^{210}Pb and its radioactive decay in sediments (Appleby & Oldfield, 1978). There are two kinds of ^{210}Pb in sediments: Supported ^{210}Pb, which is present in natural minerals and soil and usually is in equilibrium with ^{226}Ra, which is a decay product in the ^{238}U series and enters rivers with detrital particles. The other kind is unsupported ^{210}Pb, which enters the sediment through atmospheric deposition. ^{222}Rn is released from surface soils, rocks and minerals (Turekian & Graustein, 2003). Atmospheric ^{222}Rn becomes ^{210}Pb through radioactive decay and is then absorbed by aerosol particles which then reach the soil and aquatic systems through precipitation. Most of the ^{210}Pb present in the water column is adsorbed by particulate matter and then remains in the sediment (Baskaran, 2011). If the influx of unsupported ^{210}Pb is constant, it should decline down the sediment profile through radioactive decay, making it possible to estimate sedimentation rates through ^{210}Pb (Pennington, 1973). Additional dating is being done presently with ^{14}C and amino-acid-racemisation (AAR) on the shells of *Gouldia minima* (6740 shells). One valve was taken per subsample. One half of the valve will be dated with ^{14}C and the other half with AAR and then correlated. The results of this analysis are not yet available and will be published later.

2.5 Ecology

Ecological characteristics (feeding types and substrate relations) were allocated to each species. The feeding type is divided into the categories carnivorous, chemosymbiotic, deposit feeding, filter feeding, filter feeding/commensal, herbivorous, scavenging and symbiotic. The substrate relation was divided into the categories epifaunal, infaunal, semi-infaunal and host/cryptic. The allocation of the categories to the species was done with several sources (Gofas et al., 2011a,b; Beesley et al., 1998; Oliver, 2014; PBDB, 2014).

Feeding types	**Subcategories**	**Definition, Comments**
Carnivorous	Browsing	Species feeding on immobile animals such as bryozoans
	Micro	Species feeding on protozoans
	Macro	Predators
Chemosymbiotic		Species feeding on the metabolic products of chemosymbiotic bacteria within their body
Deposit feeding	Surface	Species feeding on particles at the surface
	Subsurface	Species feeding on particles below the surface
Filter feeding		Species feeding on particles suspended in water
Filter feeding/Commensal		Species feeding on particles suspended in water and living commensal with other species
Herbivorous	Micro	Species feeding on microalgae
	Macro	Species feeding on seagrass and macroalgae
Scavenging		Species feeding on decaying matter
Symbiotic	Parasite	Species living as parasites in or attached to other animals
Substrate relation	**Subcategories**	**Definition, Comments**
Epifauna		Species living on the substrate
	Nestler	Species living on the substrate and building nests with their byssus
Infauna		Species living in the substrate
Host/Cryptic		Species living in a symbiotic or parasitic relationship, using their hosts as "substrate"
Semi-infauna		Semi-burrowed species

Table 1: Categorization of feeding and substrate types

3 Results

3.1 Diversity and abundance

I counted 9018 gastropod shells, 22,448 bivalve shells, 305 scaphopods and 207 plates of polyplacophorans. Gastropods were represented by 37 families, 60 genera and 90 species, bivalves by 31 families, 63 genera and 75 species, polyplacophorans by 3 families and 5 species and scaphopods by 2 families, 2 genera and 2 species. The general trend in the abundance of all species, is that the number of individuals increases from 0-30 cm very rapidly with an interruption from 12-16 cm. From 30-75 cm it declines steeply again and then remains more or less the same with some small increases and decreases (Fig. 7). The number of species increases from 0-12 cm, then decreases from 12-18 cm, then increases sharply from 18-30 cm and then decreases continuously with some ups and downs (Fig. 8). In the oldest part of the core there was an increase in the number and abundance of species. In the younger part of the core, which starts at 6 cm, this development, however, is reversed, species abundance decreases to the top. When examining the number of individuals after combining two intervals in the first 20 cm, the first peak is more similar to the second and the decrease in individuals at the top is less steep (Fig. 9). The general trend, however, stays the same, with a strong increase in individuals from the oldest part of the core until the youngest part.

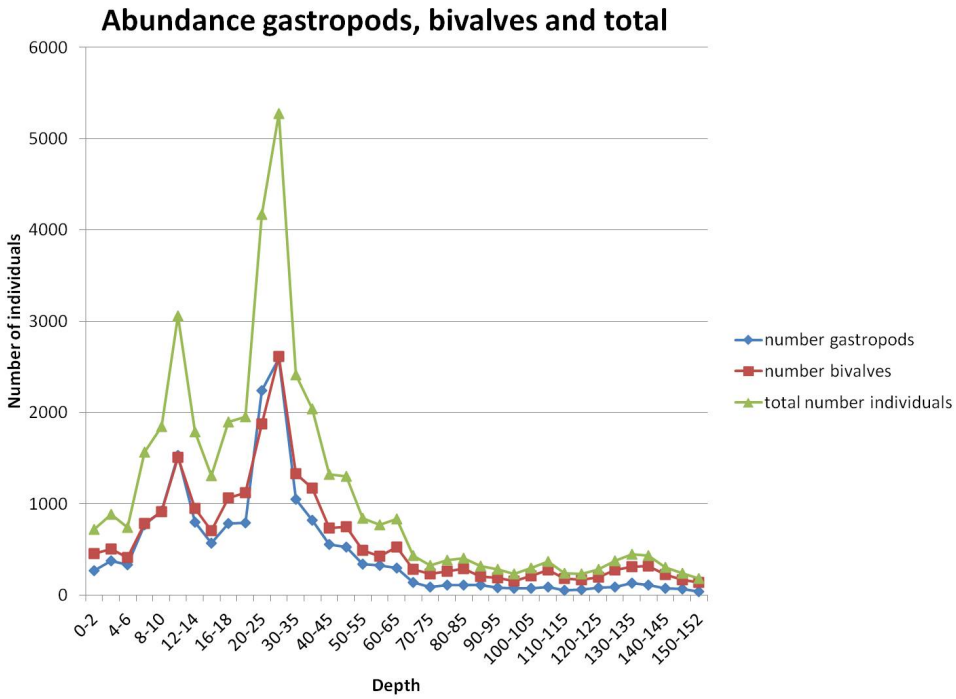

Figure 7: Abundance of gastropods, bivalves and total based on the raw data

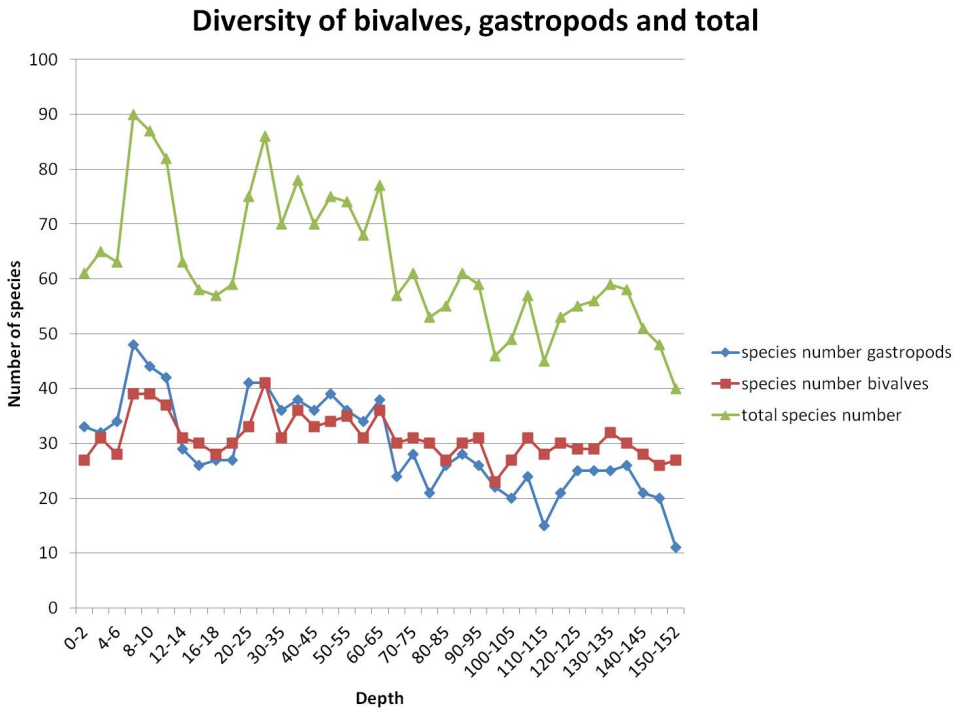

Figure 8: Diversity of bivalves, gastropods and total based on the raw data

When examining the raw data, species diversity apparently increases from the oldest to the youngest part of the core. After an individual rarefaction the results are quite different, however. At a rarefied sample size of 20 and 50 individuals the diversity changes only little through the whole core, but already shows the major trends and peaks, which are more obvious when the sample size is increased to 100 individuals. At a sample size of 150, 184 (highest sample size that still includes all samples) and 200 individuals these trends stay the same, but become stronger. The diversity increases from 152 cm to 125 cm, followed by a steep decline to 105 cm. After this low point the diversity starts to increase again to 90 cm, where it reaches the highest peak. Afterwards it declines steadily with smaller ups and downs and one more distinguished low point at 16-18 cm and 8-10 cm (Fig. 10).

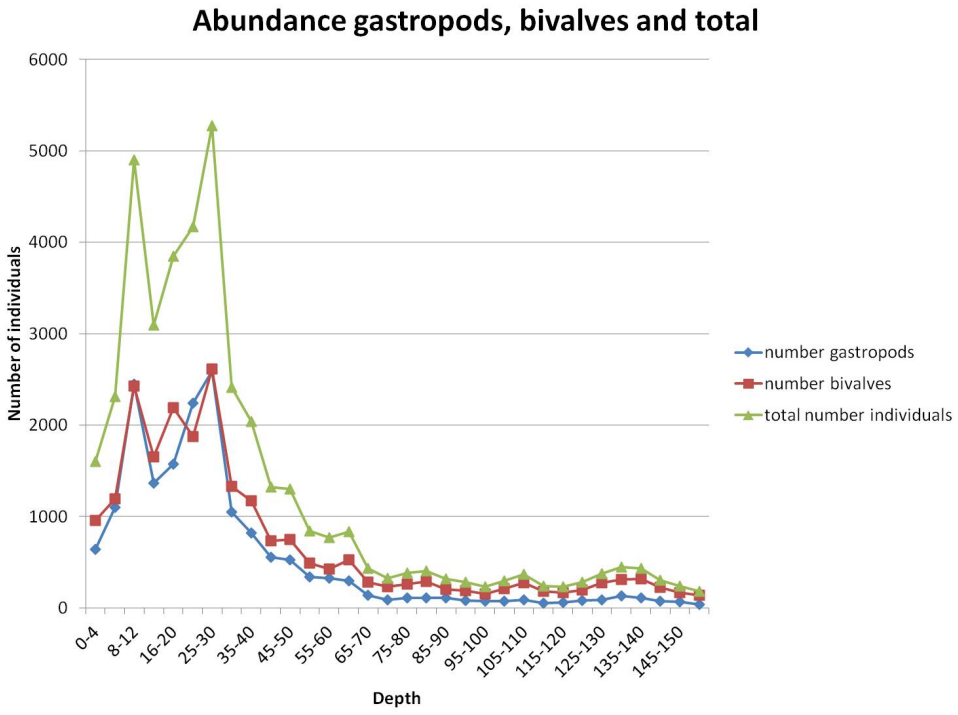

Figure 9: Abundance of bivalves, gastropods and all species through the core with the intervals from 0-20 cm combined to 4 cm intervals instead of 2 cm intervals

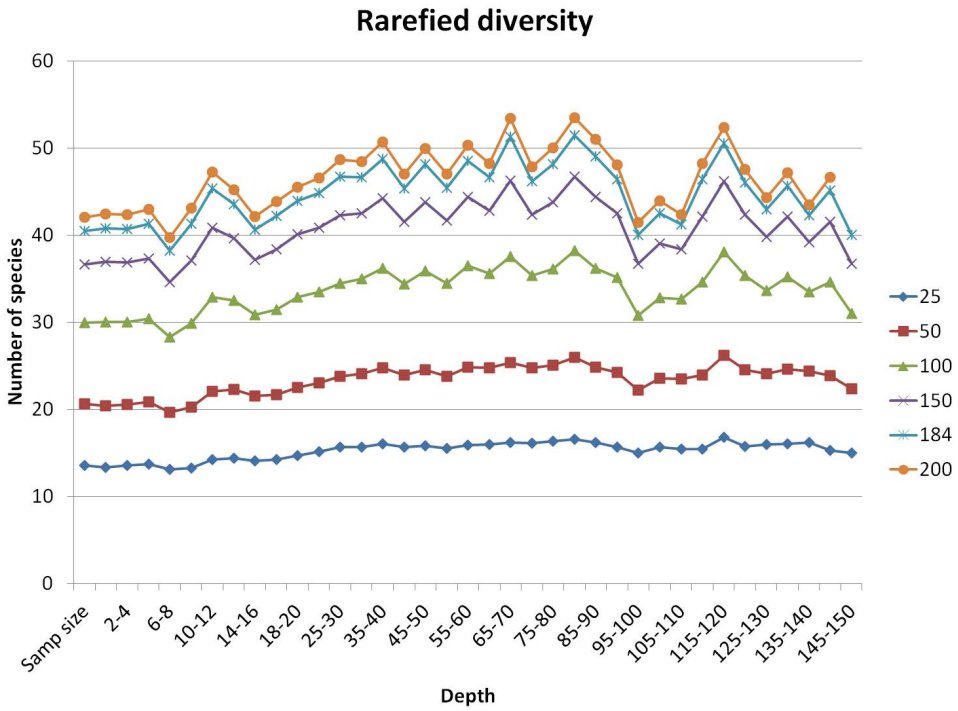

Figure 10: Diversity after individual rarefaction of each subsample at increasingly higher number of individuals

The most species-rich famlies among bivalves are the Cardiidae (9 species), Veneridae (8) and Lucinidae (5). The Veneridae are represented by the most individuals (8162), followed by the Cardiidae (3828) and Corbulidae (3343) (Fig. 11). The most species-rich families among gastropods are the Rissoidae (10 species), Trochidae (7), Cerithiidae (6) and Pyramidellidae (6). The Cerithiidae are represented by the most individuals (6739), followed by the Rissoidae (3049) and Nassariidae (2944) (Fig. 12). The polyplacophorans are represented by three families, each with few species: Acanthochitonidae (1), Chitonidae (2) and Lepidopleuridae (2). The Scaphopoda are represented by two families with one species each. The scatterplots for bivalves and gastropods show the relation of abundance and species richness. For bivalves, Veneridae and Cardiidae are both the most species- and individual-rich families, whereas the Corbulidae are the third most abundant family, but contain only two species. Among gastropods the Rissoidae are the family with the most species. The Cerithiidae are the family with the most individuals (but only six species) and the Nassariidae have many individuals (but only three species).

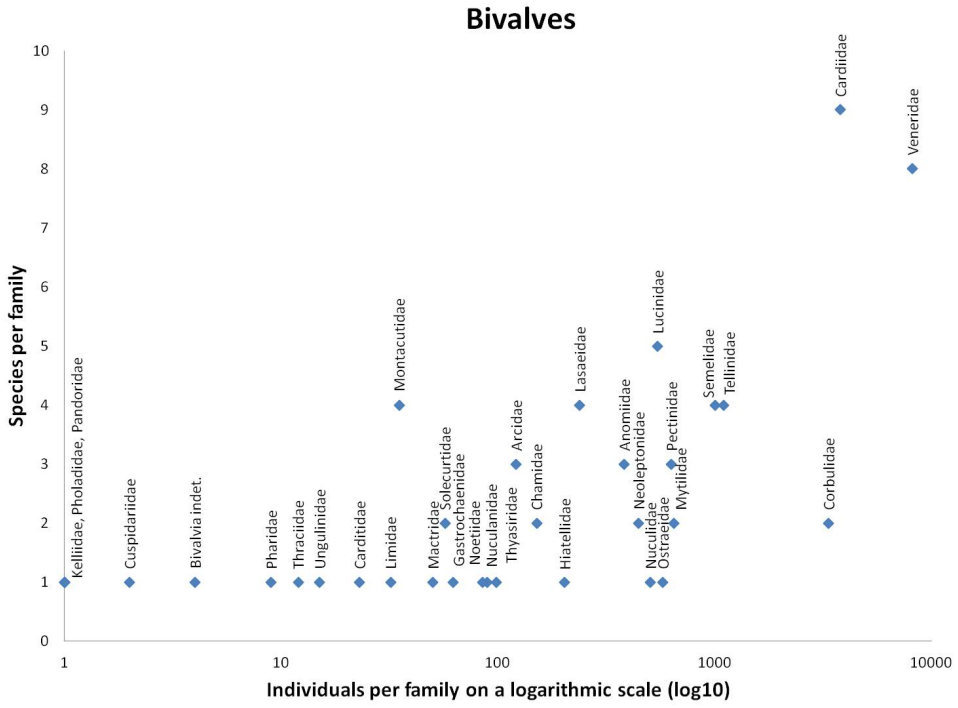

Figure 11: Scatterplot with the number of species per family and the number of individuals per family on a semi-logarithmic scale

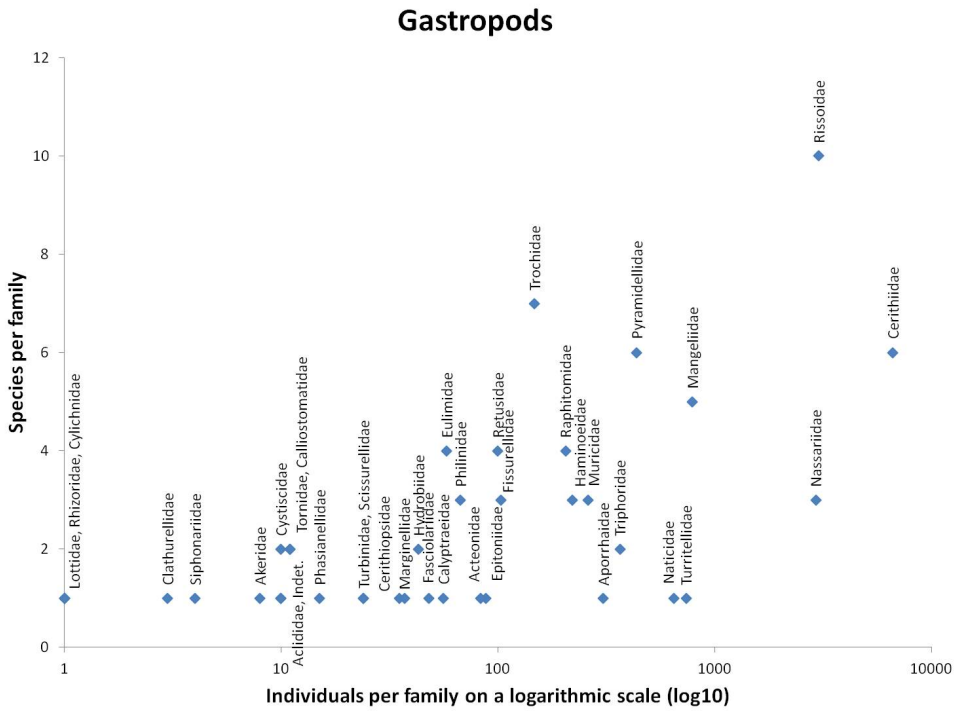

Figure 12: Scatterplot with the number of species per family and the number of individuals per family on a semi-logarithmic scale

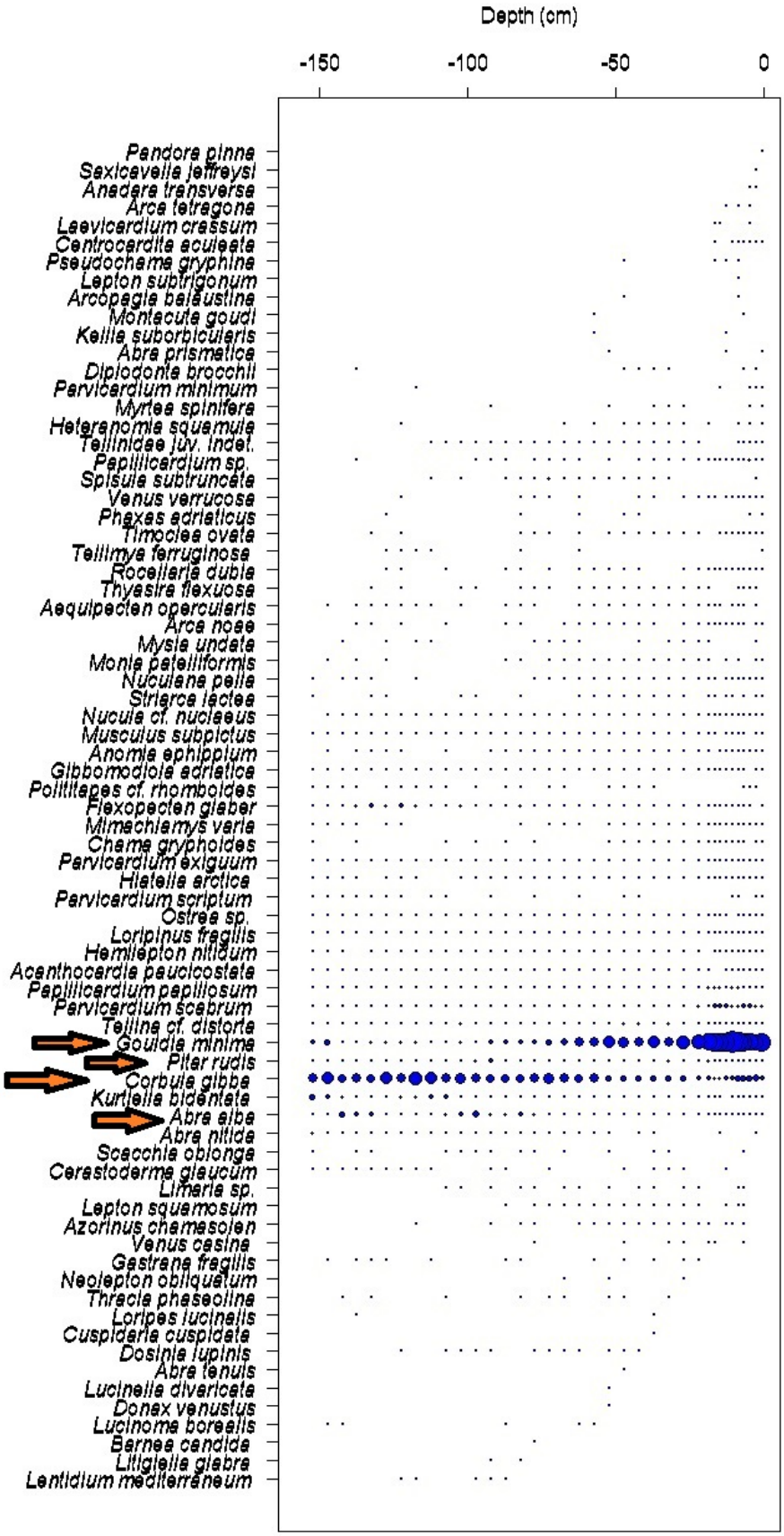

Figure 13: Relative abundance of bivalves sorted by appearance in the core

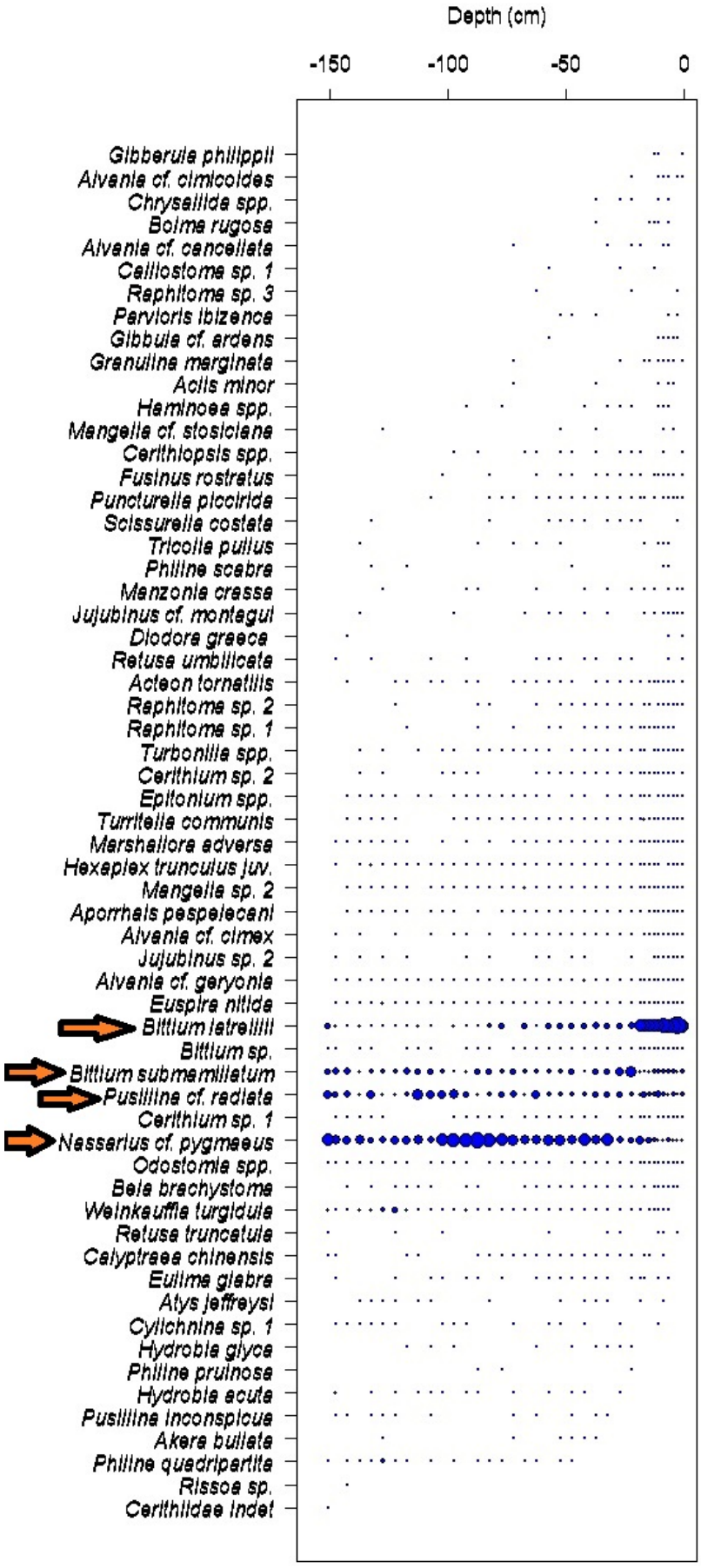

Figure 14: Relative abundance of gastropods sorted by appearance in the core

3.2 Species composition

The cluster analysis shows that the species abundance in the core can be divided into three groups, at a similarity level of 70% (Fig. 15). These three groups correspond to three depth-layers in the core. Group 1 extends from 0-18 cm and represents the youngest part, group 2 from 18-95 cm represents the middle part and group 3 from 95-152 cm represents the oldest part (Fig. 16).

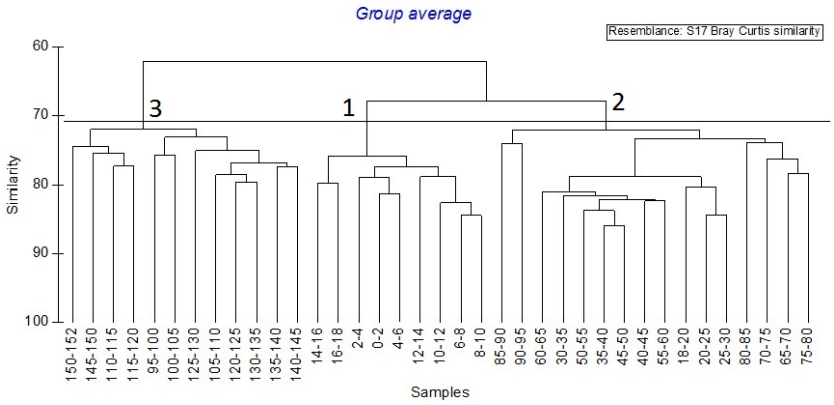

Figure 15: Cluster analysis, with square-root transformed data, on species abundance

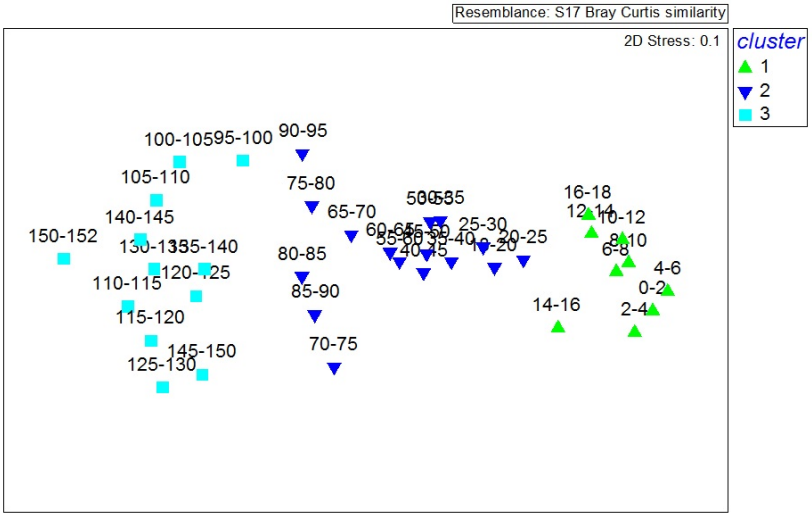

Figure 16: nMDS-plot of species abundance. Group 1, 2 and 3 that were determined with the cluster analysis for the abundance of species (compare figure 15)

The most abundant species in group 1 are the infaunal filter feeder *Gouldia minima* (22.2%), the epifaunal herbivore *Bittium latreillii* (13.7%) and the infaunal deposit feeder *Corbula gibba* with 6.6%. Five out of the ten most abundant species are infaunal, four epifaunal and one semiinfaunal. Regarding the feeding type, five species are filter feeders, three herbivores, one a deposit feeder and one a scavenger. In group 2 the most abundant species are again the infaunal filter feeder *Gouldia minima* (12.5%), the infaunal deposit feeder *Corbula gibba* and the epifaunal scavenger *Nassarius pygmaeus*. Six species are infaunal and 4 epifaunal and 3 filter feeders, three deposit feeders, three herbivores and one scavenger. In group 3 the most abundant species are *Corbula gibba* (17.2%), the infaunal deposit feeder *Abra alba* and the infaunal filter feeder *Saxicavella jeffreysi*. Seven species are infaunal and 3 epifaunal, 4 filter feeders, 4 deposit feeders, 1 scavenger and 1 herbivore. Through the whole core the most abundant species are *Gouldia minima*, *Corbula gibba* and *Nassarius pygmaeus*. Six species are infaunal, four epifaunal one is a scavenger (Fig. 17).

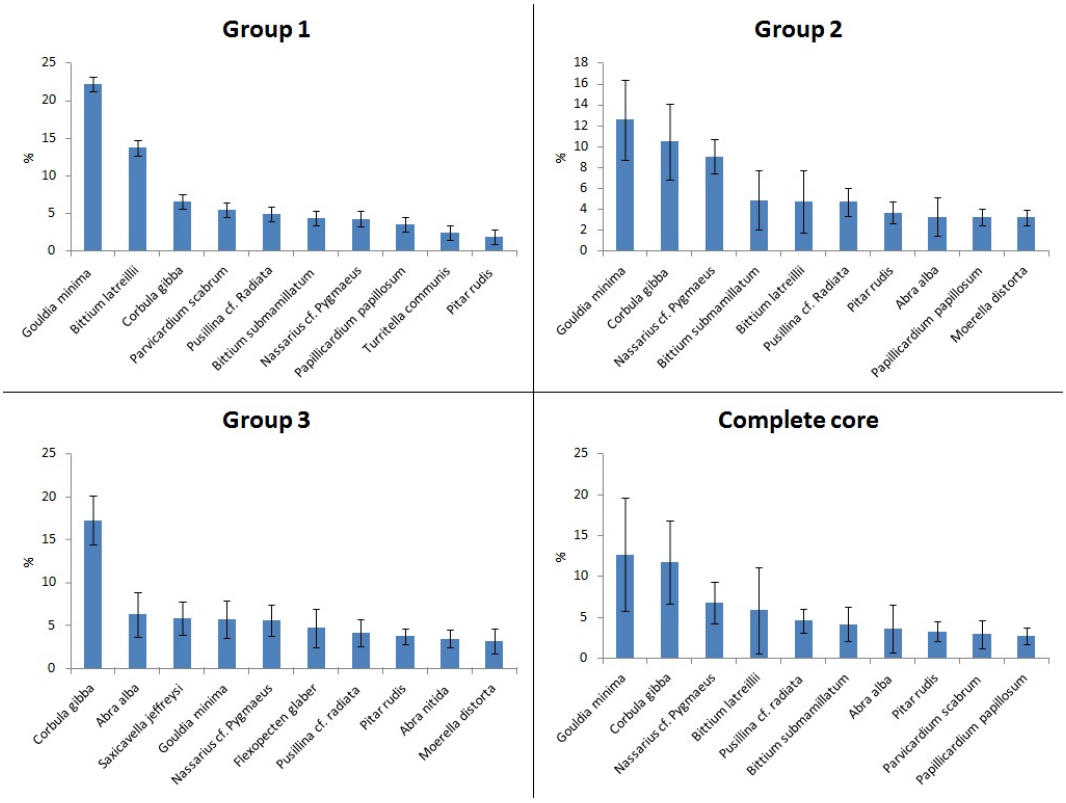

Figure 17: The ten most abundant species for each group and the complete core in percentages

In the oldest part of the core *Gouldia minima* is already abundant (5.7%) and becomes the most abundant species in the younger two parts of the core. *Moerella distorta* is abundant in the two older parts with 3.2% and becomes rare in the youngest part (only 0.8%). *Abra nitida* is the 9th most abundant species in the oldest part (3.5%) and becomes increasingly rarer in the younger parts (0.6% in group 2 and 0.04% in group 1). *Pitar rudis* is the 8th most abundant species in group 3, 7th most abundant in group 2 but decreases to 10th most abundant in group 1. *Pusillina cf. radiata* becomes more abundant in the younger part of the core (4.1% in the youngest to 4.9% in the oldest). *Flexopecten glaber* is very abundant only in the oldest part. *Nassarius pygmaeus* initially increases from 5.6% to 9.1%, but in the youngest part it decreases again to 4.3%. *Saxicavella jeffreysi* is very abundant only in the oldest part of the core (5.9%). *Abra alba* is the second most abundant species in the oldest part, then decreases to 3.2% in the middle part and is absent at the top. *Corbula gibba* is the most abundant species (17.3%) in the oldest part of the core and then decreases to second in the middle part and to third in the youngest part. *Papillicardium papillosum* is among the most abundant species in the middle and youngest part of the core, but not in the oldest. *Bittium latreillii* is not among the most abundant species in the oldest part of the core, but in the second part it is the 5th most abundant species (4.7%) and it even increases in the youngest part of the core (13.7%). *Bittium submamillatum* is not among the most abundant species in the oldest part as well, but is 4th most abundant in the second part (4.8%) and 6th most abundant in the youngest part (4.2%). *Turritella communis* is among the 10 most abundant species (2.4%) only in the youngest part of the core. The following species decrease from the oldest to the youngest part: *Moerella distorta*, *Abra nitida*, *Pitar rudis*, *Flexopecten glaber*, *Nassarius pygmaeus* (with a peak in the middle part), *Saxicavella jeffreysi*, *Abra alba*, *Corbula gibba* and *Bittium submamillatum* (but only very abundant in group 2 and 1). Increasing from the oldest to the youngest part are *Bittium latreillii*, *Pusillina cf. radiata*, *Gouldia minima*, *Papillicardium papillosum* and *Turritella communis*. When considering the abundance in percent of the four most abundant bivalve species, it is striking that *Gouldia minima* practically replaces the other three species by increasing massively while *Corbula gibba*, *Abra alba* and *Pitar rudis* decrease (Fig. 18). All four species are infaunal, two of them are deposit feeders and two are filter feeders. For gastropods the situation is less clear at first sight. *Bittium latreillii* increases very strongly, while *Pusillina cf. radiata* fluctuates, but always stays within the same range, *Bittim submamillatum* has a very strong peak between 20-45 cm, but is almost the same before and after this peak and *Nassarius pygmaeus* has a plateau

of higher abundance in the middle of the core.

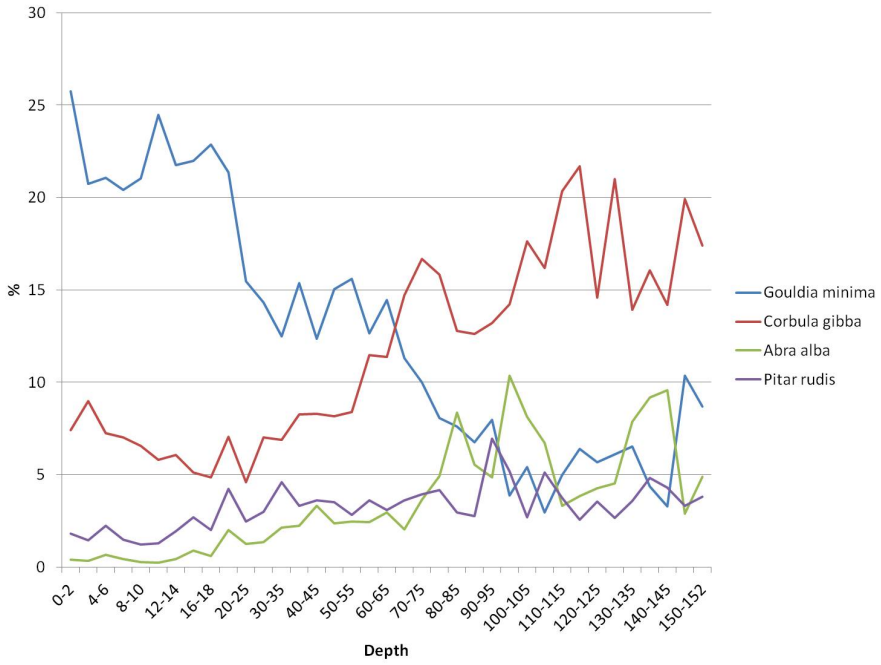

Figure 18: Development of the four most abundant bivalve species through the core

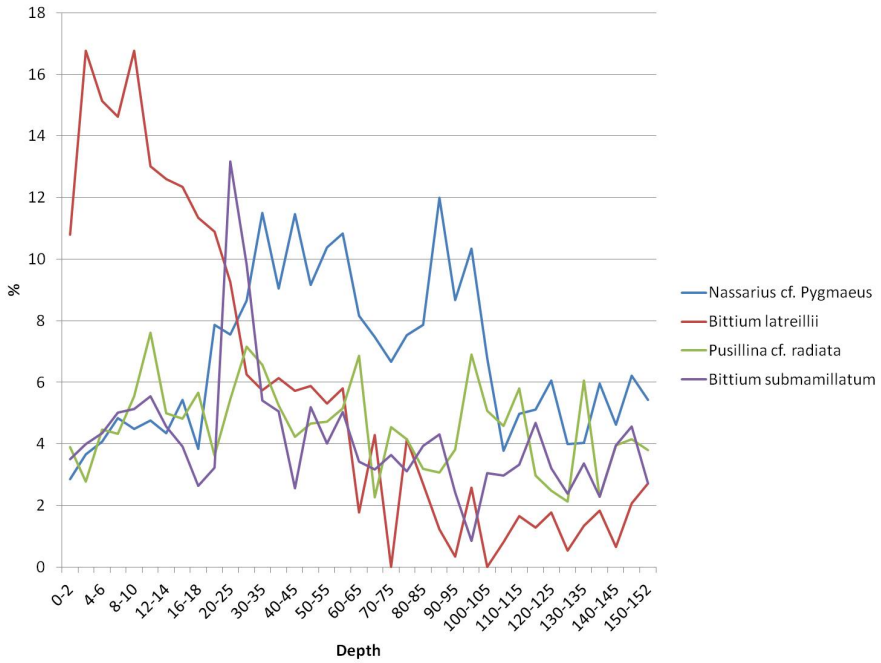

Figure 19: Development of the four most abundant gastropod species through the core

3.3 Feeding type

The cluster analysis for the different feeding types yielded similar groups as the cluster analysis for species-abundances at a similarity level of 90%. There is one group from 0cm to 30cm, a second group from 30cm to 95cm and a third from 95cm to 152cm with an outlier from 70-85cm (Fig. 20, 21).

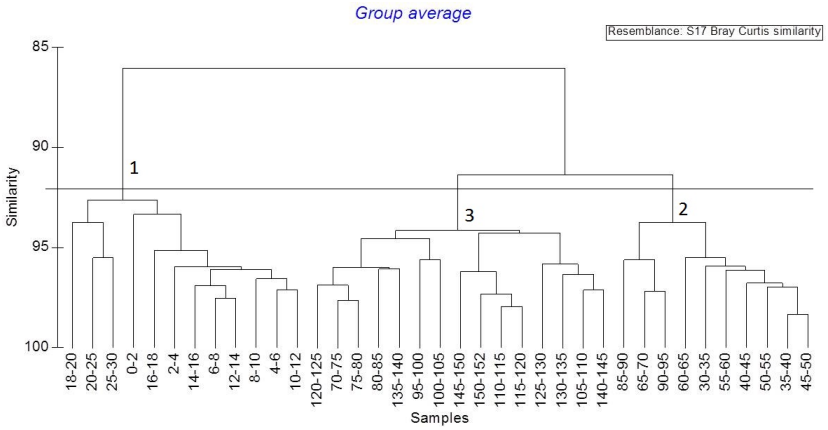

Figure 20: Cluster analysis, with square-root transformed data, on the feeding guilds

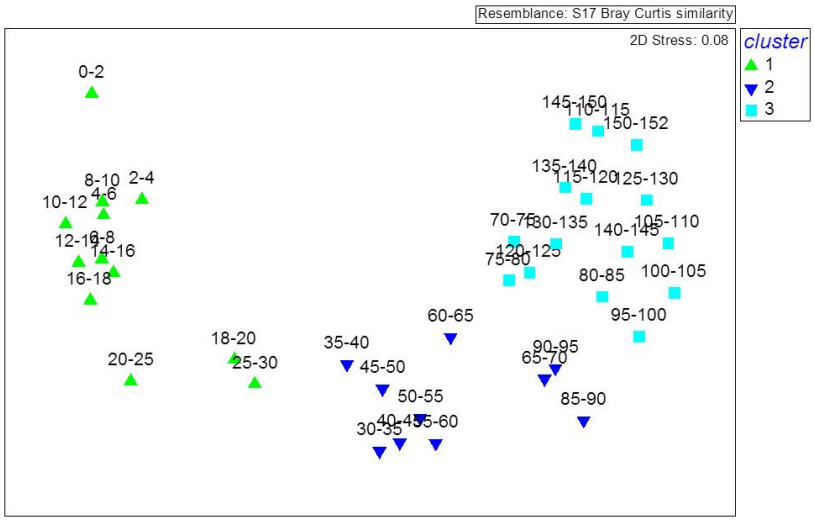

Figure 21: nMDS of feeding types. Group 1, 2 and 3 were determined with the cluster analysis for the feeding guilds (compare figure 20)

Group 3 is characterized by a very high abundance of filter and deposit feeders (>30%), some herbivores (>10%) and the rest represented by <10%. In group 2, filter feeders are again very abundant (>30%), deposit feeders and herbivores are represented by 20% and the rest by less than 10%. In group 1 filter feeders are even more abundant (>40%), herbivores (30%) and the rest of the feeding guilds is represented by less than 10%. Therefore there is an increase of filter feeders by 10% from the oldest to the youngest part of the core; herbivores increase by 20% and deposit feeders, decrease by 20%. Carnivores first increase and then decrease only very slightly, chemosymbiotic and commensal species decrease slightly, scavengers first increase and then decrease, and symbiotic species increase slightly (Fig. 22,23). The general trend is a shift from a community dominated by filter feeders and deposit feeders to a community of filter feeders and herbivores.

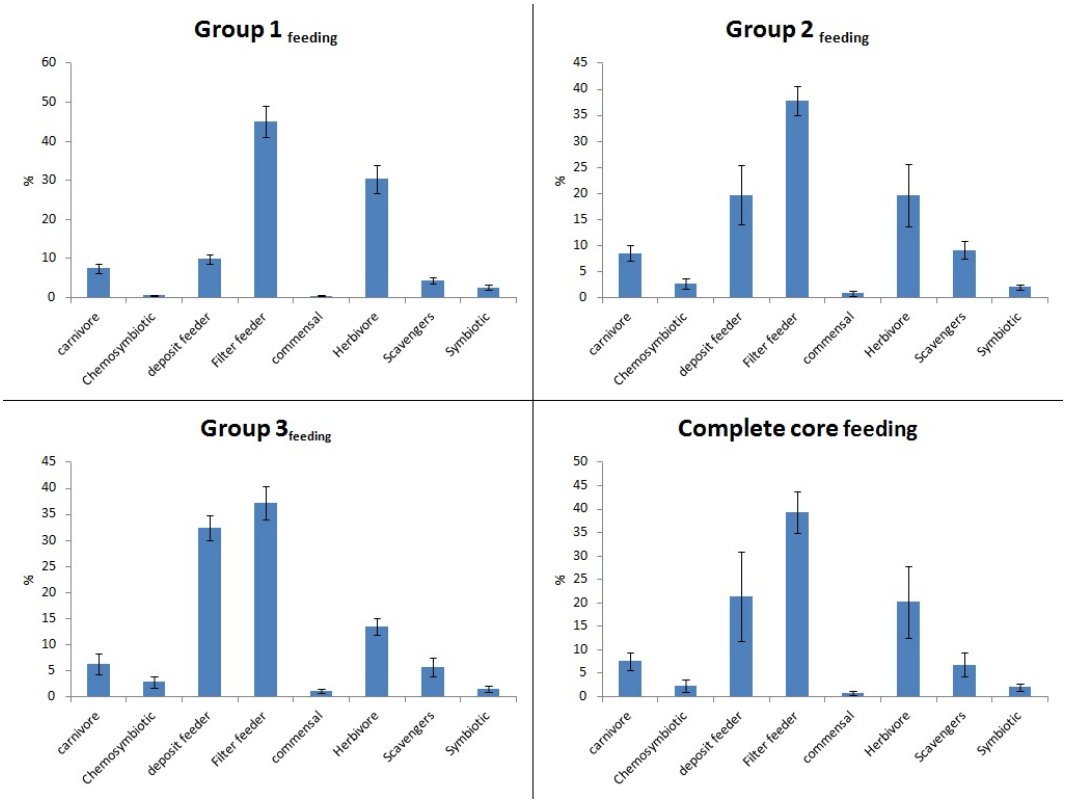

Figure 22: Abundances of the substrate types in group 1, 2 and 3 of the cluster analysis and the complete core

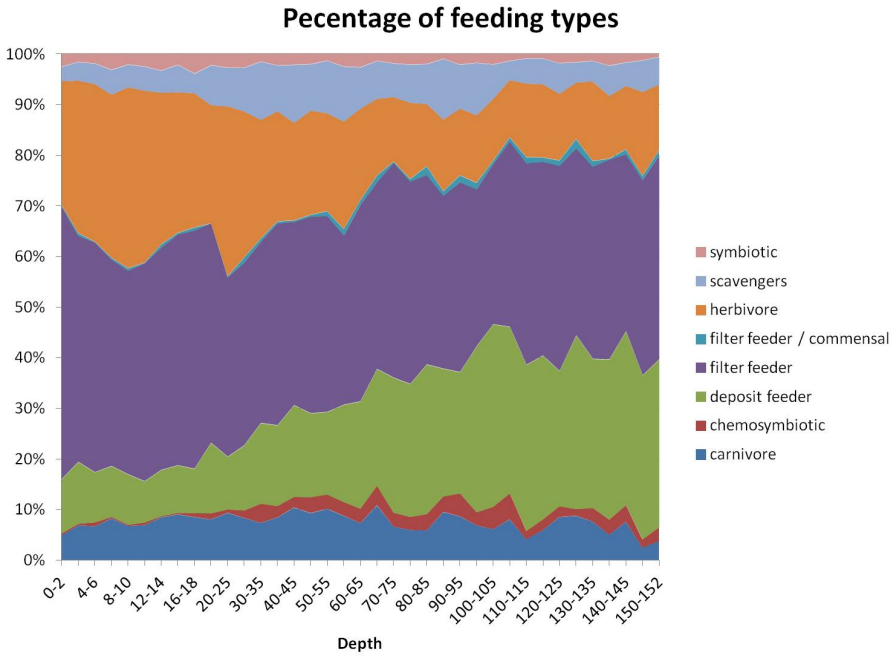

Figure 23: Proportion of feeding guilds through the core

3.4 Substrate

The cluster analysis of substrate types results in different groups than the cluster analysis of species composition and feeding type. Two groups are formed at a similarity level of 93%. The first one covers the depth from 2-60 cm and an outlier at 85-90 cm, and the second group covers the depth from 60-150cm and an outlier at 0- 2cm (Fig. 24, Fig. 25). Group 2 is characterized by a very high abundance of infauna (60%), half as much epifauna (30%) and the rest of the categories by less than 10%. In group 1, infauna is still the most abundant category, but not as dominant as earlier, and epifauna becomes almost as abundant. The other categories are still represented by less than 10%. Species living on hosts or cryptic and nestling species show no change in abundance, and semi-infaunal species increase slightly from the older to the younger part of the core. The general trend is therefore that infaunal species decrease from the older to the younger sediments while epifauna increases at the same time (Fig. 26.

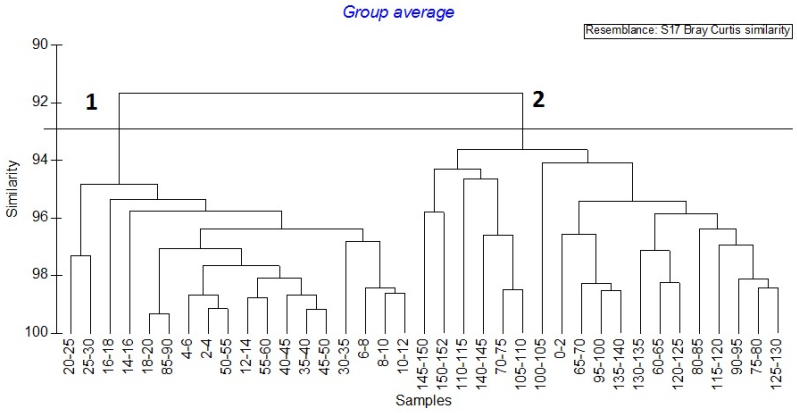

Figure 24: Cluster analysis, with square-root transformed data, on substrate preferences

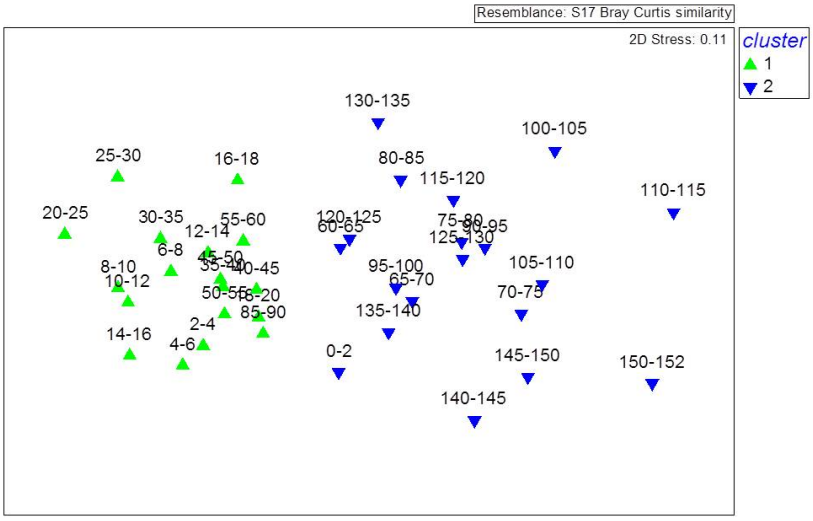

Figure 25: nMDS of substrate relations. Group 1 and 2 were determined with the cluster analysis for substrate preferences (compare figure 26)

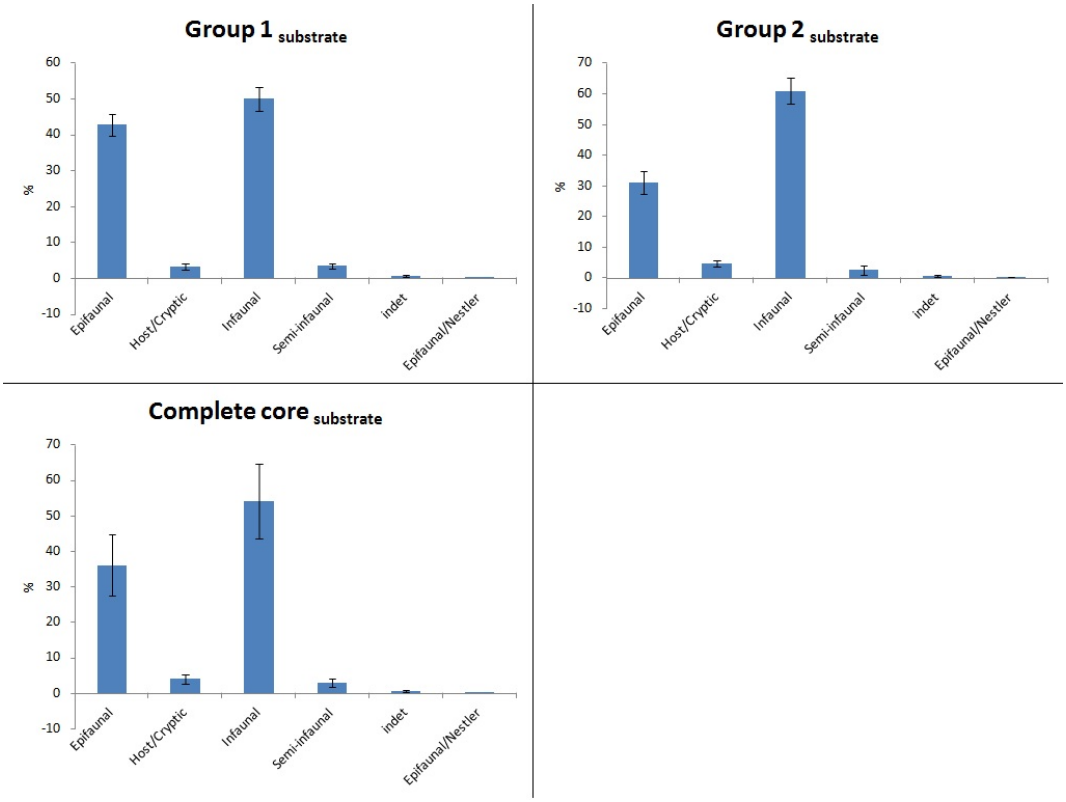

Figure 26: Abundances of the substrate types in group 1 and 2 and the complete core

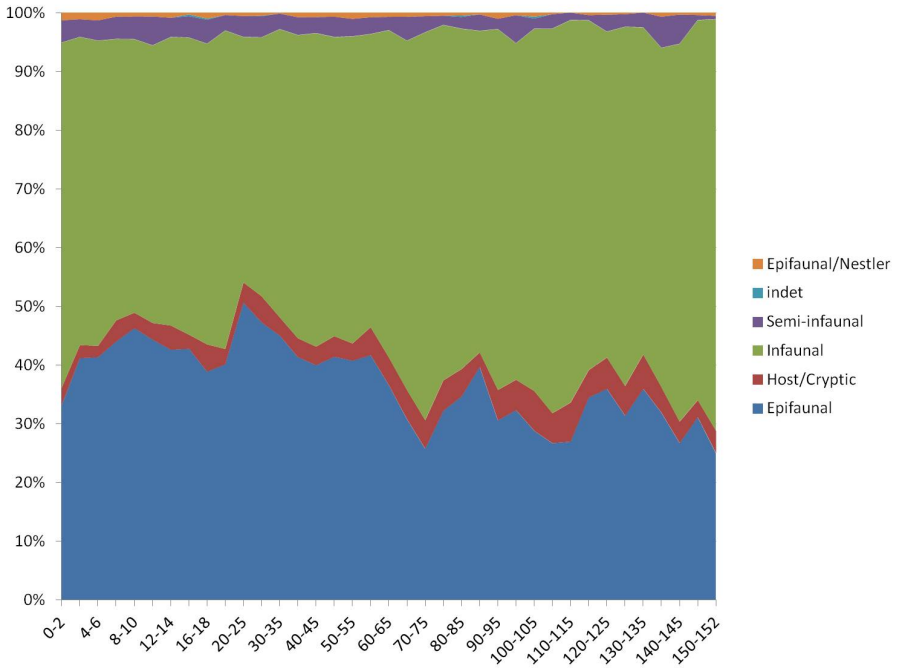

Figure 27: Proportion of substrate types through the core

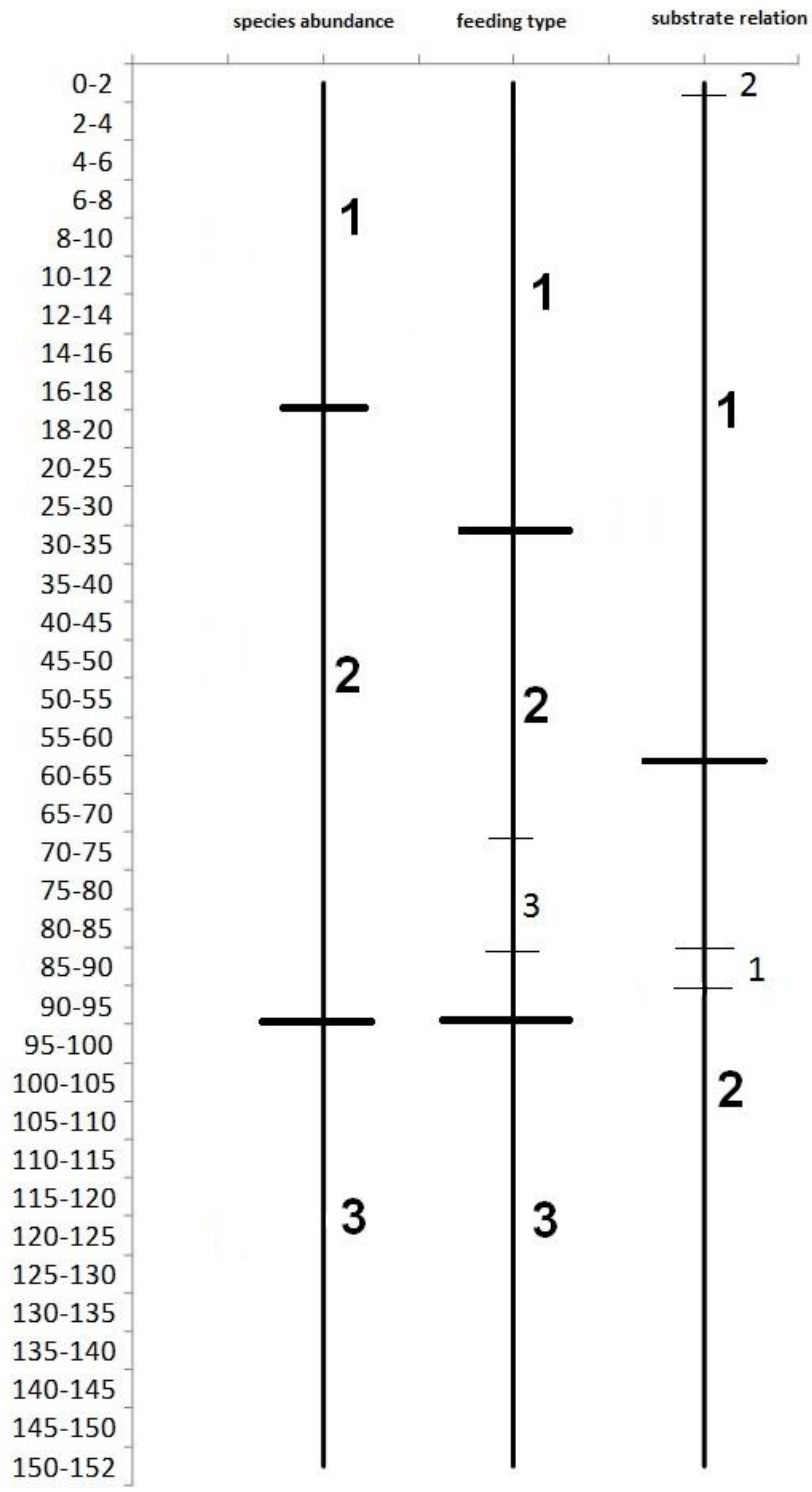

Figure 28: Distribution of groups that resulted from the cluster analysis along the core

3.5 Sediments

The analysis of the sediments shows that the composition changes through the core. The deepest sediments have a high proportion of silt, which declines up the core. The sandy fraction, however, is high at the top and declines with increasing depth (Fig. 29). The clay fraction decreases steadily with some minor ups and downs from 23.1% in the oldest interval of 150-152cm to 14% in the youngest interval of 0-2cm. The silty fraction decreases very strongly from 62.3% in the oldest interval to 13.1% in the youngest interval. The sandy fraction shows the opposite trend from 12.8% in the oldest interval to 63.1% in the youngest interval. The fraction >1 mm shows a curve that starts with 1.8% in the oldest sediments and ends with 9.8% in the youngest sediments, but has two very distinct peaks of 13.2% at 120-125 cm and 26% at 14-16 cm (Fig. 29).

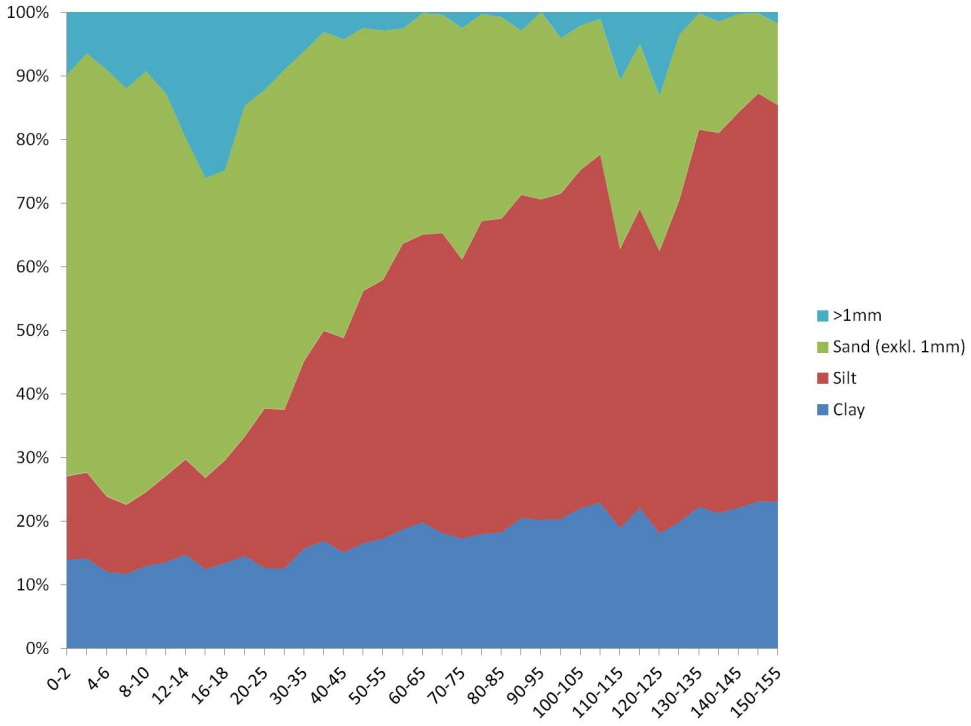

Figure 29: Composition of sediments in 4 major categories

The ^{210}Pb dating of the sediments shows that the sedimentation rate in the upper part of the core is about 1.6 mm/year and that the core has an approximate age of 112 years at a depth of 18 cm, 67 years at a depth of 13 cm and 22 years at a depth of 5 cm (Fig.: 30). It is, however, not possible to conclude that the sedimentation rate remained the same for the whole history of the core, especially because the grain size

changes so strongly from base to top. Furthermore there might be gaps in the profile where erosion occurred. Therefore we need ^{14}C dating and AAR for a more reliable dating of individual layers of the core.

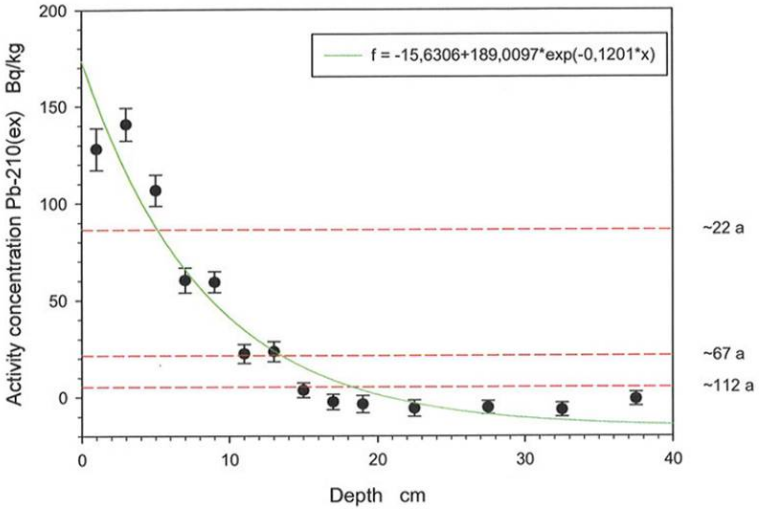

Figure 30: ^{210}Pb dating of the core PIR 2 S50

3.6 Heavy metals and pollutants

The results of the analysis of pollutants and heavy metals are very striking. Almost all the studied parameters (Zn, Mn, P, Fe, Al, Cr, Ni, Pb, Cu, Hg, Cd, PAH and PCB) have a more or less pronounced peak in the 10-8 cm interval. Exceptions are lithium, arsenic, total organic carbon, total carbon and total nitrogen. Phosphorus and manganese develop very similarly: both decrease from 138 cm to 20 cm. Then increase very steeply to the interval of 10-8 cm, and decrease again towards the sediment surface. Zinc shows the same strong peak at 10-8 cm, decreases to the top, but remains stable from 138cm to 20 cm (Fig.31). The polycyclic biphenyls have a very constant abundance from 138 cm to 22 cm, then decrease in the interval of 22 cm to 20 cm, but also have a very strong peak at 10-8cm, after which they decrease again (Fig.32). Polycyclic aromatic hydrocarbons show an even stronger peak at 10-8cm: they increase from 21.61 ng/g in 136-138 cm to 109.68 ng/g in 22-20 cm and then jump to 4184.42 ng/g in 10-8 cm, followed by a fall to 48.8 7ng/g in 6-4cm and 59.97 ng/g in 2-0 cm (Fig.33). Iron and aluminium decrease from 138 cm to 42 cm, then increase slightly to 20 cm, increase steeply to 10-8 cm and then decrease again steeply (Fig.34). Chrome and nickel have a very similar curve: both decrease from 138 cm to 44 cm and then increase to a peak at 10-8 cm and a decrease afterwards (Fig.35). Copper has almost the same development except that the low point is at 22-20 cm. Lead is very stable from 138 cm to 20 cm, followed by a steep increase towards the interval of 10-8 cm and then by a weak decline (Fig.36). Cadmium decreases from 138 cm to 54 cm, then increases to a peak at 10-8 cm, after which it decreases again. Mercury has one small peak at 44-42 cm and then a big peak at 10-8 cm as well (Fig.37). Total nitrogen shows the exact opposite trend with a peak at 120-118 cm, then a decrease to a low point at 10-8 cm, followed by a steep increase (Fig.38). Total carbon increases steeply from 138 cm to 4 cm with a small low point at 78-76 cm (Fig.39), whereas total organic carbon decreases steadily from the oldest samples to the youngest with a small peak at 78-76 cm (Fig.40). Lithium decreases as well towards the top of the core (Fig.35). Arsenic increases from 138 cm to 20 cm and then drops to a low point in the 10-8 cm interval (Fig.36).

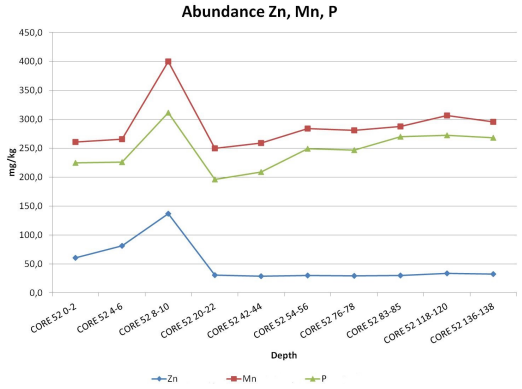

Figure 31: mg/kg of manganese, zinc and phosphorus

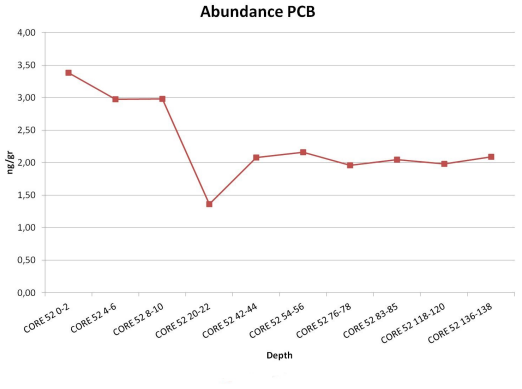

Figure 32: ng/g of Polycyclic biphenyls

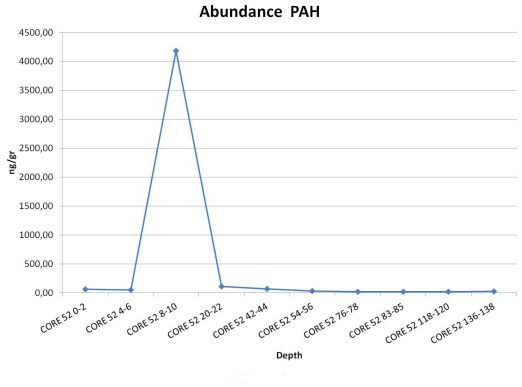

Figure 33: ng/g of Polyaromatic hydrocarbons

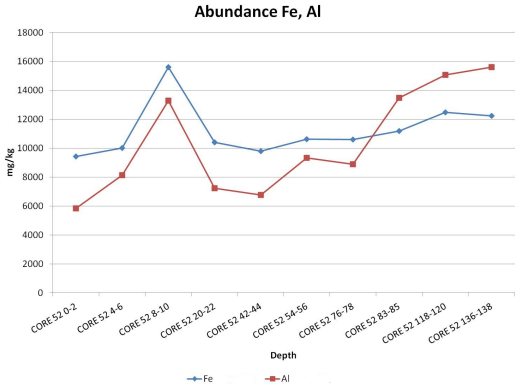

Figure 34: mg/kg of aluminium and iron

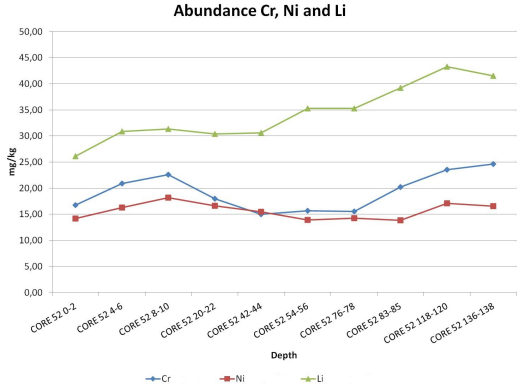

Figure 35: mg/kg of chrome, nickel and lithium

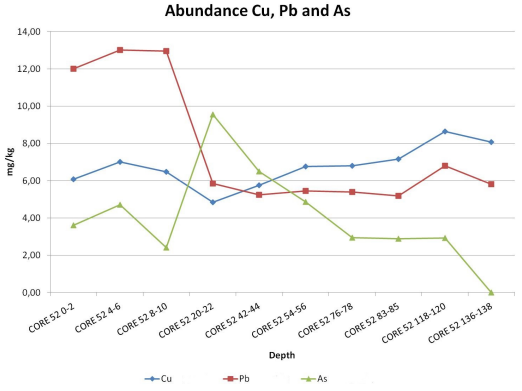

Figure 36: mg/kg of copper, lead and arsenic

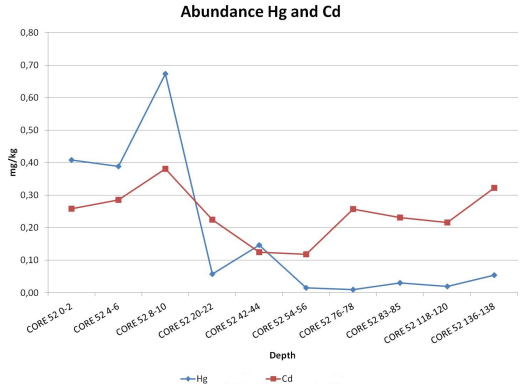

Figure 37: mg/kg of mercury and cadmium

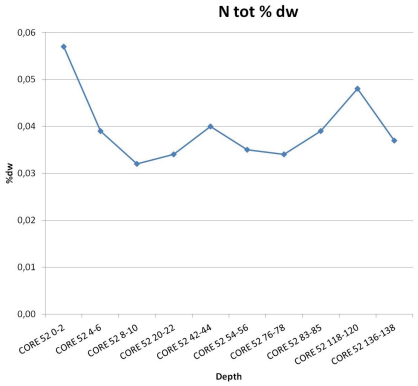

Figure 38: % dry weight of total nitrogen

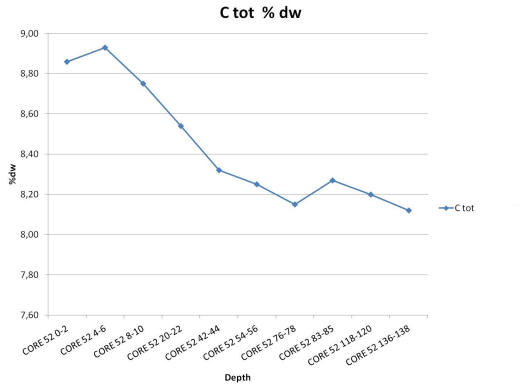

Figure 39: % dry weight of total carbon

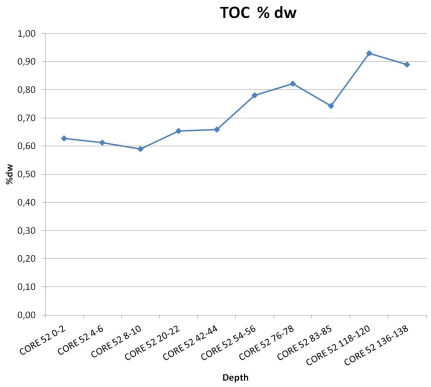

Figure 40: % dry weight of total organic carbon

3.7 Correlation analysis

3.7.1 Correlation with grain size

The correlation with grain size reveals two groups. One group is highly positively correlated with clay and silt and highly negatively with sand and sediments with a grain size >1 mm, and a second group with the exact opposite correlations. The first group therefore prefers clay and silt, whereas the second group preferes sand as a habitat. Highly positively correlated with clay and silt and negatively with sand and sediments >1mm are: deposit feeders, infauna, *Corbula gibba*, *Abra alba* and *Pitar rudis*. Highly negatively correlated with clay and silt and positvely with sand and sediments >1mm

are: herbivores, epifauna, the total species number, *Gouldia minima*, *Bittium latreillii*, *Parvicardium scabrum*, *Papillicardium papillosum* and filter feeders (significant, but not very strongly correlated). The correlation of heavy metals and pollutants with grain size yields the same two groups. Copper, lithium, aluminium and total organic carbon are positively related to clay and silt and negatively to sand and sediments >1 mm. Mercury, lead, zinc, PCB and total carbon are negatively correlated with clay and silt and positively correlated with sand and sediments >1mm. Rarefied species richness, however, does not correlate significantly to any grain size (Table 2, Appendix).

Categories	**Pearson *r***			
	Clay	Silt	Sand	>1mm
Deposit feeders	0.92	0.92	-0.91	-0.65
Infauna	0.77	0.73	-0.73	-0.51
Corbula gibba	0.84	0.82	-0.81	-0.58
Abra alba	0.77	0.81	-0.79	-0.58
Pitar rudis	0.56	0.63	-0.60	-0.47
Filter feeders	-0.51	-0.62	0.53	0.57
Herbivores	-0.87	-0.90	0.88	0.64
Epifauna	-0.76	-0.72	0.73	0.49
total species number	-0.65	-0.60	0.70	0.17
Gouldia minima	-0.84	-0.91	0.88	0.65
Bittium latreillii	-0.86	-0.92	0.89	0.65
Parvicardium scabrum	-0.83	-0.87	0.85	0.63
Papillicardium papillosum	-0.62	-0.62	0.62	0.41
Hg	-0.66	-0.83	0.83	0.61
Pb	-0.60	-0.84	0.81	0.65
Zn	-0.55	-0.72	0.72	0.52
PCB	-0.41	-0.65	0.66	0.34
C tot	-0.84	-0-96	0.94	0.83
Cu	0.80	0.56	-0.59	-0.55
Li	0.91	0.84	-0.88	-0.68
Al	0.70	0.55	-0.60	-0.43
TOC	0.96	0.89	-0.93	-0.69
rarefied species richness	0.25	0.39	-0.33	-0.34

Table 2: Correlation of species, ecological groups and pollutants with grain size

3.7.2 Correlation with heavy metals and pollutants

Chemosymbiotic species, deposit feeders, infauna, *Corbula gibba*, *Abra alba* and species living on hosts or with a cryptic life habit are all negatively correlated with mercury, lead, arsenic, zinc and total carbon and positively with copper, lithium, aluminium and total organic carbon. Filter feeders, herbivores, epifauna, the total species number, total number of individuals, *Bittium latreillii* and *B. submamillatum*, *Parvicardium scabrum*, *Papillicardium papillosum* and *Pusillina cf. radiata* are all negatively correlated with copper, lithium, aluminium and total organic carbon and positively with mercury, lead, arsenic, zinc, PHA, PCB and total organic carbon with a few exceptions. Only filter feeders are positively correlated with nitrogen.

Scavengers and rarefied species richness do not fit into any group and are negatively correlated only with mercury, lead, cadmium, zinc, PCB and total carbon.

Chrome, nickel, manganese, phosphorus and iron do not have any significant correlations and also do not show any specific trend in their abundance (Table 3, Appendix).

Category	Hg	Cu	Pb	As	Li	Zn	Al	PCB	C tot	TOC
Chemosymbiotic	-0.84		-0.83		0.72	-0.73			-0.89	0.75
Deposit feeders	-0.66	0.75	-0.63		0.90		0.70		-0.83	0.88
Infauna		0.67		0.68						
C. gibba		0.85			0.86		0.67		-0.69	0.91
P. rudis	-0.71	-0.73			-0.70			-0.78	0.64	
Filter feeders			0.70					0.85	0.64	
Herbivore	0.73	-0.62	0.69	0.50	-0.73	0.71			0.83	-0.81
Epifauna		-0.66		0.72						
G. minima	0.78		0.80	-0.87	0.64		0.73	0.92	-0.84	
B. latreillii	0.89		0.86		-0.76	0.85		0.65	0.92	-0.87
P. scabrum	0.71		0.75		-0.88		-0.68	0.65	0.93	-0.92
P. cf. radiata		-0.75		0.65	-0.70					-0.72
Rarefied species richn.	-0.89		-0.93			-0.87		-0.71	-0.85	
Scavengers	-0.65		-0.82			-0.64		-0.70	-0.63	

Table 3: Correlation of species and ecological groups with heavy metals and pollutants

4 Discussion

Death assemblages, as found in the core I studied, represent the organisms that lived and currently live in the sampling area and therefore provide evidence for the recent and former populations. They can be used to study anthropogenic impacts on populations and macroecological dynamics and to obtain biological information that is impossible to gain from living organisms alone (Kidwell, 2013). Furthermore, benthic invertebrates are often used as bio-indicators of water quality, because stress on different levels (anthropogenic or natural) is reflected in changes of populations. It is also important to use biological criteria when assessing water quality, because they can reveal problems missed by other methods, are a direct indicator of the population condition and can show progress in restoration (Dauer, 1993). Very often, soft-bottom communities are used, because sedentary organisms (which are very frequent in those communities) cannot escape the conditions of their surrounding, live relatively long and have a very high diversity of species that are tolerant to different kinds of stress or environments (Dauer, 1993). The methods I used to study my core originate from the relatively new field of conservation paleobiology (Dietl & Flessa, 2011). The aim of the study was to find potential major ecological changes through the last thousands of years, which cover a period of time during which anthropogenic impacts in the northern Adriatic Sea became increasingly stronger (DeGroot, 1984; Thrush & Dayton, 2002; Kovačević, 2002; Lotze et al., 2010). I found distinct down-core changes in the species composition, feeding modes and substrate relation. Species composition and feeding modes show similar changes with three distinct clusters that form with increasing depth of the core, whereas the substrate relation shows a different trend with only two clusters. Some of the species that were found can be used as bio-indicators (Hrs-Brenko, 2006; Borja et al., 2000). The correlation analysis showed in general that abundance of ecological groups and pollutants correlate with the grain size of the sediment.

4.1 Diversity and abundance

Throughout the core, I found huge numbers of gastropods and bivalves and a few scaphopods and polyplacophorans. The total abundance of all species increased strongly towards the younger parts of the core, with a steep increase again in the youngest samples above 30 cm (Fig. 9). The latter roughly represents the last century during which bottom trawling and anthropogenic pollution became a factor (DeGroot, 1984; Thrush & Dayton, 2002). The minimum values between between 12 cm and 30 cm (Fig. 7) coincides with a peak in Ostraeidae and Arcidae. I interpret this to mean that the biomass in those intervals is probably not smaller, but there were larger individuals, which resulted in a lower number of individuals. This also corresponds to the time in which mussel beds were still marked on fishing maps (Manzini, 1927). The rarefied species richness, however, is not influenced by the abundance of individuals and shows three minima. The first is between 100-150 cm, the second at 16-20 cm and the third at 10-8 cm (Fig. 10). The minimum at 8-10 cm is the lowest value of the whole core and coincides with peak values in many of the environmental parameters measured (Zn, Mn, P, Fe, Al, Cr, Ni, Pb, Cu, Hg, Cd, PAH and PCB). One potential explanation is an event with a big influx of pollutants into the sea, which caused a decrease in diversity. From 16-18 cm on, *C. gibba*, which is an indicator for disturbances, starts to increase again (Hrs-Brenko, 2006). The species composition changes in three distinct clusters down-core. The oldest cluster is dominated by the infaunal deposit feeder *Corbula gibba*, which is referred to as species indicative of environments with high pollution, low oxygen levels, high turbidity and frequent disturbances (Hrs-Brenko, 2006). In my core, however, it decreases towards the younger sediments at the top (Fig. 18) and can therefore not be seen as a clear indicator for anthropogenic pollution and disturbances. Instead, *C. gibba* correlates highly positively with the abundance of clay and silt, which are also decreasing in the higher sediments (Fig. 29). The infaunal filter feeder *Gouldia minima* and *Bittium latreillii* (Fig. 19), however, replace *C. gibba* in the younger samples and correlate positively with sand. Cerithiids are usually associated with algae and seagrass (Gofas et al., 2011a). *Bittium latreillii* is often found associated with eelgrass beds (*Zostera marina*) (Rueda et al., 2009) or *Posidonia oceanica* (Albano & Sabelli, 2012). At the Slovenian coast, *Bittium reticulatum* was found to be the most abundant gastropod species in *Cystoseira* algal associations, with *B. latreillii* being present as well, but not as abundant (Pitacco et al., 2014). Those authors also found that the upper layer of the substrate provides a suitable habitat for *Gouldia minima*. My interpretations is, that the increase of sand

resulted in an increase in algae, which in turn provided a suitable habitat for Cerithiidae. According to the correlation analysis the most abundant species can be divided into three groups. One that correlates positively with sand (*C. gibba, A.alba, P. rudis*), one that correlates positively with clay and silt (*G. minima, B. latreillii, P. scabrum, P. papillosum*) and one that does not correlate with the sediments at all (*Nassarius cf. pygmaeus, Pusillina cf. radiata, B. submamillatum*). The group that is found preferentially in more sandy sediments is also positively correlated with heavy metals and pollutants, which are found mostly in sand, and the group typical for clay and silt also correlates with the heavy metals and pollutants typical for clay and silt. Accordingly, I interpret that the abundance of species depends on the grain size rather than on the abundance of heavy metals. The rarefied species richness, however, did not significantly correlate with any grain size. The total species number is positively correlated to sand, which suggests that sandy sediments are providing a better habitat for many individuals (Table 2).

4.2 Ecology and species composition

The cluster analyses for ecological groups and species composition yield three distinct groups that are distributed with depth through the core, suggesting a shift in species composition and dominance with time. Group three represents the oldest part of the core and extends from 152-95 cm. It is characterized by a very high abundance of infaunal deposit feeders (*C. gibba* and *Abra alba*) and infaunal filter feeders (*Gouldia minima, Saxicavella jeffreysi*). Deposit feeders and infauna decrease towards group two (95-18 cm species composition, 95-30 cm ecology), whereas herbivores (*Bittium latreillii*) increase together with epifauna. Towards group 1, herbivores increase even more together with filter feeders and epifauna, whereas deposit feeders and infauna decrease. The cluster analysis for substrate relation, however, results in only two clusters, the older one from 150-60cm and the younger from 60-2 cm. Both, feeding type and substrate relation correlate highly significantly with grain size, resulting in two groups similar to the analyses for species abundance. Deposit feeder and infauna are highly negatively correlated to sand and positively to clay and silt and filter feeders, whereas herbivores and epifauna are correlated highly negatively to clay and silt and positively to sand. (Table 2) This also supports the hypothesis that the faunal composition is mainly dependent on grain size and less on other environmental factors, which was found in earlier studies as well (Sanders, 1958; Alexander, 1993). The correlation of substrate

relation and feeding mode with heavy metals and pollutants also yielded two groups. Epifauna, herbivores and filter feeders correlate positively with the pollutants, which are correlated positively with sand and infauna. Deposit feeders and chemosymbiotic species correspond with the pollutants that are typical for clay and silt. Only scavengers do not fit in the two groups and only show negative correlations (Table 3). This could mean that pollutants are differently retained by the different grain sizes and do not have a strong impact on the species composition.

4.3 Pollutants

All the measured pollutants are present in all sampled layers and almost all of them (Zn, Mn, P, Fe, Al, Cr, Ni, Pb, Cu, Hg, Cd, PAH and PCB) show a distinct peak at 8-10cm. This could be explained by an event, in which a big amount of pollutants was brought into the sea, for example an oil spill. Especially PAHs show a very large peak in this interval and also PCBs increase sharply. Both remain in the sediment for a long time (Adami et al., 2000) and are defined as priority pollutants (Keith & Telliard, 1979; Lang, 1992). Nitrogen, chrome, manganese, phosphorus and iron do not show any major trends through the core and do not have any significant correlations either. The other pollutants, however, correlate significantly with sediment grain size (Table 2) and therefore also with the species and ecological groups that were found in those grain sizes. These pollutants apparently do not affect abundances of ecological groups or species. They do, however, seem to have an impact on the rarefied species richness. The latter has only negative correlations to pollutants (mercury, lead, zinc, PCB and total carbon) and does not correlate to the grain size of the sediment. I interpret this to mean that those heavy metals and eutrophication negatively impact species diversity.

4.4 Sediment age and composition

The sediment age was determined to be 112 years at a depth of 18cm at a sedimentation rate of approximately 1.6 mm per year. To determine the age of the rest of the core, ^{14}C and AAR dating is presently being performed, but the results are not yet available. The composition of the sediment changes strongly through the core from a very high proportion of silt in the oldest part to a high proportion of sand in the youngest part. Clay also decreases up the core, but not as much as silt. The increasing amount of sand may reflect an autogenic succession with increasing amount of accumulating biogenic

material, which resulted in a change from infaunal deposit feeders, to epifaunal suspension feeders towards the top (Dodd & Stanton, 1990). The strong peak in sediment >1mm in the depth of 18-14 cm could represent the mussel beds (Arcidae) that were still present in 1927 (Manzini, 1927). The strong decrease in sediment >1 mm shortly thereafter, can be explained by more frequent bottom trawling and dredging during the last century (DeGroot, 1984; Thrush & Dayton, 2002).

4.5 Conclusion

A general shift from an infaunal, deposit-feeding community in mainly silty sediment to an epifaunal, herbivore and filter-feeding community that lives mainly in sandy sediments was identified. The species composition is strongly shaped by sediment parameters and from bottom to top may reflect a natural succession, in which, biogenic hardparts of the fauna change the natural environment, resulting in an increase of epifaunal suspension feeders at the expense of infaunal deposit feeders. The youngest sediments may also show changes that can be explained by anthropogenic impact. Pollutants and heavy metals are strongly correlated with grain size and are therefore interpreted to have a minor influence on faunal composition. Diversity, however, is negatively affected by certain heavy metals and eutrophication.

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6 Appendix

Family	Species	Diet	Preferential substrate
Nuculanidae	*Nuculana pella* (Linnaeus, 1767)	Deposit feeder / Filter feeder	Infauna
Nuculidae	*Nucula cf. Nuclaeus* (Linnaeus, 1758)	Deposit feeder / Filter feeder	Infauna
Arcidae	*Arca noae,* Linnaeus, 1758	Deposit feeder / Filter feeder	Epifauna
Arcidae	*Arca tetragona,* Poli, 1759	Filter feeder	Epifauna
Arcidae	*Anadara transversa* (Say, 1822)	Filter feeder	Semi-infaunal
Noetiidae	*Striarca lactea* (Linnaeus, 1758)	Filter feeder	Epifauna
Mytilidae	*Musculus subpictus* (Cantraine, 1835)	Filter feeder	Host/Cryptic
Mytilidae	*Gibbomodiola adriatica* (Lamarck, 1819)	Filter feeder	Semi-infaunal
Pectinidae	*Aequipecten opercularis* (Linnaeus, 1758)	Filter feeder	Epifauna
Pectinidae	*Flexopecten glaber* (Linnaeus 1758)	Filter feeder	Epifauna
Pectinidae	*Mimachlamys varia* (Linnaeus, 1758)	Filter feeder	Epifauna
Anomiidae	*Anomia ephippium,* Linnaeus, 1758	Filter feeder	Epifauna
Anomiidae	*Heteranomia squamula* (Linnaeus, 1758)	Filter feeder	Epifauna
Anomiidae	*Monia patelliformis* (Linnaeus, 1761)	Filter feeder	Epifauna
Limidae	*Limaria* sp., Link, 1807	Filter feeder	Epifauna
Ostreidae	*Ostrea* sp. Linnaeus, 1758	Filter feeder	Epifauna
Lucinidae	*Loripinus fragilis* (Philippi, 1836)	Chemosymbiotic	Infauna
Lucinidae	*Lucinella divaricata* (Linnaeus, 1758)	Chemosymbiotic	Infauna
Lucinidae	*Lucinoma borealis* (Linnaeus, 1767)	Chemosymbiotic	Infauna
Lucinidae	*Loripes lucinalis* (Lamarck, 1818)	Chemosymbiotic	Infauna
Lucinidae	*Myrtea spinifera* (Montagu, 1803)	Chemosymbiotic	Infauna
Thyasiridae	*Thyasira biplicata* (Montagu, 1803)	Chemosymbiotic / Filter feeder	Infauna
Chamidae	*Chama gryphoides,* Linnaeus, 1758	Filter feeder	Epifauna
Chamidae	*Pseudochama gryphina* (Lamarck 1819)	Filter feeder	Epifauna
Neoleptonidae	*Coracuta obliquata* (Chaster, 1897)	Filter feeder / Commensal	Host/Cryptic
Montacutidae	*Saxicavella jeffreysi,* Winckworth, 1931	Filter feeder	Infauna
Montacutidae	*Kurtiella bidentata* (Montagu, 1803)	Filter feeder / Commensal	Host/Cryptic
Montacutidae	*Tellimya ferruginosa* (Montagu, 1808)	Filter feeder / Commensal	Host/Cryptic
Montacutidae	*Litigiella glabra* (P. Fischer in de Folin & Périer, 1873)	Filter feeder / Commensal	Host/Cryptic
Lasaeidae	*Montacuta goudi,* van Aartsen, 1998	Filter feeder / Commensal	Host/Cryptic
Lasaeidae	*Scacchia oblonga* (Philippi, 1836)	Filter feeder	Infauna
Lasaeidae	*Lepton squamosum* (Montagu, 1803)	Filter feeder / Commensal	Host/Cryptic
Lasaeidae	*Lepton subtrigonum,* Jeffreys in de Folin & Périer, 1874	Filter feeder / Commensal	Host/Cryptic
Kelliidae	*Hemilepton nitidum* (Turton, 1822)	Filter feeder / Commensal	Host/Cryptic
Neoleptonidae	*Kellia suborbicularis* (Montagu, 1803)	Filter feeder / Commensal	Host/Cryptic
Cardiidae	*Acanthocardia paucicostata* (G. B. Sowerby II, 1834)	Filter feeder	Infauna
Cardiidae	*Papillicardium papillosum* (Poli, 1791)	Filter feeder	Infauna
Cardiidae	*Papillicardium* sp., Sacco, 1900	Filter feeder	Infauna / Epifauna
Cardiidae	*Parvicardium exiguum* (Gmelin, 1791)	Filter feeder	Infauna / Epifauna
Cardiidae	*Parvicardium scriptum* (Bucquoy, Dautzenberg & Dollfus, 1892)	Filter feeder	Infauna
Cardiidae	*Parvicardium scabrum* (Philippi, 1844)	Filter feeder	Infauna
Cardiidae	*Parvicardium minimum* (Philippi, 1836)	Filter feeder	Infauna
Cardiidae	*Cerastoderma glaucum* (Bruguière, 1789)	Filter feeder	Infauna
Cardiidae	*Laevicardium crassum* (Gmelin, 1791)	Filter feeder	Infauna
Mactridae	*Spisula subtruncata* (da Costa, 1778)	Filter feeder	Infauna
Semelidae	*Abra alba* (W. Wood, 1802)	Deposit feeder	Infauna
Semelidae	*Abra nitida* (O. F. Müller, 1776)	Deposit feeder	Infauna
Semelidae	*Abra prismatica* (Montagu, 1808)	Deposit feeder	Infauna

Family	Species	Diet	Preferential substrate
Semelidae	*Abra tenuis* (Montagu, 1803)	Deposit feeder	Infauna
Tellinidae	Tellinidae juv. Indet, Blainville, 1815	Deposit feeder	Infauna
Tellinidae	*Moerella distorta* (Poli, 1791)	Deposit feeder	Infauna
Tellinidae	*Gastrana fragilis* (Linnaeus, 1758)	Deposit feeder	Infauna
Tellinidae	*Arcopagia balaustina* (Linnaeus, 1758)	Deposit feeder	Semi-infaunal
Solecurtidae	*Azorinus chamasolen* (da Costa, 1778)	Filter feeder	Infauna
Solecurtidae	*Donax venustus,* Poli, 1796	Filter feeder	Infauna
Pharidae	*Phaxas adriaticus* (Linnaeus, 1758)	Filter feeder	Infauna
Veneridae	*Mysia undata* (Pennant, 1777)	Filter feeder	Infauna
Veneridae	*Gouldia minima* (Montagu, 1803)	Filter feeder	Infauna
Veneridae	*Pitar rudis* (Poli, 1795)	Filter feeder	Infauna
Veneridae	*Polititapes rhomboides* (Pennant, 1777)	Filter feeder	Infauna
Veneridae	*Dosinia lupinus* (Linnaeus, 1758)	Filter feeder	Infauna
Veneridae	*Venus verrucosa,* Linnaeus, 1759	Filter feeder	Infauna
Veneridae	*Venus casina,* Linnaeus, 1759	Filter feeder	Infauna
Veneridae	*Timoclea ovata* (Pennant, 1777)	Filter feeder	Infauna
Ungulinidae	*Diplodonta brocchii* (Deshayes, 1850)	Filter feeder	Infauna
Carditidae	*Centrocardita aculeata* (Poli, 1795)	Filter feeder	Epifauna
Corbulidae	*Corbula gibba* (Olivi, 1792)	Deposit feeder	Infauna
Corbulidae	*Lentidium mediterraneum* (O. G. Costa, 1830)	Filter feeder	Infauna
Pholadidae	*Barnea candida* (Linnaeus, 1758)	Filter feeder	Infauna
Gastrochaenidae	*Rocellaria dubia* (Pennant, 1777)	Filter feeder	Infauna
Hiatellidae	*Hiatella arctica* (Linnaeus, 1767)	Filter feeder	Epifauna
Pandoridae	*Pandora pinna* (Montagu, 1803)	Filter feeder	Infauna
Cuspidariidae	*Cuspidaria cuspidata* (Olivi, 1792)	Carnivore	Infauna
Thraciidae	*Thracia phaseolina* (Lamarck, 1818)	Filter feeder	Infauna
Indetermined			
Lottiidae	*Tectura virginea* (O. F. Müller, 1776)	Herbivore	Epifaunal
Fissurellidae	*Diodora graeca* (Linnaeus, 1758)	Carnivore	Epifaunal
Fissurellidae	*Diodora italica* (Defrance, 1820)	Carnivore	Epifaunal
Fissurellidae	*Puncturella piccirida,* Palazzi & Villari, 2001	Carnivore	Epifaunal
Scissurellidae	*Scissurella costata,* d'Orbigny, 1824	Deposit feeder	Eipfaunal
Phasianellidae	*Tricolia pullus* (Linnaeus, 1758)	Herbivore	Eipfaunal
Turbinidae	*Bolma rugosa* (Linnaeus, 1767)	Herbivore	Eipfaunal
Calliostomatidae	*Calliostoma* sp.1, Swainson, 1840	Carnivore	Epifaunal
Calliostomatidae	*Calliostoma* sp.2, Swainson, 1840	Carnivore	Epifaunal
Trochidae	*Gibbula cf. ardens* (Salis Marschlins, 1793)	Herbivore	Epifaunal
Trochidae	*Gibbula* sp. 2, Risso, 1826	Herbivore	Epifaunal
Trochidae	*Gibbula* sp. 3, Risso, 1826	Herbivore	Epifaunal
Trochidae	*Gibbula cf. Fanulum* (Gmelin, 1791)	Herbivore	Epifaunal
Trochidae	*Jujubinus cf. montagui* (Wood, 1828)	Herbivore	Epifaunal
Trochidae	*Jujubinus* sp. 2, Monterosato, 1884	Herbivore	Epifaunal
Trochidae	*Jujubinus* sp. 3, Monterosato, 1884	Herbivore	Epifaunal
Rissoidae	*Alvania cf. Geryonia* (Nardo, 1847)	Herbivore	Epifaunal
Rissoidae	*Alvania cf. cimex* (Linnaeus, 1758)	Herbivore	Epifaunal
Rissoidae	*Alvania cf. cimicoides* (Forbes, 1844)	Herbivore	Epifaunal
Rissoidae	*Alvania cf. cancellata* (da Costa, 1778)	Herbivore	Epifaunal
Rissoidae	*Alvania cf. Lineata,* Risso, 1826	Herbivore	Epifaunal

Family	Species	Diet	Preferential substrate
Rissoidae	*Pusillina cf. radiata* (Philippi, 1836)	Herbivore	Epifaunal
Rissoidae	*Pusillina inconspicua* (Alder, 1844)	Herbivore	Epifaunal
Rissoidae	*Rissoa sp.,* Desmarest, 1814	Herbivore	Epifaunal
Rissoidae	*Crisilla semistriata* (Montagu, 1808)	Herbivore	Epifaunal
Rissoidae	*Manzonia crassa* (Kanmacher, 1798)	Carnivore	Epifaunal
Aporrhaidae	*Aporrhais pespelecani* (Linnaeus, 1758)	Carnivore	Semiinfaunal
Calyptraeidae	*Calyptraea chinensis* (Linnaeus, 1758)	Filter feeder	Epifaunal
Hydrobiidae	*Hydrobia glyca* (Servain, 1880)	Deposit feeder	Epifaunal
Hydrobiidae	*Hydrobia acuta* (Draparnaud, 1805)	Deposit feeder	Epifaunal
Tornidae	*Circulus tricarinatus* (S. V. Wood, 1848)	Deposit feeder	Infaunal
Tornidae	*Tornus subcarinatus* (Montagu, 1803)	Deposit feeder	Infaunal
Naticidae	*Euspira pulchella* (Risso, 1826)	Carnivore	Infaunal
Cerithiidae	*Bittium latreillii* (Payraudeau, 1826)	Herbivore	Epifaunal
Cerithiidae	*Bittium* sp., Gray, 1847	Herbivore	Epifaunal
Cerithiidae	*Bittium submamillatum* (De Rayneval & Ponzi, 1854)	Herbivore	Epifaunal
Cerithiidae	*Cerithiidae* indet., Fleming, 1822	Herbivore	Epifaunal
Cerithiidae	*Cerithium* sp. 1, Bruguière, 1789	Herbivore	Epifaunal
Cerithiidae	*Cerithium* sp. 2, Bruguière, 1789	Herbivore	Epifaunal
Turritellidae	*Turritella communis,* Risso, 1826	Filter feeder	Semiinfaunal
Cerithiopsidae	*Cerithiopsis spp.,* Forbes & Hanley, 1850	Carnivore	Epifaunal
Triphoridae	*Marshallora adversa* (Montagu, 1803)	Symbiotic	Host
Triphoridae	*Similiphora cf. similior* (Bouchet & Guillemot, 1978)	Symbiotic	Host
Epitoniidae	*Epitonium* spp., Röding, 1798	Symbiotic	Host
Aclididae	*Aclis minor* (Brown, 1827)	Symbiotic	Host
Eulimidae	*Eulima* spp., Risso, 1826	Symbiotic	Host
Eulimidae	*Eulima glabra* (da Costa, 1778)	Symbiotic	Host
Eulimidae	*Vitreolina curva* (Monterosato, 1874)	Symbiotic	Host
Eulimidae	*Parvioris ibizenca* (Nordsieck, 1968)	Symbiotic	Host
Muricidae	Muricidae juv. Indet, Rafinesque, 1815	Carnivore	Epifaunal
Muricidae	*Hexaplex trunculus* juv. (Linnaeus, 1758)	Carnivore	Epifaunal
Muricidae	*Ocenebra erinaceus* (Linnaeus, 1758)	Carnivore	Epifaunal
Cystiscidae	*Gibberula turgidula* (Locard & Caziot, 1900)	Carnivore	Epifaunal
Cystiscidae	*Gibberula philippii* (Monterosato, 1878)	Carnivore	Epifaunal
Marginellidae	*Granulina marginata* (Bivona, 1832)	Carnivore	Epifaunal
Fasciolariidae	*Fusinus rostratus* (Olivi, 1792)	Carnivore	Epifaunal
Nassariidae	*Nassarius cf. pygmaeus* (Lamarck, 1822)	Scavengers	Epifaunal
Nassariidae	*Nassarius reticulatus* (Linnaeus, 1758)	Scavengers	Epifaunal
Nassariidae	*Nassarius* sp., Duméril, 1805	Scavengers	Epifaunal
Mangeliidae	*Mangelia* sp. 1, Risso, 1826	Carnivore	Epifaunal
Mangeliidae	*Mangelia cf. Stosiciana,* Brusina, 1869	Carnivore	Epifaunal
Mangeliidae	*Bela brachystoma* (Philippi, 1844)	Carnivore	Epifaunal
Mangeliidae	*Bela* sp.1, Leach, 1847	Carnivore	Epifaunal
Mangeliidae	*Bela* sp. 2, Leach, 1847	Carnivore	Epifaunal
Raphitomidae	*Raphitoma* sp 1, Bellardi, 1847	Carnivore	Epifaunal
Raphitomidae	*Raphitoma* sp 2, Bellardi, 1847	Carnivore	Epifaunal
Raphitomidae	*Raphitoma* sp 3, Bellardi, 1847	Carnivore	Epifaunal
Raphitomidae	*Raphitoma* sp 4 , Bellardi, 1847	Carnivore	Epifaunal
Clathurellidae	*Comarmondia gracilis* (Montagu, 1803)	Carnivore	Epifaunal

Family	Species	Diet	Preferential substrate
Pyramidellidae	*Odostomia* spp., Fleming, 1813	Symbiotic	Host
Pyramidellidae	*Turbonilla* spp., Risso, 1826	Symbiotic	Host
Pyramidellidae	*Eulimella ventricosa* (Forbes, 1844)	Symbiotic	Host
Pyramidellidae	*Chrysallida* spp., Carpenter, 1856	Symbiotic	Host
Pyramidellidae	*Ondina vitrea* (Brusina, 1866)	Symbiotic	Host
Pyramidellidae	*Euparthenia bulinea* (Lowe, 1841)	Symbiotic	Host
Acteonidae	*Acteon tornatilis* (Linnaeus, 1758)	Carnivore	Epifaunal
Haminoeidae	*Haminoea* spp, Turton & Kingston in Carrington, 1830	Herbivore	Epifaunal
Haminoeidae	*Weinkauffia turgidula* (Forbes, 1844)	Herbivore	Epifaunal
Haminoeidae	*Atys jeffreysi* (Weinkauff, 1866)	Herbivore	Epifaunal
Philinidae	*Philine quadripartita,* Ascanius, 1772	Carnivore	Epifaunal
Philinidae	*Philine scabra* (O. F. Müller, 1784)	Carnivore	Epifaunal
Philinidae	*Laona pruinosa* (Clark W., 1827)	Carnivore	Epifaunal
Cylichnidae	*Cylichna cylindracea* (Pennant, 1777)	Carnivore	Infaunal
Retusidae	*Retusa truncatula* (Bruguière, 1792)	Carnivore	Infaunal
Retusidae	*Cylichnina umbilicata* (Montagu, 1803)	Carnivore	Infaunal
Retusidae	*Cylichnina* sp 1, Monterosato, 1884	Carnivore	Infaunal
Retusidae	*Pyrunculus hoernesii* (Weinkauff, 1866)	Carnivore	Semiinfaunal
Rhizoridae	*Volvulella acuminata* (Bruguière, 1792)	Carnivore	Semiinfaunal
Siphonariidae	*Siphonariidae* indet., Gray, 1827	Herbivore	Epifaunal
Akeridae	*Akera bullata* (O. F. Müller, 1776)	Herbivore	Epifaunal
Indetermined	Gastropoda indet		
Dentaliidae	*Antalis* sp., H. Adams & A. Adams, 1854	Carnivore	Infaunal
Fustiariidae	*Fustiaria* sp., Stoliczka, 1868	Carnivore	Semiinfaunal
Acanthochitonidae	*Acanthochitona,* Gray, 1821	Herbivore	Epifaunal
Chitonidae	*Chiton* sp.1, Linnaeus, 1758	Herbivore	Epifaunal
Chitonidae	*Chiton* sp. 2, Linnaeus, 1758	Herbivore	Epifaunal
Leptochitonidae	*Lepidopleurus* sp 1 , Risso, 1826	Herbivore	Epifaunal
Leptochitonidae	*Lepidopleurus* sp 2, Risso, 1826	Herbivore	Epifaunal

	Hg mg/kg		Cr mg/Kg		Cu mg/Kg		Ni mg/kg		Pb mg/kg		As mg/kg	
	Pearson r	Significance	Pearson r	Significance	Pearson r	Significance	Pearson r	Significance	Pearson r	Significance	Pearson r	Significance
Chemosymbiotic	-0,84	<0,01	-0,08	0,83	0,44	0,20	-0,47	0,18	-0,83	<0,01	-0,26	0,46
Deposit feeder	-0,66	0,04	0,36	0,30	0,75	0,01	-0,15	0,68	-0,63	0,05	-0,58	0,08
Infaunal	-0,33	0,36	0,06	0,87	0,67	0,04	-0,46	0,18	-0,19	0,60	-0,68	0,03
Corbula gibba	-0,53	0,12	0,42	0,23	0,85	<0,01	<0,01	1,00	-0,41	0,24	-0,61	0,06
Abra alba	-0,63	0,05	0,30	0,40	0,54	0,11	-0,25	0,48	-0,66	0,04	-0,53	0,12
Pitar rudis	-0,71	0,02	-0,06	0,86	0,29	0,42	-0,28	0,44	-0,73	0,02	-0,26	0,46
Host/Cryptic	-0,58	0,08	0,19	0,60	0,54	0,11	-0,22	0,54	-0,58	0,08	-0,46	0,18
Filter feeder	0,53	0,12	-0,09	0,80	-0,02	0,96	-0,24	0,51	0,70	0,02	-0,24	0,50
Filter feeder / Commensal	-0,54	0,10	-0,06	0,88	0,39	0,26	-0,55	0,10	-0,50	0,14	-0,22	0,53
Herbivore	0,73	0,02	-0,03	0,94	-0,62	0,05	0,49	0,15	0,69	0,03	0,50	0,14
Epifaunal	0,31	0,38	-0,10	0,77	-0,66	0,04	0,44	0,20	0,19	0,61	0,72	0,02
Epifaunal/Nestler	0,36	0,31	-0,38	0,28	-0,55	0,10	0,06	0,86	0,27	0,44	0,23	0,52
Total species number	0,56	0,09	-0,11	0,76	-0,58	0,08	0,42	0,23	0,33	0,35	0,40	0,25
Gouldia minima	0,78	0,01	-0,27	0,45	-0,55	0,10	0,05	0,90	0,80	0,01	0,33	0,36
Bittium latreillii	0,89	<0,01	<0,01	0,99	-0,48	0,16	0,38	0,28	0,86	<0,01	0,24	0,50
Pusillina cf. radiata	0,47	0,17	-0,42	0,23	-0,75	0,01	0,19	0,60	0,35	0,33	0,65	0,04
Bittium submamillatum	-0,05	0,90	-0,03	0,93	-0,56	0,09	0,33	0,36	-0,04	0,92	0,73	0,02
Parvicardium scabrum	0,71	0,02	-0,29	0,41	-0,59	0,07	<0,01	1,00	0,75	0,01	0,41	0,24
Papillicardium papillosum	0,60	0,07	-0,35	0,33	-0,59	0,07	-0,02	0,95	0,40	0,25	0,27	0,45
Symbiotic	0,17	0,63	-0,11	0,77	-0,68	0,03	0,17	0,64	0,08	0,83	0,44	0,20
Total number individuals	0,13	0,72	-0,17	0,65	-0,77	0,01	0,38	0,28	0,00	0,99	0,77	0,01
Rarefied species richness	-0,89	<0,01	-0,30	0,39	0,20	0,59	-0,50	0,15	-0,93	<0,01	0,08	0,83
Scavengers	-0,65	0,04	-0,58	0,08	-0,29	0,42	-0,42	0,23	-0,82	<0,01	0,42	0,23
Nassarius cf. pygmaeus	-0,59	0,07	-0,56	0,09	-0,27	0,45	-0,38	0,28	-0,77	0,01	0,39	0,26
Semi-infaunal	0,40	0,25	0,12	0,74	-0,38	0,28	0,26	0,47	0,28	0,43	<0,01	0,99
Carnivore	-0,14	0,69	-0,54	0,10	-0,55	0,10	-0,03	0,93	-0,29	0,42	0,74	0,01

	Cd mg/kg		Li mg/kg		Zn mg/kg		Mn mg/kg		P mg/kg		Fe mg/kg	
	Pearson r	Significance	Pearson r	Significance	Pearson r	Significance	Pearson r	Significance	Pearson r	Significance	Pearson r	Significance
Chemosymbiotic	-0,42	0,22	0,72	0,02	-0,73	0,02	-0,24	0,51	0,09	0,81	-0,17	0,64
Deposit feeder	-0,06	0,86	0,90	<0,01	-0,56	0,09	0,02	0,95	0,38	0,28	0,13	0,71
Infaunal	-0,04	0,91	0,47	0,17	-0,36	0,31	-0,12	0,74	0,23	0,52	-0,18	0,63
Corbula gibba	0,02	0,95	0,86	<0,01	-0,41	0,24	0,11	0,77	0,42	0,23	0,20	0,59
Abra alba	-0,01	0,98	0,77	0,01	-0,56	0,09	-0,07	0,85	0,28	0,44	0,05	0,89
Pitar rudis	-0,22	0,55	0,51	0,14	-0,70	0,03	-0,36	0,31	-0,14	0,71	-0,26	0,47
Host/Cryptic	-0,01	0,98	0,75	0,01	-0,46	0,18	0,11	0,76	0,41	0,25	0,19	0,61
Filter feeder	0,28	0,43	-0,50	0,14	0,35	0,32	-0,10	0,77	-0,09	0,81	-0,27	0,46
Filter feeder / Commensal	-0,31	0,39	0,58	0,08	-0,42	0,23	<0,01	0,99	0,33	0,36	-0,01	0,98
Herbivore	0,35	0,32	-0,73	0,02	0,71	0,02	0,21	0,55	-0,17	0,63	0,17	0,63
Epifaunal	-0,02	0,95	-0,46	0,18	0,36	0,31	0,13	0,73	-0,23	0,52	0,17	0,64
Epifaunal/Nestler	0,12	0,74	-0,65	0,04	0,26	0,47	-0,10	0,79	-0,36	0,30	-0,17	0,64
Total species number	0,09	0,81	-0,52	0,12	0,58	0,08	0,43	0,22	0,06	0,88	0,38	0,27
Gouldia minima	0,16	0,65	-0,87	<0,01	0,64	0,05	0,05	0,90	-0,22	0,54	-0,12	0,75
Bittium latreillii	0,46	0,18	-0,76	0,01	0,85	<0,01	0,30	0,39	-0,03	0,94	0,19	0,61
Pusillina cf. radiata	-0,01	0,99	-0,70	0,02	0,48	0,16	0,17	0,64	-0,21	0,56	0,08	0,82
Bittium submamillatum	<0,01	0,99	-0,25	0,48	<0,01	0,99	-0,15	0,68	-0,37	0,29	-0,01	0,98
Parvicardium scabrum	0,14	0,71	-0,88	<0,01	0,56	0,09	-0,13	0,73	-0,37	0,29	-0,28	0,44
Papillicardium papillosum	0,07	0,85	-0,63	0,05	0,60	0,07	0,41	0,25	0,14	0,70	0,25	0,49
Symbiotic	0,32	0,36	-0,49	0,15	0,09	0,80	-0,24	0,51	-0,44	0,20	-0,16	0,67
Total number individuals	<0,01	1,00	-0,47	0,17	0,12	0,75	-0,08	0,82	-0,42	0,23	0,02	0,95
Rarefied species richness	-0,75	0,01	0,54	0,10	-0,87	<0,01	-0,42	0,23	-0,18	0,62	-0,35	0,32
Scavengers	-0,76	0,01	0,13	0,73	-0,64	0,04	-0,36	0,30	-0,34	0,34	-0,33	0,35
Nassarius cf. pygmaeus	-0,77	0,01	0,12	0,74	-0,58	0,08	-0,30	0,41	-0,29	0,42	-0,28	0,43
Semi-infaunal	0,40	0,25	-0,41	0,23	0,31	0,39	0,07	0,85	-0,11	0,77	0,10	0,78
Carnivore	-0,67	0,03	-0,31	0,39	-0,15	0,68	-0,20	0,57	-0,43	0,22	-0,22	0,55

	Al mg/kg		PAH ng/gr		PCB ng/gr		C tot % ss		TOC % ss		N tot % ss	
	Pearson r	Significance	Pearson r	Significance	Pearson r	Significance	Pearson r	Significance	Pearson r	Significance	Pearson r	Significance
Chemosymbiotic	0,36	0,31	-0,53	0,12	-0,62	0,06	-0,89	<0,01	0,75	0,01	-0,32	0,37
Deposit feeder	0,70	0,03	-0,37	0,30	-0,45	0,19	-0,83	<0,01	0,88	<0,01	0,04	0,91
Infaunal	0,28	0,44	-0,43	0,22	0,14	0,69	-0,42	0,23	0,61	0,06	0,51	0,13
Corbula gibba	0,67	0,04	-0,30	0,41	-0,30	0,40	-0,69	0,03	0,91	<0,01	0,18	0,61
Abra alba	0,61	0,06	-0,36	0,30	-0,47	0,17	-0,77	0,01	0,69	0,03	-0,15	0,67
Pitar rudis	0,20	0,59	-0,54	0,10	-0,55	0,10	-0,78	0,01	0,64	0,05	-0,24	0,51
Host/Cryptic	0,57	0,08	-0,21	0,56	-0,46	0,18	-0,74	0,01	0,75	0,01	0,04	0,91
Filter feeder	-0,37	0,29	-0,02	0,96	0,85	0,00	0,64	0,05	-0,33	0,34	0,68	0,03
Filter feeder / Commensal	0,36	0,30	-0,26	0,46	-0,34	0,34	-0,54	0,11	0,47	0,17	-0,05	0,89
Herbivore	-0,42	0,22	0,56	0,09	0,36	0,31	0,83	0,00	-0,81	0,00	-0,18	0,63
Epifaunal	-0,30	0,41	0,43	0,22	-0,16	0,66	0,42	0,23	-0,61	0,06	-0,49	0,15
Epifaunal/Nestler	-0,57	0,09	0,18	0,62	0,25	0,49	0,35	0,32	-0,46	0,18	-0,28	0,44
Total species number	-0,21	0,56	0,70	0,02	0,15	0,67	0,42	0,22	-0,64	0,05	-0,44	0,20
Gouldia minima	-0,62	0,06	0,36	0,30	0,73	0,02	0,92	<0,01	-0,84	<0,01	0,26	0,47
Bittium latreillii	-0,39	0,26	0,62	0,06	0,65	0,04	0,92	<0,01	-0,87	<0,01	-0,09	0,80
Pusillina cf. radiata	-0,54	0,10	0,50	0,14	0,10	0,77	0,53	0,11	-0,72	0,02	-0,41	0,24
Bittium submamillatum	-0,23	0,52	0,07	0,85	-0,43	0,21	0,24	0,51	-0,28	0,43	-0,25	0,49
Parvicardium scabrum	-0,68	0,03	0,22	0,54	0,65	0,04	0,93	0,00	-0,92	<0,01	0,18	0,63
Papillicardium papillosum	-0,34	0,34	0,66	0,04	0,38	0,28	0,49	0,15	-0,72	0,02	-0,29	0,42
Symbiotic	-0,37	0,30	0,08	0,83	-0,15	0,67	0,34	0,34	-0,53	0,12	-0,24	0,50
Total number individuals	-0,37	0,30	0,24	0,51	-0,34	0,34	0,30	0,40	-0,50	0,14	-0,36	0,31
Rarefied species richness	0,13	0,73	-0,62	0,06	-0,71	0,02	-0,85	<0,01	0,61	0,06	-0,12	0,74
Scavengers	-0,20	0,58	-0,35	0,32	-0,70	0,03	-0,63	0,05	0,18	0,62	-0,45	0,19
Nassarius cf. pygmaeus	-0,17	0,63	-0,28	0,43	-0,64	0,05	-0,60	0,07	0,15	0,68	-0,45	0,19
Semi-infaunal	-0,14	0,71	0,27	0,44	0,25	0,49	0,34	0,33	-0,39	0,27	-0,14	0,70
Carnivore	-0,45	0,20	-0,01	0,98	-0,36	0,31	-0,04	0,91	-0,30	0,39	-0,42	0,22

	Clay		Silt		Sand (exkl. 1mm)		>1mm	
	Pearson r	Significance	Pearson r	Significance	Pearson r	Significance	Pearson r	Significance
Carnivore	-0,17	0,30	-0,25	0,14	0,26	0,12	0,09	0,60
Chemosymbiotic	-0,01	0,97	-0,07	0,68	0,11	0,52	-0,08	0,65
Deposit feeder	0,92	<0,01	0,92	<0,01	-0,91	<0,01	-0,65	<0,01
Filter feeder	-0,51	<0,01	-0,62	<0,01	0,53	<0,01	0,57	<0,01
Filter feeder / Commensal	0,53	<0,01	0,52	<0,01	-0,54	<0,01	-0,32	0,05
Herbivore	-0,87	<0,01	-0,90	<0,01	0,88	<0,01	0,64	0,00
Scavengers	0,07	0,68	0,23	0,18	-0,11	0,50	-0,34	0,04
Symbiotic	-0,56	<0,01	-0,51	<0,01	0,46	<0,01	0,51	<0,01
Epifaunal	-0,76	<0,01	-0,72	<0,01	0,73	<0,01	0,49	<0,01
Host/Cryptic	0,52	<0,01	0,52	<0,01	-0,56	<0,01	-0,27	0,10
Infaunal	0,77	<0,01	0,72	<0,01	-0,73	<0,01	-0,51	<0,01
Semi-infaunal	-0,50	<0,01	-0,43	0,01	0,42	0,01	0,34	0,04
Epifaunal/Nestler	-0,41	0,01	-0,36	0,03	0,47	<0,01	0,01	0,95
Rarefied species richness	0,25	0,13	0,39	0,02	-0,33	0,05	-0,34	0,04
Total species number	-0,65	<0,01	-0,60	<0,01	0,70	<0,01	0,17	0,32
Total number individuals	-0,67	<0,01	-0,59	<0,01	0,59	<0,01	0,45	0,01
Gouldia minima	-0,84	<0,01	-0,91	<0,01	0,88	<0,01	0,65	<0,01
Corbula gibba	0,84	<0,01	0,82	<0,01	-0,81	<0,01	-0,58	<0,01
Nassarius cf. Pygmaeus	0,07	0,67	0,22	0,19	-0,12	0,50	-0,33	0,05
Bittium latreillii	-0,86	<0,01	-0,92	<0,01	0,89	<0,01	0,65	<0,01
Pusillina cf. Radiata	-0,26	0,12	-0,27	0,11	0,26	0,13	0,21	0,22
Bittium submamillatum	-0,45	0,01	-0,35	0,03	0,39	0,02	0,20	0,23
Abra alba	0,77	<0,01	0,81	<0,01	-0,79	<0,01	-0,58	<0,01
Pitar rudis	0,56	<0,01	0,63	<0,01	-0,60	<0,01	-0,47	<0,01
Parvicardium scabrum	-0,83	<0,01	-0,87	<0,01	0,85	<0,01	0,63	<0,01
Papillicardium papillosum	-0,62	<0,01	-0,62	<0,01	0,62	<0,01	0,41	<0,01
Hg mg/kg	-0,66	0,04	-0,83	0,00	0,83	0,00	0,61	0,06
Cr mg/kg	0,36	0,31	0,14	0,70	-0,23	0,53	0,04	0,91
Cu mg/kg	0,80	0,01	0,56	0,09	-0,59	0,07	-0,55	0,10
Ni mg/kg	-0,12	0,74	-0,28	0,43	0,19	0,60	0,49	0,15
Pb mg/kg	-0,60	0,07	-0,84	0,00	0,81	0,00	0,65	0,04
As mg/kg	-0,59	0,07	-0,40	0,25	0,40	0,26	0,54	0,11
Cd mg/kg	-0,13	0,72	-0,25	0,48	0,22	0,53	0,25	0,49
Li mg/kg	0,91	0,00	0,84	0,00	-0,88	0,00	-0,68	0,03
Zn mg/kg	-0,55	0,10	-0,72	0,02	0,72	0,02	0,52	0,12
Mn mg/kg	0,07	0,86	-0,12	0,75	0,10	0,78	0,01	0,98
P mg/kg	0,41	0,24	0,21	0,56	-0,22	0,54	-0,32	0,36
Fe mg/kg	0,17	0,63	0,01	0,99	-0,05	0,90	0,02	0,96
Al mg/kg	0,70	0,02	0,55	0,10	-0,60	0,07	-0,43	0,21
PAH ng/gr	-0,35	0,32	-0,46	0,18	0,46	0,19	0,33	0,35
PCB ng/gr	-0,41	0,24	-0,65	0,04	0,66	0,04	0,34	0,34
C tot % ss	-0,84	0,00	-0,96	0,00	0,94	0,00	0,83	0,00
TOC % ss	0,96	0,00	0,89	0,00	-0,93	0,00	-0,69	0,03
N tot % ss	0,11	0,76	-0,17	0,63	0,11	0,77	0,19	0,60

Curriculum Vitae

Name: [Email-address:] nanni.mautner@gmx.at

Education

2012–2014 Master Paleobiology, University of Vienna

2014 Training as Safety guide in the climbing park Riegersburg, Austria

2012–2013 Training as Ecopedagogue at WWF Austria

2008–2012 Bachelor Paleobiology, University of Vienna

2000–2008 Gymnasium Wiedner Gürtel 68

1999–2000 Volksschule Phorusgasse

Education abroad

2011–2012 Erasmus at the University of Antwerp, Belgium

September 2007 Language course in Cannes, at *Ecole Supérieure de Français Langue Etrangère "Pierre Overall"*

Work experience in Austria

2014 Tutor at the University of Vienna

2014 Teaching assistant at the faculty of Earth sciences, Geography and Astronomy at the University of Vienna

2013–2014 Summer camps with children and excursion days with school classes for WWF Austria

2012–2013 Personal assistant of disabled people

September 2012 Summer job at Naturhotel Steinschalerhof, Austria

September 2008 Summer job at "AWS", Vienna

August 2008 Summer job at "Österreichische Lotterien GmbH", Vienna

2006–present Volunteer work for Malteser Hostpitaldienst Austria

Work experience abroad

August 2011 Excavation, Museo da Lourinã, Portugal

July 2010 Voluntary service at "Tropenstation la Gamba", Costa Rica

September 2009 Voluntary work at the organic Farm Durantis, St. Germain de Calberte, France

Languages

German mother tongue

English C2

French B1

Dutch B1

Spanish basics