Coverage analysis of intertidal species in different habitat types and tidal elevations

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ABSTRACT

Marine life is threatened by the proliferation of coastal defense structures in response to sea-level rise as a result of climate change. The artificial structures used, lack heterogeneity and cannot provide ecosystem services as natural surrogates. As a consequence, there is a reduced biodiversity in coastal and marine environments. With efforts being made to enhance artificial ecosystems, artificial intertidal pools have been proven to have a significant role in the formation of new habitats with improved biodiversity. They resemble rocky intertidal habitats in which tides cause strong changes in abiotic conditions from low to high elevations. The aim of this study is to examine the species coverage with different tidal elevations per habitat type (artificial intertidal pools and rocks). Tidal elevations showed species-specific differences with some species more positively correlated with low tidal elevations, while other species showed increased coverage with low tidal elevations. In general, differences in species coverage percentage were caused by a variety of abiotic factors.
Keywords: Artificial structures, Coastal development, Environment heterogeneity, Habitat enhancement, Rocky intertidal, Species coverage, Tidal elevation, Tidal pools

INTRODUCTION

Approximately 60% of the world's population lives along coasts (Perkol-Finkel et al., 2018). Climate change, sea level rise and stormier seas pose a threat to these populations, thus, coastal defense improvement is inevitable (Perkol-Finkel and Sella, 2015). Until now, the anthropogenic coastal defense mechanisms comprised hard-substrate structures that usually are not designed to consider marine life to develop on them (Perkol-Finkel et al., 2018). These artificial structures are designed with: sharp boundaries between water and land, steep slopes, low structural complexity, low water-retaining features, and poor substrate for flora and fauna (Perkol-Finkel et al., 2018). These characteristics limit the ability of artificial structures to serve as natural surrogates because, usually, natural habitats have softer boundaries and are more heterogeneous. Furthermore, they do not support biodiversity as natural coastal and marine habitats and generally, they sustain a high number of invasive species (Perkol-Finkel and Sella, 2015). Therefore, artificial structures that replace natural habitats cannot provide ecosystem services comparable to those offered by natural environments.

With the growing awareness of these artificial structures being detrimental to marine flora and fauna, several parties are making efforts to establish new artificial habitats with ecological value in order to boost biodiversity (Perkol-Finkel and Sella, 2015). These artificial habitats most closely resemble rocky intertidal habitats. In rocky intertidal habitats, tides cause strong changes in abiotic conditions from low to high elevations. While low elevations are mostly submerged, high elevations are exposed to longer periods of air exposure (Scrosati and Freeman, 2019). Although intertidal species are adapted to some degree of aerial exposure, temperature and desiccation stress are significant at high elevations. Studies have shown that in both natural and artificial environments, tidal height has a substantial effect on community structure and functioning. In addition, it has long been recognized that the biodiversity is greater at low tidal elevations than upper tidal levels (Firth et al., 2013). Rock pools are ubiquitous features of natural rocky shores that retain water. They are ecosystems in which their water experiences extreme fluctuations in: water temperature, salinity, pH, carbon dioxide and dissolved oxygen (Pribadi and Kanza, 2017) (Firth et al., 2014). Despite these fluctuations, natural tidal pools enhance the diversity of colonizing epibiota because they provide higher amounts of food, shelter and nursery grounds than exposed rocks that cannot retain water.

Attempting to resemble artificial coastal infrastructures to rocky shores, several studies (Firth et al., 2014) (Firth et al., 2013) (Perkol-Finkel et al., 2018) (Perkol and Sella, 2015) have designed and monitored artificial tidal pools focusing on their role as new habitats and their capacity to enhance biodiversity. The artificial pools' design aims to create more ecological niches and promote biodiversity by modifying their physical properties. Environmental heterogeneity can be increased, by varying different aspects of the pools such as: area, inclination, depth, and heights. Although many of these physical properties are known to have a significant effect on species performance, diversity and community composition, little is known about the effects of tidal elevation on the coverage of species (Firth et al., 2013).

This research is part of a big monitoring project that will test if including nature-based infrastructures (artificial intertidal pools) at the foot of the dike (Lauwersmeerdijk, North of the Netherlands) will enhance the ecological value and increase the biological productivity in the intertidal area of the dike. We focused on the species coverage and examined how it changes in between habitat types and tidal elevations. The habitat types that we examined are the inside of the artificial intertidal pools, the outside of the artificial intertidal pools, the rocks holding the pools on the dike (new rocks) and the rocks that were part of the dike before the pools were installed (old rocks). In this paper, we tested the following hypotheses:

1. Species coverage will be higher in the inside of the intertidal artificial pools compared to the surrounding rocks, because the pools provide a high amount of food and shelter during low tide because of their water-retaining feature.
2. Species coverage will decrease with increased tidal elevation in all habitat types, because at high elevation, organisms are more subjected to less favorable conditions.

MATERIALS AND METHODS

1. Study location

We conducted fieldwork at Lauwersmeerdijk; a 9 km dike located in between the Lauwersoog harbor (53.40964,6.20664) and the Westpolder (53.37854, 6.29119) in Groningen, the Netherlands. This dike will be reinforced by 2023. In combination with the safety plans, several parties (Arcadis, ECOncrete, Heijmans, Heuvelman Ibis, ReefSystems, University of Groningen, Van Hall Larenstein University, Van Oord, Waterschap Noorderzijlvest) sought to improve the ecosystem on and surrounding the dike by adding artificial intertidal pools and reefs in November 2021. Our monitoring focused on 23 out of 26 intertidal pools (6 pools of ReefSystems and 17 of ECOncrete) installed in the intertidal zone of the dike with depths ranging from 0 to 3.4 m. Their location was determined with a GPS (Garmin eTrex 22x) and their elevation with a DGPS (Trimble R8 gps receiver and Trimble TSC3 controller). The locations of the pools are shown in Figure 1.

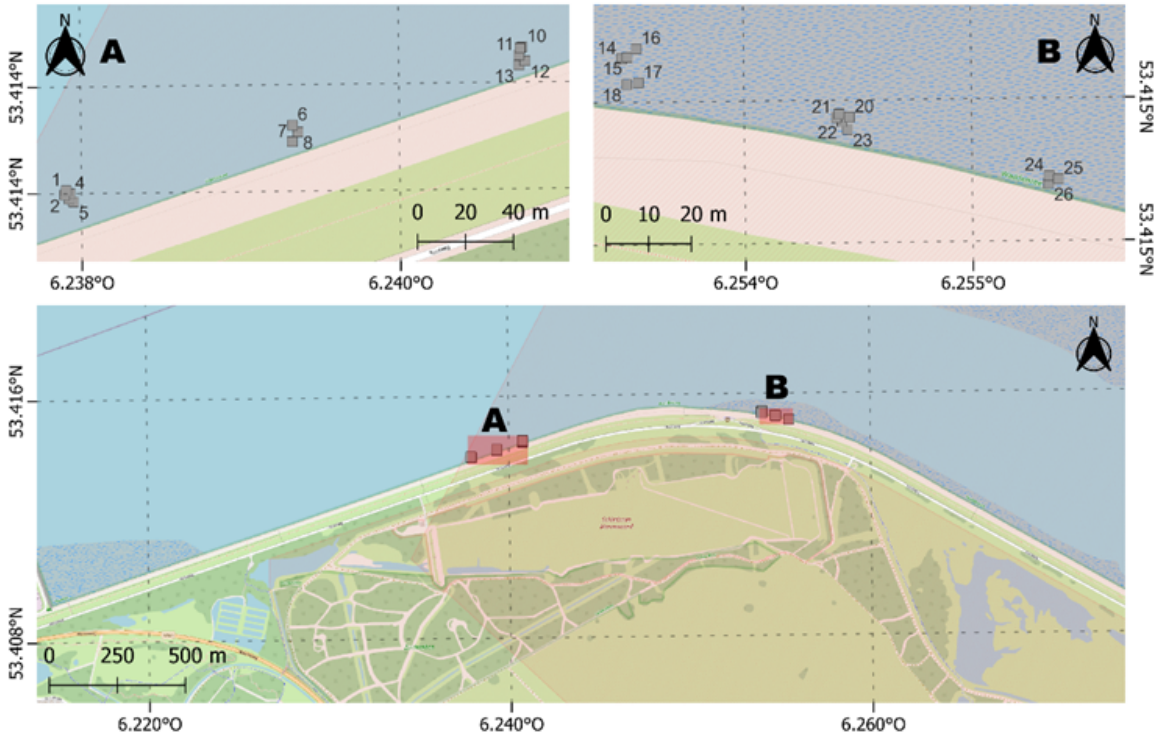

Figure 1. Map of study location at Lauwersmeerdijk

The grey boxes represent the placement of the artificial intertidal pools with their designated number. There are several groups consisting of 3 or 5 pools divided over two sites A and B.

2. Sampling method

The monitoring lasted 9 days in May 2022 (2nd to 6th May and 16th to 19th May). We started sampling three hours before low evening tide and finished our sampling an hour after low tide. Because this research is part of a big monitoring project, more abiotic and biotic factors were monitored than we eventually used for our final results. For the abiotic factors, we measured the pools' elevation and we aimed to monitor the salinity and the temperature (Multiparameter Meter Multi 3320 2FA310 Xylem – WTW) at least twice per sampling day: once when arriving and once before finishing the fieldwork. The outside weather conditions were monitored during the two weeks by using weather forecast, focusing on temperature, precipitation, and humidity.

2.1 Percentage of coverage

The goal of this type of monitoring was to compare the percentage of coverage of the organisms in the pools, on the outside of the pools, on the rocks holding the pools on the dike (from now on we will refer to them as new rocks) and the rocks that were part of the dike before the pools were installed (from now on we will refer to them as old rocks). We haphazardly placed 4 different totally transparent Plexiglas quadrats (0.1 x 0.1 m) (Martens Acrylplaat Transparant 50 x 100 cm 2 mm) on each site. On each quadrat we painted, with permanent marker (Edding 3000 permanent marker (1,5 - 3 mm round)), 40 randomly distributed points, each point represents 2.5%.

The percentage of coverage of species was measured by reporting the species in-situ that fell under each point. We tried to identify every species in the field to the lowest possible taxonomic level. Some unidentified species were taken to the laboratory for further identification. Organisms in the quadrant that were not present under any point, were added to overall species list, but were not included in the statistical analysis. At each site, the entire area under one quadrat was scraped off with a 40 mm metal spatula, put in a pre-labelled zip-lock bag and stored in a cooling bag. At the end of the sampling the biomass samples were stored at -20 °C in the laboratory.

2.1.1 Biomass

We separated the biomass samples by sampling site and species in Petri dishes. To identify the species, we used a stereomicroscope (Olympus SZ51 Stereo Microscope 0.8x - 4x). After separating, we weighted the sorted samples. We pre-weighted a pre-labelled aluminum cup, then we put the sample into the cup and weighted it again. After this we let the samples dry in an oven for six days at 60 °C. The dried samples cooled down in a glass container with silica gel to prevent air moisture to get into the samples. Finally, we weighted the samples. After weighing, we calculated the biomass by subtracting the dry weight from the wet weight.

3. Data analysis

3.1 Map

Maps were produced using QGIS (version 3.24). The coordinates taken with the DGPS and imported to QGIS are shown in the Appendix. When importing the data in QGIS we transformed the imported data to EPSG: 28992 – Amersfoort/RD new Coordinate Reference System (CRS).

3.2 Statistical analysis

3.2.1 Habitat type

The statistical analysis was done in Rstudio (version 4.1.2). The data was separated on quadrants per habitat type using the dplyr package (v.1.0.7, Wickham et al, 2021). To calculate the percentage of total species coverage per habitat type, the tabyl function of the janitor package (v.2.1.0, Firke, 2021) was used again. Then a boxplot was created using the ggplot2 package (v.3.3.5, Wickham, 2016). The normality was again checked with the Shapiro-Wilkinson test. The test showed that the data was non-normal and transforming it with a square root or logarithm did not make the data normal. An additional Bartlett test also showed that the variance of the data was not homogenous. This lead to the choice of doing a Kruskal-Wallis test from the PMCMRplus (V.1.9.3, Pohlert, 2021). As a Post Hoc Test, the Conover test from the PMCMRplus package was used (V.1.9.3, Pohlert, 2021).

3.2.2 Tidal elevation

The statistical analysis was done in RStudio (version 4.1.2). First the data was separated based on the sample site and quadrant using the dplyr package (v.1.0.7, Wickham et al, 2021). To calculate the percentage coverage of the species for each habitat type and quadrant, the tabyl function of the janitor package (v.2.1.0, Firke, 2021) was used. This function calculates the percentage of every species for every pool by counting under how many points a species was seen and then calculated what percentage the species covered. The graphs were produced using the ggplot2 package (v.3.3.5, Wickham, 2016). The normality of the data was checked with a Shapiro-Wilkinson test. The data was non-normal and could not be transformed using a logarithmic or square root transformation, so a Spearman's Rank Correlation Test was performed to find significant correlations between tidal elevation and the percentage coverage of species in each habitat type.

RESULTS

We divided our results in differences between species' percentage of coverage per habitat type at different elevation (Figure 2).

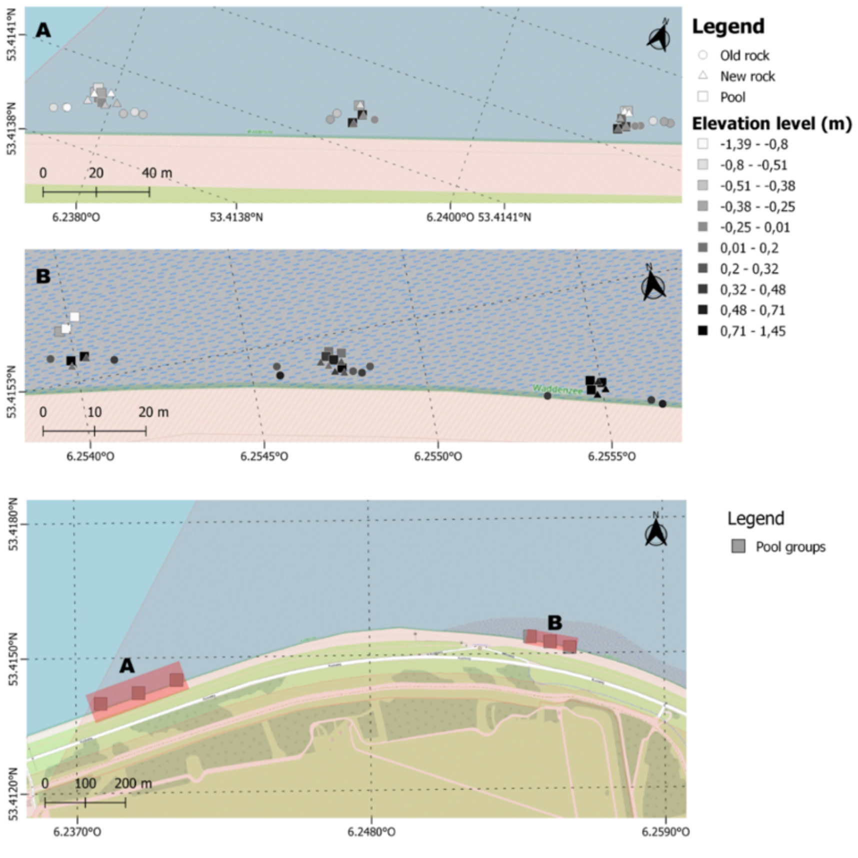

Figure 2. Location of the habitat types and their elevation

The locations of the pools, new rocks, and old rocks and their elevation level are shown. There are several pool groups consisting of 3 or 5 pools divided over two sites. Panel A shows one site and panel B the second site. The circles represent the old rocks, the triangles represent the new rocks, and the boxes represent the artificial intertidal pools. The elevation ranges from - 1.39 – 1.445 m.

1. Habitat type

The pools and surrounding rocks that were sampled in Lauwersmeerdijk showed a total amount of 13 species (table 1). A visual demonstration of how the species were covering the different habitat types is shown in figure 3.

Table 1. Overall species list

Species
Balanus balanus Linnaeus (1758)
Berkeleya rutilans Grunow (1880)
Cerastoderma edule Linnaeus (1758)
Crassostrea gigas Thunberg (1793)
Diadumene cincta Stephenson (1925)
Fucus vesiculosus Linnaeus (1753)
Gracilaria sp. Greville (1830)
Littorina littorea Linnaeus (1758)
Mytilus edulis Linnaeus (1758)
Obelia sp. Person and Lesueur (1810)
Porphyra sp. C. Agardh (1824)
Semibalanus balanoides Linnaeus (1767)
Ulva sp. Linnaeus (1753)

Analysis demonstrates that the total percentage of species coverage is highest on the outside of the pools, followed by the old rocks, new rocks, and then the inside of the pools (Figure 4). The mean values differed statistically significantly ($P = 1.046e05$, $N = 23$). Statistical analysis of the results showed a significant difference between the inside of the pools and the outside of the pools ($P = 2.9e-05$). Suggesting that the total percentage of species coverage is higher on the outside of the pools compared to the inside of the pools. The total percentage of coverage of species also showed a significant difference between the new rocks and the outside of the pools ($P = 0.00012$). In this case, the total percentage of species coverage is also higher on the outside of the pools compared to the new rocks.

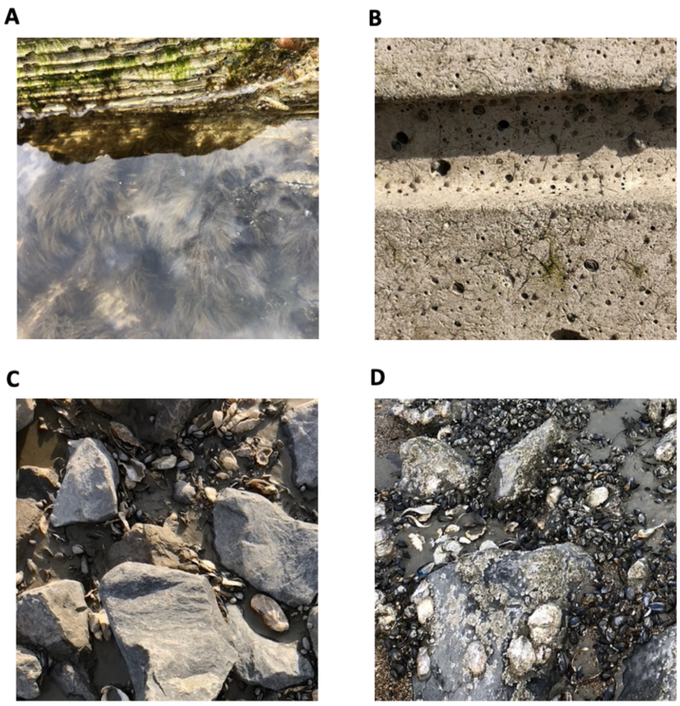

Figure 3. Species coverage on different habitat types
Species coverage on: A. the inside of a tidal pool. B. the outside of a tidal pool. C. new rocks. D. old rocks.

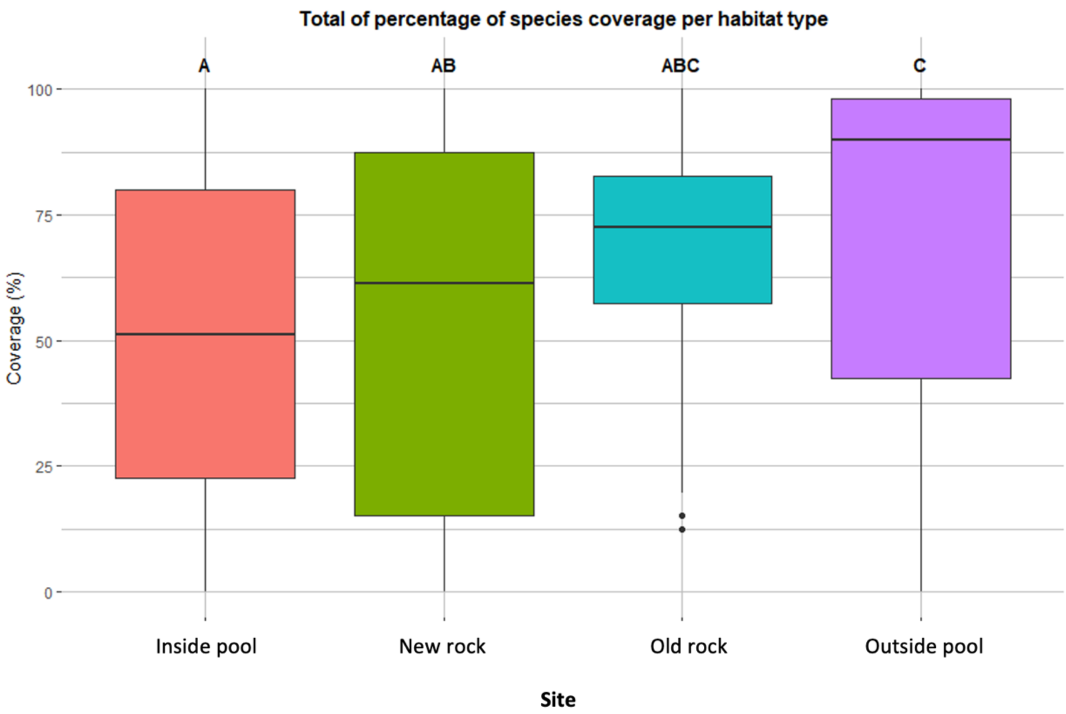

Figure 4. Total percentage of species coverage per habitat type
On the y-axis the percentage of species coverage. On the x-axis the habitat type. Inside of the pool (red), new rock (green), old rock (blue), outside of the pool (purple). With N = 23. The boxes with the same letters (A, B, C) do not differ significantly from each other.

2. Elevation level

2.1 Inside of the pools

Inside of the pools we found nine species from which *Berkeleya rutilans* and *Obelia sp.* were unique for this habitat. We analysed how elevation affected the species percentage of coverage inside of the pools (Figure 5). Analyses of the inside of the pools showed only one significant effect. The percentage of coverage of barnacles was negatively correlated with the elevation (Spearman's Rank, $P = 0.0009049$, $\rho = -0.644352$) (Figure 6). Barnacle coverage decreases with increased elevation. Other species found in the pools did not show a significance between coverage and elevation.

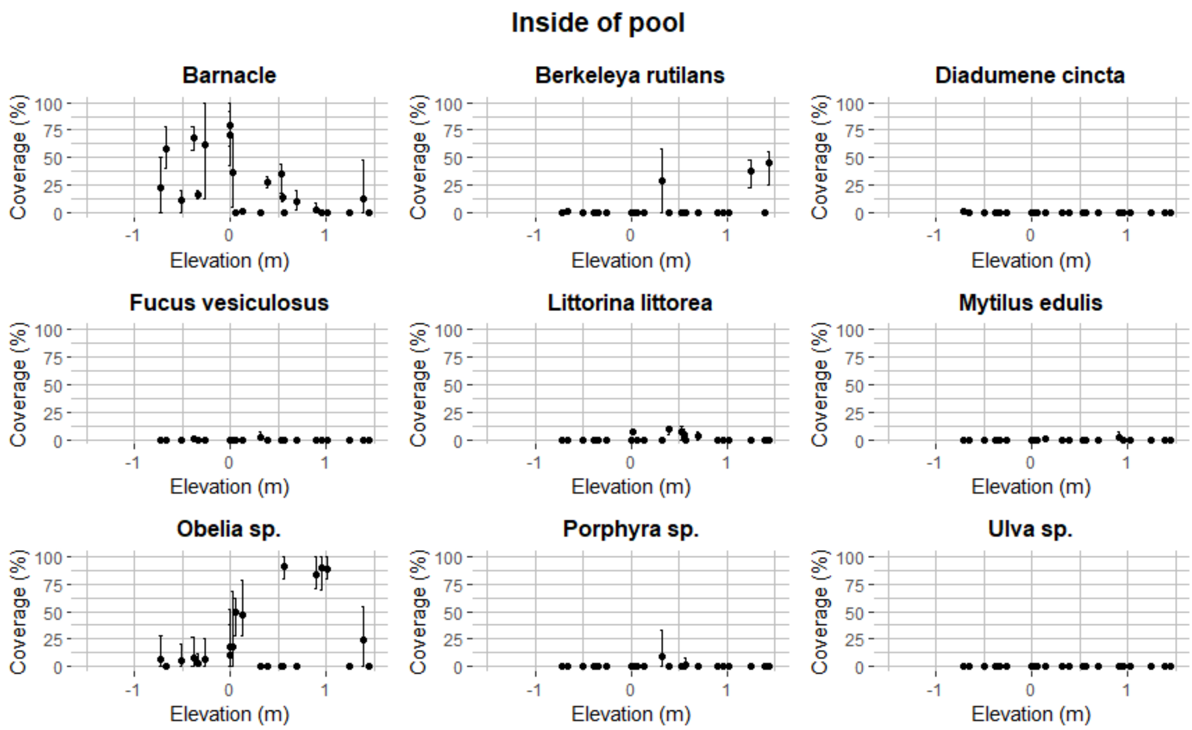

Figure 5. Correlation between species coverage and elevation of the pools
The y-axis represents the percentage of coverage. The x-axis shows the elevation of the sample site in meters. The dots represent the percentage of coverage of species per pool with their variance.

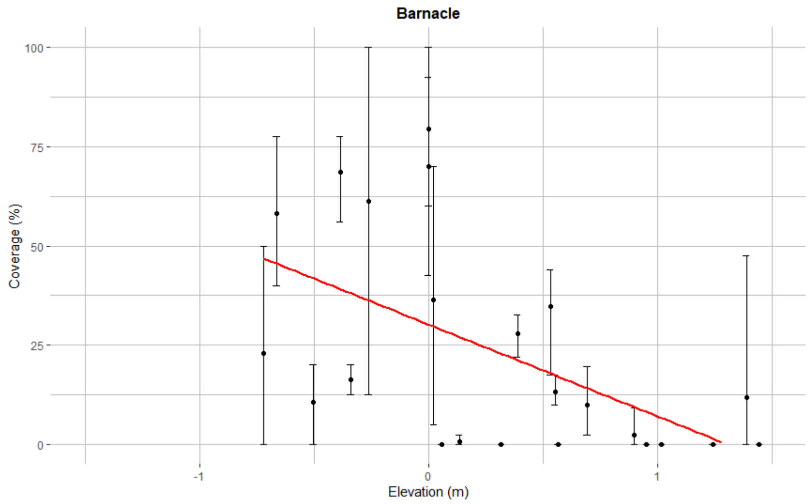

Figure 6. Correlation between barnacle coverage and elevation of the pools
The y-axis represents the percentage of coverage of the barnacles. The x-axis shows the elevation of the sample site in meters. The line shows the correlation between the coverage of barnacles and the elevation of the pools.

2.2 Outside of the pools

Outisde the pools, we found 5 species (Figure 7). In this habitat, elevation affected the percentage of coverage of barnacles and *Ulva sp.* (Figure 8). The percentage of coverage of barnacles is strongly negatively correlated with the elevation (Spearman's Rank, P = 6.89E-09, ρ= -0.896882). This indicates that the barnacle coverage decreases with increased elevation. In contrast, the coverage of *Ulva sp.* increases with increasing elevation (Spearman's Rank, P = 0.001948 and ρ = 0.6111362). The elevation had no significant effect on the coverage of *Fucus vesiculosus*, *Littorina littorea*, and *Porphyra sp*.

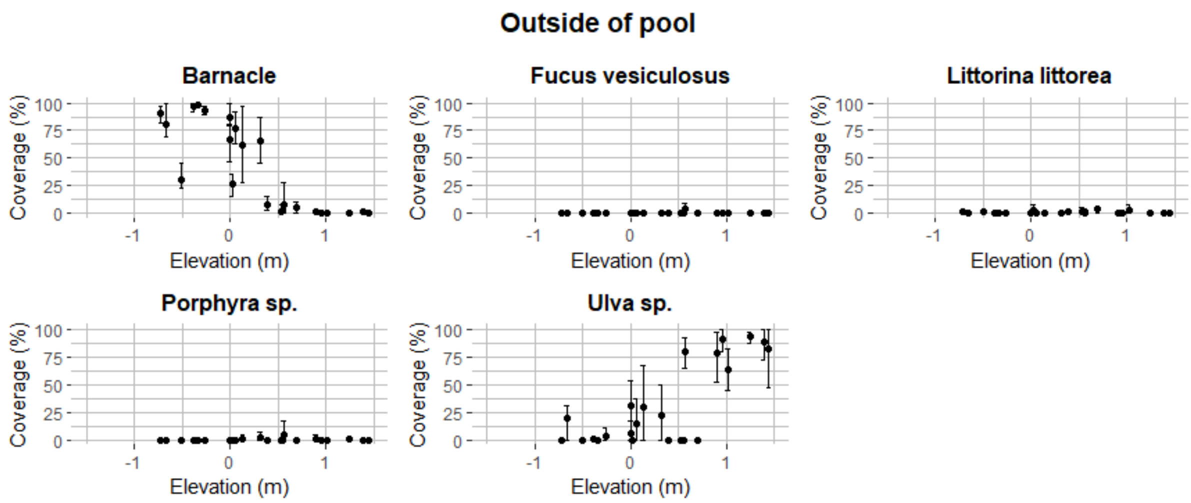

Figure 7. Correlation between species coverage and elevation of the pools
The y-axis represents the percentage of coverage. The x-axis shows the elevation of the sample site in meters. The dots represent the percentage of coverage of species per pool with their variance.

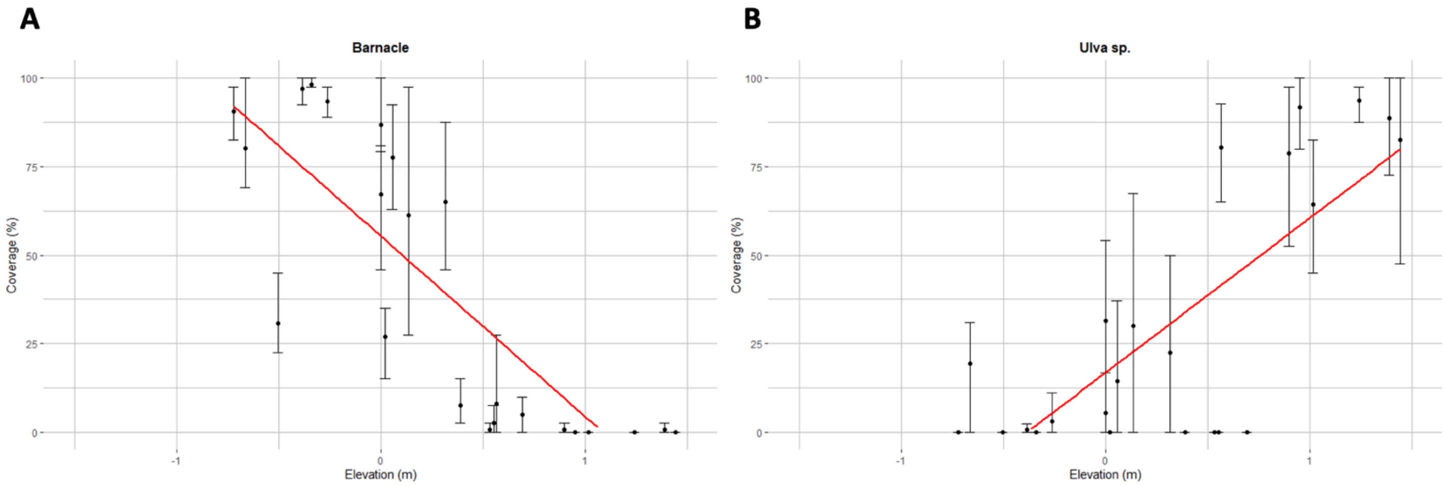

Figure 8. Significant correlations between barnacle and *Ulva sp.* coverage and elevation of the pools. Panel A shows the significant negative correlation between barnacle coverage and elevation of the pools. Panel B shows the significant positive correlation between Ulva sp. coverage and elevation of the pools. The y-axis represents the percentage of coverage of the species. The x-axis shows the elevation of the sample site in meters.

2.3 New rocks

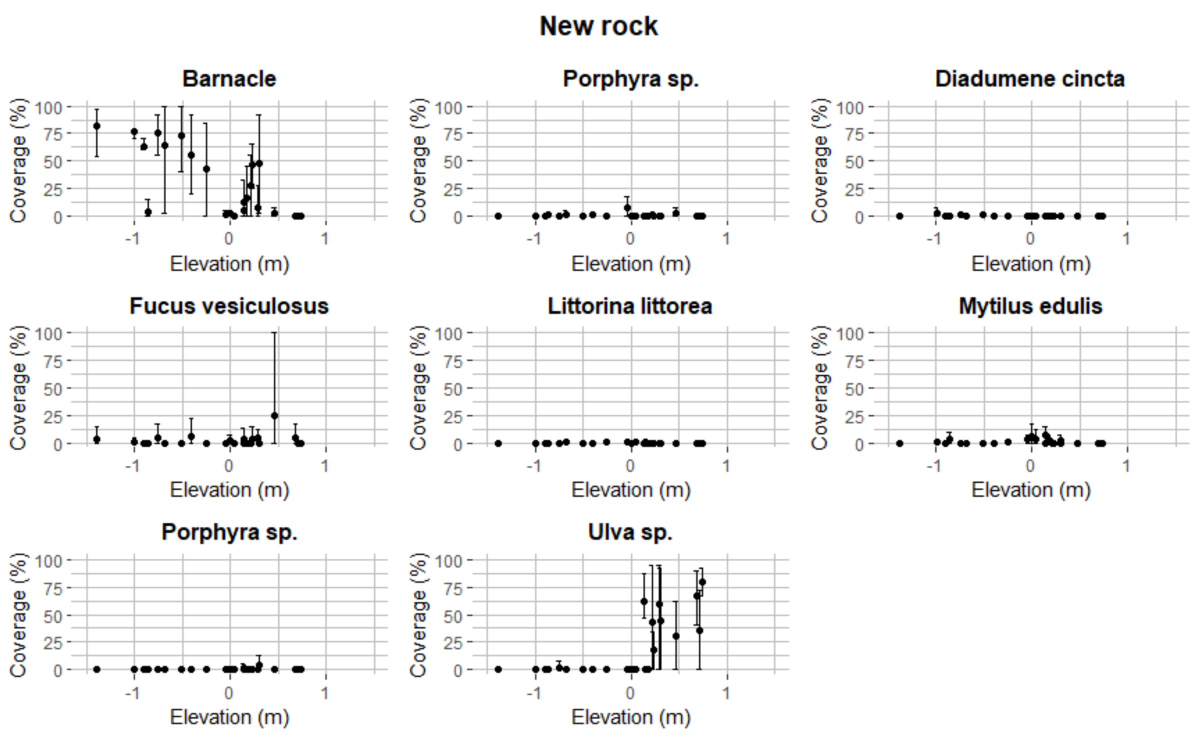

Figure 9. Correlation between species coverage and elevation of the new rocks The y-axis represents the percentage of coverage. The x-axis shows the elevation of the sample site in meters. The dots represent the percentage of coverage of species per rock with their variance.

On the new rocks, we found a total of eight species (Figure 9), from which, three species were significantly affected by elevation (Figure 10). Statistical analyses of the results showed a moderate negative correlation between the percentage of coverage of barnacles and the elevation of the sample site (Spearman's rank, $P = 0.00024$, $\rho = -0.69341$). Barnacles showed a higher percentage of coverage at lower elevations. Furthermore, we found a negative correlation between the percentage of coverage of *Diadumene cincta* and elevation of the sample site (Spearman's rank, $P = 0.03954$, $\rho = -0.43200$). When the elevation increases, the percentage of coverage of *D. cincta* decreases. Lastly, the data indicated a significant result (Spearman's rank, $P = 2.87E-05$ and $\rho = 0.75723$) between the percentage of coverage of *Ulva sp.* and elevation. While elevation increases, the percentage of coverage of *Ulva sp.* increases too. The other species did not show significant correlations with elevation of the new rocks.

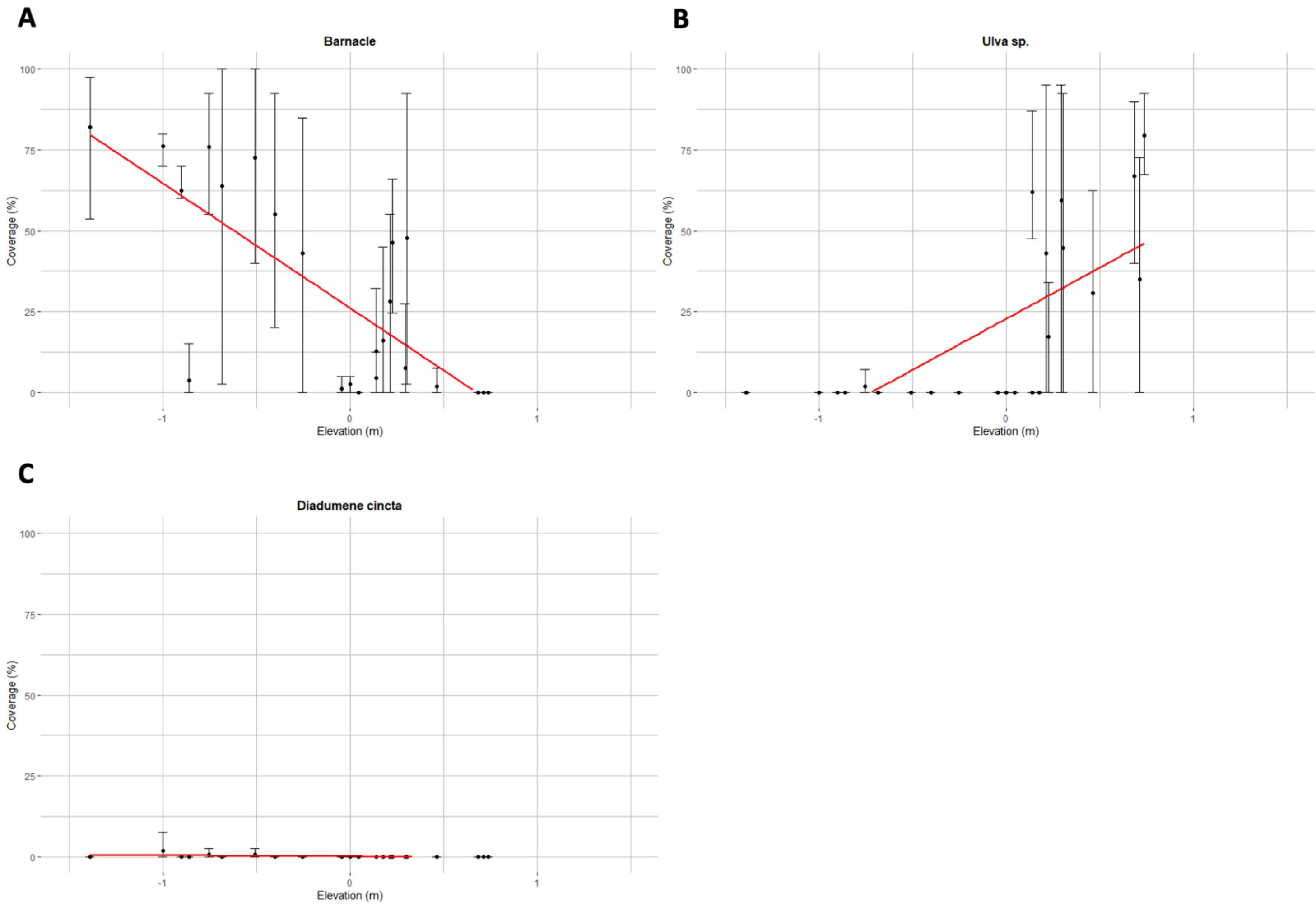

Figure 10. Significant correlations between barnacle, *Ulva sp.* and *D. cincta* coverage and elevation of the new rocks
Panel A shows the significant negative correlation between barnacle coverage and elevation of the new rocks. Panel B shows the significant positive correlation between *Ulva sp.* coverage and elevation of the new rocks. Panel C shows the significant negative correlation between *D. cincta* and elevation of the new rocks. The y-axis represents the percentage of coverage of the species. The x-axis shows the elevation of the sample site in meters.

2.4 Old rock

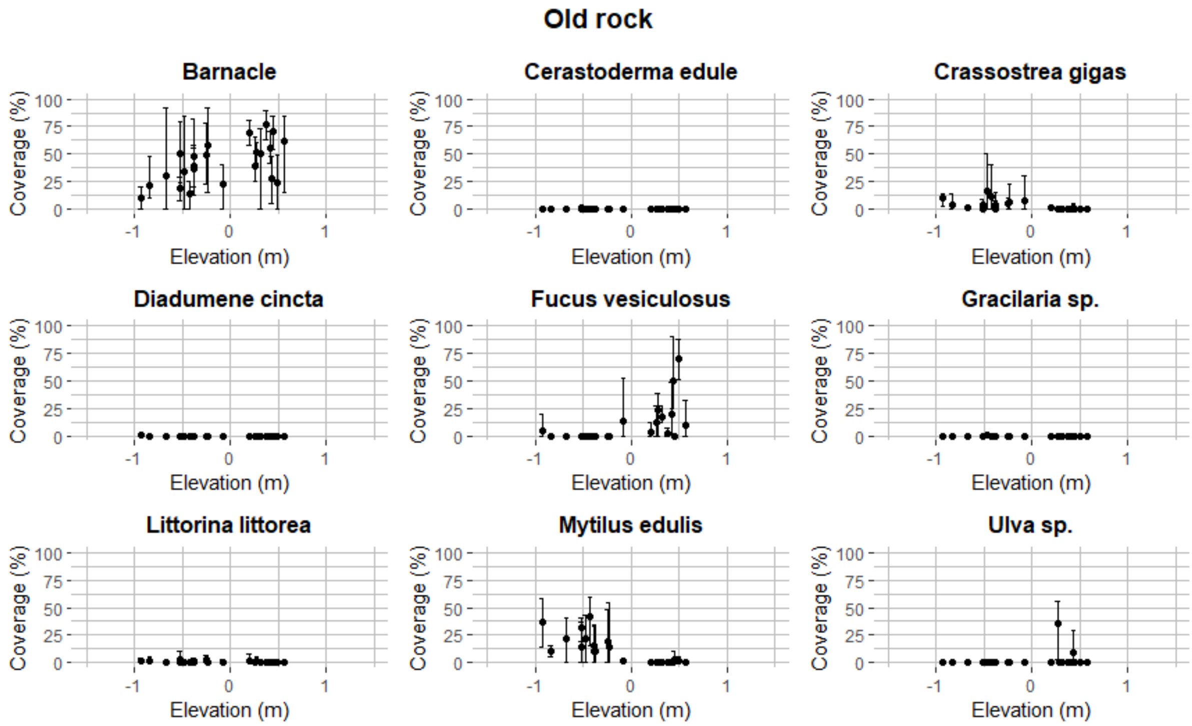

Figure 11. Correlation between species coverage and elevation of the old rocks The y-axis represents the percentage of coverage. The x-axis shows the elevation of the sample site in meters. The dots represent the percentage of coverage of species per rock with their variance.

On the old rock we found 9 different species (Figure 11). *Cerastoderma edule and Gracilaria sp.* were unique to the old rocks. In this habitat, elevation affected the percentage of coverage of barnacles, C. gigas, F. vesiculosus, and M. edulis (Figure 12). The percentage of coverage of barnacles was positively correlated with elevation (Spearman Rank's, P = 0,00413, ρ = 0,58300). Barnacles were covering the old rock more densely at higher elevations. Figure 12 shows that there is a moderate negative correlation between the percentage of coverage of *Crassostrea gigas* and elevation (Spearman's rank, P = 0,003464, ρ = -0,58358). *C. gigas* coverage decreases with increasing elevation. The percentage of coverage of *F. vesiculosus* increases with increasing elevation. Lastly, a strong negative correlation was found between the percentage of coverage of *Mytilus edulis* and elevation (Spearman's rank, P = 1,63E-06, ρ = -0,82057). At lower elevations the percentage of coverage of *M. edulis* was higher. *C. edule, D. cincta, Gracilaria sp., L. littorea*, and *Ulva sp.* did not show significant correlations with elevation of the old rocks.

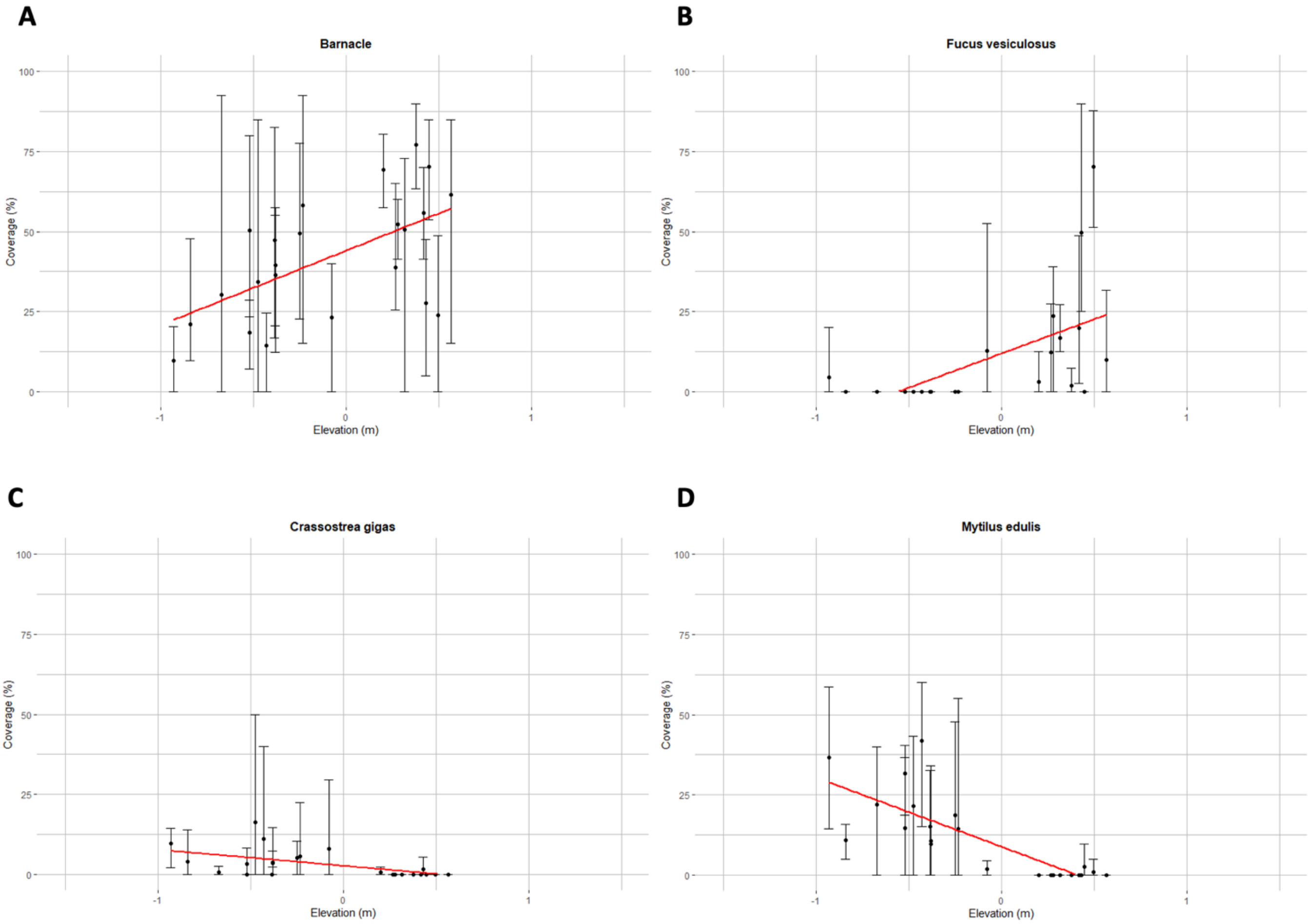

Figure 12. Significant correlations between barnacle, *F. vesiculosus*, *C. gigas* and *M. edulis* coverage and elevation of the old rocks.
Panel A shows the significant positive correlation between barnacle coverage and elevation of the old rocks. Panel B shows the significant positive correlation between *F. vesiculosus* coverage and elevation of the old rocks. Panel C shows the significant negative correlation between *C. gigas* and elevation of the old rocks. Panel D shows the significant negative correlation between M. edulis coverage and elevation of the old rocks. The y-axis represents the percentage of coverage of the species. The x-axis shows the elevation of the sample site in meters.

DISCUSSION

With the growing need for coastal defense structures against sea-level rise, marine ecosystems are threatened by the use of artificial structures lacking heterogeneity (Perkol-Finkel et al., 2018). Efforts are being made to mimic natural habitats by improving physical properties of artificial structures, such as incline, depth, and water-retaining features. Artificial intertidal pools showed promising results in previous studies having positive effects on biodiversity (Firth et al., 2014). However, there is little known about the effect of tidal elevation on the coverage of species. The results indicate that the percentage of species coverage differs with tidal elevation per habitat type. With tidal elevation showing species-specific differences in each habitat type. The coverage of some species increases with increased elevation, while other species coverage decreases with increased elevation.

1. Inside of the pools

Our data does not support the hypothesized association that the species coverage of the inside of the pools is higher than the species coverage on the new and old rocks. In fact, the inside of the pools holds the lowest percentage of species coverage in total. This is an unexpected finding since the environment inside the pools does not fluctuate as much as that of the exposed surrounding rocks, and therefore may be an important refuge. This, however, has yet to be quantitively proved (Metaxas and Scheibling, 1993). A reason for the low percentage of coverage can be explained by the fact that the pools have only been there for 7 months. A short period of time for organisms to colonize the new habitat. But observations showed that this period is long enough for barnacles to settle inside the pools. With barnacle coverage decreasing with increased elevation. This is in line with our hypothesis that species coverage will decrease with increased elevation and the finding that barnacle distribution range spans low to high elevations (Scrosati and Freeman, 2019). However, pools with low elevation show some variance in the percentage of coverage of the site.

2. Outside of the pools

The outside of the pools shows the highest percentage of species coverage; however, the data is skewed. The majority of the data are located on the upper part of the graph. This may be linked to the high percentages of barnacle and *Ulva sp.* coverage at certain elevation levels. Barnacle coverage is high at low elevations, while Ulva sp. coverage is high at high elevations. Two different correlations, where barnacle coverage only supports our prediction of increased species coverage at low elevations.

3. New rocks

The percentage of total species coverage shows variability on the new rocks. The boxplot is comparatively tall, suggesting that there are big differences in the sample data. Assumably, because of all species found on the new rocks, only the barnacles and Ulva sp. showed a high percentage of coverage.
Barnacle and *Ulva sp.* coverage show variances in the sampled rocks. This might be because some of the new rocks did show some live cover, while others were completely empty.

4. Old rocks

The data analysis of the total percentage of species coverage on the old rocks showed some outliers. Assumably, because several species such as *D. cincta, C. edule,* and *Gracilaria sp.* were found rarely in the samples of the old rocks.
In present study, significant results show that the coverage of barnacles increases with increased tidal elevation on the old rocks. Contrary to the correlations found in the pools and new rocks. In these sites the barnacle coverage decreases with increased tidal elevation. Unfortunately, it is difficult to address this difference in correlation. Because we did not look at the effect of elevation on species between sites, but instead divided it by site.

A limitation of this study is the large number of variables that might have an impact on the outcomes. To begin with, the elevation of the pools and rocks is lower in site A than in site B. According to the map, site B is situated on a tidal flat. Aside from the difference in elevation between site A and B, additional abiotic factors unique to each site, such as currents and sand, may favor different species. Which can indirectly result in differences in species coverage. Another drawback is that the pools differ from each other in terms of design. In total, three different pool types from two companies were sampled. Fluctuations in these pools' micro-environments vary with surface area, volume, and depth of the pool (Metaxas and Scheibling, 1993). Thus, none of these pool types are similar in their physical regime, making it difficult to ascertain if the elevation has an effect on the species coverage.
Future studies should take these variables into account and design a study using the same type of pools in one particular area with similar external abiotic factors. A greater elevation range could be applied in future research by lining up the pools and distributing them further apart. In such a manner, some pools remain exposed for a longer period of time and do not completely submerge during high tide. This will increase the availability of potential habitat types. With each one providing an optimal environment for different species communities.

CONCLUSION

This research aimed to examine how species coverage changes in between habitat types and tidal elevations. Based on the data analysis of the total percentage of species coverage per habitat type and the correlation between habitat type and tidal elevation, it can be concluded that different abiotic factors have consequences for the colonizing species. The coverage difference is species-specific for tidal elevation. While some species coverage decreases with increased elevation, other species are more abundant with increased elevation. Accordingly, not all our findings are in line with the hypothesis that species coverage will decrease with increased tidal elevations. As the need for ecological enhanced artificial structures grows, different tidal elevations should be used to increase the availability of potential habitat types. Accordingly, supporting all kinds of species.

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APPENDIX

Coordinates and elevation of dGPS elevation measurements. (CRS = EPSG:28992 – Amersfoort/RD new)				
Number	Site	Longitude	Latitude	Elevation (m)
1	Pool	211565.694	603412.279	-0.385
2	Pool	211566.262	603414.13	-0.662
3	Pool	211567.563	603410.609	0.001
4	Pool	211567.962	603412.77	-0.261
5	Pool	211569.349	603409.452	0
6	Pool	211660.79	603441.496	-0.338
7	Pool	211660.646	603434.593	0.694
8	Pool	211663.074	603438.667	0.553
9	Pool	211755.758	603473.731	-0.719
10	Pool	211756.497	603474.177	-0.502
11	Pool	211755.288	603470.803	0.024
12	Pool	211757.795	603468.416	0.39
13	Pool	211755.237	603466.604	0.533
14	Pool	212632.753	603580.467	-0.367
15	Pool	212634.136	603580.812	-0.818
16	Pool	212636.155	603582.796	-1.051
17	Pool	212636.672	603574.886	0.954
18	Pool	212633.983	603574.484	1.019
19	Pool	212683.674	603567.565	0.057
20	Pool	212686.066	603566.825	0.136
21	Pool	212683.023	603566.718	0.319
22	Pool	212684.366	603565.782	0.567
23	Pool	212685.69	603563.951	0.901
24	Pool	212732.832	603553.163	1.39
25	Pool	212734.999	603552.418	1.244
26	Pool	212732.732	603551.35	1.445
1	Old rocks	211557.314	603403.148	-0.838
2	Old rocks	211557.715	603403.287	-0.93
3	Old rocks	211552.903	603401.489	-0.671
4	Old rocks	211582.213	603410.355	-0.52
5	Old rocks	211578.409	603408.318	-0.465
6	Old rocks	211585.507	603410.492	-0.427
7	Old rocks	211653.912	603435.922	-0.474
8	Old rocks	211652.369	603432.885	-0.378
9	Old rocks	211668.095	603438.498	-0.077
10	Old rocks	211773.128	603475.287	-0.381
11	Old rocks	211770.727	603475.133	-0.384
12	Old rocks	211766.783	603473.927	-0.519
13	Old rocks	211762.949	603470.677	-0.247
17	Old rocks	211761.073	603469.826	-0.232
18	Old rocks	212630.109	603575.527	0.267
19	Old rocks	212642.309	603573.203	0.448
20	Old rocks	212687.699	603562.973	0.279
21	Old rocks	212689.368	603562.371	0.378
22	Old rocks	212691.123	603563.311	0.316

23	Old rocks	212673.588	603564.618	0.568
24	Old rocks	212673.241	603566.441	0.202
25	Old rocks	212745.944	603546.262	0.498
26	Old rocks	212743.902	603547.363	0.433
1	New rocks	211574.899	603410.871	-0.507
2	New rocks	211571.533	603413.658	-0.998
3	New rocks	211565.641	603411.371	-1.387
4	New rocks	211564.18	603408.249	-0.752
5	New rocks	211570.965	603408.718	-0.4
6	New rocks	211661.172	603441.712	-0.684
7	New rocks	211661.273	603434.236	0.045
8	New rocks	211663.657	603438.396	0
9	New rocks	211755.611	603473.408	-0.9
10	New rocks	211757.358	603473.296	-0.859
11	New rocks	211755.124	603470.492	-0.375
12	New rocks	211754.968	603470.463	-0.253
13	New rocks	211758.04	603468.236	-0.042
17	New rocks	211755.551	603466.435	0.142
18	New rocks	212636.978	603574.328	0.215
19	New rocks	212633.944	603573.207	0.177
20	New rocks	212681.751	603565.59	0.303
21	New rocks	212685.74	603565.052	0.229
22	New rocks	212683.159	603564.674	0.139
23	New rocks	212684.206	603563.353	0.466
24	New rocks	212685.952	603562.85	0.295
25	New rocks	212734.282	603552.543	0.685
26	New rocks	212735.482	603550.853	0.738