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Could this be a concrete solution to biodiversity loss?

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Abstract

Did you know that in some parts of the world, we have replaced over half of our natural shorelines with man-made coastal defences?

This is important because these structures aren't usually as good at supporting a wide range of different species (we call this biodiversity) as natural rocky shores. The reason for this is that artificial structures lack important habitats like rock pools, pits and crevices that trap water and provide shelter for marine organisms.

We wanted to find out what effect creating artificial rock pools on these structures would have. Would it help to attract more species? Did the pools need to be a particular size or at a particular shore height to work well? Was exposure to wave action important? We set out to find the answers to these questions to help engineers and coastal managers increase biodiversity on their man-made coastlines.

Introduction

Man-made coastal defences are being built to protect more and more of the world's coastlines. Coastal engineers build these structures to protect developments near the sea from flooding and erosion, and the threat of rising sea levels caused by climate change.

Some scientists think that the growing amount of artificial (man-made) coastline is one of the biggest threats to our marine ecosystems. The materials used to make the coastal defences are generally smooth and featureless, making it hard for marine organisms to make their homes in them (Fig 1).

Rock pools are important features on natural rocky beaches because they trap water in them when the tide is out. They offer small organisms protection from drying out and shelter from larger animals that might eat them (predators). Think about how many different seaweeds and animals you can see when you go rock pooling!

We created our own rock pools in some coastal defence structures to see if this would make them better habitats for marine biodiversity.

We wanted to find out:

1. Were our pools better at encouraging a variety of seaweed and animal life than the surrounding boulders on the coastal defence structure?
2. Were shallow or deep pools better?
3. Were the pools that we made on sides that faced out to sea better than those that were sheltered from the waves?
4. Were the pools that we made lower down on the structure better than those that were higher up?

For Figure 1, please check page 2

Figure 1:
Compare the coastal defence structure on the left with the natural rocky shore on the right. Where can you see more seaweed and animal life?

Methods

To test our first two questions, we made rock pools by drilling holes of different depths on a coastal defence breakwater. We drilled half of them to 5cm deep (the shallow ones) and the other half to 12cm deep (the deep ones). They were all the same width (Fig. 2a and b).

We marked out test areas of the same surface area as the pools on the flat rocks of the breakwater. These areas were to compare how well the pools worked at attracting organisms compared to the surrounding rock.

We then scraped off everything that was living on and around our test areas. We blasted them with a flame-gun (that was quite exciting!) to make sure the areas were completely clear to begin our study.

To test our third and fourth questions, we made rock pools by pouring concrete in the gaps between coastal defence units along two sides of a causeway (Fig. 2c and d).

We constructed half of the pools on the side that faced out to sea (the exposed side), and the other half on the side that faced towards the land (the sheltered side). On each side, half were constructed high up on the structure (upper pools) and half were constructed low down on the structure (lower pools). The ones higher up did not get covered by seawater on every tide.

To answer all the questions in our study, we monitored the organisms that we found in our pools and test areas for between 18 and 24 months. We then compared the number and types of species that were using each type of habitat.

a)

d)

b)

c)

Figure 2:
Our work
a) Engineers helped us create rock pools on the breakwater.
b) Our rock pools were used by lots of different seaweeds and marine animals.
c) Engineers helped us to create rock pools on the causeway.
d) We used quick drying cement to make rock pools in the gaps between boulders on this causeway.

Results

1. Rock pools vs. Surrounding rock:

a) We found that our pools supported more species than the surrounding rocks on the coastal defence breakwater (Fig 3a).

b) We also found that the pools contained a greater variety of species, including lots that weren't on the surrounding rocks (Fig 3b).

2. Shallow vs. Deep pools: We found that there was no difference in the average number of species using our shallow and deep pools by the end of our study. They both worked as well as each other. However, some species preferred deep pools while others preferred shallow ones.

3. Exposed vs. Sheltered: At first we found that the pools we made on the exposed side of the causeway had a significantly greater variety of species than those on the sheltered side (Fig 3c). Then after a year the pools on the sheltered side filled up with mud and sand and weren't much use as rock pools after that!

4. Lower vs. Upper: We found that the pools we made lower down on the structure had similar numbers of species to those we made higher up when we looked at averages. However, when we counted the total number of species, the lower pools had way more species in them than the upper pools (Fig. 3d).

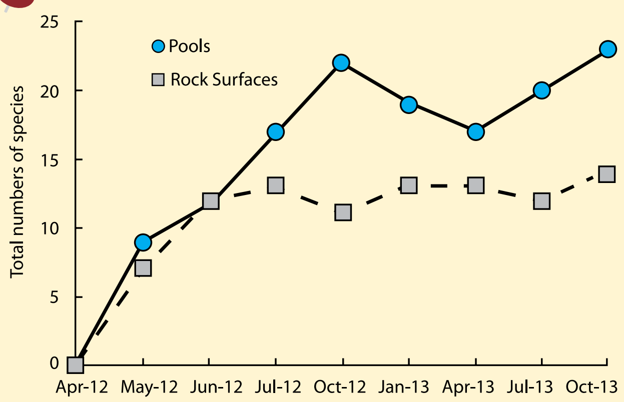

Figure 3a:
We found more species in our drilled pools than on the surrounding rock surfaces throughout our study

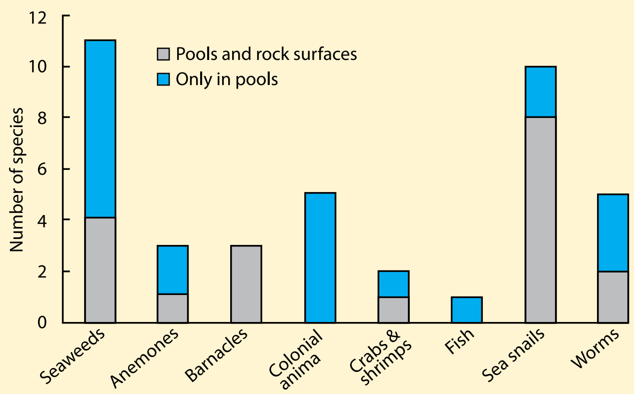

Figure 3b:
Number of species (grouped into similar types) found during our study. We found lots of species that were living only in the drilled pools (blue bars) and not on the surrounding rock.

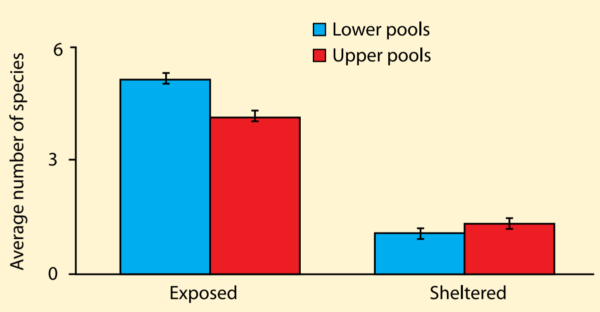

Figure 3c:
After 12 months, the concrete pools that were facing out to sea (exposed) had significantly more biodiversity than the sheltered pools.

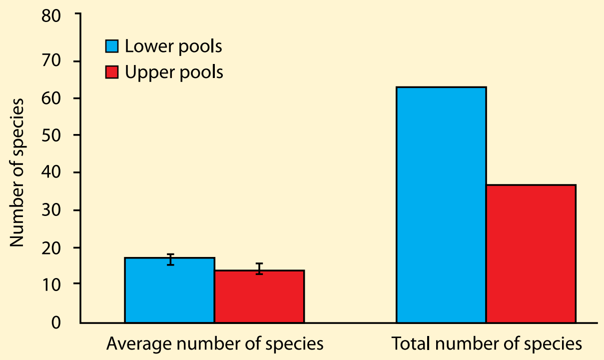

Figure 3d:
After 24 months, we found a similar average number of species in the lower and upper concrete rock pools. But the total number of species was higher in the lower ones.

Discussion

We found that by creating rock pools, we increased the biodiversity of the coastal defence structures in our study. This is great news because these pools can be cheaply and easily put into existing or new structures to improve their ability to accommodate marine life (Fig. 4).

It was also really encouraging that we found little difference in biodiversity between the shallow and deep pools, although some species preferred the deep pools and some preferred the shallow ones. If engineers and coastal managers don't mind which exact species are attracted to their artificial structures, we can recommend that they create shallow pools to increase biodiversity, reducing the cost of making these improvements.

The pools that we made on the sheltered side of the causeway supported relatively few species, and the pools filled up after 12 months. These results show that it may not be worth making pools on the sheltered sides of coastal defences if they are likely to be covered by sediments sometimes.

What's more, the pools created lower on the structure supported more species. Many of them were rare! If engineers are going to spend money on improving coastal defences and their goal is to enhance biodiversity, then creating pools lower down gives better results.

One of the biggest concerns of coastal managers is the introduction of non-native species. The current methods to get rid of these species can be expensive and have negative effects on the surrounding environment. However, previous studies have shown that the presence of high biodiversity in an ecosystem may make it harder for non-native species to become established.

Man-made structures aren't normally very good at supporting marine biodiversity. In our study when we made rock pools in these structures, we found more biodiversity and rare species. These results could really help with coastal management.

Halichondria panicea

Figure 4: Marine life near the coast where we performed our study. Some of the organisms we saw were blennies, crabs, limpets and sponges.
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Conclusion

Natural shorelines are important ecosystems for many marine organisms. If we have to replace them with man-made structures to protect our land from rising sea levels, then it's important that we consider how we can make them better for marine life.

Artificial rock pools like the ones we created are affordable, long lasting solutions to improve biodiversity on man-made coastal defences. The best thing is that engineers can easily design them into new defences, or add them to existing structures to make them more attractive to lots of different species.

Next time you're rock pooling, why not try to count all the different species you can see?

Glossary of Key Terms

Artificial – Something that doesn't occur naturally. We could also call it "man-made".

Biodiversity – The variety of organisms that live in any given ecosystem. We say that there is high biodiversity when there are lots of different types of plants and animals in an ecosystem.

Breakwater – A coastal defence structure - normally made from concrete or rock boulders - designed to shelter land from waves and flooding.

Causeway – A raised road across the sea that links an island to the mainland.

Coastal Managers – The people who are responsible for managing a stretch of coastline. Coastal Managers work with engineers to make sure that the land and properties close to the sea don't get damaged by it. They are also responsible for managing the coastline in a way that isn't damaging to the environment.

Ecosystem – A community of animals that interact with each other, and their physical environment.

Erosion – The gradual wearing away of rock or soil by wind or water. In our study, it refers to the wearing away of the land by the sea.

Habitat – The place, or type of place, where an animal lives and hangs out.

Native species – Species that naturally occur in a particular ecosystem and that are not brought in by human activity.

Non-native species – A species that would not normally occur in a particular ecosystem. Human activities sometimes result in the introduction of non-native species.

Significant – A result that is likely not due to chance, but rather due to a real process. Scientists define a result as "significant" if it would happen by chance less than 5% of the time.

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A news article in the The Irish Times about rock pools:
http://www.irishtimes.com/news/science/putting-the-marine-life-back-into-ocean-sprawl-1.2878213

Benny the Blennie by Teresa and Paul Naylor
http://www.bennytheblenny.com

Check your understanding

1. Why did we need to clear the research areas of all life before we started our study?
2. Why is it cheaper to drill a shallow hole than a deep hole? Why is this important?
3. How can non-native species be a threat to an ecosystem?