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BIODIVERSITY
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ORGANISMS THAT CREATE HOMES FOR OTHER ORGANISMS ON MARINE SHORES

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YOUNG REVIEWERS:

VICTORIA
AGE: 10

The intertidal zone is a narrow strip along marine shores where the ocean meets land. Tides make this environment different from any other. Every day, low tides expose the intertidal zone to the air, while high tides completely submerge it. Given the daily alternation between dry and wet conditions, one would expect that very few species could live at the intertidal zone. Yet, it is common to find diverse and abundant communities there. How can so many organisms thrive in these stressful environments? The answer is foundation species. Foundation species, such as some bivalves, seaweeds, and seagrasses, often cover large areas of the intertidal substrate, and their body structures create 3-dimensional homes for smaller creatures. Not only do foundation species provide habitats, but they also protect smaller species from environmental stress, making an otherwise dangerous place substantially safer. This makes foundation species the heroes of stressful environments like the intertidal zone.

THE STRESSES OF THE INTERTIDAL ZONE

The ocean covers over 70% of the world's surface and includes many different ecosystems. Perhaps one of the most fascinating is the **intertidal zone**. The intertidal zone is the narrow strip on the shore that is fully covered by seawater at high tide and exposed to the air at low tide. This zone is relatively small compared to other marine environments, but it experiences unique challenges that are not present anywhere else.

Twice a day, every day, the tide changes. Therefore, the organisms living at the intertidal zone are forced every day to switch from being underwater to being exposed to the air and vice versa. During low tides, organisms must deal with environmental stresses resulting from being exposed to the air. For example, while water temperatures are relatively moderate, the air can be really hot in the summer or really cold in the winter. Additionally, intertidal creatures can lose a lot of water when they are in direct contact with the air. On the other hand, during high tides, organisms can be beaten by waves, which might damage or even kill them. Finally, intertidal organisms can be eaten by land-based predators such as birds and mammals when they are out of the water and by ocean-based predators such as fish when they are underwater (Figure 1).

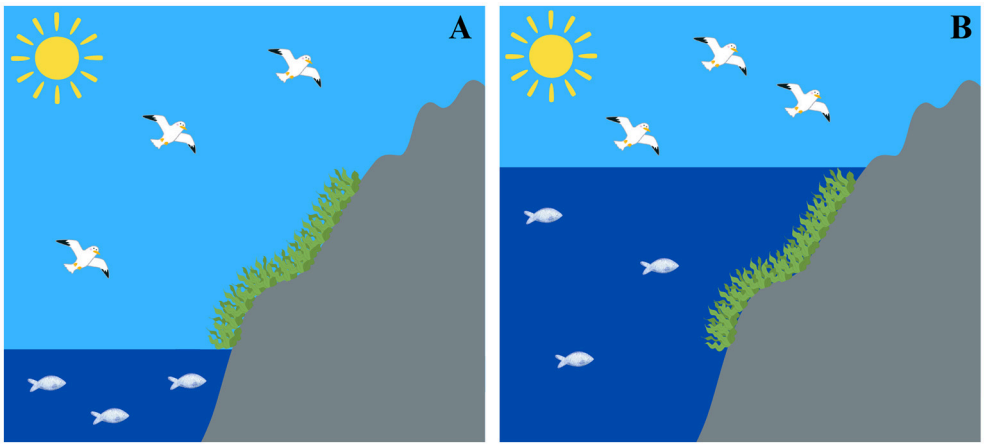

Figure 1

INTERTIDAL ZONE

The narrow strip along a marine shore that is covered by seawater at high tide and exposed to the air at low tide.

Figure 1

The intertidal zone has different challenges depending on whether it is low tide or high tide. **(A)** At low tide, intertidal foundation species (such as the seaweeds shown here) form canopies that help many small organisms to avoid extreme air temperatures and water loss, and that protect them from predators such as birds. **(B)** At high tide, intertidal foundation species are fully under water and their canopies protect many small organisms from waves and predators such as fish.

BIODIVERSITY

Diversity of species and their genetic variants in a biological community.

FOUNDATION SPECIES

Organisms that occupy large areas of an environment and whose body structures create safe habitats for many small species.

SUBSTRATE

The surface that an organism lives and grows on, which typically is rock, sand, or mud on marine shores.

WHAT IS A FOUNDATION SPECIES?

In such a stressful environment, you might expect to find only a few hardy species. However, intertidal zones often have a high **biodiversity**. Why? One explanation is that many small species find refuge in populations of **foundation species**. Foundation species are organisms that typically occupy large areas of the **substrate**, and the 3-dimensional structures of their bodies create homes for many small organisms [1]. Think, for example, of the trees in a forest. Trees

create habitats for many creatures by increasing the 3-dimensional complexity of the habitat and by creating a canopy that protects forest creatures from harsh conditions such as intense sunlight and strong winds. In fact, trees are foundation species. At the intertidal zone, foundation species also create canopies that protect many small organisms from harsh conditions such as extreme air temperatures and water evaporation during low tides and wave action during high tides (Figure 2).

Figure 2

Intertidal foundation species come in many forms: **(A)** bivalves (mussels shown here), **(B)** red turf algae such as Irish moss, **(C)** large brown algae such as knotted wrack, and **(D)** seagrasses. These photographs were all taken at low tide (photo credits: Ricardo A. Scrosati).

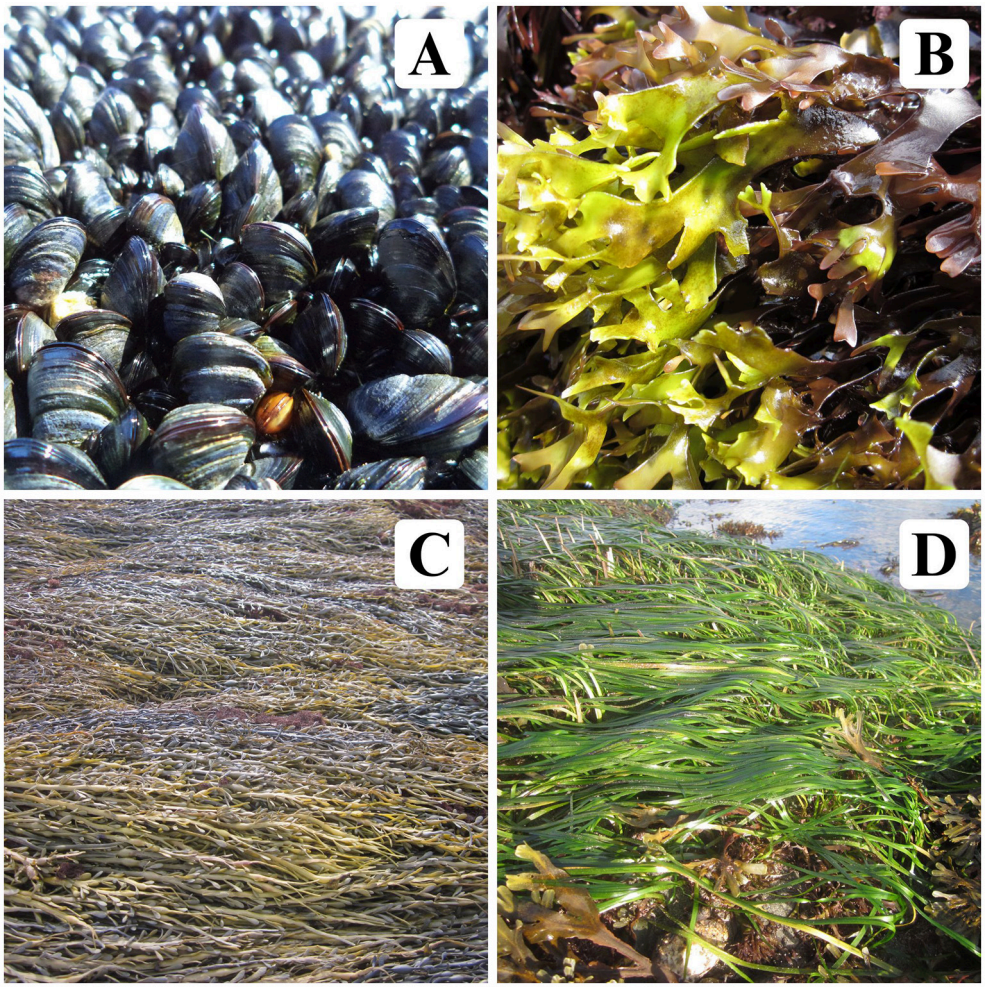

Figure 2

UNDERSTORY

Habitat found below a canopy.

Foundation species can also make it easier for small organisms to survive thanks to small gaps in the **understory** where such organisms can hide from large predators. Furthermore, through their complex body structures, foundation species also increase the 3-dimensional structure of the habitat and thus create extra spaces where other organisms can live. Organisms can live both on a foundation species itself and in the gaps that the foundation species creates (Figure 3). A coral reef is a good example. In some areas, if corals were not present, the ocean floor would be almost barren and not very habitable for other creatures. However, with corals, there are more spaces to live in and places for small fish to hide, making coral reefs some of the

most biodiverse areas in the ocean. Many foundation species live in the intertidal zone and have adapted to thrive in the ever-changing conditions, creating habitats for other creatures and increasing the biodiversity of the community.

Figure 3

Zooming into foundation species reveals many small organisms living in their protection. **(A)** Barnacles live on the extra substrate provided by mussel shells and worms take shelter among the mussels. **(B)** Snails and crustaceans like amphipods avoid temperature extremes and drying out during low tides under the canopy created by seaweed fronds.

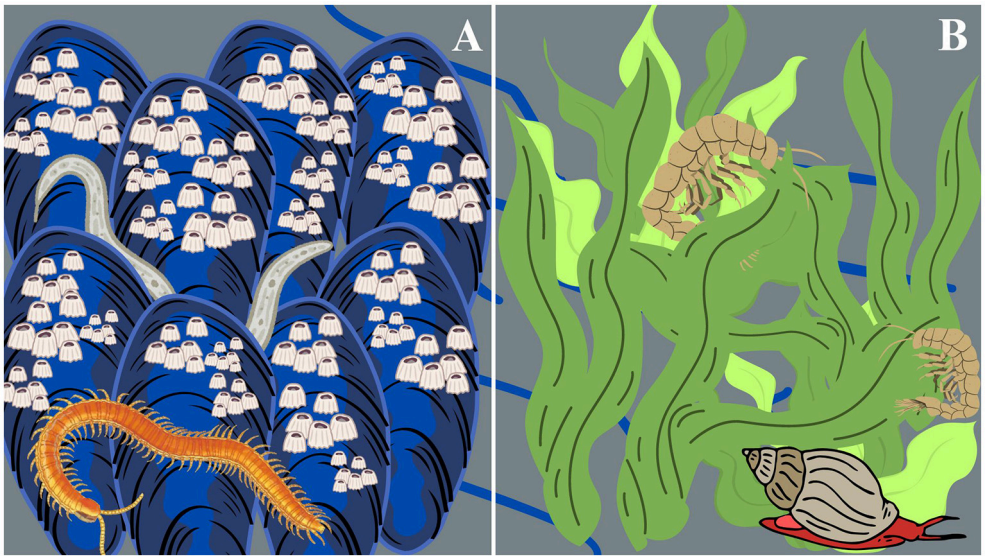

Figure 3

MEET INTERTIDAL FOUNDATION SPECIES: BIVALVES, SEAWEEDS, AND SEAGRASSES

INVERTEBRATES

Animals that lack a vertebral column.

SEDIMENTS

Particulated solid materials such as sand or mud.

Bivalves are mollusks that have two shells and often act as foundation species at the intertidal zone [2]. Bivalves include mussels, oysters, and clams, all of which can form extensive clumps of densely packed individuals attached to the intertidal substrate. The small spaces between individual bivalves are safe spaces for small animals to live, as the shells of the bivalves protect those animals from waves, predators, extreme temperatures, and drying out. The shells can also be an extra substrate (similar to rocks) that small algae and **invertebrates** can grow on. The close quarters of a dense clump of bivalves also trap **sediments** among the bivalve shells, creating an environment for small burrowing invertebrates.

FRONDS

The leaf-like structures of a seaweed where photosynthesis mostly occurs.

Seaweeds, also known as macroalgae, can also be foundation species in intertidal habitats [3]. Some red seaweeds such as Irish moss are foundation species that live low in the intertidal zone. They live permanently attached to the substrate and produce upright **fronds**, forming dense clumps where many small organisms can live. Similar to bivalves, the canopies created by these fronds limit temperature extremes by providing shade and retain moisture during low tides, making the habitat more favorable for small organisms. Brown seaweeds such as knotted wrack are larger and create a more complex canopy than those red algae. As the fronds of knotted wrack

are very flexible, they lay flat on the shore at low tide, providing shade, retaining moisture, and creating more spaces for critters to hide in. These brown seaweeds also act as an anchor for smaller algae and invertebrates to attach to and grow from.

Seagrasses are marine flowering plants that act as foundation species on many sandy, muddy, and rocky shores [4]. Seagrasses such as eelgrass have roots that keep sediments in place and thus create areas for burrowing invertebrates. Seagrasses also form canopies that can keep temperatures relatively stable and prevent water loss during low tides. These canopies also keep large predators from accessing intertidal habitats during high tides, making them important nurseries for young fish, for example.

TYING IT TOGETHER

Many organisms that live in the stressful intertidal zone rely on one or more foundation species. Bivalves, seaweeds, and seagrasses all live on the shore and provide safe places for other small organisms by creating living space that is protected from environmental extremes and predators. Often, different kinds of foundation species, each creating homes for different organisms, live near each other, resulting in an impressive biodiversity across the whole shore. Unfortunately, foundation species are at risk due to climate change and other human pressures such as pollution, overharvesting, and coastal development. Climate change is bringing bigger storms and more extreme temperatures beyond what foundation species can handle. If intertidal foundation species are lost, the diverse communities that call them home will likely be lost, too. Fortunately, since foundation species do such a good job at creating homes and maintaining biodiversity, restoring biodiversity in damaged intertidal systems can sometimes be relatively simple. Instead of having to recreate a whole community, reintroducing the foundation species is a good strategy that will naturally draw critters looking for homes and can help rebuild a biodiverse community.

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CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

VICTORIA, AGE: 10
Victoria is a curious and energetic 10-year-old in 5th grade. She loves reading and hanging out with her three adorable cats. On the softball field, she shines as the star pitcher for her team. Victoria is also a talented harpist, playing the harp since she was 4 years old. She enjoys playing Minecraft and Roblox. She dreams of becoming a scientist someday.

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