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BIODIVERSITY
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WRACK N' ROLL: THE ECOLOGICAL ROLE OF BEACH WRACK

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YOUNG REVIEWERS:

HARMONY
AGE: 12

SAMARTH
AGE: 13

Beach wrack is the stinky weed that gets washed up on the beach after a big storm. This weed is made up of old marine plants such as seaweeds and seagrasses, and it gets washed up onto beaches all over the world. Although it can be ugly and smell like rotten eggs, it is very important for the health of our beaches. Lots of tiny animals make their homes in beach wrack, while others feed on it or use it as a hunting ground for their favorite snacks. This feeding frenzy produces nutrients through animal poop and bones, which get delivered back into the water and help to keep our oceans healthy. Coastal development and beach cleaning upset these natural processes and can impact the ecosystems that make our beaches so great.

WHAT IS WRACK?

Each year, you may notice a lot of "weedy" stuff washed up onto the beach, especially after big storms. This weedy stuff is called beach

wrack, and many people want to keep it off our shores. Although it can be smelly and it takes up room in the sand near the water, it plays an important role in coastal ecology. But before we get into the serious stuff, let us talk about what wrack is and how it comes to be sitting on beaches all over the world.

Wrack is dead marine plants such as seaweeds and seagrasses that get washed up onto beaches all over the world (Figure 1). The amount of wrack washed up on beaches varies a lot around the world, between as little as 0.1 kg up to a huge 325 kg of wet wrack per meter of coastline. This wrack originates in the seagrass meadows and seaweed forests offshore, which regularly shed old leaves—just like trees lose their leaves in autumn. These leaves are then carried to the shore by tides, waves, and wind and it then drifts on and off the beaches and may even travel back offshore, completing a wrack lifecycle. At every point along this journey, the wrack provides important **ecosystem functions**.

ECOSYSTEM FUNCTIONS

Different jobs that nature does to keep everything healthy and working well.

Figure 1

Beach wrack providing habitat and food for fauna on **(a)** a sandy beach in New Zealand and **(b)** a rocky forested shore in Scandinavia and **(c)** underwater in the surf zone. **(d)** Dissolved nutrients (the brown stains on the sand) are released from wrack on a beach. **(e)** An excavator removing wrack from a beach and **(f)** massive accumulations of wrack trapped behind a marina **groin** (barrier wall) in Western Australia.

GROIN

Low wall or barrier built out into sea from the beach.

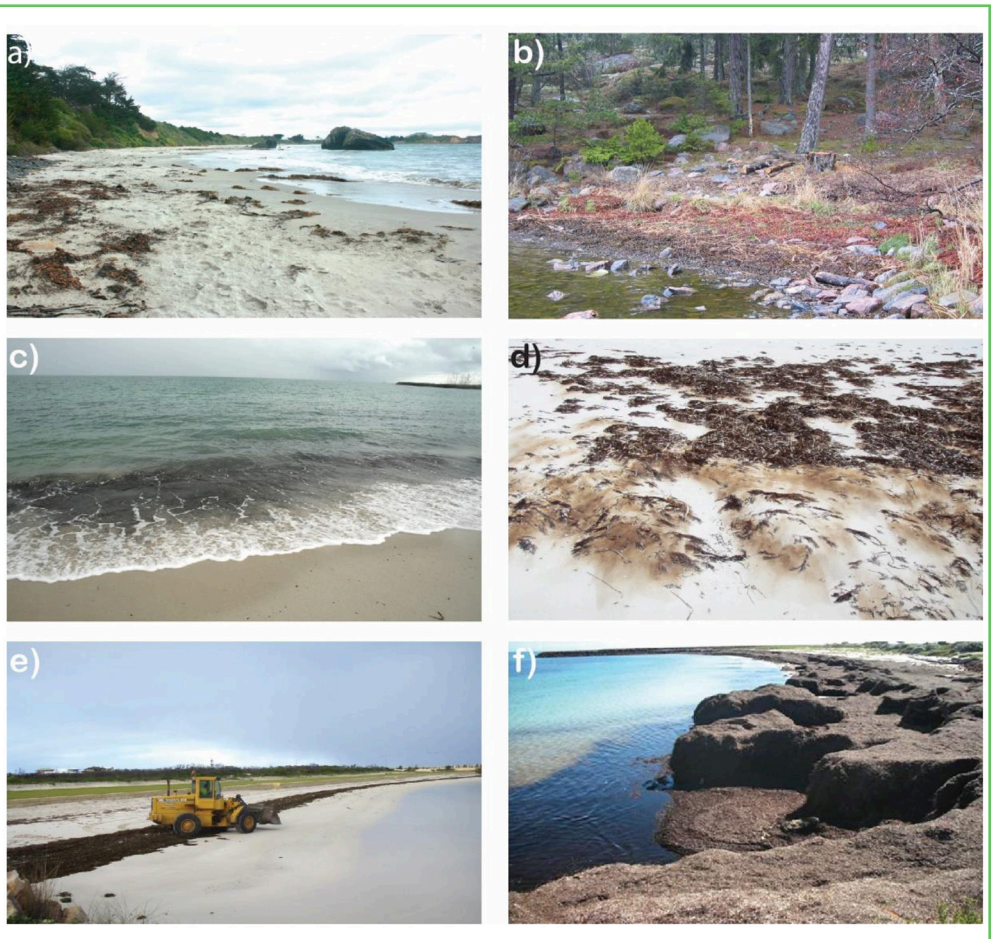

Figure 1

ECOSYSTEM FUNCTIONS AND SERVICES

Ecosystem functions are the interactions between living and non-living things that maintain a healthy environment. These can include things

ECOSYSTEM SERVICES

Helpful things that nature gives us to make our lives better.

such as the production of food by plants through photosynthesis as well as pollination, in which bees visit plants to collect nectar and in turn help the plants complete their life cycles. **Ecosystem services** are the group of ecosystem functions that benefit people. Marine plants that become wrack along the coastline also perform important functions and provide ecosystem services that benefit humans. Next, we will describe some of these functions and service, illustrating why it is important to share the beaches with wrack and the creatures that live in it, to maintain a healthy environment.

LITTLE CREATURES CALL WRACK HOME

The coastal habitat can be very harsh but beach wrack makes an excellent home for many animals, providing safety from predators and other dangers such as heat (Figure 2). Most of the animals that make beach wrack their home are invertebrates (animals without backbones), including beetles and tiny crustaceans called isopods and amphipods (kind of like a shrimp). Some of these animals are only found in beach wrack and do not live anywhere else, making wrack very important for the survival of these species. Beach wrack is also a fantastic nursery for many invertebrates, such as adorable baby maggots.

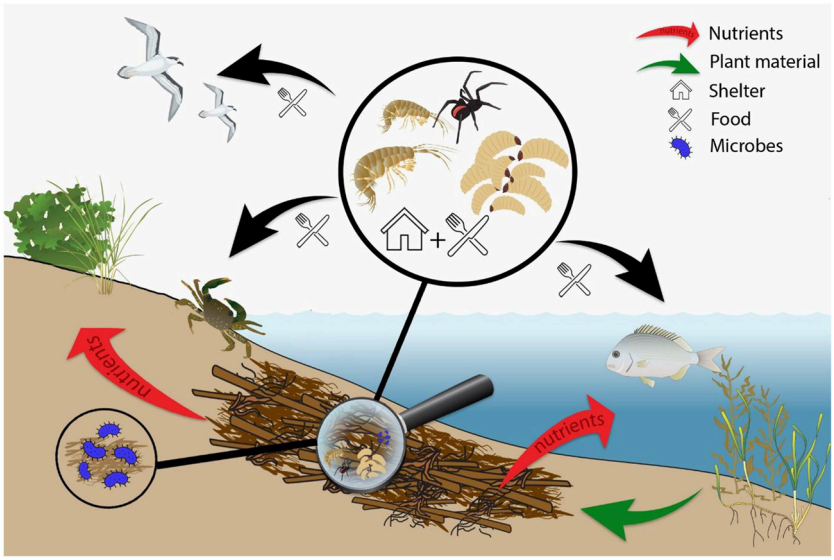

Figure 2

A closer look at the ecological roles of wrack. The green arrow points out how living seagrass is transported onto the beach to make wrack. The magnifying glass zooms in on some beach wrack to display tiny microbes as well as other little creatures that use wrack as shelter and food. The arrows coming from the magnified view outline what other animals then feed on the tiny creatures that live in the wrack. The red arrows display how nutrients from wrack can be transported to land environments or back to the ocean.

DETRITIVORES

Animals that eat dead plants and animals.

FOOD WEBS WITHIN WRACK

Most of the animals that live in wrack are **detritivores**, meaning they love to eat dead plant material (detritus) just like roly-polies in your garden. But not all marine plants are equal when it comes to being food! The detritivores in wrack love to eat kelp, a type of seaweed,

because it is more nutritious than seagrass. But the ability to eat even their favorite food depends on how moist it is, as dry food is hard to eat. It also depends on the amount of microbes (e.g., bacteria) on the detritus, which are very tasty! These microbes improve the food quality for detritivores by breaking down the detritus. Microbes themselves are also a food source.

Greater amounts of food on the beach leads to larger numbers of invertebrates, which are eaten by fish in the water or beetles and spiders on the beach. Many fish in wrack are young and benefit from feeding on amphipods in the wrack. These fish can then be eaten by larger fish or birds in, around, or above the wrack. Similarly, emerging kelp flies and their maggots become food for birds. In this way, wrack supports a whole **food web** on the beach and in the shallow waters (Figures 2, 3) [1].

FOOD WEBS

A connection of food chains that involve animals feeding on each other.

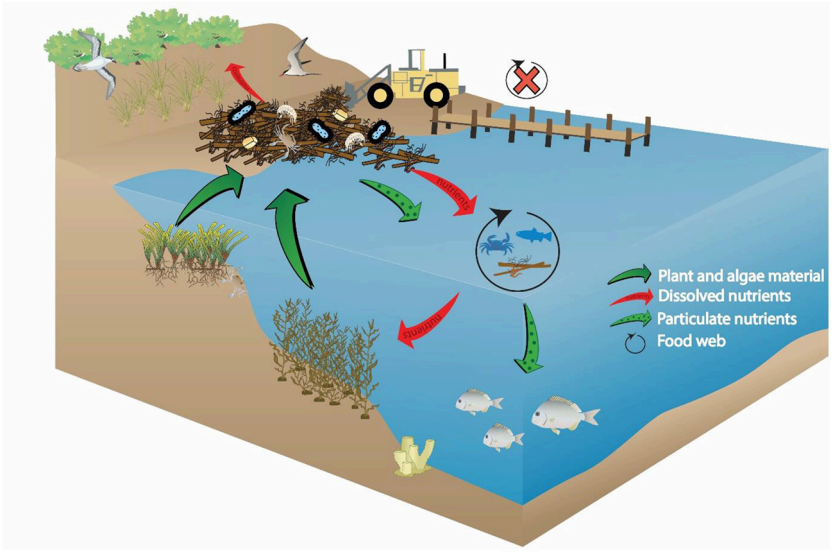

Figure 3

The lifecycle of wrack, showing its source and flows of nutrients it provides between land and sea, and how the cycle can be disrupted or broken by removal and coastal development. This cycle involves seaweed and seagrass being transported to the beach where it forms wrack. This wrack then breaks down and provides nutrients to the land, or back to the ocean as dissolved (similar to how salt dissolves in water) or particulate nutrients (solid food), which then fuel marine food webs and help maintain healthy ecosystems. When wrack is removed from beaches, these cycles can be negatively impacted.

NATURE'S FERTILIZER

Similar to a compost bin at home, beach wrack is a slow-release fertilizer in the ecosystem as it gradually breaks down (Figure 3). The nutrients in wrack—for example, nitrogen—provide the energy needed for life—, just like carbs, fats, and proteins do for us. Tiny microbes feeding on the wrack help to break it down and release its nutrients through the process of **decomposition** [2]. You may have noticed a funky smell at the beach; this is caused as the wrack breaks down and releases toxic "rotten egg" gas (called hydrogen sulfide). Similarly, invertebrates feeding on the wrack digest the plant material and their poop also adds to the nutrients. Altogether, this maintains a healthy environment where plants, algae, and animals grow, die, and decompose in the wrack cycle of life.

DECOMPOSITION

Breakdown of organisms once they die.

CONNECTING LAND AND SEA, THE WRACK CIRCLE OF LIFE

Wrack is a temporary feature on beaches but plays a vital role in the connection between land and sea (Figure 3). Above, we highlighted the importance (for invertebrates and juvenile fish) of wrack on the beach and in the surf zone (area of the beach where waves crash). The nutrients taken up by the juvenile fish are taken out to deeper waters where the fish eventually become adults and reproduce [2]. In this way, nutrients in wrack connect the beach with the open ocean. Similarly, invertebrates in wrack can be eaten by land animals that then transfer nutrients inland [3]. You will also remember we discussed dissolved nutrients being recycled through decomposition of wrack. Once released, these nutrients can be washed back into the ocean where they are used by ocean plants to grow, or they can be used by shoreline vegetation.

WRACK OFF!

LANDFILL

Big holes in the ground where people bury rubbish.

Despite the clear ecological importance of beach wrack, it is often unloved by people. Our desire to lounge on clean, white beaches has led to frequent removal of wrack which then get dumped in **landfills** (Figure 1e). That is truck load after truck load of habitat and food being removed! This practice also leads to the release of greenhouse gases, such as carbon dioxide and methane, as the wrack decomposes in the landfill.

Coastal development (think marinas and jetties) can have a massive impact on wrack. These developments can destroy the seaweed forests and seagrass meadows that create the wrack, and can trap large amounts, preventing it from moving along the shoreline. This can cause marinas to be clogged up with wrack, or mountains of it to build up on beaches (Figure 1f), releasing toxic gases. This trapping also breaks the cycle of wrack shown in Figure 3, starving other areas that need wrack to function properly.

Questions remain about the impact that climate change will have on wrack. In many colder locations, seaweeds and seagrasses are being lost as the oceans warm. Will these cool-region seaweeds and seagrasses simply be replaced by other, warm-water species that provide the same ecosystem functions and services? Climate change may also alter where and how much wrack accumulates on coasts due to altered currents, sea-level rise, and the number and intensity of storms.

Many people may view wrack as a smelly nuisance, but it is essential for keeping our coasts healthy and productive. Changing people's perspective on wrack is a critical first step in ensuring that we manage

it, and our coasts, sensitively and sustainably. It is important that we continue to learn about beach wrack, the creatures that call it home, and the impacts of its removal, so we can ensure correct management for healthy beaches into the future. Where possible, it is encouraged that wrack be left on the beach so it can be buried by sand and add to the structure of the beach face, helping to limit **erosion**, or be washed back into the ocean where it will break down and continue to add to the food web.

EROSION

When wind and waves cause the beach to wear away.

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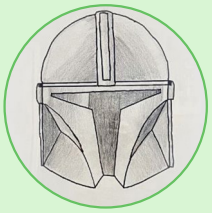
CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

HARMONY, AGE: 12

Harmony is a 12-year-old that loves birds, biology, and stick figures. Some of her favorite hobbies include birdwatching, bird photography, reading, and booping her bunny Spot.



SAMARTH, AGE: 13

I am 13 years old, and I am interested in science and math. One of my favorite things to do is to read and play music. I play piano and trumpet in the school band. I also love history, sports, and cooking!

AUTHORS

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Shannon is a marine ecologist who studies ecosystem interactions and functions. Her Ph. D. focused on inshore coral reefs of northwest Western Australia, which are exposed to harsh environmental conditions. She is now researching intertidal habitats of the same coastline as a post-doctoral research fellow at Edith Cowan University, with the aim of understanding rates of primary production and nutrient flows within these ecosystems. *s.dee@ecu.edu.au

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Jess is an early career marine scientist and recently completed a master's with Edith Cowan University. Her master's research focused on the interactions between kelp beds and seagrass meadows and how connections between marine systems can alter food webs. Jess is now working as an early career scientist investigating seagrasses and algae in estuaries along the Western Australian coast and contributing to their management.

PAUL S. LAVERY

Paul is a professor of marine ecology at Edith Cowan University. He has more than 30 years of experience working in marine science. He is an expert on the ecology of seagrass ecosystems. Paul established and implemented the W.A. State Government's seagrass monitoring programme and is involved in global research programs that examine the role of seagrasses and other blue carbon ecosystems (carbon that is stored in the ocean and coastal places like mangroves, salt marshes, and seagrasses) in climate change mitigation. He published the first estimate of Australia's blue carbon sequestered in seagrasses. This research has informed the

Australian government's blue carbon method for climate change mitigation and its associated model "BlueCAM".

OSCAR SERRANO GRAS

Oscar Serrano is a senior researcher at the Spanish National Research Council. His research focuses on how humans have impacted the landscape over the past centuries. His research contributes to the understanding of how we can manage coastal ecosystems to slow climate change and to preserve the biodiversity of plants and animals living along our coasts.

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John Whale is a postdoctoral research associate at Edith Cowan University in Australia whose expertise is understanding the capacity of native plants and their ecosystems to adapt to climate change. This aims to help management and conservation of our native forests.

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Glenn is a professor of marine ecology at Edith Cowan University, and his research focuses on marine ecology and fisheries science. Specifically, he studies food webs within and between habitats in the marine environment; interactions of animals with coastal habitats, such as seagrass meadows and surf zones; and fisheries interactions with the environment and management. He primarily seeks to understand the importance of the movement of nutrients from one habitat to another in coastal seascapes.