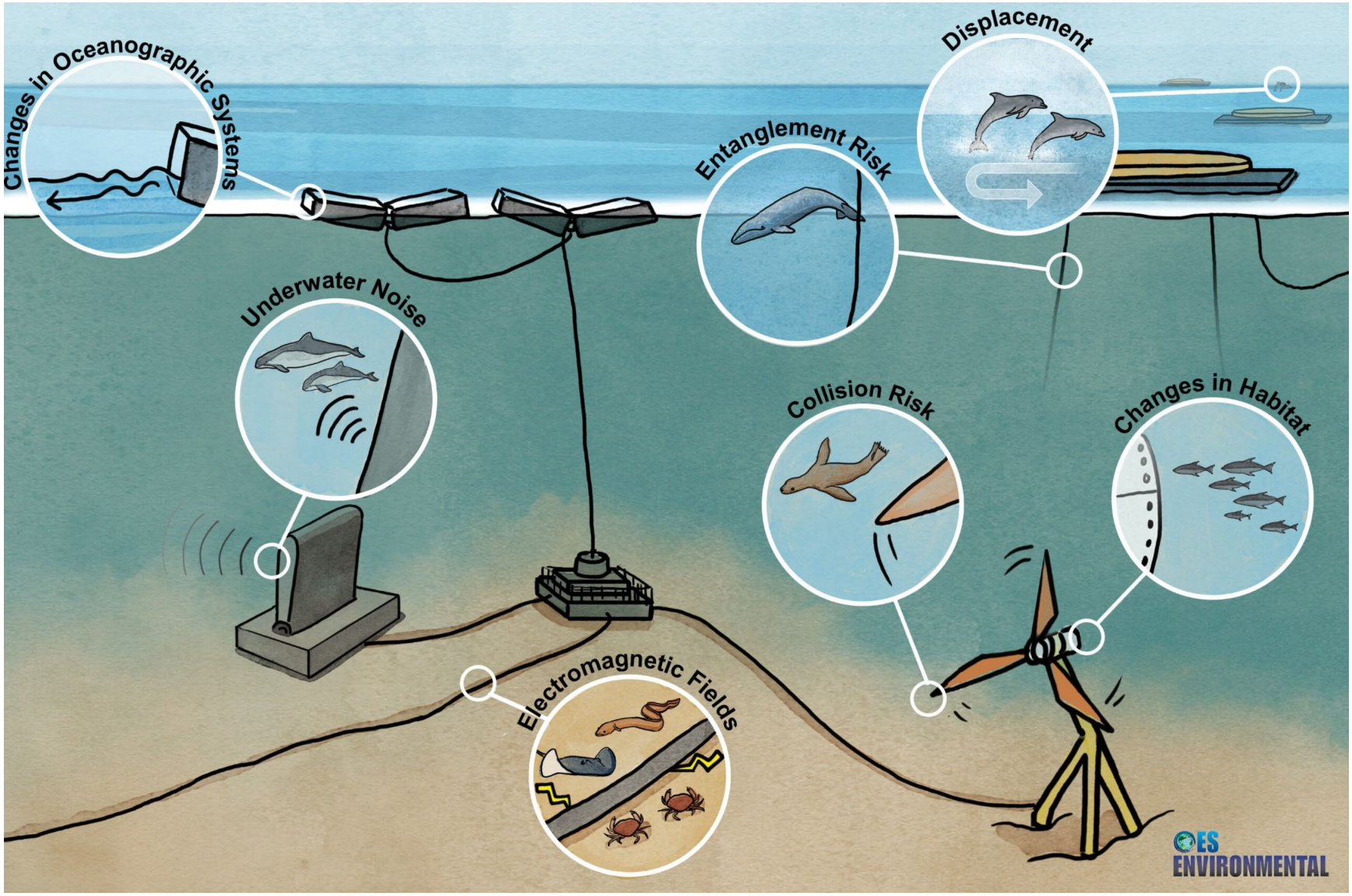
Marine Renewable Energy and the Environment: A Coloring Book



For more information and educational materials, see https://tethys.pnnl.gov/marine-renewable-energy-educational-resources

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U.S. DEPARTMENT of ENERGY | Pacific Northwest NATIONAL LABORATORY | OES ENVIRONMENTAL | TETHYS

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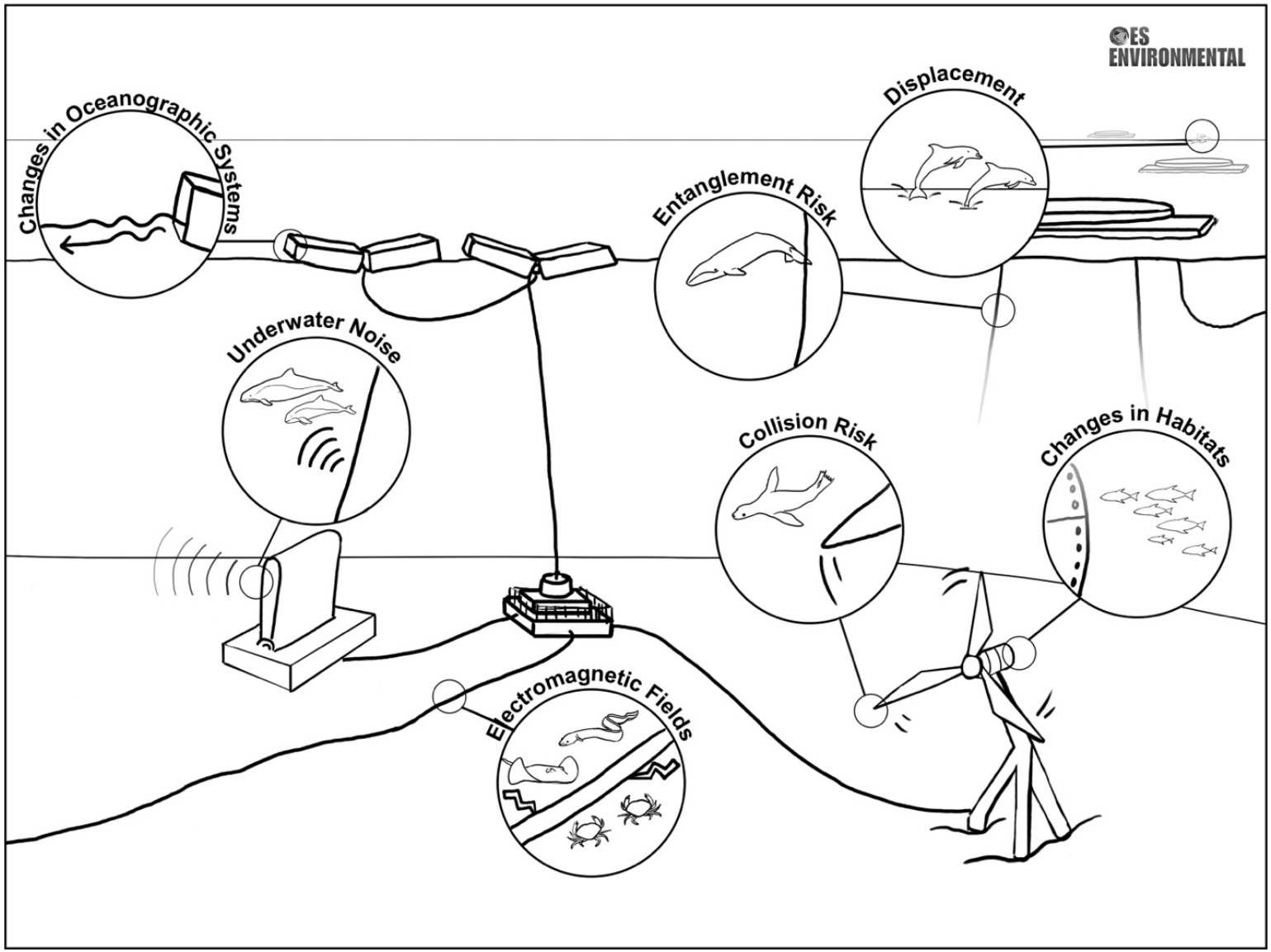
Marine Renewable Energy and the Environment

Marine renewable energy devices generate electricity from the ocean's waves, tides, and currents. As these devices are installed in the ocean to provide clean energy and help address climate change, it is possible that they could affect the marine environment. However, scientists and engineers are making sure animals and their habitats will not be harmed. As you look through the coloring pages, you will learn more about how marine renewable energy devices interact with the environment.

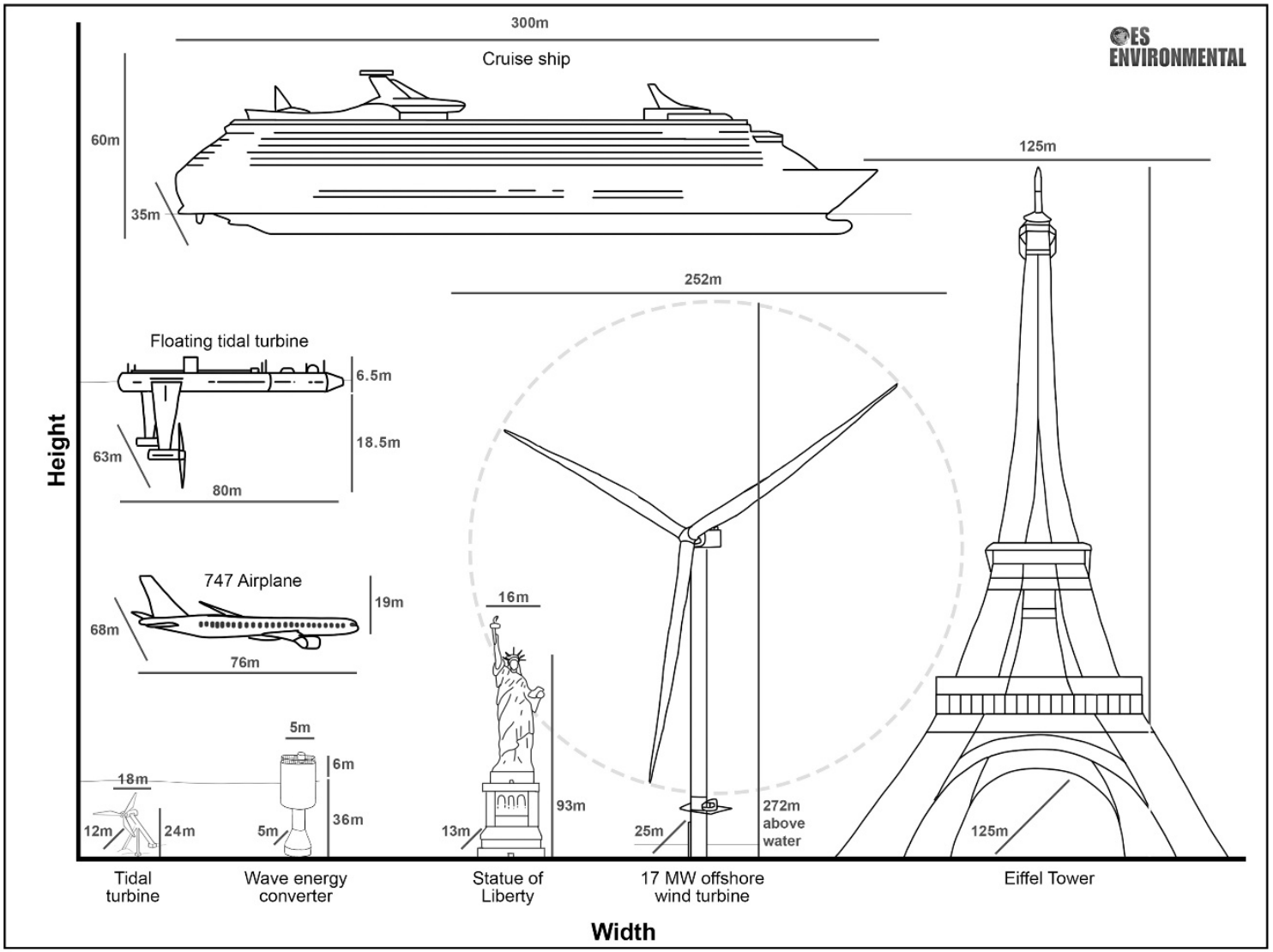
Find and color the animals and the marine renewable energy devices! How many different animals can you count?



Marine Renewable Energy Device Sizes

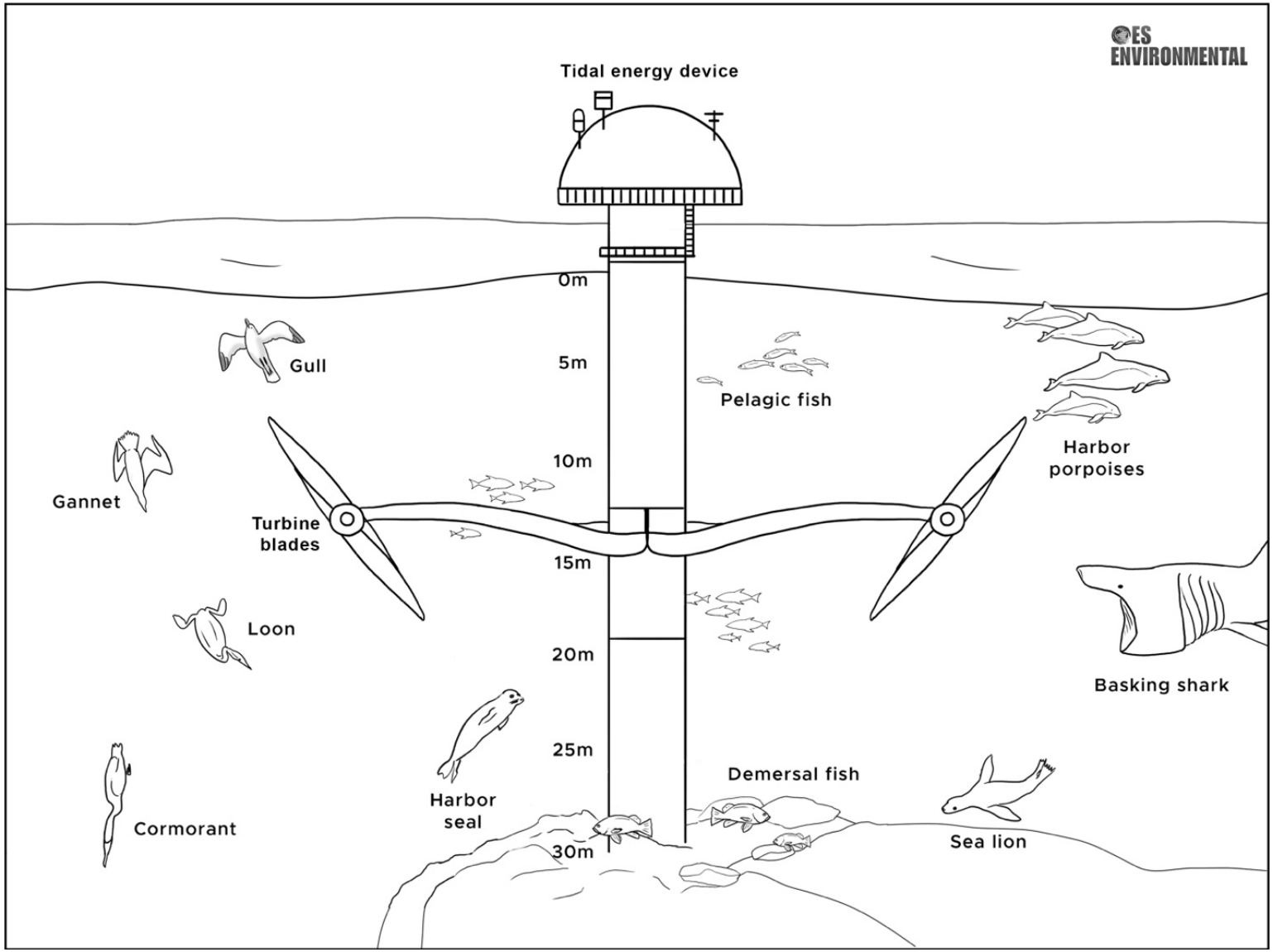
Marine renewable energy devices come in different shapes and sizes and are placed in different areas of the ocean. Some float on the surface of the water, some are mostly submerged with only small parts visible above the surface, and others are placed on the seafloor and cannot be seen at all above the water.

Below, you can see how the size of marine renewable energy devices (tidal turbine and wave energy converter) compares with some commonly seen technologies (e.g., cruise ship, airplane, wind turbine) and world landmarks (e.g., the Eiffel Tower and the Statue of Liberty). Are the wave and tidal energy devices bigger or smaller than you thought?



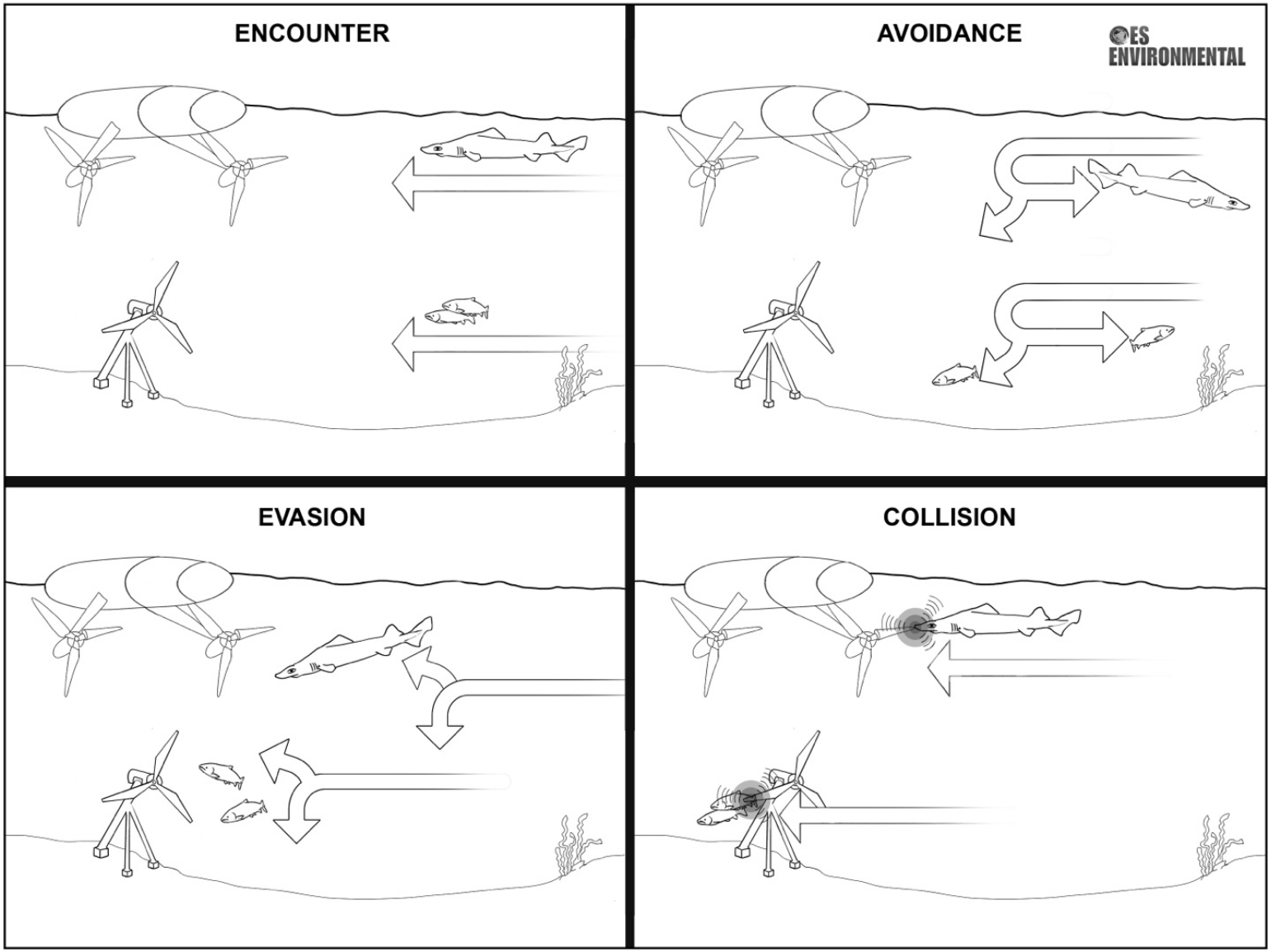
Collision Risk for Marine Animals around Turbines

Marine renewable energy devices have many different parts. Some of them, like the slow-moving, rotating blades of tidal turbines, could hurt marine animals if they swim too close to the device and collide with these moving parts. However, some studies show that marine animals can see and/or hear a device and avoid it, even from far away. Also, no scientist has ever seen a marine animal collide with a tidal turbine in the ocean!



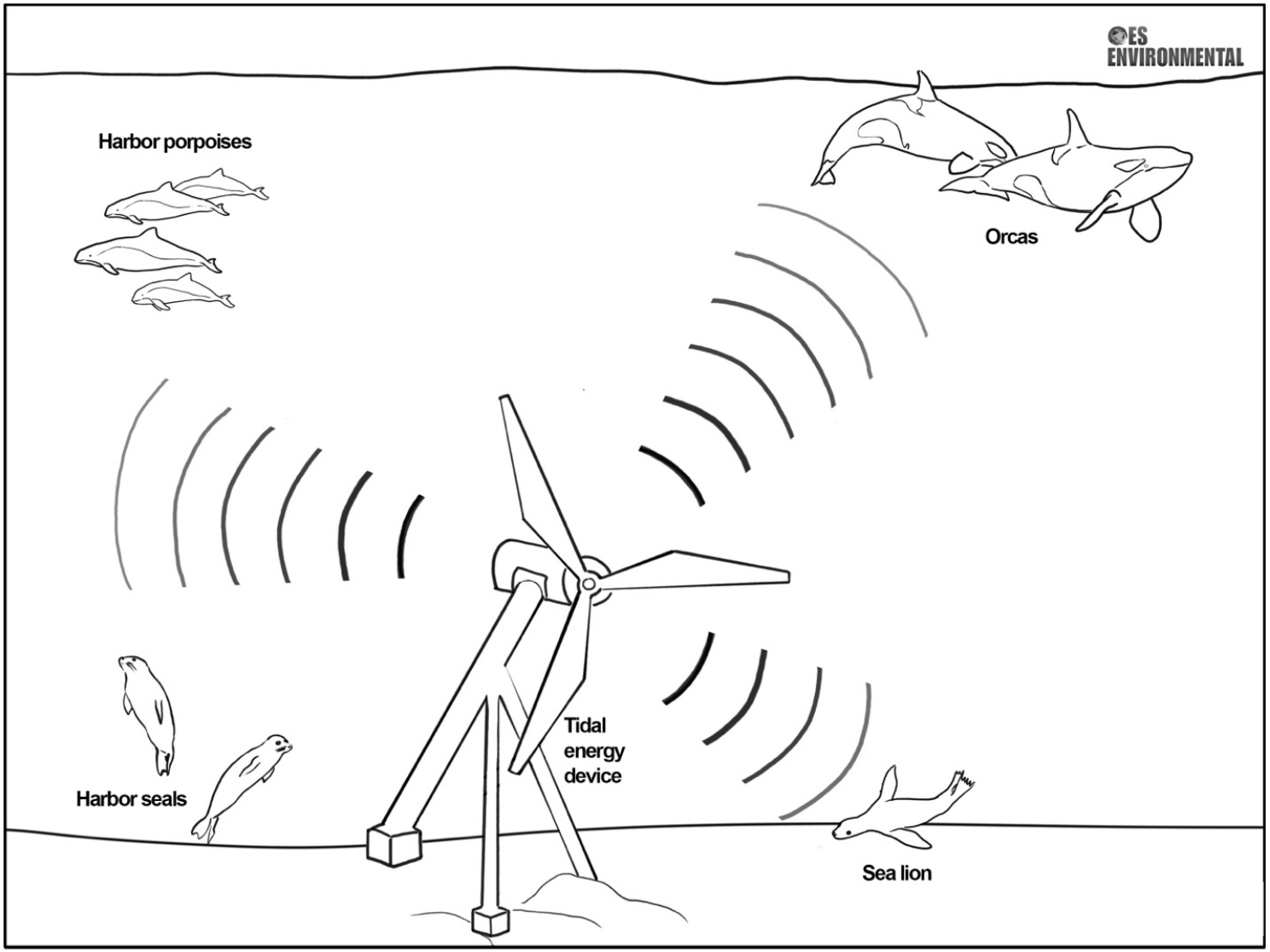
Collision Risk for Marine Animals Around Turbines

When an animal approaches a tidal turbine, we say it encounters the device. Several outcomes may happen when an animal encounters a turbine. The animal could swim away and avoid the device before getting too close to it (avoidance); it could swim closer to the device and then swim around or away from the device before getting hit (evasion); or it could swim into moving parts of the device, like the rotating turbine blades, and collide with them (collision). So far, the most common behavior seen by scientists around turbines has been avoidance.



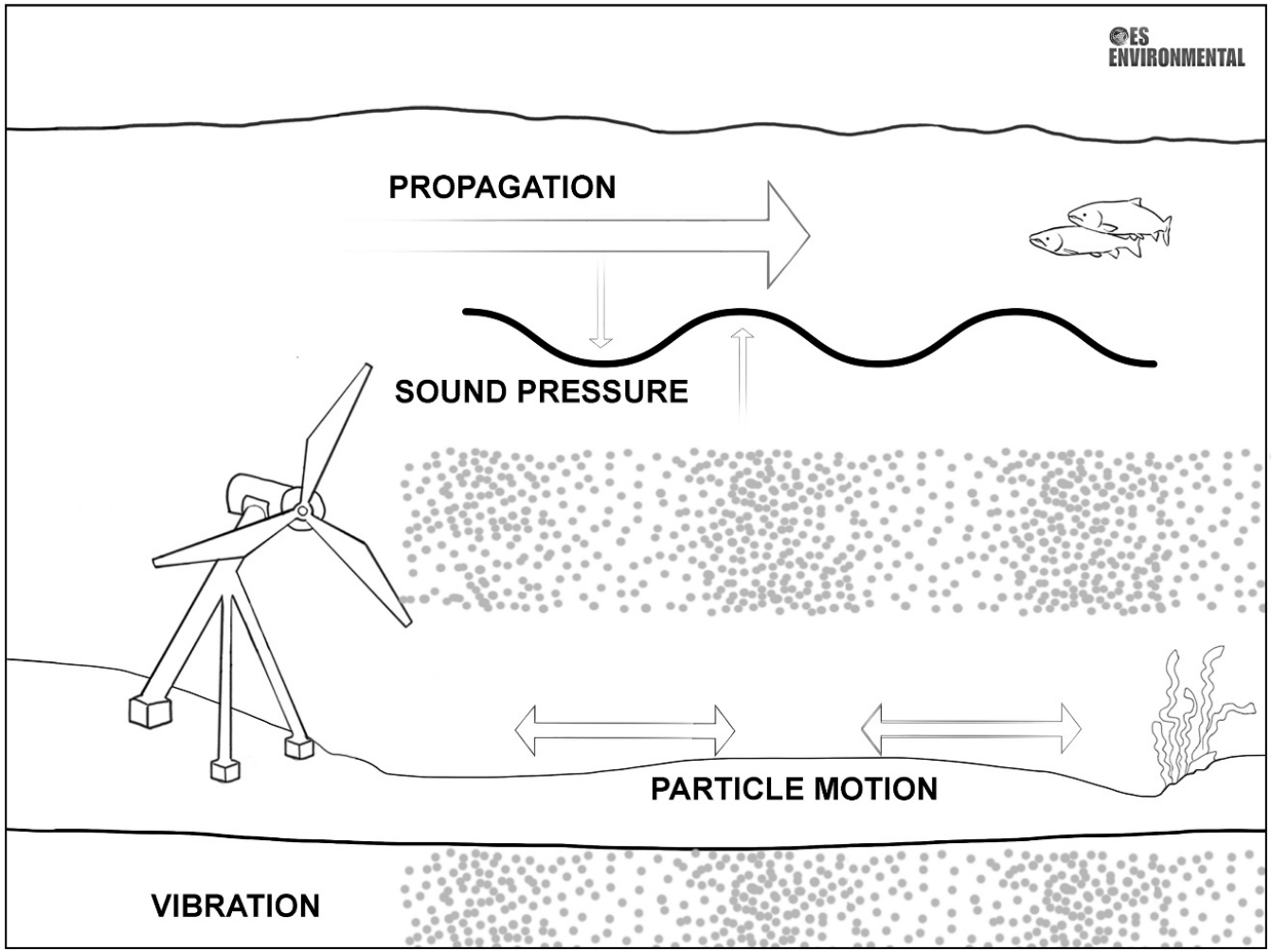
Risks to Marine Animals from Underwater Noise Generated by Marine Renewable Energy Devices

In the ocean, many marine animals use sound to communicate, find food, and escape from predators. Marine renewable energy devices in the water can add noise that could be heard by marine animals. This additional noise could cover up animal's sounds or cause harm to the animals. Engineers who make marine renewable energy devices have designed them to be as quiet as possible, and scientists have found that most underwater noise from marine renewable energy devices is low enough that it is unlikely to harm marine animals.



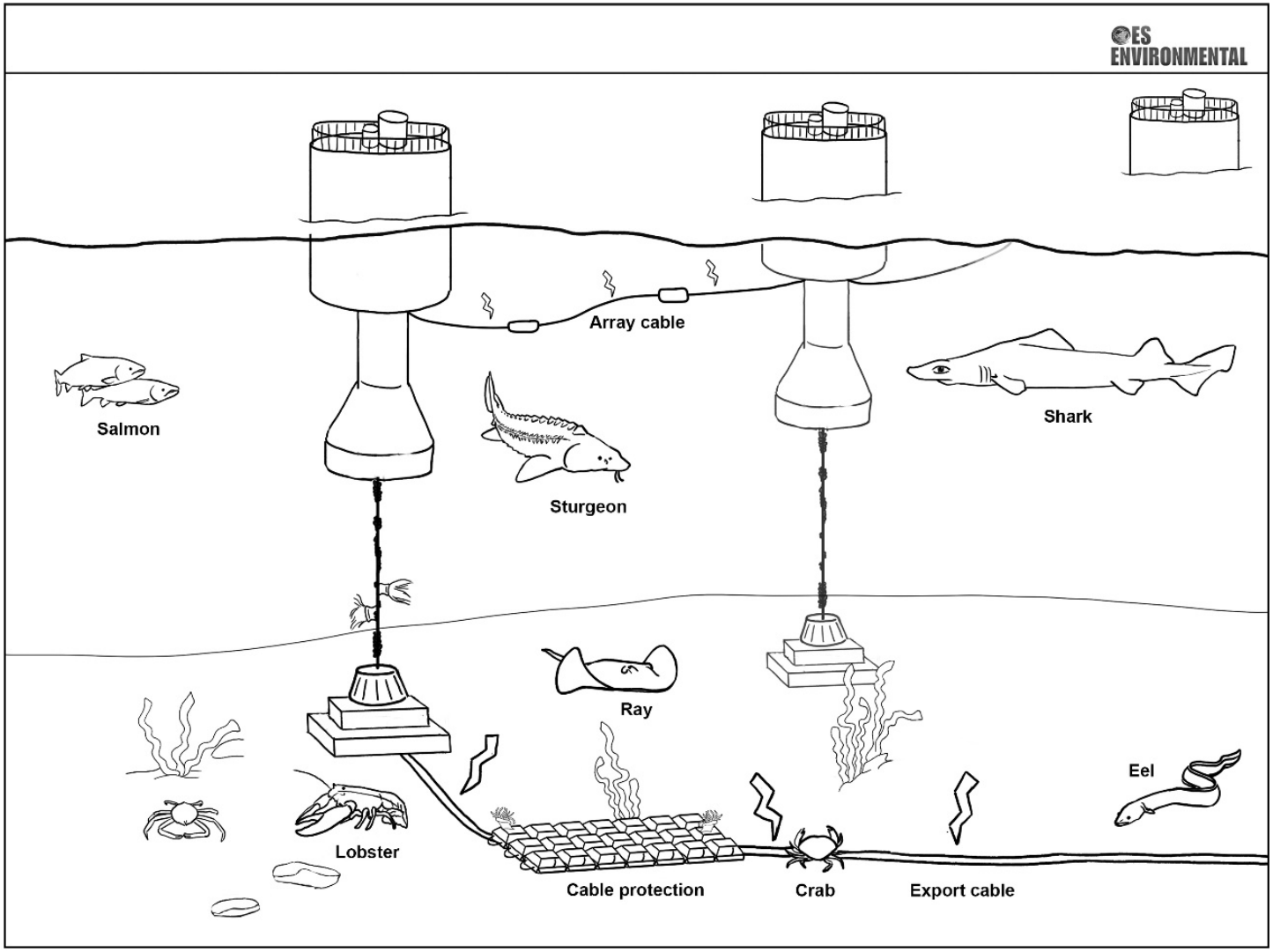
Risks to Marine Animals from Underwater Noise Generated by Marine Renewable Energy Devices

When marine renewable energy devices make noise, that sound moves in several ways. A sound wave is the way sound moves through something, like air or water, to get from one place to another, also called propagation. Sound pressure is the small change in air or water pressure when the sound wave travels through it, creating areas of high and low pressure. In addition, the noise can cause individual particles in the water column and in the seafloor sediment (such as sand) to move from side to side. This is called particle motion (in the water) and vibration (in the sediment). It is important to understand how noise is created and spreads from devices so that scientists can make sure marine animals are not harmed by it. Note on the image below how the particles in the water and sediment are closer together where the sound pressure is high (up arrow) and more spread apart where the sound pressure is low (down arrow).



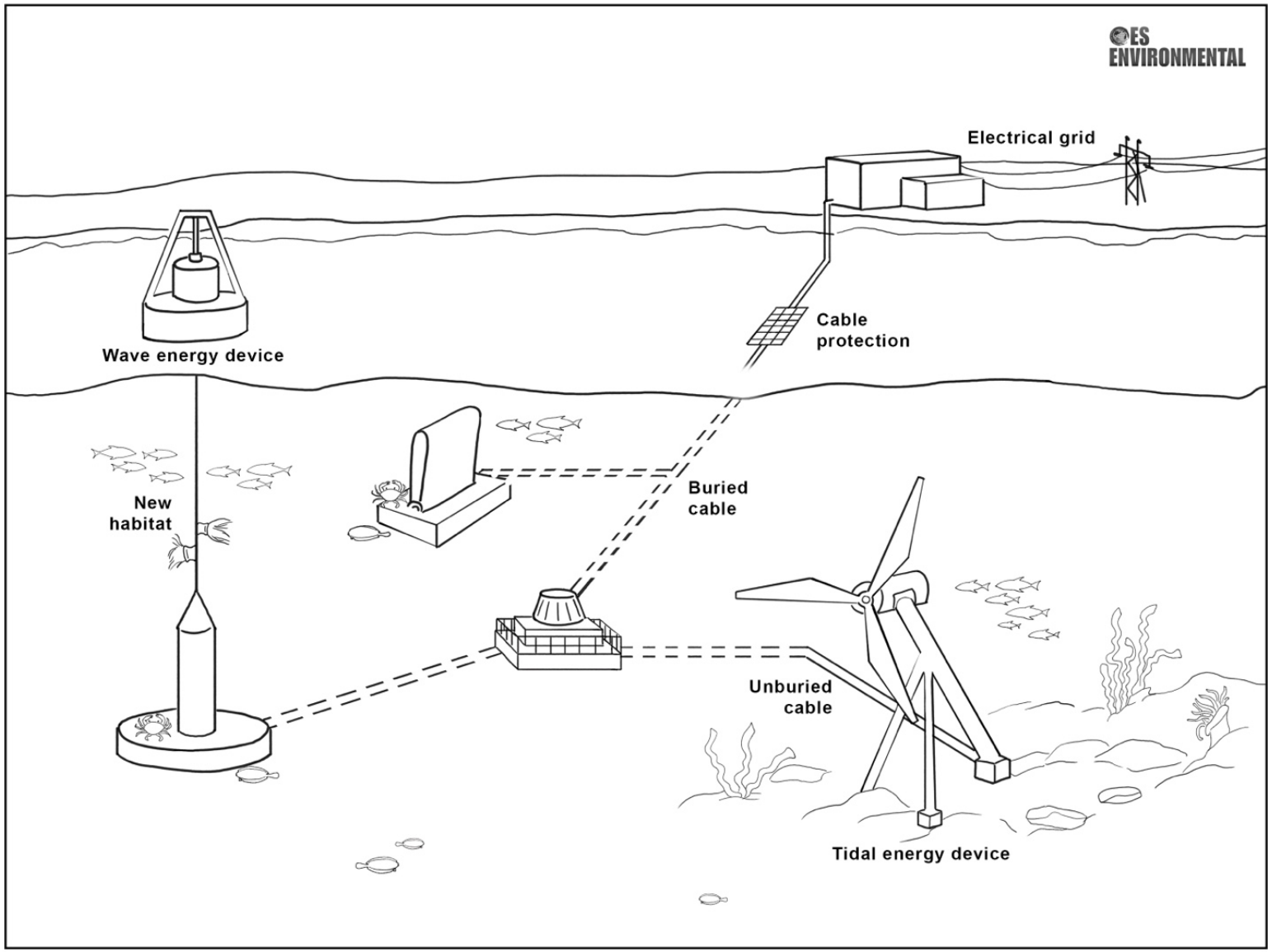
Electromagnetic Fields Effects from Power Cables and Marine Renewable Energy Devices

Some marine animals, such as crabs and sharks, can sense natural electric and magnetic (or electromagnetic) fields. These animals use electromagnetic fields to find food and explore their environment. Electric cables from marine renewable energy devices can add new electromagnetic fields to the environment, which could confuse the animals that rely on the natural fields. Scientists have studied this, and while some sensitive animals may act differently around marine renewable energy cables, they are unlikely to be harmed. In fact, cables can be buried underneath the seabed or covered with concrete and other materials to keep animals from coming too close to the cables and their electromagnetic fields.



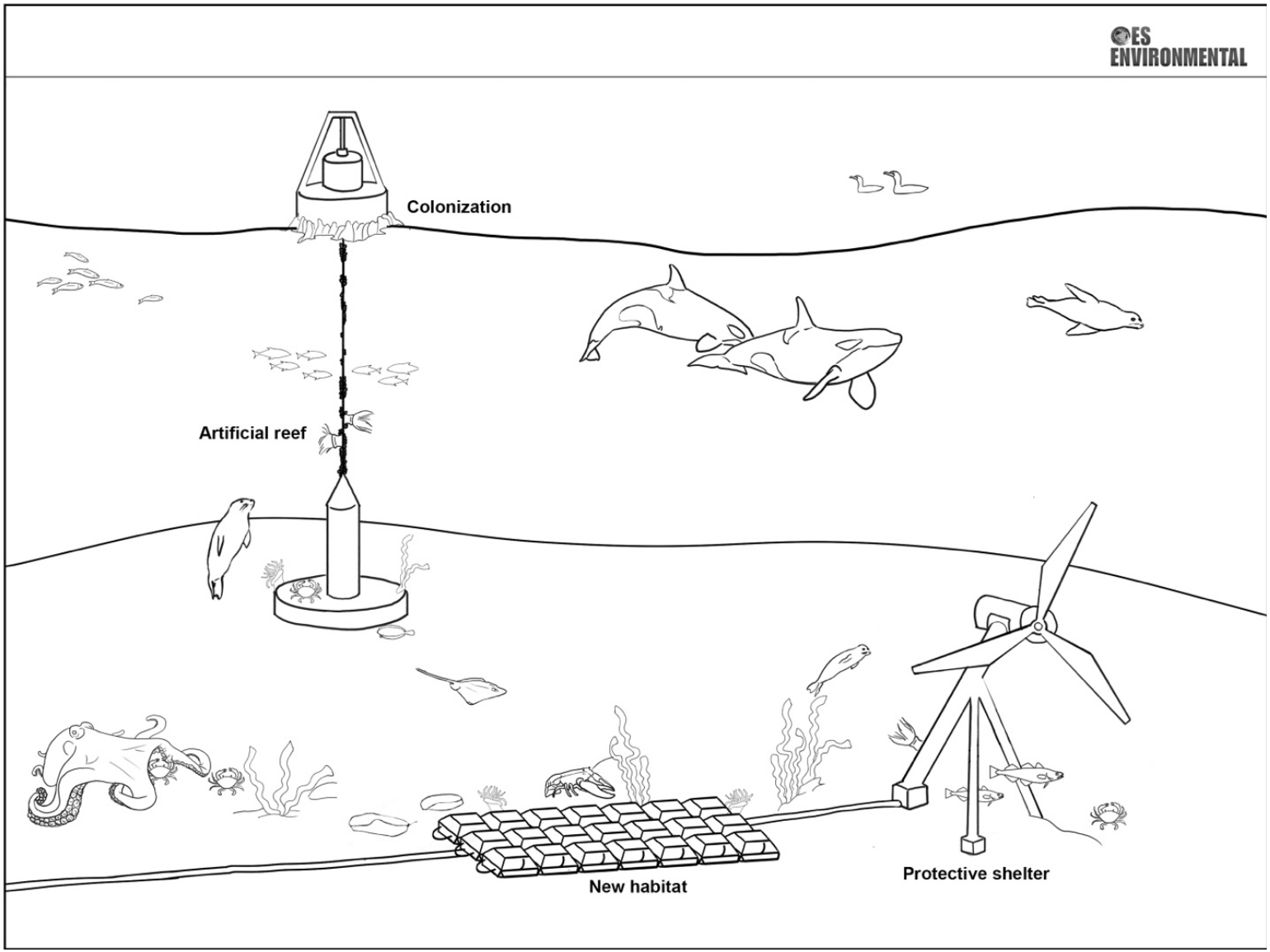
Changes in Benthic and Pelagic Habitats Caused by Marine Renewable Energy Devices

Adding any human-made structure to the marine environment can affect the habitats that marine animals rely on. These structures can be piers, sunken ships, pipelines, or marine renewable energy devices. Marine renewable energy devices can be placed on the seafloor, in the middle of the water column, or on the surface of the water. Many devices will also have electric cables or anchors on the seafloor that may be buried or have coverings or cable protections. Placing these devices, cables, and anchors seafloor (benthic) and water column (pelagic) habitats may cause changes to these habitats and the animals that use them.



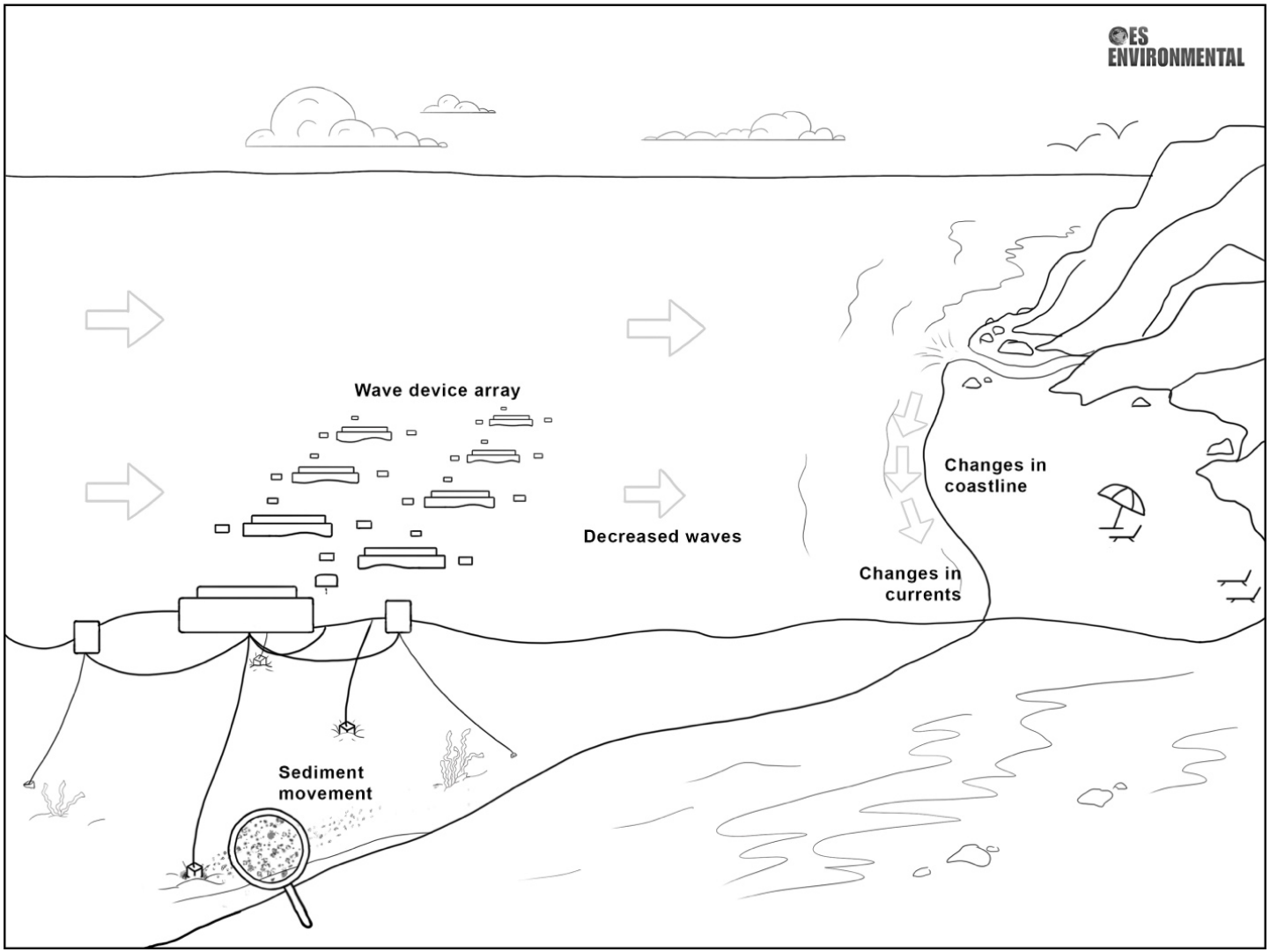
Changes in Benthic and Pelagic Habitats Caused by Marine Renewable Energy Devices

Marine renewable energy devices installed on the seafloor (benthic) or in the water column (pelagic) can create new habitats for marine animals or take away existing habitats. While these changes in habitats may affect marine animals, scientists have found that habitats recover over time from disturbances caused by installing or operating marine renewable energy devices. However, in most cases, marine renewable energy devices provide new homes and shelters for local marine animals, especially offering protection for larvae and juveniles.



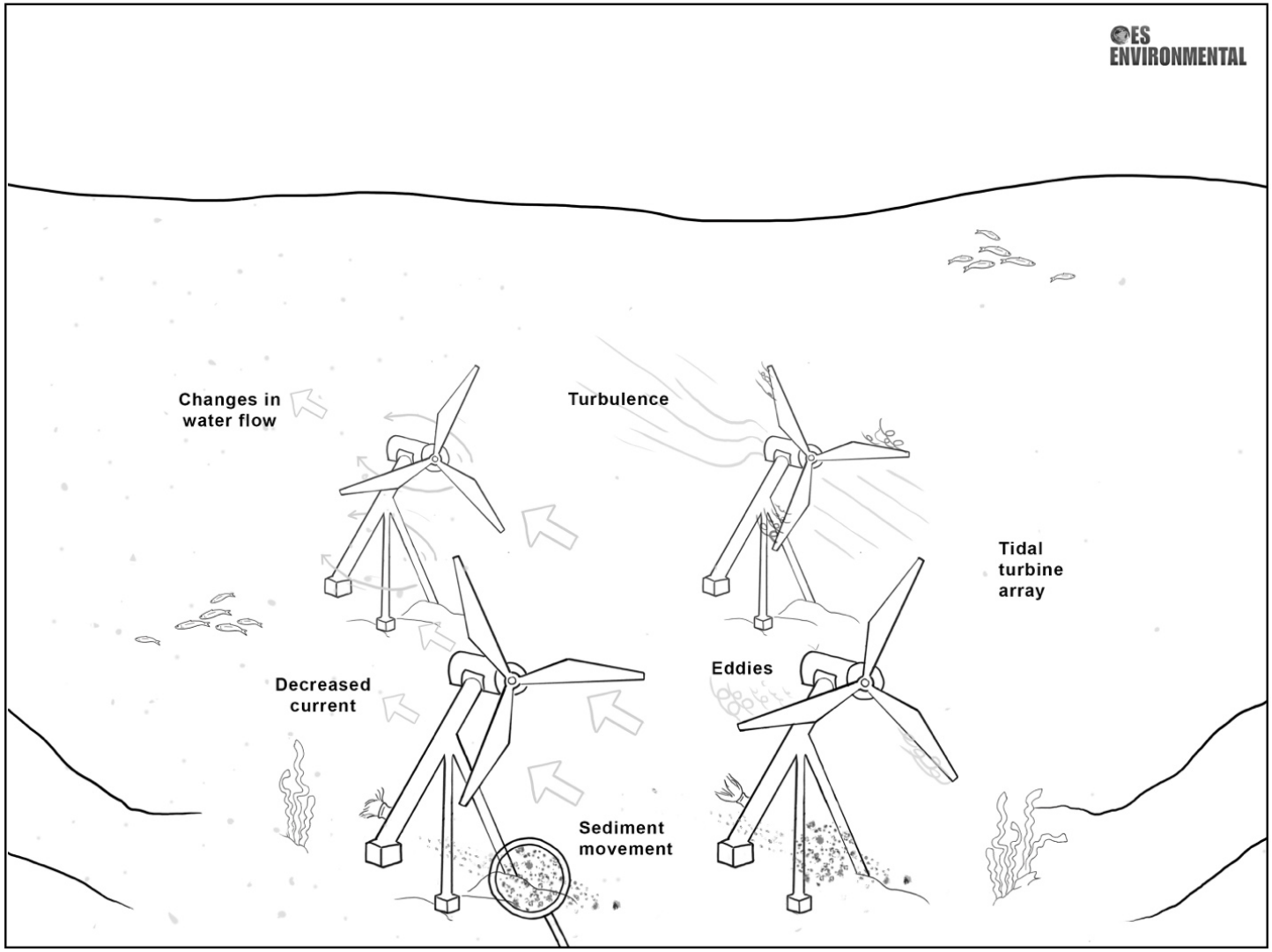
Changes in Oceanographic Systems Associated with Marine Renewable Energy Devices – Wave Energy

There are many important processes in the ocean, including the movement of the waves and tides, sediment (like sand and rocks), and nutrients – these are oceanographic systems. Marine animals and the environment rely on these processes and placing marine renewable energy devices in the water can affect them. Both wave energy devices (shown below) and tidal energy devices (shown on the next page) can reduce the power of the waves or the tides as they use those water movements to create electricity. This can change the direction and power of waves on the surface, make the water move more slowly or in new ways around the device, or change the movement of sediment.



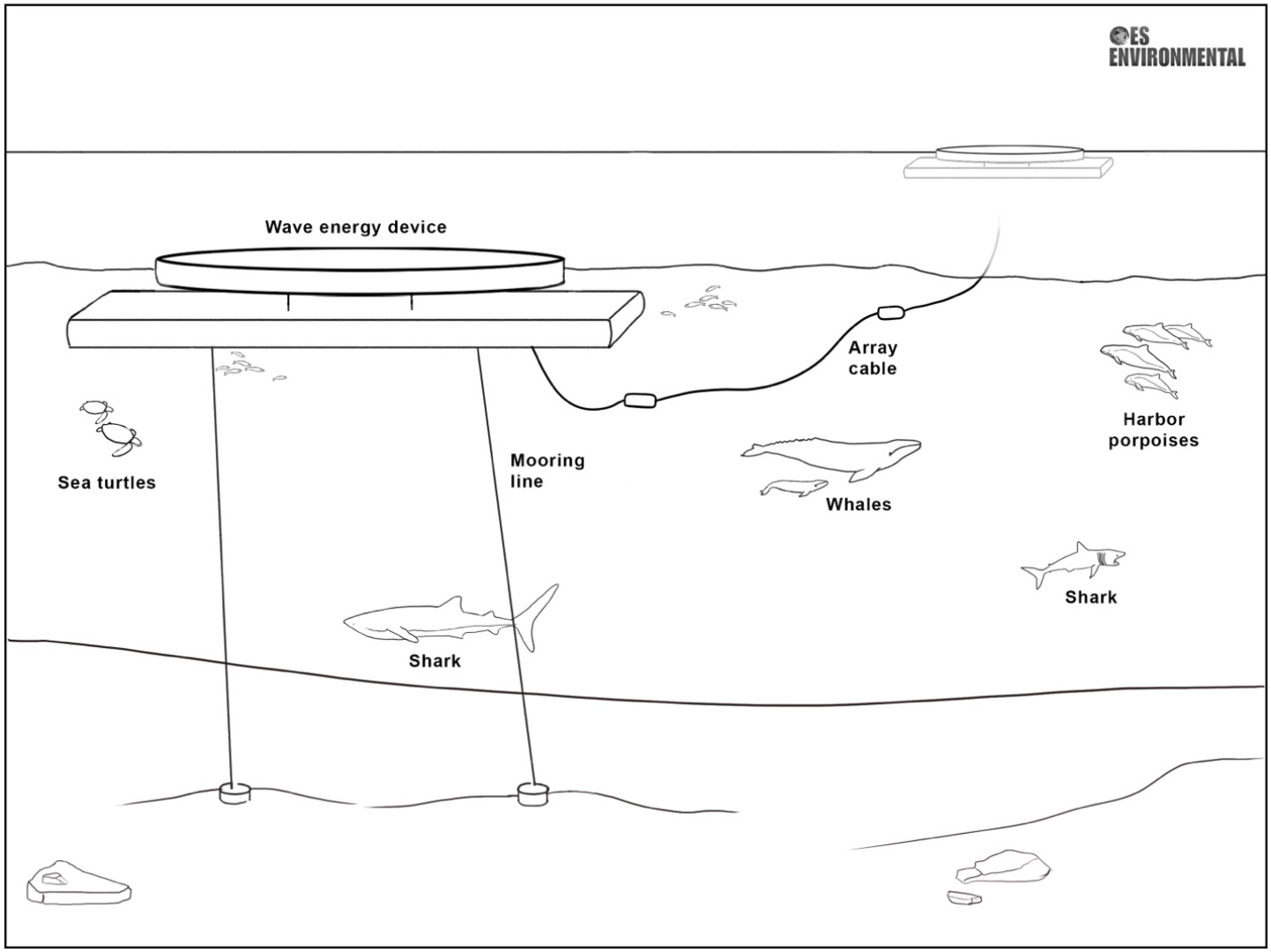
Changes in Oceanographic Systems Associated with Marine Renewable Energy Devices – Tidal Energy

The changes to oceanographic systems are mostly a concern when there are many marine renewable energy devices grouped together (called an “array”). Understanding how water movement, sediment along the coastline, and other parts of oceanographic systems will change when new devices are placed in the ocean is important for scientists to keep marine environments, animals, and people safe. Scientists have used computer models to predict potential effects on the environment, but measurements around arrays of marine renewable energy devices are needed to better understand these impacts to oceanographic systems.



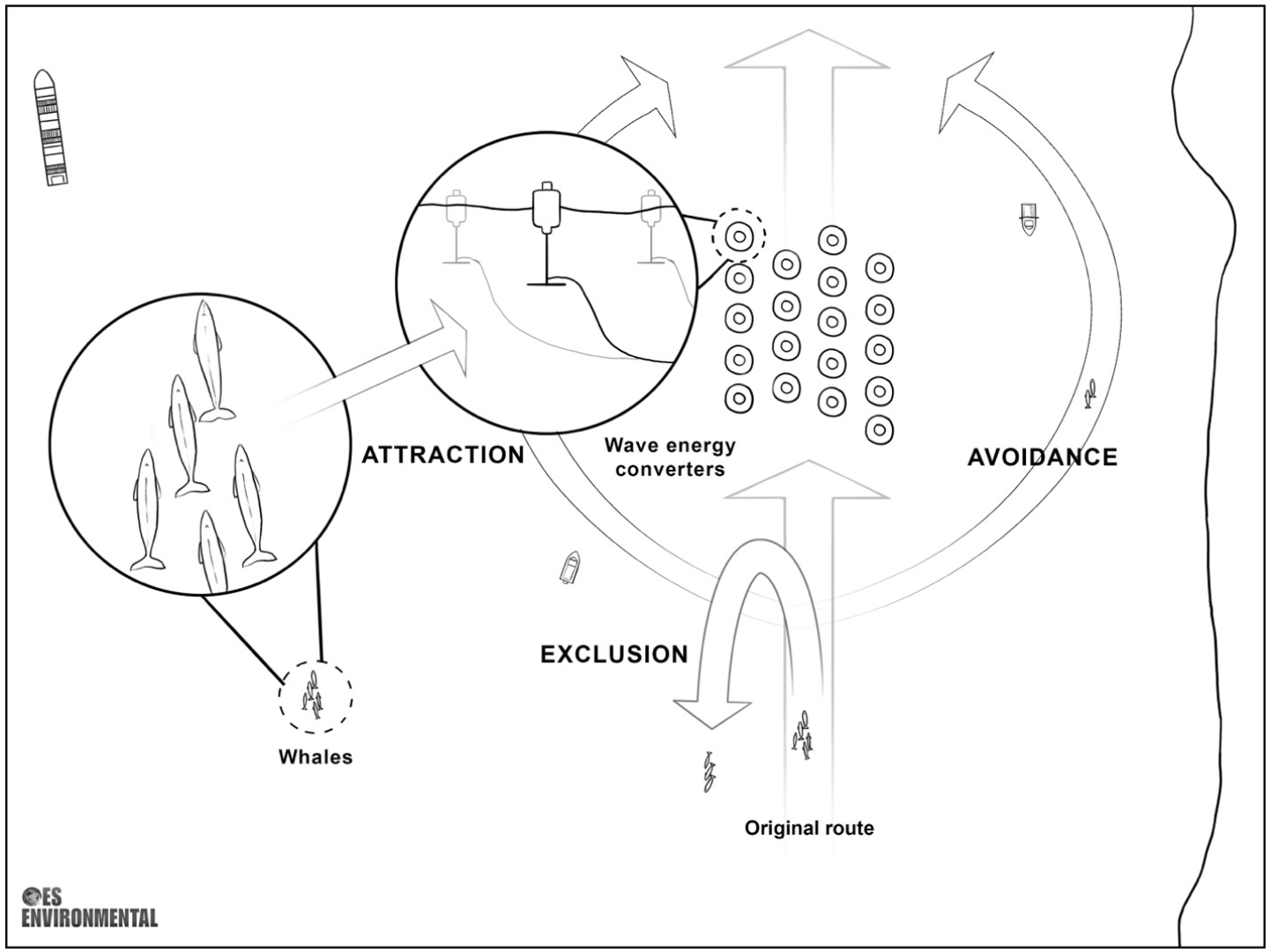
Entanglement Risk with Marine Renewable Energy Mooring Lines and Underwater Cables

Floating marine renewable energy devices are attached to the seafloor with mooring lines and anchors to keep them in place. Devices may also have electrical cables that connect them together under the water. Whales and other large marine animals can come close to these lines or cables while swimming in the ocean. Although there is a chance that animals could become tangled in the lines or cables, engineers have designed them to be tight so they will not create loops for animals to be caught in and are as safe as possible. Scientists have not seen any entanglement of animals around marine renewable energy devices and do not expect animals to be harmed by mooring lines and cables.



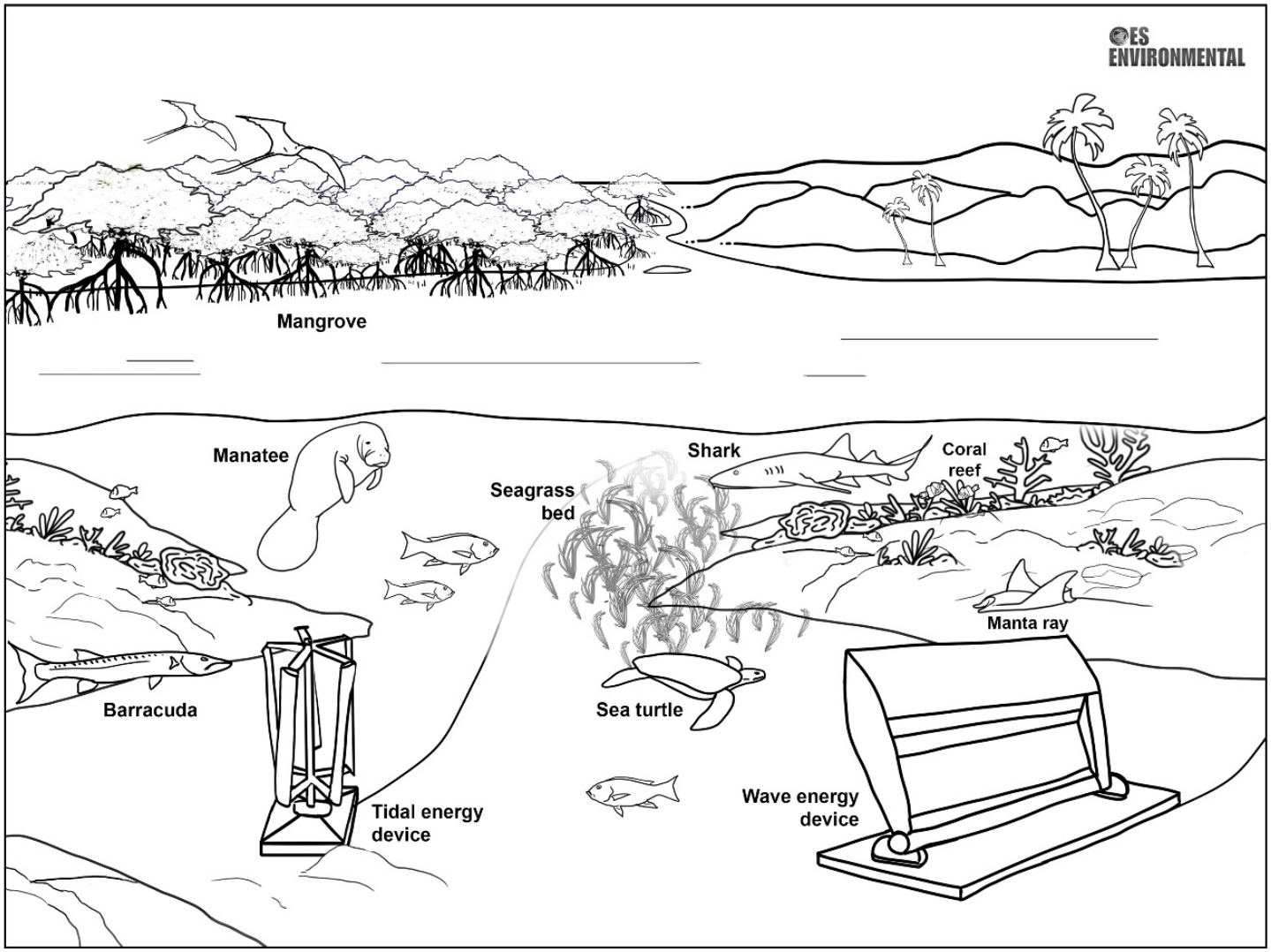
Displacement of Animals from Marine Renewable Energy Development

When large numbers of marine renewable energy devices (or “arrays”) are placed in the ocean, they may cause animals such as large migratory fish or whales to act differently or be displaced from the area. Displacement can happen when animals may need to swim longer and farther to go around arrays of devices (avoidance) or when they see the array as a barrier and are not able to get to their preferred habitat (exclusion). Other animals may swim toward the devices out of curiosity or for the new habitats provided (attraction). There are currently no large arrays of marine renewable energy devices in the ocean, but scientists are already beginning to study displacement to understand the ways marine animals could be affected.



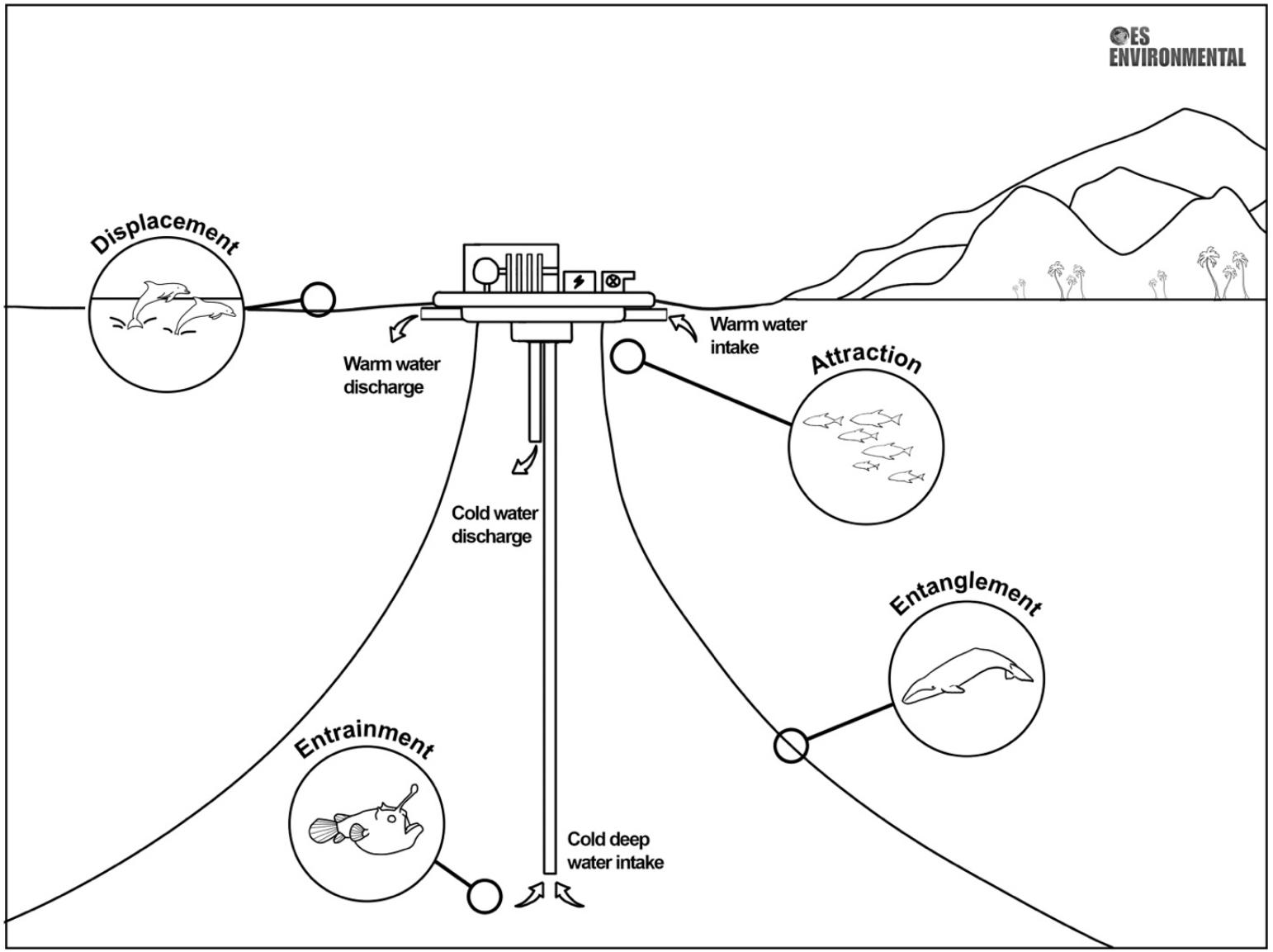
Marine Renewable Energy in Tropical and Subtropical Ecosystems

Marine renewable energy devices and studies about their potential environmental effects have mostly taken place in temperate regions, which are areas with mild temperatures that have changing seasons like spring, summer, fall, and winter. As more marine renewable energy devices are placed in different regions, scientists need to understand how new environments and animals may be affected differently. Tropical and subtropical regions, which are areas that are warm all year, have unique ecosystems, such as coral reefs and mangrove forests; a lot of different marine habitats, plants, and animals (known as high biodiversity); and complex food webs. Marine renewable energy development may present additional risks compared to temperate regions, which makes studying them really important!



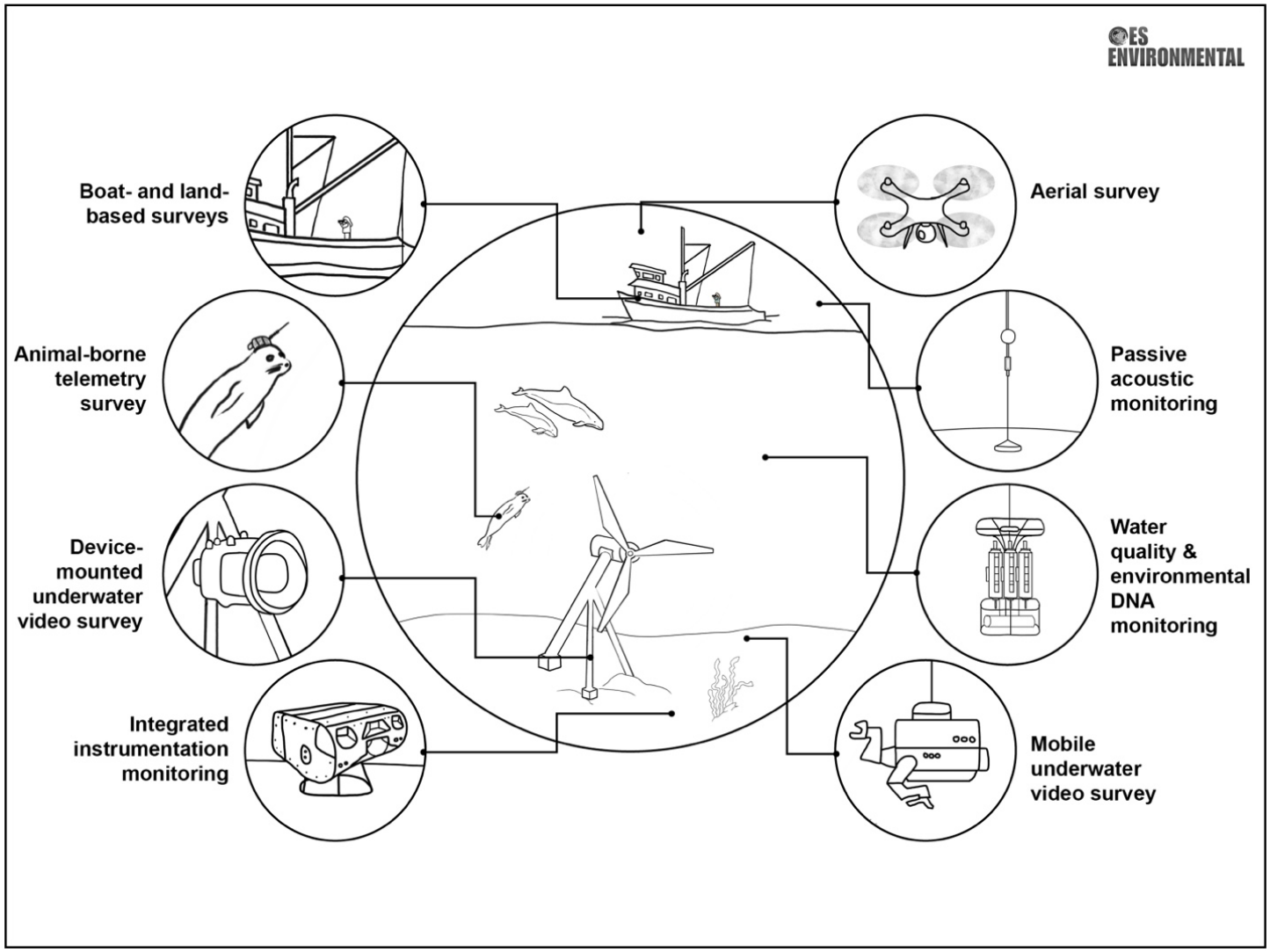
Environmental Effects of Ocean Thermal Energy Conversion

In tropical and subtropical regions with warm waters, a different kind of marine renewable energy is available: ocean thermal energy conversion (OTEC). OTEC produces power from the ocean by using the difference in temperature between warm water at the surface of the ocean and cold water deep in the ocean to generate electricity. This process can only take place year-round in tropical environments where there is enough temperature difference between the surface and deep waters. Scientists think OTEC may be a good energy source for tropical and subtropical coastal areas and islands, but it might create new challenges for the environment that need to be studied more.



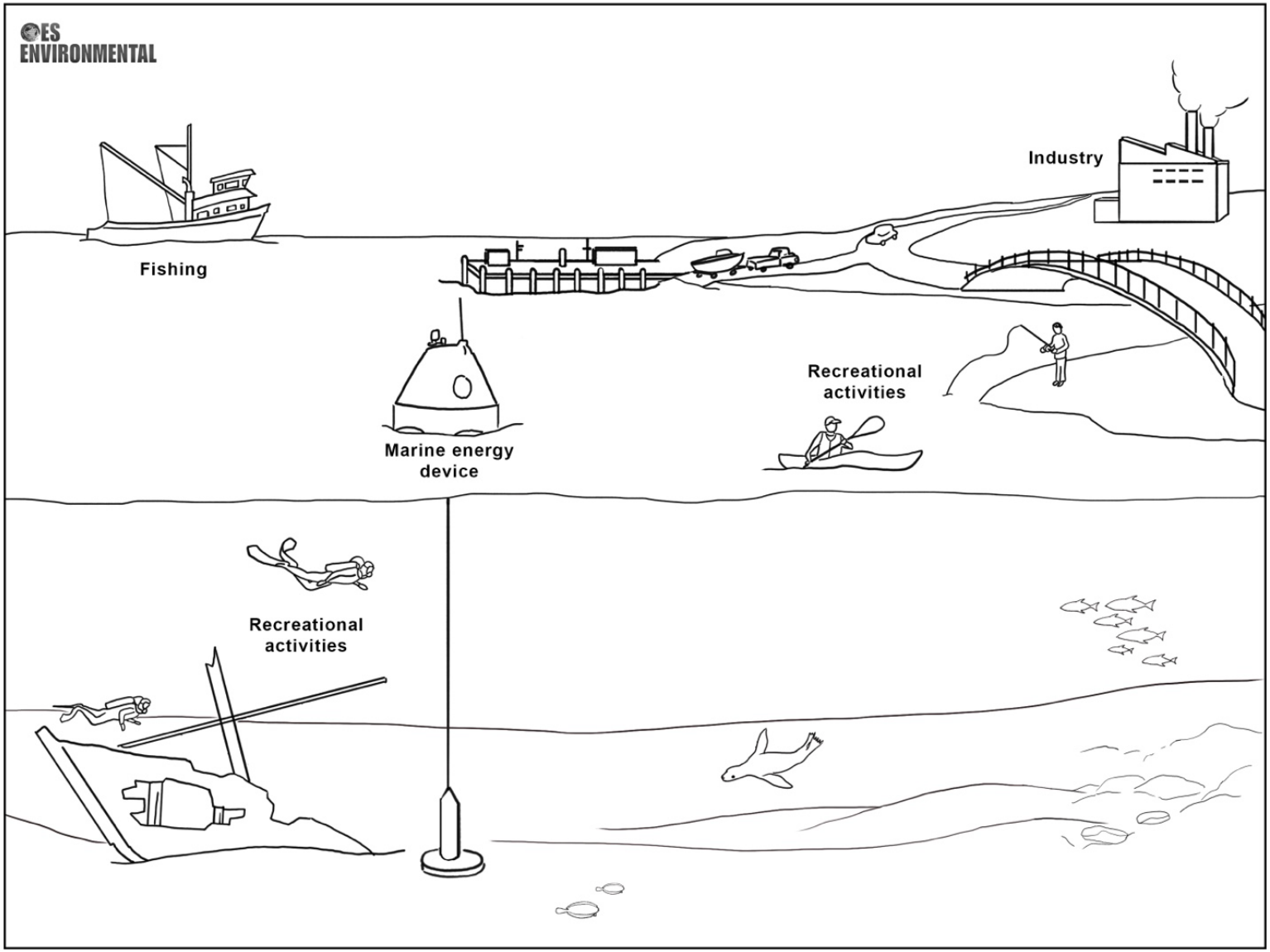
Marine Renewable Energy Environmental Monitoring

Observing and measuring the environmental effects of marine renewable energy devices can be challenging in harsh marine environments, where the water currents run fast, and it is hard to see underwater. Scientists can use a lot of different tools and methods to record marine animal interactions around devices, like underwater cameras or underwater microphones, called hydrophones. Other methods scientists use are surveys from boats and high viewpoints on land, where scientists mark down what animals they see, or aerial surveys, where aircrafts (like drones) collect information on the environment and animals in the area from above. Scientists can also attach tracking devices to animals that work like GPS, which allows them to follow an animal around and see where it goes. All this information can help scientists see or hear what goes on above and below the surface of the water!



Social and Economic Effects of Marine Renewable Energy

In addition to understanding how marine renewable energy devices interact with the environment, it is also important to understand how they may affect people and communities. Before a device is put in the water, scientists try to understand how new marine renewable energy devices and projects could affect the people who live and work in the area. Planning a project carefully can help create new jobs and support the local community while protecting the ways people use the area for work or for fun. And marine renewable energy can also create reliable, clean electricity.



Social and Economic Effects of Marine Renewable Energy

Marine renewable energy projects may positively or negatively affect people, communities, and other marine industries. This could include affects to tourism, fishing, social services like local infrastructure, and ports and shipping. For example, marine renewable energy devices in the ocean could become a tourist attraction and lead more people to visit an area, bringing more money into a community. In addition, temporary construction activities related to developing a marine renewable energy project, especially large-scale arrays, may impact ports used by other marine industries or local traffic. Social and economic effects of marine renewable energy are often tied to environmental effects, and it is important to consider them together.