# SeaKeepers Digital Lesson Plans

## Lesson 19: Pip Hare – Global Warming

**This activity was created in partnership with Pip Hare Ocean Racing as part of SeaKeepers' Inspirational Figures lesson plan series for educational engagement on virtual platforms.**

**Activity:** Global Warming

**Preface:**

Our oceans face many threats today, including climate change and pollution. In order to protect and preserve our oceans, we need to understand these threats and how the oceans respond to them. The International SeaKeepers Society supports marine research and education by connecting scientists with yacht owners, creating research opportunities for scientists to better understand our oceans – and to create plans to protect them.

Taking inspiration from the real-world experiences of Pip Hare and created in partnership with Pip Hare Ocean Racing, this lesson explores the theme of global warming and its impacts on the ocean environment. By highlighting the different ways that marine ecosystems are detrimentally affected by rising temperatures, students will explore ocean warming from the eyes of global ocean-racing yachtswoman Pip Hare. They will discuss how the changing climate has affected her 2024 Vendee Globe race and the challenges faced by the threatened, but resilient, marine species encountered along the way.

**Objectives:** Students participating in this lesson should see improvement in the following areas:

- Understand the topic of global warming from a marine perspective.
- Investigate the ways in which global warming impacts marine ecosystems and ocean life.
- Describe how global warming affected Pip Hare's Vendee Globe race.

**Age Group:** Key Stage 3.

While this lesson plan was produced by SeaKeepers UK Chapter, our lessons are available and applicable to students globally. For further information on which education curriculum standards this lesson meets for your region, please reach out to programming@seakeepers.org

**Estimated time:** 70+ minutes

**Required Materials:**

Students do not need any background knowledge of global warming to take part in this lesson. Teaching resources are included for this lesson, but feel free to use other materials you may have to explain these concepts. To create their infographics, students will need:

- Paper
- Pens/pencils
- Erasers
- Rulers (optional)

- Glue/Sellotape/Blu tack (optional)
- Recyclable crafting materials, such as cardboard, ice lolly sticks and newspaper (optional)

**Lesson Breakdown:**

- Introduction to Global Warming, the ocean's role in absorbing atmospheric heat, the impact of ocean warming on marine environments and ecosystems, and the impacts of ocean warming on Pip Hare's Vendee Globe race (20 minutes)
- Main Activity: Create an infographic describing how chosen marine species and ecosystems could be affected by global warming, including ideas for how they might adapt to the changing temperatures and the importance of resilience (30+ minutes)
- Wrap up Discussion (15 minutes)
- Clean up (5 minutes)

**Lesson Vocabulary:**

- **Aerobic** – relating to, involving, or requiring free oxygen.
- **Algal blooms** – rapid increase or accumulation in the population of algae in freshwater or marine water systems**.**
- **Basal melting** – the process where the base of an ice shelf or glacier melts due to contact with warm ocean water.
- **Cliff retreat** – process of erosion in which a cliff recedes inland.
- **Endemic** – native and restricted to a certain location.
- **Evaporation** – the process of turning from liquid to vapour.
- **Fisheries bycatch** – unintended capture or entanglement of non-target species in fishing gear.
- **Intertidal zone** – the area on a shoreline that is alternatively covered and uncovered by tides, namely the region between high and low tide marks.
- **Lesions** – an area of abnormal or damaged tissue caused by injury, infection or disease.
- **Migration** – seasonal movement of animals from one region to another.
- **Photosynthesis** – the process by which plants use sunlight, water and carbon dioxide to create oxygen and energy in the form of sugar.
- **Physical weathering** – the breakdown of rocks into smaller pieces without any change in their chemical composition.
- **Precipitation** – any liquid or frozen water that forms in the atmosphere and falls back to the Earth's surface.
- **Saturated** – holding as much water or moisture as can be absorbed.
- **Surface run-off** - the movement of water over the land surface when it cannot infiltrate into the soil or evaporate.
- **Suspended sediment** – fine particles that are carried in suspension by a fluid but are unable to settle to the seafloor.
- **Symbiosis (mutualistic)** – a relationship where both species involved benefit from their interaction.
- **Turbidity** – cloudiness or haziness of a solution, caused by larger numbers of individual particles that are generally invisible to the naked eye.
- **Water cycle** – biogeochemical processes by which water circulates between the Earth's oceans, atmosphere and land, involving precipitation as rain and snow, drainage in streams and rivers, and the return to the atmosphere by evaporation and transpiration.

**Lesson Introduction/Overview:**

**Why are the global oceans getting warmer?**

Around 12,000 years ago, the human population on planet Earth consisted of approximately 4 million people. This grew to 1 billion in the 1800s, 2 billion in the 1920's and 3 billion in the 1960's. Today, March 2025, the world's population is estimated to be 8.2 billion people! To support this population growth, towns and cities expanded, developing new technologies and infrastructure to provide jobs and livelihoods. However, in order to expand, excess greenhouse gases were, and continue to be, released into the atmosphere through the burning of fossil fuels, providing a source of energy for transportation and industrial processes. To make space for these new civilisations, many areas were, and still are, deforested, removing large numbers of plants from the landscape. Where previously these plants would photosynthesise and remove excess carbon dioxide from the atmosphere, the newly established industries emit this gas instead. Overall, industrial development has therefore led to a greater quantity of greenhouse gases entering the atmosphere annually, changing our global climate.

In the natural environment, greenhouse gases are regularly taken up and released by carbon stores and sinks. These are perfectly balanced to ensure the global greenhouse gas layer at the edge of the atmosphere remains constant. This layer acts like a blanket, trapping solar rays near the Earth's surface to keep the planet warm. However, as this layer grows due to greenhouse gas pollution from human activities, more and more rays are trapped at the surface, causing the planet to become even warmer. This is a phenomenon called global warming.

The ocean is the largest carbon sink on Earth, absorbing approximately 31% of all carbon dioxide emissions released into the atmosphere. Similarly, the ocean is considered the largest heat sink on Earth, absorbing 90% of the excess heat trapped in the Earth's climate system. Water has a high heat capacity, which enables the global oceans to store large amounts of heat energy without vastly changing the overall temperature. However, this heat is not evenly absorbed throughout the water column. Surface waters are permanently in contact with the atmosphere and directly absorb the heat from solar rays, whereas the deep ocean relies on downwelling currents to transport warmer water to the seafloor. This is a much slower process. As such, sea surface temperatures are increasing more rapidly than temperatures in the deep. However, marine species have spent hundreds and thousands of years adapting to specific environmental conditions and are sensitive to any thermal shifts, therefore any temperature change, big or small, can still have significant impacts.

**How does global warming impact marine environments and ecosystems?**

Atmospheric and ocean warming impact many marine environments and ecosystems across the globe. Ranging from polar melting and rising sea levels to overstimulation of microorganisms, species are having to adapt or migrate in order to survive. Those that are unable to do so are threatened with extinction in this warmer underwater world.

Over millennia, species have either adapted to survive in particular environmental conditions, or evolved migratory behaviour to exploit different locations based on their seasonal advantages. Immovable organisms, such as corals, seaweeds, sponges and anemones, have formed attachments to seafloor substrates to ensure they remain in a specific position with consistent temperatures. However, as the global oceans warm, these plants and animals are increasingly threatened as they are unable to move to more hospitable conditions, unlike their migratory counterparts. For example, corals are enigmatic, keystone animals that are essential components of the most colourful marine habitat in the world - coral reefs. Despite covering less than 0.1% of the global seafloor, coral reefs are biodiversity hubs, supporting approximately 25% of all marine species. Coral structures are naturally white, gaining their vibrant colour from microscopic algae, zooxanthellae, that live within their tissues. These algae provide the corals with food, while they protect the algae from consumers through mutualistic symbiosis. However, warmer temperatures cause

these algae to become overactive, producing harmful amounts of nutrients. Corals therefore expel the algae from their tissues to remove the immediate source of harm. However, over time this leads to a long-term lack of nutrients and a subsequent loss in colour, through a process called coral bleaching. Bleached corals cannot support the extensive biodiversity of their healthy reef counterparts; therefore corals and their symbiotic algae must adapt to warmer temperatures if entire coral reef ecosystems are to feature in future global oceans.

Rising atmospheric temperatures are causing land-based ice masses, such as ice sheets and glaciers, to melt at a faster rate. This increase in terrestrial ice melt causes more water to be released, introducing huge quantities of freshwater into the sea. Warmer ocean temperatures are also increasing the rate of glacial and ice sheet decline through basal melting, further increasing the amount of freshwater entering the polar oceans, causing sea levels to rise. At present, global sea levels are rising at a rate of 3.4mm per year. Did you know, if all the glaciers and ice sheets on Earth were to melt, global sea levels would rise by more than 60 metres - that's the same as approximately 13 double decker buses!

Sea level rise threatens valuable coastal habitats, such as tropical coral reefs, seagrass meadows, salt marshes and mangrove forests, with the risk of flooding. Tropical coral reefs and seagrass meadows both thrive in shallow water habitats as their symbiotic algae and seagrass plants, respectively, require light for photosynthesis and growth. Salt marshes, which are found in the intertidal zone, rely on regular, intermittent flooding and exposure to the atmosphere to provide their specialised inhabitants with sufficient oxygen and nutrients to thrive. Whereas mangroves have highly specialised roots that have adapted to obtain sufficient oxygen from the intertidal, waterlogged, muddy seafloor. As waters become deeper, light penetration becomes weaker, preventing tropical coral reef and seagrass growth, salt marshes become permanently inundated with water, and mangroves become submerged, threatening these habitats and all species that call them home.

As the ocean warms, the individual water molecules held within gain more energy. Once this energy becomes great enough to overcome the bonds that keep them in liquid form, water molecules can be released into the atmosphere as a gas - a process called evaporation. Ocean warming is greatly increasing evaporation rates across the globe, enabling more water molecules to enter the atmosphere. However, the atmosphere can only hold a certain amount of water molecules before they are forced to be released as precipitation. As such, evaporation rates are closely linked to precipitation rates - specifically, increased evaporation leads to increased precipitation. Because atmospheric warming inhibits the formation of snow and ice, this precipitation largely falls as rain, causing ocean salinity and water quality to decrease, and large-scale coastal habitat destruction. These changes can greatly disrupt the delicate balance of marine food webs.

Precipitation introduces large amounts of freshwater into the ocean, reducing the salinity and altering seawater chemistry. Species, such as sea urchins, are well-adapted to regular levels of ocean salinity (roughly 32 to 35 parts per thousand of dissolved salts). However, they are particularly vulnerable to low salinity levels, which reduce their ability to stay upright, inhibit their movements and decrease their growth rates. By introducing more freshwater into the oceans through global warming-induced rainfall, marine species with specific salinity tolerances can become severely threatened if they are not able to rapidly adapt. Similarly, increased rainfall can increase coastal surface run-off, introducing more pollutants into the ocean and decreasing the water quality. Excess nutrient run-off, for example from sewage influx, can raise nitrogen and phosphorus concentrations in coastal waters, leading to the formation of harmful algal blooms. Algae utilise these excess nutrients to photosynthesis and grow at a rapid rate, covering the ocean surface with floating plants. This prevents light from penetrating to the seafloor, inhibiting benthic plant growth. When algae die, a large amount of oxygen is required for their decomposition. This leads to oxygen-depletion, often forming "dead zones" which can suffocate marine life. Algal overgrowth can therefore severely harm coastal ecosystems and threaten the survival of the various species within the food web.

Ocean warming and high levels of associated precipitation can lead to the formation of large storms. These extreme weather systems can cause accelerated erosion of seafloor habitats and cliff faces, which support a variety of marine life from seabirds to vibrant fish. High winds and extreme rainfall cause physical disturbance in the ocean, physically damaging seafloor structures, such as coral reefs and kelp forests, and churning seafloor sediments into the water column, increasing the turbidity. This suspended sediment reduces visibility, preventing light from reaching seafloor plants and predators from finding prey, and smothers benthic organisms when it falls as conditions stabilise, suffocating aerobic seafloor dwellers. Heavy rainfall can also cause soil and rock within a cliff face to become water-saturated, while strong winds can physically weather the structure. Together, these actions can cause the cliff to become destabilised and subsequently collapse, leading to cliff retreat. Many seabirds, including gannets, kittiwakes and albatross, nest either in crevices within the cliff face, or on-top of the cliff itself. Ocean warming therefore greatly threatens the survival of their nests and young due to high habitat vulnerability, putting the population at greater risk of extinction. In particular, Albatross are classified as endangered due to human interactions, such as fisheries bycatch, and habitat destruction. These birds spend their entire lives at-sea, only returning to land to breed. As they only nest in coastal areas, albatross breeding success is greatly threatened by sea level rise and coastal erosion from increased precipitation. Did you know that albatross are the largest seabirds on Earth, with a wingspan of up to 3.7 meters!

Pathogens thrive in warmer conditions as higher temperatures promote faster replication and metabolic activity, allowing their populations to grow more rapidly. Ocean warming enables diseases to spread to locations that were previously too cold to support their growth. Endemic species found in these previously inaccessible locations therefore encounter unfamiliar diseases, increasing their susceptibility, likelihood of becoming infected and subsequent risk of harm. For example, ocean warming is increasing the risk of bacterial degradation of American lobster exoskeletons through a syndrome called epizootic shell disease (EZD). Thought to be caused by pathogenic bacteria, this disease enters the lobster through pores or previous injuries and causes lesions in the exoskeleton. In extreme cases, EZD can lead to lobster mortalities and significantly impact the survival of whole populations. Heat-related stress also makes lobsters more likely to contract EZD, further enhancing the spread throughout Northwest Atlantic hatcheries.

The marine environment is experiencing widespread changes as a result of anthropogenic global warming. Whether in the polar regions or the tropics, ocean flora and fauna must adapt or migrate in order to survive. These shifts are also forcing humans to reconsider how they use the marine environment to ensure they are safe in often unpredictable and highly-changeable conditions - Pip Hare's Vendee Globe race is a good example.

**How was Pip Hare's 2024 Vendee Globe Race affected by global warming?**

Due to glacial and ice sheet melt, large pieces of dense ice are regularly breaking off near the polar coastlines and travelling out into the open ocean using surface-water currents. These pieces, termed icebergs, provide valuable platforms for marine megafauna to hunt and rest, such as polar bears and seals, respectively, but are a serious hazard to boaters that wish to explore the region. Icebergs can be much larger underwater than at the surface, making their true size difficult to estimate. Boats can therefore strike the underwater part of an iceberg before they reach the visible mass of ice. Collisions can leave large holes in the ship's hull and lead to severe flooding or, in extreme cases, sinking. As icebergs are not stationary objects, they can be unpredictable, making it difficult to estimate where they are likely to be encountered within the polar regions.

The Vendee Globe 2024 route required the global ocean-racing yachtsmen and women to voyage around the northern boundary of the Southern Ocean - the water body that surrounds Antarctica. For the race, an imaginary ring fence is drawn around the region, known at the Antarctic Exclusion Zone (AEZ). This "fence" provides a lower latitudinal limit for the boaters to prevent skippers from sailing too far into the Southern Ocean where icebergs are more common. By following this route, the racers were able to avoid crashing into

these increasingly common features and continue their journey safely. However, many skippers spotted icebergs outside of the AEZ during the race. Each boat is equipped with a radar that notifies the racer of any large hazards in the water to ensure they safely avoid these features. However, smaller icebergs are often undetectable on the radar, posing a significant risk to the racers, forcing them to be more vigilant. Ocean Warming has forced these extreme athletes to be more aware of their surroundings to ensure their safety in a highly variable, increasingly less-frozen landscape.

**Pip Hare**

Pip Hare is a global ocean racing yachtswoman who in 2021, became the 8th woman ever to finish the Vendee Globe; a non-stop solo race spanning approximately 24,000 nautical miles across the world. In 2024, Pip returned to the race, showcasing her resilience and determination. Unfortunately, during the Vendee Globe 2024, her yacht, Medallia, dismasted approximately 800 miles from Australia, although a challenging setback in her journey, Pip demonstrated remarkable self-rescue skills and managed to stabilise her boat to ensure her safety and make her way slowly to Australia.

During the race, many boaters participated in environmental conservation research projects to provide valuable data to various scientific initiatives. Pip used a Calitoo photometer to measure atmospheric particles as she raced to provide researchers with crucial information about the atmosphere from previously understudied regions. Her participation in the project allowed researchers to investigate environmental health without the costs associated with collecting the data themselves. By becoming a citizen scientist, Pip, and the other Vendee Globe competitors that participated in conservation research projects, proved that boaters can play a vital role in scientific data collection and increase global understanding of key environmental issues, proactively conserving the natural world for future generations.

With a professional career of over 25 years, Pip has made sailing her life. Her passion, determination and hard work have enabled her to succeed where others might struggle. After racing through the world's toughest environments and overcoming many challenges along the way, Pip uses her experiences and accomplishments to inspire others to aim high and strive to achieve their goals. Her story shows one of grit, determination and resilience beyond what some may say is humanly possible. Having achieved her life-time goal of completing the Vendee Globe at 46, and in a male dominated environment, Pip proves what is possible when you are determined, ambitious and resilient in the face of adversity. When faced with unforeseen obstacles, Pip's ability to adapt under pressure has allowed her to think clearly, find a solution and continue to achieve success. Her ability to cope in any scenario enables her to do things differently and hit targets that others wouldn't even consider. This resilience provides her with the capacity to both withstand changeable weather conditions in the open ocean when aboard her vessel Medallia, and disregard the status quo to become an inspirational changemaker. Pip shows why it is important to think beyond the norm and be resilient in all walks of life, navigating the challenge of achieving your goals in order to become the best version of yourself.

**Activity Instructions:**

1. Split the class into small groups (roughly 3-6 students).
2. Provide each group with a blank piece of paper and a list of specific ecosystems and species to evaluate. To ensure the activity is suitable for the target group:
    - If the students have sufficient background knowledge of the topic, allow the groups to choose their own species and ecosystems to evaluate.
    - If the students have no background knowledge of the topic, begin the activity with the students pairing up the list of species/ecosystems included below with the example descriptions provided that indicate how ocean warming could affect each.
3. Students should work together and collate their ideas into an infographic The infographics should discuss how each species or ecosystem is likely to be affected by ocean warming, how this change

would affect the resulting marine environment, and whether conservationists, industry professionals or the general public could better protect these species to limit harm to the global oceans.

4. Groups should present their infographics to the class, before discussing why the species or ecosystems would be affected in the way they suggested, what impact this would have on the wider marine environment, and how each species or ecosystem might adapt to survive in a warmer environment (if this were a possibility!).

**Wrap up Discussion:**

Once all groups have shared their infographics, educators should ask the groups to answer the following questions (there is no correct answer):

- Which species and environments are likely to be most affected by ocean warming? Why?
- If only one could be protected from the impacts of ocean warming, which species or ecosystem should be protected? Why?
- Are these species and ecosystems resilient to ocean warming? Why, or why not?
- How important is resilience when faced with challenging situations? Why?

Educators should use these questions to begin a discussion with the students about the importance of resilience when overcoming adversity, whether this be species and ecosystems withstanding inhospitable ocean temperatures, or experiences faced by the students in their daily lives.

For more information, here are some useful websites:

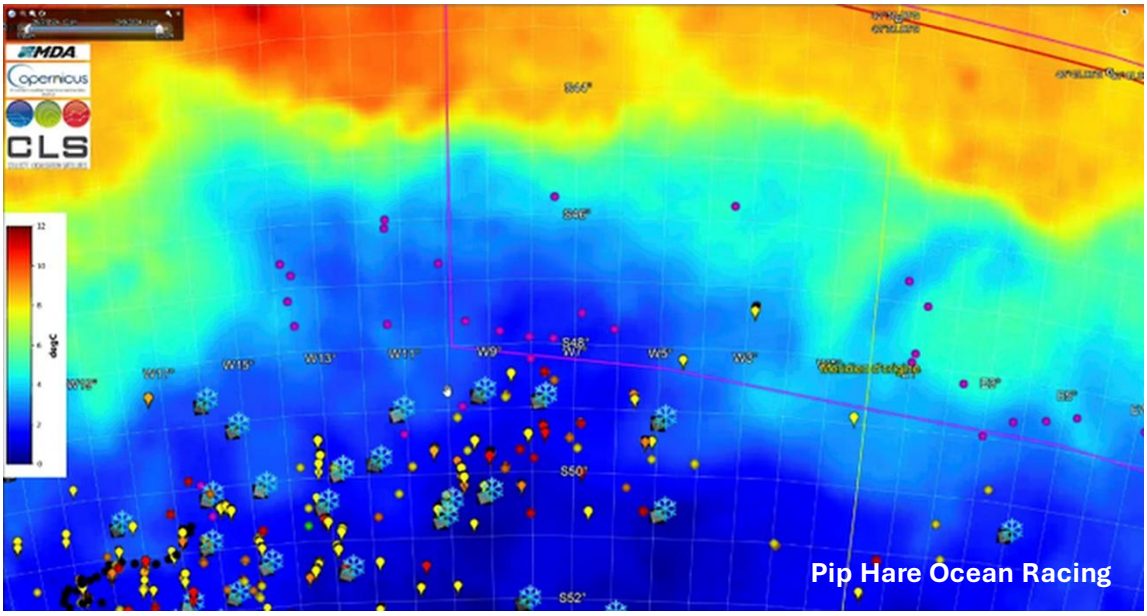
Pip Hare Ocean Racing and the Vendee Globe:

- https://www.piphare.com/
- https://www.vendeeglobe.org/en

Global Warming:

- Global Warming - Britannica
- What is Climate Change? – United Nations
- Ocean Warming – Woods Hole Oceanographic Institution
- Climate Change: Ocean Heat Content – Climate.gov

**Media:**




**Map showing iceberg detection software used during the Vendee Globe 2024 race, as boaters travelled through the Southern Ocean.**

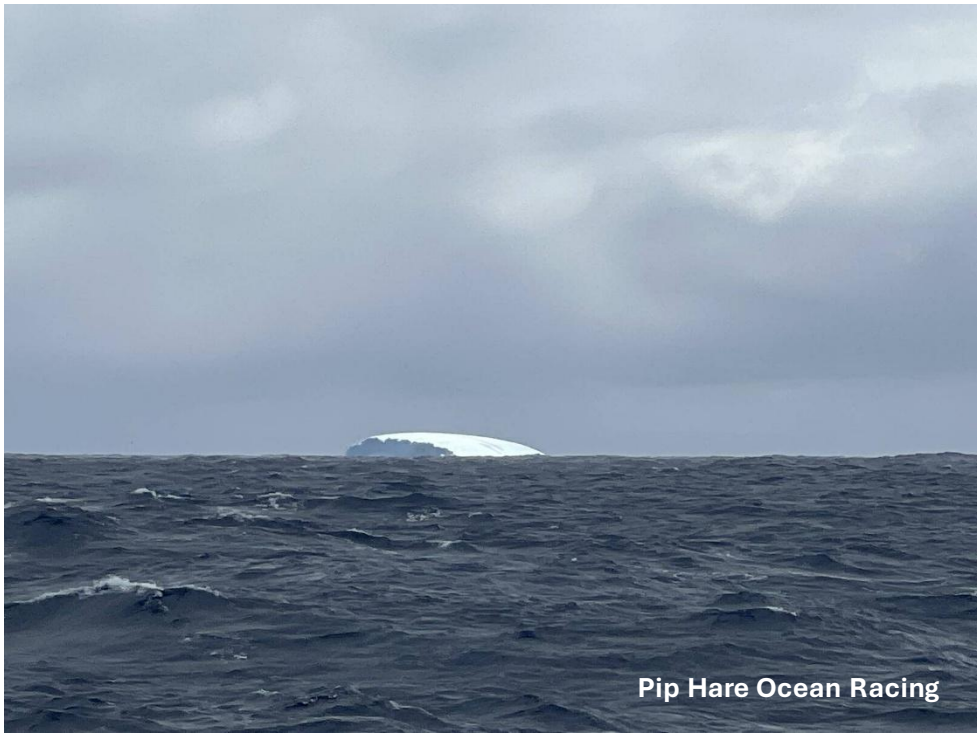



**Image of an iceberg that Pip Hare encountered during her Vendee Globe 2024 race.**


**Pip Hare encountered various forms of marine life during her Vendee Globe 2024 race, including these hourglass dolphins.**

**Example species and ecosystems, with the intended focal point in brackets:**

- Penguins (polar sea ice melt leading to habitat and breeding ground loss)
- Polar bears (polar sea ice melt leading to a loss of hunting grounds)
- Coral Reefs (coral bleaching leading to ecosystem collapse)
- Humpback Whales (rising ocean temperatures, leading to shifts in migratory patterns to remain in hospitable waters)
- Phytoplankton (overstimulation leading to the formation of harmful algal blooms)
- Mangroves (rising sea levels leading to habitat flooding (if the process is fast enough))
- Basking sharks (rising ocean temperatures altering ocean currents, leading to prey distribution shifts and lower food availability)
- Lionfish (rising ocean temperatures, leading to more habitats becoming hospitable, increasing the spread of invasive species)

Below, these are presented in a format that enables each species/ecosystem and their descriptions to be cut out for the students to match up as a learning exercise.

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|---|---|
| Penguins | Polar sea ice melt, leading to habitat and breeding ground loss |
| Polar bears | Polar sea ice melt, leading to a loss of hunting grounds |
| Coral Reefs | Coral bleaching, leading to ecosystem collapse |
| Humpback Whales | Rising ocean temperatures, leading to shifts in migratory patterns to remain in hospitable waters |
| Phytoplankton | Overstimulation, leading to the formation of harmful algal blooms |
| Mangroves | Rising sea levels, leading to habitat flooding |
| Basking Sharks | Rising ocean temperatures altering ocean currents, leading to prey distribution shifts and lower food availability |
| Lionfish | Rising ocean temperatures, leading to more habitats becoming hospitable, increasing the spread of invasive species |