museum
National Museum of Ireland
Ard-Mhúsaem na hÉireann

Teachers Notes

Classroom Activity: The Irish Coast Climate Change Virtual Visit

Discover the effects of climate change in Ireland using a 3D walkthrough of the museum from the comfort of the classroom. Students can explore the effects of climate change on Irish coastal ecosystems on their own virtual visit using the 3D viewer. Detailed teacher's notes on featured animal species and associated impacts of climate change are provided, with suggested follow-up classroom activities. These may be used to create classroom discussion and expand upon on the topics of climate change effects and the environment in an Irish context.

Level: Transition Year

Format: Classroom activity - resources to be used within the classroom

Duration: 30+ mins

Availability: Online and self-guided

Curriculum Links:

- National Council for Curriculum and Assessment - Transition Unit "What's with the Weather?"
- National Council for Curriculum and Assessment - Transition Unit "Environmental Studies".

Learning Outcomes:

On completion of this lesson students should be able to:

- Recognise changes in global weather patterns and their effects on populations.
- Identify global patterns by evaluating case studies of these effects.
- Review, reflect, and make decisions on their role in the stewardship of the environment and protection of our earth.

Suggested Lesson Plan:

1. The specimens included on this virtual visit can be used as a catalyst for discussion and linked to the TY Biology and Geography curricula through the topics of Ecosystems, Food Chains, Food Webs, Animal Interdependence, Environments, Animal Adaptations to the Environment, Stewardship, Sustainability, Climate Change, Energy and Conservation Biology.
2. Explain to your class they are going to make a virtual visit to the museum today. They are to listen out for examples of ways climate change will impact the way of life for coastal communities in Ireland, animal and human alike. Ask your students do they know of any effects of climate change on Irish coastal and marine species?
3. Ask them to explore the museum specimens using the 3D Virtual Visit, and think about the role and function of each species within their ecosystem, what they feed on and what feeds on them (predators, parasites, scavengers), what impacts climate change will have on that species, and what might be the knock-on effects in that ecosystem or food web.

Options for Classroom Activity Follow-up:

- A classroom lesson or independent pupil research project. This can focus on climate change impacts on Irish species. Students may choose one of the species included in the virtual visit, and research the impacts of climate change on that species and any potential solutions to reverse these impacts. The IUCN Red List is a good place to start. See the Useful Websites and Resources list below.

Instructions for Using the 3D Virtual Visit:

- Click on the link (https://www.museum.ie/en-IE/Museums/Natural-History/Visitor-Information/3D-Virtual-Visit). These interactive presentations require up-to-date versions of Internet browsers (Chrome, Safari, Internet Explorer, Firefox).
- We strongly recommend to practice using the 3D Virtual Visit in advance of using with your class. It can be tricky at first but gets easier with practice!
- Begin with the Ground Floor – Irish Fauna, click the play button. The 3D Virtual Visit will launch and automatically zoom in to a view of the Giant Irish Deer at the entrance. Please see image below.

Image 1: 3D Virtual Visit – View upon launching Ground Floor – Irish Fauna

- The viewer can be expanded to fullscreen by clicking the Fullscreen icon in the bottom right-hand corner. See highlighted icon in the image below:

Image 2: 3D Virtual Visit – Expand to Fullscreen

- Click and drag the cursor to move the camera view 360 degrees.
- Double-click any area on the floor of the museum to move your virtual position and get different views and perspectives on animals.
- Double-click on the walls, cabinets, or animals to zoom in for a closer view.
- To navigate to a different animal represented on your map, click the Floorplan icon which is highlighted in the image below. This will zoom out to provide an overhead floorplan view corresponding with that on the maps provided. Click on an area of the floorplan that corresponds with the number of your chosen animal on the map provided. An example of this process is given in images below. Remember, you may then have to click and drag the cursor to move the camera view around to face your animal of interest!

Image 3: 3D Virtual Visit – Change to Floorplan View

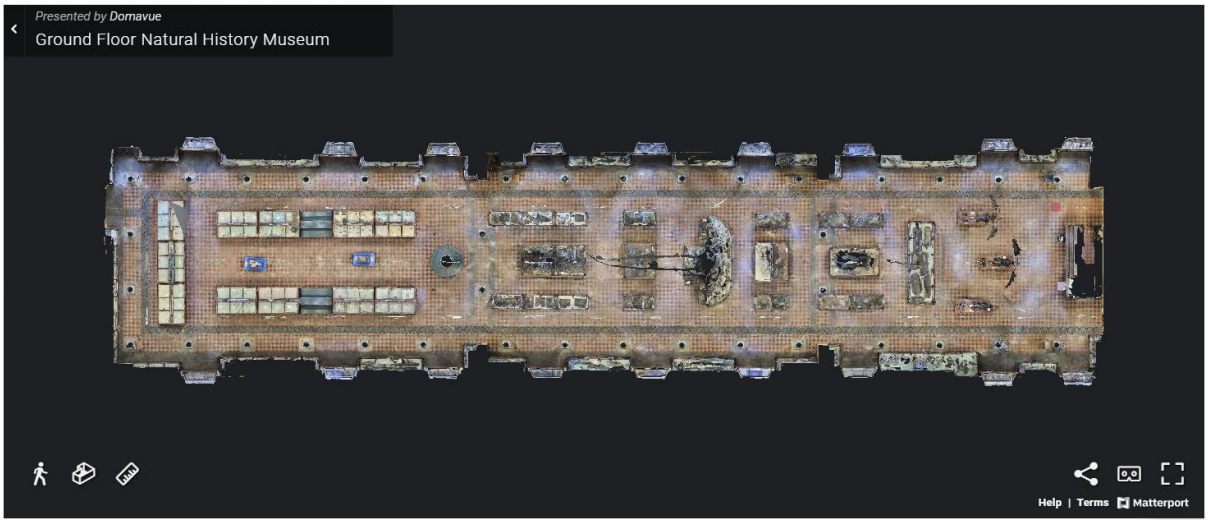


Image 4: 3D Virtual Visit – Floorplan View

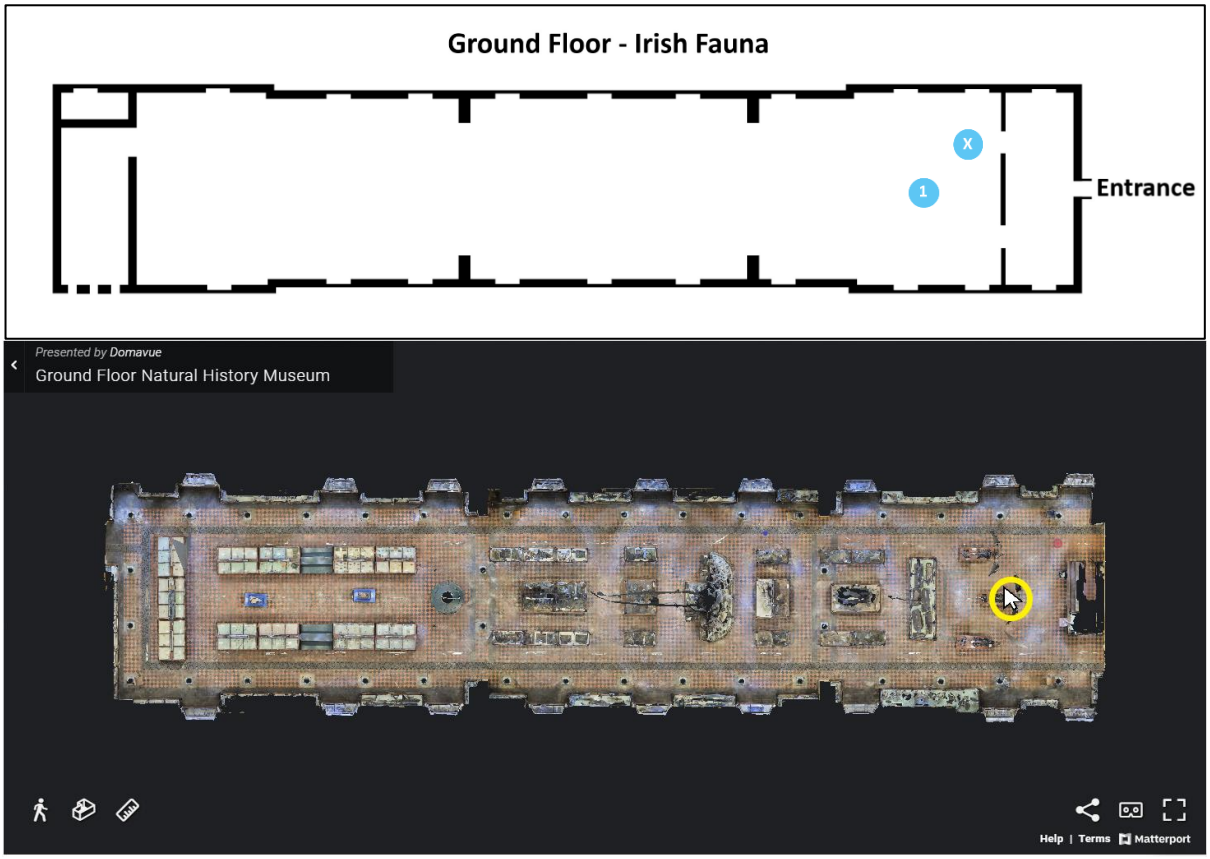


Image 5: 3D Virtual Visit – Double-click an area corresponding with your map to zoom in

- Note the 3D Virtual Visit also contains a Ruler function to allow real measuring of animals in the museum! Simply click the ruler icon as indicated in the image below and follow the instructions on-screen to measure the size of an animal, or the size of their head, jaws, legs etc. Play around and explore!

Image 6: 3D Virtual Visit – Ruler Function

- Once the Ground Floor map has been completed, press the "Esc" key on your keyboard to exit out of fullscreen mode. Scroll down the webpage to the First Floor – Mammals of the World. Click play, and once the 3D Virtual Visit launches, click the floorplan icon and navigate to the area corresponding with the next animal of interest on the map(s) provided. Use the features of the viewer to examine this animal.
- Play around and explore!

Virtual Visit Teacher Notes and Itinerary:

1. **Introduction to Coasts, Oceans and Climate Change:**
   Begin by providing students with an introduction to Climate and Oceans. A YouTube video titled "How Whales Change Climate" is recommended as a good introduction to the topic (follow this link). We recommend that teachers view this video in advance of screening to students.

   The following section can be used to provide further information on oceans and climate change. The following is adapted from the Fish Carbon Report (Lutz and Martin 2014, see Useful Links section):

   A healthy ocean is vital to our life on Earth. Covering nearly three-quarters of the surface of the planet, the ocean provides a wide range of resources and services that support human life, well-being, societies, cultures and economies. As pressure on the ocean to provide these resources and services increases, its ability to deliver many of them is compromised.

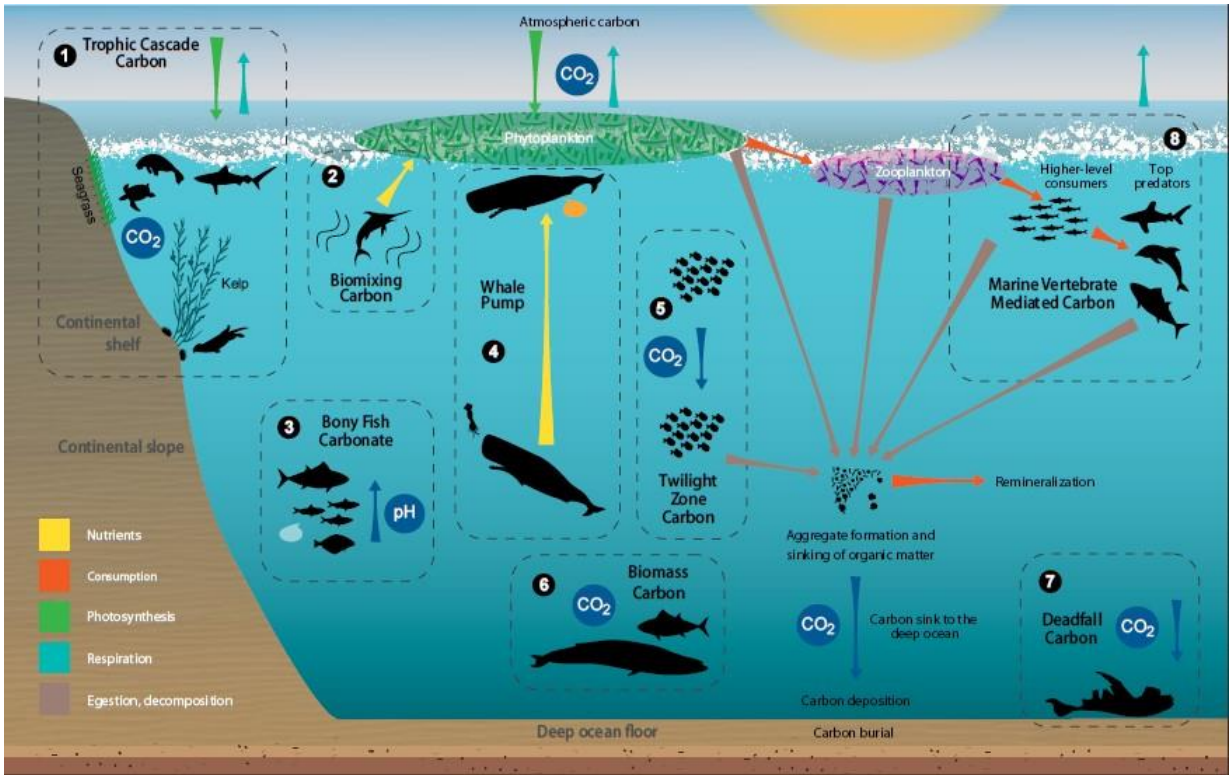
   Many human activities impact ocean health, and are directly impacting marine wildlife and the carbon services they provide. Among the greatest issues caused by human activities are climate change and ocean acidification. These impacts are estimated to cause

potential disruption of 60% of the ocean's present marine biodiversity by 2050, through local or global extinctions, and changes in the pattern of species' distributions.

Climate change is driving marine vertebrates such as fish and whales to migrate away from the tropics and toward the poles to find food, with implications for food security. We can see this shift in the distribution of fish stocks in the Atlantic. Many popular fish species such as Cod and Haddock are adapted to live in cold waters, and these species are moving further north as the oceans continue to warm. For us, this means further to travel to find fish to eat, meaning less time spent fishing, which results in reduced catches. However, it doesn't end there, because as the oceans continue to warm, eventually there will come a point at which cold-water species such as Cod have nowhere further north to go.

While climate change gets most of the publicity, did you know that the ocean absorbs about 25% of atmospheric carbon? There are pros and cons to this: the ocean provides a buffer without which our climate would warm more rapidly, but the process of absorbing carbon dioxide is changing the chemistry of the oceans. Rising levels of atmospheric carbon leads to increased amounts of dissolved carbon in the oceans. This additional carbon lowers oceanic pH levels. Current rates of this process, termed "ocean acidification", have never before occurred throughout the history of Planet Earth. Ocean acidification prevents the formation of calcium carbonate ($CaCO_3$) structures such as shells, and impacts the larvae and adult stages of many marine vertebrates such as fish, and invertebrates who use this material to make their shells and other hard structures. The impacts on corals and shellfish are expected to present a serious challenge for the sustainability and way of life for coastal and island communities. Through its effects on phytoplankton (aka plant plankton), ocean acidification may also impact the formation of clouds and weather patterns globally.

The Fish Carbon mechanisms described in the diagram below demonstrate how, in healthy marine ecosystems, marine vertebrates such as fish, sharks, and whales facilitate absorption of atmospheric carbon into the ocean and transport carbon from the ocean surface to deep waters and sediment, so providing a vital link in the process of long term carbon sequestration. Fish Carbon additionally provides a natural buffer against ocean acidification through the Bony Fish Carbonate mechanism (see 3 on diagram). As such, Fish Carbon potentially lends itself to the global climate challenge in mitigation of both atmospheric and oceanic impacts of climate change.



1	Trophic Cascade Carbon	Food web dynamics help maintain the carbon storage and sequestration function of coastal marine ecosystems (e.g. the health of primary producers such as seagrass meadows and kelp forests is maintained by herbivory and predation).
2	Biomixing Carbon	Turbulence and drag, associated with the movement of marine vertebrates, causes enhanced mixing of nutrient rich water from deeper in the water column towards the surface, where it enhances primary production by phytoplankton and thus the uptake of dissolved CO_2.
3	Bony Fish Carbonate	Bony fish excrete metabolised carbon as calcium carbonate ($CaCO3$) enhancing oceanic alkalinity and providing a buffer against ocean acidification.
4	Whale Pump	Nutrients from the faecal material of whales stimulate enhanced primary production by phytoplankton, and thus uptake of dissolved CO_2.
5	Twilight Zone Carbon	Mesopelagic fish feed in the upper ocean layers during the night and transport consumed organic carbon to deeper waters during daylight hours.
6	Biomass Carbon	Marine vertebrates store carbon in the ocean as biomass throughout their natural lifetimes, with larger individuals storing proportionally greater amounts over prolonged timescales.
7	Deadfall Carbon	The carcasses of large pelagic marine vertebrates sink through the water column, exporting carbon to the ocean floor where it becomes incorporated into the benthic food web and is sometimes buried in sediments (a net carbon sink).
8	Marine Vertebrate Mediated Carbon	Marine vertebrates consume and repackage organic carbon through marine food webs, which is transported to deep waters by rapidly sinking faecal material.

Figure 1: A conceptual diagram of marine vertebrate carbon services (not to scale) (The Fish Carbon report, Lutz and Martin 2014).

2. **Explore Climate Change Impacts on the Irish Coast in the 3D Virtual Visit:**
Teachers have the option to hold this lesson in the classroom and show the 3D Virtual Visit on the board, or they may instead choose to hold the lesson in a Computer Room and allow students to explore the stops individually or in groups.

1	**Basking Shark:** Basking sharks are the second largest species of shark in the world, and the waters off Ireland provide a rich source of food for them during the summer months due to the abundance of plankton. Basking sharks are filter feeders that use special structures inside their gills called "gill-strainers" to filter tiny crustaceans called copepods from the water column. The cold waters around Ireland support huge numbers of these zooplankton. Climate change has been suggested to influence the distribution of their preferred prey group (copepods), making some areas less suitable for this species, offering one possible explanation for declines in basking shark sightings within areas of its historical range. In recent years, sightings of basking sharks off the Irish coast have gone viral, and public interest in these gentle giants has increased. Basking sharks can contribute to rural economies through ecotourism, and contribute to carbon sequestration by the same mechanisms as shown in the "How Whales Change Climate" video.
2	**Atlantic Puffin:** These colourful and clownish-looking members of the Auk family are long-lived birds (30 year average lifecycle) that congregate in great numbers around the Irish coast during the summer months to nest. Their preferred prey are a type of rich oily fish called sand eels, also one of the key prey species for larger fish such as cod. Puffins swim underwater like penguins and can dive up to 60m in search of fish. The record for the largest number of sand eels found in a puffin's beak is 62! Sand eel populations in Irish waters have declined due to warmer waters causing a distribution shift northward, and also due to intensive fishing, often to produce feed for salmon farms. While fish can shift their range to find suitable water temperature, nesting seabirds have fixed limits as to how far they can travel from nesting islands because longer fishing trips require the parents to burn more energy to find ample food for themselves and their young. Each puffin pair lays a single egg each year, and if that nest fails they will not reproduce again until the following year. Puffin colonies in the Atlantic and North Sea have shown declines of more than 30% since the 2000s. In addition to impacts on breeding success rates, under-conditioned Puffins who have been unable to find sufficient food during the summer months are more vulnerable to winter storms at sea, and recent years have seen large numbers of Puffins wash up on the coasts after bad weather.
3	**Bony Marine Fish Case including Cod:** Cod is one of the most important commercial species in the North Atlantic. Recent falls in cod numbers in the North Sea are in part due to a combination of fishing pressure and climate change, which is linked to increasing ocean temperatures. Cod has a pan-Atlantic distribution and inhabits waters with temperatures ranging from below −1°C to over 20°C, although usually they are found in waters with a temperature range of 0–12°C. It is one of the most important commercial species in the North Atlantic, in spite of significant declines that have occurred in several regions during recent decades. The regions occupied by cod are expected to experience some of the largest anthropogenic climate changes in the world. Stocks in the Celtic and Irish Seas are expected to disappear under predicted temperature changes by the year 2100, while those in areas to the north will decline. This has implications for food security and sustainability of the fishing industry.
4	**Jellyfish Case:** Warming oceans and other consequences of climate change are driving animal populations down on an unprecedented scale. However, one group of creatures is bucking

	this ominous trend: jellyfish. Jellyfish have roamed Earth's oceans for over 500 million years. They can be found all over the world, and there are over 4,000 species of them. Over the past twenty years, global populations of many jellyfish species have skyrocketed. Swarms of them, known as "jellyfish blooms," have become more common worldwide and in Ireland, forcing beach closures, and killing other fish. Recent research has revealed that the increases in jellyfish populations can be linked to human activity. As greenhouse gases trap heat on the planet, oceans are heating up — they absorb 93% of that excess heat. Unlike many marine species, jellies can thrive in warmer water with less oxygen. Jellies aren't vulnerable to fluctuating temperature, acidity, and salinity like other marine species. Typically, jellyfish populations are kept under control by marine predators like turtles and fish. But those populations have been dwindling due to overfishing. Fishing also removes jellies' competition for food; anchovies and squid eat the same type of plankton as jellyfish, so the more those species get removed from the seas, the more plankton jellies can access. In 2007, a mauve stinger jellyfish swarm 25 square kilometres in size killed 100,000 salmon in a fish farm off the coast of Ireland. However, perhaps the greatest concern is the proposed self-enhancing feedback loop termed 'the never-ending jellyfish joyride', whereby jellyfish become established so strongly that it may be impossible for fish abundance to recover to pre-exploitation levels, even if commercial fishing is reduced.
5	**Shellfish Case Including Mussels, Clams, Scallops:** Carbon changes the chemistry of the water by making it more acidic, 30 percent more since the start of the Industrial Revolution. Ocean acidification acts a lot like osteoporosis, the condition that causes bones to become brittle in humans. For oysters, scallops and other shellfish, lower pH means less carbonate, which they rely on to build their essential shells. The building of skeletons in marine species is particularly sensitive to acidity. To make calcium carbonate shells, shell-building marine animals such as corals and oysters combine a calcium ion (Ca+2) with carbonate (CO3-2) from surrounding seawater, releasing carbon dioxide and water in the process. As acidity increases, shells become thinner, growth slows down and death rates rise. The planktonic larval stages of many fish and shellfish species are also vulnerable, a concern for hatcheries and wild populations of shellfish. Of course, the loss of these organisms would have much larger effects in the food chain, as they are food and habitat for many other animals. Beyond lost biodiversity, acidification will affect fisheries and aquaculture, threatening food security for millions of people, as well as tourism and other sea-related economies.
6	**Northern Gannet:** The northern gannet is the largest seabird in the North Atlantic, with a 2 metre wingspan. Gannets feed on fish and perform dramatic plunge dives from a height to reach speeds of 100km/h and depths of 30 metres, and can stay submerged for over half a minute. They have developed an inbuilt "inflatable airbag" adaptation to prevent them breaking their necks when they hit the water at such high speeds! They also feed from the surface on small shoaling fish like sand eels and on discards from fishing vessels, where their large size helps them out-compete most other scavenging species. The northern gannet is endemic to the North Atlantic and most breed in Britain and Ireland. There are 21 "gannetries" around Britain and Ireland, with most being on remote offshore islands and stacks. Some colonies have been occupied for centuries and are large and conspicuous, such as that on Skellig Beag in Co. Kerry. Diminishing fish stocks around gannets' natural habitats, caused partly by an increase in sea temperature, are forcing birds to search further afield in search of food for their young. Some have been shown to now travel distances of over 1000km away to hunt. This means adults must leave their single chick on the nest unprotected for longer and longer periods, leaving the chicks at risk of starvation and predation.

7	**Fin Whale & Humpback Whale Skeletons:** Whales play a key part in helping to combat climate change through their role in the marine ecosystem. They play a vital role in the health of the oceans where they help provide up to 50% of our oxygen, combat climate change and sustain fish stocks. The way that whales feed, poo, migrate, and dive between the surface and the ocean depths (known as the 'whale pump'), circulates essential nutrients throughout the ocean. This in turn supports healthy marine ecosystems and the growth of phytoplankton, which locks in a massive amount of carbon from the atmosphere. By their sheer scale, large whales lock in huge amounts of carbon, however researchers estimate that this has been reduced by approximately nine million tonnes by commercial whaling. Indeed, the mass slaughter of whales in the 19th and 20th centuries may well have accelerated the effects of climate change, by both increasing the release of carbon into the atmosphere and diminishing the role whales play in locking it back in the oceans. Baleen whales, such as Fin whales and Humpback whales rely on stable environmental conditions and food resource availability for their survival. Their slow growth rates and dependence on prey such as zooplankton and smaller fish makes them highly sensitive to climate change. Ocean acidification affects marine invertebrates including zooplankton which are a major food source for whale species such as the Fin whale and Humpback whale, and climate change shifts the distribution of prey fish species such as herring further north. It has been estimated that climate change is likely to decrease the range of all the cetacean species listed as threatened by the IUCN, including Fin and Humpback whales.

3. Conclusion: What Can You Do to Help?

Even though the problem may seem huge, and far away from your control, there are things we can all do in our lives and our homes that can help to slow ocean acidification and carbon dioxide emissions.

The best thing you can do is to try and lower how much carbon dioxide you use every day. Try to reduce your energy use at home by recycling, turning off unused lights, walking or biking short distances instead of driving, using public transportation, and supporting clean energy, such as solar, wind, and geothermal power.

One of the most important things you can do is to tell your friends and family about ocean acidification. Because scientists only noticed what a big problem it is fairly recently, a lot of people still don't know it is happening. So talk about it! Educate your classmates and friends about how acidification will affect the amazing ocean animals that provide food, income, and beautiful wildlife to billions of people around the world.

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Maps:

Ground Floor – Irish Fauna

X **You Are Here**

1

Basking Shark

2

Atlantic Puffin

3

Bony Marine Fish Case incl. Cod

4

Jellyfish Case

5

Shellfish Case incl. Mussels, Clams, Scallops

6

Northern Gannet

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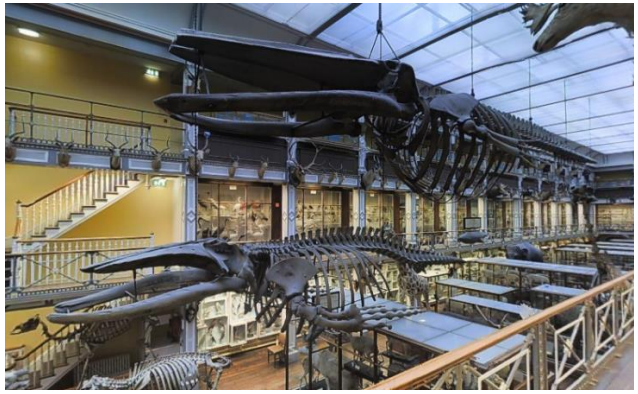
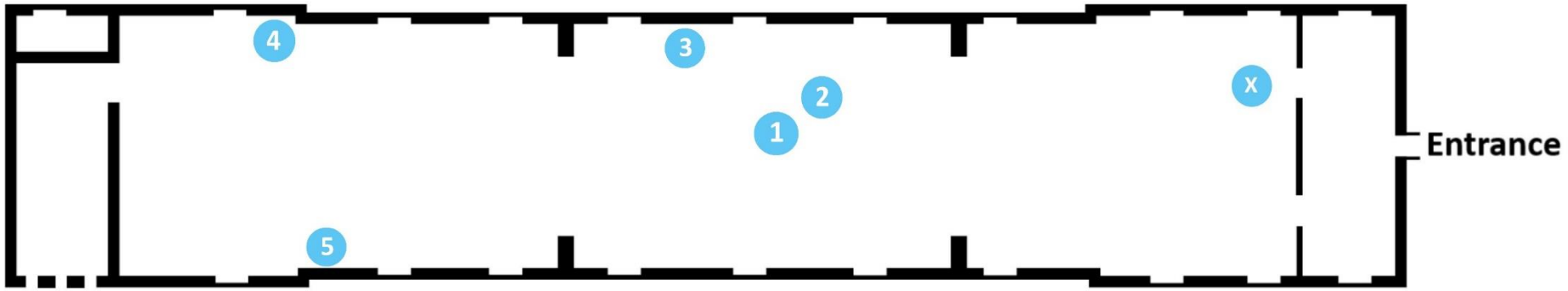
7



Fin Whale & Humpback Whale Skeletons

Ground Floor - Irish Fauna



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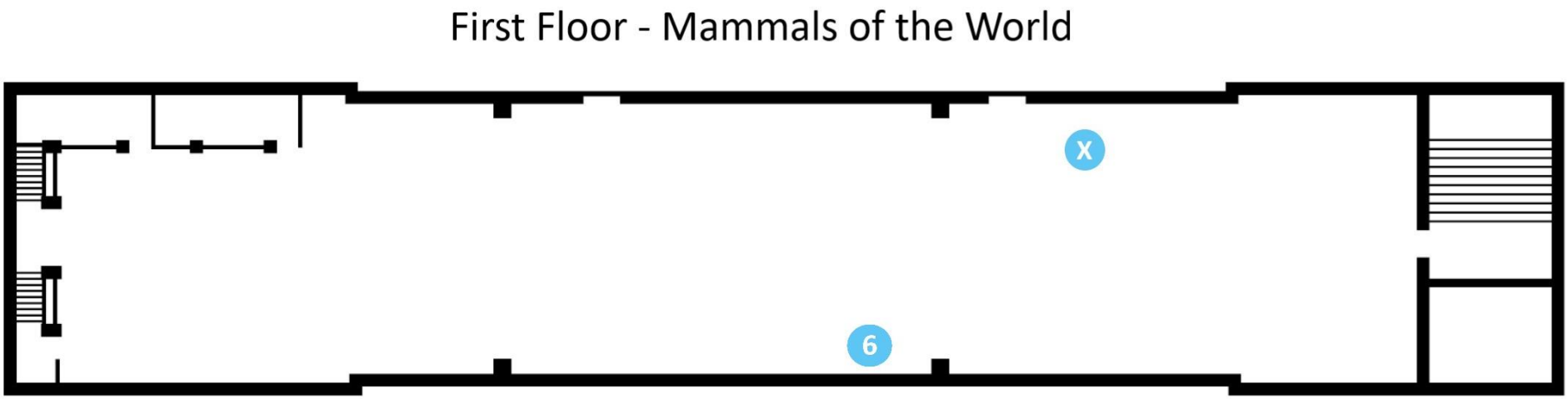
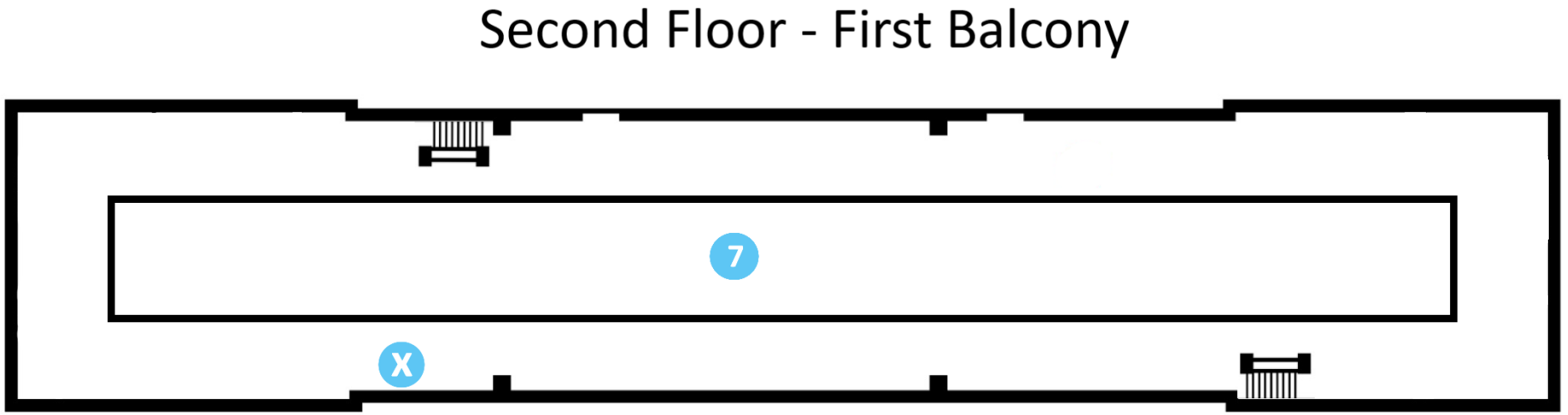
First Floor – Mammals of the World



Second Floor – First Balcony



Useful Websites and Resources:

- "How Whales Change Climate" YouTube Video Resource: https://www.youtube.com/watch?v=M18HxXve3CM
- Fish Carbon: Exploring Marine Vertebrate Carbon Services: https://www.grida.no/publications/172
- European Science Foundation "Impacts of Ocean Acidification": http://archives.esf.org/fileadmin/Public_documents/Publications/SPB37_OceanAcidification.pdf
- BirdWatch Ireland Ocean and Climate Change: https://birdwatchireland.ie/ocean-and-climate-change/
- An Taisce Green Schools Secondary Climate Change Curriculum: https://greenschoolsireland.org/resources/secondary-climate-change-curriculum-teachers-resource/
- Schools Climate Action Network: https://www.schoolsclimateaction.ie/
- Climate Ambassador Schools Climate Actions: https://climateambassador.ie/actions/school/
- Environment Protection Agency Environmental Education and Secondary Schools: https://www.epa.ie/researchandeducation/education/secondary/
- The IUCN Redlist of Threatened Species: https://www.iucnredlist.org/
- Watch the new David Attenborough "A Life on Our Planet" film available on Netflix. This film outlines the threats humanity faces due to climate change, and provides a constructive and hopeful vision for the future: https://www.netflix.com/ie/title/80216393. We recommend teachers view in advance of screening to students.