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Climate change

Sustainability Goals:



Subject links:

Science, Geography

Age: 14-16

Curriculum links:

Climate, Human impact, Natural environment, Topical issue, Investigation, Data analysis, Environmental responsibility

Ocean Literacy Principles:

3. The ocean is a major influence on weather and climate.
6. The ocean and humans are inextricably interconnected

Aim:

Pupils will understand the connections between climate change and the ocean.

Learning Objectives:

- To discover how the ocean helps to reduce the effects of climate change
- To discover how climate change is affecting the ocean
- To discuss ideas to help reduce the effects of climate change on the ocean

Resources provided:

- [Climate change Fact File](#)
- [Climate change and the ocean PowerPoint](#)
- [Ocean acidification worksheet](#)
- [Blue carbon variation worksheet](#)
- [How can we help reduce climate change? - template](#)
- [How can we help reduce climate change? - completed example](#)
- [Full curriculum links](#)

Step 1

Background

Climate change is the long-term global shift in the planet's average temperatures and weather patterns. Human activities are adding greenhouse gases into the atmosphere accelerating the rate of change.

Climate change is causing both atmospheric and sea temperatures to rise, and our ocean and its ecosystems are suffering from rising sea levels, ocean acidification, changes in ocean currents and increased extreme weather events. Globally, we all need to reduce carbon emissions from activities both on land and at sea to reduce the rate of climate change. You can find more information in the [Climate change Fact File](#).

Step 2

Set the Scene

Using the slides and notes in the [Climate change and the ocean PowerPoint](#), lead a group discussion on how climate change affects the ocean.

Step 3

Activities

Activity 1 – Ocean acidification

To study one of the impacts in more detail, watch the ocean acidification video in the [PowerPoint](#). In the video, there is a clip briefly showing what happens to calcium carbonate in acidic solutions. To investigate this further, set up an acidification experiment.

In small groups, students should work together to set up the experiment. Each group will need a calcium carbonate object (e.g. shell or chalk) and two beakers, one with a water/vinegar mix (to mimic an acidic ocean) and the other with just water. Ask students to record the pH of each solution on the [Ocean acidification worksheet](#). Students should be guided to create a hypothesis of what will happen to the calcium carbonate object in the two different solutions over time. Refer back to knowledge gained in the video to help with the hypothesis. Before starting the experiment, students should sketch the calcium carbonate object and record its size and weight. If you have access to a microscope or magnifying glass, it's also really useful for students to compare the structure of the object pre and post-experiment. This experiment needs time, and you should review and analyse results the following week.

When analysing results, students should repeat measurements of weight, size, and pH level. Students should also sketch what the object looks like now and examine using a magnifying glass or microscope. Compare results and discuss how this experiment relates to ocean acidification.

Resources required: [Climate change and the ocean PowerPoint](#), [Ocean acidification worksheet](#), shells or chalk, microscopes/magnifying glass, beakers, distilled water, vinegar/water mix, litmus paper.

Activity 2 – Blue Carbon Ecosystems

Introduce students to blue carbon habitats and their role in helping to reduce carbon in the atmosphere by watching the video in the [PowerPoint](#).

Students should interpret and analyse the three graphs in the [PowerPoint](#) that show global carbon variation between ecosystems. Students should use the [Blue carbon variation worksheet](#) to explain what is being measured and what is being compared. They should describe patterns, trends and range in the data for each graph by quoting figures and units and identifying any anomalies. Students should explain the results of each graph and then compare the three graphs and draw a conclusion.

Resources required: [Climate change and the Ocean PowerPoint](#), [Blue carbon variation worksheet](#)

Activity 3 – How can we help reduce climate change?

Using the [PowerPoint](#), introduce the various methods we can take to protect our ocean.

In small groups, students should use the [mind map template](#) to draw together everything they have learnt in Activities 1, 2 and 3. A completed example of a mind map is provided.

Students should summarise:

- The effects of climate change on the ocean.
- How the ocean helps reduce climate change.
- Threats to the ocean.
- How we can manage our seas more efficiently.
- How we can all make changes to benefit the ocean and reduce climate change.

Once students have completed their mind maps, they should make links between the answers they gave for each question. For example:

- Extreme weather causes storms which damage fragile habitats and destroy coastal properties.
- Plants in carbon storing habitats like saltmarsh, mangroves and seagrass absorb and store carbon dioxide through photosynthesis.
- Coastal development destroying habitats like saltmarsh and mangroves.
- Reduce coastal construction that damages climate smart habitats like saltmarshes and support marine conservation charities.

Students should then use these links to come up with a campaign idea to help reduce climate change. They should write a persuasive text for why their campaign needs action. They could use the themes of each mini mind map to help structure their text.

Resources required: [Climate change and the ocean PowerPoint](#), [How can we reduce climate change? template](#), [How can we reduce climate change? completed example](#)

Extension activity ideas

Climate Diary

If you have time to run this session over several classes, start the topic with a diary exercise. Ask students to write down briefly what they have done so far today. Then ask them to link these actions to energy consumption and climate change. For example, what did they eat for breakfast? How does this link to climate change and energy? To finish the topic, ask students to review their diaries. Students should think creatively and write down ideas for alternative greener diary entries. How could they make simple changes to the actions in their day to reduce their climate impact? For example, could they make changes to what they have for breakfast to make it a greener meal?

Biofuels

Shipping and ocean transport currently make up 3% of global anthropogenic greenhouse gas emissions. This is expected to double by 2050. One way to reduce emissions is by using alternative greener fuels such as biofuels.

The following experiment explores how we could reduce carbon emissions for our shipping and ferries and pleasure boats. Students will see how using biofuels can create green energy and is therefore a possible solution to reduce our dependency on fossil fuels in the transport industry. Full instructions can be found on page 11 of the [Biotechnology and Biological Sciences Research Council workbook](#).

Step 4

Reflect

Describe one way the ocean helps to reduce the effects of climate change. Can you describe what ocean acidification is and how it affects marine animals? How can we help to directly and indirectly reduce the effects of climate change on the ocean?

Step 5

Follow up

To continue looking into key threats affecting the ocean, take a look at our [Sustainable fishing](#) lesson, which explores how unsustainable fishing practices are depleting the world's fish stocks and damaging marine ecosystems.

Our [Marine pollution](#) lesson explores how pollution enters the ocean, how it damages the marine environment and what we can do to reduce pollution.

Climate change Fact File



Why is the ocean so important?

- The ocean is incredibly diverse and home to a huge range of habitats and species
- Marine plants and algae produce over 50% of the oxygen we breathe
- Marine habitats help to store carbon, which is incredibly important in the fight against climate change
- The ocean regulates our climate and weather systems, and plays a major role in the water cycle
- Coastal habitats help to protect coastal communities and towns from storms and flooding by reducing wave energy
- Millions of people have jobs in marine industries
- The ocean is important for our health and wellbeing, with millions of people using the ocean and coastline recreationally and creatively
- Seafood provides a source of food and protein for millions of people



How does climate change affect the ocean?

Sea temperature – Global warming is causing a rise in both atmospheric and sea temperatures. In fact, the ocean has absorbed more than 90% of the excess heat in the climate system.

Ocean currents – The ocean plays a huge role in regulating our climate and our water cycle. But rising temperatures are impacting ocean currents and the circulation of water around our planet, which in turn is having an impact on our climate.



Franz Josef Land
© Christopher Michel

Climate change Fact File



How does climate change affect the ocean? (continued)

Sea level rise – Ice melting on land in our polar regions is causing sea levels to rise. It is estimated that by 2050 sea levels will rise globally by one metre. Flooding caused by sea level rise will affect many coastal communities and habitats, with some low-lying islands in countries like the Maldives becoming submerged. Sea level rise also leads to increased coastal erosion, threatening UK towns like Happisburgh which is losing 2 metres of land per year.



Road collapse near Aldbrough © Michael Livsey

Ocean acidification – Increasing concentrations of carbon dioxide are causing a decrease in ocean pH, known as ocean acidification. This causes problems for animals that grow a calcium carbonate shell, like corals. Coral reefs create vitally important habitats for many other animals. Shellfish and some plankton species, which are important food sources, also have calcium carbonate shells and will be affected by ocean acidification.



Bleached corals © ARC Centre of Excellence for Coral Reef Studies

Distribution of animals and plants – Plant and animal species are travelling further north, and to greater depths, to search for cooler waters. These new areas may not provide animals with the food they need or effective reproduction sites. New species moving to an area could also have a negative impact on native plants and animals through competition for resources and space.



Storm clouds over the sea © Sr. Pacman

Extreme weather – Climate change is causing an increase in the frequency and size of storms and extreme weather events. These events have devastating effects on fragile marine coastal environments, like coral reefs and seagrass beds.

Climate change Fact File



How does the ocean help to *reduce* climate change?

Blue carbon – The term ‘blue carbon’ refers to carbon that is removed from the atmosphere by ocean plants and is then stored in ocean ecosystems and sediments – carbon sequestration in the ocean.

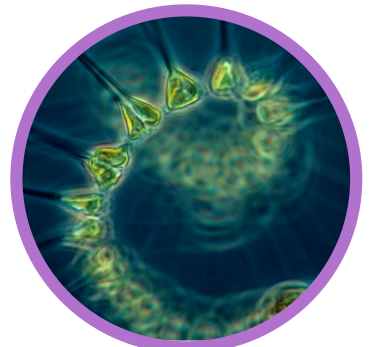
Habitats – In the UK, habitats like seagrass beds and saltmarshes, as well as mangrove forests in tropical waters, are brilliant at absorbing carbon dioxide from the atmosphere through photosynthesis. These habitats can absorb and store more carbon per metre than forests on land. Activities that are damaging to these habitats, such as dredging, not only harm the plants and animals living there, but release sequestered carbon, methane and nitrous oxide into the atmosphere.

Plankton – Plankton is the term for tiny algae (phytoplankton) and animals (zooplankton). Phytoplankton produce huge amounts of oxygen and absorb huge amounts of carbon dioxide through photosynthesis. Carbon is transferred up the food chain from small plankton species to larger fish species. When plankton that isn't eaten dies, their bodies sink down to the seafloor (known as marine snow), and carbon in the plankton is buried and stored in the seabed.

Fish – As fish move from deep waters to shallow to feed, they bring nutrient-rich waters from below. These nutrients enhance the production of plankton, and therefore enhance the uptake of carbon dioxide. Carbon also builds up through the food chain and is stored in the bodies of marine species. When they die, their bodies can sink to the seafloor and some of this carbon is eventually stored and buried in deep ocean sediments.



Eelgrass bed
© Divedog



Phytoplankton
© NOAA



Shoal of sardines
© Rich Carey

Climate change Fact File



Protecting our ocean for the future

Globally we need to reduce carbon emissions both on land and at sea.



We need to increase the amount of **renewable energy** sources including wind, wave and tidal, and decrease extraction of fossil fuels. Marine industries like shipping, ferries and fishing need to improve their **environmental efficiency** to reduce carbon emissions.



Damaging activities like dredging, coastal development or destructive fishing methods, can release carbon from sediments and destroy important blue carbon habitats. These activities need to be **managed in a climate-smart way**.



Protein that we get from meat produced on land generates huge amounts of carbon emissions. **Sustainable fishing** practices produce much less carbon, and a shift towards a sustainable fish diet could offer a positive solution to consuming protein with fewer carbon emissions. Protein doesn't just come from fish, but other seafood species like mussels, crabs and even seaweed, which have especially low carbon emissions.



Marine Protected Areas (MPAs) are like nature reserves in the ocean, and they're a great way to help protect and recover blue carbon habitats. Currently MPAs don't protect against all activities. To give blue carbon habitats a chance to recover and thrive, we need to introduce Highly Protected Marine Areas where no damaging activity at all is allowed.



Outreach and education helps to raise awareness amongst schools, universities, the public and businesses, and guide them on how to take action for the climate.



Everybody can help to reduce the effects of climate change on the ocean. Shifting diets to eat more sustainable protein, buying second-hand clothing, buying less and fixing things when they're broken, switching energy suppliers to support green energy, and decreasing electricity, heating and transport use all help reduce your own carbon emissions.

Ocean Acidification

Name:

Hypothesis:

Calcium carbonate sketch

Before experiment:

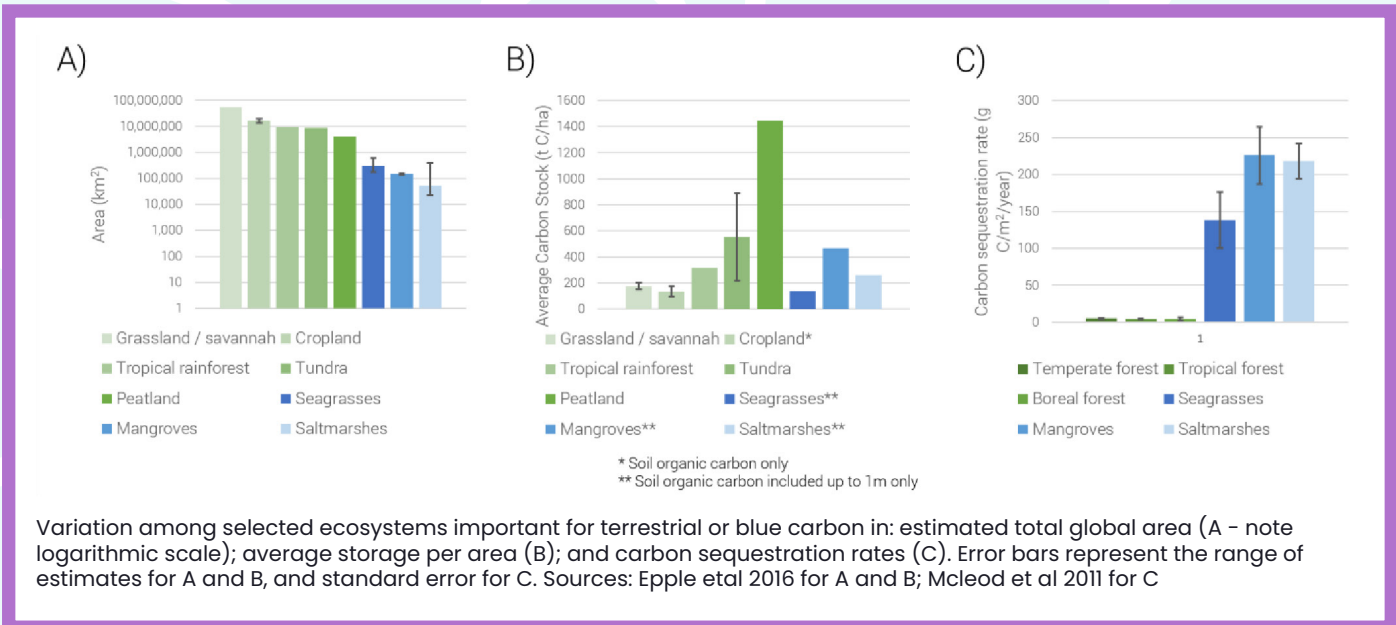
After experiment:

	Acidic water		Neutral water	
	Before	After	Before	After
pH				
Size				
Weight				

This experiment shows...

Blue Carbon Variation

Name: _____



What is being measured in graph A?

Describe patterns, trends and range in the data for graph A. Quote figures and units, and identify any anomalies:

What is being measured in graph B?

Describe patterns, trends and range in the data for graph B. Quote figures and units, and identify any anomalies:

What is being measured in graph C?

Describe patterns, trends and range in the data for graph C. Quote figures and units, and identify any anomalies:

Compare all the results for all three graphs and summarise what the data is showing:

How can we help reduce climate change?

Name:

How is climate change
affecting the ocean?
How is this affecting
people?

How does a healthy
ocean help to reduce
climate change?

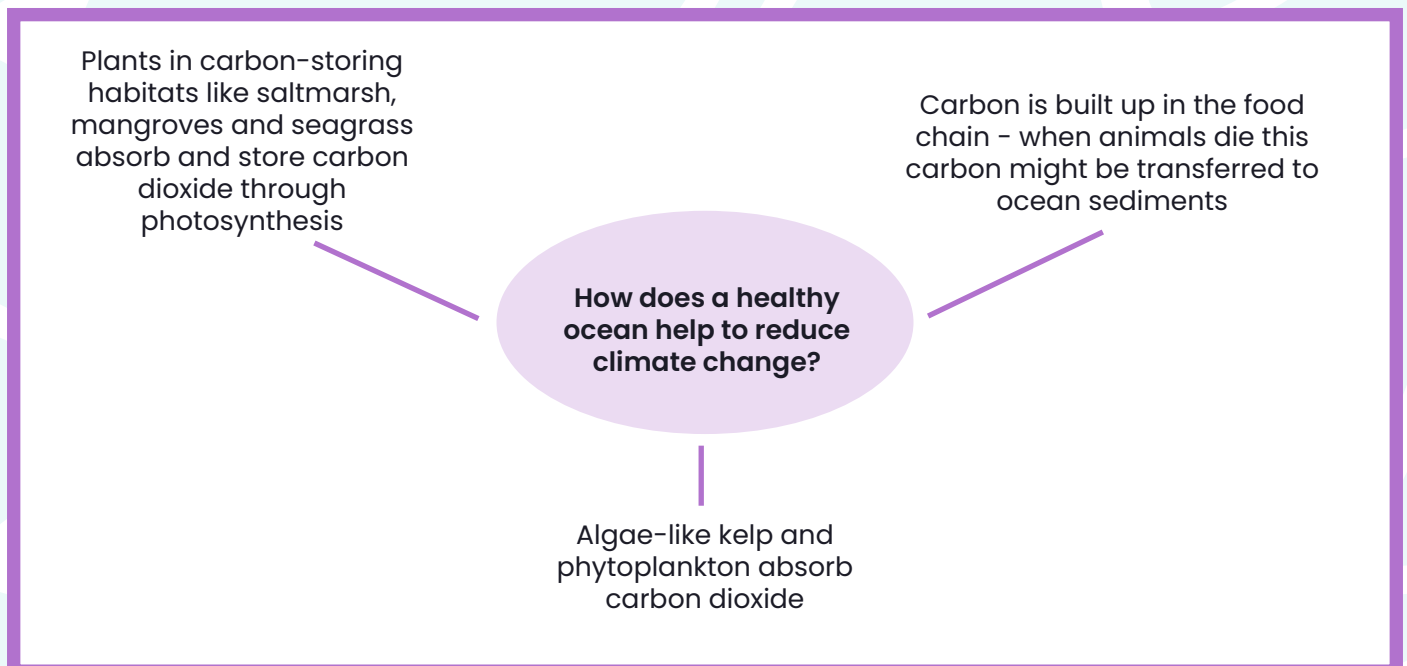
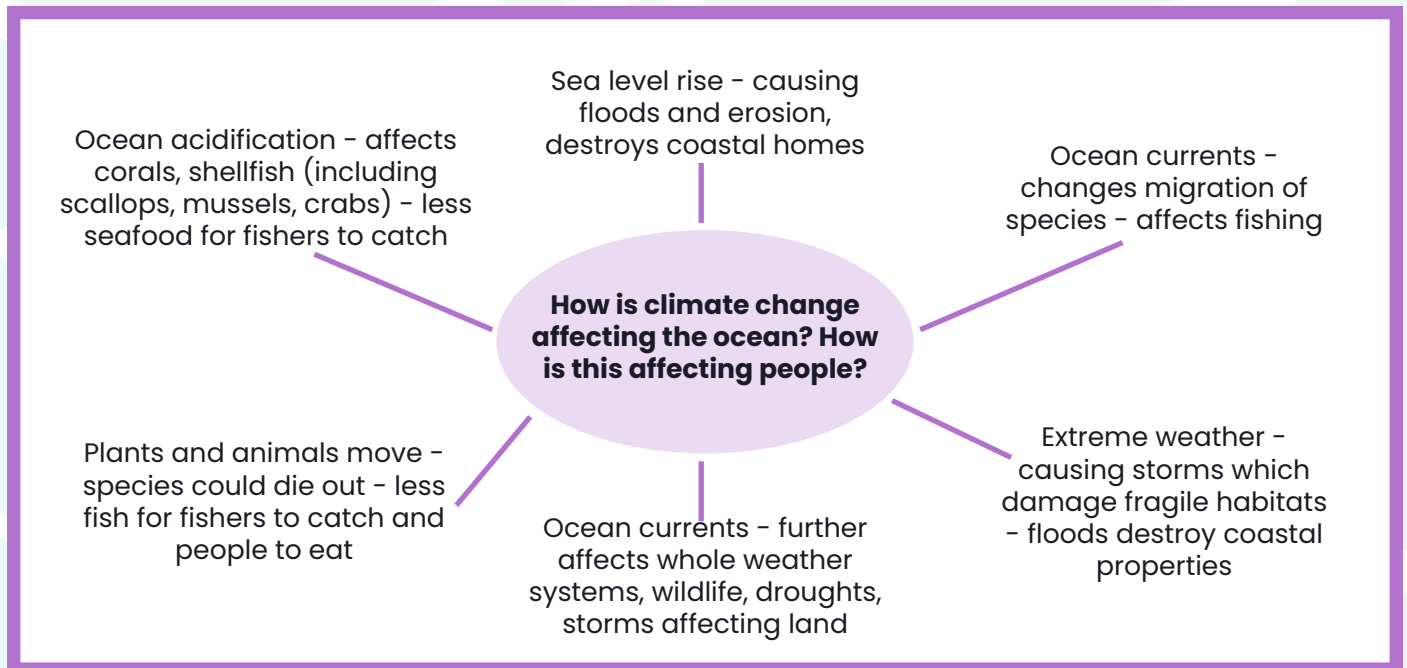
What threats to the ocean might prevent it from being able to reduce climate change?

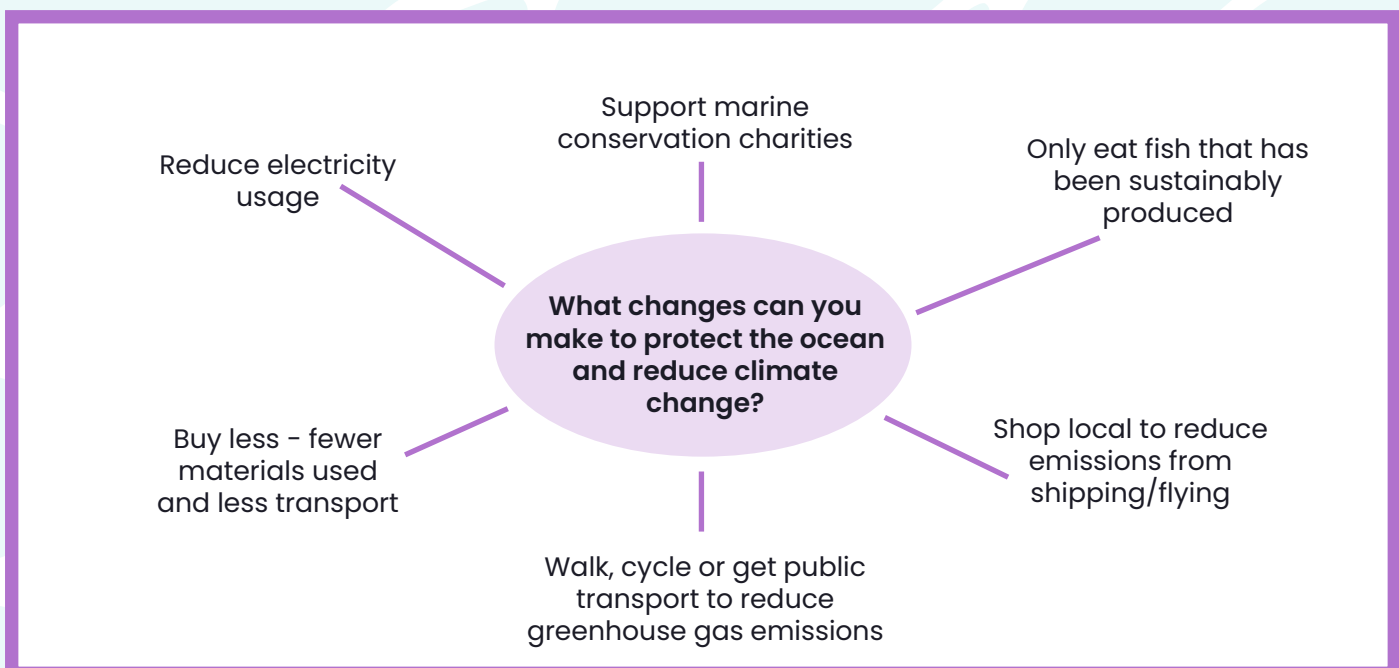
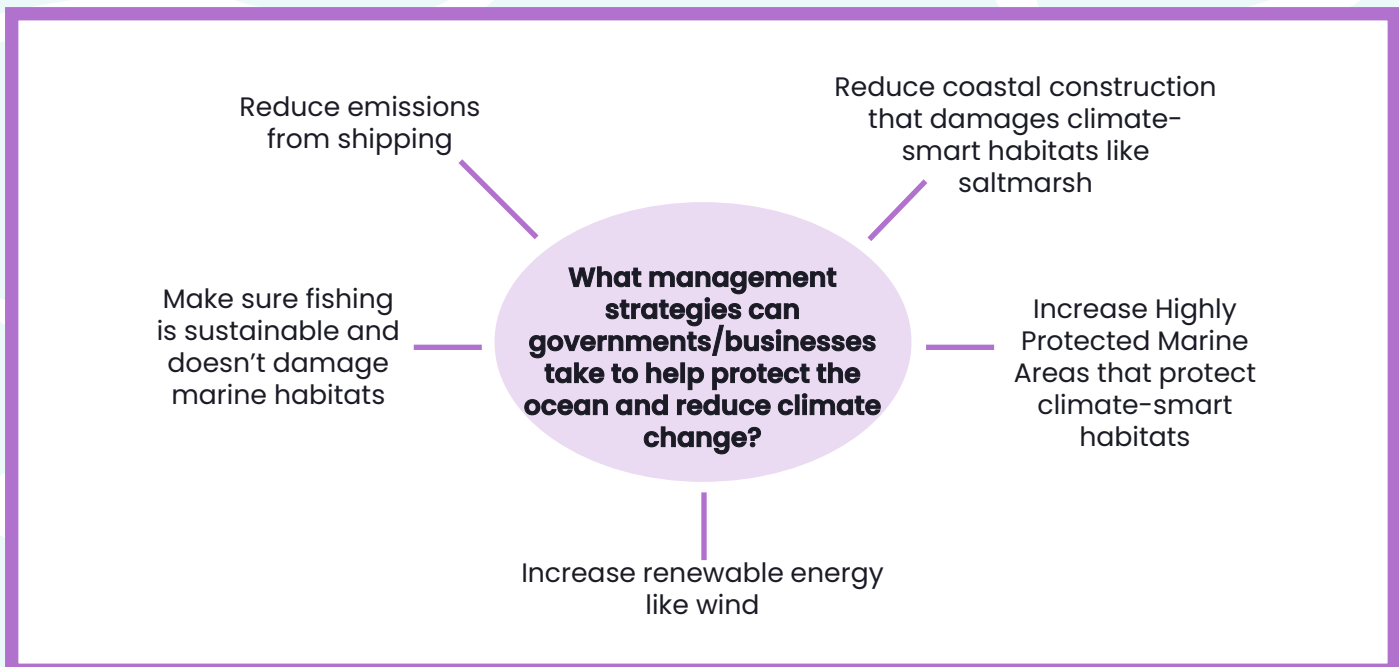
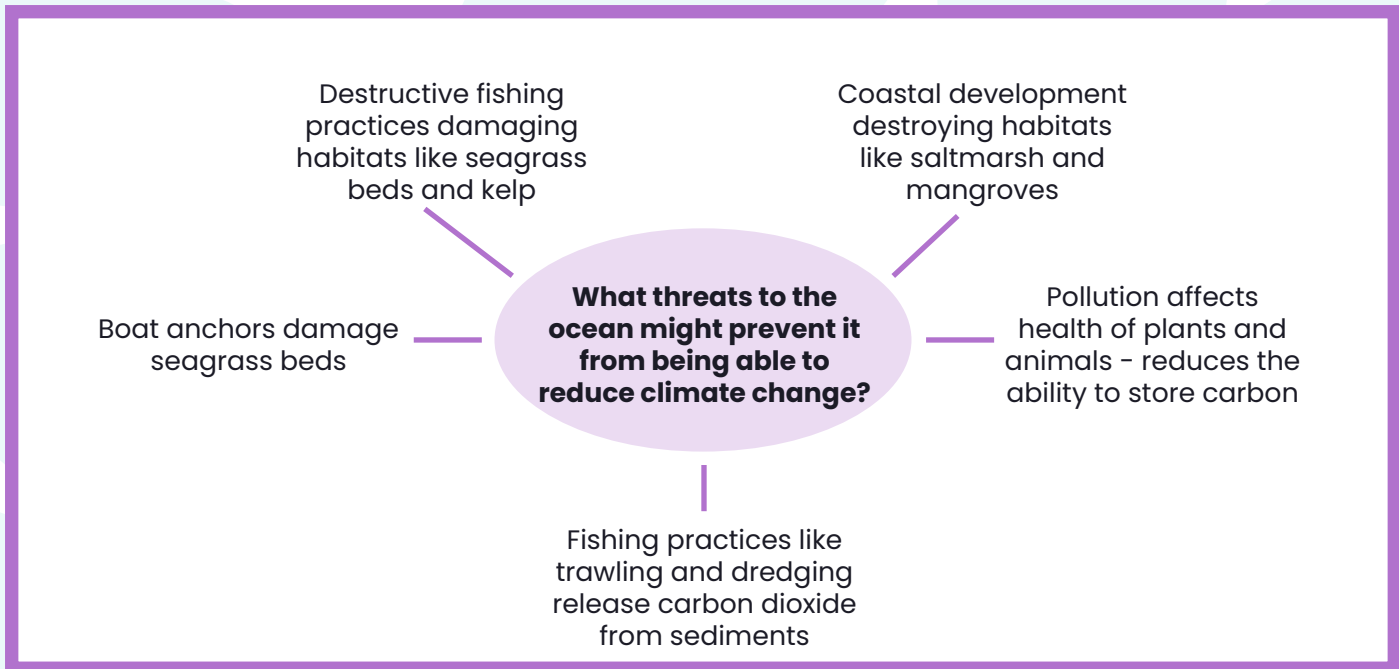
What management strategies can governments/businesses take to help protect the ocean and reduce climate change?

What changes can you make to protect the ocean and reduce climate change?

How can we help reduce climate change?

Name: _____





Curriculum Links – England

Key Stage 3

Science

- Experimental skills and investigations
 - Ask questions and develop a line of enquiry based on observations of the real world, alongside prior knowledge and experience
 - Make predictions using scientific knowledge and understanding
 - Use appropriate techniques, apparatus, and materials during fieldwork and laboratory work, paying attention to health and safety
 - Make and record observations and measurements using a range of methods for different investigations; and evaluate the reliability of methods and suggest possible improvements
- Skills and attributes of scientifically literate citizens
 - Expresses informed views about topical scientific issues, including those featured in the media, based on evidence and demonstrating understanding of underlying scientific concepts.

Geography

- Understand the processes that give rise to key physical and human geographical features of the world, how these are interdependent and how they bring about spatial variation and change over time
- Collect, analyse and communicate with a range of data gathered through experiences of fieldwork that deepen their understanding of geographical processes
- Interpret a range of sources of geographical information, including maps, diagrams, globes, aerial photographs and Geographical Information Systems (GIS)
- Communicate geographical information in a variety of ways, including through maps, numerical and quantitative skills and writing at length.
- Human and physical geography
 - Understand, through the use of detailed place-based exemplars at a variety of scales, the key processes in:
 - Physical geography relating to: the change in climate from the Ice Age to the present and coasts.
 - Understand how human and physical processes interact to influence, and change landscapes, environments and the climate; and how human activity relies on effective functioning of natural systems.

Curriculum Links – England

Key Stage 4

Science

- Experimental skills and strategies
 - Using scientific theories and explanations to develop hypotheses
 - Planning experiments to make observations, test hypotheses or explore phenomena
 - Carrying out experiments appropriately, having due regard to the correct manipulation of apparatus, the accuracy of measurements and health and safety considerations
 - Making and recording observations and measurements using a range of apparatus and methods
 - Evaluating methods and suggesting possible improvements and further investigations.
- Ecosystems
 - Levels of organisation within an ecosystem
 - Some abiotic and biotic factors which affect communities; the importance of interactions between organisms in a community
 - The importance of biodiversity
 - Positive and negative human interactions with ecosystems.

Geography

- Use of data
 - Data should include both qualitative and quantitative data, digital sources; visual and graphical sources; and numerical and statistical information. Using data should include its interpretation and analysis.
- Physical geography: processes and change
 - Changing weather and climate – The causes, consequences of and responses to extreme weather conditions
- People and environment: processes and interactions
 - Global ecosystems and biodiversity – An overview of the distribution and characteristics of large scale natural global ecosystems. Issues related to biodiversity and to their sustainable use and management.
 - Resources and their management – An overview of how humans use, modify and change ecosystems and environments in order to obtain food, energy and water resources. Detailed study of one of either food, energy or water, recognising the changing characteristics and distribution of demand and supply, past and present impacts of human intervention, and issues related to their sustainable use and management at a variety of scales.

Progression Step 4

Science

- Being curious and searching for answers is essential to understanding and predicting phenomena.
 - I can research, devise and use suitable methods of inquiry to investigate my scientific questions.
 - I can use my findings to draw valid conclusions.
 - I can evaluate and identify ways of improving the reliability of data, taking anomalies into account.
 - I can use a range of models to explain and make predictions
 - I can explain how the impact of our actions contribute to the changes in the environment and biodiversity.

Humanities

- Enquiry, exploration and investigation inspire curiosity about the world, its past, present and future.
 - I can analyse, present and reflect on my findings, describing patterns and explaining relationships across data and sources.
 - I can analyse the usefulness and consider the reliability and validity of a range of evidence relating to my enquiry.
- Our natural world is diverse and dynamic, influenced by processes and human actions.
 - I can understand and explain how human actions affect the physical processes that shape places, spaces, environments and landforms over time.
 - I can understand and explain the range of factors that affect the interrelationships between humans and physical processes.
- Informed, self-aware citizens engage with the challenges and opportunities that face humanity, and are able to take considered and ethical action.
 - I have an understanding of my own and others' environmental, economic and social responsibilities in creating a sustainable future.

Progression Step 5

Science

- Being curious and searching for answers is essential to understanding and predicting phenomena.
 - I can devise, justify and use systematic methods of inquiry to rigorously investigate my scientific questions and recognise limitations.
 - I can link experimental findings and theoretical knowledge to draw valid conclusions.
 - I can critically evaluate the quality of data and justify improvements.
 - I can evaluate contemporary issues that affect the planet and biodiversity.

Humanities

- Enquiry, exploration and investigation inspire curiosity about the world, its past, present and future.
 - I can evaluate and reflect on my findings, synthesise information, analyse patterns and trends, predict possible outcomes (where appropriate), and present well-supported and justified conclusions.
 - I can independently evaluate the success of enquiries, suggesting improvements and refining methods for future enquiries.
- Our natural world is diverse and dynamic, influenced by processes and human actions.
 - I can explain and analyse the wide range of interrelationships and interdependencies between the human actions and physical processes that shape places, spaces, environments and landforms over time.
 - I can give comprehensive explanations and analysis of how and why places, spaces, environments and landforms have changed over time.
- Informed, self-aware citizens engage with the challenges and opportunities that face humanity, and are able to take considered and ethical action.
 - I can explain the importance of the role played by groups, governments, businesses and non-governmental organisations in the creation of a sustainable future, and how they impact on people and their rights and on the environment.

Third-Fourth Level

Science

Third Level

- Inquiry and investigative skills
 - Plans and designs scientific investigations and enquiries
 - Carries out practical activities within a variety of learning environments
 - Analyses, interprets and evaluates scientific findings

Fourth Level

- Inquiry and investigative skills
 - Plans and designs scientific investigations and enquiries
 - Carries out practical activities within a variety of learning environments
 - Analyses, interprets and evaluates scientific findings

Social sciences

Third Level

- People, place and environment
 - I can identify the possible consequences of an environmental issue and make informed suggestions about ways to manage the impact.
 - I can investigate the climate, physical features and living things of a natural environment different from my own and explain their interrelationship.

Fourth Level

- People, place and environment
 - I can discuss the sustainability of key natural resources and analyse the possible implications for human activity.
 - I can develop my understanding of the interaction between humans and the environment by describing and assessing the impact of human activity on an area.
 - I can identify threats facing the main climate zones, including climate change, and analyse how these threats impact on the way of life.
 - I can carry out a geographical enquiry to assess the impact and possible outcomes of climate change on a selected region and can propose strategies to slow or reverse the impact.

Senior Phase

Environmental science

National 4

Skills, knowledge and understanding

- Demonstrating knowledge and understanding of environmental science by making statements, describing information and providing explanations
 - Planning and safely carrying out practical investigations/experiments to illustrate effects
 - Making generalisations based on evidence/information
 - Drawing valid conclusions and giving explanations supported by evidence
 - Suggesting improvements to practical investigations
- Living Environment
 - The impact of population growth and natural hazards on biodiversity.
 - Earth's Resources
 - The responsible use and conservation of non-renewable and renewable resources; the formation and use of fossil fuels; the carbon cycle and processes involved in maintaining the balance of gases in the air, and the causes and implications of changes in the balance
 - Sustainability
 - The sustainability of key natural resources and possible implications for human activity; the interaction between humans and the environment and the impact of human activity on an area.

National 5

- Skills, knowledge and understanding for the course – the following provides a broad overview of the subject skills, knowledge and understanding developed in the course:
 - Demonstrating knowledge and understanding of environmental science by making statements, describing information, providing explanations and integrating knowledge
 - Applying knowledge of environmental science to new situations, interpreting information and solving problems
 - Planning, designing, and safely carrying out experimental/fieldwork investigations to test given hypotheses or to illustrate particular effects
 - Drawing valid conclusions and giving explanations supported by evidence/justification
 - Suggesting improvements to practical experimental/fieldwork investigations
 - Communicating findings/information
- Living Environment
 - Investigating ecosystems and biodiversity
 - Human influences on biodiversity
- Sustainability
 - Introduction to sustainability
 - Energy

Senior Phase

Geography

National 4

- Skills, knowledge and understanding
 - Developing and applying straightforward skills, knowledge and understanding in geographical contexts
 - Using and interpreting a limited range of numerical and graphical information in familiar contexts
 - Demonstrating knowledge and understanding of selected global issues by giving factual descriptions and straightforward explanations
- Physical Environments
 - Location of landscape type; formation of key landscape features; land use management and sustainability; and weather. Learners will study a selection of landscape types from contexts within Scotland and/or the UK. Landscape types will be chosen from: glaciated upland; upland limestone; coastal landscapes; and rivers and valleys.
- Global Issues
 - climate change; the impact of human activity on the natural environment.

National 5

- Skills, knowledge and understanding for the course
 - Developing and applying skills and detailed knowledge and understanding in geographical contexts
 - Using and interpreting a range of numerical and graphical information
 - Demonstrating knowledge and understanding of selected global issues by giving detailed descriptions which are mainly factual with some theoretical content, and giving detailed explanations
- Global issues
 - Climate change
 - features of climate change
 - causes – physical and human
 - effects – local and global
 - management strategies to minimise impact/effects