OCEAN ACIDIFICATION

This science pack has been created by the Marine Alliance for Science and Technology (MASTS). MASTS is an organisation that enhances the excellence of marine research in Scotland across 17 institutes and 700+ members. With such a large number of scientists working at the forefront of marine science, MASTS recognises the importance of communicating what we learn to the public.

People Ocean Planet (POP) is an initiative within MASTS, helping to drive positive changes across society for the ocean by making best use of our scientific knowledge.

To deliver this information we have worked with experts from MASTS Research forums. There are 12 of these forums in MASTS, creating a network of experts who meet to discuss, direct and support the research in their field. In this section of the pack you will hear from Matthew Wale the representative of the Marine Stressors forum.

You can learn more about MASTS, People Ocean Planet and the Marine Energy Forum in the QR links to the right.

MASTS

POP

Marine Stressors Forum

Curriculum Links
Age 11-14

Science - Acidity of metals and non-oxides
- The carbon cycle
- Production of carbon dioxide by human activity and the impact on climate
- Relationships in an Ecosystem

Geography - Human and Physical Geography

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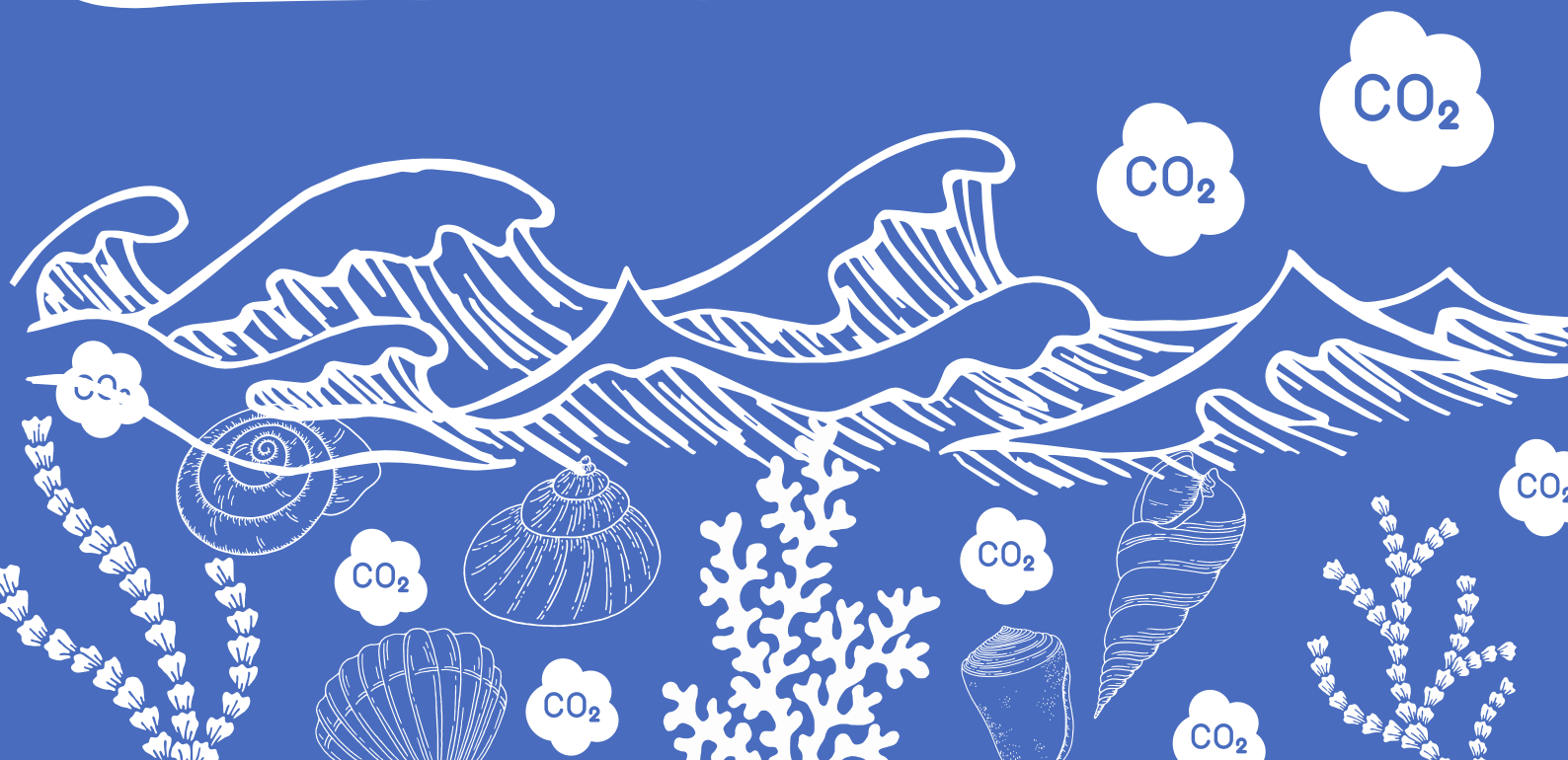


Great Science Share for SCHOOLS

DR MATTHEW WALE

UNIVERSITY TUTOR

UNIVERSITY OF EDINBURGH

ABOUT MATT

HIS JOURNEY INTO STEM

Matt has been fascinated with the marine world from a very early age, regular seaside holidays rock pooling led him to announce, at the age of 4, that he wanted to be a marine biologist. From then on, he worked towards this goal, finally enrolling at the University of Plymouth to study Marine Biology. During his time at university, he developed a love of marine invertebrates and how they interact with human impacts in the environment. He continued his studies with research degrees from the University of Bristol and Edinburgh Napier University, followed by postdoctoral research at Edinburgh Napier and King Abdullah University of Science and Technology in Saudi Arabia.

HIS JOB

Matt now works as a tutor at Edinburgh Napier University where he helps to teach the next generation of marine scientists. Alongside his teaching commitments, Matt conducts research to understand the ways marine invertebrates interact with their environment and how these interactions are affected by human disturbance. The overarching goal of Matt's research is to use the information he gains by understanding these interactions to begin to reduce human impacts on the marine environment.

HIS HOBBIES

Even when not at work Matt is around water, spending time scuba diving, surfing, and kayaking. He equally enjoys exploring the Scottish wilderness and regularly goes wild camping and hill walking in the highlands and islands of Scotland.

THE QUESTION MATT WANTS TO ANSWER IS...

How do marine invertebrates respond to human made disturbances in their environment?

As human populations have increased large proportions of the marine environment are regularly in contact with human activities. These activities bring with them a number of potential disturbances that can affect the biology of the organisms that experience them. By understanding the ways marine organisms are influenced by human activities we can reduce their impacts and conserve marine biodiversity for future generations.

MATT INSPIRES YOU TO THINK ABOUT...

How the things humans do in the oceans can have unforeseen effects on marine organisms, and that we need to study these effects to limit our impact on the oceans and the organisms that live there.

IT'S TIME TO EXPLORE OCEAN ACIDIFICATION WITH MATT - LET'S GO!

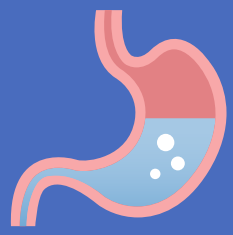
WHAT?

WHAT IS AN ACID?

An acid is a substances which can release hydrogen ions H+ when dissolved in water. The acidity is measured on a pH scale, which is an abbreviation of measuring the 'power of hydrogen'.

ACTIVITY 1

Can you match up the pH of these items with the right number on the pH scale. Matt has given you the answers to a few to get you started.



STOMACH ACID

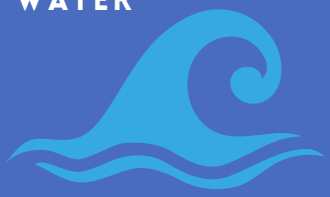
BAKING SODA

PURE WATER

BLEACH

BLACK COFFEE

MILK



SEAWATER

LEMON JUICE

TOMATO

VINEGAR

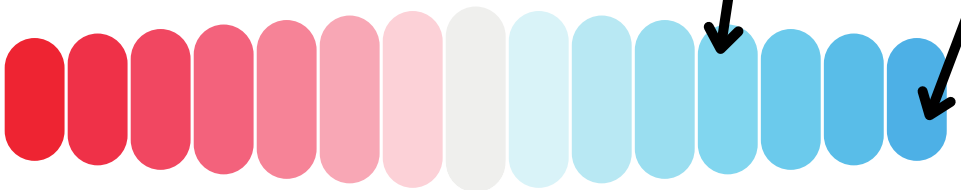
SOAP

AMMONIA

DRAIN CLEANER

pH scale

Acidic Neutral Alkaline



0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

WHAT?

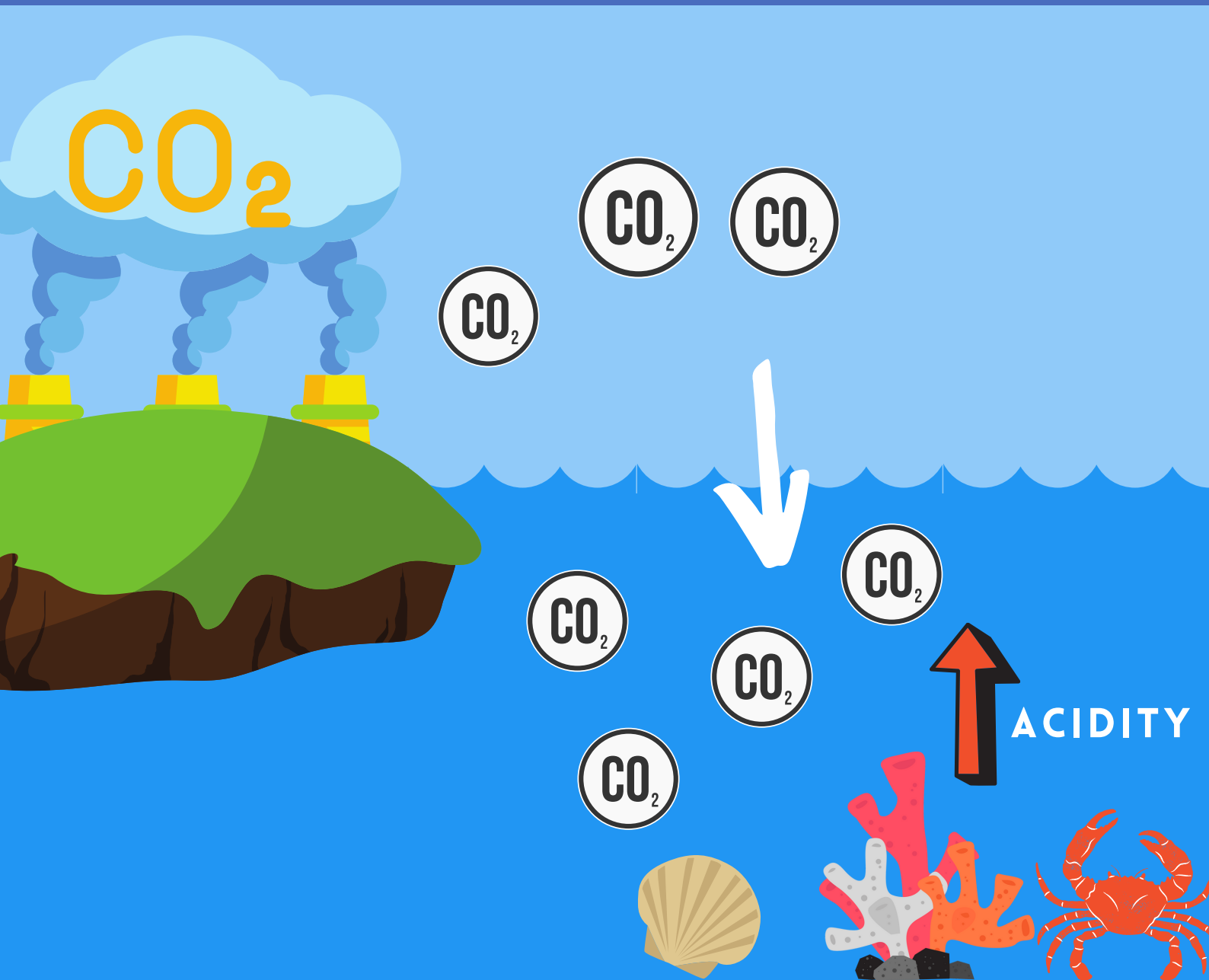
WHAT IS OCEAN ACIDIFICATION?!

Our oceans are a mixture of water and trace amounts of other substances. These other substances can effect the pH of the ocean as different chemicals have a different pH. When we measure the pH of a substance we can find out if it is acidic (low pH) or alkaline (high pH).

Carbon Dioxide (CO_2) is acidic. When we burn fossil fuels CO_2 is released into the atmosphere which dissolves in seawater (just like sugar dissolving into tea).

When you add a lot of acidic CO_2 into seawater, which is normally neutral (middle of the pH scale) it starts to get more acidic.

This is not good news for some sea creatures....



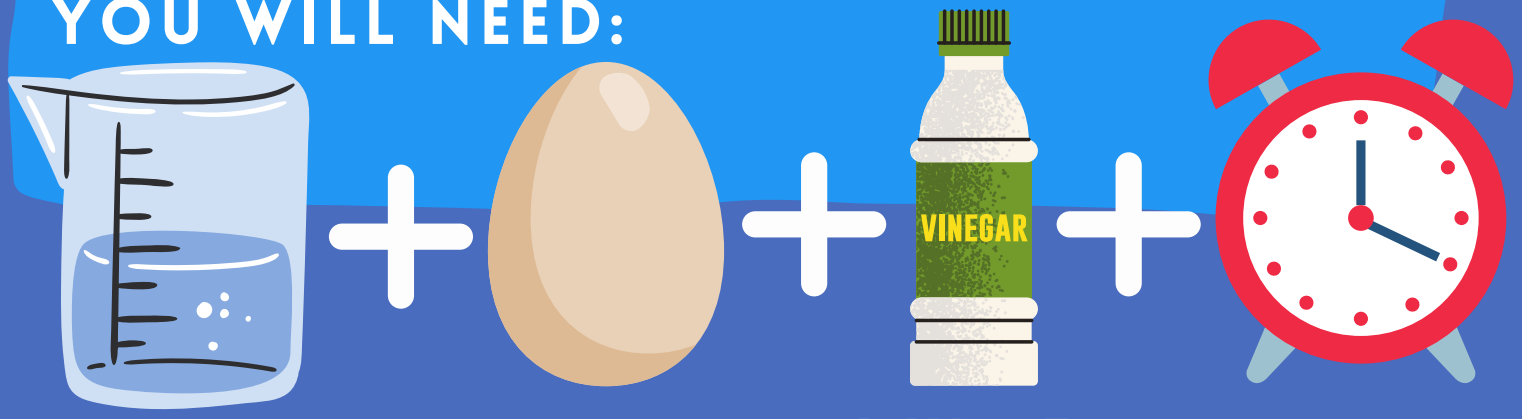
EXPERIMENT - DISSOLVING SHELLS

To see how increasing the acidity of the ocean influences sea creatures with a shell we are going to be doing an experiment alongside Matt our ocean acidification scientist.

Matt will be showing how an acidic solution influences Maerl skeletons. You might not have heard of Maerl but this is a fascinating organism that forms a protected habitat - you will learn more about Maerl later.

Maerl is just one example of lots of marine creatures, both animals and plants, that create shells to protect themselves. These shells are made of a similar material to egg shells - which you will be using in your experiment.

YOU WILL NEED:



JAR + EGG + WHITE VINEGAR + 24 HOURS

1) You will need a jar (with a lid to help stop spills) that is big enough to fit an egg in and some room for extra liquid.

2) Place an egg into the jar

3) Pour white vinegar into the jar so the egg is entirely covered

4) Put the lid onto the jar and leave it at least 24 hours

5) Keep checking back to see if the shell has dissolved.

6) After the experiment be sure to throw away and don't keep longer than a few days.

DID YOU NOTICE BUBBLES?

That is CO_2 being released and is a product of the chemical reaction taking place to break down the shell!

IS?

IS THIS WHAT WOULD HAPPEN IF WE PUT AN EGG IN THE OCEAN?

NO

It is important to understand that this experiment uses a liquid much more acidic than the ocean. Therefore, you see what acidity can do to shell much more quickly and more extremely than is happening in the ocean right now.

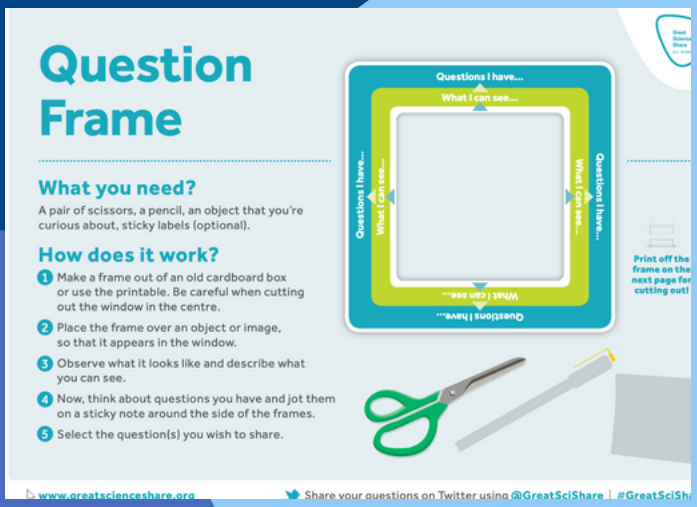
But what you can see is how even on a much slower scale how bad it could be for sea creatures, and how even a small acidicity change can negatively impact sea creatures with shells.

It is an important part of a scientist's job to ask questions. Asking questions is the first step to learn more about a topic. We can then go and find the answers by reading more information on the topic, or if there are no answers we can do our own experiments and research to find out.

ACTIVITY 2

After watching/conducting your own experiment and learning about what ocean acidification is, write down any questions you have about this topic

TIP: you can use a question frame for your experiment to help you think questions as you observe the changes to the shells.



Question Frame

What you need?

A pair of scissors, a pencil, an object that you're curious about, sticky labels (optional).

How does it work?

1. Make a frame out of an old cardboard box or use the printable. Be careful when cutting out the window in the centre.
2. Place the frame over an object or image, so that it appears in the window.
3. Observe what it looks like and describe what you can see.
4. Now, think about questions you have and jot them on a sticky note around the side of the frames.
5. Select the question(s) you wish to share.

Questions I have...
What I can see...
Questions I have...
What I can see...
Questions I have...
What I can see...
Questions I have...

Print off the frame on the next page for cutting out!

www.greatscienceshare.org
Share your questions on Twitter using @GreatSciShare | #GreatSciSh

Download the question teller and other question makers using this QR code!

Space to write your questions:

Now that we have our questions it is time to find some answers.
Matt has answered some questions below. Read these through carefully as they will help you when you with an upcoming activity.

WHAT?

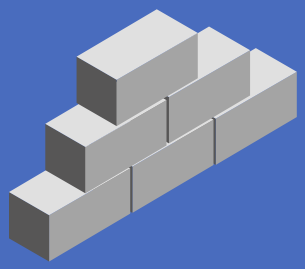
WHAT ARE THE MAIN CAUSES OF CARBON DIOXIDE EMISSIONS?

ACTIVITY 3

Can you match the below causes of CO_2 emssions with the percentage of CO_2 emissions

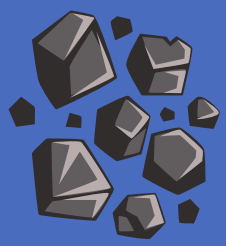
BURNING NATURAL GAS

OTHER INDUSTRY AND FUEL

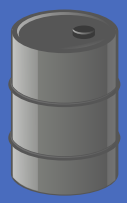


PRODUCTION OF CEMENT FOR CONCRETE

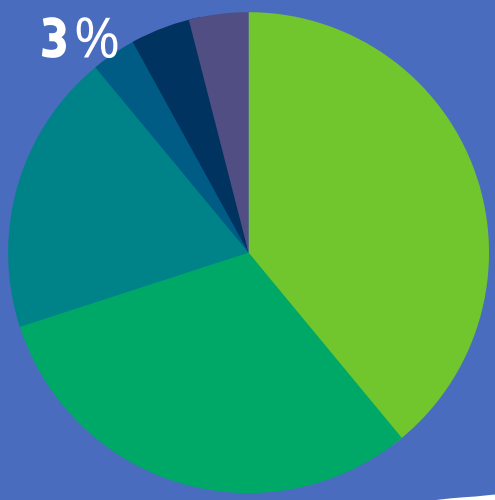
NON-ENERGY FUEL USE E.G. CREATING CHEMICALS



BURNING COAL



BURNING OIL



Trends in Global CO_2 and Total Greenhouse Gas Emissions - 2020 Report. Olivier and Peters (2020)

HOW?

HOW DO WE MEASURE OCEAN ACIDITY?

Geologists can drill into the earth and take soil samples which are known as sediment cores. These cores contain soil and rocks from millions of years ago through to modern times. They can record the amount of carbon trapped within the different layers of the core and work out the pH of the ocean at that time.

Photo from Carolina Marine Lab, University of North Carolina (Flickr)

https://www.flickr.com/photos/uncims/51204279357

Direct measurements of ocean pH have been happening for the last 30 years – another benefit of now knowing about this issue is we can build up big sets of data to help map how quickly these changes are happening.

Seawater has a pH of 7.4 – 8.5 so is considered to be fairly neutral. However, over the past 100-200 years scientists have observed that the oceans are becoming more acidic. Over the last million years, the average surface seawater pH has been quite stable, at between 8.3, during cold periods and 8.2, during warm periods. However, the pH has dropped today to an average of 8.1

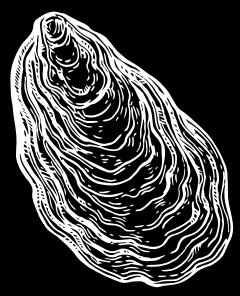
THIS IS THE SAME AS A 30% INCREASE IN ACIDITY!

HOW DOES OCEAN ACIDIFICATION AFFECT DIFFERENT SEALIFE?

CALCIFYING ORGANISMS

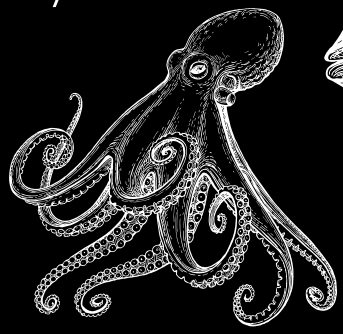
Animals and plants that produce shells or skeletons from calcium carbonate are especially at risk from ocean acidification. Including

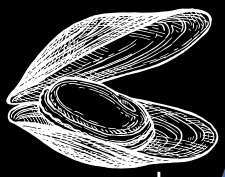
MOLLUSCS


oysters


squid

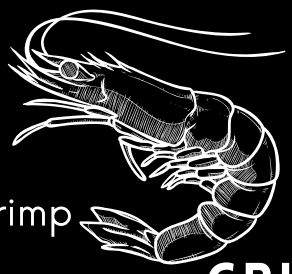

sea snails

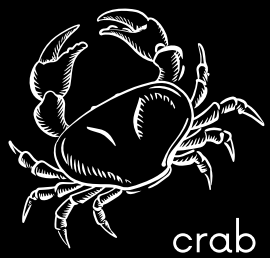

octopus


mussels

PLANKTON

CRUSTACEANS


shrimp


crab


lobster

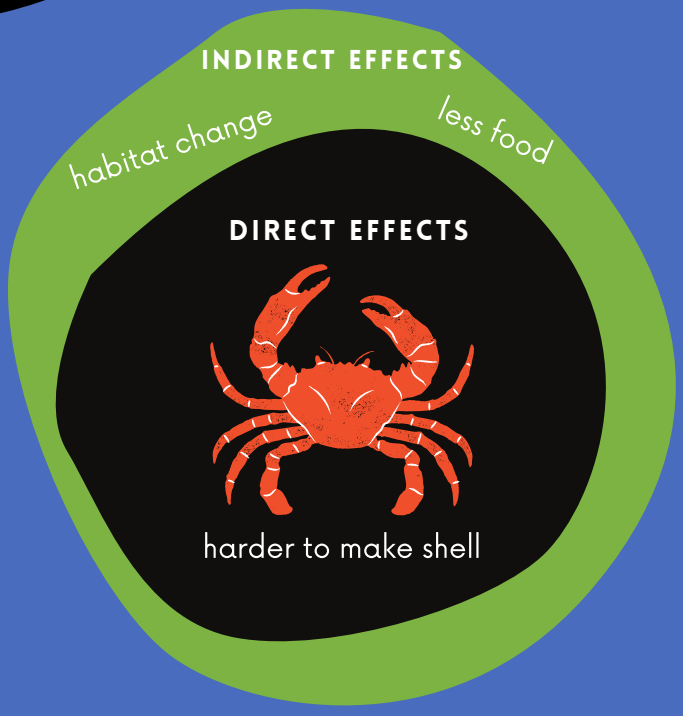
ECHINODERMS


urchin

CORALS

All these species will experience a DIRECT EFFECT to their own body with ocean acidification.
But it is also important to consider INDIRECT EFFECTS too.

How will marine creatures food and habitats be affected?



HOW DOES OCEAN ACIDIFICATION AFFECT DIFFERENT SEALIFE?

ANIMALS THAT FEED ON CALCIFYING ORGANISMS

The animals and seaweeds that are directly affected by ocean acidification often lie at low levels of food webs. Therefore, any animals that feed on them will be indirectly affected as their food source reduces in abundance/number.

ANIMALS THAT LIVE ON REEFS

The shells and skeletons of calcifying organisms are solid surfaces that other plants and animals can live on. When multiple of these organisms are together a reef is formed, providing a home for many other animals and plants. Ocean acidification can erode these reefs reducing the areas where reef living organisms can safely live.

HOW WILL FISH BE AFFECTED?

While fish don't have shells and are not affected in the same way as the other organisms mentioned, they can still feel the effects of acidification. Fish balance their body chemistry to that of the surrounding water, so a drop in water pH will be reflected by the same drop in the pH of the fish's blood. A drop of 0.2-0.3 in blood pH can be fatal for fish.

Some fish, like clown fish, have been observed to less effectively detect predators in more acidic conditions, making them more vulnerable to predation.

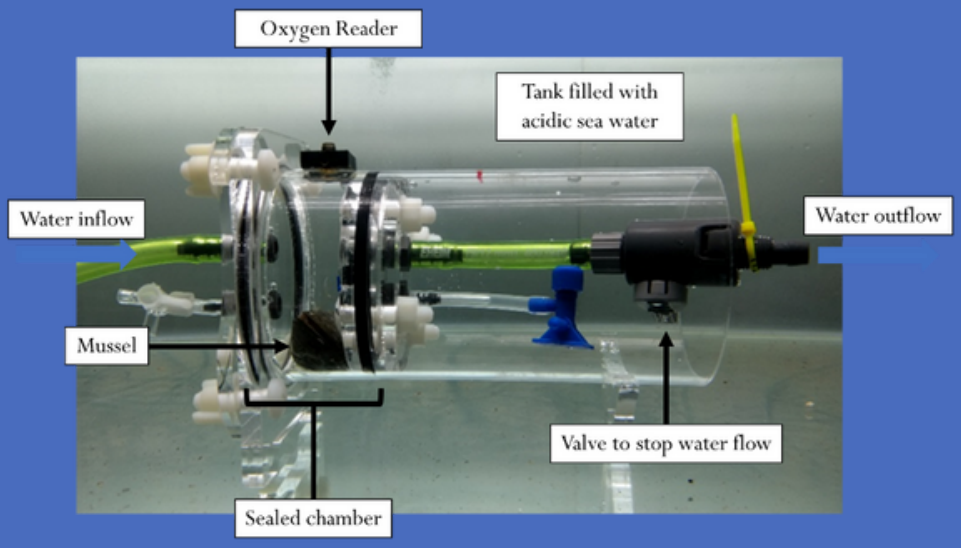
HOW DO SCIENTISTS STUDY HOW SEALIFE IS AFFECTED BY OCEAN ACIDIFICATION?

There are two main ways scientists can study ocean acidification.
1)Laboratory studies
2) Recording species in the wild at sea

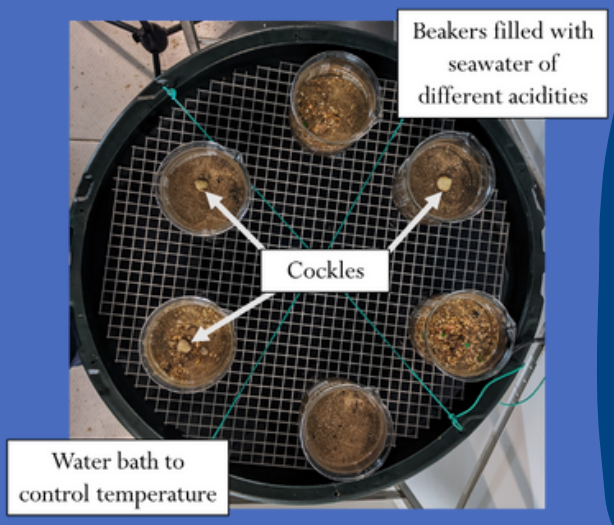
LABORATORY STUDIES

Smaller animals can be brought into the laboratory where the water conditions can be altered to reflect different levels of ocean acidification, either over a long period of change or as a sudden change. The ways the animal responds to these changes can then be recorded.

Laboratory studies also allow scientists to observe the ways that two different animals interact under different levels of acidification



This experiment is testing how a mussel's breathing changes under different environmental conditions!



This experiment films the impact of different acidities on the behaviour cockles burrowing into the sand where they live and feed.

You often find hundreds of cockle shells on beaches.

STUDIES IN THE SEA

You can observe the number of animals in a particular environment over long periods of time and combine these with measurements of the water pH.

TYPE OF SURVEY

Diving Surveys

Divers can go under water and directly look at and record sealife

ROV/Camera Footage

Remote operated vehicles (ROV e.g. underwater drones) can take video footage for scientists to record sealife

Counting Marine Mammals or Birds from a Boat or Cliff

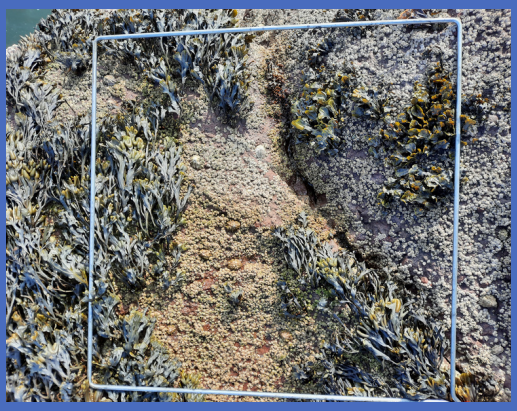
For marine mammals and birds which breathe air we can record these species when they come up for air

HOW TO MEASURE CHANGE?

Measure pH by using a pH meter

It is important to measure the pH to be able to monitor the change

Counts or Percentage cover



We can count how many individuals of a species there are. Or when some species like seaweeds can be difficult to count individually so instead we measure the percentage cover of the space they occupy e.g. 70% of a rock

ACTIVITY - SCIENTIFIC REPORT

Scientists want to know both how animals and seaweeds react to when acidity increases, and also whether these organisms have ways to cope with these changes.

Some species may even surprise us! For instance, scientists have found that some corals are able to control their own chemistry and combat the effects of ocean acidification. They have also found that when certain seaweeds grow close to vulnerable organisms, they can absorb the carbon dioxide from the surrounding water, reducing the acidity.

To do this, scientists conduct experiments and in this activity you write a scientific report on a type of sealife creature of your choice.

1 PICK A SPECIES

You get to choose what type of species you want to research! It can be one of the 8 species below (which already has some information on them) or you can go away and research a different species yourselves!

2 CREATE AN HYPOTHESIS

This is your prediction of the results. Given what you have just learnt about, how do you think this type of species might be impacted by ocean acidification?
Example Hypothesis: An acidic liquid with a pH of 3 will dissolve a shell quicker than pure water.

3 WRITE A METHOD

This is how you will conduct your experiment. Use the information found in this pack to plan it. Will you use a boat to go diving and count sea snails? Or maybe you will run a laboratory study investigating crabs?

It is up to you - there is no right or wrong answer as long as you understand why you want to do it.

4 STATE YOUR RESULTS

Read this pack and use the information to say how the type of sea creature may be directly or indirectly affected. Not sure? You can always do some of your own research too - you might find some even more amazing facts!

5 WRITE WHAT YOU HAVE LEARNT

As well as sharing the results it is important to reflect on what you enjoyed and learnt as a scientist. What was your favourite new fact? How did you feel writing a scientific report?

6 DO SOME EXTRA RESEARCH

Did you find this interesting - want to know more? Great here space to write down any more information you go away and learnt!

CALCIFIED SEAWEED

Description: Some seaweeds have a really neat trick to stop them getting eaten. They have a calcium carbonate skeleton, which means they are partially made out of rock (not tasty).

Fun fact: These are nick-named Coral weeds because corals also have a calcium carbonate skeleton

Food: Algae photosynthesises so gains energy from light from the sun, just like plants!

SEAWEED

Description: The name "seaweed" applies to any algae that grow in the sea except phytoplankton. Many seaweeds attach themselves to solid structures with holdfasts (they can look like plants roots) and can provide a home for many different marine animals.

Fun fact: Seaweeds and phytoplankton produce at least 50% of the earth's oxygen!

Food: Algae photosynthesises so gains energy from light from the sun, just like plants!

SEALS

Description: Seals are marine mammals that live around the coast of mainly cold water environments. In UK waters seals are at the top of the marine food web.

Fun fact: Seals can sleep underwater!

Food: Seals mainly eat fish but will also eat squid, crabs, and lobsters.

SEA SNAILS

Description: Sea snail is the name given to many slow-moving marine molluscs with external shells and a muscley foot to move around on. They come in many different shapes and sizes with a huge variety of shells.

Fun fact: Most sea snails breathe in water, but some species can also breathe in air.

Food: Many sea snails are herbivores, which eat only plants. They lick tiny seaweeds off of rocks with a tongue that is covered in teeth. Others sea snails are active predators feeding on worms, barnacles and even other sea snails.

FLAME SHELLS

Description: Flame shells are small clams with bright orange tentacles. They live hidden on the seafloor in nests which they build from shells and stones they find around themselves.

Fun fact: When many flame shells live together they form a reef that can be home to over 250 different species.

Food: Flame shells filter small food particles from the surrounding water with their tentacles.

FISH

Description: Fish are aquatic vertebrates that swim through water with fins and breathe through gills. They come in many shapes and sizes from tiny gobies to massive sharks.

Fun fact: The UK is home to many fish species including the second largest fish in the world, the basking shark.

Food: Fish eat a wide range of food including seaweed, krill, worms, crabs, and other fish.

Image Taken From:
https://www.flickr.com/photos/tooiake/

MAERL

Description: Mearl are coralline algae (algae that grow hard calcium carbonate skeletons) that look like miniature stag's horns. Individuals grown together in large reefs called beds that sit on the seafloor.

Fun fact: Mearl beds are so important for biodiversity that they are often protected under UK laws.

Food: Algae photosynthesise so gain energy from the light from the sun, just like plants!

CRABS

Description: Crabs are decapod (10 legs) crustaceans with short tails that curl under their body, and (usually) a hard Skeleton on the outside of their bodies. They live all over the world in the oceans, fresh water, and even on land.

Fun fact: Crabs need to shed there entire shell to grow bigger!

Food: Crabs are scavengers and not picky eaters. They eat everything from algae to shrimp and snails, they will also eat the meat of dead fish and mammals that sink to the seabed.

STUDY SPECIES:

SPACE FOR DRAWING/PICTURE OF SPECIES

HYPOTHESIS:

METHOD FOR EXPERIMENT:

RESULT:

WHAT YOU LEARNT:

SPACE FOR EXTRA RESEARCH IDEAS:

People · Ocean · Planet

#POPSCIKIT

MARINE ALLIANCE FOR SCIENCE AND TECHNOLOGY FOR SCOTLAND

THE SPECIES I CHOSE TO LEARN AND SHARE ABOUT WAS...

I CHOSE THAT SPECIES BECAUSE...

MY FAVOURITE FACT WAS..

WHAT I WANT TO LEARN ABOUT NEXT IS...

#POPSCIKIT

Great Science Share for SCHOOLS

People · Ocean · Planet

MARINE ALLIANCE FOR SCIENCE AND TECHNOLOGY FOR SCOTLAND

I CHOSE TO LEARN ABOUT HOW CLIMATE CHANGE IMPACTS...

I LEARNT THAT...

WHAT I WILL RESEARCH NEXT IS ...

I FEEL INSPIRED TO...

Share with us so we can learn with you!

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