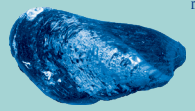
Eco-Systems:

The marine habitat off of the coast of Scotland supports an abundance of life, both local and migratory, that lives between the North Sea, the North Atlantic, and the Arctic Ocean.

KELP is a class of marine algae that forms dense forests in coastal waters. There are several species - some grow to tens of metres in length, others only 1m or so. Kelp forests are vitally important biodiversity hotspots, and also represent large carbon stores. Like the rainforests on land, kelp forests are an important part of the story of how we might combat climate change by locking carbon in living material.

BLUE CARBON is stored in coastal and marine ecosystems. It is the largest carbon store on the planet, capturing more carbon than the world's forests.

MUSSEL shells are very commonly found on beaches. Mostly these are the small blue common mussel which live between the tide lines attached to rocks and piers, or on buoys or moored boats. Horse mussels, related to common mussels, are larger and grow slowly, usually living deep below the low-tide line. Horse mussels can form large reefs which become biodiversity hotspots in their own right. For this reason we call horse mussels a "habitat-forming species". Many horse mussel reefs in Scotland are protected sites. Horse mussels feed by filtering plankton out of the water.



BRYOZOANS form colonies attached to submerged rocks or structures in coastal and marine environments. They form exoskeletons much like coral, so are also at risk from ocean acidification. The microscopic invertebrates have delicate feeding structures that they filter food through such as diatoms, phytoplankton, cyanobacteria and green algae.

RED ALGAE is a type of seaweed that can be found along the west coast of Scotland, the Inner Hebrides, the west coast of the Outer Hebrides, around Orkney and Shetland, and in smaller patches on the north and east coasts.

OCEAN ACIDIFICATION reduces the pH levels in the ocean. This makes it difficult for marine species to form shells and skeletons, and existing shells and coral may become damaged.

blue carbon

kelp

red algae

bryozoans

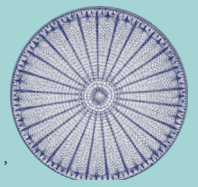
diatoms

ocean acidification

horse mussel

Mapping Ocean Change: Scotland - Arctic 2022

Mapping changes to the migration routes and food chains of marine species, impacts to marine and coastal ecosystems, and knock-on effects of changes to ocean currents and circulation due to climate change, in partnership with Creative Carbon Scotland, Strathclyde University and Sea Watch Foundation, supported by the Natural Environment Research Council.



DIATOMS are single-celled, plant-like organisms with elegant, elaborate glass shells. In spring and summer, when conditions are right, they multiply into huge blooms that tint the water green and support the rest of the food web, the same way grass does in a grassland. They have existed since the time of the dinosaurs.

Food-chain

Connections

SPRAT are small silvery fish that live in dense shoals and eat copepods and krill. They are a key species in the food chain - channeling energy from plankton to the larger fish, birds, and sea mammals including whales - all of which eat sprats. Sprat have recently taken over from herring over on the west coast as the main plankton eating fish. We don't know why this has happened.

GREY SEALS are rare, and are only found in the North Atlantic, the Baltic Sea and the Barents Sea. They travel further than 100km to forage, favoring coasts and islands of Shetland, Orkney, the Outer Hebrides, west and north coast of Scotland. They live for 20-30 years and are up to 2m in length. They feed mainly on sandeel, cod, ling and saithe. However, there has been a decline in sandeel, saithe and cod, which may impact the species which rely on them.

AURELIA (MOON JELLIES)

The pink moon jellyfish (Aurelia) is abundant around the UK. In the winter they live as tiny polys on the seabed and look more like a plant, but in the spring they turn into tiny jellyfish and multiply very rapidly, feeding on copepods. Jellyfish compete with sprats for plankton. In some areas of the world where fishing has depleted fish stores we see enormous blooms of jellyfish.

PUFFINS can be found on the isles around the north of Scotland from late-spring to early summer. Other common seabirds include Guillemots, Fulmars, Oystercatchers, Kittiwakes and a variety of gulls. Climate-driven sandeel decline is having an impact on seabird populations.

KRILL are 1-2cm shrimp-like animals that live in mid-water in very large numbers. They have a life-span of typically 2 years and accumulate fats inside their bodies from the copepods that they eat. This makes them very attractive food for mackerel, birds and whales.

COPEPODS are tiny 1 - 5mm crustaceans, found in freshwater and ocean habitats. They eat diatoms and other phytoplankton, and are a vital source of food for many other species; they are a fundamental part of the food chain.

Large copepods and krill carry energy from the open ocean into coastal seas over the course of their long life cycles. Climate change affects their food supply (phytoplankton), their ability to survive the winter on limited energy reserves, and the ocean currents that transport them.

It is the partial loss of these species from the coastal North Sea that has driven the biggest change in the amount of energy available to fuel sandeel growth there, and researchers are currently trying to determine if the same is true on other Scottish coasts.

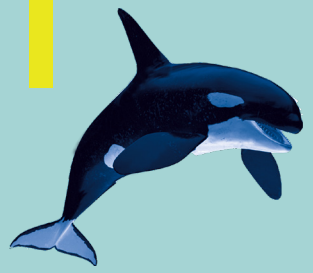
HARBOUR PORPOISE

The smallest cetaceans found in Scottish waters, at up to 1.9m. They inhabit temperate and sub-Arctic seas. They are the most common cetacean in European seas, and their distribution ranges from the continental shelf in the Barents Sea, South Iceland, to the coasts of France and Spain. They inhabit Scotland's north coast, the Hebrides, northern isles, and the east of Scotland where they may be permanent residents. They feed on fish including herring, sprat, sandeel, cod, whiting and crustaceans.

Talk about:

- What local sea-life do you know of? Have you spotted any?
- Does it live here all the time or does it migrate?
- What does it eat?
- How does climate change affect it?

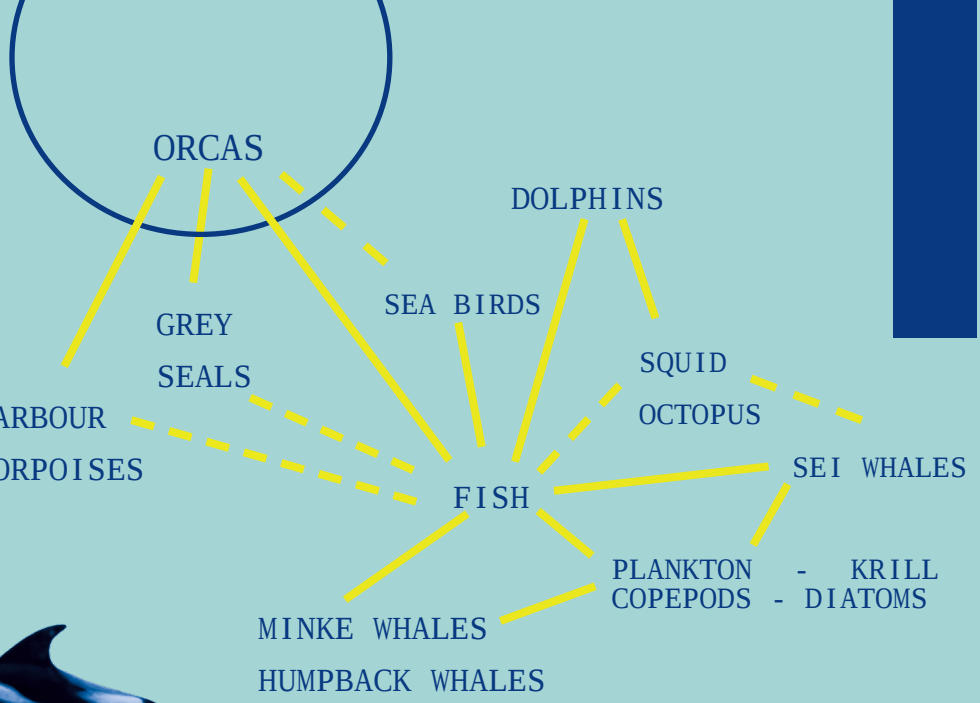
ORCAS off of the coast of Scotland and the northern isles migrate between Iceland and Scotland. They travel to Iceland to feed on overwintering herring in the winter, and to Scotland in the warmer seasons, around the northern mainland, Orkney, Shetland and the Hebrides. They are occasionally spotted further south along the Scottish coast. They are at the top of their food chain, feeding on smaller marine mammals such as seals, porpoises and herring. They live up to 90 years - what could they tell us about climate change? They can grow up to 9.8 metres in length.



HUMPBACK WHALES have a global distribution, and can be spotted around the coast of Scotland. They travel thousands of miles from warm water breeding grounds off of Africa, to cold water feeding grounds around Iceland and Norway. They grow up to 17 metres in length. They feed on fish and krill, using their baleen plates, like Minke Whales.

RISSO'S DOLPHIN - Scotland is the northern-most extent of their temperate, tropical and subtropical range. They can be seen close to the continental shelf to the north and west of Scotland. They feed mainly on squid, octopus, cuttlefish and fish, often foraging for food at night, diving up to 1000m deep where squid can be found. Squid inhabit deeper water, and migrate vertically at night when it is dark. Risso's Dolphin exhibit light grey and white scarring, due to the sharp beaks of their squid prey.

FACT: Whales, dolphins and porpoises are collectively known as cetaceans. There are 23 species of cetaceans in Scottish waters, with the greatest diversity found off of the continental shelf to the north and west of Scotland. Some are localised in distribution, and others take on international seasonal migrations.



WHITE-BEAKED DOLPHINS can be found throughout the North Sea and shelf waters of the sub-Arctic North Atlantic. They migrate between Norway, the Barents Sea, South West Sweden and the North, North-East, and North-West of Scotland. The UK is at the southern edge of their range of distribution. They live up to 30+ years and are up to 3m long. Climate change is pushing them northwards due to observed rises in sea temperatures. They mainly feed on haddock and whiting off the north coast.

BOTTLENOSE DOLPHINS can be found in coastal and continental shelf waters. Their distribution lies between Norway in the north, and the tip of South Africa in the Atlantic Ocean. Some travel south in the winter, following movements of fish, and due to variations in temperature. They feed on fish, squid and octopus, and live for up to 40-50 years. They grow up to 4m long.

MINKE WHALES winter in equatorial waters and summer in polar waters. They can be found around Scotland between May and October. They feed on schooling fish, mainly sandeel, herring and sprat, and sometimes Arctic cod and haddock. They also eat plankton, including krill, by 'lunge feeding' with their mouths wide open. They have baleen plates instead of teeth, comb-like bristles that hold their prey in place when they close their mouths once they have caught food by lunge feeding. They live up to 50 years and grow up to 7-10 metres long. Minke Whales, like many other large marine mammals, often feed in association with sea birds, which may follow the whales to find small fish. Kittiwakes and gulls feed in association with Minke Whales.

Migration routes

Many species travel great distances to feed, over-winter, and gain access to the different resources they need to live, just as we depend on resources from all over the world. The ecosystems between Scotland and the Arctic are rich and diverse with interconnected species.

Climate-driven effects will have local and international impacts, creating knock-on effects across ecosystems, migration routes and food-chain connections, and to natural resources that we also rely on to live.

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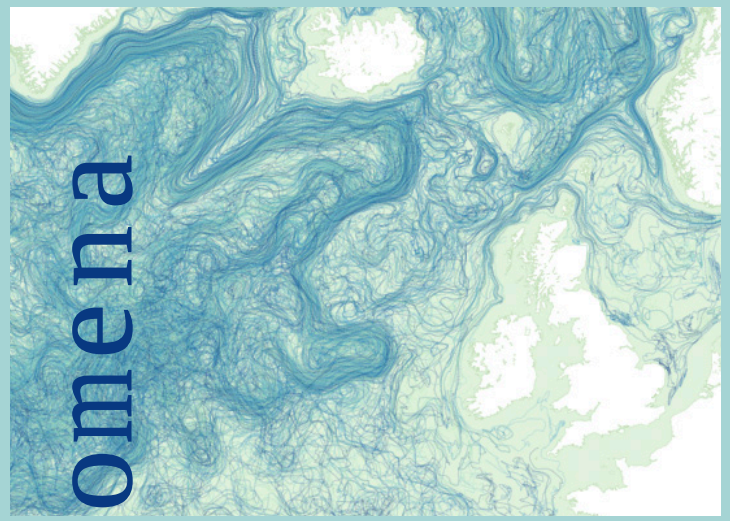
Ocean Phenomena



Ocean circulation in the Arctic and North Atlantic

Existing + climate-driven:

MIXING is change that occurs in the ocean due to changes in temperature, gas, salt and nutrient levels, caused by tides, wind and ocean circulation.

SUBPOLAR GYRE is the system of circulating ocean currents in the North Atlantic. The subpolar gyre helps copepods migrate around the Arctic.

THERMOHALINE CIRCULATION is part of the large-scale ocean circulation that affects the temperature of the ocean in different regions. Thermohaline circulation brings heat to the Arctic, and influences the amount of sea ice formation near the poles.

SHELF-EDGE JETS are jets of water associated with features of coastal morphology, areas where the ocean is shallow around land masses, before the ocean floor slopes down to greater depths.

ADVECTION is the transportation of different organisms or properties around areas of the ocean. For instance, copepods are transported across the North Atlantic and the Arctic Oceans by ocean circulation.

Existing:

POLAR NIGHT is the term for the period from September - March when there is 24-hour darkness in the Arctic. Marine biologists have found that there is still an abundance of life in the Arctic Ocean during polar night, as marine animals and organisms adapt to the darkness.

VERTICAL MIGRATION is when some species migrate to lower depths of the ocean or lochs and up to the surface over varying periods of time. Zooplankton such as copepods migrate vertically to overwinter safely at depth where there are fewer predators, and during daylight hours throughout the year, rising to the surface at night to feed when it is dark.

Ocean Phenomena

Climate-driven:

ICE LOSS occurs when the temperature of the ocean rises. This is currently occurring at an unprecedented rate. Changing habitats will affect local and international ecosystems. Many species will have to adapt and / or change their migration routes.

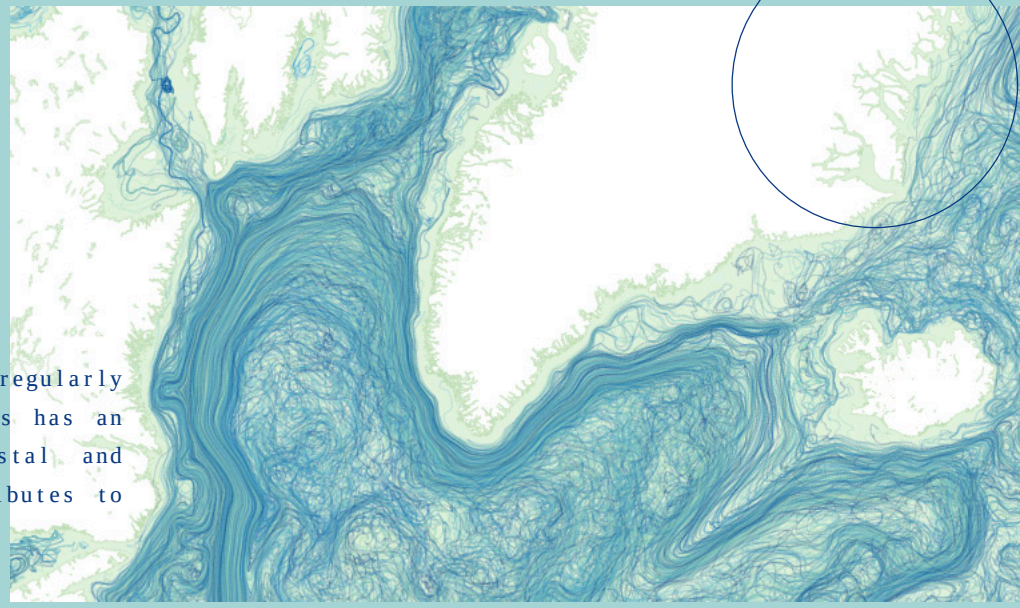
SEA LEVEL RISE is taking place as the ice sheets and glaciers melt due to ocean warming and heatwaves. Water also increases in volume as it warms.

RANGE SHIFT - When the distribution of a species changes due to the changing climate and knock-on effects caused by it, such as a change in temperature, or lack of usual food sources. Some species are migrating further northwards due to warmer currents flowing further north. Some species rely on cooler habitats and are having to go further north to find them.

HEATWAVES are happening more regularly as the climate changes. This has an impact on land-based, coastal and marine ecosystems and contributes to ice loss.

ACIDIFICATION - Ocean acidification is taking place as the pH value of the oceans decreases, as a result of the uptake of carbon dioxide from the atmosphere. The burning of fossil fuels is the main cause of an increase in carbon dioxide in the atmosphere. Acidification has an impact on marine life with shells and exoskeletons, meaning they either can not grow them, or damage is caused to existing ones.

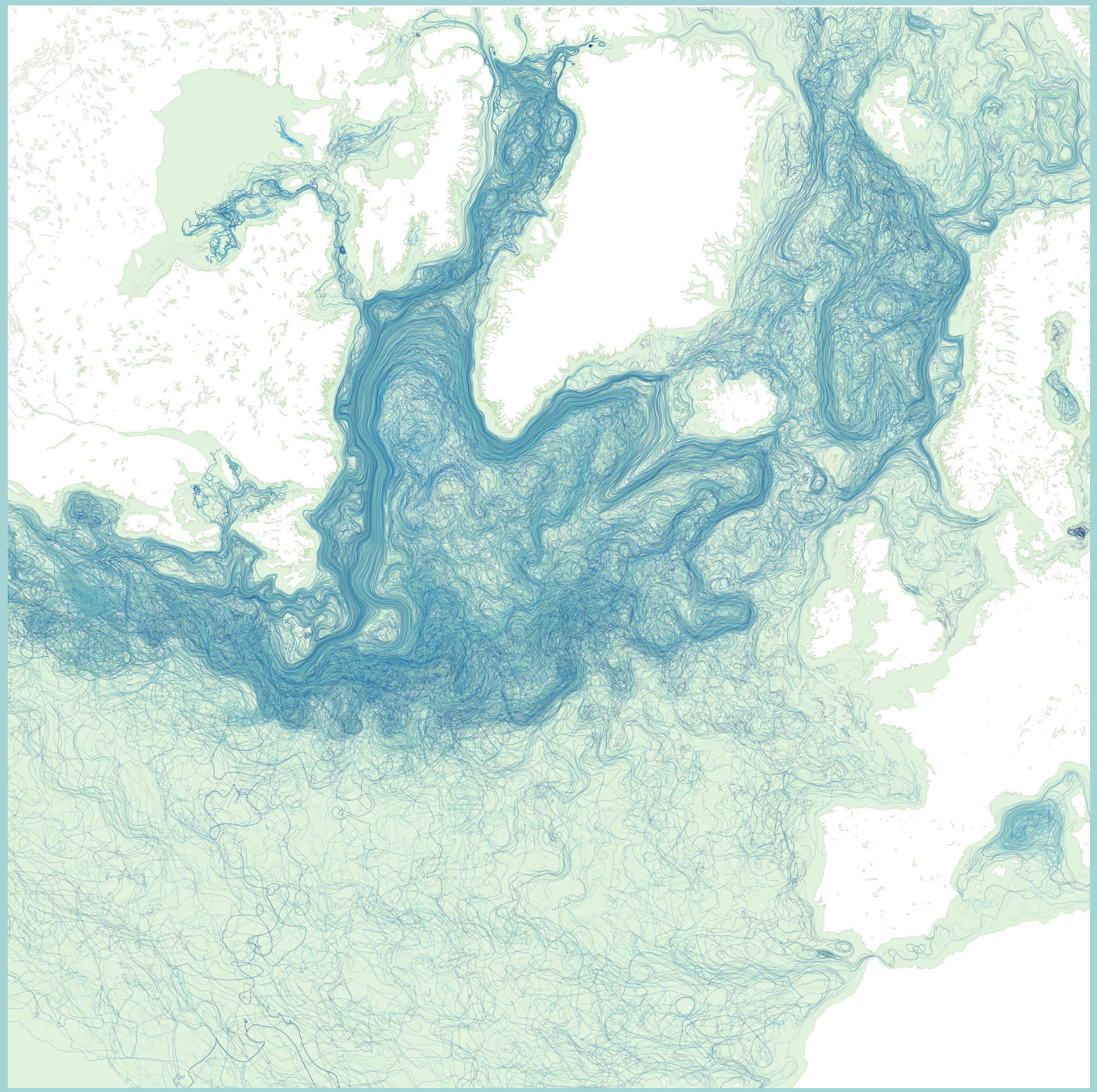
Please scan the QR code to fill out a short survey about Mapping Ocean Change.



Ocean circulation in the Arctic and North Atlantic

Mapping:

- What species and migrations can you place on the map below?
- Some species may belong to local ecosystems.
- Others may travel vast distances as part of much larger ecosystems that they contribute to and that they rely on to live.



OCEAN CIRCULATION map of the North Atlantic, the Labrador Sea, Baffin Bay, the Arctic Ocean, the Greenland Sea, the Norwegian Sea, and the North Sea by Dr Neil Banas, based on data models by Dr Emma Tyldesley.

Some marine species migrate passively, that means they are carried across distances, through local and / or international waters, by ocean circulation.

Plankton such as copepods migrate passively, travelling from the North Atlantic, around the Arctic Ocean and back over multiple generations. They also actively migrate vertically, travelling to greater ocean depths during the daylight hours to hide from predators near the surface, and rising to the surface at night, and Arctic Night, when it is dark. They also migrate vertically to lower depths to overwinter during their developmental stages.

Other species such as whales and other marine mammals migrate actively, choosing locations based on access to resources and seasonal temperature changes.