

Fuelling the Future



Explore the diversity of seaweed
and what you can do with them!

EPSRC



Fuelling The Future — Biofuels from Kelp

Was an outreach project in the Shetland Islands funded by the Marine Alliance for Sciences and Technology for Scotland and delivered by Christine Rolin and Rhiannon Inkster who worked on the Shetland Seaweed Growers project (Coastal Communities Fund) and MacroBioCrude (Engineering and Physical Sciences Research Council) at the NAFC Marine Centre, University of Highlands and Islands. The project collaborated with the RSPB in Shetland on delivering the programme “Coastal Creatures” in 2016.

The materials in this education pack were made with the aim of getting school kids out and exploring their local sea shore by discovering what seaweeds grow there and how they can be a useful resource for art, food and biofuels.



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Suggested lesson plan

Morning session	Afternoon session	Follow up
Explore the rocky shore using the seaweed ID guide.	In the classroom use basic tools to make your own seaweed press.	Leave to dry in a warm dry place. Change newspaper as needed (every few days).
Bring a bucket to collect seaweed if you want to make your own art, food or biogas!	Get a water bottle and balloon add some seaweed and in a few weeks you have biogas.	Monitor the size of the balloon to see how much gas is produced.
	Find any creepy crawlies hiding in the seaweed, use a microscope to draw them.	Collect all the drawings and display them.

Health & Safety

Suggested practical activities and health & safety tips are for guidance only.

Always make risk assessments for any activity whether outdoors or indoors.

Remember :

- Be careful to **avoid slips, trips and falls**. Have a **first aid kit** nearby just in case..
- Wear **appropriate clothing** i.e. non-slip footwear, gloves, etc.
- Plan your collection time, check the tide times and weather before you leave
- Monitor your surroundings and people around you

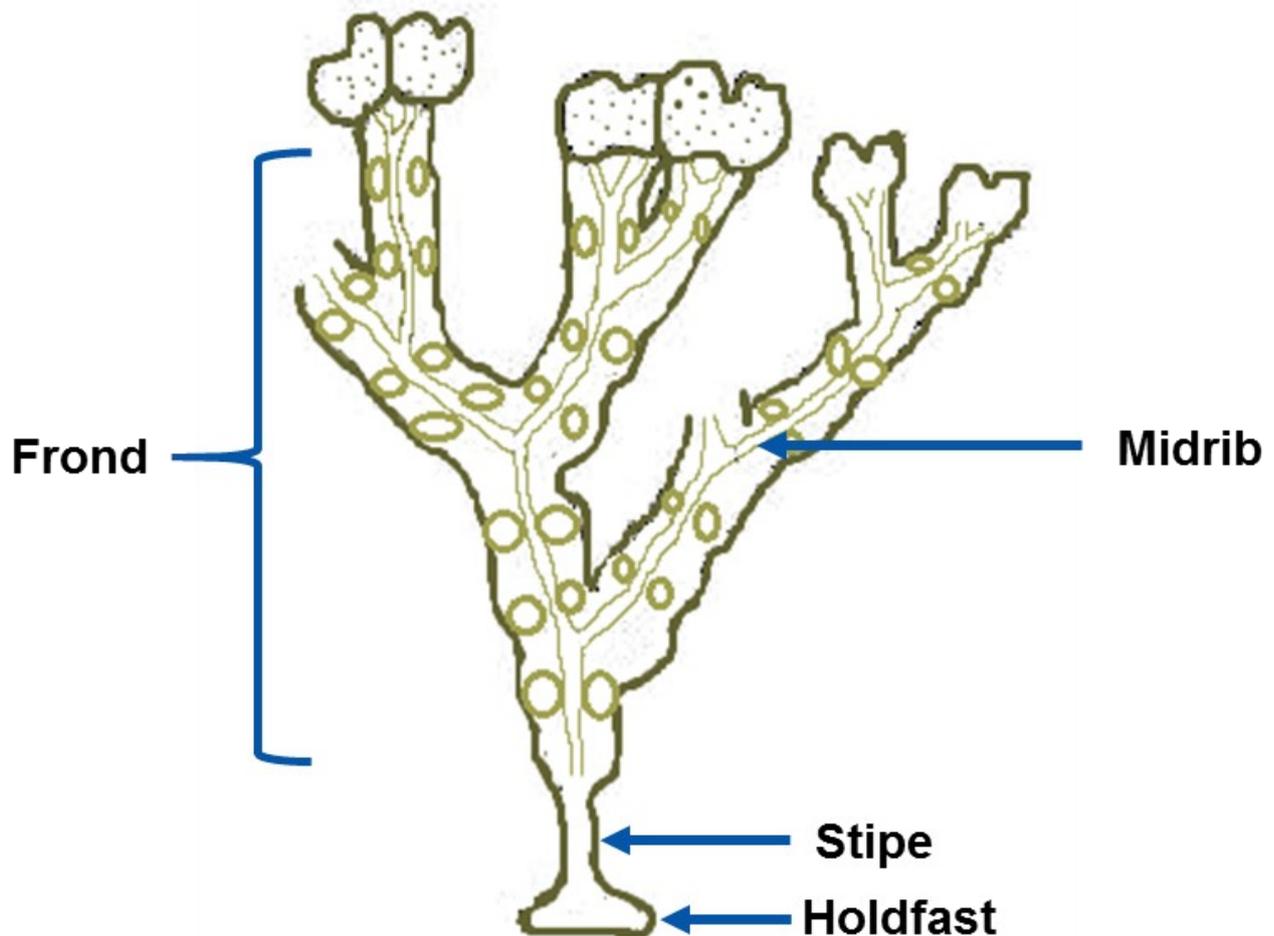
Always let someone know:

- **Where you are going**
- **Who you are with**
- **When you will return**

NAFC Marine Centre accepts no liability for any injury or loss that arises from activities that are undertaken as a result of this publication.

Basic morphology of seaweed

Seaweeds come in many shapes and sizes but share a few basic characteristics such as a frond, stipe and holdfast. Fronds range from branched to single blades and stipes may be a few centimetres long or over 1 m. Below is a basic drawing of a bladder wrack.



Glossary

Frond	the 'blade' of a seaweed.
Holdfast	the part of the seaweed that attaches it directly to the substrate.
Stipe	stalk or stem of a seaweed frond.
Midrib	a thickened ridge along the midline of a frond.

Discover the diversity of seaweeds

There are over 10,000 different types of species worldwide and many different species can be discovered on your sea shore. Here is a guide to help you identify some of Britain's brown, red and green seaweeds.

Brown Seaweeds



← **Serrated Wrack** *Fucus serratus*

Easily recognised by its **edges serrated like a bread knife**. Found in the mid intertidal and grows to 60 cm long. It has a midrib and lacks airbladders.



↑ **Spiral Wrack** *Fucus spiralis*

The frond is green to yellow and the fronds **curl in spirals** which means the fronds don't lie flat. The spiral wrack only grows to about 20 cm long and is found very high on the shore

⇒ **Egg Wrack**

Ascophyllum nodosum

Olive green—light brown, it grows very long thin fronds that can reach several meters long and is found on sheltered shores. It has large **egg shaped air bladders** all along its fronds. Find out how old it is by counting the number of airbladders in a row, one for each year.



Airbladders



← **Bladder Wrack**
Fucus Vesiculosus

The bladder wrack is found on the lower shore and has **paired airbladders**, one either side of the midrib. The airbladders help this seaweed float and compete for sunlight. It can grow between 15 to 90 cm long.

↓ **Channel Wrack**

Pelvetia canaliculata

Found high on the shore often on top of rocks, the channel wrack is small seaweed that grows in **tufts** no bigger than 15 cm long. The blades of the seaweed roll towards each other creating a channel on one side.



⇒ **Horned Wrack**

Fucus ceranoides

Feels papery to the touch and the frond ends in a set of **"horns"**. Often found close to freshwater outlets and grows between 30 and 60 cm long. Airbladders are usually found inflated either side of the midrib.



Midrib



← **Winged kelp**

Alaria esculenta

Dark brown blade tapering towards the end and with a mid-rib. On either side there are delicate “wings”. You’ll find this in very exposed locations and at the bottom of sea cliffs. Along the

stipe there may be two rows of leafy reproductive blades called sporophylls.

Sugar kelp →

Saccharina latissima

Sugar kelp can grow up to 5 m long and is found below the low water mark. It has a single yellowish brown blade with **wavy edges** and a dimpled band along the middle. The sugar kelp is named after its sweet taste.



Sea spaghetti →

Himantalia elongata

Sea spaghetti looks like long green strings of spaghetti and can also be cooked, best as a stir fry. The young plants start out as small **buttons** attached to rocks, **long fronds** then grow from the middle of the button up till 3 m long forming dense mats close to the shore.



Young “button” shoots



← **Oar Weed**

Laminaria digitata

Tough brown kelp that can grow up to 2 m long, the blade divides into **finger-like** segments as it grows. It is found low in the shore. It looks very similar to Tangle kelp but it is smaller and the stipe has an oval cross-section and is not easily snapped.

Tangle kelp →

Laminaria hyperborea

Brown kelp with a digitated blade and long stipe that forms vast **kelp forests** down to 24 m depth. Looks very similar to oar weed, the easiest way to tell them apart is by looking at the stipe, the tangle kelp stipe is round in cross-section and snaps easily when bent. After storms you can often see these kelp washed up on the beach and sometimes find sheep grazing on this delicious and nutritious resource.



Red Seaweeds

Pepper Dulse *Osmundia pinnatifida* →

Fern-like seaweed that ranges in colour from brown to purplish-red. This seaweed is found growing in small tufts of up to 20 cm but generally smaller, on damp surfaces and the lower shore. It is also known as the “truffle of the sea” and tastes peppery with a hint of garlic. Try it, but don't eat too much!

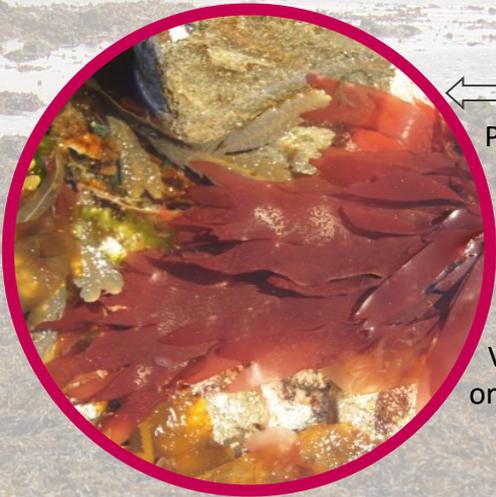


Different colours!



← Dulse *Palmaria Palmata*

Purplish red seaweed with several flat, finger-like blades that can grow up to 50 cm. It grows lower on the shore often **underneath the kelp canopy**, you can therefore find it attached to the stipes of kelp washed up on the beach. Very delicate flavour can be eaten fresh or cooked.



← False Irish Moss

Mastocarpus stellatus

Dark, reddish-brown seaweed that grows between 5–10cm on exposed shores. Like channel wrack False Irish Moss has **curved fronds** that roll inwards on itself to create a channel on the seaweed. The blades of this seaweed are tough and stiff.



Coral Weed

Corallina officinalis →

Light pink in short tufts on the rock in rock pools. Easily recognisable as unlike other seaweed it has a **calcified skeleton**! Other coralline species within this group can be found growing as maerl beds or crusts.



Look out for their crustose forms!

Green Seaweeds

← Sea Lettuce *Ulva lactuca*

A delicate, **translucent green flat** seaweed with thin blades and a lettuce-like appearance. This seaweed can be found all over the shore growing on rock, limpets and other seaweed. There are many species of sea lettuce and they can be very difficult to tell apart.



Common Green Branched Weed

Cladophora rupestris

Dark green thinly branched seaweed that looks like **tufts**. It absorbs a lot of water like a sponge and is found from mid-tide down.



Make your own seaweed art

Pressing seaweed has a long history. Botanists pressed seaweed to preserve specimens of each species but later it became trendy among the Victorians to collect seaweed and create scrapbooks of pressed specimens. You can **collect seaweeds** that are red, green or brown and while some are leaf-like others have very delicate branching patterns that you won't notice till you spread them out underwater. Seaweed pressing can help you reveal the hidden colours and patterns of seaweed!

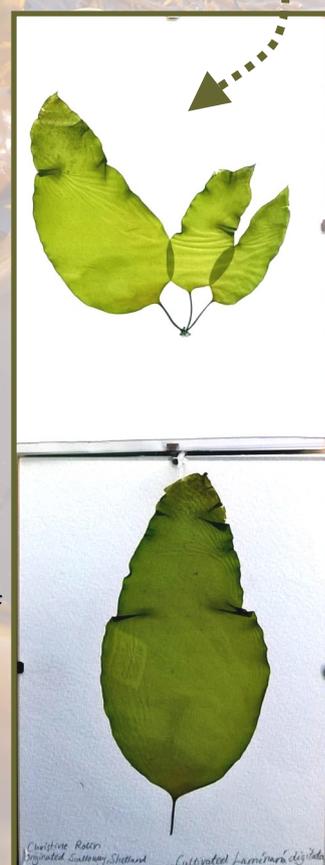


Materials

- ◆ Wellies and a bucket
- ◆ Water colouring paper
- ◆ Scissors and/or sharp knife
- ◆ Tweezers, mounted needle, brushes
- ◆ Seawater and shallow tray
- ◆ Corrugated cardboard and newspaper
- ◆ Non-stick layer (e.g. synthetic cloth)
- ◆ Your freshly collected specimens!

Method

- 1) Go to your favourite rocky shore armed with a bucket and some scissors to collect your seaweed specimens. Make sure to check the weather forecast, tide tables and don't go alone.
- 2) Back home or in the lab pour seawater (or freshwater) in your tray, put a piece of paper in the tray and immerse your chosen specimen. Use brushes, needles and pipettes to adjust its position and reveal its shape, you can be creative here. Remove any blades if necessary, remember less is more!
- 3) When you are happy with your artwork slowly lift out the paper from one end of the tray to let the water run off. Your seaweed might have moved so use a brush or pipette for the final touch.
- 4) To press the seaweed place a piece of cardboard on the table, then a layer of newspaper and the non-stick cloth before placing your paper on it. Make sure the seaweed lays flat. Now add another layer of non-stick cloth followed by newspaper and finally cardboard. Carefully place all your presses in a neat pile in a dry, warm place and put some large, heavy books on top.



Make your own scientific drawings

Seaweeds don't only provide oxygen for terrestrial and marine habitats, which is home to many millions of organisms, they are also home to many marine organisms that inhabit the ocean. Marine invertebrates and juvenile fish species live on and around seaweeds as they provide food and shelter. The seaweed itself forms the basis of many marine **food webs** providing food for many **herbivorous** invertebrates and fish who graze on it. These small invertebrates and fish are in turn are **predated** upon by other marine organisms, such as commercially important crab and fish species which helps to provide money and jobs for fishermen! Explore the sea shore and make your own scientific drawings of these important marine organisms.

Materials

- ◆ Microscope
- ◆ Ruler
- ◆ Species ID book
- ◆ Paper
- ◆ Petri dishes
- ◆ Pipette

Method

- 1) Find the animals living among the seaweed. Larger animals are best to leave, but you can take a picture or make a quick drawing in the field. If you have collected any seaweed you can find many small invertebrates living within them. If you do collect any animals, make sure to touch them as little as possible and keep them in cool seawater.
- 2) Draw any organisms you've found and try to label their important body parts which will help you identify them. Use a species ID guide to identify the species.
- 3) If you have smaller organisms you can place them in a petri dish with some water and look at them under the microscope. Remember to include a scale on your drawing to remind yourself how small or large these organisms are!

Suggested experiments:

- A. *Where do you find the animals in the seaweed? High or low on the shore? On the rock or in rock pools?*
- B. *Alternatively, just take pictures and identify the species. How many different ones can you find?*



Think about how these different organisms are important and why it is important to safeguard seaweed habitats

Make your own biogas

Seaweed are full of carbohydrates or sugars similar to many land plants. Biogas is produced when these sugars are broken down by microscopic bacteria through a process called **anaerobic fermentation**. Biogas is mainly made up of methane and carbon dioxide which can be used as a fuel or turned into electricity and heat. Biogas is a renewable energy source with a small **carbon footprint** as it often uses waste products such as manure, sewage and food waste. Plant crops such as grasses or seaweed are added to increase gas production.

Seaweed farming is environmentally sustainable and does not compete for space on land with crops for human consumption. Make your own biogas generator and think about how the gas is produced, what raw materials can you source and how big the carbon footprint of different materials are?

Materials

- ◆ **Plastic bottles** (best with wide opening)
- ◆ **Balloons**
- ◆ **Electrical tape**
- ◆ **Biomass:** seaweed, food waste, manure, grass, garden waste, crops (corn, wheat, rapeseed).
- ◆ **Notebook**

Method

- 1) Collect your biomass, you can go cut some seaweed from the shore or grass from a field, or bring some food waste from home. Any biomass you think might work!
- 2) Cut or grind the biomass into smaller pieces and fill a plastic bottle 2/3 to the top.
- 3) Carefully cover the top with a deflated balloon. Inflate the balloon once before use to make it more flexible. Secure and seal the balloon to the bottle with electrical tape. Make sure no air can get in or out!
- 4) Monitor your biogas generator at least once a week, write down observations on how the biomass and balloon changes. Mostly carbon dioxide will be produced, but make sure to keep the balloons in a well-ventilated area.

Suggested experiments:

- A. *What happens if you add an acid (lemon juice or vinegar)?*
- B. *Does light or temperature change how fast gas is produced?*
- C. *Compare different raw materials.*
- D. *You can also monitor the change in pH if you create several sealed plastic bags and measure their pH at different times.*

Think about why any differences occur and what processes are involved



Make your own seaweed food

Seaweeds are becoming more mainstream in Western culture, but has been a staple diet for centuries in Asian countries, in particular in Japan, you might know it from **sushi**. Increasingly people are becoming interested in seaweed or “**sea vegetables**” as a food for foraging or buying in the shops. You can make anything out of seaweed, for example you can use seaweed flakes instead of salt on your dinner.

Historically there is a tradition for using seaweed in the British Isles, for example, laverbread in Wales (it’s not actually bread) or dulse served as a side to potatoes. Seaweed are as diverse as all vegetables, and each contains different **nutrients and minerals** such as vitamin C, iodine and calcium. Each seaweed also tastes different, while some have a more fishy taste, others can be very mild and they vary from salty to nutty and sweet. The possibilities are endless!

Materials

- ◆ Freshly collected seaweed
- ◆ Cutting board
- ◆ Knife
- ◆ Pan or dish
- ◆ Stove or oven

Method

- 1) Collect seaweeds at your local rocky shore, make sure the sea area is clean and there are no sewage outlets nearby.
- 2) Bring back your foraged food to your kitchen
- 3) Clean under tap water (or skip this step to retain more flavour), cut large pieces (bear in mind they will shrink).
- 4) You can dry your seaweed in an oven to make crisps, heat the oven at a low heat such as 100°C, keeping the door open or regularly opening to allow moisture to escape.
- 5) Place the seaweed on a tray with baking paper, regularly turn the seaweed in the oven to stop it from sticking.
- 6) Once it is completely dry you can eat it as a crisp or try dipping it in chocolate.

You can also eat the seaweed raw, boil it or fry it or add it to other dishes or baked good. Whatever you like you can try!

Look up some seaweed recipe books for ideas.



