

# What is Kelp?

Kelp is the largest subgroup of **SEAWEED** which is all part of the **ALGAE** Family

You might hear seaweed referred to as **macroalgae**. Algae come in a variety of colors, but the three major groups are...

**RED**  
Rhodophyta

  
Dulse  
*Palmaria palmata*

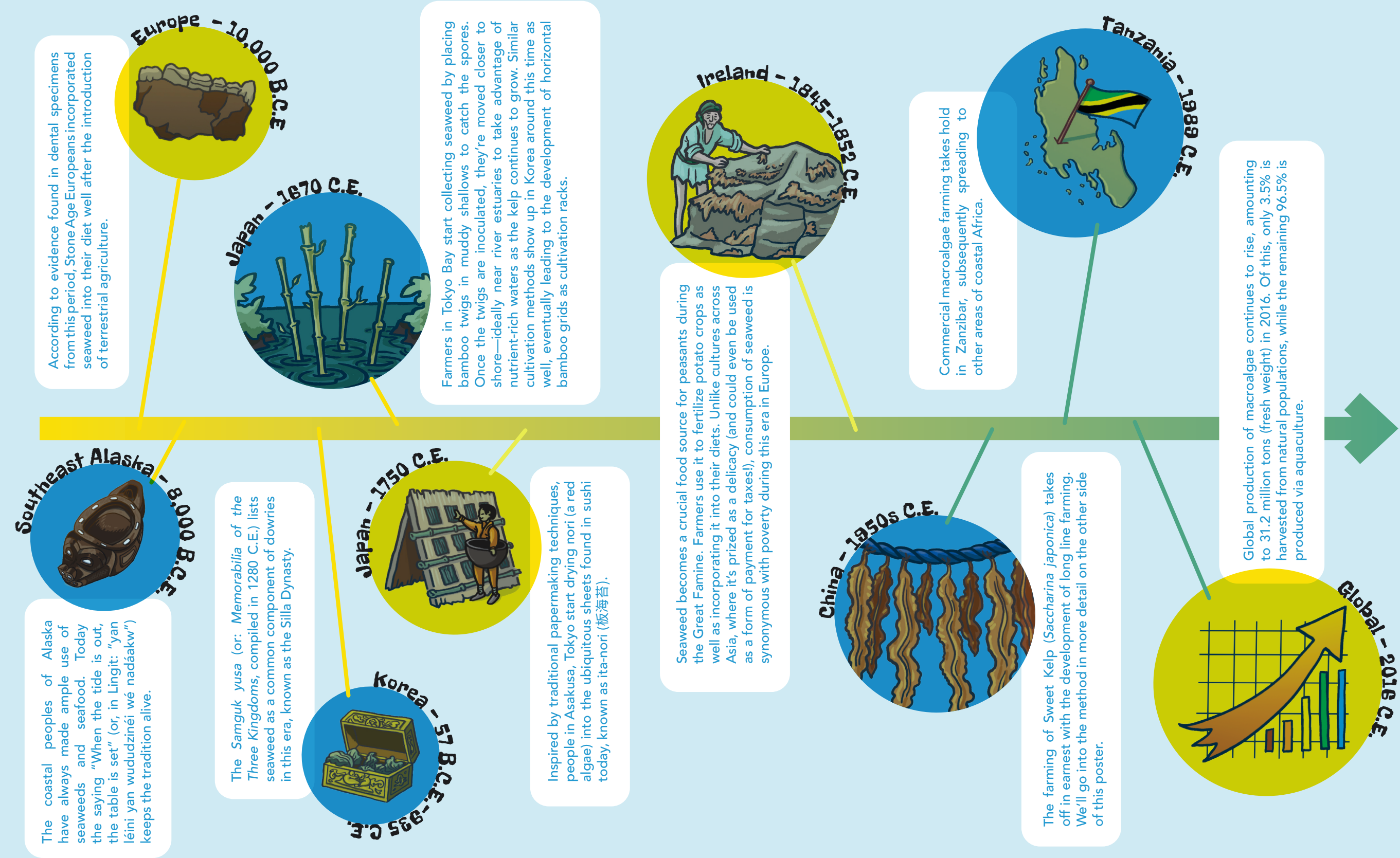
**BROWN**  
Phaeophyceae

  
Wakame  
*Undaria pinnatifida*

**GREEN**  
Chlorophyta

  
Sea lettuce  
*Ulva lactuca*

## Humans & Kelp: A Timeline



Brought to you by Adventure Cartoonist Lucy Bellwood in partnership with Blue Robotics, with special thanks to Ocean Rainforest, X'unei Lance Twitchell, Meg Chadsey, and the Aquaculture Information Exchange.

Take a tour through an 86-acre kelp farm off the coast of central California, explore the history of longline kelp cultivation, and meet some of the farmers working to make kelp the crop of the future.

What were our ancestors doing with kelp? Has nori always come in those tasty little snacking sheets? And which kelp byproduct is hanging out in our toothpaste?

In this educational poster, we'll explore the current global resurgence of kelp farming.

Humans have had a relationship with kelp for thousands of years, but can this corner of the aquaculture world hold the key to fighting climate change, providing renewable food sources, and more?

## Carrageenans

Extracted from red seaweeds, carrageenans are a family of linear sulfated polysaccharides. They're commonly found in the food industry, acting as a thickener and stabilizer in things like ice cream, pudding, and deli meats. They can also be used as a vegetarian and vegan alternative to gelatin.

Outside the food industry, you'll find them in everything from toothpaste to air freshener gels.

Humans have been using gelatinous extracts from seaweeds like Irish moss (*Chondrus crispus*) as food additives since the 15th century!

## Agar

A similarly popular additive, agar is a mixture of two components: the linear polysaccharide agarose and a heterogeneous mixture of smaller molecules called agaropectin. It creates gels that are firmer and more brittle than carrageenan.

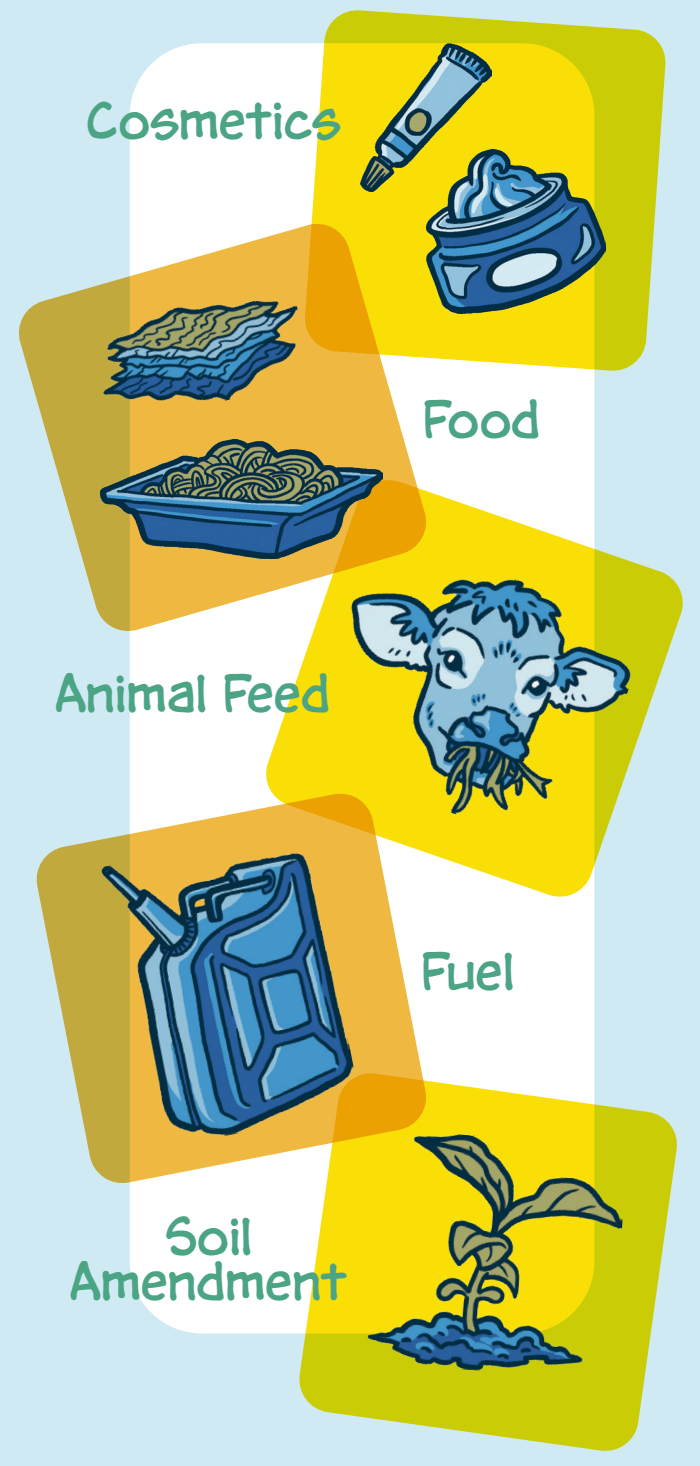
If you've ever taken an Introductory Biology course, you'll remember using an agar plate—a Petri dish with a layer of agar gel for culturing bacteria. You'll also find it as an ingredient in many Asian desserts.

The earliest textual mention of its use is from 1754, when two Jesuit priests in the Philippines defined it as "a herb, from which a jam-like preserve is made, grows in the sea".

## Alginate

Alginate is a biopolymer extracted from brown seaweed that transforms liquids into soft gels with just a bit of calcium. This ion-driven crosslinking makes it super useful in everything from molecular gastronomy to biomedical applications.

## Common Uses



### Did You Know?

Oceans cover 71% of the Earth's surface, yet produce less than 2% of the Earth's food!

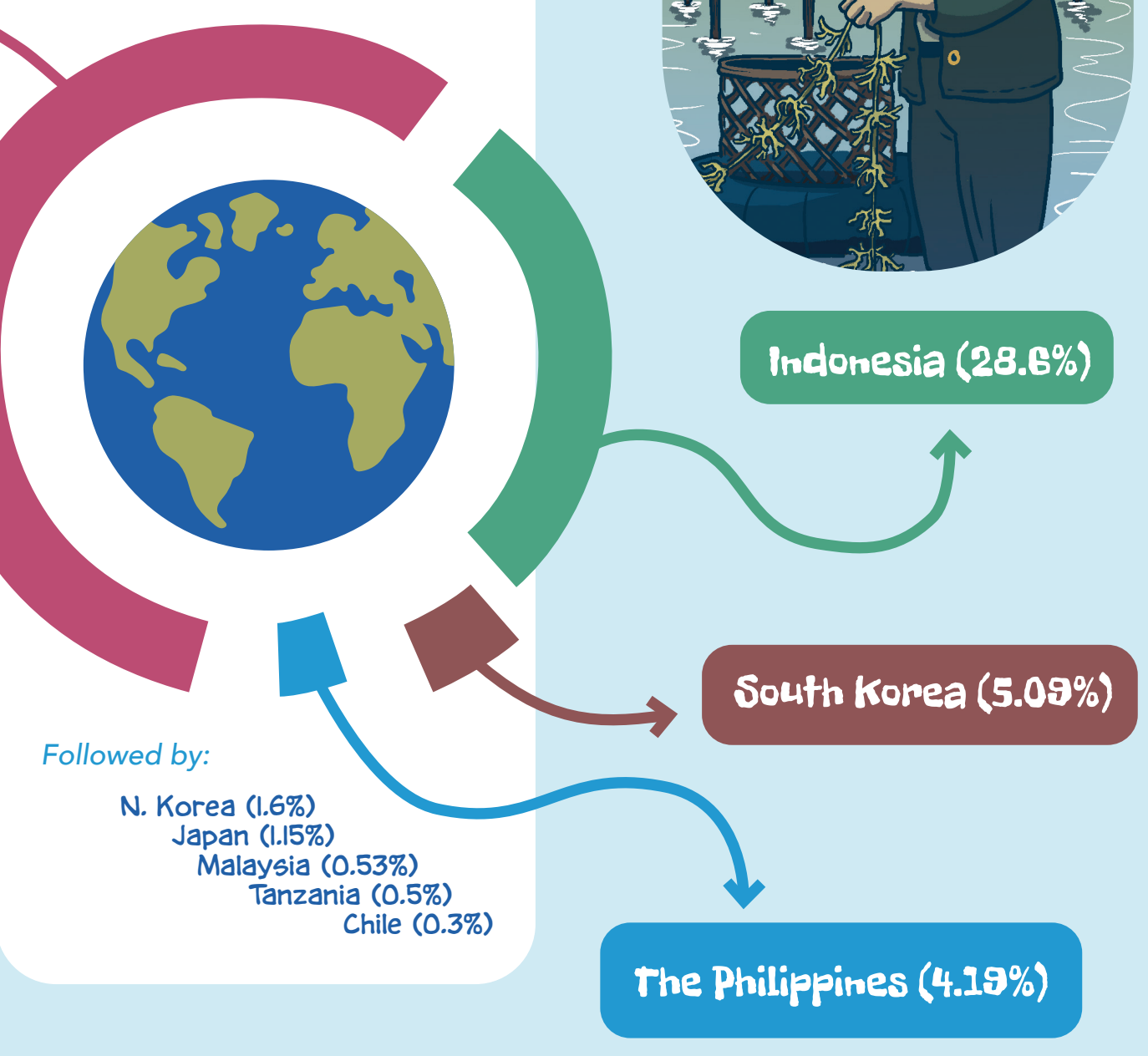
**China (58.62%)**



**In Tanzania, seaweed is the country's third largest export, employing over 25,000 farmers, 80 percent of whom are women.**

## Where in the World?

America is coming late to the party on commercial seaweed farming. As of 2022, the largest seaweed-producing countries around the globe are:



## Intro to Kelp Farming

Cultivating more sustainable ocean farming





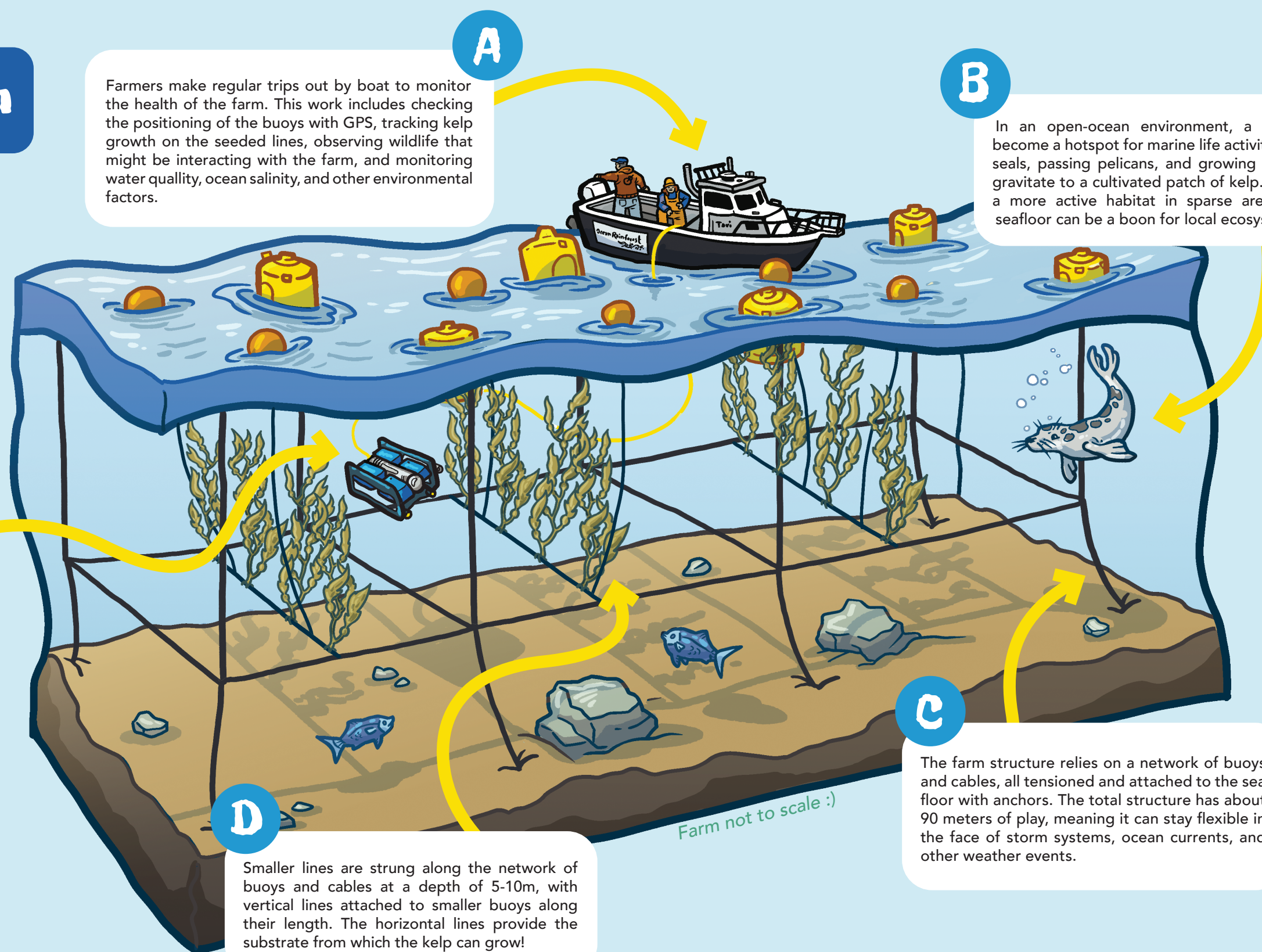
# Tour a Farm

Requiring no feed, no fertilizer, and no freshwater, kelp is a deeply appealing option for open ocean farming operations. While some companies use wild-foraged kelp, many are turning to long line farming for mass cultivation.

Take a closer look at this 86-acre farm off the coast of Santa Barbara, California, USA.

Farmers make regular trips out by boat to monitor the health of the farm. This work includes checking the positioning of the buoys with GPS, tracking kelp growth on the seeded lines, observing wildlife that might be interacting with the farm, and monitoring water quality, ocean salinity, and other environmental factors.

Modern kelp farmers use technology in many ways. ROVs outfitted with cameras and sonar can allow farmers to track kelp growth and monitor infrastructure without having to send down human divers. Buoys can be outfitted with GPS trackers to monitor the drift and position of the farm array.



Smaller lines are strung along the network of buoys and cables at a depth of 5-10m, with vertical lines attached to smaller buoys along their length. The horizontal lines provide the substrate from which the kelp can grow!

In an open-ocean environment, a farm can become a hotspot for marine life activity. Curious seals, passing pelicans, and growing fish might gravitate to a cultivated patch of kelp. Providing a more active habitat in sparse areas of the seafloor can be a boon for local ecosystems.

The farm structure relies on a network of buoys and cables, all tensioned and attached to the sea floor with anchors. The total structure has about 90 meters of play, meaning it can stay flexible in the face of storm systems, ocean currents, and other weather events.

This farm is growing the largest of all the macroalgae: **giant kelp!** Reaching up to 60 m (197 ft) long, and growing up to 60 cm (2 ft) *per day*, these brown algae really live up to their name. Giant kelp is most commonly found growing in sprawling forests, and prefers cool, nutrient-dense waters from Baja California to southeast Alaska.

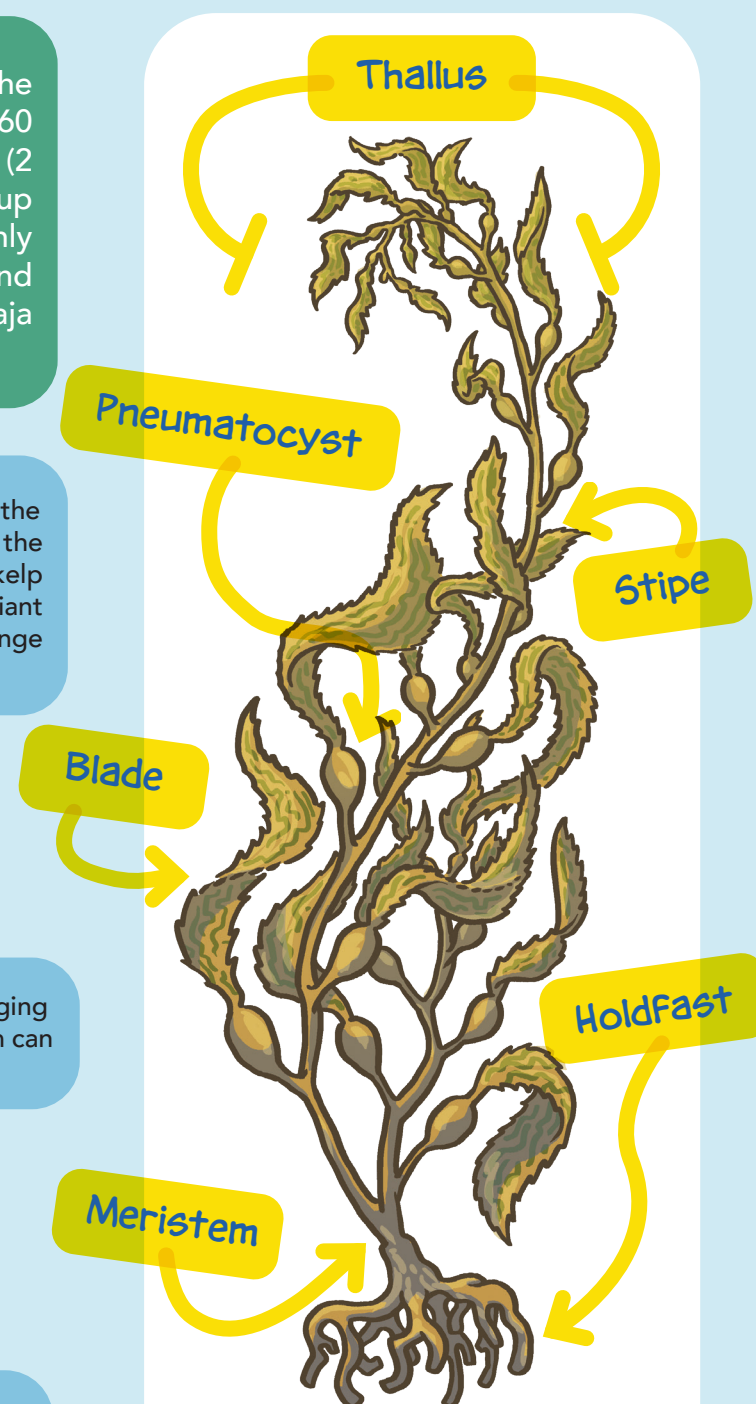
Gas-filled bladders called **pneumatocysts** help the **thallus** (that's the whole organism) stay close to the surface to absorb sunlight. Some species, like bull kelp (*Nereocystis luetkeana*) have just one bladder, but giant kelp has them at the base of every blade. They change shape depending on the current they're grown in.

The **blade** is where the magic of photosynthesis takes place. Giant kelp blades have serrated edges (known as dentate margins).

The **stipe** is the stem-like structure emerging from the meristem. An individual organism can have as many as 60 stipes!

Above the holdfast you'll find the **meristem**, which is made up of undifferentiated cells capable of cell division.

The **holdfast** is a claw-like structure that helps the kelp stay anchored to the seafloor. Individual fingers in the holdfast are called **haptera**. Unlike roots, holdfasts are purely structural and absorb no nutrients. They vary in appearance depending on what they're attaching to.



**GIANT KELP**  
*Macrocystis pyrifera*

1.

Farmers begin by collecting sorus (the part of kelp that contains the sporangium, or cells that hold and produce spores) from healthy kelp in the wild. The sorus tissue is then taken back to the lab and dried out. This stressor is required to trigger a release of spores for reproduction.

2.

A single plant can produce trillions of spores per year! To replicate this process in the lab, the sorus tissue is rehydrated in sterile seawater. Within an hour, given a healthy specimen, the water should turn brown and cloudy with spores.

3.

Once the correct density of spores has been reached, farmers seed the spores onto spools of twine wrapped around PVC pipe for 24 hours in a settling tube, then submerge them in a filtered seawater bath. The whole process has to be monitored carefully to ensure the kelp isn't crowded out by opportunistic algae or other contaminants.

4.

Spores on the twine grow into branching gametophytes, which then mature into sporophytes (more blade-like structures) over the course of 4-6 weeks.

5.

Once the sporophytes are mature enough (typically within six weeks), they're put out on farm by passing thicker rope through each PVC tube, spiraling the twine around it to embed the sporophytes. These ropes are referred to as "longlines," which gives longline farming its name.

6.

Farmers monitor the kelp's growth over the next six months, checking on it every two weeks or so with human divers or an ROV.

7.

When the kelp reaches maturity, farmers harvest the desired amount by pulling longlines to the surface and cutting the kelp down. It can then be processed on shore for any number of applications—from cosmetics to food to farming.

**Kelp Farming Basics**

## Faces of Kelp

Farmers flock to kelp for all kinds of reasons. Here are some folks working in the field today.

"Three years ago our waterways were declared a disaster. After we got the farm in the water the species that started coming back astonished everyone. Scallops, seahorses, horseshow crabs, shore birds, seals—it became something observable that people could rally around."

"We use shallow water kelp farming. There are no boats, so we're putting our bodies in the water. It holds you. You develop a relationship with the water and the tides."

"Whatever kind of background you're bringing, you can find satisfaction here. There's personal wealth that comes from this work."



Jackie Dexter  
Owner, Holdfast Mariculture  
Blaine, Washington, USA



Tela Troge  
Shinnecock Kelp Farmer  
Southampton, New York, USA

"I'm adopting the Triple Helix model of innovation, collaborating with academia, industry, government, and donors including the World Wildlife Fund."

"Seaweed cultivation greatly empowers women and youth in smallholder communities where situations are dire."



Oscar Ikinya  
Educator, Mwani Africa  
Kilifi, Kenya

## Cultivating Cautious Optimism

In the age of rapid and terrifying climate change, people are desperate for solutions. Investors are also keen to capitalize on emerging climate technology. Wherever there's money on the line, it's important to keep an eye on the hype.

Kelp farming can still have negative impacts on the local environment. Sometimes farmers cut down existing mangrove forests (or even wild kelp forests!) to make way for commercial grow sites. For companies promising kelp farming as potential carbon mitigation strategy, the actual act of carbon sequestration (sinking the kelp deep, deep in the ocean) requires substantial energy and infrastructure.

As with all developments in the climate and sustainability sector, there's no silver bullet. "Blue Carbon" may be a buzzword right now, but the ocean is a highly complex and delicate ecosystem. Every action will have repercussions. Climate change has never been more urgent, but the need to be thoughtful remains.



This poster was written and illustrated by Lucy Bellwood, a professional Adventure Cartoonist documenting everything from rafting through the Grand Canyon to sailing aboard 18th-century replica tall ships. Learn more about her work at [lucybellwood.com](http://lucybellwood.com)