Atlas of
SEAWEED

Anna Ohmsen

It flows, it nourishes, it transforms, it provides shelter, it cleanses, it purifies, it grows, it ...

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By reading "*The future of food and agriculture – Alternative pathways to 2050*", by Food and Agriculture Organization of the United Nations (2018), and through my research of DTU Food Institute. The future of food and agriculture describes that "*The overarching concern regarding the future of food and agriculture is whether global systems will be able to sustainably feed humanity up to 2050 and beyond, while at the same time accommodating the demand for non-food agricultural commodities.*" Questions as what will we eat in the future? What types of food will be available and how can we reduce our carbon footprint arose.

The awareness of food security, our growing population, lack of ressources and climate changes paved the way as a starting point for my project. Since 70% more food will be needed in 2050 than today to feed the world's growing population. The UN see a great potential in utilizing the sea's resources such as seaweed and micro-algae for food, to demand healthy and easy food access. I saw a potential for creating a seaweed facility, that both teach and produce some of our future food sources. By implementing seaweed in a known context and allowing people to experience a closer contact to our sorroundings and see its potentials, the thought of greater knowlegde and appreciation is strenghten.

This booklet investigates and gathers research of seaweed and its potentials in a production.

FAO. 2018. The future of food and agriculture – Alternative pathways to 2050. (2018), Rome.

The Sustainable Development Goals are a universal call to action to end poverty, protect the planet and improve the lives and prospects of everyone, everywhere. The 17 Goals were adopted by all UN Member States in 2015, as part of the 2030 Agenda for Sustainable Development which set out a 15-year plan to achieve the Goals.

12. Responsible production and consumption
Responsible production appears in the seaweed source. The production of seaweed is sustainable and has a positive impact on the carbon footprint. The production are cultivated naturally, since the water contain all the elements seaweed need to grow.

14. Life below water
The seaweed production creates a close relation to this action plan because of its sustainable use of the sea to create a starting point for new developments. The seaweed purifies the water and take part in our ecosystem in a positive direction.

2. No hunger
The UN goal no hunger deals with achieving food security and promote sustainable agriculture, the seaweed production goes hand in hand with this goal due to its food security, sustainable impact, and its rapid cultivation.

The geological epoch

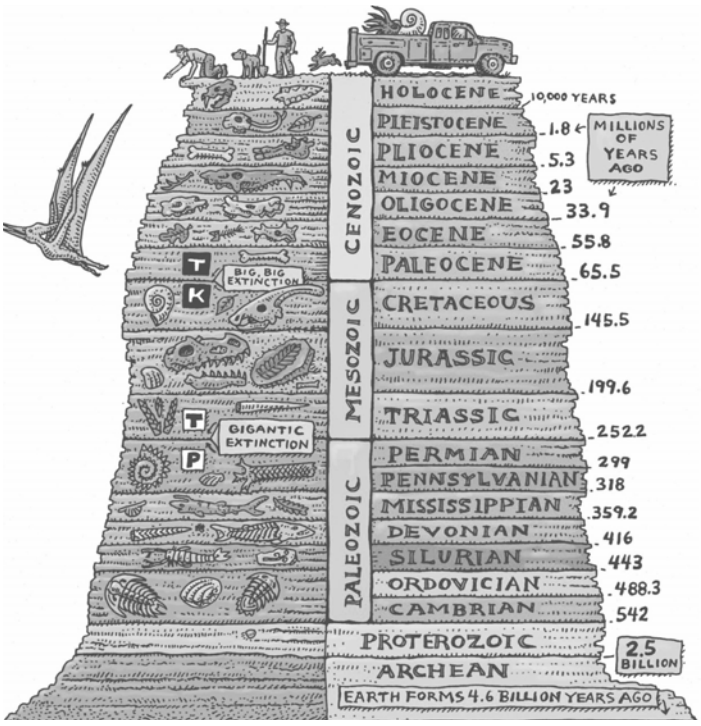
The Holocene

Geologists have divided the history of the Earth with a geological time division or time scale. Each unit of time has a name that simultaneously refers to geological layers that have been detected in and on the earth.

The Anthropocene

The human being is the dominant life form on the planet and the climate crisis is a reality. By reading fragments from the book 'Connectedness, An Incomplete Encyclopedia of the Anthropocene' by Marianne Krogh (2020) the thought of combining and connecting humans with its surroundings and all living things on Earth arose. The book unfolds the challenges the world is facing and how it is necessary to look at what binds us together and how we can strengthen the connection to the nature. As Krogh describes, "*Most of us have lost sight of the fact that our societies and their continued development are completely dependent on our connectedness with the Earth and its resources*" (Connectedness, p. 10, 2020) In other words we need to invest in a closer relationship to the Earth for humans to create a positive impact on our surroundings.

Questions as, who are we when we are not only human but also nature and how to connect humans with other species and surroundings on Earth, created a starting point for developing the project.



"Connectedness" by Marianne Krogh (2020)

New stone age

"Neolithic Revolution."

Fixed human settlements and the invention of agriculture.

Modern age

"*Landborereformen*"

Increased agricultural production and gathering of farmers land.

Industrial Age

"The Industrial Revolution"

Machinery and inventions for maximum production capacity and economic growth.

Present Day

"The digital"

The negative human impact and climate change.

Holocene

Official unit

The current epoch is called the Holocene, which began 11,700 years ago after the last major ice age, characterized as the age of the human species.

Anthropocene

Unofficial unit

The Anthropocene Epoch is an unofficial unit of geologic time, used to describe the most recent period in Earth's history when human activity started to have a significant impact on the planet's climate and ecosystems.

https://www.researchgate.net/figure/Timeline-of-geological-epochs-archeological-periods-in-human-prehistory-and-history_fig3_338634231

Interview and dissimination, Bodil Sofie Espersen, Havhøst

11 mar. 14:00

They have a focus on oyster mussels and few types of seaweed and enjoy working with small scale and telling stories. They borrowed some containers for educational work and 4 months a year schools take part in the farm and are involved in the process. They spend a lot of time to help new communities growing, regenerate and testing crops. It all started in Copenhagen and now they have a platform for growing and learning - a floating classroom and working zone in Kalvebod Brygge, "Bølgen".

Their primary cultivation are mussels, but they test and cultivate seaweed as well. Cultivating an existing species and make use of their natural resources in the sea are an easy way to grow mussels and seaweed. All the natural nutrients flow with the stream and the spices also attaches themselves to the rope from the farms.

The regenerate a crop, means that they only grow crops naturally because they don't have to add anything to the water. They can cultivate and harvest the crops without ruining the sea. Mussels and seaweed filter the nutrients when they eat and is efficient for the bio-atmosphere that cleans the ocean, that's why the water around them is so clear. The growing platform is 5x7 meters and underneath every year they produce 1 ton of mussels, if comparing to beef you were to grow 8 football fields to get the same output. Around the growing platform they cultivate seaweed because they need light to grow due to photosynthesis.

The seaweed they cultivate at the platform is sugar kelp and is a bit more difficult to grow than mussels. When they start to get darker spots, they are fertile. Here they cut out the fertile dry spots and they spread it into a box of saltwater and add lots of rope where the seaweed attaches themselves to. After the rope begin to look muddy and the seaweed have been growing a bit, they put the rope into the water where they grow in its natural surroundings. They do not have any statistics on how big the production is but their seaweed farm measure 2x20 meters around the platform.

They want to learn people to eat this crops/ seaweed and make people aware of the quality of seaweed- and marine farms. To get access to make a marine farm you will have to look for permission and it is a good idea to know the actors of the community, such as fishing and sailing communities as well as the municipality and locals. Make friends with them and make them aware of the project.

Havhoest only harvest by hand and do not create a monoculture. They try to avoid the agriculture we know on land and seek to keep it multicultural and small scale.

Interview, Bjarne Ottesen, CEO Nordisk Tang

Fragments, 11 feb. 13:24

There are 400 different species of seaweed in Denmark, and they are divided into 3 categories: The brown, the green and the red. The different types contain different nutritions and are depended on the salinity in the water. The more salt, the greater species richness.

It grows on stones, and some also dive to get them, they are not always easy to get access to.

Depending on the sun they grow 10-12 meter under the water and some species can grow 100 meters below the water surface due to the clearance of the water. They grow up against the sun.

Nordisk tang facilitates seaweed-safari, dissemination, a shop, pop-up restaurant and work together with "Jysk Rejsebureau".

Seaweed absorbs heavy metals and pesticides due to its capability of cleaning the ocean. You can't eat them, but instead they are burnt to ashes and by that you can remove the metals.

Seaweed cleans the sea and, in some cases, they are put out in the ocean to remove poison.

Zoom meeting, Susan Holdt, Professor DTU

Fragments, 14 feb. 13:00

You can lay close to the harbor without heavy metals being absorbed in the seaweed. The moles create good growing conditions for the seaweed, because they attach themselves on stones and hard surfaces.

Once the fishing boats caught the seaweed and sailed it into the harbor.

People speaks about the Baltic Sea as a "Dead Sea", but you can reestablish the nature/sea by implementing marine farms.

If we think about cultural landscapes, as the fields on land, maybe we can create cultural landscapes in the sea by adding marine farms - the seaweed forests can take part in the aqua tourism and involve fishermen to create better economics.

There are many possibilities in using seaweed as a product. But due to its many nutrients and it is becoming a food source; seaweed as food supplement seems like a great idea. Make the seaweed become a part of our vegetable's palette.

"Uma-meats" have replaced 30% meat with seaweed, not does it only taste better but at the same time they reduce our meat intake with 30%.

Annette Bruhn, Senior Researcher, phd, AAH University

Fragments from phone calls

Annette Bruhn told me about how to grow seaweed on lines and how the different species vary from one another.

To start growing seaweed, pick up with seaweed with spores. The seaweed will release the spores when you stress them and thereby the spores stick to a hard surface, we do that in a hatchery. From the nature the surface is stones or mussels, but in vessels you place the lines in which the seaweed thereby attaches itself. The lines are stored in water in a vertical farm inside, with access to plenty of light, here seaweed will grow directly from the lines and after 4-6 weeks they are 0.5-1 mm and ready to be released into its natural environment in the sea.

Depending on the species cultivated, the lines must be set out into the sea at different depths, and according to the clarity and conditions in the water, the seaweed will grow up against the sunlight due to photosynthesis. After 8-9 months, the seaweed has grown large and is ready to be harvested. Most seaweed species taste best in the spring, as the seaweed in the winter occupies nutrients and vitamins. However, most of the seaweed can be harvested all year round, but the sizes will vary based on the water quality.

In other words, the spores are set out primarily in September-January and harvested in April-June. But the seaweed is harvested by cutting them above the growth point. Some also pull them off or use a tool-eye that removes all seaweed from the lines.

The sea lettuce can be grown all year round and grows quickly in summer as it settles in the water surface. It can be harvested 4 times a year and needs more protection from the waves, as it is not thick-skinned and can break more easily.

The bladderwrack can also be cultivated by catching wild seaweed and attaching it directly to the lines. The bladderwrack is strong and does well the waves, as the waves removes other wildlife and dirt that could cover for the sunlight. It is thick-skinned and does not break easily, its bladder helps them float up against the water surface so it gets the best outcome from the sunlight.

The texture of the sugar kelp is similar of the bladderwrack, it is thick-skinned and can withstand the waves well. However, the sugar kelp is found in deeper water and needs a lot of salt. On Bornholm there is not much salt in the water, but you will be able to grow smaller sugar kelp, which will contain a lot of flavor.

Depending on the color pigments in the seaweed, they can be found at different depths. The green species are at the top, the brown ones in the middle and the red ones are found deepest. The seaweed can be used for many purposes, but if it is based on food, the seaweed is good for being dried and eaten fresh.In connection with your project you can easily smoke the seaweed and make seaweed chips or converted into salt, spice, granules or flour.

Lector ‘About Denmark’s sea alge’ by lecturer emeritus Ruth Nielsen

Arranged by Tangnetværket and Danish Botanical Association, 17.03.2022

Algae are a very important part of the marine ecosystem. We see them mostly flushing on the beach and stuck on our docks. This evening, Ruth Nielsen will introduce us to the most important conditions for the algae flora in Danish waters. Ruth provides tips for determining the algae with information on the algae's life stories. For the "green kitchen", it is important to know edible algae.

Consultants

People I have been in contact with through my research

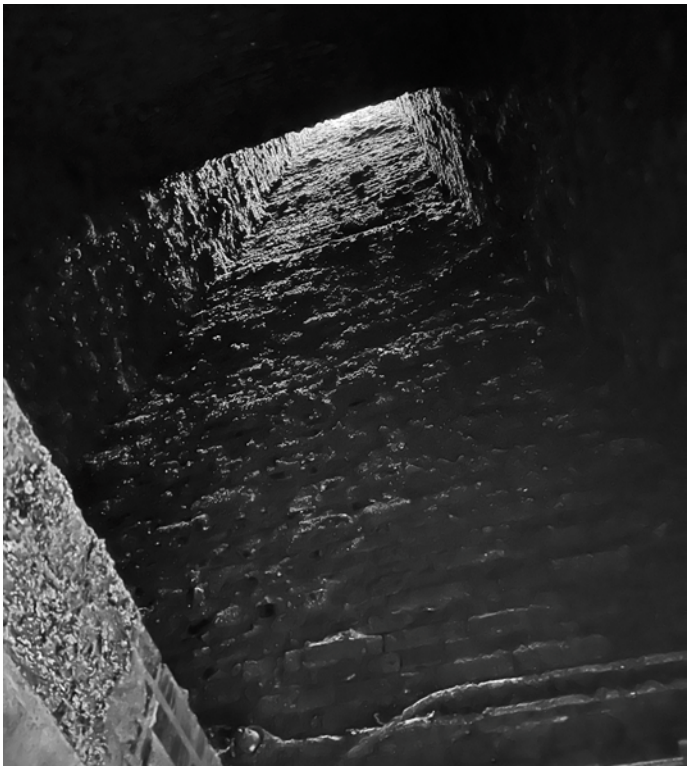
- Bjarne Ottesen, CEO of Nordisk Tang, responsible for: Producing and harvesting seaweed
- Kristina Panduro, Architect, knowledge in: Buildings and environment on Bornholm.
- Magnus Heide Andreasen, Marine biologist, CEO of IVandet, experience in: The Baltic Sea and life below water at Bornholm
- René Thisen, Nordbornholms Røgeri, knowledge in: Smokeries and their function.
- Slots & Kulturstyrelsen, knowledge in: History, conservation and culture on Bornholm.
- Susan Løvstad Holdt, Professor at DTU National Food Institute, experience in: (bioactive) components, ingredients, threshold values and Danish and EU regulations of seaweeds.
- The municipality of Bornholm, Gugga Zakariasdottir, knowlegde in: The life and plan for Bornholm.
- Bodil Espersen, CEO of Havhøst, have a dissemination and teaching facilities located on Kalvebod Bølge, knowledge in: Cultivating marine farms.
- Jørn Pedersen, Business consultant at Business Center Bornholm, knowledge in: The development of Bornholm and its inhabitants.
- Hovedet I Havet, organisation that dissiminate about life below water, focus on: Marine farms and its function.
- Institute of technologies, knowlegde in: Reaserching the seaweed and its possibilities.
- Pure Algea, firm that explore landbased seaweed farms, knowledge in: Developing seaweed growth.
- Tangnetværket, an organization that gather people who are interested in seaweed.
- Ruth Nielsen, Old lector and professor at KU, knowlegde in: Everything about seaweed.


100% SALT
sel
CLASSIC

Existing smokery

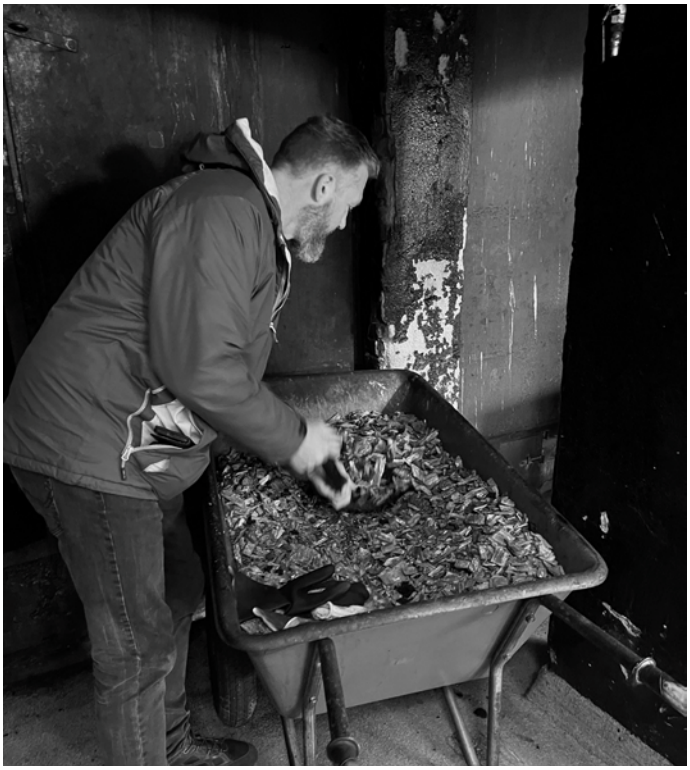
'Nordbornholms Røgeri'

1. Cutting Hall
2. Toilet
3. Changing room
4. Furnace
5. Smokery
6. Cooling room
7. Kitchen
8. Storage
9. Shop
10. Smokery
11. Staffroom
12. Entrance
13. Oven
14. Working tables



View inside chimney

Chimney oven with tar



Wood chips

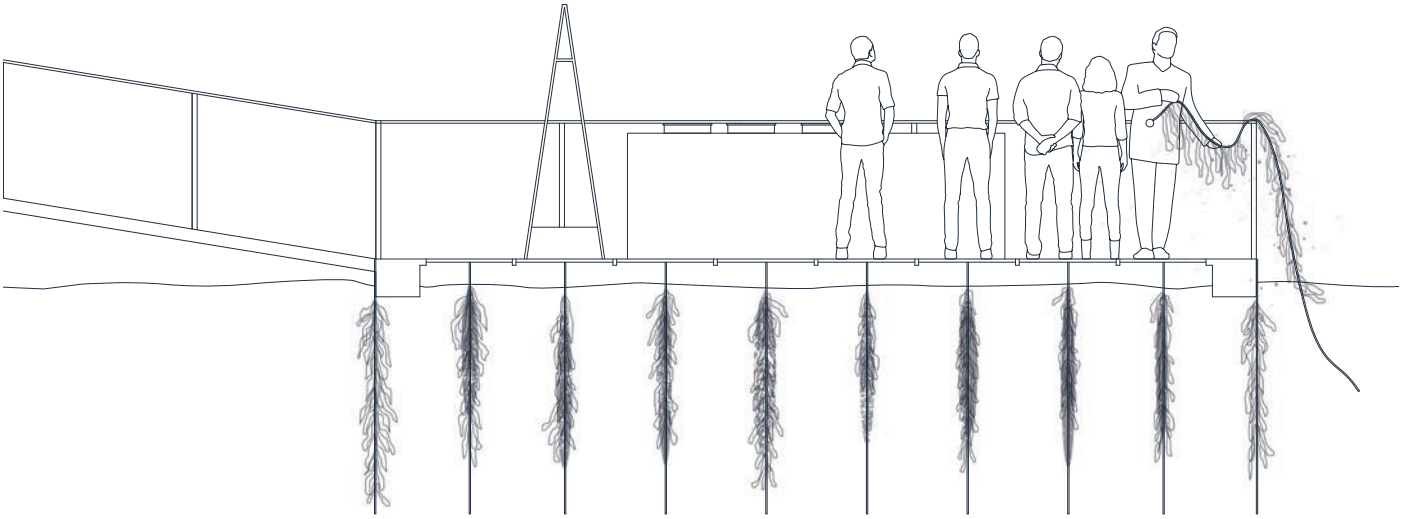
Smokery ovens

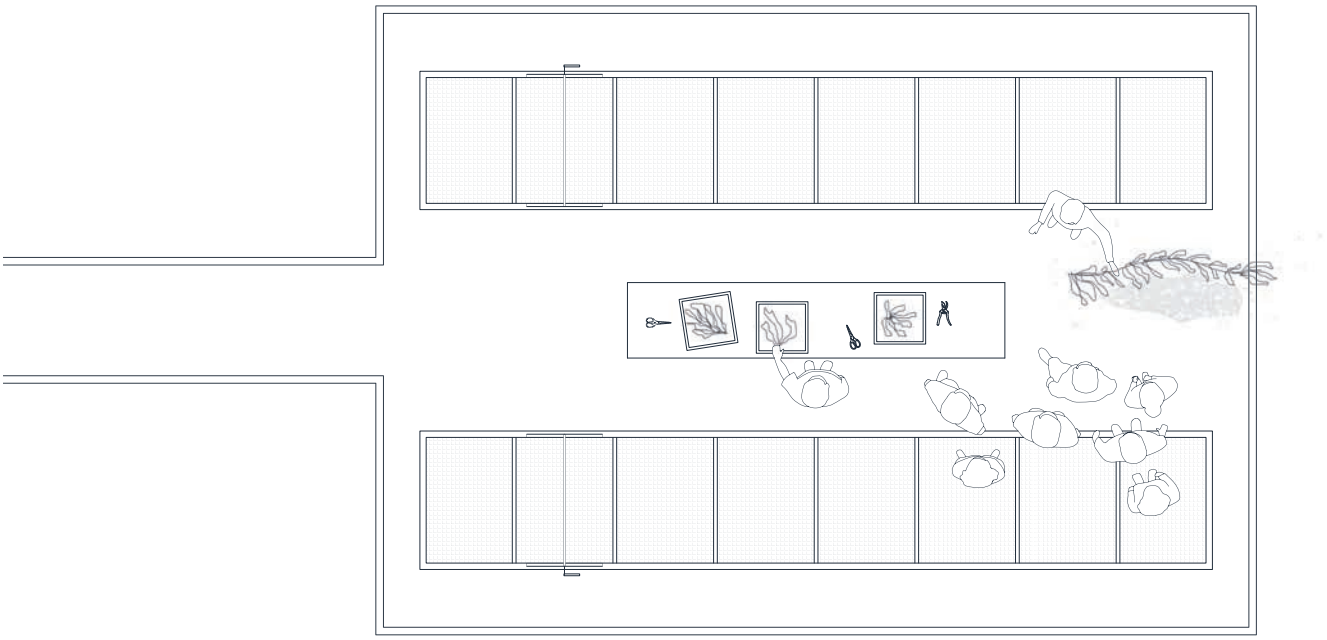
Wagon

Salt water vessel

Cutting table

Cleaning area

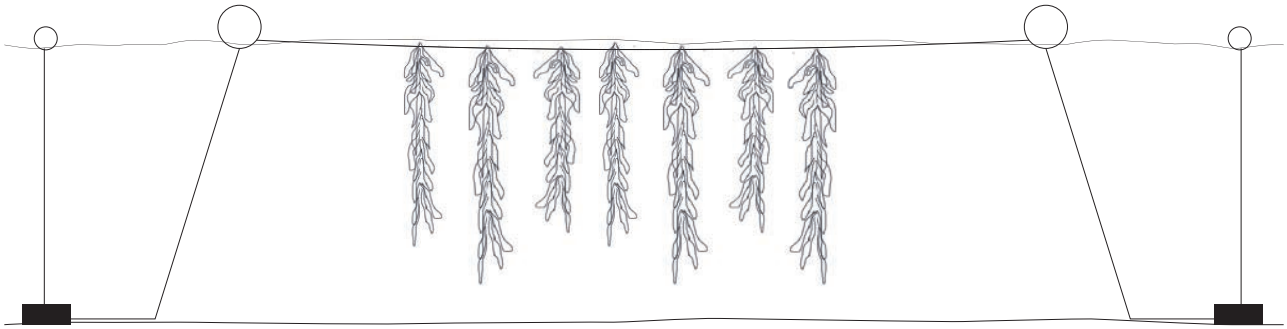




Sugar kelp on lines

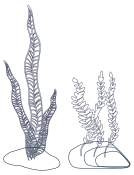
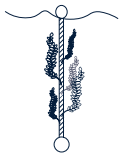
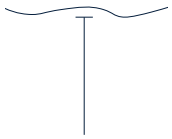
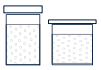
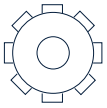
Musselfarm and mechanical function

Dissemination, learning platform



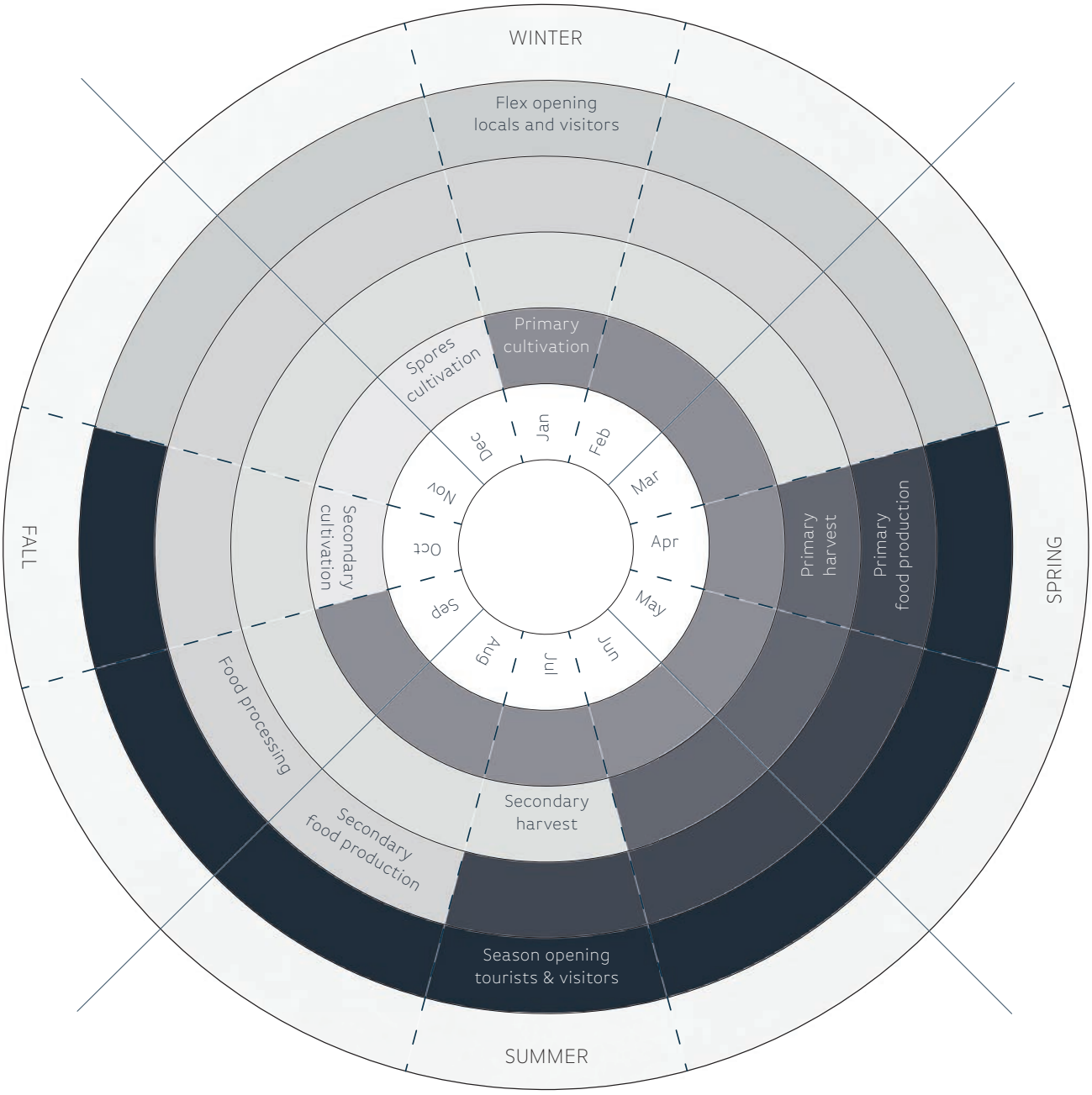
The line is kept roughly stretched by two mooring buoys, which are connected with strong chains to each of their anchors that are firmly attached to the seabed. It is a little different what type of anchor is best to use - among other things, it depends on what bottom is underneath the sea garden. Screw anchors are often a good idea, but if there are many stones and rocks, for example, it can be difficult to screw the anchor. Alternatively, you can use so-called *delta anchors* or similar. From the anchor, a stern tail emerges, indicating the location of the anchor with a buoy at the top of the waterline.

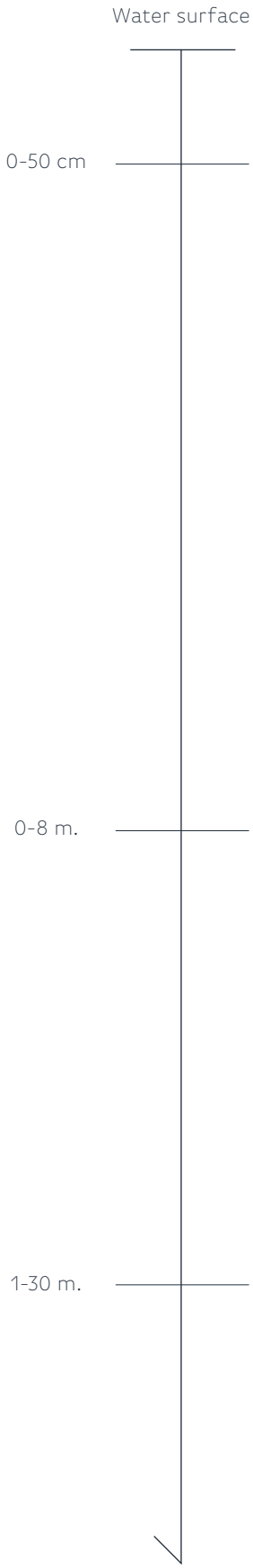
A sea farm basically consists of a lot of liner stretched out next to each other.

Grow					
	Natural	Cultivated			
Conditions					
	Salt	Temperature	Sunlight	Elements	Depth
Food source					
	Fresh	Dried	Smoked	Fermented	Food supplement
Harvest					
	Waders	Dive	Mechanical		

Seasonal diagram

Cultivate and harvest





Green: Sea lettuce
Grows: 0-50 cm. depth
Lenght: 20 cm.
Known: Salad/bread/soups

Brown: Bladderwrack
Grows: 0-8 m. depth
Lenght: 50-100 cm.
Known: Salad/chips/salt

Brown: Sugar Kelp
Grows: 1-30 m. depth
Lenght: 3 m.
Known: Salad/chips

Shape of sea lettuce

Herbarium - Ulva Lactuca

Sea lettuce

The sea lettuce can grow on rocks, but as something very special it can also float in the water. Free-floating sea lettuce can develop into giant leaves. The sea lettuce is found floating in wide belt in shallow areas where there is shelter from wind and current.

How to recognize sea lettuce

1. The fresh, green color.
2. Floating in the water
3. Looks like lettuce leaves without stems

Sensory

Sea lettuce has a rather distinctive mineral taste and a pleasantly soft and supple texture. When dried it gets a stronger taste and does not really have any odor.

Kitchen

Thoroughly clean the sea lettuce in salted water to remove sand, mud and small mussels in the ripples before cooking. The fresh sea lettuce can be used as an ingredient in a salad, in a risotto or soup. A good idea is to replace parsley or other herbs with dried and granulated sea lettuce.

Cultivate and harvest

The sea lettuce is normally put out in the ocean at fall, but can be cultivated and harvested all year. Taste best in the early spring.

Best quality

April, May, June, July, August.

Shape of sugar kelp

The sugar kelp consists of one long, brown leaf on a stalk that grows on a rock. The slightly curled leaf can grow up to three meters long and looks like moist leather. Sugar kelp should always be covered with water. Therefore it is found at slightly greater depths - all the way down to 30 meters. There must be a good portion of salt in the water for the sugar kelp to thrive.

How to recognize sugar kelp

1. Its leather like texture
2. Consists of one long leaf
3. The brown/yellow color

Sensory

In summer, up to 25% of the sugar kelp consists of the sugar substance mannitol, which when drying settles as a white, sweet-tasting powder layer on the outside of the seaweed. Sugar kelp has lots of umami and is pretty tough until you cook it, and it does not have a stong smell.

Kitchen

Sugar seaweed taste salty - almost like licorice.
The freshly picked sugar kelp is very salty and chewy, so it should either be dried or cooked before eating it. After cooking, it becomes more compliant, but still with good bite. Sugar kelp is well suited for drying. The fresh, cooked sugar kelp can be used directly in a salad, in soups or in hot dishes. The leaves can be roasted in oil and used as seaweed chips. Dried seaweed can be granulated, mixed with sea salt and sprinkled over dishes for a distinct umami taste.

Cultivate and harvest

The sugar kelp is put out in the sea in the fall, and can can be picked and eaten all year round, but it tastes best in the spring.

Best quality

January, February, March, April, May, June.

Shape of bladderwrack

Herbarium - Fucus vesiculosus

Bladderwrack

The bladderwrack is a brown algae that grows up to 70 cm long and is naturally attached to stones with a small suction cup. It shoots towards the surface carried by air-filled blisters along the brown leaves. It tries to create an optimal balance between sunlight, salt and nutrition in the water.

How to recognize bladderwrack

1. The brown/yellow color
2. Often seen washed up on the beach
3. Its many air bladders on its leaves

Sensory

Bladderwrack has a mild salty taste with lots of sea umami. However, the taste can vary greatly depending on where the seaweed has grown - sometimes it gets completely smoky or iodine-like notes. Once the bladder wrack is dried, the taste becomes more mineral. It has a light smell of sea and shellfish.

Kitchen

After cleaning the seaweed, the bladderwrack can be eaten fresh, but benefits from being cooked to heat so it becomes more tender. It can be baked, grilled and cooked and is good to dry for chips, granulate and use as a spice. Brown seaweed turns green when heated.

Cultivate and harvest

The fertilized bladderwrack is put out in the ocean at fall and can be harvested all year round, but it is best in the spring months.

Best quality

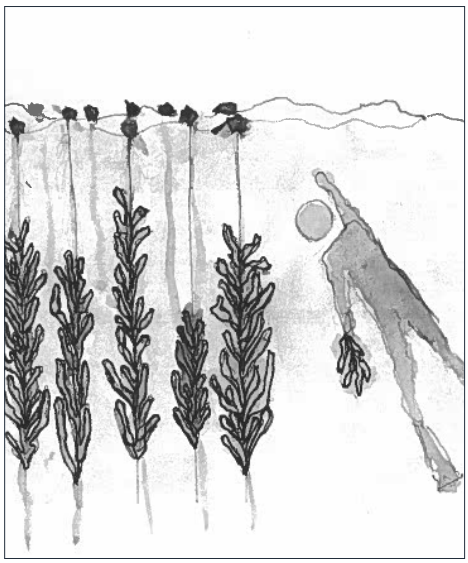
March, April, May, June.

Color scheme

Perception of seaweed

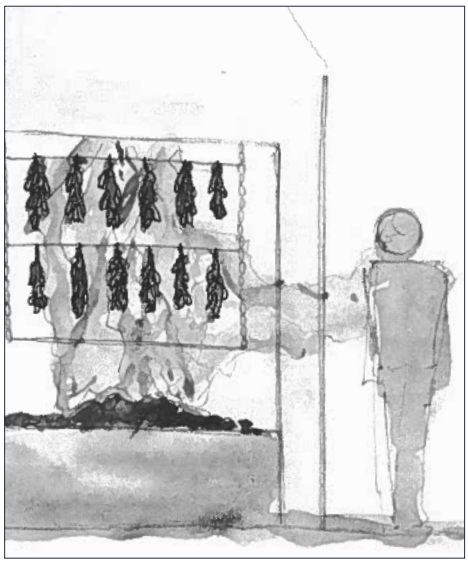
How can seaweed be experienced

Feel, the feel of seaweed



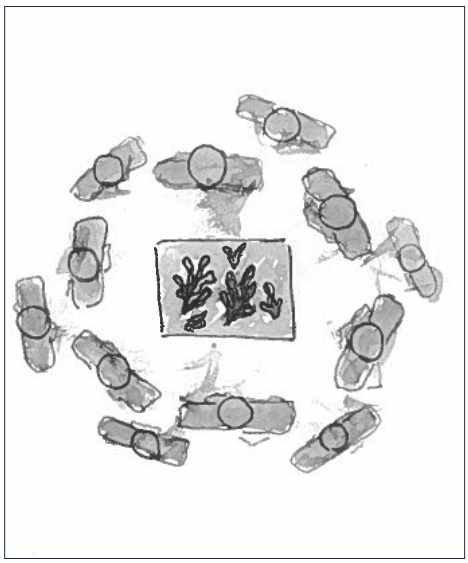
Vision, the view of seaweed below water

Taste, the taste of seaweed

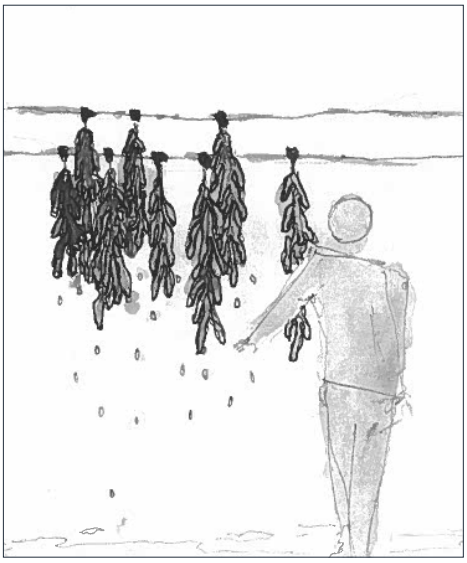


Smell, the smell of smoked seaweed

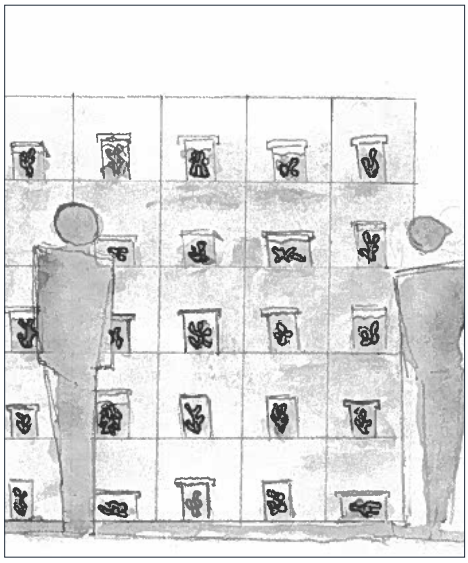
Sound, the sound of seaweed



Vision, gathering and teaching of seaweed

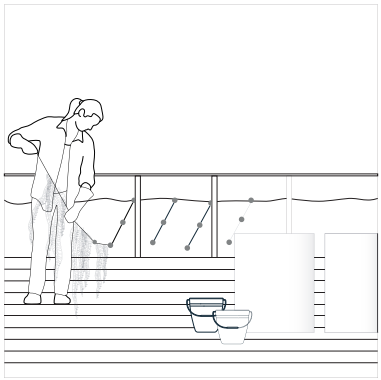


Feel, the feel of seaweed



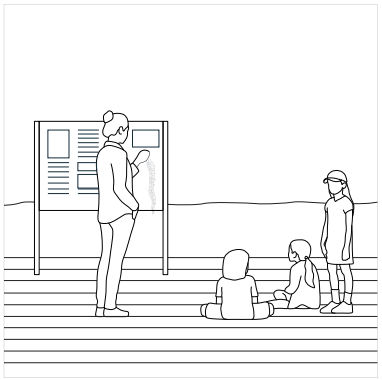
Vision, the view of seaweed

Cultivating and harvesting



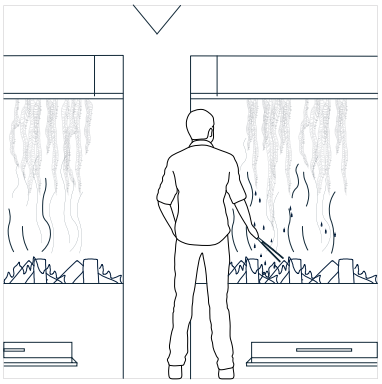
Various processes are involved in growing and cultivating seaweed. The cultivation is divided into 3 main stages: Fertilizing, growing and harvesting. In the project both inner and outta sea gardens take place.

Dissemination and workshops

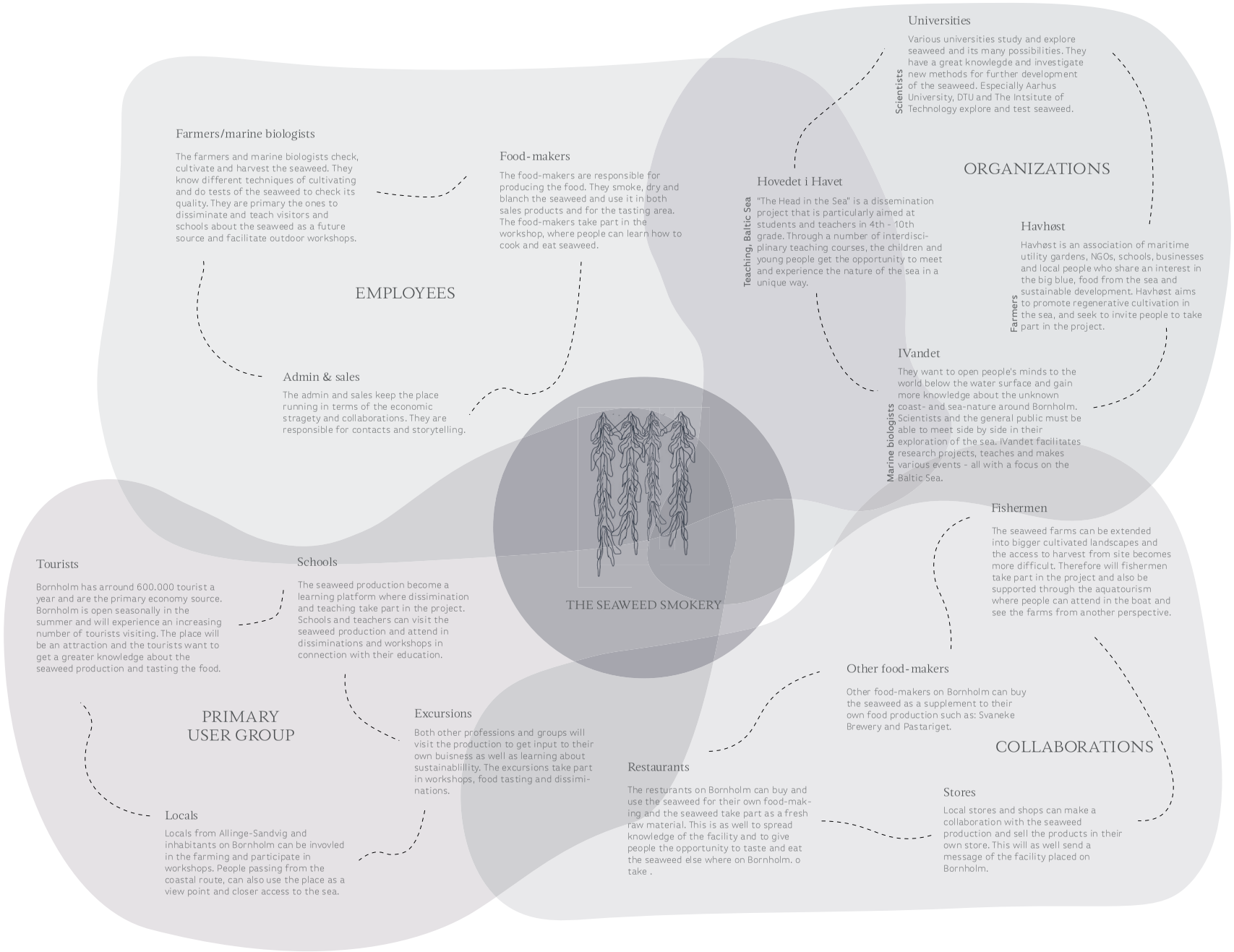


The production of seaweed creates an opportunity for dissemination and workshops. The cultivation of seaweed and how it can be used as a future food will be communicated. The dissemination provides space for visitors, tourists, schools and groups.

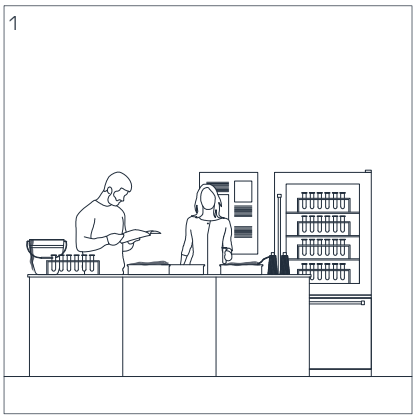
Food production and processing



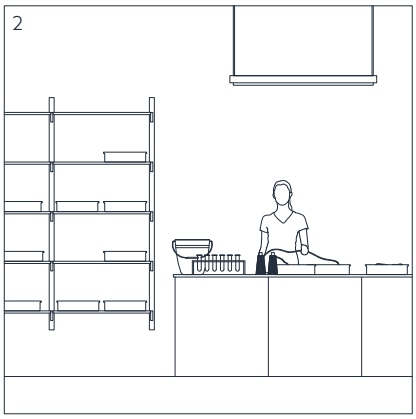
The food production harvest the seaweed needed to prevent from harvesting too much, therefore the harvesting, preparation and production of food takes place the same day. The primary food making is: fresh, drying and smoking. The main food sources can be used to create other foodproducts. Visitors and foodmakers can also taste and buy the processed seaweed.


Universities
Various universities study and explore seaweed and its many possibilities. They have a great knowlegde and investigate new methods for further development of the seaweed. Especially Aarhus University, DTU and The Intsitute of Technology explore and test seaweed.
Scientists
ORGANIZATIONS
Farmers/marine biologists
The farmers and marine biologists check, cultivate and harvest the seaweed. They know different techniques of cultivating and do tests of the seaweed to check its quality. They are primary the ones to dissiminate and teach visitors and schools about the seaweed as a future source and facilitate outdoor workshops.
Food-makers
The food-makers are responsible for producing the food. They smoke, dry and blanch the seaweed and use it in both sales products and for the tasting area. The food-makers take part in the workshop, where people can learn how to cook and eat seaweed.
EMPLOYEES
Hovedet i Havet
"The Head in the Sea" is a dissemination project that is particularly aimed at students and teachers in 4th - 10th grade. Through a number of interdisci-plinary teaching courses, the children and young people get the opportunity to meet and experience the nature of the sea in a unique way.
Teaching, Baltic Sea
Havhøst
Havhøst is an association of maritime utility gardens, NGOs, schools, businesses and local people who share an interest in the big blue, food from the sea and sustainable development. Havhøst aims to promote regenerative cultivation in the sea, and seek to invite people to take part in the project.
Farmers
Admin & sales
The admin and sales keep the place running in terms of the economic stragety and collaborations. They are responsible for contacts and storytelling.
IVandet
They want to open people's minds to the world below the water surface and gain more knowledge about the unknown coast- and sea-nature around Bornholm. Scientists and the general public must be able to meet side by side in their exploration of the sea. IVandet facilitates research projects, teaches and makes various events - all with a focus on the Baltic Sea.
Marine biologists
THE SEAWEED SMOKERY
Fishermen
The seaweed farms can be extended into bigger cultivated landscapes and the access to harvest from site becomes more difficult. Therefore will fishermen take part in the project and also be supported through the aquatourism where people can attend in the boat and see the farms from another perspective.
Tourists
Bornholm has arround 600.000 tourist a year and are the primary economy source. Bornholm is open seasonally in the summer and will experience an increasing number of tourists visiting. The place will be an attraction and the tourists want to get a greater knowledge about the seaweed production and tasting the food.
Schools
The seaweed production become a learning platform where dissimination and teaching take part in the project. Schools and teachers can visit the seaweed production and attend in dissiminations and workshops in connection with their education.
Other food-makers
Other food-makers on Bornholm can buy the seaweed as a supplement to their own food production such as: Svaneke Brewery and Pastariget.
PRIMARY USER GROUP
Excursions
Both other professions and groups will visit the production to get input to their own buisness as well as learning about sustainablility. The excursions take part in workshops, food tasting and dissimi-nations.
COLLABORATIONS
Restaurants
The resturants on Bornholm can buy and use the seaweed for their own food-mak-ing and the seaweed take part as a fresh raw material. This is as well to spread knowledge of the facility and to give people the opportunity to taste and eat the seaweed else where on Bornholm. o take .
Stores
Local stores and shops can make a collaboration with the seaweed production and sell the products in their own store. This will as well send a message of the facility placed on Bornholm.
Locals
Locals from Allinge-Sandvig and inhabitants on Bornholm can be invovled in the farming and participate in workshops. People passing from the coastal route, can also use the place as a view point and closer access to the sea.

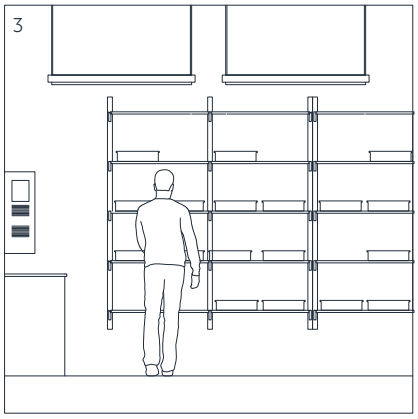
The building is organised through different observations and interviews. The seaweed production connects spaces from an existing herring smokery and a marine farm. Yet we do not have that many seaweed productions in Denmark, but through the research these steps will be the primary and most functional ones.



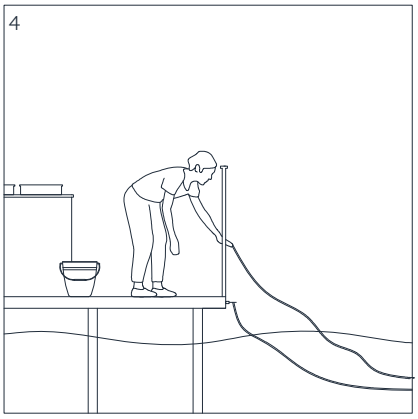
Make seaweed spores in hatchery



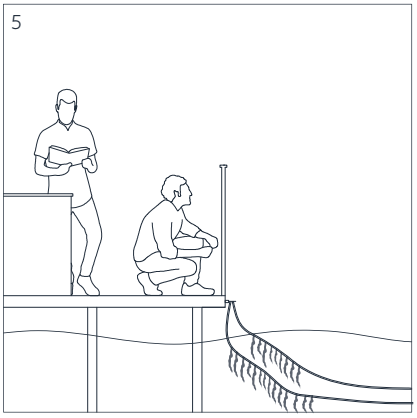
Fertilize the lines with spores in a tub



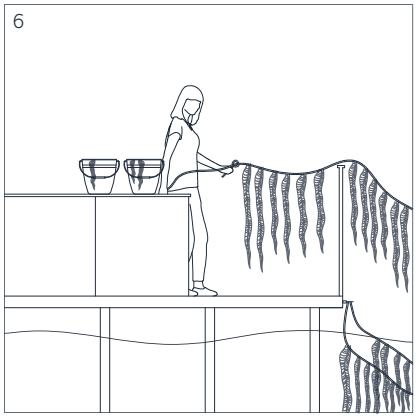
Store fertilized lines 4-6 weeks



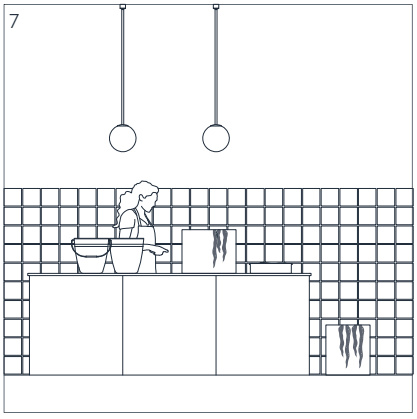
Put lines with 0,5 mm grown seaweed out in the sea



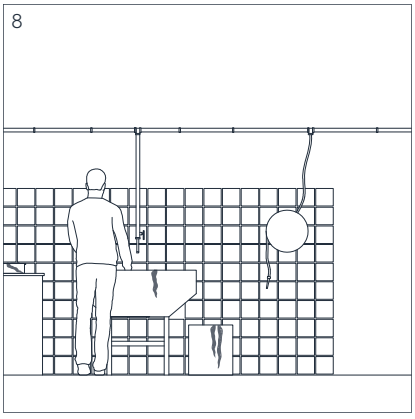
Check its condition every month



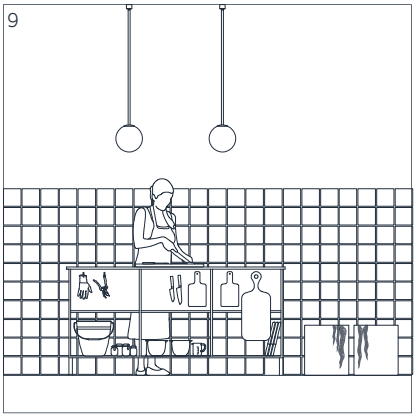
Harvest the grown seaweed after 8 months



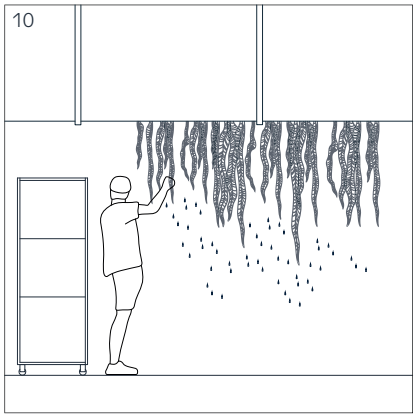
Fresh harvested seaweed ready for food-making



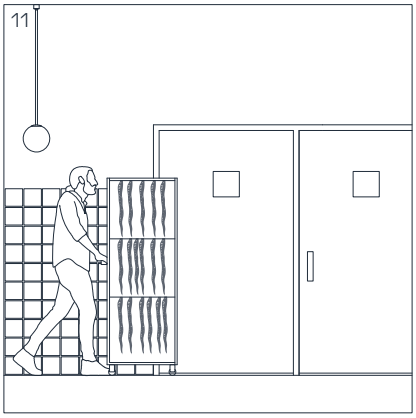
Clean the seaweed in salt water



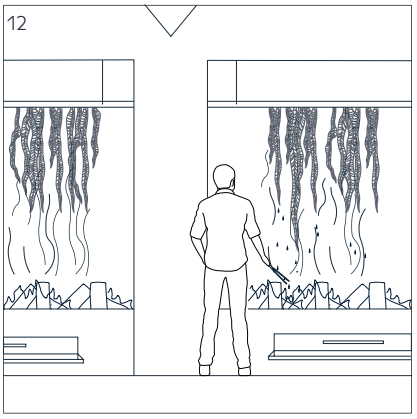
Cut and prepare the seaweed



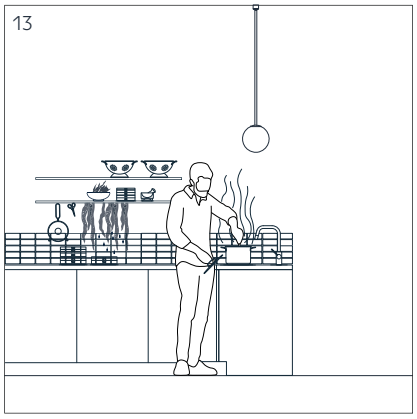
Dry the seaweed on lines



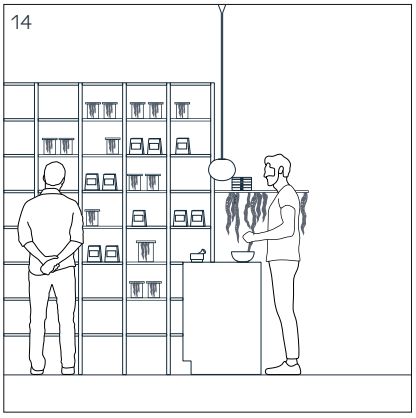
Preheat the seaweed in ovens



Smoke the seaweed in smokery

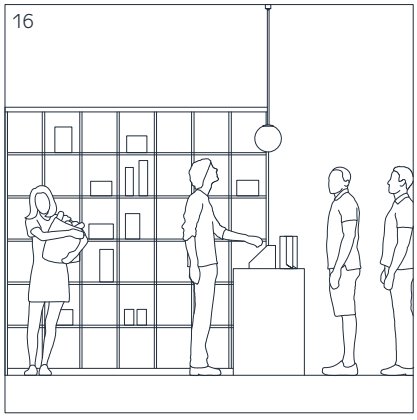


When smoked and dried the seaweed is further produced for food-tasting

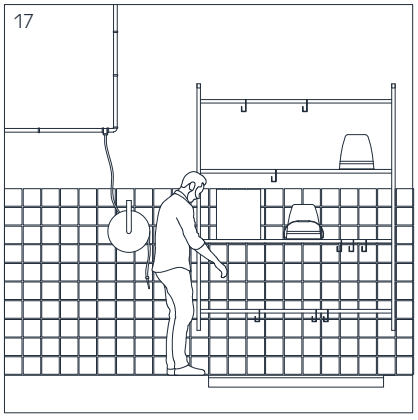


The seaweed is ready for tasting

The processed seaweed is packed



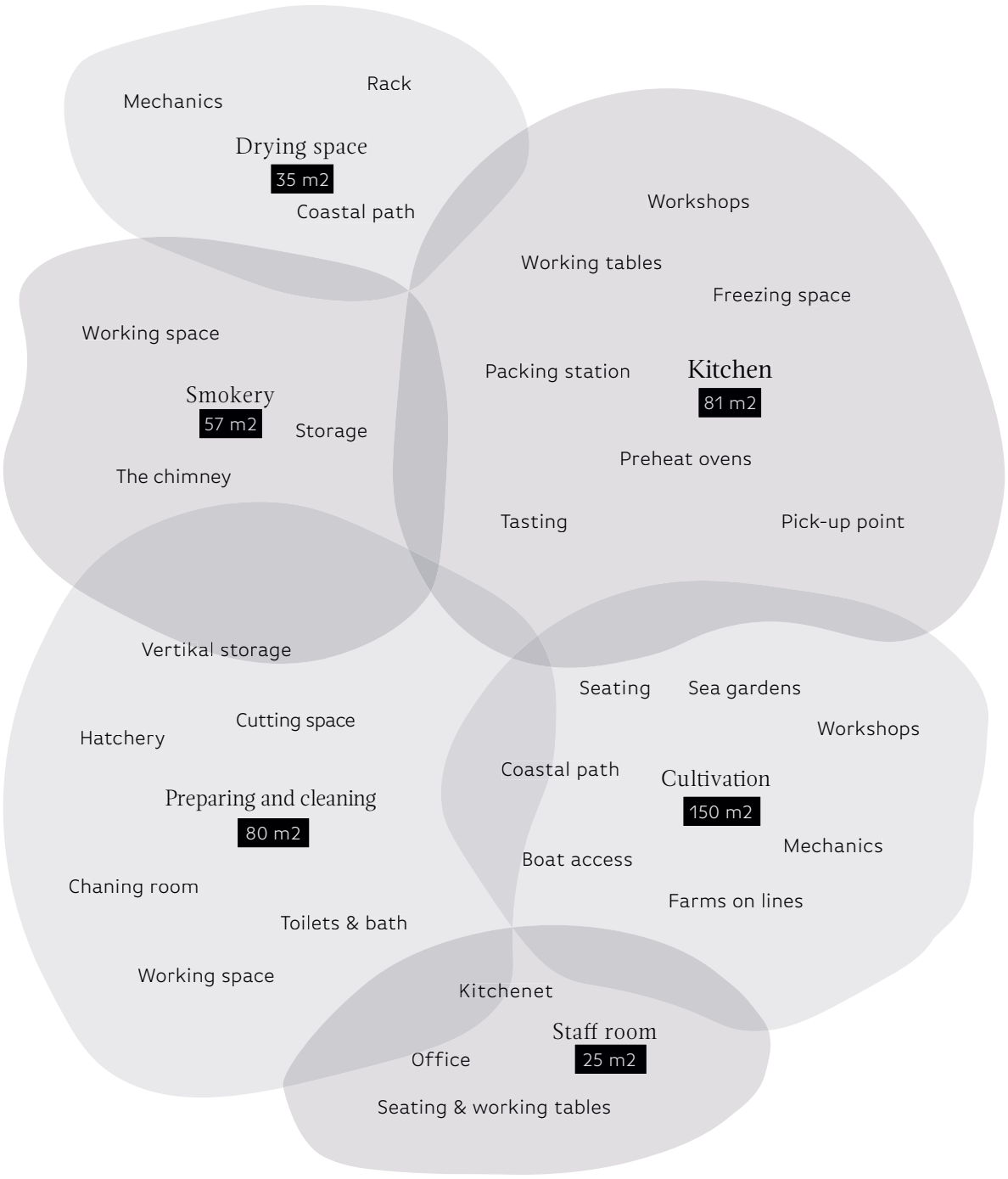
The seaweed is stored ready for pick-up and buyers



All tools are cleaned and dried

Functional diagram

Approximately building size




Chimney
A monolith and fixpoint in the landscape. The place become an end-station of the path and lead people to the site. The chimney informs about the production and leads back to Bornholm's fishing history.
THE EXPERIENCE OF THE COASTAL PATH
Drying area
The area is thought as a feeling of being below water, to experience the seaweed above, dripping with water and the sun shining through the aquatic plants. Also to understand the food processing.
Sea garden
The sea garden creates a closer contact to the marine farms. It underlines the interrelation between humans and seaweed. People can experience the seaweed in the ocean and understand its natural environment.