



Lichtkogel

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Foreword

It was in the summer of 2019 that I cooked a menu in Brasserie 2050 at the Lowlands festival in the Netherlands. The idea was to serve our guests with food issues. Every dish told a story about climate change and the loss of biodiversity. Or about future sources of food that aren't in the spotlight yet.

We also served *plastic soup*. The stock for the fish-flavoured soup was made from seaweed and bound with vegetables such as fennel, leek and tomato, the vegetables that give the classic bouillabaisse its characteristic flavour. And there was an edible plastic bag floating in the soup containing crunchy croutons and seaweed. When I served it to a young couple, they said they'd never eaten seaweed. So I asked them if they'd never eaten sushi. She blushed. Sushi was her favourite food...

Seaweed. We do eat it in the Netherlands but we are hardly aware of the fact. Seaweed is an essential ingredient in sushi and anybody who has used agar agar perhaps knows it is made of seaweed.

Seaweed is a very broad term for almost all the plants that live in our oceans. There are around 19,000 different species. In this country, we sometimes pretend that eating seaweed is something futuristic but seaweed already has an entrenched position in many kitchens.

I am sure you will be more enthusiastic about seaweed after reading this booklet. The untapped potential of growing food at sea and the fact that seaweed can be a nutritious and protein-rich addition to our diet - for both humans and animals - speaks volumes. The contributions from the various authors afford a glimpse into the ocean of opportunities offered by cultivating and consuming seaweed.

But for me as a chef, the success of an ingredient really starts in the kitchen and at our dining tables. I myself fell in love with seaweed during a trip through Japan. I saw a stall on the market in Kyoto where dozens of species were on display. Dried whimsical varieties, fresh bright-green sea lettuce in tubs of salt water and small fragile twigs of seaweed with the structure and taste of caviar.

This issue of De Lichtkogel dives into the history of seaweed: discover its nutritional value and health benefits, and learn more about cultivation and all the possibilities the future holds. Enjoy!

Samuel Levi

Sausage maker, chef, columnist and food entrepreneur

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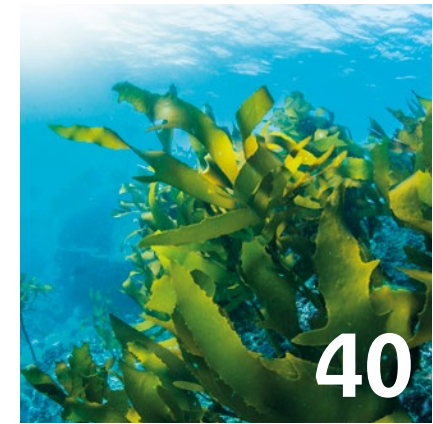
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Seaweed: cultivation and the sector.
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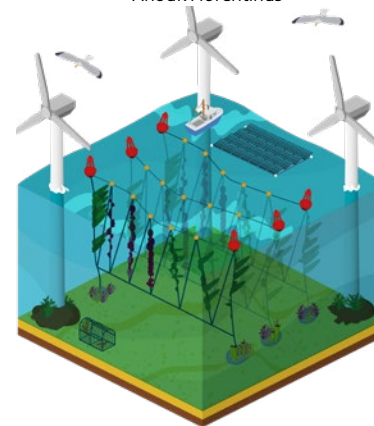


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Seaweed

Sustainable Raw Material for Food and Energy in the 21st Century

By Ingrid Zeegers

» Get used to it: seaweed is going to save us. Why? Because seaweed filters water, and it provides protein for food, as well as biomass for energy production or for bio-based products. There are also plans to grow seaweed near wind farms in the North Sea. And nature also benefits. Anouk Florentinus, an advocate of the seaweed transition, tells us more.

‘Large-scale seaweed cultivation at wind farm off the coast of Zeeland’, was the headline in an agricultural newsletter in mid-July 2020. This turned out to be the Belgian wind farm Norther, where a Dutch-Flemish consortium is working on a large-scale, automated, seaweed production system. A complete seaweed farm is being installed and tested at the wind farm so that seaweed cultivation in the North Sea will soon be ‘safe, sustainable, ecologically

“Numerous pioneers are working very hard on upscaling”

sound and offshore-proof’. Anouk Florentinus is a member of the Advisory Board of North Sea Farmers, an organisation established to accelerate and strengthen the seaweed sector. “The results are relevant for the seaweed sector *and* for the design and layout of our offshore wind farms. Space on the

North Sea is used for several purposes, so the question is always how to use the available space in multifunctional ways. As far as I’m concerned, the combination of wind farms and seaweed farms is an obvious step for the future.”

For Florentinus, the fact that parts of the North Sea will soon be cultivated for wind turbines and seaweed fields marks a logical next step in our agricultural evolution. “And let’s face it: in the North Sea, we’re still behaving more or less like hunter-gatherers. We go after the fish and extract materials like oil, sand and gas. From a cultural point of view, seaweed cultivation in the Netherlands is thousands of years behind the rest of the agricultural sector.” Indeed, now in 2020, the Netherlands hardly has a commercial seaweed sector. Seed enhancement, the cultivation of seaweed and processing into products have been small-scale until now. But many pioneers are working very hard on scaling things up in order to get a coordinated and commercially successful seaweed sector off the ground.

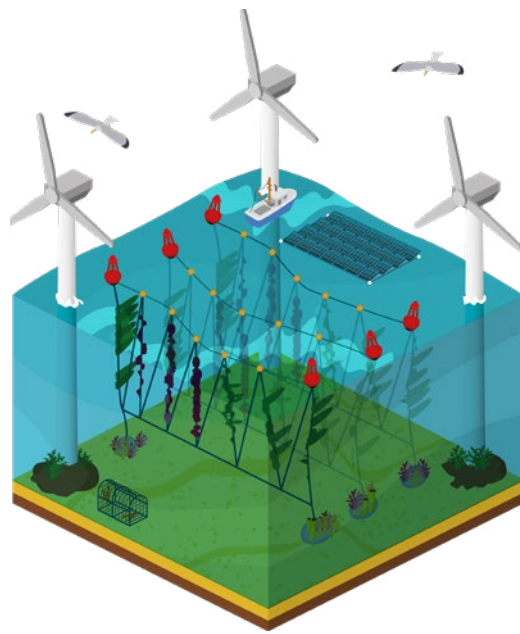
The question is: why is everyone looking at seaweed all of a sudden? Florentinus, who used to work on the subject of seaweed at Ecofys and the Nature & Environment Foundation, thinks the time is ripe. She believes that we can position seaweed as “the solution to a series of urgent problems caused by using land in the wrong way”.

Filter for nutrients

Florentinus mentions one example: the eutrophication problem. “Intensive agriculture in the Dutch delta means that many nutrients - nitrogen, phosphate and potassium - flow back into the sea through the rivers. Seaweed is a filter that grows on these nutrients.” Even if the flow of nutrients from Dutch agriculture were to decline in the future, the supply of nutrients from the hinterland would continue, Florentinus expects. And there will be no need to fertilise seaweed pastures in the North Sea. But she believes there should be thorough research before the seaweed farms are definitively drawn in on the charts. “If you switch from farming on land to farming at sea, you have to make changes to the intensity of cultivation in line with the availability of nutrients.” Florentinus says that seaweed will not only help to improve water quality in the North Sea, but also enhance biodiversity, for example in combination with offshore wind farms. “Seaweed needs a hard substrate to grow on. That means a calm, sheltered location in the North Sea where there aren't many other activities. Offshore wind

“Seaweed is an alternative for animal protein and so it can be helpful in the protein transition”

farms, for example. It is worth looking at whether smart, precisely located, growing installations can be located between the wind turbines in these areas, in combination with nature restoration on the seabed. New ecosystems can be developed there,



Example of multi-use farm: a mixed farm that harvests seaweed, crustaceans and shellfish, wind and solar in a nature-inclusive way.

in combination with reef structures and lost species such as flat oysters.”

Protein transition

Seaweed has also turned out to be an important factor in terms of the food challenges facing the world. “Seaweed is an alternative for animal protein and so it can be helpful in the protein transition. Not only for *food* - direct human consumption - but also for *feed*. Protein from seaweed can play a major role in feed for both cattle and fish.” She explains the difficulty with the current situation. “As consumers, we have created a bizarre situation. Our menus mainly include farmed carnivorous fish such as salmon and tuna. At the moment, the fishing industry fishes for fish to make fish meal, which we then feed to the carnivorous fish in fish farms. That has to change.” It turns out that the food chain could be much shorter if we develop fish feed based on algae. The same applies to the cattle feed we currently use. “It consists of soy products from tropical regions. That's not exactly sustainable. Seaweed protein could replace the soy protein here as well.” Using seaweed protein in *food* and *feed* does still require more research, for example into the quality of the protein if seaweed is grown on the open sea.

“We also need to study the biorefinery process used to extract the protein from the seaweed. Biorefining is crucial in the cascading of materials from the seaweed chain. This means that high-value applications (such as food) have priority over low-value applications (such as energy production).”

“Policymakers should embrace seaweed cultivation and set ambitious objectives”

Biomass for green energy

Once all the valuable proteins and other useful substances have been extracted from the seaweed, enough biomass remains for the production of green gas. So seaweed is also a factor in the energy transition. “Everybody wants to eliminate fossil fuels but there is a lot of debate about the details. Where can you obtain enough sustainable biomass? Biomass from waste is finite.” Florentinus argues that seaweed can therefore also play a role in tackling the energy dilemma. “For example, you could ferment the residual fraction from the biorefinery to produce green gas. That's very promising. But a lot of research is still needed in this area before it can be commercially viable.”

Why are we still waiting for the first specific seaweed objective?

The information from Florentinus shows that seaweed has enormous potential. What does she think is needed to launch large-scale seaweed cultivation? “It's important for policymakers to embrace seaweed cultivation and to formulate challenging targets. Targets for the capture of nutrients, the protein transition and the energy supply. Using seaweed as an answer to the nitrogen problem, or as a way of making the fishing industry more sustainable. Compare it with the extremely specific policy objectives formulated in the past for renewable energy: it was only after quantitative

targets were in place that the transition from fossil to renewable energy really took off. Only then do companies dare to invest.”

Upscaling

Florentinus says that the first steps are already being taken: policymakers are thinking about a general goal for seaweed cultivation and ‘multi-use in offshore wind areas’. As part of the Knowledge and Innovation Agenda for Agriculture, Water & Food, for example, people are working towards a large-scale demonstration project in wind farms. Some entrepreneurs aren't hanging around to wait and see how things develop. They are already rolling up their sleeves so they can get to work when the tide turns. The first rolls of seaweed matting - with seaweed seeds sown in - are ready to be rolled out, as it were. Meanwhile, the various seaweed initiatives are steadily converging. If you look closely, you can see the outline of a blueprint for a new seaweed sector. “If the scale of seaweed cultivation increases significantly, things could happen very quickly”, concludes Florentinus. “Seaweed will then really become our sustainable raw material for food and energy in the 21st century.”



Anouk Florentinus

Anouk Florentinus is a member of the Advisory Board of North Sea Farmers. She worked in the past for the Dutch Nature & Environment Foundation and consultancy firm Ecofys (now Guidehouse). She graduated in Natural Sciences & Innovation Management and she is currently working as renewable energy policy officer for energy company Vattenfall.

Offshore Protein Producers

By René Didde

» Seaweeds are large algae with no phobias about bonding and with the ability to produce large amounts of protein and carbohydrates in salt water with sunlight. They represent an opportunity to safeguard food security for the world's growing population in a sustainable way. And there are numerous other applications. Even so, these wild plants need to be tamed more first, says Professor Klaas Timmermans.

Seaweed is immensely popular, says Professor Klaas Timmermans, a researcher at the Netherlands Institute for Marine Research (NIOZ) on Texel, and also the Professor of Marine Vegetable Biomass in Groningen and a lecturer in Aquaculture at the Zeeland University of Applied Sciences in Middelburg. "It's fascinating: no one can keep their hands dry when they see a tank with these large aquatic organisms." That was confirmed in 2014 when King Willem-Alexander came to open the NIOZ Seaweed Centre, which was established by Timmermans and others. "He grabbed the seaweed straight away."

Popularity

Seaweeds are also known as "macro-algae". They look very different from micro-algae, the familiar small green plants. Seaweeds are less phobic about bonding than micro-algae: they attach themselves to everything. But big brother and little brother do exactly the same thing. They convert sunlight and carbon dioxide (CO₂) into biomass full of carbohydrates, and they also produce oxygen as a by-product. This is photosynthesis, the reaction at the basis of all life. Timmermans' life is dominated by seaweed. "The popularity of seaweed may be related to the artistic, almost plastic, leaves that are often many metres long. And the fact that they easily

"The popularity of seaweed may be related to the artistic, almost plastic, leaves that are often many metres long."

attach to stone, wood or rope. That makes it possible to grow seaweed at sea.”

Green, red, brown

Over the last decade, Europe and the Netherlands have been reviewing the possibilities of seaweed as a new form of marine agriculture, or aquaculture. Plans have been developed for the European seas, including the North Sea, to grow three species of seaweed that are common here: green, red and brown seaweed. “They differ in colour but they all do roughly the same,” explains Timmermans. “They make precious biomass in their stringy leaves that consists of roughly 20 percent protein and 20 percent carbohydrates (sugars).” They are also a source of vitamins and alginates, which can be used as binders in food products in the form of a gel. Timmermans tells us that green seaweeds thrive at higher seawater



Klaas Timmermans holding some *Saccharina latissima* (sugar kelp) at the NIOZ seaweed centre on Texel.

“Seaweeds offset the acidification of the sea caused by climate change”

temperatures. “Brown seaweeds, on the other hand, are productive at lower temperatures, which allows for the alternation between the two seaweeds in summer and winter.”

Sustainable food supplies

Seaweed in the form of protein and carbohydrate factories at sea can contribute to sustainable food supplies for both humans and animals. “For example, seaweed in animal feed can help reduce bovine emissions of methane, a greenhouse gas that is 23 times more potent than CO₂.” The expectation is also that seaweed cultivation can provide sufficient proteins to meet ambitious targets in the field of human nutrition. For example, by cutting the environmental and raw materials burden twice over to produce twice as much and feed nine billion people. Five years ago, Wageningen University & Research estimated that an area roughly four times

the size of Portugal could produce enough protein from the sea to feed the entire global population. Seaweed could also provide organic growth products (stimulants) and fertilisers, as well as vitamins, pigments and pharmaceuticals. And all this without using land and scarce fresh water. Timmermans: “And another nice thing is that seaweeds also capture a lot of CO₂, offsetting the acidification of the sea caused by climate change.”

Taming seaweed

Given these almost magical promises, there is no surprise that Klaas Timmermans is often asked how long it will take. “Ten years ago, my answer was ‘twenty years’ and now I say ‘at least another ten years’,” the professor explains in a video conversation. Seaweed may make astonishingly few demands in terms of its diet and living environment - sunlight, salt, running water and CO₂ are all it takes - but he believes that the Climate Agreement is really pushing very hard. “Many of the commercially interesting seaweeds need to be domesticated further to make large-scale cultivation truly possible.” Domesticated?

“Taming, upgrading for large-scale application,” explains Timmermans. “We need to understand the life cycle better.

And above all, to learn much more about the sexual reproduction of the organisms. Green seaweeds, like sea lettuce, can still be propagated vegetatively by tearing them, like cuttings, as it were. But to grow brown seaweed, and red seaweed in particular, you

“We need to organise a cultivation system that's balanced”

really need small plants: a bit like seed potatoes.” A PhD student has been studying the propagation of the promising sugar kelp, a carbohydrate-rich member of the brown seaweed family. Timmermans also believes that red seaweeds such as Irish Moss or Dulse are also interesting because of their medicinal properties for lung disorders. “But that's only possible if we can achieve large-scale propagation.”

Biorefining

There are other challenges in addition to these biological issues. Seaweeds, with their watery leaves, are vulnerable after harvesting. Processing needs further development. “After a few hours, they start to rot, so it's important to dry them quickly or freeze them for further processing.” In addition to a fundamental understanding of cultivation techniques, a whole chain of technology has to be developed to extract the proteins and carbohydrates from the algae on a commercially viable basis. This process is known as biorefining. “We also need to learn more about how to manage the strong taste of seaweed and how to change its texture (the bite, and how it feels in the mouth). We think there is more texture in the leaf when the weed grows in a dynamic environment, such as a surf zone or in a strong current between two islands.” And it all has to be sustainable. More sustainable than in Asia, where

the focus on the environment is not as strong. “We need to organise a cultivation system that's balanced. If, for example, we switch to seaweed cultivation in wind farms, there has to be enough light left for smaller organisms such as micro-algae. Because they are important for the food chain of fish. And if the seaweed absorbs too much nitrogen and phosphate, that could also impact other marine life. The weeds could also act as a stepping stone, a location for exotic species we don't know about yet. And even though we don't think we need pesticides for seaweed cultivation, the standard lesson from any monoculture is that there are always organisms ready to pounce if we build a big snack bar for them.” The message from Klaas Timmermans, in short, is that it's not all moonlight and roses. Even so, this is one seaweed expert who believes that the prospects are good. “Potentially, seaweed has an important contribution to make to sustainably produced proteins and carbohydrates, to animal feed and to human consumption. And, of course, they're beautiful organisms to look at.”

Klaas Timmermans

Klaas Timmermans works as a scientific researcher in experimental marine biology at the Netherlands Institute for Marine Research (NIOZ). He is also Professor of Marine Vegetable Biomass at the University of Groningen. In his research and teaching, he focuses on fundamental and applied knowledge, in particular about micro-algae and seaweeds.

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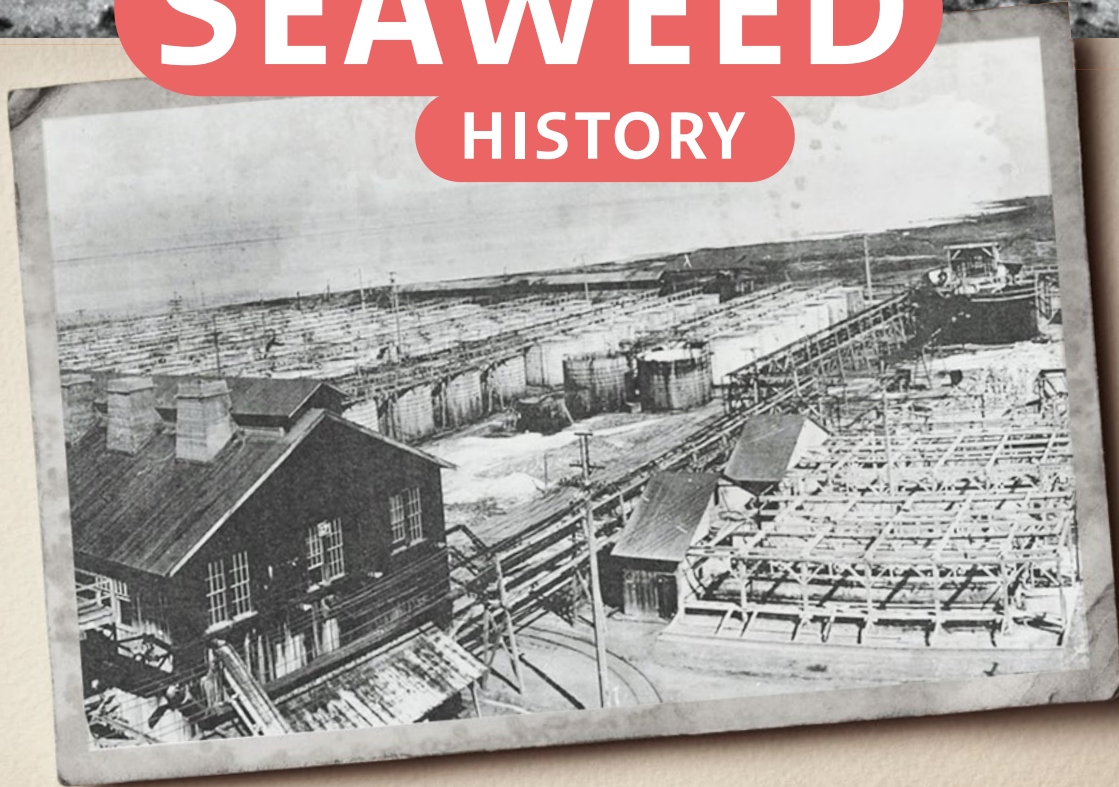
Top: The Bacchus, one of three kelp harvesters designed by engineers of the American company Hercules Powder Company, c. 1916.

Bottom: The Hercules Powder Company kelp processing plant.

A SHORT

SEAWEED

HISTORY



By Jurgen Tiekstra

» Seaweed is mainly eaten and processed in Asia at the moment. But Europe and the US also have a long seaweed history. Seaweed has been used as food and as a fertiliser but also as a raw material for the soap and glass industries. It was even used to extract materials needed for the production of munitions.

Picking seaweed in the wild is illegal in the Netherlands. But a coach sometimes arrives on the Dutch coast with Asian tourists who get out and pick kelp or sea lettuce from the Eastern Scheldt. Because, unlike the Dutch, many Asians are completely used to eating seaweed.

Longer life in Japan

Seaweed Day is celebrated every year on 6 February in Japan. When Marieke Brown of Stichting Zeewierwijzer visited the country herself, she had *kombu* (a brown seaweed) in her soup and was served with wraps made from *nori* (a red seaweed). “Seaweed is also available in supermarket fridges there in large quantities. The fact that people eat it so much is probably also why people in Japan live longer on average and have fewer cardiovascular problems.” Indeed, recent Japanese research has found a correlation between the almost daily consumption of seaweed and a lower risk of heart attacks.

Harvesting on European coasts

But Europe, like the United States, has a long (although forgotten) seaweed history. People in Great Britain and Ireland have been eating it for thousands of years, writes Welsh microbiologist Jessica Adams of the University of Aberystwyth. She says that seaweed was an everyday ingredient taken from British beaches until a hundred years ago. And indeed, seaweed was at the heart of the British chemical industry in the 17th century, when soda was extracted from kelp (a brown seaweed). Soda was an important raw material for the soap and glass industries. Demand for soda from kelp rose during the Napoleonic Wars in the early 19th century when exports of Spanish soda came to a standstill.

When peace returned to Europe, the kelp industry was forced out again by the cheaper Spanish product. After that, iodine was mostly extracted from kelp until, in the late 19th century, it became more economical to import minerals from Chile.

“Europe also has a long (though forgotten) seaweed history”

Faster healing

Around that time, people also discovered that seaweed contains alginates. And more than a century later, those alginates are still an important seaweed derivative in the Netherlands and many other countries, as shown by the e-numbers in toothpaste, ice cream or chocolate drinks. Alginates are used as thickeners and stabilisers. In addition, they are still used to dress wounds and for taking dental impressions at the dentist. Marieke Brown: “Apparently, people in Roman times put a piece of seaweed on a cut so that the wound would heal faster. Nowadays, seaweed is also present in plasters: because seaweed absorbs moisture well, the wound dries faster and the plaster doesn't stick to the wound.”

Fertiliser and soil improver

In agriculture and horticulture, seaweed products are used as fertilisers and soil improvers. That also goes back a long way. As in the Netherlands, it is illegal to pick seaweed on the channel island Jersey. But after storms in the autumn, when large mounds of seaweed can be washed ashore, they are still collected by tractors and spread onto farmland. This is a centuries-old custom, and not just on Jersey.



Potash has long been used to make barren land fertile. Originally, it was extracted from burnt wood but it was discovered in Scotland in the eighteenth century that potash could also be extracted from the ashes of seaweed. This seaweed was dubbed 'kelp', which later became a generic name for brown seaweed.

Kelp industry in California

The United States was a major consumer of potash during the First World War. The raw material was needed to make poor, sandy soils fertile. However, the problem was that the US depended on imports of potash from mines in the German empire. When World War I broke out, Germany stopped exporting, mainly because potash was also used to make gunpowder. However, even before the war, the American government had been concerned about over-dependence on potash imports from Germany. So it mapped out the kelp forests off the coast of California to see whether they could serve as an alternative to the German potash mines. When the war broke out, the Californian kelp industry was rapidly built up out of nothing, as American historian Peter Neushul describes in a study. Not only to fertilise poor American land but also because acetone could be extracted from kelp. Acetone was used to make cordite, a smokeless explosive that the British needed for their rifles. The American munitions company Hercules Powder Co set up a factory with twelve hundred employees during the war years and designed fifty-metre-long floating

harvesters that worked day and night to extract giant kelp from the Californian coastal waters. When the war was over, German exports of potash resumed, undermining the profitability of the American kelp industry. At the time, says historian Neushul, people failed to realise the commercial potential of alginate. The extraction of alginate from seaweed developed into a major industry later.

“We now have about 220 seaweed species in the Netherlands”

Young seaweed culture in the Netherlands

The Netherlands has a much shorter seaweed history because of our sandy shores. Seaweed needs a solid subsurface, such as the rocky coasts of France or southern England. But the disastrous floods of 1953, says Brown, transformed the opportunities for Zeeland. “Basalt blocks were installed in the Eastern Scheldt to strengthen the coastline. Seaweed can grow on them and, as a result, we now have about 220 seaweed species in the Netherlands. In Ireland, there are at least 600 species. There has been a seaweed culture there for much longer. The seaweed culture here is still young.”



Marieke Brown

With her seaweed foundation, Stichting Zeewierwijzer, Marieke Brown is trying to introduce people to seaweed as a food. Her work is financed by the Dutch import company Your Well.

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Case

Seaweed as a solution for Alzheimer's disease?

By Johan Koning

» We are lost in the immense Erasmus Medical Centre building in Rotterdam. At least, that's how it feels. But Monique Mulder is heading straight for her destination: the office where she studies the use of seaweed for diabetes, cardiovascular disease and Alzheimer's disease.

The feeling you have when you're lost in an unfamiliar building is the feeling that Alzheimer's patients have. All the time. And there is no effective medication or other treatment for the disease. “Of course, we'd like to find something to prevent it, or at least postpone it for longer.” Monique Mulder is using seaweed in the hope of achieving that goal.

Dried seaweed

Research has shown that the cause of Alzheimer's is partly genetic. “I'm working on a protein involved in both cardiovascular disease and Alzheimer's: apolipoprotein E. People with a specific form of this protein are more likely to develop Alzheimer's.” Age also plays a role, explains Mulder. “Just as we record music on vinyl, memory needs a carrier to store things on: in this case fat. But the record in an Alzheimer patient is broken. And less of this fat is

produced as you get older. We want to stimulate it again.” Mulder discovered that this can apparently be done in mice. “Our research shows that you really can improve memory. The substance we use turns out to be present in seaweed as well. So we fed mice dried seaweed. Old mice learned better and we even managed to prevent loss of memory in young mice.”

North Sea and Eastern Scheldt

Mulder says they started with a seaweed from China that also grows in Korea and Japan. “These are all countries where people suffer less from cardiovascular disease, diabetes and Alzheimer's and people eat more seaweed. Now we want to try it with seaweed from the North Sea and the Eastern Scheldt. Perhaps in food, or in capsule form. We're still working on that. If it really does slow down Alzheimer's, that would be wonderful.”



Monique Mulder

Monique Mulder is the head of the Vascular Medicine Laboratory of the Internal Medicine Department of the Erasmus University Medical Centre.

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Beyond the Laboratory Phase

By Jurgen Tiekstra

» Large-scale seaweed production is a future that is closer than people think. With the development of large wind farms in the North Sea in the years to come, there will be opportunities for seaweed farms in the space between the turbines on a large scale. Four drivers of innovation tell us about the next steps needed to make this dream come true.

Kees de Gooijer bursts out laughing. The question was whether 'seaweed' is a big thing for him. "Seaweed isn't a big topic on today's agenda," he answers. "But it should become an important one on tomorrow's." De Gooijer is the director of the Agri & Food TKI. The nine economic top sectors that are being stimulated by the Dutch government include Top Consortiums for Knowledge and Innovation (TKIs) that drive innovation in their own sector through public-private partnerships. The large-scale cultivation of seaweed in the North Sea is one of those innovation dreams.

Turning point

Especially with the construction of huge wind farms on the North Sea in the years to come, we are at a turning point: seaweed farms can be set up between the turbines. De Gooijer is genuinely enthusiastic about the possibilities. He once went on a seaweed picking course in Brittany. The first thing he learnt was: when seaweed is floating loose, leave it alone. "That means it's dead. Seaweed must be fresh." He also says that seaweed contains a lot of protein. "That's industry-standard protein, like the standard for chicken protein. You can do anything with it: use

MARIN's testing facility for seaweed cultivation in Wageningen.



it as a foam, a gel, as glue and so on. The only vegetable variety in use at the moment is potato protein. The protein market is potentially insatiable: take meat substitutes for example." So De Gooijer believes that the business case will primarily depend on the protein fraction. "But there are also interesting polymers that you can extract from seaweed: carrageenans, alginates, agar agar. And what is left can be gasified or fermented. Another option is to develop a channel for fresh products: the complete weed on the menu. In addition, there have been interesting studies of the use of seaweed in feed for cows, with an impressive reduction in methane emissions."

Upscaling

Is there already enough policy support for the development of large-scale seaweed production? "I'm not on the policy side," says De Gooijer. "But I do know that we've managed to shake things up by

"The systems and ships require significant investments"

now. The Dutch Ministries of Economic Affairs and Climate, Agriculture, Nature and Food Quality and Infrastructure and Water Management have got together. Their main job now is to create the conditions needed for a demonstration project. The funding isn't available yet but it is being considered." Upscaling is needed, confirms

Marnix Krikke, the secretary of the Water & Maritime Top Sector. "The seaweed sector is reasonably developed in Asia but it's still in its infancy in Europe. The projects are small-scale and they tend to focus on the demonstration and experimental aspects." At the same time, the core of the problem is actually upscaling. "Operations at sea are always expensive," says Krikke. "It's an aggressive environment, with seawater, wind and waves. So the investments in the systems and ships you need are considerable. Economies of scale are needed to minimise those costs. But the companies who want to work in this area don't have the funds needed to invest in research & development. You really do need government, whether national or European, to play a catalyst role. Fortunately, we have the large UNITED project, which is co-financed by the EU. It is investigating possible options for the multiple use of offshore areas five pilot projects. At a national level, we have the TKI scheme for promising developments of this kind but that is not enough to help the companies concerned. They can obtain a 30% subsidy from the scheme for the work they do at research institutes like MARIN in Wageningen and the TNO maritime environment. But they still have to find 70 percent of the investment themselves. That money just isn't there."

Large-scale trial

The next step should be a large-scale trial with seaweed cultivation in the North Sea, for example in the experimental plot in the new Borssele wind farm. Jörg Gigler, the director of the New Gas TKI, emphasises this point as well. "You can make green

gas (which can be used in the Dutch gas network) from seaweed, as well as green CO₂ (a basic material for the chemical industry) and even hydrogen. Seaweed can also be used as a source of transport fuel. And that's what major corporations like ExxonMobil and B.P. are looking at." Gigler is convinced that the laboratory phase is behind us. "If the idea for the future is that we are going to cultivate seaweed between the offshore wind

"If you engage in other activities in a wind farm, you really have to work with others"

turbines, you want to test that now. We need to know how fast seaweed grows under those conditions and how best to harvest it. And to find out more about the costs and what a seaweed sector would be like. We need to think about planning for the North Sea. A North Sea agreement is in place now and a lot of thinking has been done. Even so, decisions have to be made soon: How can we establish the ideal combinations of space use? What can be permitted where? We will only be able to make those decisions after major seaweed trials: they provide a wealth of information."

Multiple use of space

Bob Meijer, the director of the Offshore Wind TKI, has also been thinking about seaweed for some time. He is working hard on the multiple use of space in the new wind farms. "Wind turbines are spaced at quite large distances and those distances will be even bigger in the future with the arrival of even larger turbines. The gap was 600 metres in wind farms five years ago; that distance is now increasing to between 800 metres and 1.2 kilometres." Once the new wind farm near Borssele has been completed, turbine capacity in the North Sea will be 2.4 gigawatts. That's more than double what we used to have. But the idea is to boost capacity to 11 gigawatts by 2030. "In the long term, in 2050, when our energy transition should be largely completed, we will be talking about much bigger numbers. The scenarios vary considerably. The Netherlands Environmental Assessment Agency has calculated that wind energy capacity in the North Sea will have to be between 35 and 75 gigawatts. We are basing our own calculations on about 60 gigawatts: sixty times as much as it is now."

Working with others

You have to take a down-to-earth approach to the multiple use of space. Meijer: "If you engage in other activities in a wind farm, you really have to work with others. For example, there are cables buried

First seaweed production system used by North Sea Farmers in 2015. It is a wheel-based system with a diameter of five metres. The seaweed was grown at a depth of about two metres.





Technologies for the extraction of algae molecules.

everywhere. If you want to anchor other structures in the seabed, you obviously have to do that where there aren't any cables. And you also need space for the maintenance work on the turbines. If you grow

“I expect you will see considerably scaled-up projects by 2030”

seaweed everywhere, it's going to get in the way. So research is vital before upscaling operations: What are the risks? How can we mitigate them? You can't, for example, keep on building until there

is no room left at all. You also have to think about how to work around each other. It's not just a question of making operational agreements. You also have to think about things like the legal implications if you damage each other's infrastructure. Wind farms and seaweed cultivation use expensive kit.” Does Meijer think there will be large-scale seaweed cultivation in the North Sea in 2030? “The scale depends on how the chain as a whole develops, and how much demand there is for seaweed. I don't expect the entire North Sea to be full by 2030 but I do think you'll be seeing quite sizeable projects by then. I'm incredibly optimistic. We're a very innovative country, especially offshore. We've demonstrated that convincingly throughout the world.” <



Kees de Gooijer

Kees de Gooijer has been the director of the Agri TKI since 2012 and he chairs the board of the Biobased Economy (BBE) TKI. In addition, he is the vice-chair of the KNCV (Royal Dutch Chemicals Association) and he has a number of national and international positions on boards and committees.

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Bob Meijer

Bob Meijer is the director of the Offshore Wind TKI. He has a background in physics and in the development of offshore wind farms. At the Offshore Wind TKI, he focuses primarily on alliances between government, business and research institutes in research and innovation.

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Marnix Krikke

Marnix Krikke is the secretary of the Water & Maritime TKI, which focuses primarily on marine transport and services. He spent seventeen years with the Royal Netherlands Navy's Equipment Logistics Centre. Since 2007, he has been working at the maritime sector's branch organisation, Netherlands Maritime Technology.

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Jörg Gigler

Jörg Gigler is the director of the New Gas TKI. He obtained his doctorate from Wageningen University on the subject of biomass. He now works as an independent consultant in the field of energy, sustainability and innovation relating to gas. He concentrates primarily on the significance of hydrogen for the energy transition.

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Seaweed for Plant and Animal Health

By Anne Rhebergen and Lianne Verhoef

» The coast of Brittany calls to mind beautiful rock formations, idyllic coastal towns and an unspoilt emerald sea. This is why Brittany is a prime holiday destination. What the holiday photos don't show is what is going on further out on the rough seas: the harvesting of seaweed that is processed inland by the company Olmix into natural stimulants for plants and animals.

Pi Nyvall Collén, the scientific director of the Olmix Group, explains that Olmix is a French company - based in Brittany and founded in 1995 - that wants to offer natural alternatives for products such as fertilisers and pesticides. “Over the years, Olmix has developed a process to extract all sorts of useful products from seaweed.”

Natural stimulants

“We make multiple products for animals and plants based on algae like seaweed. In the case of plants, they include substances that help to encourage soil life and soil fertility. That reduces the use of artificial fertilisers and conventional pesticides.”



Seaweed harvester on the coast of Brittany (France).

Improving the immune system

“We also develop animal products using a technology based on components including algae and clay. These products reduce the impact of fungal toxins (mycotoxin) and improve food efficiency. We also develop products based on marine sulphated polysaccharides (MSP) from seaweed: these are substances that improve animal immune systems directly and indirectly.”

Challenge

“At the moment, we aren't cultivating seaweed ourselves. We are mainly using a red and green seaweed that grows off the coast of Brittany - a very variable source. Our main challenge is to maintain the availability and accessibility of the seaweed and to make sure that the quality remains consistent.” <



Pi Nyvall Collén

Pi Nyvall Collén is the scientific director of the Olmix Group. Collén has more than 25 years of experience in research into seaweed, genomics, biochemistry, enzymology and physiology.

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11 March
2021

Exploring Together

The 'Exploring together' article on page 36 describes the first major step towards multiple use of space in the North Sea, with an important role for seaweed: the Borssele wind farm. The North Sea *Community of Practice* is planning to conduct a study of multi-use in this wind farm in the years to come, focusing on nature, energy and food: an exceptional exploratory study involving alliances between government authorities, the business community, environmental organisations, and research and knowledge institutes. The Community of Practice will be presenting the current status of this exploration at the upcoming international Lichtkogel Experience on Thursday, 11 March 2021.

In addition, we are interested in hearing about any ideas that may be circulating to allow large-scale seaweed cultivation in harmony with other functions. Advances in Dutch seaweed cultivation are impossible without collaboration inside and outside the sector: between business and government advisers, between environmental organisations and researchers, both nationally and internationally. We would like to call on readers and other interested parties to use this Experience to present their ideas for new solutions and new alliances, and to discuss them with the public.

Are you involved in innovative alliances for seaweed cultivation and would you like to share your ideas and initiatives on 11 March? Please contact us at lichtkogel@rws.nl

Lichtkogel EXPERIENCE:

When?

Thursday, 11 March 2021

What time and where?

10.00 - 15.00 CET

Online

Registration and more information:

Lianne Verhoef

lichtkogel@rws.nl

“There are so many uses for seaweed; they look almost inexhaustible”

Blue Growth for a Green Future

By Anne Rhebergen and Lianne Verhoef

» In late 2019, the European Commission launched the ‘European Green Deal’ with the goal of a fully climate-neutral Europe by 2050. An ambitious plan that will involve pulling out all the stops. And also a plan in which algae, such as seaweed, play an important role, says Andrea Weber of the Directorate General for Maritime Affairs and Fisheries (DG MARE) of the European Commission.

DG MARE is responsible for maritime affairs and fisheries. The DG also coordinates all activities in the field of algae, including the macro-algae seaweed, in the various departments of the European Commission (EC). Andrea Weber works in the Blue Economy, Aquaculture and Maritime Spatial Planning unit. She talks enthusiastically about the growth of the seaweed sector and about the importance of blue growth - sustainable growth at sea and in the maritime sectors - for the green future of Europe. “There are so many uses for seaweed; they seem almost inexhaustible. And many of those applications have the potential to provide solutions

for urgent social challenges: pollution, climate change, plastic waste, carbon emissions and food shortages.”

Eliminating barriers

But why aren't we seeing those solutions actually being rolled out everywhere yet? Weber confirms the reasons also mentioned by other experts. These include the need for regulatory clarity, further research and feasible business cases for the sector, which is still very much in its infancy. With coordination from DG MARE, the European Commission has launched a plan to tackle these causes in a

structural way. “Although responsibility for aquaculture legislation resides with the Member States themselves, the European Commission can encourage important developments inside Europe. The initiative could therefore also focus on the elimination of four major barriers or - in other words - on furthering measures in four areas where there is still a lot to be gained.”

Permit procedures

“European regulations on novel foods, for example, involve work to allow more algae species on the European market,” Weber says. “Biomass is also in very short supply at the moment and that could be remedied by cultivating algae.” However, we don't want the over-exploitation of our seas as a result. “Which is why DG MARE is in the process of adapting the strategic guidelines for aquaculture to ensure that aquaculture is conducted in a sustainable, environmentally friendly or environmentally supportive way.”

Financial support

Secondly, Weber explains that small and medium-sized enterprises (SMEs) find the costs for things like mandatory toxicity studies a severe burden. “Financial support from the EC could help here. An example is the ‘Blue Invest’ programme that stimulates innovation by SMEs. In addition, there is the European Fund for Maritime Affairs and Fisheries (EMFF), which also finances projects with algae. Programmes of this kind can be further developed and promoted.”

Gaps in scientific knowledge

Thirdly, the lack of consumer acceptance and, above all, consumer awareness seem to be a major obstacle to the growth of the seaweed sector. “European consumers still don't know enough about either the many current applications or the potential of seaweed. And finally, there are still gaps in scientific knowledge about algae. We still need to know more about the capacity of the European seas and lakes for



The harvesting vessel with seaweed growing on the lines: *Saccharina latissima*, also known as sugar kelp.

the large-scale cultivation of seaweed. And we know too little about the potential of algae and seaweed to capture CO₂ or the impact of seaweed cultivation on the ecosystem. There's still a lot of experimentation needed, and still a lot to learn about production methods."

“The Farm to Fork Strategy has granted an important role to algae such as seaweed”

Long-term vision needed

Although Weber is enthusiastic about the prospects for the seaweed sector, she also says that a long-term vision is needed. “A lot of work has to be done yet and it's a question of priorities.” One of those priorities for DG MARE is to encourage the use of algae in human and animal nutrition. The European Green Deal also explicitly calls for a focus on global

food security, mainly in the form of the *Farm to Fork Strategy*, and it argues that algae such as seaweed can play an important role here. “In terms of food supplies, agriculture has led the way in Europe historically,” says Weber. “It's time we realised that the sea can contribute much more.”

Upscaling

An organisation that has been turning to the sea since 2010 is Ocean Rainforest. This company, which is located on the Faroe Islands, specialises in the cultivation of seaweed. What is the market's experience with the nascent European seaweed sector? Ólavur Gregersen, the managing director and co-founder of Ocean Rainforest, says: “At the moment, we're still in the first phase in Europe. We know what it takes to grow and process seaweed. We know what the market will pay for it. But the costs of cultivation are still relatively high. Ocean Rainforest is scaling up to reduce variable costs. We also want to grow selectively so that we generate more biomass and reduce costs.”

Impact on the living environment

Cultivating seaweed can have an enormous positive effect on the living environment. Why are there still relatively few initiatives in this direction? The answer is clear. “At the moment, it is simply cheaper and easier to harvest seaweed in the wild than to grow it,” Gregersen argues. “On the other hand, cultivating seaweed, rather than harvesting in the wild, is almost sustainable by definition. Not only does

“The Netherlands is very enthusiastic and ambitious when it comes to scaling up seaweed production”

the extra biomass result in richer fish and bird life, growing seaweed also captures greenhouse gases.” Gregersen confirms Weber's observation: the current regulations don't always make things easy for start-ups who want to cultivate seaweed, in part because they have to jump through all the hoops of product testing. His solution: “It would be nice to have an incentive system that rewards you for the amount of carbon you capture from the ocean.”

Gregersen believes that the subsidies made available by the EU do help. “They get initiatives off the ground when they are still not appealing enough for financiers. In addition, there is interest at the European level in encouraging blue growth in collaboration with the market.” Gregersen himself has collaborated in a DG MARE research group.

Netherlands in the forefront

On the basis of his experience in both Europe and the US - where Ocean Rainforest is now leading a demonstration project off the coast of California - how does he see developments in the Netherlands? “The Netherlands is very interesting. Compared with other countries in Europe, there is a very clear awareness of climate and sustainability. The people working there are capable and passionate about seaweed. That's important because you can't get anything done without human strength.” Weber confirms that the Netherlands is playing a leading role on the seaweed stage. “We can see that the Netherlands is very enthusiastic and ambitious when it comes to upscaling seaweed production. It is also at the forefront of integrating seaweed production in wind farms: an innovation that we are monitoring very closely indeed.”



Andrea Weber

Andrea Weber studied cultural anthropology and worked at the European Commission's Blue Economy, Aquaculture and Maritime Spatial Planning department of DG Mare from 2018 to 1 October 2020. Before that, she worked at various EC directorates on themes such as air pollution, climate adaptation in cities and the European strategy for plastics.



Ólavur Gregersen

Ólavur Gregersen is the managing director and co-founder of Ocean Rainforest. Gregersen is involved in several seaweed projects, such as the European Horizon 2020 BioBased Industry project 'Macro Cascade'. He is also the technical director of the 'MacroSystems' project in the US funded by the Advanced Research Projects Agency - Energy (ARPA-E).

MARE LIBERUM OF MARE NOSTRUM?

HARVESTING OR EXPLOITATION?



By Dirk Sijmons

For many people and disciplines, the sea has remained unknown and underestimated for a very long time. The North Sea, for example, had to wait well into the 21st century before being recognised as a force for shaping the surrounding countries.

We can date the discovery of the North Sea in spatial planning terms fairly accurately: the 1975-1976 academic year, the year when the multidisciplinary North Sea Urbanism Study Group was active. After

graduating, the students from the group set up Stichting De Noordzee (The North Sea Foundation), following the example of the Wadden Sea Foundation. This new NGO got involved actively with the virtual

absence of a spatial and environmental policy for the North Sea. That work was seen in 1979 in the first chapter of the annual report of the Dutch Physical

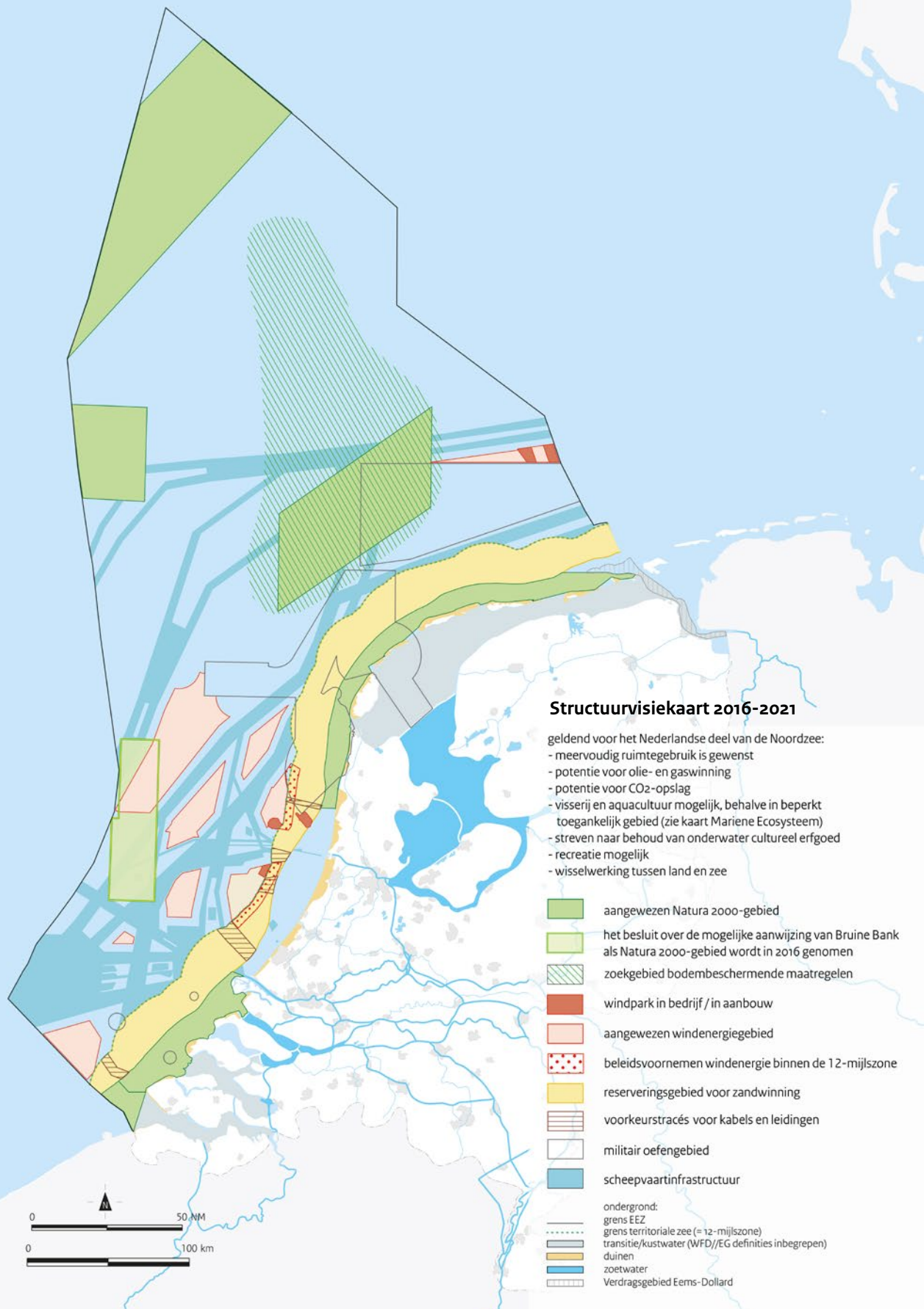
Netherlands turned out to cover some 57,065 km², one and a half times larger than they had thought.

“These remaining hunter-gatherers of our society cannot be pinned down by charts”

Planning Agency, which was devoted to the North Sea. To their amazement, the government planners discovered that, by adding the Dutch section of the continental shelf, the territory of the

Full debut

The North Sea only really made its full debut in spatial planning in the Fifth Policy Memorandum on Spatial Planning in 2001. This was the first time the North Sea was drawn at full scale in the charts. The most striking elements on the charts were the shipping lanes which, like a motorway, all have two navigation directions. Particularly in the north-south direction but also towards the Baltic Sea, with a safe northern route and a route grazing the Wadden Islands.



The pie slices 'left over' between the shipping lanes contain areas reserved for sand extraction, areas for military exercises and areas for detonating unexploded ordnance. There are also a large number of dots on the map showing oil and gas platforms. Numerous smaller symbols showing the location of shipwrecks make it clear that the North Sea can be a challenging and dangerous area. It is also interesting that there are no designated fishing areas. These remaining hunter-gatherers of our society cannot be pinned down by charts. Partly because of competitive considerations, partly because the fish are always on the move and - perhaps most importantly - because they feel they are the original users of 'their' sea and want to exercise their rights everywhere: so no chart is needed.

“It is striking that the charts still do not set out any spatial claims for the fishing industry”

Offshore wind

We are now twenty years later. During those two decades, a lot has happened on and around the North Sea. The charts have become fuller and more colourful, with new legend units. The 'protected areas' on the chart, for example, are now green. And 'offshore wind' is obviously the new kid on the block and it should be pointed out that the success or failure of the Dutch energy transition depends on the sea. The key role of offshore wind means that the North Sea has gradually become a crowded policy arena. There has been a flood of initiatives and studies in recent years. It is striking that - for the same reasons - the charts still do not set out any spatial claims for the fishing industry. Research over these two decades has clarified the impact of seabed fishing - with trawls and beam trawls - on benthic life. The fishing sector has almost a protestant philosophy: the North Sea seabed has to be cultivated like a field because it will become infertile otherwise.

This *tacit knowledge* should certainly not be dismissed as semi-scientific nonsense: complex interactions with benthic life can indeed produce more pioneer fish species in certain conditions. These days, it is also clear to organised fishing that protected areas and the expansion of wind farms are gradually restricting their room for manoeuvre. As a result, there have been intensive discussions between the various sectors in the North Sea led by Jacques Wallage. The result is a package of agreements on how to protect, use and structure the North Sea better with the aim of establishing a healthy balance in terms of ecology, energy and protein production. The agreement was presented to the Dutch Lower House in early 2020. It is good to see that the Dutch polder model also works on the high seas. At the same time, this agreement is a result of negotiations. And that does not automatically guarantee a new approach to development in the North Sea after 2030.

Fundamental dilemmas

It seems to me that there are still two quite fundamental dilemmas that need to be resolved in order to establish a future-proof North Sea policy. The first is the desired level of collaboration between the sectors. Do we want a *mare liberum* where every sector can make its own decisions on the high seas or do

“We shouldn't make the same mistakes we made on land”

we want to focus more on collaboration: a *mare nostrum*? And will we then want to work together, for example on the shared use of wind farms, or do we actually want to make wind farms instruments for nature restoration and development?

Sustainable harvesting or exploitation?

The second dilemma is the most complicated. I think we need to become aware of the scope of our intervention in the North Sea. Do we want sustainable harvesting from the marine system or



Textile, paint, a cover and a rug made with seaweed from Nienke Hoogvliet's SEA ME collection.

Case

will we ultimately turn to a form of exploitation of the North Sea? And: is there a tipping point where one thing changes into the other? Sustainable harvesting involves striking the right balance between harvesting proteins with fishing and the harvesting of sustainable energy in the form of wind, doing justice to ecology by optimising fishing and making nature-inclusive construction mandatory in wind farms. Obviously, it is difficult to say when this becomes 'exploitation'. But there is a danger that we will end up using the dense forest of the piles under turbines as a sort of base camp for exploitation. An obvious step is to anchor floating solar arms to the turbine foundations. Another option is to fasten a seaweed farm or a fish farm to this sturdy structure.

“It all looks as though the North Sea has become the new frontier for our modernist ambitions”

Ethical discussions

I'm also enthusiastic about the potential of seaweed as a food or as a substitute feed, eliminating the need to import soybean meal and tapioca. But I am also aware that, in modern history, 'discovery' has always been followed by 'mapping', 'exploration' and finally 'colonisation'. It all looks as though the North Sea has become the new frontier for our modernist ambitions. Which is why we need to discuss the ethical issues long before tipping points like this emerge on the horizon. And not just stumble from project to project until we find we've gone beyond the point of no return. So we shouldn't make the same mistakes we made on land. And if people think I'm being too alarmist: the possible applications for seaweed are endless, and the first pesticides and growth boosters for seaweed are already on the

market. Upscaling is just around the corner if the tests are successful with, for example, seaweed-based cattle feed as a way to combat methane emissions from dairy cows. Or going one step further: if the petrochemical industry were to use seaweed instead of oil as the basis for its CH (carbon) chains.

North Sea Embassy

The dilemmas mentioned here may be a little too abstract for our policy grandees. So I think we should be immersing them in the artistic medium of the 'North Sea Embassy' that was established recently. Yes indeed, the North Sea Embassy. An inspiring mix of art project and think-tank at a very smart location in the Hague. The embassy was opened to make the North Sea a fully-fledged player on the political chessboard by giving a voice to everything that lives and exists in and around the North Sea. From herring to jellyfish, from drilling rig to shells, from sailor to seaside visitor, from sea anemone to oyster. All these forms of life should be listened to because 'the sea belongs to itself'. ◀

Dirk Sijmons

Dirk Sijmons worked for various ministries and Staatsbos-beheer from 1977 to 1989. In 1989, he was one of the founders of H+N+S Landscape Architects, with whom he has been associated as a senior consultant since 2017. In 2004, Sijmons became the first State advisor on landscape. He was also the Professor of Environmental Design (2008-2011) and Landscape Architecture (2011-2015) at Delft University of Technology.

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By Johan Koning

» Although Nienke Hoogvliet used to spend a lot of time on the beaches of The Hague, she would never have imagined as a little girl that she would work with seaweed later in life. “As a child I was very idealistic. I became a vegetarian at an early age and I gave a school presentation about animal testing.” But it was only at the Art Academy that she learned to combine her social ideals with art.

Seaweed as the **New Bamboo**

“Seaweed is really hot at the moment,” says Nienke Hoogvliet. “People who are working on it want to make it sustainable - to use it in the best possible way.” She developed her own thread and made a rug. “We also developed a textile dye. At the moment, we can only obtain specific colours from red, brown and green seaweed. Trend-watchers believe those colours

will shape fashion in the years to come. But by processing the fabric differently - in a natural way with minerals or protein - I can get a broader colour palette from seaweed.”

One step at a time

Hoogvliet sometimes feels almost like a chemist. “But I ended up here because of my artistic vision. On a small scale with little experiments. You make progress one step at a time. In the end, we will work with large companies but we also want to keep things local and transparent. We hope seaweed will be the new bamboo.” ◀



Nienke Hoogvliet

Nienke Hoogvliet studied Lifestyle & Design at the Willem de Kooning Academy in Rotterdam. In 2013, she founded Studio Nienke Hoogvliet in her home town The Hague.

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Exploring Together

Subsustainable Multi-use in the North Sea

By Lianne Verhoef

» Although the Dutch seaweed sector is still young and unexplored in many ways, the pioneers of green gold are not alone. Seaweed is part of a larger development towards a sustainable blue economy in which government, business, environmental organisations, and research and knowledge institutes are taking important steps together. Steps in the sea.

We are facing a number of major social challenges on the North Sea, says Nathalie Scheidegger, the sustainable multi-use project leader at the Dutch Ministry of Agriculture, Nature and Food Quality (LNV): “New wind farms at sea will provide more sustainable energy and the sea will play a greater role in our food supplies with a robust ecosystem in the North Sea as the basis. These three developments - nature, energy and food - will be the triangle underpinning the sustainable blue economy in the Netherlands.”

The future of the North Sea

Seaweed cultivation in the North Sea will make an important contribution, primarily to food, sharing this position with fisheries and shellfish farming. Looking at all the other activities on the North Sea such as shipping, sand extraction, oil and gas extraction, recreation and military exercises, it is immediately clear that a seaweed farm has to cope with more elements than just wind and water. “But all these sectors and their interests are no obstacle to the growth of seaweed as a raw material of the future,” says Nico Buytendijk, programme manager in the field of the sustainable blue economy at the Netherlands Enterprise Agency (RVO). “On the contrary: together we’ll actually get much further.” The 2022-2027 North Sea Programme, which is being developed under the wing of the Ministry of Infrastructure and Water Management, is also helping here. One of the related components of the North Sea programme is the policy framework for transit and multi-use. This policy framework helps to combine different ways of using space in wind farms on the North Sea. Scheidegger: “In this programme,

we are trying to take an integrated approach to the sustainable blue economy in the North Sea, and seaweed plays an important role here.”

Exploring together

The potential of this integrated approach will be explored in concrete terms in the Borssele wind farm during the years to come. Buytendijk: “The North Sea Community of Practice (CoP) wants to explore multiple uses of space on a large scale in an area of one square kilometre. We are not only hoping to combine seaweed cultivation with an existing wind farm here; we also plan to conduct studies in conjunction with other marine crops and various approaches to nature development.” The North Sea CoP is a network of organisations from the business community, NGOs, research and educational institutions and government/top sectors whose shared aim is to make the sustainable blue economy in the North Sea a reality.

Borssele Wind Farm

What will the plans for the Borssele wind farm be like? The CoP video ‘Smart use of the North Sea’ gives a good idea of what a wind farm in the North Sea could look like in the future. It visualises how wind turbines, with a large safety zone, can be combined with various other ways of using the space. Examples are nature-inclusive scour protection, marine crops and new oyster banks. At the top of the water column, there is room for growing shellfish and seaweed. In a wind farm like this, it is even possible to add other functions such as floating fish farms, floating solar panels or wave energy.

Ambitious

When will this overall picture become a reality? “We first need to establish a clear picture of which species can be grown,” Scheidegger explains in an environmental journal. “There are EU regulations, such as the exotic species policy, safety issues and environmental, technical and economic factors, for example. But we want to get this testing ground up and running in the next few years.” Buytendijk adds: “In the meantime, we are using this reconnaissance work to see who can adopt which role in order to roll out large areas of mariculture in the long term. In other words: what should the government do? What is Rijkswaterstaat’s role? What is the remit of the Ministry of Agriculture, Nature and Food Quality, the Ministry of Economic Affairs and Climate, and the Ministry of the Interior and Kingdom Relations, and what will RVO take on? But also: what should entrepreneurs do?” Buytendijk says that all the organisations in the CoP, including the seaweed sector, will tackle their areas of the exploratory phase independently. “The idea is that there really will be a square kilometre by 2027. And that’s quite ambitious because the risks at sea are considerable. Safety, for example, plays an important role at sea. All this makes business in the North Sea capital-intensive. In short, we need to tackle the development of the sustainable blue economy as a whole, while also focusing very explicitly on the earning model, and form consortiums of entrepreneurs who can help each other.”

Teamwork

Buytendijk’s answer to the question of the role played by competition is clear: “At this stage, collaboration is much more important than competition: why mow the grass when it’s just been sown? We really are taking on the challenge together. Concentrating all these activities in a single area not only saves valuable space in the North Sea, it also allows parties to work together more effectively and, for example, to share the supervision and maintenance of the area efficiently (and cost-efficiently). Research is also being conducted to see whether the various nature-inclusive cultivation activities are useful in terms of preventing metal fatigue and extending the useful life of wind turbines. That allows us to make multi-use of the North Sea interesting for everyone.”

The role of Rijkswaterstaat

So what exactly is Rijkswaterstaat’s role? Kristien Bijpost, the project leader for Navigation and Multiple Use at Rijkswaterstaat, explains: “Rijkswaterstaat Sea and Delta drafts site decisions on behalf of the Ministry of Economic Affairs and Climate, and issues permits under the Water Act. This means that we say where, and under what conditions, a wind farm can be built and operated. We are also responsible for facilitating navigation and multi-use in wind farms. In addition, on behalf of the Ministry of the Interior and Kingdom Relations, Rijkswaterstaat produces area passports that show what types of multiple use

are possible in a wind farm. That involves looking at the condition of the bed, the numbers of crustaceans and shellfish that are already present, and requirements relating to nature development. It is important for multiple use to be distributed evenly, applied in a balanced way and, above all, to be safe. Multi-use and activities with permanent structures for a longer period of time, such as seaweed cultivation, also require permits under the Water Act. Rijkswaterstaat is developing an

“At this stage, collaboration is much more important than competition”

appraisal framework for this purpose so that it is clear to applicants what is needed. As the managing authority, we are also responsible for supervision and enforcement. Not only for the construction of wind farms but also for the management and maintenance of turbines and the other infrastructure in a wind farm, such as the infrastructure for multiple use. Effectively, we act as a central hub.”



Nathalie Scheidegger

Nathalie Scheidegger works as the project leader for sustainable multi-use at the Ministry of Agriculture, Nature and Food Quality on integrated marine and maritime policy for the North Sea and in EU waters. Before that, she worked as a project leader at the Ministry of Economic Affairs and Climate, and at the Netherlands Enterprise Agency (RVO).

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Nico Buytendijk

Nico Buytendijk is a programme manager with the Netherlands Enterprise Agency (RVO), where he works on the sustainable blue economy and the North Sea Community of Practice with partners from the Dutch national government. In both cases, on the basis of task-driven working.

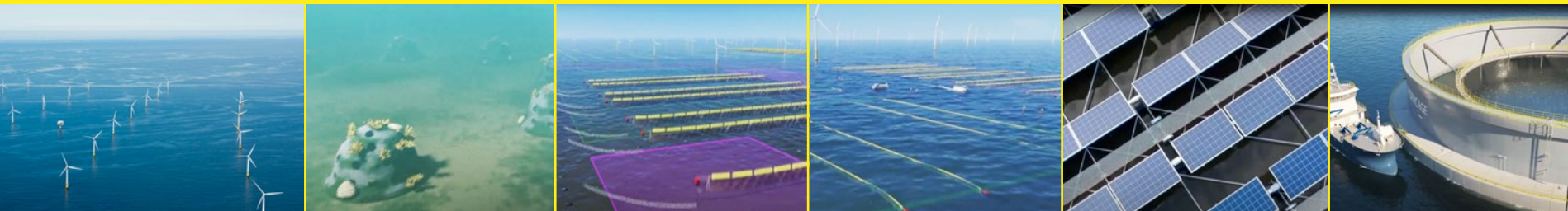
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Kristien Bijpost

Kristien Bijpost is the deputy Programme Manager for Offshore Wind Energy and the project leader for Navigation and Multiple Use at Rijkswaterstaat Sea & Delta. She worked previously as a programme manager at the Consumer & Market Authority, as a barrister at NautaDutilh and as a legal consultant at Brunel Legal.

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Multiple use between offshore wind turbines, ample space within safe margins

Grid of 'eco-anchors' brings solid structures back into the North Sea ecosystem

Spatial proposal for hanging cultivation of shellfish

Spatial proposal for seaweed cultivation

Floating solar cells may also fit in

Fish farming at sea may also be a possibility



Alaria



Ulva



Gracilaria



Asparagopsis



Saccharina



Palmaria

Seaweed: Cultivation and the Sector

By René Didde

» The European seaweed sector is still small. But that is changing. There are major plans in the pipeline that will bring sustainable, large-scale cultivation within reach. Two seaweed producers, one from Ireland and the other from the Netherlands, bring us up-to-date.

The possibilities of growing seaweed in Europe have been studied for twenty years. But so far, only a few hundred tonnes of seaweed have been grown each year, mainly in Norway and Ireland and on the Faroe Islands. Wild seaweeds are also harvested, for example on the French Atlantic coast.

Labour-intensive

Cultivation in the European Union is a drop in the ocean compared with the 31 million tonnes of seaweed grown annually in Asia. “Two-thirds of that seaweed is sold to the food industry and to kitchens, for example as a binding agent and, of course, as

nori in sushi,” explains Stefan Kraan of The Seaweed Company. A small proportion ends up in pharmaceutical applications. In Asia, the process is still largely old school, using the method a Japanese emperor introduced to his peasants in the eighteenth century: sailing past sticks or ropes in the water and cutting off pieces of seaweed. “That’s very labour-intensive,” says Kraan.

Seeder and harvesting module

Kraan has been working with seaweed for 35 years. Not only was it the subject of his doctoral dissertation, he also founded Ocean Harvest Technology, which makes seaweed products as a healthy supplement in the diet of pigs and cows. “One example is the replacement of antibiotics in pig farming. You can do so much with seaweed.” According to Kraan, the

“In Europe, it's not enough to cultivate seaweed for a single application like they do in Asia”

Asian method of cutting seaweed will never be financially viable in Europe. And so his current business, The Seaweed Company, has a seeder which is used to cultivate ten hectares of seaweed in Ireland. The machine can set out nets measuring eighty by four metres that are impregnated with small seaweed plants. “A machine like this is a prerequisite for industrial cultivation in Europe,” says Kraan. A harvesting module to collect the mature seaweed is also a necessity. “The nets are then washed and re-sown. They last fifteen years.”

No ecological risks

Kraan says there are no ecological risks associated with large-scale cultivation. “There’s plenty of

sunlight, and nitrogen and phosphate, which flows abundantly from land into the sea. Seaweed absorbs all that. It captures these fertilisers, and is then used as a supplement in animal feed on land. The places where seaweed is cultivated also act as spawning grounds and havens for fish.” Biorefining is used to extract the most valuable components from the seaweed for use throughout the supply chain.

“In Europe, it’s not enough to cultivate seaweed for a single application like they do in Asia,” says Kraan. “We want to extract a variety of substances. That makes cultivation even more sustainable.” Kraan talks about extracting pigments that help to combat obesity, biostimulants for plants and animals, carbohydrates and proteins for human food and animal feed, minerals and fibres. “We can gasify the residue to produce energy”.

Large-scale, mechanical cultivation

Marco van Duijvenvoorde has been working with seaweed since 2015. With his companies Green Marine Farming and SeaFlavours, he harvests seaweed six times a year in Vietnam in the old-fashioned way. “Harvesting weed from the lines with a lot of people on boats,” he says. His seaweed is used for food and feed. In addition, he imports sea lettuce, and wakame for vegetarian sea burgers and salads for numerous supermarket brands in Europe and the United States. Like Kraan, Van Duijvenvoorde believes that large-scale, mechanised cultivation is the only way to be successful in Europe. “That means that as growing companies we have to improve our mastery of the seaweed life-cycle even more. We know a lot about sugar kelp but we don’t know, for example, when fertilisation takes place. With onions, for example, 64 percent of the seedlings come up but the success rate for seaweed at the moment is only about 5 percent.” In addition, the presence of nutrients and light in European waters means that harvest yields here are lower than in Asia. Growers there manage 150 to 200



Undaria

Codium

Hymanthalia

Laminaria

tonnes of wet weight per hectare. In Europe, growers like Van Duijvenvoorde and Kraan manage yields of 40 tonnes wet weight. “Fortunately, Hortimare is working hard on studies of enhancement and propagation for the most promising seaweed varieties,” says Van Duijvenvoorde. “The Netherlands Institute for Marine Research (NIOZ) is also engaged in a lot of important research that is very useful for our sector.”

“Europe needs to speak more with one voice”

Speaking with one voice

Kraan believes that Europe is ‘on the cusp’ of large-scale seaweed cultivation. “A company like Nestlé is very interested in the food applications of seaweed. But we can’t yet provide them with what they need. You need a hundred tonnes a month on a permanent basis.” Permits are also a difficulty in Europe. For example, Kraan is waiting for a permit in Ireland for a few square kilometres. “The problem



Stefan Kraan

Stefan Kraan studied Analytical and Marine Biology and obtained his doctorate in marine botany at the University of Ireland (Galway) in 2000. He then worked as a manager at the Irish Seaweed Centre in Galway and co-founded Ocean Harvest Technology in 2005. Since 2016 he has worked as the co-founder and scientific director of Aquaceuticals, and he has occupied the same position for The Seaweed Company since 2018.

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is that each country uses different criteria. Europe needs to speak more with one voice.” Van Duijvenvoorde also thinks that the regulations on concessions are lagging behind. That is not helpful for the seaweed business case.

Perspective

Nevertheless, Van Duijvenvoorde believes that the prospects for seaweed cultivation in Europe are good. “North Sea Farmers now has a trial with 12 hectares off the coast near Scheveningen and it is planning to launch a pilot project with a seaweed farm covering 160 hectares. That will certainly have an impact, especially if, in addition to a winter seaweed (sugar kelp), a summer seaweed can be cultivated there, or if we can combine seaweed cultivation with mussels or shellfish.” The new research project ‘Weed and wind’ in the Belgian wind farm Northor on the border with the Netherlands could also accelerate European cultivation, he thinks. “The wind farms produce sustainable energy and the seaweeds beneath them capture CO₂ and produce a range of food applications. How cool is that?”



Marco van Duijvenvoorde

Marco van Duijvenvoorde founded SeaFlavours and Green Marine Farming in 2015. Before that, he worked in the financial world after studying Financial Management at Haarlem Business School and General Management at Nyenrode Business University.

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Case



John Huiberts peeling and sorting the flower bulbs.

The Max Verstappen of Flower Bulbs

By Johan Koning

» John Huiberts has been working with bulbs since the age of fourteen. “It’s in the family,” he says. But Huiberts doesn’t grow his bulbs in the traditional way. Every bulb that leaves his farm is grown organically. Thanks to seaweed, among other things.

In 2012, John Huiberts identified the first signs of bulb fatigue caused by nematodes. “Even though it couldn’t be any cleaner here. We never had weeds, for example. Then I took a course in soil biology. And that’s where you are actually learn that you don’t have to have clean soil at all, and that you certainly shouldn’t plough. And you mustn’t use fertiliser or Roundup.”

Seaweed and bokashi

Instead, Huiberts now uses natural materials such as seaweed. He’s finding out a lot of things himself. “We make our own plant boosters based on seaweed, we make our own compost, bokashi (a Japanese term for fermented organic material, ed.), and also our

own machines. In the end, we get really nice bulbs like this and we have almost no failures.”

Suspicion

He believes this is the only way. “Our colleagues are a bit suspicious about us. And the same goes for buyers. Normally, a failure rate of 2% is normal. We refuse to accept that. A trader once said to me: ‘There are a lot of people who drive cars but there’s only one Max Verstappen’. Well, I’m happy to be the Max Verstappen of flower bulbs.”

John Huiberts

John Huiberts runs an organic flower bulb nursery with his wife Johanna in Sint Maartensvlotbrug, North Holland.

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Blueprint for New Seaweed Sector

“Seaweed does not need farmland, fresh water or extra fertiliser”

By Ingrid Zeegers

» The Dutch seaweed sector is *under construction*. Logistics chains are being established, alliances are being forged. “In three years’ time, the sector will not yet be profitable but it is entirely obvious that seaweed will help to shape our future,” say entrepreneur Mark Soetman and financial specialist Rogier van Steennis.

Mark Soetman, who has commercial interests in numerous seaweed activities, believes that the Netherlands is not only good at agrifood, logistics and seed enhancement, but also at marine and maritime activities. “The idea is to integrate seaweed as a raw material in value chains like these, allowing new markets to emerge.” Soetman says that seaweed can be used as a raw material for functional proteins, green gas, bioplastics, fertilisers and even

medicines. So it is hardly surprising that this modest, fast-growing, macroalgae is rapidly gaining in popularity.

Leap in scale

Seaweed does not need farmland, fresh water or extra fertiliser. It does need calm, nutrient-rich fields in the sea. “We are hoping to launch a seaweed project in the Haringvliet, just in front of the Second

Maasvlakte, next year,” Soetman says. “The permit procedures have almost been completed. We are going to use the seaweed as a raw material for all

We’re switching from annual sugar beet harvesting to sugar kelp harvesting.” This is a reference to the leap in scale needed to really launch the seaweed sector.

“Biorefining is a crucial factor in seaweed logistics”

kinds of products. We are building a biorefinery plant in Stellendam now. We can start experimenting there in the next four years.” Soetman explains that biorefining is a crucial factor in seaweed logistics. “We need to transform all the agricultural knowledge that was previously developed for tomatoes, potatoes and sugar beet, and use it for seaweed.

Grip on the value chain

Because fair is fair: we don’t have a large-scale seaweed industry in the Netherlands at the moment. There are, however, promising companies that, taken together, could form a complete value chain. But who will take the lead? In order to get a grip on the value chain, financial specialist Rogier van Steennis of service company EY developed a business case. The aim is to answer questions such as ‘On what scale can a seaweed sector become profitable at all?’. Van Steennis knows the answer: “According to our estimates, the turning point for nearshore seaweed cultivation is approximately 1,000 hectares.



Seaweed spores (sporophytes) in a bath attached to a thin line wrapped around a PVC pipe. The spores grow in this basin and are then wrapped around a heavier and thicker growing line ("twining") and taken to sea.

The current trials in our region are based on seaweed fields of between five and a maximum of ten hectares. This means that we need to upscale the current small-scale cultivation in stages to establish a commercial sector." Furthermore, the business case shows that there has to be a logical owner for each part of the seaweed chain. "The risks in the chain are not evenly distributed. The financial and technical risks associated with working in the North Sea are different from those on land. You have to take that into account. All the links in the value chain are needed: without seed, there can be no seaweed; without seaweed, there will be no biomass and no biorefining, and so on. In other words, in order to share the risks of the sector as a whole, we need to build an alliance of committed companies. The required direction will then be provided by that alliance."

Knowledge, investment and patience

Why is the business case actually important for a practical story about logistics and valorisation? Van Steennis: "In 2018, I was asked how much money would be needed to get a large-scale sector up and running. No one could answer that question back then. Our model means that we are now in a better position to determine the cost of an activity in the seaweed chain. To give an example: we have drawn up the current business case for a period of twenty years, gradually scaling it up to 4,000 hectares of nearshore seaweed cultivation. On the basis of those

assumptions, we arrive at an investment of 300 to 400 million euros. The calculation may be different for offshore seaweed cultivation but we'll find that out later. The same applies to calculations for the multiple use of space and the combination with the shellfish sector. But we have to start somewhere. The business case seems feasible and that's the important thing at the moment."

Looking for investors

The calculations made by Van Steennis are all based on a commercial business case that will eventually work without subsidy. The idea is to prevent this type of cash flow from having a major impact on the desired actual course of the sector, which is still

"Our model means that we are now in a better position to determine the cost of an activity in the seaweed chain"

under development. Even so, he is not ruling out the possibility that some start-up subsidy may turn out to be necessary in the future, for example to accelerate parts of the business case and to cover disproportionate risks. Soetman agrees: "It's going pretty well. But the game is still in progress. Where

are the customers? The large companies or end users who have to get involved - for example from the food industry, biobased chemistry and the green energy sector - are still on the sidelines. They are following developments with interest but that's all. That really has to change." Van Steennis adds: "We're looking

"We're looking for investors with a long-term vision"

for investors with a long-term vision. That is vital because the seaweed sector is complex and many different kinds of knowledge have to be combined. Even with ambitious upscaling, the sector will not be profitable after three to four years. And so investors will also have to be patient."

Industrial approach

So a lot has to be done before the first seaweed fleet can return to a port with the green gold on board. There is still an urgent need to remedy some gaps in our knowledge. A few examples. "There are as many as 19,000 species of weed," Soetman says. "But which species should we use to maintain a constant supply of biomass all year round? We need more laboratory

research." And a lot of innovation is still needed at sea as well. "Cultivation systems in the North Sea have to be robust enough to cope with severe storms. Those techniques do exist but they are still unproven. Examples are the development of special ships, harvesting machines, drones and monitoring equipment to observe the nutrient flux and underwater life. But another possibility is using satellites to decide when to harvest the seaweed. This high-tech industrial approach to seaweed cultivation is brand new and it can't be found anywhere in the world yet."

Seaweed knowledge and skills as an export product

The conclusion is clear: Soetman and Van Steennis believe it will take at least another ten years before large-scale seaweed cultivation is operational. They expect that growth to be gradual. "We can't scale up to 4,000 acres in one fell swoop. But it is important to really get started soon. Of course, there are still challenges at every stage of development. But that is precisely where we see the best opportunities for innovation. In the Netherlands, we have all the knowledge and skills we need to get the hatchery, cultivation, mechanisation, biorefining, as well as all the related techniques, off the ground. That new knowledge will also be a valuable export product." <



Rogier van Steennis

Rogier van Steennis is a senior manager at EY Strategy and Transactions and he works for both public and private bodies on infrastructure financing, public-private partnerships and support for businesses upscaling their activities.

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Mark Soetman

Mark Soetman works on innovative projects in the field of sustainability and the marketing of food and nutrition. Examples include Radio Magnetic Freezing, the extraction of crab meat from smaller crab species, and the establishment of large-scale seaweed crops for biorefining in the Haringvliet estuary.

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By Johan Koning

» **How can you maximise the value of seaweed and make the most of all its components? Biochemist Theo Verleun of GOA-Ventures has the answer: “We brought together several large organisations who all want something different from seaweed. We call that ‘cascading’ seaweed.”**

“Before I explain exactly what cascading involves, I’d like to take a step sideways. Seaweed is a form of biomass, a term that isn’t always used with much nuance. It evokes images of primeval forests being cut down to burn the timber. But biomass is more. It includes all the plant and animal material that Mother Nature makes for us and that grows or is created by light, air, water and nutrients.”

Five basic elements

“Biomass always consists of five basic elements: water, minerals, fats, proteins and carbohydrates. There are also components that don’t belong in biomass such as heavy metals and other contaminants that man has brought into nature. Wood contains little water but a lot of carbohydrates and minerals. Soy beans contain a lot of protein and fat, and much less carbohydrates and water. And seaweed contains a lot of water, little fat and relatively high levels of protein and carbohydrates. So you can describe every type of biomass by reference to the proportions of these five elements. There are good reasons to look at these basic elements: it’s only when you have a clear picture that you can understand the principle of cascaded value extraction. For example, one company may want to use fats, another carbohydrates and a third may want to use water. Which means you have to come up with a process that allows each company to extract the raw material it needs. In that way, you can keep everybody happy and maximise the value from every kilogram of biomass. That’s very different from the approach in which a company extracts what it needs from a product, rejecting the rest as waste and leaving it up to the buyer to see what can still be done with it.”

Value creation

“With GOA-Ventures, I want to apply this principle to seaweed. I was already doing that when I worked at DSM. I set up GOA-Ventures with the support of DSM, Gasunie and Eneco, among others. Gasunie and Eneco want to use seaweed to extract uncontroversial and future-proof energy from it - while at the same time preparing for the secondary use of wind farms. They also understand that you can’t make a business case on the basis of energy alone. So working with

“Cascading prevents a battle for biomass”

DSM and a few foreign companies, they looked at the combination with protein production for human consumption. Multiple value creation - in other words, cascading - prevents a battle for biomass between, for example, the food industry and the energy sector. After all, it’s not about who pays most for seaweed as a raw material but how we can work together to generate most value from seaweed. The great thing about our approach is that the food industry can extract a valuable fraction of protein from seaweed through cascaded value creation and then actually generate a higher energy yield from the remainder of the biomass. This is cascading in practice, with benefits for everyone involved.”

Seaweed consortium

“GOA-Ventures focuses on the protein transition in particular, in combination with the needs of the

energy transition. More and more people are coming into the world and they want more sustainable food. We have demonstrated that you can refine high-quality functional proteins for human consumption from seaweed. You can then use the remaining carbohydrates for animal feed, bioplastics or biogas (green gas). That is cascaded processing at its best: when several companies want to work with seaweed at the same time, for example in a seaweed consortium. Seaweed grows up to six percent a day. A number of varieties can even be harvested several times a year. Even so, it's a seasonal product. There are ten to twelve thousand species, about thirty of which grow in the North Sea. If you group them together, you can harvest about ten months a year. At the laboratory scale, we have now more or less worked out what is in eight of the most common North Sea species, and how you can extract those components so that all the organisations involved

“We really need to start thinking and, above all, acting on a larger scale”

can get their share. Because all parties need a stable supply so that they can include those components in their own products. We have already done this on a larger scale for two types of seaweed. We're talking about dozens of kilos. And we were also able to test the functional protein in consumer products such as biscuits and mayonnaise.



Biscuit made with seaweed protein.

Government's turn to step in

“The next step is to build a pilot plant: a test array that can operate with the common North Sea seaweed species. It's the government's turn to step in here as well. I think we need a smarter, more coordinated, cross-ministry stimulation effort. Developments are much faster outside the Netherlands. Countries like Denmark and Norway, for example, are very much on the right track. They see seaweed as an opportunity for a new future. If we continue shilly-shallying, without being genuinely committed to furthering knowledge and research, the role of the Netherlands as a maritime leader will be eroded further. And a lot is being done with seaweed in our country as well, for example by chefs. I have a lot of respect for that but we really need to be thinking, and above all acting, on a bigger scale.”

Business cases without subsidies

“We want the pilot plant to demonstrate that we can make high-quality consumer products (protein and green gas) in Dutch waters as well with several types of seaweed. And that - after some upscaling - we can establish a business case without subsidies. Cascaded value creation internalises that subsidies aren't needed. We also want to show the investors and early adopters who get involved at the outset that they can all get their share and that it pays off. It would be wonderful if seaweed cultivation could be located between offshore wind turbines. There are no ships sailing there anyway and that makes it an ideal environment. Processing can be easily located in nearby ports, leading to an immediate boost for employment there.”

Turning off the fossil gas

“For subsidy-free production, we think we will need half a million tons of seaweed per plant. So you need a maximum of 25 km². That sounds like a lot but the space is available. More than 14,000 km² of wind farms are planned on the Dutch section of the North Sea. If you use 20% of that area for seaweed, you can soon provide 30 million people with their daily dose of protein. And more than 50 percent of homes with

green gas. If we persist with a structural approach together, we really can close the fossil gas field in Slochteren! We will ultimately need all forms of renewable energy. Gasunie is investing a great deal of time and money in hydrogen, which has enormous potential from 2040 onwards. But green gas can already play an important role. Once the seaweed industry is up and running, seaweed refining will develop further. Then we can supply the chemical industry with seaweed fractions as raw material for products such as green carbon and real bio-plastics, in other words without modifications.”

Limitless possibilities

“It's now up to the government to make choices. Which cascaded projects have most impact on carbon reduction? What do we find important? For clothes to be more sustainable? Health? Energy? Or food supplies as an alternative to, for example, soy imports? What is certainly important is to encourage new forms of supply chain collaboration. In addition, the combination of agricultural and

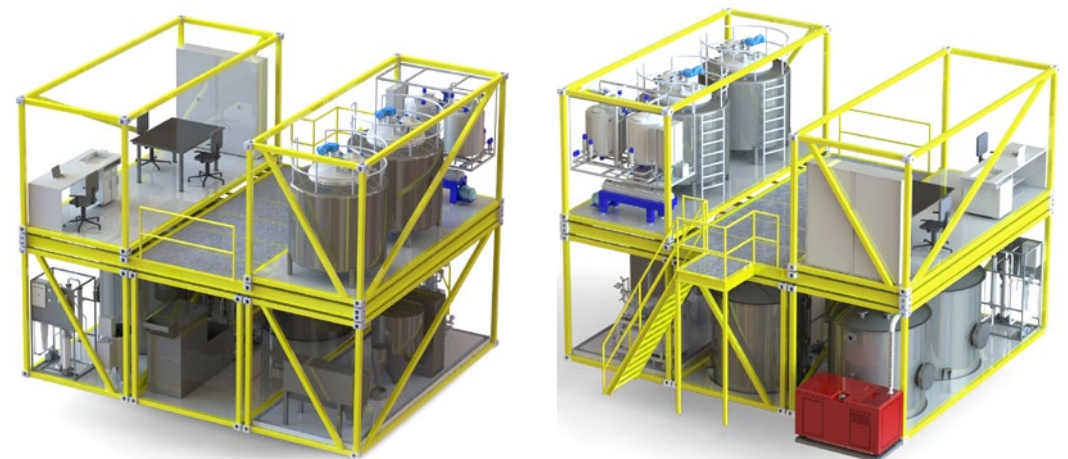
offshore technologies is right for maritime Netherlands. The potential of seaweed is undisputed worldwide and the Netherlands is in a position to develop a large export position. The sky's the limit as far as that's concerned.”



Theo Verleun

With DSM, Eneco and Gasunie, Theo Verleun founded GOA-Ventures, a company that focuses on seeking ways for different organisations to collaborate on getting most out of seaweed. Verleun has 35 years of practical experience around the world in biochemistry and a history of management tasks at DSM and other organisations.

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Design of test installation by ECE-Offshore using the GOA-ventures process.

Case



The Most Normal Thing in the World

By Lianne Verhoef

» **Jing Liu, an Industrial Design student at Eindhoven University of Technology, makes lively gestures when she talks about her passion: the future of sustainable materials. Her showpiece: seaweed.**

As far as Jing Liu is concerned, seaweed could be the raw material of the future. She demonstrates this with a strong, soft and pliable material that can be used to make everyday products such as shoes, bags and wallets.

Ready-made product

Liu developed this material herself by experimenting with different processes in her kitchen. That led to a simple and sustainable production process which, in addition to the raw seaweed, requires only distilled water and glycerine. By folding the resulting material around a mould and letting it dry, she can make all kinds of shapes. Like leather, it can then be sown together into a ready-made product. A product consisting only of natural ingredients that could even - after washing - be eaten by the owner.

Creating awareness

Liu's goal with this project is not to market realistic seaweed products. The shoes, for example, are not yet strong enough. What she wants is to create awareness about the possible shape of our future with sustainable materials like seaweed. A future in which wearing shoes or a wallet made from seaweed leather will be the most normal thing in the world. ◀



Jing-cai Liu

Jing-cai Liu graduated in Industrial Design from Eindhoven University of Technology in 2020. Liu has a passion for designing objects that help us to think about how to tackle social challenges. She is fascinated by the combination of art, culture, sustainability, trends and future developments.

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Other trends
that get us thinking

TREND WATCH



What is going on in society, what are the trends that will affect our work and our organisations?
Short articles that merit our attention.

Do you have any suggestions for trends that you would like to present with us here?
Please tell us at lichtkogel@rws.nl

By Amanda Verdonk

» As the circular economy picks up speed, circular service models are also becoming more popular. The focus here is not on owning a product but on use and access. The trend is blowing in from the business market to the consumer market, says Ed Nijssen, professor of technology marketing at Eindhoven Technical University.

A RICH LIFE WITHOUT POSSESSIONS

Renouncing all your possessions doesn't mean going into poverty. Now, in 2020, it is almost possible to live a life without any possessions and still have everything you need in terms of a house full of furniture, kitchen appliances, a washing machine, TV, telephone and a full fridge. The renowned sustainable architect Thomas Rau predicted this development as far back as 2015 in a documentary on Dutch television: "We don't want to own; we want to have access and use". So you can subscribe to almost anything these days: a car (Greenwheels, Snappcar), a bike (e-bike-to-go), a phone (Swapphone), a bed (Auping), office furniture (Ahrend), lighting (Philips), a central heating boiler (Energy Bridge) and even the facade of a building (Alkondor). *Product-as-a-Service*, *Building-as-a-Service* and even *Everything-as-a-Service*; so the end of possession is no longer a distant dot on the horizon.

Mindset

Offering a product in combination with a service is not new; in the business-to-business market,

appliances are often supplied with a maintenance contract. A more recent development are the services that focus not on the delivery of a product (such as lamps) but on a service (lighting). In other words, services in combination with a product on the basis of a performance contract. Increasingly, products are returned to manufacturers after use and that provides an incentive to make good products that retain some value. Circular service models of this kind have become popular in recent years with the rise in environmental awareness. Younger consumers in particular have also got used to subscription models such as Spotify, Netflix and e-bike-to-go. "The mindset has changed and this approach has become acceptable and desirable," explains professor of technology marketing Ed Nijssen. "That's a difference with older generations, who are used to buying things only when they've saved up for them."

Digital native

Nijssen points out that service models have been common on the business market for twenty years.

Tailor-made mobility

If you use Mobility-as-a-Service (MaaS), you pay a fixed monthly fee and consult an app for tailor-made travel advice. That may consist of different forms and combinations of shared transport, such as a shared car, bicycle, scooter, taxi or public transport. But we haven't got there yet. Pilot projects are currently ongoing in seven different regions in the Netherlands. The Netherlands is a good place for a system of this kind, argued Henk Meurs, extraordinary Professor of Mobility at Radboud University Nijmegen, recently in *OV-Magazine*, a trade journal about public transport. "We have multi-modal travel information with route planners, we have the right payment system with a public-transport chip card and we store our travel data in the central NDOV Loket. So the next step is: to develop a platform where you can plan, book and pay for multimodal travel."

"Studies show that companies that offer services are more profitable. You sell a product only once but a service always comes back and that generates a consistent and enduring cash flow." Digitalisation is also an important driver. "Companies are including more and more sensors and software in their products. By collecting data in this way, they learn about customer processes and they can also link maintenance services to them." Rolls-Royce, the manufacturer of industrial engines, was one of the first companies to make the switch. The company now sells 'operating hours' instead of engines. And Xerox has been offering *document management services* instead of photocopiers for years. With the help of sensors and digital monitoring, companies of this kind can conduct maintenance on their equipment at the right time or call them back if necessary.

Profitability

But Nijssen is far from convinced that companies like this are actually more profitable. "Manufacturers make cars full of digital gadgets but they struggle

Service and performance contracts

Organisations such as Rijkswaterstaat and ProRail have been using service and performance contracts for the tendering of large infrastructure projects for some years now. The contractor who constructs a road or tunnel, for example, is then responsible for design, construction and maintenance, and sometimes the operational side. These contracts emerged from the idea that the risks and responsibilities should reside with the organisation that can best manage and bear them. Nijssen: "Companies are increasingly focused on delivering integrated, service-driven solutions, and so we may be seeing more and more contracts of this kind."

with the software and digitalisation. That's why you see that *digital native* companies such as Tesla and other start-ups find it easier to penetrate this market." And not everyone is eager to go through life without any possessions at all. "These are primarily solutions for customers who want to have things taken off their hands and who don't want any fuss. I can't really see people leasing something like a bag of salt. A service model makes sense only if the product is very important for you." <



Ed Nijssen

Ed Nijssen is professor of technology marketing at Eindhoven University of Technology. He studies strategic sales and marketing for radical and incremental innovations. His most recent work focuses on servitization: the development, production and sale of solutions.

By Amanda Verdonk

» From a crackling modem to an endless stream of messages on social media: the internet has evolved from a communications tool for scientists into a mass medium driven by large commercial platforms. Internet pioneers say we need to return to the basic idea behind the internet: a decentralised network for everyone.

Digital free state under pressure

“There it is”, Piet Beertema called out to his colleague Steven Pemberton on 17 November 1988 at the Mathematics & Informatics Centre (CWI) in Amsterdam. Beertema had put a lot of effort into establishing the first European connection to the internet, which cost millions of guilders a year back then. Pemberton had the honour of being the first person to try it. “I was already sitting at my computer and I logged into a university computer in New York. Yep, it’s working, I called back. Otherwise, I didn’t do anything impressive, haha.” That was how computer scientist Pemberton, who is now retired, became the first user of the open internet outside North America. The native Englishman had been working at the CWI since the early 1980s and was, among other things, involved in the development of programming languages. Beertema and Pemberton are members of a select group of founders of the internet, which now allows all of us to look up information, send each other messages or watch videos incredibly quickly.

Commonplace

The basic building blocks for the internet were put into place as early as the 1960s at, among other places, the American Ministry of Defense and at American, British and French research institutes. Effectively, the internet is a network of computers connected to each other with phonelines or fibre-optic cables. In the early days, it was primarily used for emails and exchanging files but the invention of the World Wide Web in 1991 (with an important contribution from CERN researcher Tim Berners-Lee) and the advent of browsers (programs that convert websites into form that humans can read) meant it really became commonplace. Pemberton: “I was walking on Times Square in New York in 1995 when I saw a web address on a poster for the first time and thought: game on.” Now there are more and more computers, laptops, phones and other devices connected to the internet and there are 4.6 billion internet users worldwide.

Urge to centralise

The basic infrastructure hasn’t really changed much in thirty years but the way we use it has, Pemberton points out. “The basic idea behind the internet is that it is distributed (spread over multiple computers, ed.) and that you can access your files anywhere. The web has also been designed in such a way that you can use it not only to retrieve information but also to publish it. But the first successful web browser, Mosaic, didn’t include the second option.” A big mistake, he thinks. “People had to think of other ways to publish and that led to Facebook, for example. But those large commercial platforms have an enormous urge to centralise. That’s a major risk

“It’s difficult to have good public debate on social media”

for privacy and freedom of speech.” The social media like Instagram and Twitter are not just places where people get in touch with each other. They are also platforms where your personal information is not always safe and where abuse, conflict and fake news are everyday. Attempts by tech companies to curb this tendency have had only limited success. “These are environments that are very polarised and where personal attacks are a constant threat,” observes Jurriën Hamer, a researcher of the digital society at the Rathenau Institute. “It’s hard to engage in good public debate there.”

Skewed information

Moreover, this arena attracts not only individual citizens but also companies, political parties and even nation states. Because certain messages are shown, sometimes with misleading information, or precisely because messages are suppressed, the users of these platforms receive skewed information. And that means even more polarisation. There are numerous examples of this kind of manipulative information:

from possible Russian interference in the U.S. presidential election to the news that a lotto winner has dumped thousands of pounds of manure in the garden of his former boss - a 2018 report that was read 2.3 million times.

Back to basics

As far as Pemberton is concerned, we have to go back to basics: to the distributed internet as it was once meant to be. “You don’t need Facebook to publish at all; the web protocols allow you to do without it. You can post all your information on a small web server in your modem at home. Even then, you can still use a Facebook-like interface but you don’t have to use a central server. Anyone can be a publisher and you can dispense with hosting, advertising and violations of

privacy.” The idea is similar to that of his ‘fellow pioneer’ Berners-Lee, who is working on the decentralisation project Solid. “I think everyone’s waiting for a distributed Facebook of this kind because that’s exactly what we’re looking for.”

“We’re less naive and increasingly aware of the dangers”

Less naive

That won’t bring an end to the sometimes poisonous discussions on social media, believes Hamer. “Are we having a debate that benefits everyone? That’s partly up to individual people themselves; it can’t just be solved by a government or new technology.” Hamer says that the internet is no longer the natural free state it once was. “You have to have the right skills, and the ability to circumvent the dangers and find the right information.” But Hamer hasn’t given up hope yet. “Awareness among the general public is on the rise, and governments are now taking serious steps to tackle privacy infringements and fake news. We’re less naive and we are increasingly aware of the dangers.”



Steven Pemberton

Steven Pemberton worked as a computer scientist at the universities of Sussex, Manchester and Brighton, where he wrote, among other things, programming languages for future generations of computers. From 1982 onwards, he worked at the CWI on areas including the HTML markup language and the programming language ABC (the predecessor of the popular Python) and a ‘browser-like’ program.

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