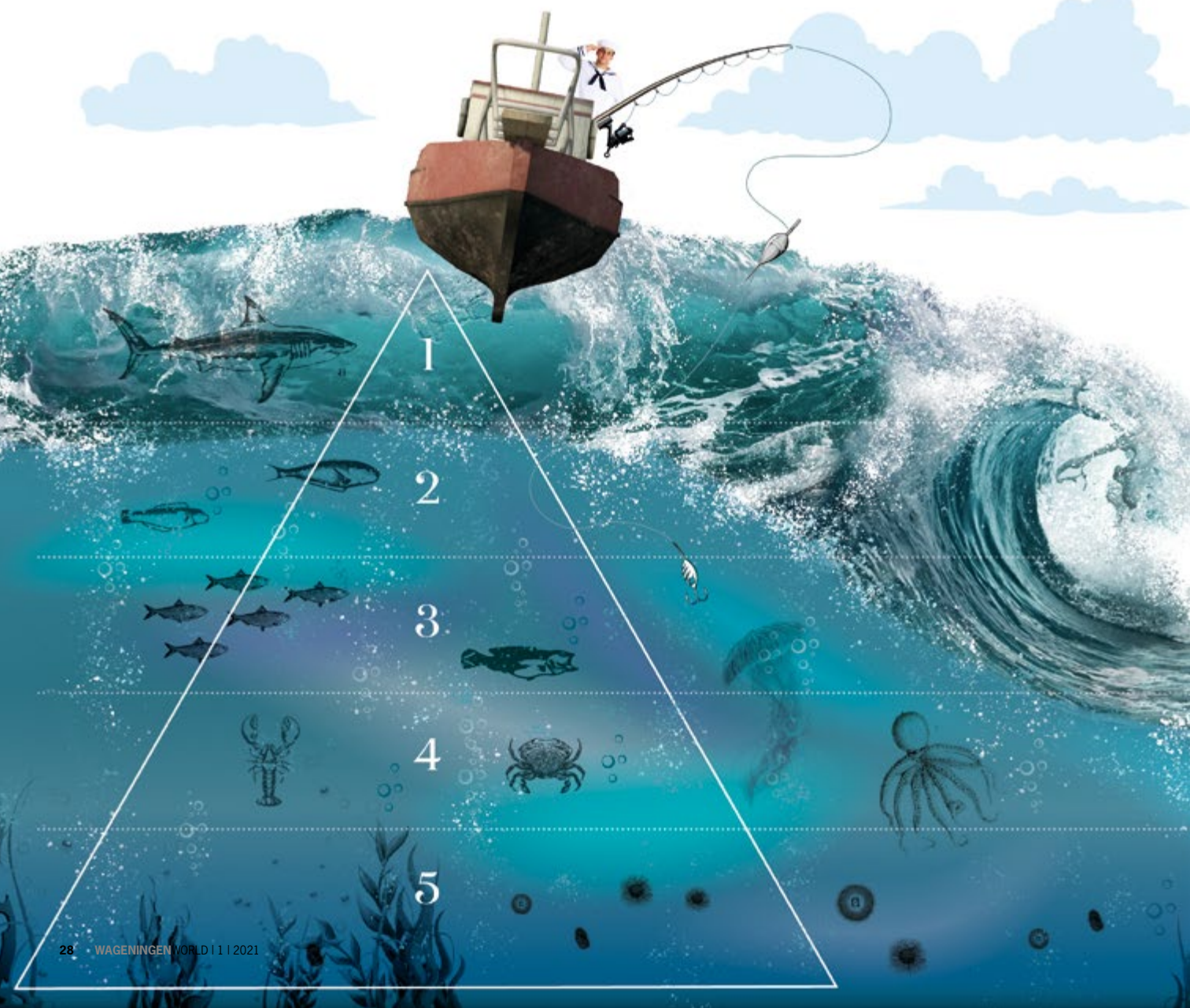
Food from the sea won

There are high hopes for the production of food in the sea. But its potential is limited, argues theoretical biologist Jaap van der Meer. 'We are already reaching the limits. There is not much more to be gained from it.'

TEXT NIENKE BEINTEMA **ILLUSTRATION** KAY COENEN



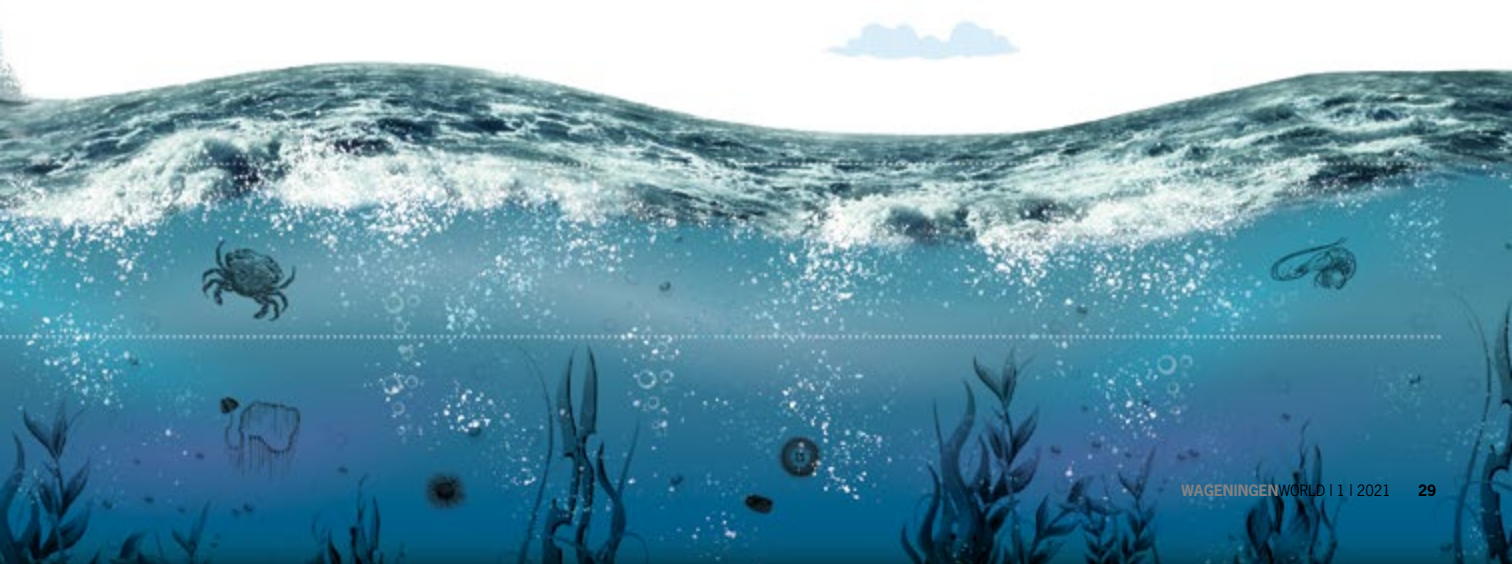
't feed many mouths

The challenge of feeding the growing world population is getting bigger all the time. Perhaps, suggest parties including the FAO, the European Commission, and scientists from Wageningen, we should look for the solution less on land and more at sea. The oceans cover about 70 per cent of the earth's surface but provide only one to two per cent of our food. That could be improved on, say proponents of the concept of 'Blue Growth', by means including developing more efficient mariculture – growing food in the sea.
'Unfortunately, it is not as easy as that,' says Jaap van der Meer, a researcher at Wageningen Marine Research and extraordinary professor of Sustainable Marine Food Production. In December he published a paper in the journal *Nature Food* which drew a lot of interest. 'The models we use are based on the available surface for mariculture, and not on the available nutrients or on the food pyramid in the sea.'
Van der Meer, who is also professor of Animal Ecology at VU University Amsterdam, is a theoretical biologist. He specializes in calculating the energy budgets of organisms and their populations. 'For the past 10 years, a lot of stories have been circulating about the potential of Blue Growth,' he says. 'But I began to wonder whether it was actually feasible. It turned out that no one had really done any calculations on it. That's why a great journal such as *Nature Food* was interested.'

FEW NUTRIENTS

The sea is a habitat full of contrasts. On the one hand, its primary production – the production of plant biomass – per surface unit is much lower than that of land. That is because seawater contains relatively few nutrients. 'In terms of nutrients you can compare large parts of the oceans with a desert,' states Van der Meer.
On the other hand, the efficiency with which that primary production is converted into animal biomass is much higher at sea than on land. On land, only 0.1 percent of plant matter ends up inside herbivores. 'In a forest, most of the biomass consists of trees,' explains Van der Meer, 'and they end up rotting on the forest floor. The main beneficiaries are fungi and bacteria, which hardly ever end up at the higher end of the food chain themselves.' Most of the plant biomass at sea consists of algae, about six per cent of which gets converted into the biomass of herbivores. That is still a low percentage, but it is 60 times higher than that on land. So the sea is a much more efficient production system than the land. Why is it, then, that at sea we got stuck at the hunter-gatherer stage – fishing wild schools of fish – whereas on land we have been domesticating plants and animals for thousands of years? 'The problem with that production at sea,' answers Van der Meer, 'is that the lowest two levels of the food pyramid, the plants and the herbivores, consist largely of single-cell algae and animal plankton that is no more than half a millimetre in size. We can't harvest those at all, not even with special nets. It would cost far too much energy to drag such nets through the water.'
So at sea, continues Van der Meer, we are left with the higher end of the food chain. Seals and whales form only a small niche; our main source of marine food is fish, which constitutes only a tiny proportion of the sea's food production. This is >

> 'In terms of fertility, the oceans are comparable to a desert'



because at each step along the food chain in the sea, 94 per cent of the energy gets lost, so after four or five steps, very little is left.

EATING SEAWEED

But what about larger seaweeds? Couldn't we eat a lot more of those? 'You rarely find those large varieties of seaweed out on the open sea,' answers Van der Meer. 'It only grows in a very narrow coastal zone, because seaweed has to attach itself to the seabed.' It is possible to grow them on the open sea, using floating installations for example. 'But that technique never really got off the ground,' says Van der Meer. 'It is expensive and technically difficult, which also makes it less feasible for poor countries. This is not something you can start rolling out on a large scale. What is more, large varieties of seaweed are difficult to harvest and they rot fast if you don't dry them straightaway. That makes them unsuitable as a staple food.'

But even in coastal seas such as the North Sea, only a limited number of mouths could be fed with seaweed, according to Van der Meer. 'There too, the limiting factor is nutrients. Even if you were to convert all the available nitrogen and phosphorus into seaweed, leaving nothing for other organisms, you would only have a very small yield per surface unit. Particularly in comparison with a crop like sugar beets.'

Fertilization is not an option. For one thing, it would change the balance of the different algae. 'We know from experience that that often benefits inedible species,' says Van der Meer. 'Species that contain a lot of defensive chemicals, for instance. You see this in coastal water that is polluted with wastewater too.' A further issue is that a lot of the nutrients you could use as fertilizer in the coastal zone end up in the soil. 'That's not the way to use scarce phosphorus. According to the forecasts, in 40 to 400 years we will have exhausted the phosphorus supplies. That is already a massive problem on land. So you're not going to start pouring that phosphorus into the sea as well.'

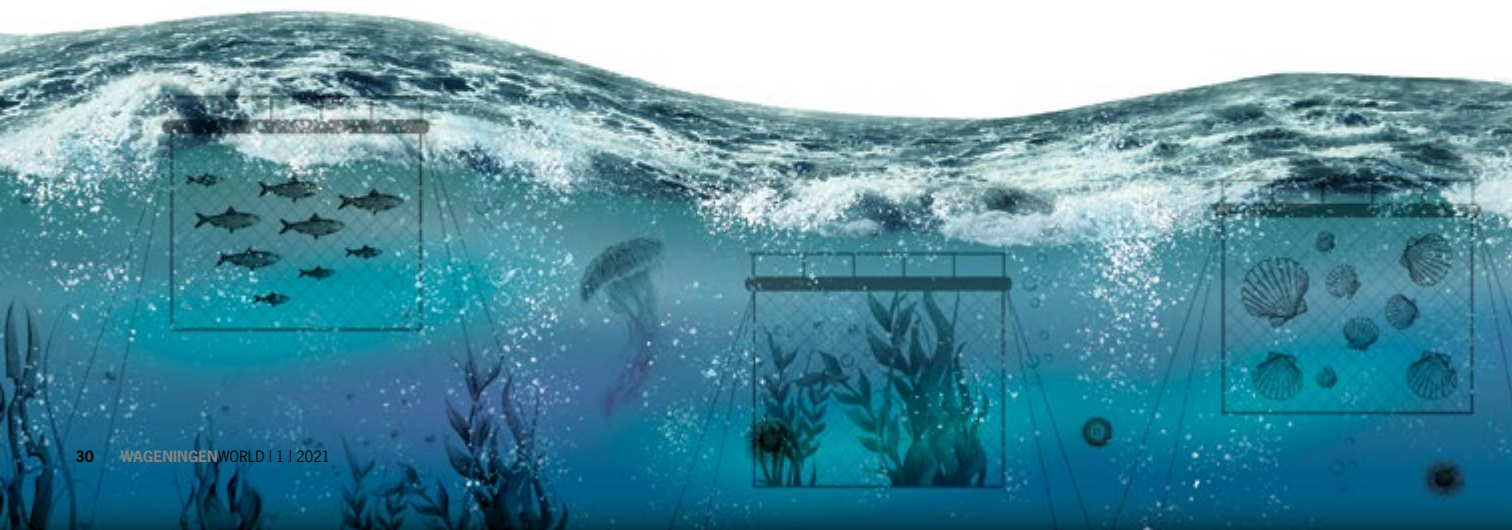
> **'You could farm seaweed on a vast scale in the South China Sea, thanks to the nutrient surplus'**

FARMING PREDATORY FISH

We are seeing another phenomenon in the coastal zone: the farming of predatory fish such as salmon in open-net pens. The salmon eat pellets that contain fish meal and fish oil that come from the sea. This form of agriculture is therefore no solution to the global food problem, according to Van der Meer. The fact is, we cannot expect to get more out of the marine system as a whole than we do already. To illustrate that, he makes the comparison with agriculture. The main advantage of livestock farming on land is that it provides a way of coping with scarcity in winter, which in nature is a limiting factor for the survival of mammals. Over the centuries, farmers have achieved this by replacing inefficient forests with grasslands on which they grow crops in the summer that they store for the winter. 'Like that, the natural efficiency with which plants are converted into animals gets boosted on land from 0.1 per cent to one per cent,' says Van der Meer. 'Ten times as much but still much less than the six per cent you get at sea.'

But what if you gave the salmon in those cages food that came from the land, like soya? 'That switch has indeed been made, but I don't call that marine production anymore,' answers Van der Meer. 'That is going back to a land-based system, using resources that are already scarce on land, and which bring their own problems with them. If you use soya, you might as well feed it to chickens. That's just as productive.'

So the conclusion is that because the efficiency at sea is already so high, there are few opportunities there for farming predatory



fish. Van der Meer: 'The best option then is to harvest lower down the food pyramid and catch or farm only herbivorous fish such as mullet. But they don't eat single-cell algae either. They eat plants growing on seaweed and rocks, dead plant matter and excreta – which are limited food sources too. What is more, the North Sea is too cold for them in winter.'

If you want to farm at sea, Van de Meer thinks the best bet is shellfish farming. Shellfish are low in the food chain but are very nutritious. Space is scarce in the coastal zone, while further offshore the costs and the technology are the limiting factors. 'You find the odd pilot project here or there, driven by subsidies. For example, the shellfish farming using floating constructions in the Voordelta, the shallow band of North Sea beyond the southwest delta. But those projects are not going to feed the world either.'

So should we bin the concept of Blue Growth? That's not the answer either, responds Marnix Poelman, Blue Growth team leader at Wageningen Marine Research. 'Let me start by saying that I agree with Jaap's viewpoint,' he says, 'certainly on the main points. But the question is: what do you do about it then? He thinks mainly on a global level. We try and look at it at a smaller scale. We can see that the agricultural pressure on land is too high. If that's the case, how can you establish production at sea at specific locations, that could be appropriate and complimentary?'

> **'Phosphorus is scarce so you don't just throw it in the sea'**

CARBON SEQUESTRATION

According to Poelman, there really are places where mariculture is feasible and of use. 'We should also consider other functions besides supplying food,' he comments, 'such as carbon sequestration and nutrient recycling in places where the marine environment has been disturbed. In the South China Sea, for example, you could farm seaweed on a vast scale thanks to the nutrient surplus there. This is already being done in Denmark on a smaller scale.'

Marine production could also contribute to making farming systems more efficient. Cows that eat seaweed-based products emit less methane, for example. Seaweed extracts make crops more resilient in the face of salt stress. And adding shellfish to fish feed improves the health of farmed fish. 'Applied research is being done on the use of such organisms from low in the food chain in a circular food system,' says Poelman. 'There truly is scope for marine farming in places where there are plenty of nutrients in the water, but we must go about it very carefully, take a very good look at the consequences for the whole system, and integrate the full picture into our decisions. In the North Sea, for example, you could never create a 10,000 square kilometre shellfish and seaweed farm, which was once the ambition. We've already scaled that down to 500 square kilometres. But we mustn't throw out the baby with the bath water: there are limits but there are definitely opportunities too.'

Van der Meer agrees. 'I'm not saying nothing can be done, just that we do need to keep a critical eye open. Blue Growth has become a kind of hype in recent years, and I'm trying to put that in perspective.' ■

www.wur.eu/limits-marine-food-production

JAAP VAN DER MEER,
a researcher at Wageningen Marine Research and extraordinary professor of Sustainable Marine Food Production