

# Nurturing growth: the Norwegian way

Report on aquaculture in Norway 2017

SEAFOOD  
FROM  
NORWAY



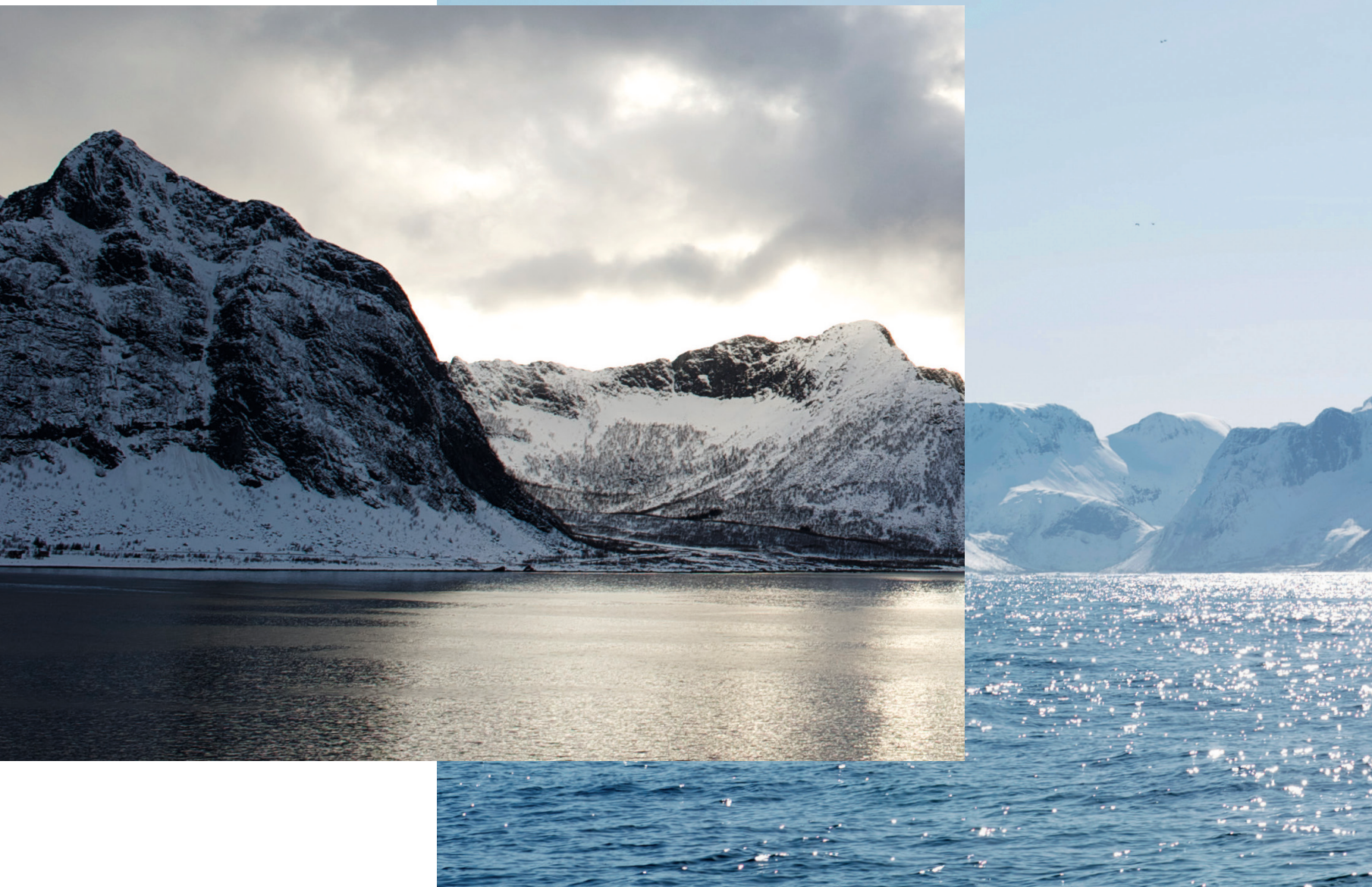




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# Foreword



## For the world and the environment

**Norway has a long tradition as a seafood nation. Throughout our long history, fisheries have formed the very basis of our livelihoods and our culture along the coast of Norway. Today Norway is the world's second largest exporter of seafood, with 31 million Norwegian seafood meals consumed daily in more than 140 countries.**

**We strive to deliver premium quality, ensure food safety through stringent controls, and make sure that we, as a seafood nation, act in line with our strong principles towards sustainable harvesting from the Norwegian waters.**

In the Seventies, when old traditions gave way to new innovations, Norway became a pioneer in aquaculture. Since then our production has doubled more than 13.000 times. Our perfect natural conditions, with pure cold waters, and more than forty years of experience, have given us the unique position as the world's largest producer of Atlantic salmon.

We can talk about this industrial adventure with pride, as the growth has happened in a sustainable way. Thanks to new technology and heavy investments in research & development, Norway has been, and will continue to be, a leader and innovator in aquaculture, and therefore a source for future global food production.

As the world's population increases, food production needs to increase. With water covering 70 percent of the earth's surface, the seas and aquaculture need to be at the forefront of future food production. As a food producer, the aquaculture industry has a global social responsibility.

Norway can and will play an important role in sharing knowledge on how seafood can be produced in a safe, controlled and sustainable way. Not only today but also in the future.

Every year the Norwegian Seafood Council welcomes journalists and opinion leaders from all over the world to Norway, for them to learn more about the Norwegian way of harvesting from the sea. In this report we want to openly and honestly share our principles with you, and to answer the most frequently asked questions about aquaculture.



**Renate Larsen**  
CEO  
Norwegian Seafood Council

Handwritten signature of Renate Larsen.



# From the cold clear sea

More than 14 million dishes featuring salmon, fjord trout or halibut from Norwegian aquaculture are served up every day in more than 100 different countries across the globe.

Fish that is rich in fat, such as salmon and fjord trout, is a good source of essential omega-3 fatty acids. These are a necessary component of our diet that cause the brain to produce dopamine, the “happy hormone”. Omega-3 fatty acids also help keep our hearts healthy. Norwegian aquaculture therefore plays an important part in making 14 million people a little healthier and happier every day.



“Food security is a situation that exists when all people, at all times, have access to sufficient, safe and nutritious food to meet their dietary needs and preferences for an active and healthy life.”<sup>1</sup>





## The last Viking

**Regarded by the Japanese as a culinary newcomer, indispensable by the French and as a bringer of good luck by the Chinese, Norwegian salmon is the greatest conqueror Norway has seen in its time.**

There are no end of reasons why Norwegian salmon has become a global best-seller. First of all, it is incredibly versatile, both bringing a smile to families enjoying meals at home and delighting demanding foodies in gourmet restaurants.

The general trend towards healthy eating has also helped boost salmon's popularity. Now that everyone is talking about omega-3 fatty acids, salmon is a firm favourite on everyone's plate.

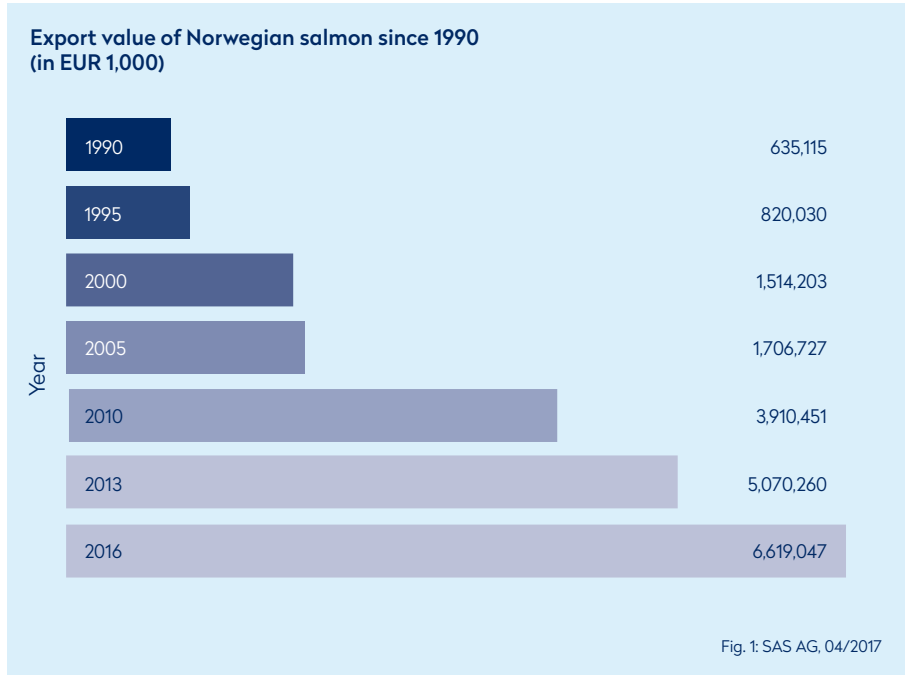
The global success story of Norwegian salmon can also be largely explained by the fact that salmon from aquaculture is never out of season. The fish is always available, with consistently high quality guaranteed. Other raw materials sourced from land or sea are only available during certain

seasons, so it is a real benefit that premium, fresh salmon can be found on menus globally all year round.

As the traditional "lunch hour" is getting shorter and shorter in Parisian companies, sushi bars are currently experiencing a huge boom. French workers will often pop to the one closest to their office if they haven't brought their own "Baguette Nordique", a French baguette filled with Norwegian smoked salmon, with them to work.

In China, it is customary to throw raw salmon in the air to celebrate the New Year. Chinese families will do this three times before sitting down to enjoy their traditional New Year feast. They ask for good luck for the New Year when they toss the salmon up in the air the first time, followed by a request for wealth with the second throw and happiness with the third.

Salmon has only been an ingredient in sushi since Norwegian salmon was exported to Japan back in 1986. It has now come to be the most popular type of sushi and sashimi in "Kaiten-Zushi" (conveyor belt sushi restaurants).





# The field of blue

As the world population continues to grow, so does the demand for food. There are already more than 1 billion undernourished people among the earth's population. If we consider the fact that although around 70 percent of the earth's surface is covered by water, only 5 % of food production in the world is currently sourced from the sea – not to mention that food production on land is limited – the hugely important role to be played by the “field of blue” in supplying protein in future becomes immediately apparent. Norwegian aquaculture is in a position to make a long-term contribution to the demand for protein amongst the growing world population.

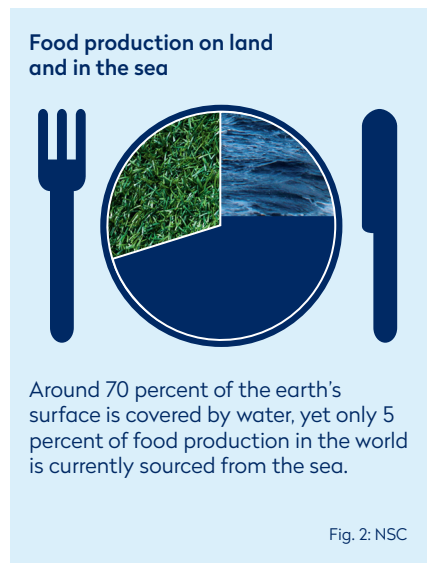
Norway has 90,000 square kilometres of sea between its coast and baseline, giving the country a potential area for food production equivalent to the total usable agricultural area in Sweden, Finland and Denmark put together. However, as it stands, just 450 square kilometres of this space is currently used for aquaculture.





It is estimated that 9.7 billion people<sup>2</sup> will be living on this planet by 2050, which is almost a quarter more than at the start of 2017 (7.47 billion<sup>3</sup>). We will need to double the amount of food we produce now if we are to be able to meet the anticipated global demand in 2050. There are already more than 1 billion undernourished people among the earth's population.

According to the Food and Agriculture Organisation of the United Nations (FAO), the only way we can fulfil the global demand for seafood is to develop aquaculture facilities further. Rather than relying on the conventional green fields on land, the focus in future will be on the “field of blue” to ensure that the world's growing population can be fed.



## Enough healthy food for all

Many people in the regions of the world that are not suffering from a shortage of food do not manage to consume the “right” food.

Over the past 40 years, the number of severely obese people in the world has increased significantly. In fact, whilst 105 million people were considered to be very overweight in 1975, this figure had risen to 641 million by 2014. Research shows that on average more than one in ten men are obese, whilst one in seven women are very overweight. These statistics reveal that more people in the world are now overweight than underweight.

Statistics from the World Health Organisation (WHO) reveal that cardiovascular diseases are now the most common cause of death.

Even in Norway, where the average amount of fish consumed per capita is 39,7 kg per year (WFE\*), coronary heart disease is the biggest killer.<sup>4</sup> Taking all this into account, the Norwegian Ministry of Health (Helse- og Omsorgsdepartementet) recommends a balanced diet that includes a high proportion of seafood.

The Food and Agriculture Organisation of the United Nations (FAO) and the World Health Organisation (WHO) advise member states to implement a range of measures with a view to informing consumers about the benefits of eating fish in a clearer and

more effective way<sup>5</sup>. This communication should include the following aspects:

- Acknowledgement that fish is an important source of energy, protein and other nutrients the human body needs.
- The potential reduction in the rate of mortality due to heart disease amongst adults if they have a balanced diet that includes a sufficient amount of fish.
- The increased risk of death caused by heart disease amongst adults who eat only a little fish or none at all.
- The positive effects on the brain development of unborn and newborn babies as a result of pregnant women and women who are breastfeeding eating a balanced diet including fish.
- The risk of negative effects on the brain development of future offspring if women of childbearing age do not eat any fish.

## The health benefits of fish

**Eating fish, especially species with a high fat content such as salmon, herring and mackerel, helps maintain a healthy heart and contributes significantly to the healthy development of fetuses and children. Norwegian farmed salmon is known as an easily digestible source of protein that is rich in nutrients such as omega-3, proteins, fat-soluble vitamins including vitamins A, D and B12, iodine, selenium and antioxidants.**

The European Food Safety Authority (EFSA) has confirmed that a daily intake of 250 mg

of long-chain omega-3 fatty acids can reduce the risk of adults suffering from heart and arterial diseases. Pregnant women and women who are breastfeeding should add 100–200 mg of docosahexaenoic acid (DHA) to this dose. The EFSA recommends eating fish as part of one to two meals every week, whilst expectant mothers should up this to three to four fish-based meals in a week. For more information: [www.efsa.europa.eu](http://www.efsa.europa.eu)

The National Institute of Nutrition and Seafood (NIFES) in Norway recommends that more than two meals with fatty fish are eaten a week. The German Nutrition Society (DGE) has issued similar recommendations, suggesting that people eat fish as part of one to two meals per week. Freshwater and saltwater fish should feature on the menu most frequently owing to their levels of selenium and omega-3 fatty acids.

Even though per capita consumption in Norway is relatively high at 39,7 kg of fish per year (WFE), the average consumption is still only about half of the recommended amount of 100 to 150 fish meals per year.<sup>4</sup>

### Essential omega-3<sup>6</sup>

Long-chain polyunsaturated omega-3 fatty acids (DHA and EPA\*\*) are proven to prevent cardiovascular diseases. EPA and DHA are also key to the development of the central nervous system in fetuses and children. Research results also suggest that omega-3 fatty acids from seafood can play a significant part in the prevention of type 2 diabetes and obesity.

In recent years, the composition of fatty acids in Norwegian farmed salmon has changed considerably. This is mainly down

to the sustainable fish feed used in Norwegian aquaculture facilities. In order to protect wild fish stock in the oceans, marine fishmeal and fish oil have largely been replaced by plant proteins and oils.

Although the content of EPA and DHA in Norwegian farmed salmon dropped by 58 percent between 2005 and 2015 (from 27.4 to 11.5 mg per gram), it is still one of the best sources of EPA and DHA. A higher proportion of these fatty acids is only found in mackerel and herring, as well as fish oil and other fish liver products. Lean fish and shellfish may contain less EPA and DHA than Norwegian farmed salmon, but the amount is still much greater than that found in poultry or pork. In fact, farmed salmon currently contains 20 times as much EPA and DHA as poultry, pork and eggs.

\* The FAO calculates the consumption figures on the basis of the “Whole Fish Equivalent” (WFE), which corresponds to the landed weight of whole fish. Per capita consumption (WFE) in Norway is 39,7 kg per year and the volume of fish actually consumed annually is 23 kg. The WFE in Germany is 14.8 kg per year, with the actual volume of fish consumed per capita sitting at 7 kg annually (Fisch-Informationszentrum e.V. (FIZ), 2014).

\*\* DHA = docosahexaenoic acid and EPA = eicosapentaenoic acid

\*\*\* ALA = alpha-linolenic acid



# Dietary recommendations

**The National Institute of Nutrition and Seafood Research in Norway does not offer any general dietary recommendations for omega-3 fatty acids and instead focuses on expectant mothers, stating that pregnant and breastfeeding women should have a daily intake of 200 mg of DHA.**

The European Food Safety Authority (EFSA) recommends a daily intake of 250 mg of EPA and DHA amongst adults in order to prevent cardiovascular diseases. Pregnant women are then advised to add an extra 100 to 200 mg of DHA to their daily diet.

In 2016, one portion of Norwegian farmed salmon (approximately 150 g) provided an average of 1.8 g of marine omega-3 (EPA and DHA) and 1.3 g of plant-based omega-3 (ALA\*\*\*). On the basis of the dietary recommendations issued by the EFSA, 150 g of Norwegian farmed salmon therefore provides a whole week's recommended intake of omega-3 for adults or the amount that pregnant women are recommended to consume in four days.

In addition to omega-3 fatty acids, the human body also needs omega-6 fatty acids, very few sources of which are found in our diets. The ratio of omega-3 to omega-6 in Norwegian farmed salmon is currently 1:1, meaning that this fish provides equal amounts of both.

## Healthy salmon

Marine omega-3 is important for us humans and is also key to ensuring a healthy immune system for the salmon too. Norwegian farmed salmon gets the dose it needs in its feed, with fatty acids in the right composition increasing immunity to viruses, bacteria and parasites.

In 2014, there was 23.2 g of marine omega-3 per kilogram of commercial salmon feed in Norway on average. Recent research has confirmed that the level of fatty acids currently being measured in fish feed is guaranteeing the health of Norwegian farmed salmon.<sup>7</sup>

## More fish on the menu

Fish contains essential proteins and fatty acids that are key components of a healthy and balanced diet. As is the case with many other types of food, fish may contain traces of unwanted residues, as wild-caught fish, for example, is exposed to the properties of the sea and potentially also pollution. Fish from aquaculture can only be guaranteed to be healthy provided all of the guidelines and requirements are followed to the letter.

The Norwegian Scientific Committee for Food Safety (VKM\*) has carried out an overall evaluation of the positive and the possible negative repercussions of pollutants on people. The report entitled "A comprehensive assessment of seafood in the Norwegian diet" came to the following final conclusion: "It is important that we continue to eat fish and, even more than that, we need to increase our current fish consumption going forward. Given the strict guidelines and increasing number of bans on

harmful additives and residues of undesirable substances in food, the health benefits of Norwegian salmon from aquaculture will be given even more weight in future."<sup>8</sup>

The National Institute of Nutrition and Seafood Research (NIFES) has calculated the following as an addition to the results from the VKM: The deaths of 39,800 people caused by heart and arterial diseases in every million could be prevented if those people were to eat 400 g of salmon every week.

## Health and safety

Norway relies on an extensive system of controls and monitoring along the entire value-added chain within the fish production industry to ensure that consumers are provided with safe fish products. Official monitoring programmes are in place to guarantee that Norwegian farmed salmon is a healthy and safe food.

The Norwegian Food Safety Authority (Mattilsynet) is the central control and supervisory body that guarantees both the food safety of fish products and the health and welfare of marine animals living in Norwegian waters. It also advises the Ministry of Trade, Industry and Fisheries, the Ministry of Agriculture and Food and the Ministry of Healthcare on specialised questions.

Within the Norwegian fishery and aquaculture industry, collaboration with scientists is of huge importance. Within this context, Mattilsynet makes use of professional advice from the following independent scientific institutes:

- The Norwegian Scientific Committee for Food Safety (Vitenskapskomiteen for mattrygghet, VKM), which conducts independent risk assessments for the different areas covered by Mattilsynet. This institute also performs environmental risk assessments for the Norwegian Environmental Authorities (Miljødirektoratet).
- The National Institute of Nutrition and Seafood Research (Nasjonalt Institutt for Ernærings- og Sjømatforskning, NIFES), which conducts research into the nutrition of farmed and wild fish as well as the effects eating fish has on human health.
- The National Veterinary Institute (Veterinærinstituttet), which is the Norwegian biomedical research institute with a focus on the health of animals that live on land and in water as well as food safety. This institute also conducts independent research that is used to advise the Norwegian authorities.
- Institute for Marine Research (Havforskningsinstituttet), which is Norway's biggest centre for marine research. Its primary role is to advise the Norwegian authorities on aquaculture and marine ecosystems in the Barents Sea, the Norwegian Sea, the North Sea and the Norwegian coastal regions.



\* VKM = Vitenskapskomiteen for mattrygghet



## Frequently asked questions

### Does salmon from aquaculture contain more pesticides than wild-caught fish?

No, checks have been in place for over a decade now to ensure that salmon from aquaculture does not contain any unwanted substances such as dioxins and polychlorinated biphenyls (PCBs). The amount of pesticide-based substances found in Norwegian salmon from aquaculture has dropped steadily since 2003. The value is now 0.6 ng TEQ\* per kg<sup>9</sup>, putting it ten times below the permissible EU boundary limit of 6.5 ng TEQ\* per kg of farmed salmon. This figure is also well below that of wild salmon, mackerel, herring and Greenland halibut. According to the Norwegian Scientific Committee for Food Safety, eating more than one kilogram of farmed salmon on a weekly basis does not pose any threat to human health.

### Does salmon from aquaculture contain residues of medication?

Residues of unauthorised medication have never been found in samples of Norwegian salmon. What's more, the strict boundary limits for legal medication and foreign substances have never been exceeded. The National Institute of Nutrition and Seafood Research (NIFES) conducts more than 12,000 tests on fish from aquaculture every year.

### Are there special boundary limits for salmon from aquaculture?

The EU sets general boundary limits for all fish but does not narrow these down to apply to specific species. These limits relate to a range of different harmful substances such as polychlorinated biphenyls (PCBs), dioxins and heavy metals. Norway even goes one step further and tests for substances that are not included in the boundary limits set by the EU. The National Institute of Nutrition and Seafood Research (NIFES) publishes these results, which can be viewed by the public at any time at: [www.nifes.no](http://www.nifes.no).

### Salmon contains omega-3 fatty acids, but what about omega-6 fatty acids?

Both omega-3 and omega-6 fatty acids are essential to the human body. Based on what we know today, the recommended ratio of omega-3 to omega-6 fatty acids is 5:1 and below. Nowadays, people are actually consuming too many omega-6 fatty acids thanks to industrialised food systems, the increasing reliance on ready meals and the rise in the amount of meat consumed. However, in most countries, there has not been an increase in fish consumption. "Salmon from aquaculture still affords the benefit of a good ratio of both types of fatty acids," according to the result of a study conducted by the Norwegian College of Fisheries Science at the University of Tromsø.<sup>10</sup> The current ratio of omega-3 to omega-6 in Norwegian salmon from aquaculture is 1:1.

\* TEQ = toxic equivalent, unit of measurement for polychlorinated dioxins and furans



### Salmon from aquaculture: Better dioxin and PCB values

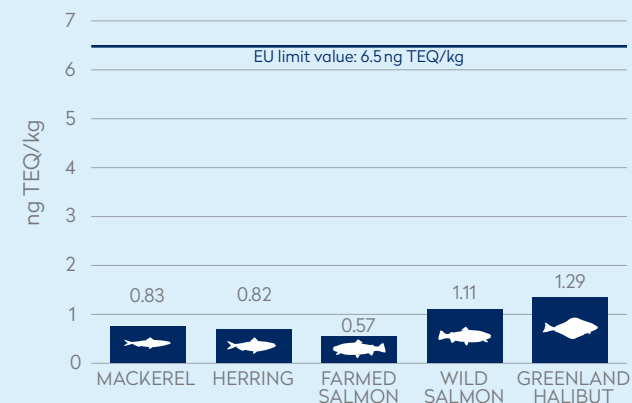


Fig. 3: NIFES, 04/2017

### Four times fewer dioxins and PCBs in salmon from aquaculture

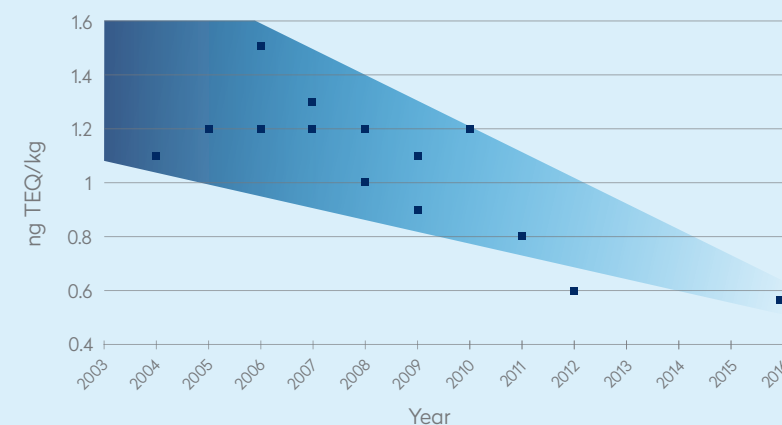


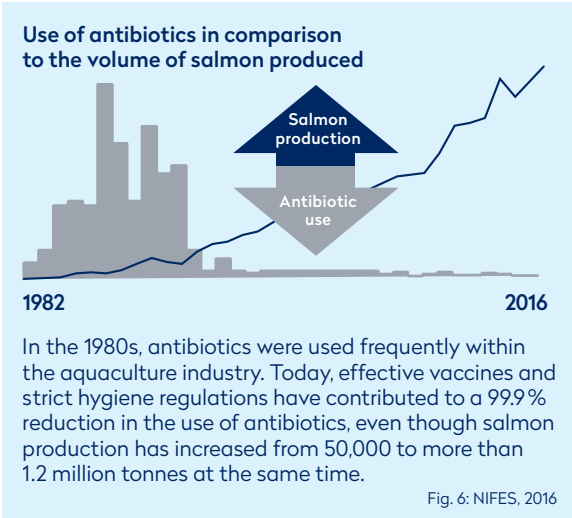
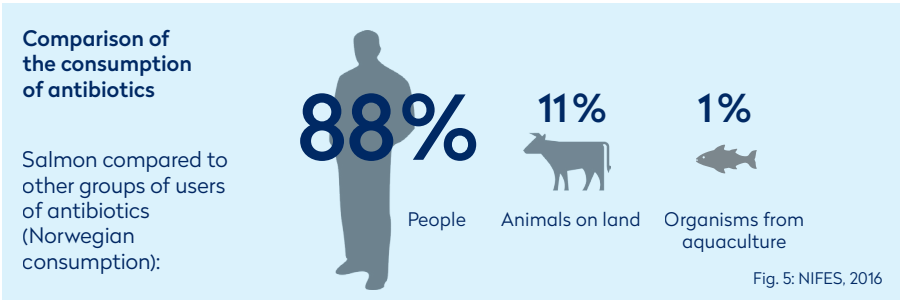
Fig. 4: NIFES, 04/2017





For further information on the benefits of eating seafood:  
[www.who.int](http://www.who.int)  
[www.fao.org/fishery/en](http://www.fao.org/fishery/en)  
[www.efsa.europa.eu](http://www.efsa.europa.eu)  
<https://sjomatdata.nifes.no/#search>

For further information on all of the boundary limits and test results:  
[www.fao.org](http://www.fao.org)  
<https://www.nifes.no/rapporter-2/>  
<https://goo.gl/cNIMfB>



**Does salmon from Norwegian aquaculture contain lots of antibiotics?**

No, because Norwegian salmon is healthy. The likelihood of Norwegian farmed salmon being given antibiotics is extremely small thanks to the one-off combined biological vaccine provided to protect against the most common bacterial infections suffered amongst salmon and the stringent hygiene regulations in place. In fact, just 1% of all farmed salmon will come into contact with antibiotics at all during its lifespan. Whilst around 175mg of antibiotics is used per kg of meat in Germany, the Norwegians only use 0.00036 mg per kg of farmed salmon, equating to 0.18g of antibiotics per 1000 kg of Norwegian farmed salmon.

Although the production of salmon has increased from 50,000 tonnes to a total of more than 1.2 million tonnes since the 1990s, the use of antibiotics has dropped by 99.9 percent within the same time frame. In 2016, the National Institute of Nutrition and Seafood Research (NIFES) checked 12,000 farmed salmon for traces of medication. There were absolutely no traces or residues of antibiotics found within any of the samples. This matches up to the results of the past 20 years, during which time

national and international food authorities and independent monitoring bodies have not detected any residues of antibiotics in Norwegian farmed salmon. The samples are selected to be removed from production at random and without any prior warning. This salmon is ready for consumption by people in Norway and all around the world.

**Does eating farmed salmon pose any risks to people caused by the plant protection product endosulfan?**

According to the limits set by the World Health Organisation (WHO), farmed salmon is classed as a harmless source of endosulfan. The World Health Organisation states that the acceptable daily intake (ADI) of endosulfan residues in food is 0.006 mg per kg of a person's body weight. The content of endosulfan recorded in Norwegian farmed salmon has never exceeded 0.0025 mg per kg<sup>11</sup>. (At 0.00014 mg per kg, the average value is actually significantly less.) This means that if a person with a body weight of around 70 kg were to eat 300 g of Norwegian farmed salmon every day, this would only equate to 0.2% of that person's ADI.



# The sea as the basis for life

From air-dried cod in the Lofoten Islands to crab on the harbour quays of Trondheim – all have the same story to tell: The rich resources of the sea provide a solid economic foundation for the many small communities that exist along the Norwegian coast, as they have done for many centuries now.



The Norwegian coast, including all of the islands and fjords, measures around 101,000 kilometres in total, which is more than double the length of the Equator. Norway's coastal waters provide the perfect conditions for both inshore fisheries and aquaculture facilities. It is no surprise then that Norway is a fishing nation boasting extensive knowledge gained from a long tradition of catching fish.



The sea is of huge importance to the Norwegians and it always has been. Without the fishing industry, the many small communities that exist along the Norwegian coast would not exist at all. This is just one of the many reasons why fishing in Norway is so strictly regulated and monitored. Sustaining the sea as a valuable basis for life for current and future generations is one of the main objectives of the fishing policy in Norway. This applies to both wild stock and aquaculture alike. Protecting and not exploiting the sea requires a sustainable approach to what is one of Norway's key resources.



## Connected to Norway's natural environment

**The Norwegian aquaculture industry operates in the natural environment, which imposes a wide range of responsibilities on everyone involved. The authorities, the research community and industry have to work closely together to ensure that operations and production within Norwegian aquaculture facilities are sustainable and that a strain is not put on the essential resource that is the sea.**

Whether it takes place on land or in the sea, food production will always impact on the environment. This might be in the form of various types of emissions, harmful effects

on biodiversity or the consumption of non-renewable resources such as crude oil.

In 1987, the World Commission on Environment and Development (WCED) provided the following definition of sustainable development: "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs."<sup>12</sup>

Sustainability can be broken down into three aspects: Social, economic and environmental sustainability. The challenges currently being faced by the Norwegian aquaculture industry fall within the scope of environmental sustainability.

In 2011, as part of a new initiative, the corporate members of the Norwegian Seafood Federation (FHL) pledged their commitment to increasing their efforts in

combating the two major factors threatening environmentally sustainable aquaculture: Escapees (salmon escaping from facilities) and salmon lice. The regulations set out by this initiative are much more stringent than those imposed by the authorities.





## The vision of zero escapees

**When salmon escapes from facilities, with these fish being known as “escapees”, there is a chance that it will become mixed in with wild stock. Another issue is that every single salmon that leaves a net pen and enters the open fjord also represents a financial loss. Norway has introduced its “vision of zero escapees” in its attempts to overcome this particular challenge.**

A special committee has been set up in Norway and tasked with the primary objective of minimising the number of escapees. There are many reasons why fish manage to escape from facilities, but the most common are technical defects, improper use of equipment, propellers that damage the nets and extreme weather conditions. The law states that facilities have to be designed to withstand the expected levels of bad weather for a period of 50 years.

Aquaculture facilities in Norway primarily produce Atlantic salmon, which is the same species, with the same genes, as the wild salmon found along the Norwegian coast and in the rivers in the country. Recent research has shown that there is farmed salmon in the rivers of Norway, although only in small quantities that are usually

below five percent. Whether farmed salmon has any impact on wild salmon, and if so what form this might take, has not yet been sufficiently documented. The Norwegian fish industry views protecting wild salmon stock against escapees as its duty. This is why significant funds have been expended over the past 15 years in attempts to prevent salmon from escaping and to allow for rivers to be monitored and research conducted.

### 80% fewer escapees since 2006

A range of different measures were developed with the aim of keeping the number of escapees to a minimum, and they are certainly working: There was an 80 percent reduction in the number of escapees in Norway between 2006 and 2016. Whilst 921,000 fish escaped in 2006, this figure was down to just 188,726 fish in 2016 (including 126,000 farmed Atlantic salmon, 62,000 fjord trout and 726 halibut), despite production increasing within the same period. Although the number of escapees is currently stable, the industry in Norway is still working on potential ways to improve the situation even further so that the figures continue to drop.

### Measures in place to minimise escapees

- Farmers check the fish within their facilities on a daily basis.
- Farm teams include escapee experts who have had specialist training and work to prevent fish from escaping as well as spotting and containing escapees.

- Compulsory risk assessments are implemented regularly and emergency plans drawn up, outlining effective ways of identifying and stopping escaping fish and of recapturing escapees.
- The mesh size of nets must be suitable for the fish in question to stop them from slipping through. All net pens must be checked regularly before and during active operation.
- Underwater cameras ensure that net pens are monitored at all times. Specially trained divers are also employed to perform regular checks underwater.
- Fish are marked and a tracking system is used in order to tell the difference between farmed and wild salmon and to be able to determine which facility the fish came from.
- OURO is an organisation tasked with removing escapee farmed fish from bodies of water.

### Farmers take their responsibilities seriously

In 2015, a new set of rules came into force in Norway to regulate the collective responsibility for recapturing farmed fish that have escaped and ended up in rivers. It also stipulates boundary limits for escaped salmon, with measures having to be implemented if these targets are to be reached. On the basis of the new rules, OURO, an organisation tasked with removing escapee farmed fish from bodies of water, was formed in the same year.

OURO is financed by the industry and involvement is compulsory for farmers. In 2015, the programme resulted in 521 fish being removed from 37 rivers at a cost of approximately EUR 350,000.

The rules introduced in 2015 replaced the previous voluntary environmental fund that was set up and funded by the farming sector itself in 2011. In the four years that this

existed, a whole range of actions were taken in more than 100 rivers. Somewhere in the region of EUR 3.3 million was spent on monitoring and recapturing escapee farmed fish from bodies of water. The funds were also used for training and projects relating to the tracking and traceability of fish.

Number (in thousands) of escaped Norwegian farmed salmon since 2001

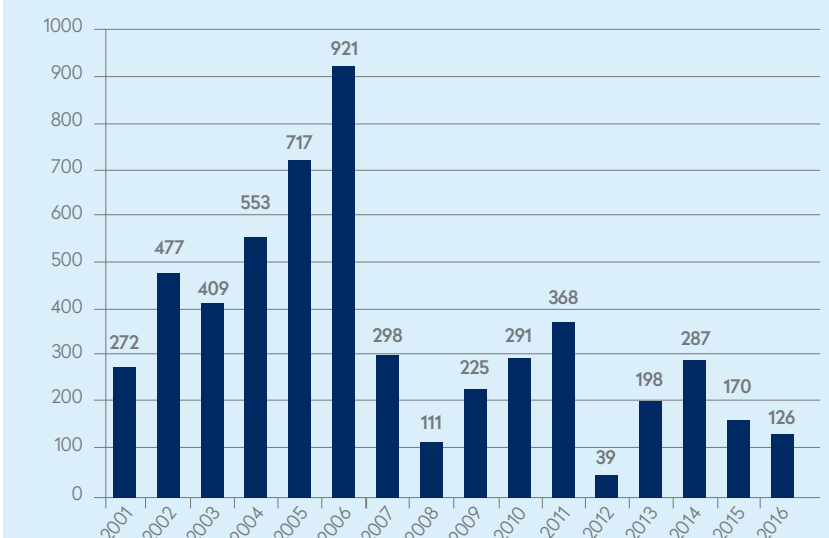


Fig. 8: Norwegian Directorate of Fisheries, 2017





## Counting salmon lice

The salmon louse (lat. *Lepeophtheirus salmonis*) is a parasite that naturally occurs in all oceans in the Northern Hemisphere. These lice live and breed on wild and farmed salmon alike and are actually a species of crab with eight stages of development. During the initial stages, they are carried along by bodies of water, meaning they can spread over relatively large areas. When a salmon louse attaches itself to a host (fish), it can develop into an adult louse that can then breed.

A salmon louse does not actually pose any problems for its host farmed salmon and it will not impact negatively on the quality or food safety of the flesh of the salmon. However, if a farmed salmon has too many salmon lice attached to it, its welfare may be affected as a result.

Given that Norwegian salmon farmers take animal welfare very seriously, government institutions, the fish industry and scientists work closely together to continually reduce the salmon louse population. Monitoring and documenting the existence of lice is crucial in this quest. In Norway, there are three different ways of combating salmon lice:

Through biological methods (e.g. cleaner fish), using a Thermolicer (patented mechanical method) or through treatment with authorised medication (baths or feed additives).

### Monitoring and control

Farmed salmon in a facility must be checked for lice infestation on a weekly basis, with lice being counted per salmon and the results recorded in writing. The permitted upper limit is an average of 0.5 female salmon lice per fish. All figures for counted lice must be submitted to the Norwegian Food Safety Authority (Mattilsynet). All documentation is compiled in the joint aquaculture industry database and can be accessed by the public at any time: <http://www.lusedata.no/>

“BarentsWatch”, an online programme run by Mattilsynet, is a weekly report on the lice status at all farms across Norway and can also be accessed by the public at any time: <https://www.barentswatch.no/en/fishhealth/>

### Effective measures

It is important to Norwegian farmers that the methods for combating lice are implemented optimally in order to keep the lice numbers to a minimum and provide maximum protection for the fish. And this has definitely paid off, given that 98 percent of all salmon farms are currently operating within the limits stipulated by the Norwegian Food Authorities (0.5 female salmon lice per fish).

In 2016, there was a significant reduction in the use of medication to combat salmon lice at Norwegian aquaculture facilities. This positive development is the result of the strategy employed by the industry as a whole. More than half of all facilities in Norway rely on biological methods to combat lice, such as the use of cleaner fish, lump fish, shields to keep lice away in the form of lice skirts, or Thermolicer systems, which provide a patented mechanical way of bathing salmon in water to gently remove lice.

### Measures for combating salmon lice

- The use of lice filters in production facilities and on transport vessels in order to lower transfer rates.
- The use of wrasse and cleaner fish. Around two or three wrasse are required to remove 100 lice. Norway has started to breed wrasse in order to preserve the limited wild stock which currently stands at about two million wrasse. Approximately 15 million wrasse are needed to cover the current demand within the Norwegian aquaculture industry.
- The extension of research activities on the basis of existing data held by the Norwegian Seafood Federation (FHL).
- The government subsidisation of projects relating to efficient and environmentally friendly ways of combating salmon lice.
- The use of lasers as a new method of removing lice from infested salmon.



# Norway's impressive ecological footprint

When it comes to salmon production, Norway's ecological footprint is impressive, especially in view of carbon dioxide (CO2) emissions. This result was determined by SINTEF, the largest independent research institute in Scandinavia, NTNU, the Norwegian University of Science and Technology, and SIK, the Swedish Institute for Food and Biotechnology.

The ecological footprint was assessed for 22 Norwegian fish species, as the measure of impact on the environment that conveys this information in the clearest way. Direct and indirect emissions of greenhouse gases during fish production were measured, taking into account the full production and life cycle of the fish, including the export of raw materials.

Some of the key results:

- 1kg Norwegian salmon fillet, which will be sold on the Paris fish market, will generate CO2 emissions equating to around 2.5kg.
- The production of Norwegian salmon has roughly the same ecological footprint as

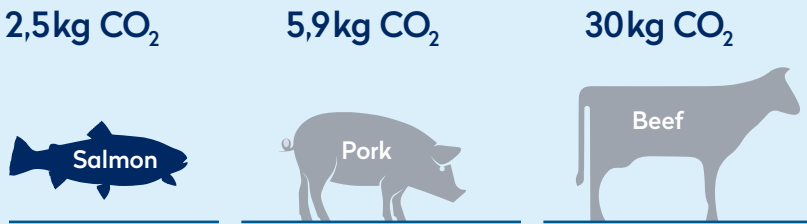
- chicken, which is much lower than that of other animals, such as pork (around 5.9 kg) and beef (around 30 kg).
- The majority of CO2 emissions associated with salmon from aquaculture occur at the feed production stage.
- The processing of the salmon itself, such as filleting, involves minimal CO2 emissions.

A group of researchers calculated the emissions that occur during the production processes for different foods in different countries and compared the resulting values. In each case, the full production cycle was taken into account, as far as the product reaching the end consumer. The following factors were considered for each of the production cycles: Energy usage, the use of living organisms, greenhouse gas emissions, pollution and unused food, such as feed. Norwegian salmon emerged victorious, with the smallest ecological footprint of all of the foods included in the test.

Although Norwegian salmon from aquaculture does have the least impact on the environment comparatively, there is still always room for improvement. The current progress report can be accessed by the public at: [www.environment.no](http://www.environment.no)



Salmon has the smallest ecological footprint



Norwegian salmon has the smallest ecological footprint: In order to produce 1 kg of salmon, just 2.5 kg of CO2 is consumed. By way of comparison, pork has an ecological footprint of 5.9 kg of CO2, whilst the figure is 30 kg of CO2 for beef, with 1 kg of meat being produced in each case.

Fig. 9: NSC, 2014



## Sustainable feed for healthy salmon

**Fisheries and aquaculture are amongst the main sources of food for people all around the world. In 2016, half of the global demand for fish was supplied by the aquaculture industry for the first time.<sup>13</sup> On the basis of salmon production having risen on a global level and the desire to ensure that the use of marine resources does not increase, in-depth research is conducted with the aim of developing sustainable methods and alternative sources for the production of fish feed.**

While salmon production has increased, the amount of feed consumed has not risen at the same rate. This is the result of optimised feeding methods that ensure more feed is

given directly to the salmon, with less just landing in the sea. Sensors and underwater cameras are used within the salmon industry in Norway to avoid the feed being released and wasted. The composition of the ingredients in the feed has also been improved, making salmon growth more efficient.

Feed represents the biggest cost that has to be factored in within the aquaculture industry. As well as being crucial to salmon farm finances, effective feeding also has a huge impact on the welfare of the fish.

### Fish feed ingredients

Salmon can convert its food into body mass more effectively than any other animal, but this relies on the individual ingredients within the fish feed having the right composition.

Salmon feed currently contains around 70 percent plant matter and around 30 percent marine animal-based raw materials. Fish feed in Norway must not contain any genetically modified ingredients.

Plant-based ingredients (69 percent) in fish feed come from soya, sunflowers, rapeseed, maize, broad beans and wheat, for example, and act as sources of protein, carbohydrates and fat.

Fish oil and fishmeal (28 percent) are produced using fish offcuts or wild fish that is not suitable for human consumption. Fish oil is rich in marine animal-based omega-3 fatty acids EPA and DHA, whilst fishmeal contains proteins and minerals.

Fish protein concentrate (1 percent) is made from fish offcuts taken from the consumer fish industry.

Other ingredients (3 percent) include minerals, vitamins, pigments and amino acids. Salmon feed also contains the antioxidant astaxanthin, which strengthens the immune system of the salmon and protects its tissue, as well as providing vitamin A and giving farmed salmon its reddish colour.

### Healthy food for healthy Norwegian salmon

As is the case with all aspects of the Norwegian aquaculture industry, fish feed is subject to strict checks in the interests of the fish, people and the environment. The Norwegian National Institute of Nutrition and Seafood Research (NIFES) monitors and compiles results from the governmental programme of checks on fish feed and its additives. The most recent report was published in 2015 and can be accessed by the public at: [www.nifes.no](http://www.nifes.no). No illegal

substances were found in any of the fish feed samples or during any of the checks on the fish feed. In addition, all of the legal substances were present within the statutory limits set out by the EU<sup>14</sup>.

## The rules for Norwegian fish feed

**Global standards apply to feed within the aquaculture industry. Within Europe, the EU regulates all aspects of fish feed and the Norwegian feed industry is directed largely by these rules and laws stipulated by the EU. However, Norway does also have some of its own rules and laws relating to fish feed within the aquaculture industry**

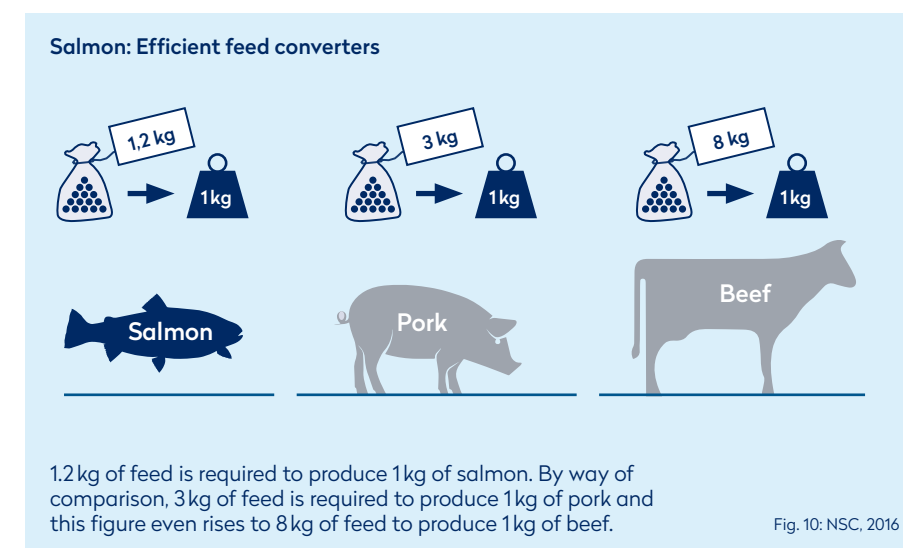
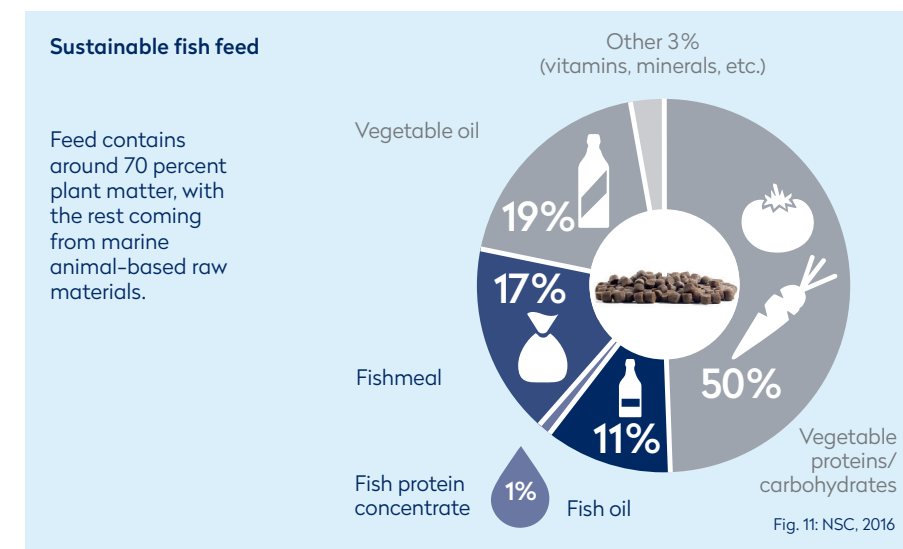
The main organisations that set the global standards for fish feed around the world are:

- The World Health Organisation (WHO) and the Food and Agriculture Organisation of the United Nations (FAO) with their “Codex Alimentarius” code of conduct for good animal nutrition.
- The World Organisation for Animal Health (OIE) with “The importance of controls for animal feed with respect to potential negative effects of the feed on animals and people.”

These rules and directives have a huge impact on the rules and laws laid down by the EU and in turn on Norway. In Norway, laws relating to feed are regulated and monitored by the Norwegian regulatory body for food safety (Mattilsynet).

Here are some extracts from the additional regulations applicable to animal feed within Norway:

- Animal feed should not cause any damage to the environment or have a negative impact on animal welfare.
- Animal feed must be healthy, genuine and authentic, suitable for its intended purpose and of high quality.
- Animal feed must be labelled and packaged in line with the provisions of the laws relating to feed. The labels and packaging should not be misleading in any way.
- All provisions relating to additives in animal feed must be observed and followed.





# Frequently asked questions

## Are the measures for combating salmon lice harmful to the environment or to crustaceans?

Aquaculture facilities implement a range of measures in their efforts to combat salmon lice, such as the use of wrasse and medication permitted by law. Any medication that is used will have been approved by the Norwegian Medicines Agency (NOMA) following a thorough testing procedure. In order to minimise any potential impact on the environment and the use of medication, the use of such substances is subject to extremely stringent regulations. The use of medication that might be harmful to crustaceans living near aquaculture facilities is strictly regulated during the summer months, as most crabs shed their shells at this time of year.

## Is using fishmeal from wild fish to feed salmon from aquaculture a waste of natural resources?

The production of salmon from aquaculture is one of the most resource-friendly processes within industrial animal breeding. Around 1.2kg of fish feed is currently required to produce 1kg of salmon. For this 1.2kg of fish feed, around 2.0 to 2.5kg of wild fish is required, consisting of fish offcuts (28 percent) or fish that is not suitable for human consumption. By way of comparison, a wild salmon needs up to 10 kg of food to put on 1kg of weight. Tracking systems and regular supplier checks ensure that the wild fish used is sourced from fisheries that are regulated by the authorities. Fishmeal and

fish oil are also certified in line with the IFFO RS standard\*. The IFFO (International Fishmeal and Fish Oil Organisation) is an observer working on behalf of the Food and Agriculture Organisation of the United Nations. The regulations forbid the use of fish from unregulated and unregistered catches.<sup>15</sup>

## Why is ethoxyquin used in fish feed and is it harmful to my health?

Ethoxyquin (EQ) is an antioxidant that EU law requires to be added to fishmeal when it is being transported on large vessels so as to prevent oxidation processes from taking place. The boundary limit set by the EU for fish feed is 150 mg per kg. In Norway, laws relating to feed are regulated and monitored by the Norwegian regulatory body for food safety (Mattilsynet). The results of the ongoing programme of checks reveal that, at between 0.02 and 0.04 mg per kg, traces of ethoxyquin are so low even in a large portion of Norwegian farmed salmon (300g) that they are between 4 and 15 percent below the daily amount permitted by the WHO. By way of comparison, the average EQ value of a pear is 6.6 times higher at 0.2mg per kg. Nevertheless, research into the optimisation of storage and transportation methods for fish feed continues to be conducted in Norway, with the aim of reducing the amount of additives used even further.

## Where does the soya used in salmon feed come from?

In order to save limited marine animalbased resources, some of the marine fishmeal in Norwegian fish feed has been substituted for soya, with the current proportion being 25 percent. Imported in the form of soya protein concentrate, soya acts as a source

of protein for salmon. Only sustainable soya products are imported into Norway and they must be certified in line with the RTRS standard\* or the ProTerra standard. Feed manufacturers are also bound by the open industry standards set out by the European Feed Manufacturers' Federation (FEFAC), which are based on global certification standards. The latter stipulate requirements relating to environmental responsibility, the prevention of deforestation, environmental emissions and erosion. Basic employment rights for farmers, employees and indigenous people also apply at all times.

## What makes the wild fish used to produce fish feed unsuitable for human consumption?

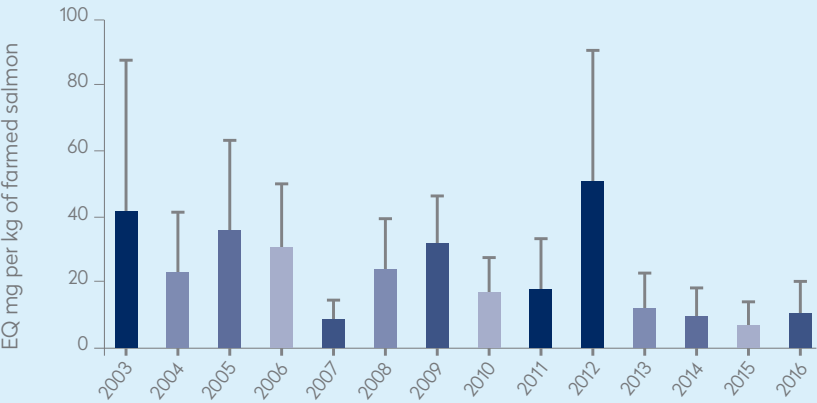
Not all species of fish are suitable or in demand for direct consumption by people. According to statistics provided by the Food and Agriculture Organisation of the United Nations (FAO), 75 percent of fish produced globally is intended for human consumption. The remainder is used mainly to produce fishmeal and fish oil.

\* Global Standard and Certification Standard for the Responsible Supply of Fishmeal and Fish Oil

\*\* RTRS = Round Table on Responsible Soy



Ethoxyquin in fish feed: Progression since 2003



The proportion of marine animal-based ingredients in Norwegian fish feed has been reduced to 30 percent over the course of the past 10 years in order to save natural resources. The sharp drop in the amount of ethoxyquin residues found in Norwegian farmed salmon corresponds to the low proportion of fishmeal used in modern fish feed.

Fig. 13: NIFES, 04/2016

Ethoxyquin: salmon vs. pear

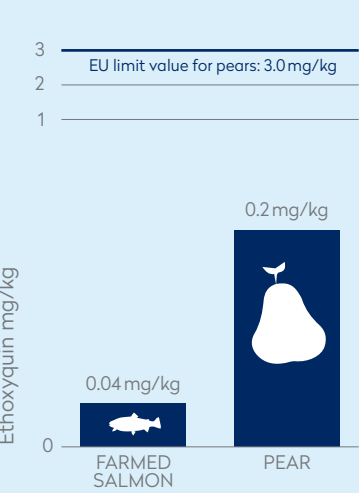


Fig. 12: NIFES, 2015



# Norwegian aquaculture

Before an aquaculture farm can start operating in Norway, an official licence must be obtained. Norwegian producers have an ethical and legal responsibility to ensure the welfare of their fish, which is why every licensed aquaculture farm is required to adhere to strict requirements relating to environmental protection, fish health and food safety.

The production of salmon has increased from 50,000 tonnes to a total of more than 1.2 million tonnes since the 1990s. Despite this, Norway is only using 0.5 percent of the sea area available for aquaculture.





Responsibility to the environment should determine the way in which aquaculture facilities in Norway are set up, operated and managed. The Norwegian aquaculture industry is governed largely by the Aquaculture Act – the currently applicable aquaculture legislation – which falls under the jurisdiction of the Norwegian Ministry of Trade, Industry and Fisheries.

## High standards in the interests of the fish

**By law, Norwegian salmon must be provided with an environment in which its welfare is guaranteed for its entire lifetime. All Norwegian fish farmers are legally responsible for ensuring that their facilities are run in a way that provides for the optimum health of their fish. The Norwegian Veterinary Institute (Veterinærinstituttet) testifies to the good health of Norwegian salmon from aquaculture. There are high standards for fish health in Norway and Norwegian farmers take the health of their fish very seriously. In fact, the Norwegian fish health service is leading the way in the industry on a global scale.**

Employees of farms, slaughterhouses and transportation companies have to be able to demonstrate that they have sufficient knowledge about the care, maintenance and general handling of fish. What's more, they are also required to complete relevant training sessions every five years as a refresher and to add to what they already

know. The Food Safety Authority (Mattilsynet) conducts regular checks to ensure that companies have the skills required. In Norway, significant funds are also invested in the research and development of new technologies and ways to best treat salmon in order to guarantee fish health.

### Optimum water quality for healthy salmon

When considering the welfare of the fish, it is important to ensure that the water is of a high quality. Breeding tanks must be set up in such a way that clean water flows through the pen at all times, with maintenance measures in place to guarantee this. The oxygen level, temperature and salt content must be checked on a regular basis. As salmon, like many fish, are cold-blooded creatures, their body temperature adapts to the temperature of their surroundings. Higher temperatures stimulate their metabolism and cause their oxygen consumption to increase. Plus, warm water contains less oxygen than cold water in the first place. It is a further requirement that all farms have an alternative system available to avoid the welfare of the fish being at risk in the event of a system failure. The Norwegian Institute for Water Research (NIVA) is responsible for research, develop-

ment, documentation and consultation on fish health within the aquaculture industry.

### Plenty of room in secure facilities

The design of facilities must allow for the salmon to have plenty of room. The fish to water ratio here is regulated by legislation in Norway: 97.5% of the space must be filled with water and 2.5% with fish. Pens must also be adapted to suit the weather conditions and other environmental factors. Facilities may not have any sharp edges or be made of any materials that may be harmful to the fish. They should also be designed to provide maximum protection for the fish to avoid them being attacked by other animals. In 2004, the regulation on the technical requirements for floating aquaculture facilities (NYTEK Regulation) was introduced with the aim of preventing fish from escaping from farms. All facilities must have been issued with the relevant farm certification.

### Monitoring is essential

Farmers within the aquaculture industry are obliged to check their fish, pens and production units every day, with the salmon being disturbed as little as possible in the process. They are also required to perform

additional checks before and after spells of bad weather. Alarm systems installed for facilities have to be checked at least once a week. All farms keep operational plans, which each cover a two-year period and are assessed by the Norwegian Directorate for Fisheries and the Norwegian Food Safety Authority.

### Needs-based feeding

It is crucial that salmon feed is healthy and that the fish like the taste. Salmon feed is based on the needs of the fish in question, with factors such as species, age, weight and physiological requirements being key in the decision-making process. For example, extra-tasty feed is given to young salmon several times a day, but the pellets are much smaller than those fed to fully grown salmon. As the salmon get older, for example, they are fed much less frequently and the size of the pellets is increased. Adult salmon also need their food to have a different composition. This phenomenon is evident throughout the animal world: Puppies are given puppy food three times a day, whilst adult dogs are given the appropriate adult food and only fed once or twice a day. Norwegian fish farmers are very careful to only ever give their fish the right

amount of food and ensure that as little as possible falls to the ocean floor. After all, fish feed is one of the biggest costs to be factored in to Norwegian salmon farming.

### Preventive hygiene measures

Good levels of hygiene are essential in guaranteeing the welfare of salmon. All facilities are subject to inspections at least six times a year and have to be examined by a vet at least twice a year. It is also the responsibility of fish farmers to keep their facilities clean at all times.



## Strict requirements for farmers

**Before a new farm can start operating, an official licence must be obtained. If farmers want to be granted a licence, they must submit an extensive application for their new farm site to the Directorate for Fisheries. This will then be assessed at length by the regional and municipal authorities, the Food Safety Authority, the National Coastal Administration and the Directorate for Water and Energy. Sites are subject to strict national requirements. These relate to aspects such as the current conditions, which stipulate that the farm must be located in an area with good water flow. Despite the growth of the aquaculture industry, the number of sites dropped by 40 percent between 2000 and 2010. There are 527 aquaculture farms in operation in Norway in 2017.**

When farmers are applying for a licence for a new site or for an extension for an existing licence, the authorities demand environmental surveys that provide information about the ocean floor conditions. Farmers are required to continually monitor the impact their facilities are having on the ocean floor in the surrounding area. The results must always be in compliance with the Norwegian NS 9410 standard and should be submitted to the Norwegian Directorate for Fisheries. All results can be accessed by the public at any time at: [www.fiskeridir.no](http://www.fiskeridir.no)

Once a production cycle is complete, the entire fish stock has to be removed from a pen. The site should then be left empty for

at least two months before it can be refilled with young fish. This measure is in place to allow for regeneration of the ocean floor and to reduce any risk of infection in the region. The fish contained within one net pen must all be the same age. If aquaculture operations are being permanently stopped at a site, all pen installations above and below the surface of the water must be removed within six months.

### Supervision by multiple authorities

The Directorate for Fisheries, the Food Safety Authority, the Coastal Administration, the regional authorities and the Directorate for Water and Energy all take on a supervisory role when it comes to environmental matters and the impact of a farm on the environment. Within the scope of the regulation on self-monitoring, the aquaculture industry is also required to perform its own risk assessment in relation to the impact on the environment amongst other things. Furthermore, it must monitor a range of environmental criteria that are explained in further detail within the various rules and licences applicable to farm operations.

### Good to excellent environmental status

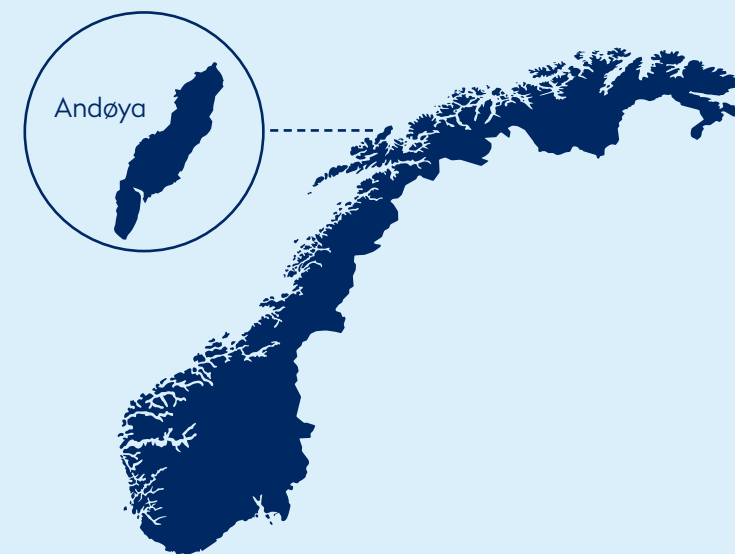
Surveys over the past few years have confirmed that everything is perfectly in order in and around aquaculture farms in Norway as far as the environment is concerned. In 2014, the status of almost all Norwegian facilities was assessed as “good” or “excellent” in both the immediate area (94 percent) and the transitional area (93 percent).<sup>16</sup> The Directorate for Fisheries monitors the results of environmental surveys and takes appropriate action in the event that they are not satisfactory.



### Leading the way for the future

In 2013, the Norwegian government introduced a new type of licence for aquaculture farms, which are called “green licences” or “development licences”. There were two reasons for this: Firstly, as the world population grows, so does the demand for healthy sources of protein. Norway’s response to this is to increase salmon production, but this can only be achieved in harmony with nature. The two biggest challenges currently being faced within the Norwegian aquaculture industry are salmon lice and escapees. On this basis, the Norwegian government issues green licences to farmers who manage to find solutions to both problems using new technologies. In other words, they need to increase the production volumes within one production cycle, whilst also curbing salmon lice and reducing the number of salmon escapees. You can read more on this in the “Future prospects” section of this report.

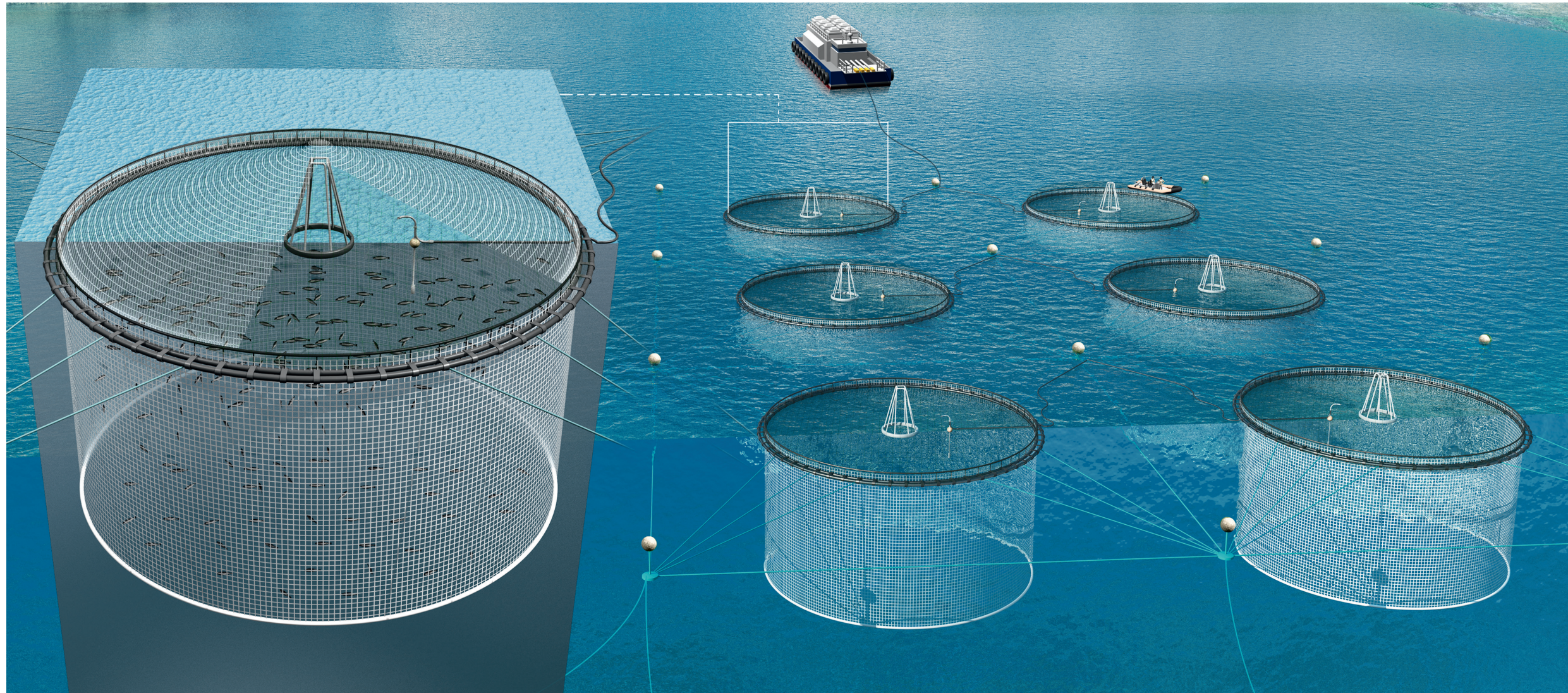
In Norway, only 450 km<sup>2</sup>, or 0.5 percent of our 90,000 km<sup>2</sup> is used for aquaculture.



If all of the aquaculture farms in Norway were combined, they would all fit on a single island: Andøya.

Fig. 14: NSC, 2014





## Values based on animal welfare

**The net pens used in Norwegian aquaculture farms are designed to insure optimal growing and living conditions for the fish. Each net pen contain approximately 2,5% fish and 97,5% water.**

- The diameter of a net pen is around 50 metres. The largest net pens have a circumference of 250 metres.

- A typical net pen is between 20 and 50 metres deep, which equates to a length between that of a short-course and long-course swimming pool.
- The net pens are firmly anchored to the ocean floor.
- The number of fish contained in one net pen is strictly limited to 200,000 in order to give them enough open space.
- A net pen includes a support element that floats on the surface of the water, a net that the fish swim around in and a net over the pen that protects the stock against other creatures, such as birds.
- The oxygen level, salt content and temperature of the sea water are checked on an ongoing basis in the interests of the health and welfare of the fish.
- A typical aquaculture farm consists of between six and ten net pens with a total maximum capacity of 3000 to 5000 tonnes of fish.
- Aquaculture farms and net pens need good water flow to guarantee the welfare of the fish and to provide a natural way of cleaning the floor underneath the facilities.





## From roe to chiller

Norwegian salmon production ensures safety and welfare throughout the entire life cycle of the fish. These supervised processes result in a product of supreme quality, which again has given a significant expansion in the markets for Norwegian salmon.

### ROE

The salmon production process within the aquaculture industry starts in an incubator. As is the case with wild salmon, the fish roe is fertilised in freshwater. After about 60 days in cold water at a temperature of eight degrees Celsius, the salmon fry hatch.



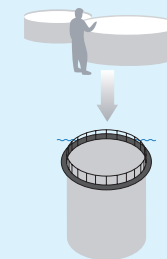
### FRY

After they hatch, the salmon fry have a yolk sac attached to their stomach, from which they draw nourishment. At this stage of their development, they are called "yolk-sac fry". The fry can be fed and transferred to freshwater tanks four to six weeks after hatching.



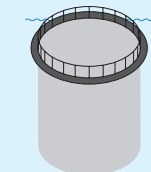
### SMOLT

After 10 to 16 months, the salmon will weigh between 60 and 100g and can be moved from freshwater to salt water. At this stage, they lose the parr marks on their skin, as they become dark on top and silver on the bottom. They also undergo organic changes and can now filter salt water out through their gills and kidneys. This process is called "smoltification" and is necessary if salmon are to survive in the sea.



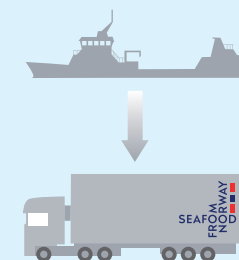
### SALMON

The salmon are kept in net pens in fjords. Depending on the target weight of the salmon, they will be left in the pens for between 14 and 22 months. Smaller salmon weigh between 3 and 4 kg, whilst larger fish can reach up to 6 kg. Norwegian law stipulates that only sterile salmon can be farmed in fjords.



### FINISHED PRODUCT

Once the salmon are ready for slaughter, they are carefully pumped from the net pens into a tank on a wellboat and transported to the production site. The top priority is ensuring that the journey is stress-free for the salmon in the interests of their welfare and to avoid any compromise on quality. When the fish reach the production site, they are stunned, slaughtered, gutted and washed, before being sorted by size and quality and put on ice in cooling cases. The cold chain must not be broken and the temperature should never drop below 4 degrees Celsius. Around 3 hours after the salmon are taken out of water, they will already be making their way to chillers within Norway or in one of the 100 countries that import Norwegian salmon.



4–6 weeks



FRESHWATER



10–16 months



14–22 months

SALT WATER







**For further information on the legal regulations that apply within the Norwegian aquaculture industry:**

[www.fiskeridir.no/English/Aquaculture/Aquaculture-Act](http://www.fiskeridir.no/English/Aquaculture/Aquaculture-Act)

<http://www.engvetinst.no/eng/content/download/17122/193717/file/Fish%20Health%20Report%202015.pdf>

## Frequently asked questions

### **What measures are taken by the Norwegian fish industry to stop diseases from spreading?**

Only 0.5 percent of Norwegian sea is taken up by aquaculture farms. There has never been a situation involving a disease spreading from one farm to another. Strict regulations are in place to dictate the distances between farms as well as the number of fish contained within pens. The Norwegian Food Safety Authority recommends that a distance of 2.5 km is maintained between small aquaculture facilities (below 3600 MTB\*), with this recommended distance rising to 5 km between large facilities (over 3600 MTB\*). The required ratio of fish to water within net pens is 2.5% salmon to 97.5% water.

### **What is Norwegian salmon vaccinated against?**

Norwegian salmon is given a one-off vaccine against the diseases that most commonly plague the species. Current vaccination offers effective protection against the bacterial infections that salmon might suffer from – this has been confirmed by the Norwegian Veterinary Institute (Veterinærinstituttet). The vaccination programme in place in Norway has resulted in a significant decrease in the occurrence of diseases that used to be the

cause of a high mortality rate amongst salmon. This also explains the minimal use of antibiotics within the Norwegian salmon farming industry now, with just 0.00036 mg being administered per kg of farmed salmon. Although the production of salmon has increased from 55,000 tonnes to a total of more than 1.2 million tonnes since the 1990s, the use of antibiotics has dropped by 99.9 percent within the same time frame. Annual reports on the health of Norwegian salmon can be accessed by the public at any time on the Norwegian Veterinary Institute's website: <http://www.vetinst.no>

### **How are salmon slaughtered in Norway?**

The slaughter of salmon is regulated by law in Norway, with compliance monitored by the Food Safety Authority (Mattilsynet). Ethical means of stunning and slaughtering the fish must be used at all production facilities. Once the salmon are ready for slaughter, they are carefully pumped from their net pens into a tank on a wellboat and shipped to the relevant production facility. Before being slaughtered, salmon are kept in resting tanks in the sea for one or two days. Salmon must be stunned before being slaughtered so as to avoid any unnecessary suffering caused by pain and fear as well as to prevent any reduction in the quality of their flesh due to stress. Stringent hygiene requirements must also be followed at the slaughtering stage. In Norway, no more than 1.5 to 3 hours pass from the start of the slaughter and processing stages to the product being ready for export.

\*MTB = the maximum total biomass permitted in an aquaculture farm



# Future prospects

Government authorities, independent research institutions and industry are working closely together to conserve the essential resource that is the sea and to secure Norway's sustainable aquaculture and traditional inshore fishery industries in the long term.



"The aquaculture industry is also hugely important for the supplier and manufacturing industries, and it revives the coastal regions and generates growth within urban areas. [...] It is for these reasons that the Norwegian government is so dedicated to nurturing and developing this particular industry. The biggest potential for growth lies with salmon, fjord trout and crustaceans, but the evolution of the aquaculture industry cannot be dictated solely by demand on the market. We also have to consider the impact on the environment every step of the way."<sup>17</sup>



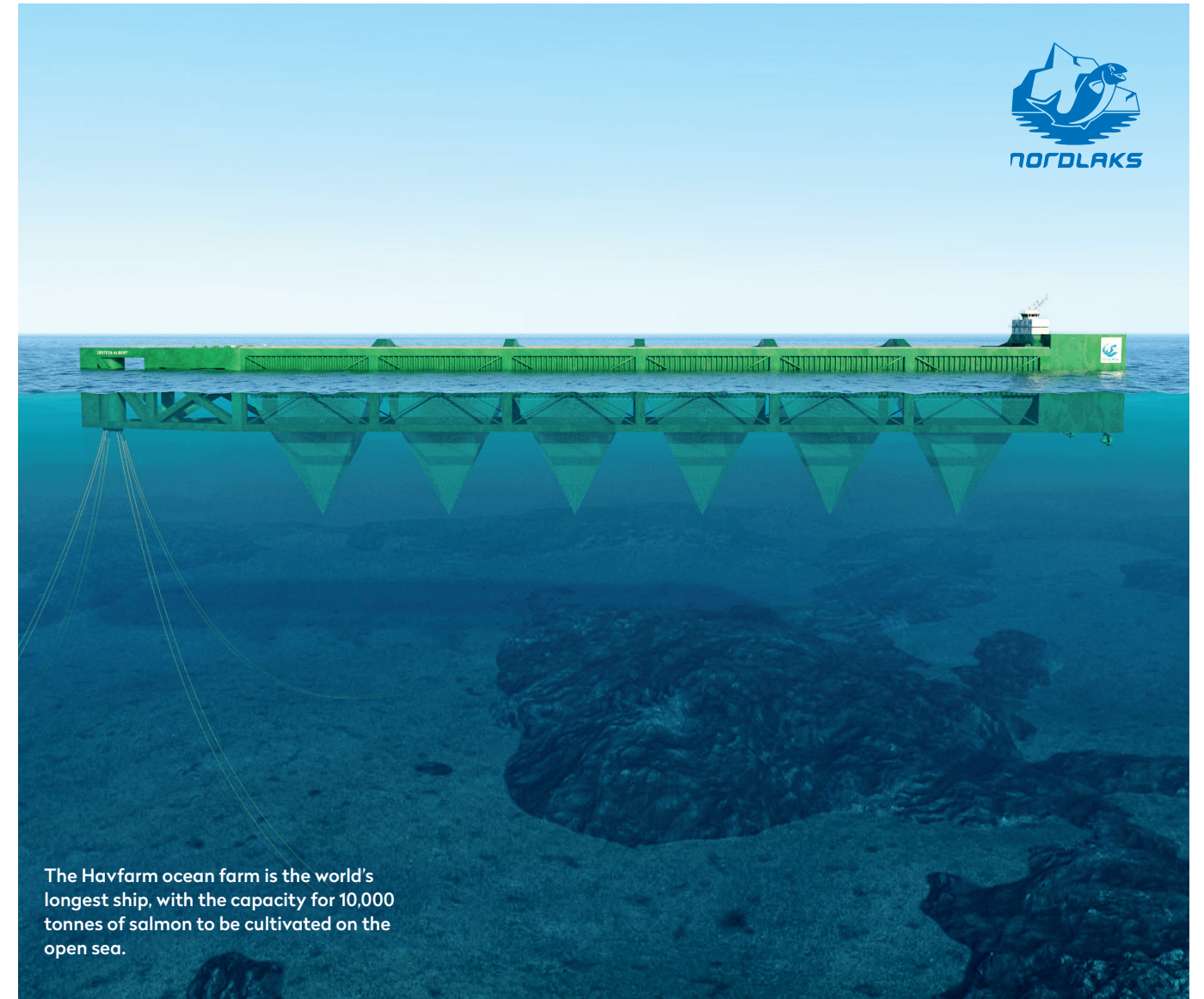


Offshore fish farming is Norway's answer to the two biggest challenges currently being faced within the aquaculture industry, as it aims to use it as a way to minimise both escapees and salmon lice infestations.

## Goals for the sea

The Norwegian government has calculated the value creation potential of the country's bodies of salt water up to the year 2050 and is working on the basis of it being six times that of today's potential. Given that wild fish stocks have been more or less steady for a decade, the only way to harness this potential is by making marine resources, such as algae and plankton, usable through research or by increasing levels of production within the aquaculture industry.

The government's view is that the most potential lies in upping salmon production. As of 2015, existing licensed aquaculture farms can grow by 5 percent once the salmon lice plight has been overcome without the use of medication having been increased. The Norwegian government has



The Havfarm ocean farm is the world's longest ship, with the capacity for 10,000 tonnes of salmon to be cultivated on the open sea.

released more funds to be spent on additional checks with a view to guaranteeing that this condition is realised.

### New technology

The future of the Norwegian aquaculture industry is not going to be determined solely by increasing production, developing new products or breaking into new markets. The most important future step is to also find new ways to keep cultivating the sea both sustainably and efficiently. In this respect, Norwegian aquaculture farms are reliant on ongoing biological and technological development.

### On the open sea: Offshore Fish Farming

Salmon farms in Norway are currently set up in fjords with good current conditions and with a whole host of factors and requirements having to be taken into account. Offshore fish farming refers to farms located

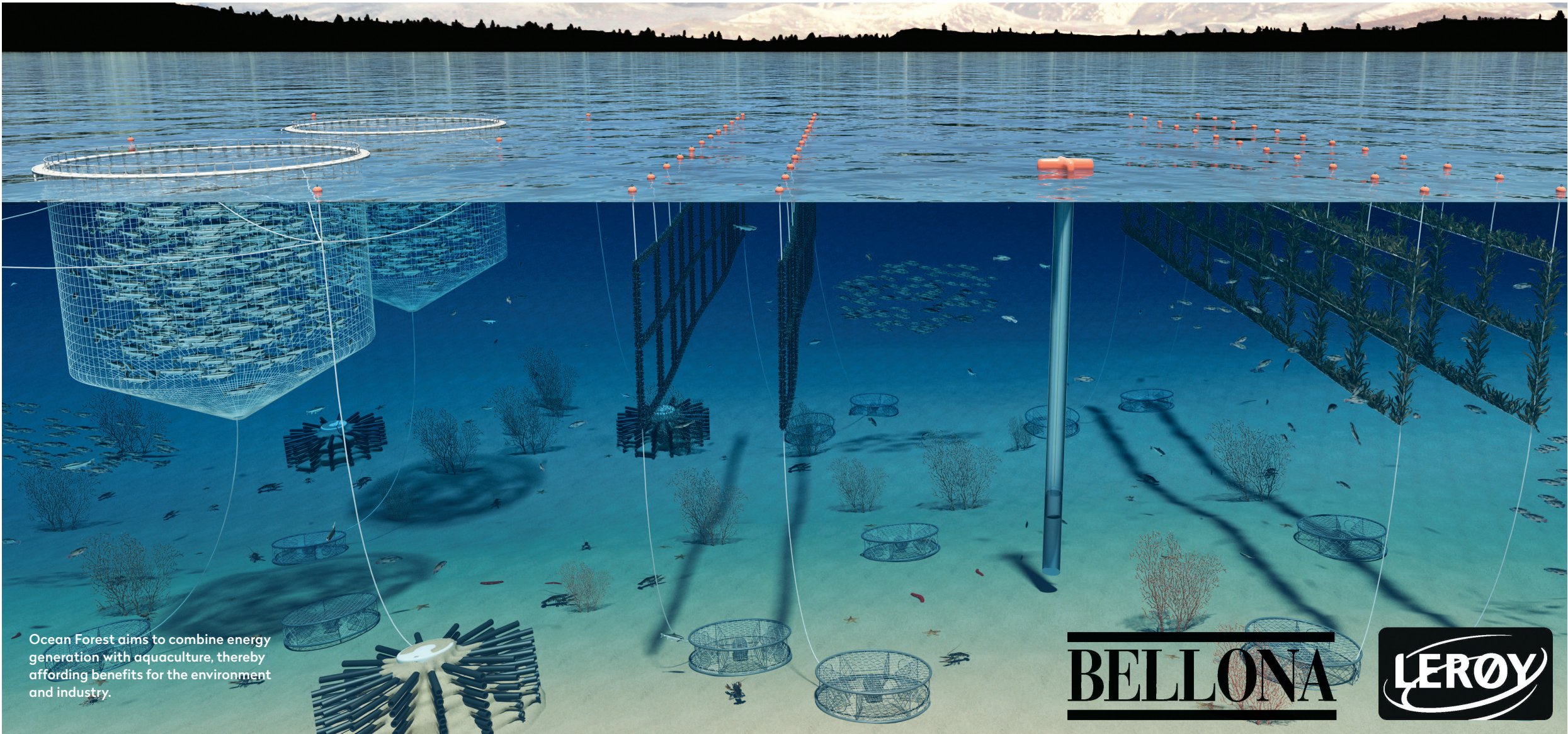
on the open sea. One potential new technology could be submersible aquaculture facilities with a more stable structure than conventional facilities, allowing them to be operated on the open sea. With their excellent flow conditions and robust design, these facilities could provide the optimal conditions for fish farming, whilst also reducing outbreaks of salmon lice and stopping the phenomenon of escapees. There are plans for an initial pilot farm to be set up and filled with young fish for the first time in autumn 2017.<sup>18</sup>

### Havfarm – the world's longest ship

One further project for the future is Havfarm, or "Ocean Farm", which is set to transport fish farming from the fjords to the open sea. Measuring 430 metres in length and 54 metres in width, this would be the longest ship in the world. It would offer the option of either being mobile or anchored to the

ocean floor in the same way as oil rigs. Havfarm is one response to the challenges currently being faced by Norwegian fish farmers, considering that its capacity of 10,000 tonnes would provide enough space for more than 2.5 times as much biomass as in conventional facilities. Havfarm's robust design means it can withstand bad weather conditions and provide protection for wild stock by stopping farmed salmon from escaping. The strong current conditions on the open sea would also serve to combat the issue of salmon lice.<sup>19</sup>





For further information on new technology within the aquaculture industry:

[www.sintef.no/home/Fisheries-and-Aquaculture](http://www.sintef.no/home/Fisheries-and-Aquaculture)

**Along the coast: Ocean Forest**

A project known as “Ocean Forest” being run jointly by the largest environmental organisation in Norway, the Bellona Foundation, and the second largest producer of salmon in Norway, the Lerøy Seafood Group, is breaking new ground when it comes to harnessing the resources offered by the sea. Against the backdrop of the growing world population and the increasing demand for food and energy this brings with it, the aim of Ocean Forest is to combine clean energy generation using biomass along the Norwegian coast with sustainable and efficient aquaculture. Seaweed can be cultivated together with farmed fish as well as mussels, benthos and microalgae. When cultivated on a large scale, algae and mussels can help prevent climate change, as they absorb and store carbon dioxide. Ocean Forest will bring a new farm concept to the aquaculture industry that involves the amount of carbon dioxide being removed from the atmosphere exceeding the amount of new carbon dioxide being generated. Ocean Forest promises improved production conditions for Norwegian industry and is set

to provide the foundation for new products to be developed, including food as well as feed for fish and animals all around the world. Energy and fertilisers are other products that will be able to be sourced from Ocean Forest.<sup>20</sup>

**The fish feed of the future**

Following on from extensive research, 70 percent of the ingredients in fish feed are now natural products from fishing and agriculture or man-made substances based on raw materials from nature. The reduction of the proportion of marine animal-based ingredients in fish feed to 30 percent is a sustainable measure that guarantees that the growing demand for fish from aquaculture can be met whilst also preserving and maintaining limited marine resources. What’s more, there is no negative impact on the welfare, health, growth or taste of the salmon.

**AQUAFLY – an exciting project for the future**

By the end of June 2018, the National Institute of Nutrition and Seafood Research (NIFES), in partnership with 12 universities

and research institutes in six countries, will have run tests on insects and insect meal being considered as a potential substitute for fishmeal and fish oil.<sup>21</sup> Insects are a source of many essential minerals and can contain a significant amount of omega-3 fatty acids. Before insects or insect meal can be used as an alternative that is both healthy and safe as far as the welfare of the fish and people as well as the environment are concerned, in-depth scientific research must first be conducted.

**Further alternatives to fishmeal and fish oil**

Work is currently being carried out on other projects that aim to reduce the proportion of marine animal-based ingredients in fish feed, with researchers performing tests on meal from the shells of blue mussels, algae and krill to identify whether or not these might make for suitable alternatives to fishmeal and fish oil.



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