

Creating value

Project year 2019





Fishing industry insights at your fingertips!

Every year, Nofima analyses the Norwegian fishing industry in terms of profitability, the number of businesses and general employment rates. These insights are now readily available to everyone, as we have published data from 1993 until today on our website.

Check out
<https://nofima.no/driftundersokelsen/>

CONTACT:
Thomas Nyrud
 Scientist
 +47 997 74 933
thomas.nyrud@nofima.no



PHOTO: JOE URRUTIA @ NOFIMA

Contents

A strategy benefiting the business community	2
Oils for healthier salmon and humans	4
Appetite entrepreneurs	6
Cool collagen research	8
Ideal onshore fish farm tanks	10
New insights into food safety	11
Omega-3 needs and new sources	12
Cabbage crops for every taste	14
Quantity over quality	15
Texture to prevent overeating	16
A popular research partner	17
Warming seas are bad news for salmon	18
Revolutionary new technology	20
The cod has become livestock	22
Socially sustainable fisheries	23
Advancements in food research	24
Developing new AGD treatment	26
Bacteria for better taste	27
From small-scale to cornerstone	28
Good food with extra protein	30
The Norwegian wheat adventure	31
Salmon feed more or less unchanged	32
Plant-based and protein-rich	33
World-leading crab research	34
Pulling together in a crisis	36
Closer to PD-resistant salmon	37
Behind the results	38
Nofima's mission	40

EDITORIAL STAFF:

Editor: Anne-May Johansen
 Editor-in-chief: Morgan Lillegård
 Contributors: Anne-May Johansen, Emil Bremnes, Lidunn Mosaker
 Boge, Reidun Lilleholt Kraugerud, Wenche Aale Hægermark,
 Wilhelm Solheim

GRAPHIC DESIGN AND PRODUCTION

Lay-out: Krysspress
 Printed by: Fagtrykk Idé AS
 Cover photo: Lars-Åke Andersen
 Translation: Semantix

Published by Nofima AS/January 2020
 ISSN 1894-4736 (printed)
 ISSN 1894 4752 (pdf)

To unsubscribe – please send email to post@nofima.no
 or call +47 77 62 90 00

A strategy benefiting the business community

A good strategy should create value for both the business and its customers. We are proud to launch our new strategy, which enables us to address emerging trends in society, among our clients, and in our field of research. In this way we will continue to provide research-based knowledge benefiting the business community.

Over the past few years, significant changes has occurred in our sector's environment, including:

- The preparation of the United Nations' sustainability goals in 2015
- The Research Council of Norway's strategy: "Research for innovation and Sustainability (2015-2020)."
- The Government's preparation and revision of the long-term plan for research and higher education (Report to the Storting, no. 4 2018-2019)
- Long-term plan for research and higher education 2019-2028
- The EU research programmes (Horizon 2020, Horizon Europe)
- The Norwegian Government's ocean strategy "Blue opportunities."
- The Norwegian Government's bioeconomy strategy "Known resources – unknown possibilities"

Common to all these strategies is the increased emphasis on finding new, sustainable solutions, while enhancing the society's ability to innovate. The changes will increasingly affect Norwegian and international research policies, and lead to changes to how policy instruments prioritize. At the same time, the industry must accommodate new demands from the market and stakeholder groups. These are key elements

of the strategy – value creation for the society, the trade and food producers.

We have also reviewed our vision, values and social mission. The new vision is 'Sustainable food for all', which reflects the UN Sustainable Development Goals and the essence of the Government's and the Research Council's strategy documents.

Our social mission has been focused to underscore the importance of the research we provide to the public administration with: "Excellent research and innovation contributing to sustainable food production and responsible governance of resources from sea and land."

Nofima's values: Engaged – Inclusive – Innovative – Responsible – Generous demonstrate that we expect our employees to be engaged in their work, including and involving their colleagues in the best interests of the company and our clients, and to think innovatively and discover new solutions.

Nofima has a clear ambition to be a leading research institute in food, fisheries and aquaculture, including adjacent industrial areas. We shall strengthen our activities oriented towards innovation and development with the objective of being a more relevant and competent knowledge provider.

In this year's edition of the magazine Creating value we present several interesting examples of how Nofima contributes to sustainable food production and a more sustainable society.

Happy reading!



Øyvind Fylling-Jensen
Managing Director



PHOTO: JOE URRUTIA © NOFIMA

Oils for healthier salmon and humans

Nofima scientists have found that a mix of plant oil and fish oil can stimulate formation of healthy omega-3 fats in animals and humans.

The healthy omega-3 fatty acids EPA and DHA are important for animal and human health. Fatty fish and fish oil contain high levels of EPA and DHA, whereas the shorter omega-3 fatty acid alpha linolenic acid (ALA) is dominating in plant oils. Both salmon and humans can synthesize EPA and DHA from ALA, but the capacity is limited. Now the researchers have found that the capacity can be improved and thereby utilize the plant omega-3 fatty acids in a better way.

Cetoleic acid as an omega-3 catalyst

Four years ago, Nofima scientists discovered that the fatty acid cetoleic acid acts as an omega-3 catalyst. Fatty fish species such as sand eel and herring from the North-Atlantic are rich in cetoleic acid. Cetoleic acid actually stimulates the conversion of the short omega-3 fatty acid ALA to the long and healthy omega-3 fatty acids EPA and DHA.

Effects in humans?

Scientists have innovatively mixed a North-Atlantic fish oil containing high amounts of cetoleic acid with a Norwegian vegetable oil (camelina oil) rich in ALA. The scientists have tested the combination of the two oils in the feed for rats, which serves as a model system for human nutrition.

“Our hypothesis is that when

camelina oil and fish oil are mixed, the cetoleic acid from the fish oil has lots of ALA from the camelina oil to work with in order to form EPA and DHA in the body”, says Astrid Nilsson, senior scientist at Nofima.

In the experiments, where up to 50 percent of camelina oil was mixed with a North-Atlantic fish oil, there was an equally high final content of the essential and healthy fatty acid DHA in the blood as there was after the ingestion of pure fish oil with high DHA content.

“This means that when you take the best of both worlds, you can use half as much of the EPA- and DHA-rich fish oil and still end up with a jackpot of DHA levels in the body”, says Nilsson.

However, the mixture ratio between available ALA and cetoleic acid will most likely be important in order to achieve the maximum amounts of EPA and DHA, and we need knowledge from in vivo human studies.

What about the salmon?

The scientists also wish to test such combinations of oils on salmon. Mixing plant oil and fish oil in fish feed is nothing new. A Nofima report from 2019 shows that from 2000 to 2016, feed producers went from not using plant oil in feed to having around 20 percent in feed. But little is known about whether salmon benefit from an

interaction between ALA and cetoleic acid in today's commercial feed.

Nofima's senior scientist Tone-Kari Østbye has studied the mechanisms behind cetoleic acid in feeding experiments involving salmon, as well as in liver cells from salmon and human. The results show that cetoleic acid increases the cells' capacity to synthesize EPA and DHA from ALA.

“When we see this in human liver cells, there is a strong indication that the same will occur in humans too. However, we can't be certain of this without investigating the effect of diets containing fish oil with high cetoleic acid levels with diets containing fish oil with low cetoleic acid levels in humans”, says Østbye.

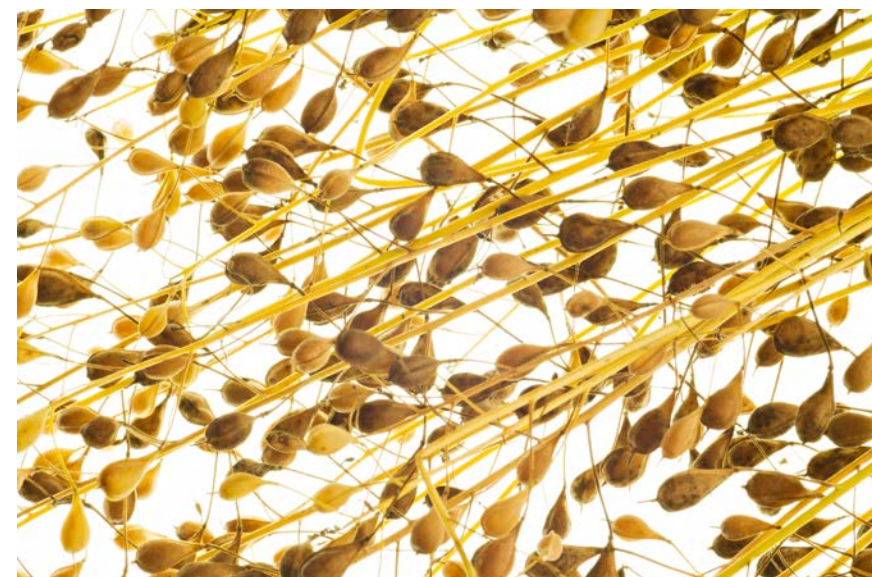
The research was carried out in two collaborative projects financed by the government and the sea and land based industries. The North-Atlantic fish oils that have been used in the trials are sand eel oil and herring oil.

The results have great commercial value for the fish oil industry:

“The knowledge gained through the projects will also be of great benefit to the aquaculture industry, in terms of optimal utilisation of marine and vegetable oils, and to better manage omega-3 levels in farmed fish”, says R&D Manager Ola Flesland from the fish oil manufacturer TripleNine.



Herring oil contains a lot of cetoleic acid, which acts as an omega-3 catalyst.



Camelina oil contains substances that are good in combinations with fish oil. Today, the oil is popular on the health food market.



Nofima scientists are working on regulating omega-3 levels in salmon by researching optimum use of oils from sea and land.

About omega-3

Omega-3 fatty acids from fish are known to contribute to good human cardiovascular health and a well-functioning immune system. And while the UN expects the world's population to grow to almost 10 billion in 2050, the supply of fatty fish from fisheries is relatively stable. This means that less marine omega-3 will be available to each individual person than before. Therefore, people all around the world are working to increase access to marine Omega-3 and to find other sources.

About the fatty acids in the article

- ALA = alpha-linolenic acid. Precursor to EPA and DHA. Certain oil plants are rich in ALA
- EPA = eicosapentaenoic acid. Essential fatty acid for salmon, which marine oil sources are rich in.
- DHA = Docosahexaenoic acid. Essential fatty acid for salmon, which marine oil sources are rich in.
- Cetoleic acid = fatty acid found in high levels in fish from the North-Atlantic. Stimulates the conversion of ALA to EPA and DHA.

READ MORE



CONTACTS:
Tone-Kari K. Østbye
Senior Scientist
+47 64 97 03 84
tone-kari.ostbye@nofima.no



Astrid Nilsson
Senior Scientist
+47 901 27 672
astrid.nilsson@nofima.no

FUNDED BY:
The Norwegian Seafood Research Fund (FHF) and the Research Council of Norway together with industry partners.

PARTNERS:
Several, among them the industrial partners Norsk matrap and TripleNine Group.



Stine Alm Hersleth and Antje Gonera find that Design Thinking is quite suitable as a methodology in research projects.

Appetite entrepreneurs

Innovation students develop concepts that can help solve the challenges linked to dietary needs and loss of appetite among the elderly.

Under the expert guidance of Nofima's Antje Gonera and Stine Alm Hersleth, a group of master's students in innovation and entrepreneurship at the Norwegian School of Economics and Business NMBU have employed the Design Thinking methodology for a new project.

The students' mission was to develop tasty, healthy and sustainable meal concepts to cover the daily needs of elderly people who live at home. The new solutions should be simple, easy to prepare and based on Norwegian ingredients, and should address a need among the target group, or break a barrier of some kind.

The students gathered insights and

challenged established truths about the kinds of meal concepts which healthy elderly people need and wish for.



The new badge framed by a scannable code. The illustration was made by the students.

The elderly want simple, good and social meals

The students approached elderly people at shopping centres and elderly centres, talked to people in cafés and visited their grandparents. They learned that elderly people want food that is simple to prepare, tasty and healthy – and to have someone to dine with.

Some established truths were also challenged. For example, the students realized that many seniors have digital skills and are familiar with using apps.

A new label: Tallerkenmerket

The students presented 11 different concepts before a panel of judges with



Students Joakim, Mekarim, Dag and Ida Marie have developed their winning concept further in collaboration with the Matlyst project.



The first brainstorming phase, where all ideas are welcome, with critical evaluation at a later stage.

representatives from Fjordland, Nofima, Nortura and Tine.

The winning concept, a new label dubbed "Tallerkenmerket", emphasized that making good choices at the grocery store should be easy.

The label indicates which food group the product belongs to, and includes scannable code that can be displayed on the product packaging to give you recipe suggestions for nutritious meals containing the ingredient or product in question.

Several of the other concepts which also impressed the judges include:

- "Turvenn" – a social entrepreneurship concept where sharing meals and going for walks is linked to providing jobs for immigrants.
- Communal living concepts where cooking together and social networks are important measures for combatting loneliness and for eating sufficient and nutritious food.

- Healthy, easy to prepare products with improved nutrient content
- Grocery store and food-box delivery concepts that facilitate a healthier daily diet among the elderly.

Discover – Define – Develop – Deliver

These four D's represent the four stages of Design Thinking. You start by discovering the needs of your target group. Then you define a specific need. Then you develop and test out ideas, concepts and prototypes, and finally you deliver the solution.

Students tested this method in practice over the course of three weeks.

"To bring the teaching up to date as much as possible, we linked it to a real-world research project, "Matlyst", where the goal is to develop solutions to motivate a healthier diet and health at an old age", says Antje Gonera.

Quick Lessons

"It's the first time we're using the Design Thinking method so systematically to focus on experience-based learning, engage with and understand a target group, develop ideas, and screen and test the ideas during an early innovation phase", says course leader and master's programme manager Elin Kubberød at NMBU.

She adds that the students reported that linking the teaching to a research project made it more interesting and relevant. The students are also amazed by how much and how fast they learned the methodology and gained insights into the needs of the elderly. And that does not just apply to the students; Stine Alm Hersleth is impressed by how fast the students were able to involve themselves in a complex issue.

"This was a refreshing contribution to the ongoing Matlyst project, and the results were so encouraging that we believe we will arrange similar case studies for other research projects", concludes Antje Gonera.



CONTACTS:
Antje Gonera
Senior Scientist
+47 400 75 077
antje.gonera@nofima.no



Stine Alm Hersleth
Senior Adviser
+47 975 41 669
stine.alm.hersleth@nofima.no

FUNDED BY:
The Research Council of Norway and participating companies

PARTNERS:
Tine, Fjordland, Norgesmøllene, Nortura, SESAM, Nofima and NMBU

Cool collagen research

Supplements containing collagen are in great demand. The fishing and food manufacturing industries can now also profit from this protein.

Less joint and muscle pain, better skin, stronger nails and hair. Many people praise the effects of taking collagen supplements, and products containing the protein have invaded the market for health food products in recent years.

The collagen currently on the market is usually extracted from cattle and pigs, which excludes vegetarians and some religious groups from using it. Now, however, Nofima scientists have found specially-adapted methods for extracting various collagen products from other species.

“We are able to extract high-quality commercializable collagen products from fish like cod, coalfish, herring and mackerel, and we are working on adding more species. This means that people who don’t eat meat can start using collagen supplements”, says scientist Kjersti Lian.

This can expand an already large market. In addition, collagen from marine raw materials is associated with a lower carbon footprint than its competing products, which is a benefit the manufacturers can highlight in their marketing.

Personal testimonials

Collagen is the most abundant protein in our bodies, and helps us stay strong and agile. It is in our skin, hair and connective tissue, but as we grow older, we produce less.

The idea behind taking collagen supplements is not only to add more collagen to the body, but also to boost

the body’s own collagen production. But does it really work?

“To document the effects of collagen supplements in humans, long-term scientific studies with a large number of participants are necessary. This has not been done yet, so currently the manufacturers rely on testimonials from individuals”, says Lian.

And there are many who swear by collagen supplements. Due to the massive demand, more and more products are introduced to the market.

Creating more value from the raw materials

This could provide new sources of revenue for food manufacturers who generate a lot of surplus raw material in the course of manufacturing the main product. Nofima has experimented with raw materials from reindeer, chicken and various marine species, and has found ways to extract this popular protein. Each source and each product requires its own method.

“When we are working to extract valuable compounds from raw materials, the overall goal is to utilize natural resources in the best possible way by turning cheap raw materials into valuable products, boosting the Norwegian food production sector”, says Kjersti Lian.

Skin, bones and intestines are tested for valuable components that can be extracted and be used for different products. Fish skin is particularly rich in collagen.



Fish skin is rich in collagen. The process must be tailored to each individual species to extract high-quality protein powder.

The desirable properties of fish skin is nothing new. In earlier times, fish skin was used for shoes and clothing. And now, the huge piles of fish skin left over after fillet production can once again become a commodity.

“Our research shows that several marine species are very suitable for collagen production. This represents a great opportunity for the Norwegian



The collagen market is about to grow even bigger, now that Kjersti Lian and her team can extract this protein from several new species.

fisheries and aquaculture industries”, says Kjersti Lian.

How is it done?

Researchers use hydrolysis where enzymes are added to the raw material, dissolving it, and a series of different processes separate dry matter from wet.

The protein is also suitable for making various gelatine products. Fifteen years ago, Nofima scientists succeeded in manufacturing gelatine from cod skin. The successful extraction of collagen from various animal species is a result of many years of research experience and excellent partnerships with industrial

partners and European research communities.

At Nofima’s pilot plant Bioteq, lab results are tried out experimentally on a larger scale. Companies can come here to test their products for production readiness and get help in developing a production process in accordance with their needs.



CONTACT:
Kjersti Lian
Chief Engineer
+47 995 26 660
kjersti.lian@nofima.no

FUNDED BY:
Regional, national and international research funds.

PARTNERS:
Various industry stakeholders

READ ABOUT BIOTEP



Ideal onshore fish farm tanks

How can we ensure decent swimming conditions and even distribution of oxygen and feed in the massive tanks used for onshore salmon farming?

In land-based fish farming, the fish is kept in onshore tanks rather than in pens or closed-containment systems at sea.

At the CtrlAQUA research centre, Khurram Shahzad is currently investigating how water currents behave in small and large tanks, and how to improve them through computational fluid dynamics and simulations.

By using these models, the need to make prototypes of tanks and carry out costly experiments is eliminated.

Improved welfare

"The main purpose of my calculations

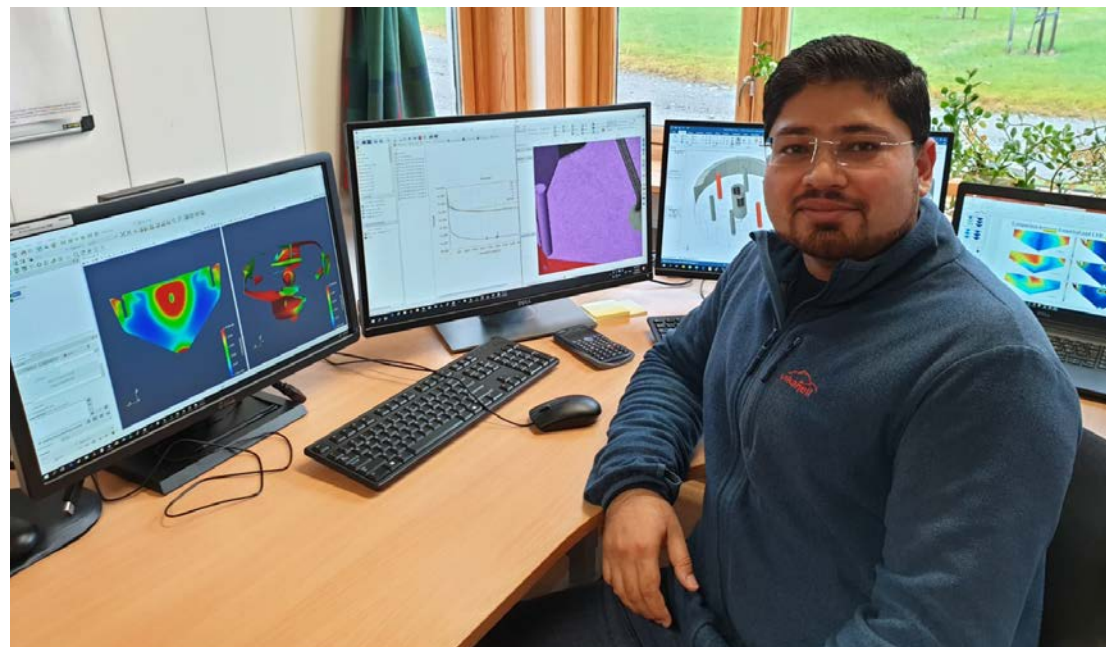
is to help the industry to develop optimal fish farming tanks that provide the fish with adequate swimming conditions and ensure that oxygen and feed is distributed evenly in order to avoid "dead zones." If done right, the tanks will also be largely self-cleaning. Facilitating the right hydrodynamics in the tanks will mean reduced energy consumption and improved salmon welfare in land-based farming", says Shahzad.

Many different sizes and types of tanks are available on the market, including circular, octagonal and race way with steadily flowing water.

Collaboration with the industry

"We collaborate extensively with the industry. They send us examples of existing tanks or drafts with new ideas which they are working on. In return we create a computer model and simulate the proposed designs. Later we carry out tests by adjusting the various parameters including inlet and outlet speed and placements at different depths, inlet directional angles and the direction and number of nozzles on each inlet.

CtrlAQUA is a centre for research-based innovation that will lay the foundation for the development of closed aquaculture concepts in the future.



Khurram Shahzad uses computational fluid dynamics for modelling and simulation to investigate how water currents behave in small and large tanks.

PHOTO: ANDRÉ MERIAC © NOFIMA



CONTACT:
Khurram Shahzad
Scientist
+47 986 11 221
khurram.shahzad@nofima.no

FUNDED BY:
The Research Council of Norway

PARTNERS:
CtrlAQUA – Centre for Research-based Innovation (SFI)

READ MORE:
ctrlaqua.no



New insights into food safety

Food safety in Norway is generally good, but foodborne disease outbreaks still occur, meaning more knowledge leading to safer food products is still required.



Nofima has unique opportunities to study pathogenic bacteria and viruses in the research institute's secure Pilot Plant

PHOTO: KJELL J. MEROK

In the research project Patfoodchain, led by Nofima senior researcher Askild Holck, new methods for producing safer food have been investigated.

The food industry is challenged by pathogenic microorganisms such as Listeria bacteria and E. coli, problem bacteria that can have costly consequences in conjunction with foodborne disease outbreaks, product recalls, regulatory compliance and various control measures.

Serious consequences

In addition, the industry is required to reduce costs and waste and to increase the shelf life of products. At the same time, there is a pressure to reduce inhibitory substances such as

salt and preservatives in food – without negatively affecting food safety. The continued focus on food safety is an important competitive advantage for Norwegian food.

"There are thousands of registered food-borne disease cases per year, and most certainly a large number of unreported cases. There can be serious consequences for those who get sick, and we have had fatal cases caused by both food-borne Listeria and E. coli in Norway", says Holck.

Nofima has unique opportunities to study pathogenic bacteria and viruses under various production and storage conditions in the research institute's secure Pilot Plant, making it ideal for studies like the Patfoodchain project.

User benefits

"The project has provided results that have a direct user benefit for the industry", says Hock.

In the Patfoodchain project we have studied products like cured sausage, eggs, chicken, salmon and leafy greens, as well as one of the greatest global health threats today, namely the problem associated with antibiotic resistant bacteria.

"By designing organizational frameworks and management strategies that handle these challenges we can contribute to reducing the risk of Norway experiencing the same serious problems associated with antibiotic-resistant bacteria that we see in many other countries", concludes Holck.



CONTACT:
Askild Lorentz Holck
Senior Scientist
+47 64 97 02 13
askild.holck@nofima.no

FUNDED BY:
The Research Council of Norway

PARTNERS:
The Norwegian Institute of Bioeconomy Research (NIBIO) and the Norwegian Veterinary Institute.



Bente Ruyter has researched salmon's need for fatty acids EPA and DHA, as well as new sources of omega-3.

Omega-3 needs and new sources

Omega-3 in the feed is a key to the welfare of salmon, but there is limited supply of omega-3 to use in feed. Can we meet the salmon's need?

There is no definitive answer to what the ideal levels of the marine omega-3 fatty acids EPA and DHA should be in fish feed. One often has to weigh the salmon's assumed need for these essential fatty acids during its various life stages against the supply available on the market at an acceptable cost.

Nofima has researched both factors in two different projects where our scientists gained new insights into how different EPA and DHA levels impact the welfare of salmon and evaluated two new potential feed ingredients that are rich in DHA.

Omega-3 is a key to salmon welfare and quality

During the first trial investigating the fatty acids' impact on salmon welfare and quality, different groups of salmon were given feed with low levels of marine protein, and with four different levels (1, 1.3, 1.6 and 3.5 per cent) of EPA and DHA in the feed. Currently, the commercial level of EPA and DHA in feed is at approx. 2.2 per cent. The trial started when the salmon weighed 400 grams and continued until it reached slaughter size at five kilos.

The results were clear: Salmon that consumed feed with a greater proportion of omega-3 fatty acids resulted in:

- faster growth and more resilient fish
- a higher proportion of EPA and DHA in the finished product
- lower occurrence of melanin spots
- redder fish fillet

Oil from GMO rapeseed and microalgae are good sources of omega-3

In the second project, two new sources were tested: Canola oil extracted from rapeseed plants that had been genetically modified to produce the omega-3 fatty acids DHA and ALA, and the microalgae Schizochytrium sp., which is naturally rich in DHA. These sources are partially available on a commercial scale.

Nofima carried out feeding trials using different levels of canola oil in salmon diets both in freshwater and seawater land-based facilities, and with a parallel feeding trial carried out on juvenile salmon in warmer waters in Australia. In another Nofima trial, salmon were fed with microalgae from when they were 100 grams to when they reached their slaughter size in sea cages.

Both ingredients turned out to provide good performance, quality, composition of fatty acids and health for the salmon.

The main findings are:

- Canola oil has high levels of the omega-3 fatty acids alpha-linoleic acid and DHA. Analysis of various health markers suggests that this is a safe source of oil in salmon feed.
- Canola oil in salmon feed in both freshwater and seawater provides equivalent growth rates as fish oil, and seawater trials showed better skin and muscle colour.
- Biomass from the algae Schizochytrium sp. is a good source of DHA in the salmon diet and also contributes to better muscle colour, creating no differences in the odour and flavour of the fillet compared to salmon fed with fish oil.

In summary, both canola oil and the microalgae have been demonstrated to be good sources of omega-3 in salmon feed.

Making better choices for the fish

Access to a greater volume of feed ingredients rich in omega-3 is one of the biggest challenges regarding growth in the aquaculture industry at large.

"While the fish oil content has previously been reduced as far as possible, we now have ways of increasing the EPA and DHA levels again, and feed manufacturers are already starting to do this. Our research reveals that high EPA and DHA levels are beneficial for the fish health, and I am happy to be able to provide documentation which helps the industry to make better decisions for the fish", says Senior Scientist Bente Ruyter, who has been in charge of both projects.

The assessment of whether oil from genetically modified rapeseed can be permitted for use in feed in Norway depends on government regulations and whether the industry itself wants to use canola oil. Knowledge gained from this project will contribute to this decision-making process.

About the "OptiHealth" project

Duration: 2017-2020

Partners: The Norwegian Institute of Marine Research, NIVA, the University of Oslo, BioMar, Skretting (Norway) and the University of Stirling (UK), Nofima (project manager).

About the project "New omega-3 sources in salmon feed":

Duration: 2015-2019

Partners: CSIRO (Australia) and the Norwegian Institute of Marine Research, Nofima (project manager).



CONTACT:
Bente Ruyter
Senior Scientist
+47 930 97 531
bente.ruyter@nofima.no

FUNDED BY:
The Research Council of Norway (NFR) (OptiHealth) and the FHF - Norwegian Seafood Research Fund (both projects)

PARTNERS:
7 partners in total

OPTIHEALTH



NEW OMEGA-3 SOURCES:





Grethe Iren Borge and Gesine Schmidt have found large variation in phytochemicals linked to taste, smell and health in cabbages.

Cabbage crops for every taste

We know that cabbage and other vegetables are healthy, but cabbage crops have not had the same sales increase as onions, tomatoes and carrots.

The industry and researchers wanted to do something about this in the KålSmak (CabbageTaste) project.

“A key objective of this project is to increase sales and consumption of cabbage crops by providing consumers with greater choice in terms of flavour and culinary uses. I believe greater product differentiation, which allows consumers to choose cabbage type and varieties for their liking, will increase the overall consumption”, says Grethe Iren Borge, project manager for KålSmak.

Tradition and innovation

The cabbage family includes many traditional Norwegian vegetables such as head cabbage, cauliflower, broccoli and Brussels sprout. Less familiar types include the popular kale and the lesser known cavolo nero and pak Choi. All of them exist in a large number of varieties with different growing and storage properties, taste, texture and nutritional content.

“We should utilize the individual characteristics of the various types to create unique Norwegian, innovative and nutritious products”, says Borge.

Cabbage maps

We have studied both new and more familiar varieties of cauliflower, head cabbage and leafy cabbages in terms of growing properties, sensory characteristics, as well as content and variation of phytochemicals related to taste and health benefits. Based on the results, profiles of the cabbage varieties are compiled into what we call a “cabbage maps.”

“There are distinct sensory differences between the different varieties of head cabbage, also within the same season. For example, some have a sweet and mild taste, and can be eaten raw and in salads. Others have a more intense taste, and are suitable for hot dishes”, says sensory assessor Kristine S. Myhrer.

The cabbage maps are the result of extensive field trials of more than 50 species.

“It is important to translate our research findings into tools that the industry can use to select different cabbage varieties for different uses”, concludes Borge.

PHOTO: JOE URRUTIA © NOFIMA

Quantity over quality

The price does not correspond to the quality of fresh cod supplied by the Norwegian fisheries fleet. This can lead to waste.

The quality of the fish depends on the fishing methods and the size of the catch. Researchers at Nofima has shown that fish caught by jigging has the highest quality, followed by line-caught fish. Fish caught by Danish seine and lastly net-caught cod has been shown to have the lowest quality.

Nofima scientists Edgar Henriksen and Thomas Nyrud have recently conducted an analysis on whether this is reflected in the price the fishermen achieve. They were surprised by what they found.

Market failure

“Larger catch size is likely to give reduced quality, yet higher prices are achieved”, says Henriksen.

“This indicates that quantity trumps quality in the first-hand market for fresh cod”, says Nyrud.

The lack of correlation between price and quality is not how a free market is meant to function. The technical term for this is market failure.

The fact that quantity is rewarded higher than quality is

most likely due to the way the intensive seasonal fisheries are carried out. The fleet captures up to 90 percent of the total cod quota during the traditional winter/spring fishing season in Northern Norway. The land-based industries are reluctant to refuse low-quality catches, fearing that they will miss out on the large quantities of fish that they rely on.

Reducing waste of values

The survey also investigates claims of underreporting.

“If it turns out that there is in fact a significant underreporting of volumes, it can help explain the apparently dysfunctional relationship between quality and price”, says Nyrud.

“A market that rewards high quality commodities will play an important part in curbing this waste of values”, concludes Henriksen.

He believes the findings provides insights into the factors leading to lower quality, giving a basis for discussing counter-initiatives with industry and authorities.



Quantity trumps quality in the first-hand market for fresh cod from the Norwegian coastal fleet.

PHOTO: FRANK GREGERSEN © NOFIMA



CONTACTS:
Grethe Iren Borge
Senior Scientist
+47 997 12 755
grethe.iren.borge@nofima.no



Kristine S. Myhrer
Sensory Analyst
+47 982 56 016
kristine.myhrer@nofima.no

FUNDED BY:
Research Funding for
Agriculture and Food
Industry (FJM) and
participating companies

PARTNERS:
NIBIO, the Norwegian Agricultural
Extension Office (NLR), BAMA
Gruppen AS, Gartnerhallen SA and
their producers, NORGRO AS, LOG AS
and Fraunhofer Institute, Germany.



CONTACTS:
Edgar Henriksen
Senior Scientist
+47 905 78 325
edgar.henriksen@nofima.no



Thomas Nyrud
Scientist
+47 997 74 933
thomas.nyrud@nofima.no

FUNDED BY:
FHF – Norwegian Seafood
Research Fund.

Texture to prevent overeating

Changing the texture of well-liked food can make people eat less.
Food manufacturers can use this knowledge to prevent overeating.

The number of slices of bread you eat for breakfast is not only dependent on how hungry you feel. Satiety – the feeling of fullness – is a complex phenomenon. And it turns out that the texture of the food plays a key role.

“Research shows that food with longer oral exposure makes you reach the feeling of fullness faster. The more you need to chew the food, the less you will eat before feeling full”, says sensory scientist Paula Varela.

As part of the FoodSmack project, she investigates how healthy food products with a texture that enhances the feeling of fullness can help people control their eating and prevent obesity.

Barley bread with different textures

She and her colleague Tormod Næs tested eight barley bread varieties on Nofima’s sensory panel and consumer test groups.

They had the same ingredients and nutritional content, but were prepared differently in order to give different texture. The breads were described on a scale from hard and compact to soft and fluffy.

The results showed that the more compact breads, which take longer to chew, increased the feeling of satiety among most of the participants – but not all.

“Personal preference also affects eating behaviour. The more you enjoy a food, the more you will eat”, says Varela.

New opportunities for food manufacturers

She believes the relationship between texture, satiety and food intake will open up new opportunities for the industry when it comes to creating food products that help prevent overeating and obesity.

“We can achieve this by creating products that are just as liked, but is served in smaller portions and will be eaten far more slowly. This applies not only to bread, but to all types of commonly eaten food”, she says.

Nofima is open to cooperating with companies interested in creating such new and different food categories.

“And we have the sensory methods that can make it happen”, concludes Varela.



Tormod Næs and Paula Varela carried out consumer analyses of barley bread. Texture and personal preference influenced how much people ate.

PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA



CONTACTS:
Paula Varela-Tomasco
Senior Scientist
+47 454 26 026
paula.varela.tomasco@nofima.no



Tormod Næs
Senior Scientist
+47 913 52 032
tormod.naes@nofima.no

FUNDED BY:
The Foundation
for Research Levy
on Agricultural
Products (FFL)

READ MORE



Bjørn Tore Rotabakk (Nofima) and John Fagan (BIM) are collaborating on developing the Irish seafood industry.

PHOTO: © NOFIMA

A popular research partner

Nofima’s work on seafood quality and processing activities has made the institute an attractive collaboration partner – in Norway and abroad.

In 2019, Nofima had clients and commissions from over 30 countries, including Ireland.

Irish fishermen catch a lot of hake, a white fish which is sensitive to handling, with meat that becomes soft fast. You get a good price for it – if the quality is good.

Improved quality

This summer, researcher Bjørn Tore Rotabakk completed a project investigating the quality and durability of hake caught by Irish fishing boats. The varying quality is a problem for the industry, and faster cooling could be the answer.

“We tested super-cooling technology, where the fish is rapidly cooled to below the freezing point, on board several boats. When done right, the quality of the meat improves, and the fishermen get paid more for the catch”, says Rotabakk.

The project was funded by Bord Iascaigh Mhara (BIM), an Irish government agency responsible for further developing the Irish seafood industry. This was Nofima’s second

assignment funded by BIM after Nofima and BIM entered into a partnership agreement in 2016.

Irish friends

“We greatly appreciate this partnership. Nofima’s valuable insights and expertise in innovation, technology transfer and sustainability represent a great advantage for BIM and the Irish seafood sector”, says John Fagan, Innovative Technologies Coordinator at BIM.

BIM finances research only on seafood technology that is close to commercialization. Magnar Pedersen, Director of the Seafood Division at Nofima, says Nofima has come a long way through strategic priorities in developing future-oriented knowledge and technology for the seafood sector.

“For several years, we have been working intensively on strategies to ensure high-class research on seafood processing and quality. The international demand confirms that we have made many correct decisions”, says Pedersen.



CONTACTS:
Bjørn Tore Rotabakk
Scientist
+47 957 41 115
bjorn.tore.rotabakk@nofima.no



Magnar Pedersen
Division Director
+47 992 96 284
magnar.pedersen@nofima.no

FUNDED BY:
Bord Iascaigh Mhara
(Irish Sea Fisheries Board)

Warming seas are bad news for salmon

Researchers have evaluated how climate change could affect Norwegian salmon farming over the next 50 years.

Ocean temperatures off the Norwegian coast have increased by 1°C on average since the 1980s. Over the next decades, temperatures will continue to rise due to human-induced climate change. This is bad news for farmed salmon, which is vulnerable to temperature increases.

Can cause problems for salmon

Salmon farming takes place along the whole coast of Norway and the country is divided into 13 production regions.

Nofima scientist Elisabeth Ytteborg and colleagues have analysed how IPCC temperature scenarios will effect salmon farming in all 13 regions from today until 2070.

“Even under the mildest scenario we see that rising ocean temperatures may pose a challenge for salmon”, she says.

The research has been conducted by researchers from Nofima and the University of Stirling as part of the EU-funded ClimeFish project. The results were published in the scientific journal *Aquaculture*.

Warmer seas may lead to fish death

Salmon have biological and environmental criteria that must be fulfilled to make farming possible.

- The ideal water temperature is between 8-14°C: the fish eats well and grows quickly.
- If the water is warmer than 16°C, the salmon gets stressed, eats less and experiences reduced growth.
- When temperatures exceed 23°C, the fish may die.

Few areas in the world meet the environmental criteria for sea-based salmon farming. Rising sea

temperatures in the future may limit production at Norwegian fish farms.

Temperatures will vary significantly across the country, and the fish's tolerance can also vary. Previous research states that salmon die at 23°C, but in 2019 there was a case where production fish died at 20°C.

“This means that the biology is more complex than we’ve assumed. We must include other factors than just temperature when assessing the biological impact of climate change”, she says.

Possible solutions and need for further research

The aquaculture industry should develop new strategies to adapt to these scenarios.

“New technologies, breeding for improved temperature tolerance and alternative farming locations are some of the solutions that could help maintain healthy fish”, she says.

However, possible measures will require more information and knowledge.

“When it comes to determining which measures we should implement, we still don’t know enough about how the farmed salmon will react to higher temperatures, increased ocean acidification, and reduced oxygen. Our research has revealed major knowledge gaps in terms of both available datasets and the biology of salmon”, she says.

Research strategy:

- IPCC has projected several scenarios for temperature increases based on greenhouse gas emissions to the atmosphere.
- The ClimeFish researchers made temperature trajectories based on IPCC RCP 4.5 – IPCC’s mildest realistic scenario, in which the increase in the global average temperature stays below 2°C.
- The temperature data for RCP4.5 were scaled down by the Norwegian Institute of Marine Research’s (IMR) calculations for ocean temperatures along the Norwegian coast from today until 2070.
- Temperature estimates were then calibrated against historical temperature data from fish farming localities across Norway, with projections from today until 2070 for a total of 56 production localities from all 13 production regions in Norway.



PHOTO: JOE URRUTIA © NOFIMA

About ClimeFish:

- A four-year Horizon 2020 project funded by the EU.
- Led by UiT - The Arctic University of Norway with Nofima as a key research partner
- 21 research and industry partners from 16 countries participate in the project, which aims at ensuring a sustainable increase in seafood production in areas – and for species – with potential for sustainable growth.
- The project includes 16 case studies investigating the impact of climate change on European fisheries and aquaculture.
- The case study on Norwegian farmed salmon is one of the project’s most comprehensive studies.

Elisabeth Ytteborg studies how climate change will affect salmon farming in Norway. Indications are worrying, and more research is needed.



CONTACT:
Elisabeth Ytteborg
Scientist
+47 649 70 450
Elisabeth.Ytteborg@nofima.no

FUNDED BY:
EU – Horizon 2020

PARTNERS:
21 partners from
16 countries, including
the University of
Stirling, UiT and IMR.

READ MORE



Revolutionary new technology

New technology using light for quality analyses of fish can revolutionize the fishing industry, and will be commercially available in 2020.

“For the first time ever, we are able to provide an objective measurement of good quality already when whitefish is delivered on shore and to the processing plants”, says Karsten Heia, senior scientist at Nofima.

By using high throughput light and imaging technologies, the fish can also be automatically sorted according to species upon delivery.

For 16 years, Karsten Heia has worked with the technology company Norsk Elektro Optikk (NEO) to develop a hyperspectral camera for food use. Since 2018, Nofima and NEO have collaborated with companies Maritech, Lerøy Norway Seafoods, and Havfisk to develop a commercial machine able to perform this kind of quality measurement of whole fish. Maritech is the largest global software provider to the seafood industry and is the lead industry partner that will commercialize the system in 2020. The industrial trials were carried out at Lerøy’s fish processing plant in Båtsfjord, Norway.

Extreme Technology

“It is extreme technology that has been produced and tested to further develop the Norwegian fisheries industry”,



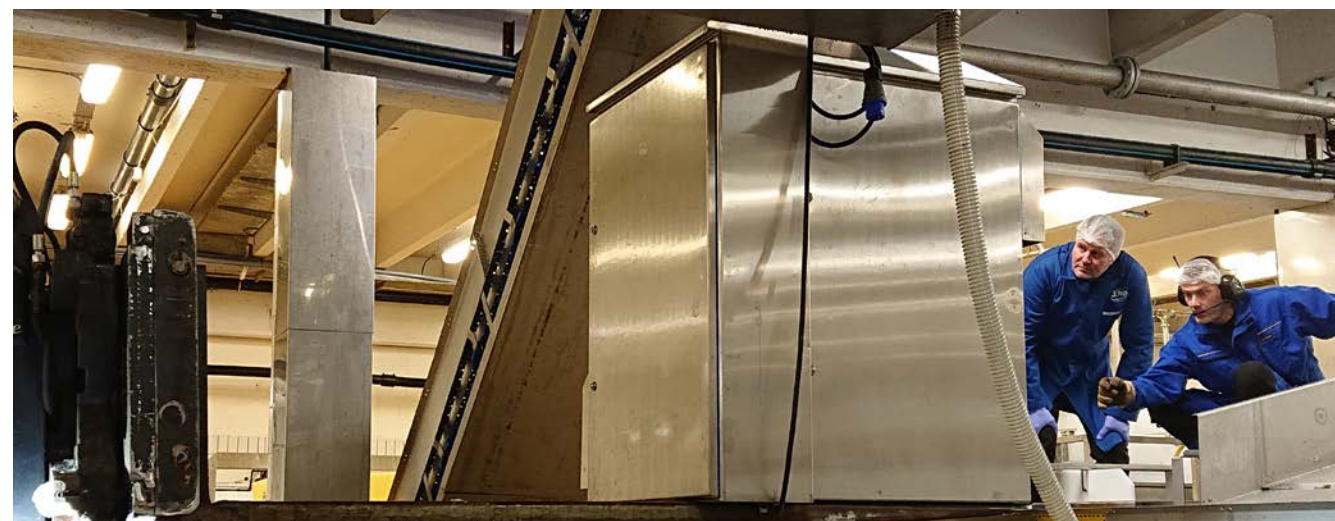
Senior scientist Karsten Heia and researcher Stein-Kato Lindberg with the machine that can revolutionize the Norwegian fishing industry.

says Heidi Nilsen, Head of Research at Nofima’s Seafood Industry Department.

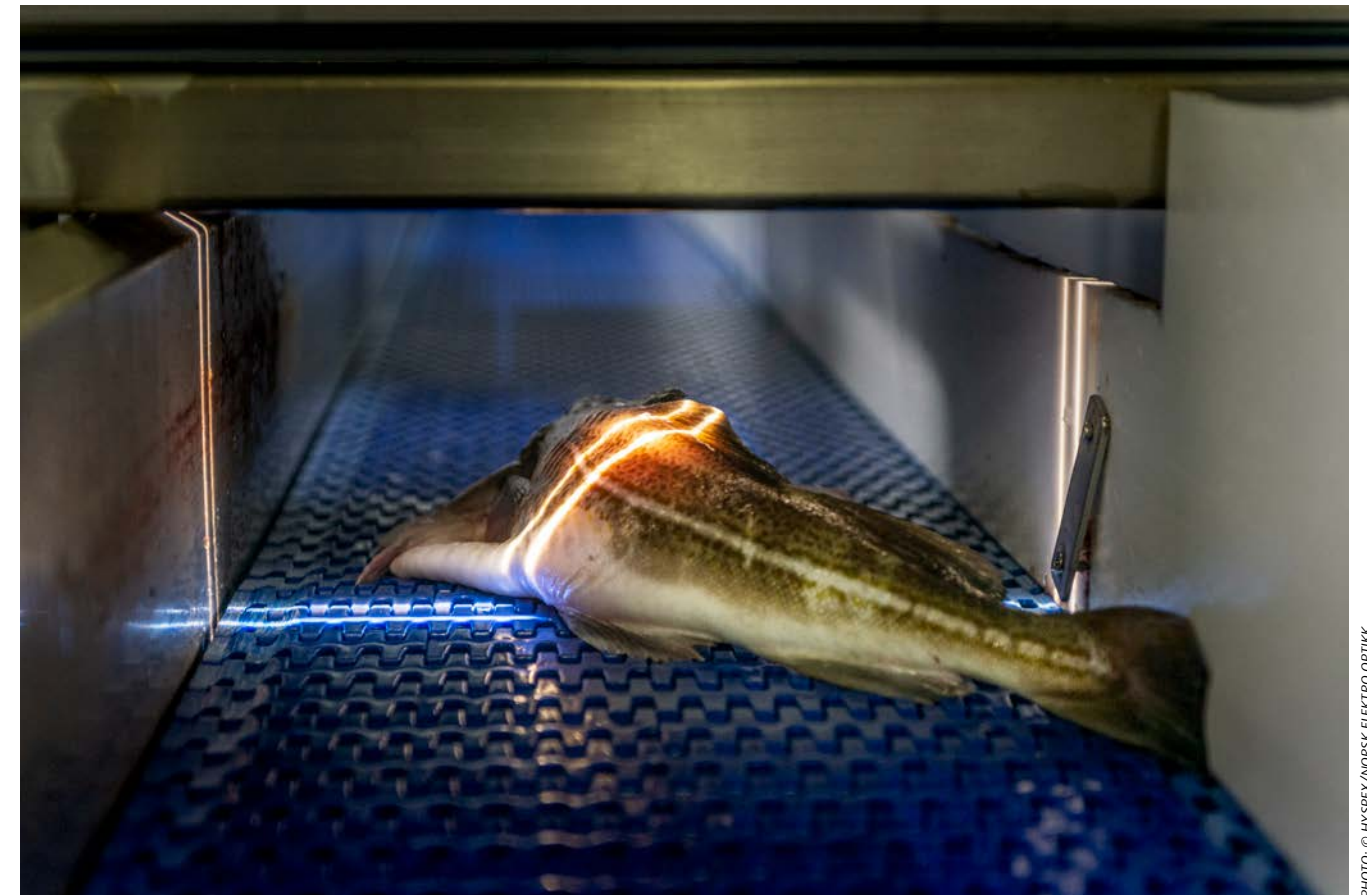
A good quality exsanguinated (bled out) fish has white and delicate flesh. A fish that was not bled or was damaged during catch will have blood discharge, blood stains and blood clots in the muscle. The fish are illuminated on the production line and blood content in the

fish muscle is assessed from the light signal reflected back to the sensor.

“The machine has been tested, and the technology works. We are able to analyse the data continuously as soon as it is generated, and the machine is integrated with the gradient – the sorting machine – on the production line. We are ready to put it into



The trial of light-based quality analyses was carried out at Lerøy Seafood Norway’s facilities in Båtsfjord.



With a hyperspectral camera, the quality of round fish can be assessed without cutting it open.

production”, affirms Karsten Heia.

“Norway has a strong global position when it comes to research into food and fish and the development of hyperspectral cameras. And we are very proud that NEO and Nofima have now developed something that works in the industry”, says Trond Løke, Manager of HySpex, the hyperspectral department at NEO.

Can deliver precisely what is offered

During 2020, the quality measurement machine will also be tested on one of Havfisk’s trawlers. Performing measurements on live fish is expected to follow.

“The technique implies several advantages to the seafood industry. Today they do not know what quality they can offer, and it is based on

their discretion, whereas after quality measurement they will know that they can deliver precisely what is offered”, says Karsten Heia.

According to the researcher, another advantage of this kind of measurement is that before production commences you know how much is available for high-quality products, such as loins and fillets, how much can be sent in bulk to be used in, for example, fish mince, or what is best suited for production of salted fish.

The entire value chain will benefit from this

The fishing fleet, which can install the system on its production line, will be able to gain much greater control of its own products.

“The sea fishing fleet delivers

a lot of frozen raw material which may not enter the market for four or five months. By measuring and documenting the quality of all fish brought on board, they are able to sort according to quality and avoid surprises and price reductions later on”, says Heia.

All the data from the measurements are collected and systematized, and workers at production facilities and the trawler fleet can learn more about the causes of quality variations. This means the entire value chain can benefit from this.

“The challenge has been to make measurement and analysis simple enough so that it will be appropriately priced to be able to mass produce without compromising on system quality. This is what we have now achieved”, says Heia.



CONTACT:
Karsten Heia
Senior Scientist
+47 412 12 127
karsten.heia@nofima.no

FUNDED BY:
FHF – Norwegian Seafood
Research Fund and
participating companies.

PARTNERS:
Norsk Elektro Optikk/HySpex,
Maritech, Lerøy Norway
Seafoods, and Havfisk

READ MORE





PHOTO: FRANK GREGERSEN © NOFIMA

The fifth generation of farmed cod has many of the desired characteristics in place regarding growth and disease resistance. The cod has become livestock.

The cod has become livestock

The breeding and farming of cod is on its way to success. As with salmon, scientists have now domesticated Atlantic cod by selective breeding.

“At least the biology indicates that we are now ready to take a step further and increase the volume of farmed cod”, says Nofima scientist Øyvind J. Hansen.

He is scientifically responsible for both the National Breeding Programme for Cod and the Centre for Marine Aquaculture, which Nofima has been running since its inception in 2003.

Grow rapidly

The aim was to breed farmed cod that have better growth characteristics than wild cod and that possess higher resistance to fish diseases.

Domesticating (turning into livestock) new species of fish takes time. With the fifth generation of farmed cod now growing at sea, many of the desired characteristics are in place regarding growth and disease resistance.

“Individuals from families of cod that have grown well and have been chosen to produce future generations have a good genetic basis for being adapted to a domesticated life. The cod bred in our facilities show no signs of wanting to escape, are not stressed by humans, and grow rapidly. Cage mortality

is 16%. We now have fish that reach the target weight of three kilos after 22 months at sea”, says Øyvind J. Hansen.

Better starting point

Nofima has breeding stock from 600 families. Breeding stock from around 200 families is used for each generation.

“At first, we started a new generation every year. We have now merged the different cohorts to have a solid base for future selections which happens every third year”, says Øyvind J. Hansen.

The improvements that have been made over these 15 years, both in breeding and in production, provide cod farmers with a much better starting point regarding their production than they had before. It provides increased production predictability and increased opportunities to achieve profitability within marine-based farming.

“The knowledge and infrastructure gained from the breeding programme for cod can be used for many different purposes. However, further genetic improvement of farmed cod is most important to us”, says Øyvind J. Hansen.



CONTACT:
Øyvind Johannes Hansen
Scientist
+47 77 62 92 36
oyvind.j.hansen@nofima.no

FUNDED BY:
The Ministry of Trade,
Industry and Fisheries

READ MORE



Socially sustainable fisheries

Violations of human rights, child labour and discrimination are virtually absent in the Norwegian fishing and seafood industry.

Internationally, tragic stories of slavery, child labour and trafficking have come to light. This has led to international customers of Norwegian seafood exporters also requesting documentation of social sustainability from their Norwegian suppliers.

Norway has systems and regulations in place which address all issues raised internationally regarding social sustainability in the seafood industry.

This is one of the conclusions in the research project “Social sustainability in Norwegian fisheries – development and sustainability of fleets and industry”, which was led by Nofima scientist Bjørg Helen Nøstvold.

Only a few cross the line

“There has been increasing focus on the topic. Inspection and penalty systems are in place should there be instances where the public requirements are not fulfilled”, says Nøstvold.

She says that the fact that more and more companies are formalizing social sustainability in their operations has a very positive impact.

“Only a small number of companies seem to bend the rules, with few going over the line. The best thing is that it is not considered acceptable to bend the rules for social sustainability in the Norwegian fisheries industry. It is considered a crime”, says Nøstvold.

Working continuously

The Norwegian seafood industry is the world’s second largest exporter of seafood, supplying 145 markets around the world. The industry employs more than 11,000 fishermen on 6,000+ ships, and 9,000 production workers in 226 industrial companies.

“We can affirm that authorities and trade unions are steadfastly working towards improvements”, says Nøstvold.

The report is based on interviews with foreign purchasers, Norwegian inspection bodies, and representatives from the Norwegian Labour-Related Crimes Centre (A-Krim), statisticians, and reference groups, as well as meetings with representatives from fleets and industry, workers and employers.



PHOTO: OLE ÅSHEIM © NOFIMA

Norway has systems and regulations that safeguard all aspects of social sustainability discussed in the international seafood industry.



CONTACT:
Bjørg Helen Nøstvold
Scientist
+47 905 34 990
bjorg.nostvold@nofima.no

FUNDED BY:
FHF – Norwegian
Seafood Research Fund.

PARTNERS:
Fafo, the University in Stirling,
stakeholders from the seafood
industry and workers’ and
employers’ organizations.

Advancements in food research

Nofima aims to bring Norwegian food production a great step forward in terms of health, taste, sustainability, safety and quality.

The following summarizes the latest research from the four strategic research programmes SunnMat, FoodSMaCK, FoodMicroPack and InnoFood.

SunnMat

In SunnMat, scientists investigate the optimum use of ingredients in terms of health benefits, general quality and new areas of application, gaining new insights into extrusion processes which provide food producers with opportunities to create new, healthy products.

They are also developing -omics methods to understand and assess the correlation between type characteristics or growth and processing conditions and the content composition of various foodstuffs.

This year, they have, for instance, examined how:

- different types of dietary fibre added to bread affect its baking qualities and health properties
- marinating, drying or storage affect meat quality and protein digestion, as experiments with enzyme-based marinades show that different enzymes break down meat and connective tissue in different ways.

FoodSMaCK

The aim of FoodSMaCK is to contribute to profitable production of sustainable and healthy food which is appealing to consumers. Sensory science is one of three key fields of research. Over the past year, researchers have developed a relatively new method of understanding and predicting consumer choices based on their unconscious attitudes towards i.a. sugar-reduced products.

They have developed Raman



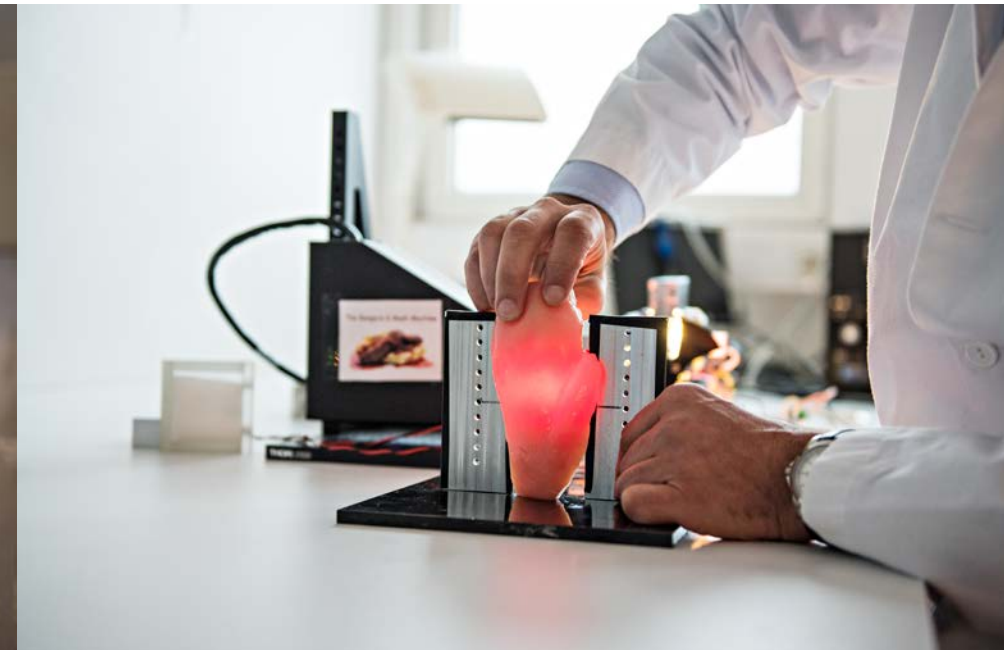
The programs ensure long-term competence building and establish Nofima's role as an internationally leading food research institute.

spectroscopy, a method that can be used for rapid and nondestructive in-line measurements of both main components, such as fat and protein, as well as more detailed chemistry, such as fatty acid composition.

The third key research area involves computational analyses and modelling. The researchers develop ways to understand relationships between "blocks" of data, such as consumer demographics, attitudes and preferences



Hans Arild Grøndahl at Grøndalen Gårdsmeieri enjoys success with Nyr. Stine Alm Hersleth researches innovation among local food producers. PHOTO: WENCHE AALE HÆGERMARK © NOFIMA



COLLAGE PHOTO: KJELL J. MEROK, JON-ARE BERG-JACOBSEN AND JOE URRUTIA

that impact food choices, or which process steps have the greatest impact on the final quality of a food item.

FoodMicroPack

The FoodMicroPack researchers

contribute new knowledge for the manufacture and production of safe food with long shelf life, optimum packaging solutions and reduced food wastage.

Since Listeria poses a great challenge for many food producers,

the FoodMicroPack project carries out extensive research into this bacteria to find out why it is so hard to get rid of. The scientists have built a massive collection of Listeria bacteria and sequenced the genome of the variety most prevalent in the meat industry in order to develop more effective strategies for getting rid of the bacteria.

Packaging is essential to preserving the quality of the food. The scientists:

- are investigating the effects of choosing alternatives to traditional plastic materials
- have found the causes of discoloration of salami
- have mapped which types of bacteria that lower the quality of chicken, and how different packaging solutions and storage conditions affect bacterial growth.

InnoFood

Design-driven innovation and strong consumer involvement are key when the InnoFood researchers are building knowledge platforms. The aim is to contribute to sustainable growth in the food industry and the public sector.

Researchers have mapped the meal needs of healthy seniors, and found that what they want is food that is tasty, healthy and simple to prepare – and above all to have someone to dine with. In this project, the researchers used creative focus groups, interviews and future scenarios as techniques for involvement.

Understanding critical factors for the innovation capabilities of small businesses and the role small-scale producers play when it comes to innovation in the Norwegian food industry provides increased knowledge that will benefit the whole food industry. It turns out that increased involvement leads to better cooperation and increased emphasis on innovation.



CONTACT:
Camilla Røsjo
Division Director
camilla.rosjo@nofima.no
+47 413 22 200

FUNDED BY:
The Foundation for Research
Levy on Agricultural Products

READ MORE





PHOTO: JOE URRUTIA © NOFIMA

The team of scientists, led by Carlo C. Lazado, have tested different doses on salmon at research stations in Tromsø, Norway and Hirtshals, Denmark.

Developing new AGD treatment

Scientists are developing a new method of treatment against AGD that will be gentler on the fish and the environment than existing methods.

Amoebic gill disease (AGD) is caused by a saltwater amoeba and results in white patches of mucus on the gills. In recent years, AGD has become a serious disease among sea-farmed salmon. Farmed salmon with AGD are currently treated with fresh water or a hydrogen peroxide bath. Scientists are now investigating whether peracetic acid can be used as a more sustainable alternative.

Treatment must be safe

The main goal of the initial trials is to investigate whether peracetic acid is safe to use in the treatment of salmon.

Scientists have tested various doses of peracetic acid on salmon and amoeba separately in three trials.

The preliminary conclusion is that peracetic acid is not harmful to salmon, that it has an effect on the amoeba that causes the disease, and that it has a low environmental risk.

“We now have good interdisciplinary evidence regarding how salmon react to peracetic acid, and we have conducted preliminary investigations concerning environmental impact”,

says Carlo C. Lazado, a fish health researcher at Nofima and head of the project.

“When salmon are exposed to peracetic acid, they react as if there is something new in the water, but the behaviour and physiological responses indicate that it is more about adapting to the change as opposed to affecting the health and welfare of the fish. It did not affect appetite, either”, says Lazado.

Degrades faster

Peracetic acid has an effect on the amoeba by reducing their viability in vitro. Peracetic acid is considered to be a more sustainable alternative than hydrogen peroxide, because it seems to be effective in lower doses and it degrades significantly faster into components that are more neutral.

The scientists are further developing the treatment method by testing peracetic acid on salmon infected by AGD. This will indicate what concentrations are most effective on the amoeba whilst not adversely affecting the salmon.

Bacteria for better taste

Challenges with unpleasant odours and flavours associated with fish and whey protein powders can soon be solved through fermentation.

Spines, heads and other residual raw material from cod, salmon and cheese production have gone from being waste or animal feed, to forming the basis for new products. Using hydrolysis, an advanced chemical process, biological “scissors” – enzymes – are added to “cut” the proteins into pieces. When protein is broken down in this way, smaller protein fractions called peptides are formed. This can result in valuable products such as marine oils and protein powders. “But to be honest, it doesn’t always smell and taste that good”, says Nofima researcher Diana Lindberg.

Fermentation

Researchers have long been working hard to try to remove the bitter flavour, so that the nutritious protein powder can become more usable and attractive.

A collaboration between hydrolysis expert Lindberg and fermentation expert Lars Axelsson may prove to be very valuable.

Lactic acid bacteria are added to the hydrolysates. The bacteria start a fermentation process which can create a

change in flavour. In most cases, we have to add sugar to make the bacteria grow.

Master’s student Magnus Rein at NMBU carried out the experiments. 42 strains of lactic acid bacteria were used in conjunction with several types of hydrolysate. The results show that there was a big difference in the growth rates of the different lactic acid bacteria.

“The results are very promising, especially for some of the hydrolysates with the most challenging flavours”, says Diana Lindberg.

Good results – and ten new questions

Good results can lead to more questions than those answered during the study.

“Until now, we have only scratched the surface of something that may prove to have a great influence on the value creation of products from residual raw material. We have had some good results, but have got ten new questions.

We are involved in very exciting things and have good reasons to continue our research”, says Diana Lindberg.



PHOTO: JOE URRUTIA © NOFIMA

Collaboration across specialist fields in Nofima, provides promising results for better taste of protein powder.



CONTACT:
Carlo C. Lazado
Scientist
+47 930 27 905
carlo.lazado@nofima.no

FUNDED BY:
FHF – Norwegian
Seafood Research Fund

PARTNERS:
Norwegian Veterinary Institute,
Technical University of Denmark,
Quantidoc AS and Lilleborg AS

[READ MORE](#)



CONTACTS:
Diana Lindberg
Scientist
+47 913 00 486
diana.lindberg@nofima.no



Lars Axelsson
Senior scientist
+47 901 57 584
lars.axelsson@nofima.no

FUNDED BY:
Nofima is researching methods for processing residual biomass for use in food products. The projects are funded by the Norwegian Research Council, FHF, Mabit, EU funding sources and more



From small-scale to cornerstone

Three years' work gave more sustainable packaging, new sausage and cured meat products, increased knowledge and better process supervision.

"With the help of Nofima and Norges Vel, we have succeeded in becoming a better and more environmentally friendly meat producer", says Kjell Ringstad, General Manager of Brødrene Ringstad.

Stronger employee involvement is another key success factor.

From a small-scale business to a cornerstone company

In recent years, the Rakkestad company Brødrene Ringstad has expanded at a rapid pace, built new facilities and taken over and renovated Nortura's previous chicken production facilities, reaching an annual turnover of 130 million. In 2002, the company was a small business with its own outlet and an annual turnover of 5-6 million.

With the vastly increased capacity came the need for more knowledge, which was the main reason why they applied for the SkatteFUNN R&D tax incentive scheme with the help of Lill-Ann Gundersen at Norges Vel.

More knowledge, less returned products

"In the work to achieve a more stable product quality and less product returns, Tom has been of great help to us. He has proposed changes to the recipes and processes and explained the chemistry of the meat to us so that all key personnel are now up to date on what we're working with at all times. We now have a smoother process and can avoid production errors. This knowledge has also been useful in the product development work", says Ringstad.

The Tom in question is Nofima's sausage maker Tom Christen Johannessen.

Several new salami varieties and snack sausages are among the products that are now being introduced in the stores, and the feedback so far has been promising. In addition, the heightened expertise has resulted in several awards for many of the products, and with improved production stability comes increased efficiency and profitability and less wastage.

Less plastic, more recycling

Using more sustainable packaging as well as minimizing its use is another important goal for Brødrene Ringstad. "Several years ago, we at Brødrene Ringstad started looking into what it would take to reduce the use of plastic and make it more recyclable", says Kjell Ringstad.

Lill-Ann Gundersen at Norges Vel put him in touch with Nofima packaging researchers Hanne Larsen and Oddvin Sørheim. They've arranged training courses and tested out a number of packaging materials with the aim of developing packaging solutions that extend or maintain shelf life and represent a more environmentally friendly option.

And they succeeded! As the number of plastic films used has been reduced from 13 to 5, the company uses two metric tonnes less plastic annually. The new films are also easier to recycle. Other benefits include cost savings, simplified storage and a more efficient packaging line as they don't have to replace plastic film rolls as often.

Keeping the craft alive

Despite the fact that the company has evolved into a relatively large-scale meat producer, Brødrene Ringstad is still a local food producer making high-quality craft products from start to finish. They follow up their hand-picked farms closely to ensure good animal welfare, among other things.

"Brødrene Ringstad is an institution for people from Østfold, and we are many locals who travel to their outlet in Rakkestad when we want to buy high quality products", says Lill-Ann Gundersen.

Kjell Ringstad confirms that the outlet is a showcase. "We mainly focus on the market around the Oslo Fjord, particularly Østfold, Akershus and Oslo. We wish to have a strong presence here where the majority of consumers live."



Team leader Roger Fladberg and production operator Martin Tvette work with Tom Johannessen in the development of recipes and production processes.



General Manager Kjell Ringstad showing off big packs of sausages with new and more environmentally friendly packaging.



In the Norwegian Meat Products Championship 2018, Brødrene Ringstad won more medals than ever before. Three products received the highest award.



Packaging operator Kestutis Jucevicius has worked with Nofima and Wipak to test out several new plastic films at the Brødrene Ringstad packing machines.



CONTACTS:
Tom Christen Johannessen
Sausage maker
tom.chr.johannessen@nofima.no
+47 901 58 783



Hanne Larsen
Senior scientist
+47 450 39 908
hanne.larsen@nofima.no

PROJECT:
SkatteFUNN

PARTNERS:
Norges Vel, Brødrene Ringstad, Wipak

Good food with extra protein

Do you think protein enrichment is only about sprinkling protein powder on food and mixing it in? Think again.

You’ve probably seen them at the grocery store – yogurts, biscuits or beverages labelled as being fortified with extra protein. There is a growing market for protein-enriched food and beverages for people who work out or people who for various reasons, such as illness or special diets, are unable to get enough protein. Others buy it because they believe protein is healthy.

Many hurdles to overcome

Protein-enriched foods can be manufactured because researchers have managed to extract protein from various types of raw materials. But how do you make that protein fit for consumption?

“Many processed protein ingredients have a bitter or sour taste. When they are added to a product, other ingredients often have to mask or compensate for that unwanted taste. The consistency and mouthfeel can also be affected. All the ingredients must complement each other, and the production methods often require certain adjustments”, says scientist Guro Helgesdotter Rognså.

She has tested many prototypes of protein-enriched foods where the taste was unsatisfactory.

“The food should not only be healthy, but also taste good”, says Rognså.

And of course, it should also yield a profit. Since many of the protein ingredients can be expensive, the manufacturers have to consider whether – and in what quantities – it pays to add protein.

Varied products

Nofima is looking into this. Over the course of several projects we have developed protein-enriched bread, pastries,



PHOTO: GURO HELGESDOTTER ROGNSÅ © NOFIMA

Does this make you crave hot pancakes? This one has extra protein, and goes well with sour cream and jam.

beverages and meat substitutes. For an assignment on behalf of AM Nutrition, Nofima chef and adviser Stian Gjerstad Iversen worked on using pea protein in pancakes and bread.

He combines his expertise and experience as a chef with insights from the latest research to develop great recipes. Stian also provides advice on the new protein ingredients’ wanted properties, to make sure they work well with other ingredients.

The result? Delicious, protein-rich pastries.



Shiori Koga and Anne Kjersti Uhlen measure the quality of bread and gluten.

PHOTO: JOE URRUTIA © NOFIMA

The Norwegian Wheat Adventure

Decades of research to ensure that Norwegian wheat is used in food production have paid off! Up to 70% can be used for baking bread in good seasons.

Norwegian wheat research started in the 1950s. At that time, hardly any Norwegian wheat was of food-grade quality. Research made it possible to breed wheat varieties with improved quality to meet the requirements for baking.

Production of Norwegian wheat for human consumption became an agricultural policy goal in the 1970s. Since then, both our knowledge and the wheat quality has improved – but recent climate change is posing new challenges.

High gluten quality = great baking properties

It is challenging to achieve sufficient quality under humid weather conditions, although current varieties have been bred both for improved quality and increased tolerance to humid conditions.

“Humid weather prior to harvest can damage grain due to pre-harvest sprouting, giving low falling number of wheat flour. Moreover, the gluten quality can be reduced”, says Anne Kjersti Uhlen.

Since the gluten quality determine the baking properties, scientists have examined why the gluten quality varies.

“Rain has been identified as one of the main threats to achieve good gluten quality. Recent research suggests that the amount and the duration of rain are key factors involved in reducing gluten quality”, says Shiori Koga.

Gluten is nutrient source for fungi

Our study has shown that fungi of the genus Fusarium have the ability to break down gluten proteins. They infect the wheat grain and use the gluten protein for their own growth.

“We think increased rain during the maturation and harvest, which also leads to a higher prevalence of infection by pathogenic fungi, is a major cause of reduced gluten quality. However, we are still investigating other possible causes”, states Uhlen.



CONTACTS:
Guro Helgesdotter Rognså
Scientist
+47 51 84 46 19
guro.rognsa@nofima.no



Stian Gjerstad Iversen
Consultant
+47 97 75 20 65
stian.iversen@nofima.no

FUNDED BY:
Various funding sources

PARTNERS:
AM Nutrition, five industrial partners and two research partners



CONTACTS:
Anne Kjersti Uhlen
Senior Scientist
+ 47 64 97 02 82
anne.kjersti.uhlen@nofima.no



Shiori Koga
Postdoctoral Researcher
+47 970 65 770
shiori.koga@nofima.no

FUNDED BY:
Research Funding for Agriculture and Food Industry

PARTNERS:
NIBIO, CIGENE (Norwegian University of Life Sciences – NMBU), Lantmännen Cerealia AS, Graminor AS, Orkla Foods Norway AS, Yara Norway AS, Felleskjøpet Agri SA, Bakehuset AS, Strand Unikorn AS, Norske Felleskjøp SA and Bayer CropScience AS

Salmon feed more or less unchanged

From 2012–2016 the amount of feed produced for Norwegian fish farms and the quantities of salmon slaughtered there have remained stable.

However, raw materials used in the feed are becoming increasingly land-based, according to a Nofima report.

Soy continues to be the main ingredient

Currently 75% of the content of Norwegian salmon feed is derived from land-based production, compared to 70% in 2012. Soy protein concentrate, protein isolated from soy beans, was the largest individual ingredient and constituted 19% of the total feed in 2016. At the same time the use of soy in feed has dropped slightly since 2012 in favour of other sources of plant-based protein such as wheat, maize and fava beans. Marine sources of protein accounted for a total of 14.5% of feed ingredients and marine oils for 10.4%.

These figures are presented in the Nofima report entitled “Resource Utilisation in Norwegian Salmon Farming in 2016”, which also includes comparison data from 2012 and 2010. In 2016 a total of 1.62 million tonnes of raw feed materials were used to produce 1.25 million tonnes of salmon in Norway.

More certification from the ocean than the land

Most of the marine ingredients were of North Atlantic origin and were approved under sustainability certification schemes.

The traceability and certification schemes which apply to plant-based raw materials are not as well developed as those which apply to marine-based raw materials. Consequently a lower percentage of the plant-based raw materials used in 2016 were certified, standardised or had known origins.

“Norwegian salmon farming appears to be the only national system for animal protein production where such detailed annual data is available in respect of feed and food production for the whole industry”, says Aas.

The report on resource utilisation in Norwegian salmon farming was made in order to document the status of feed resources used in such farming. It is intended to be a tool which the industry and the authorities can use for planning and improving the industry.

In recent decades, Norwegian salmon feed has gone from being based on fish meal and fish oil to containing a substantial percentage of plant-based ingredients.

PHOTO: JOE URRUTIA © NOFIMA

Plant-based and protein-rich

Many people want to eat a more plant-based diet. Nofima scientists are working to develop products based on Norwegian, protein-rich ingredients.

“We are working with barley, oats, yellow peas and broad beans, which can all be grown in Norwegian fields”, reports Senior Scientist Svein Halvor Knutsen at Nofima. He is responsible for the work of developing innovative and efficient processing technology in the FoodProFuture research project.

Separating proteins from carbohydrates

One way of increasing the protein content of plant-based products is to separate proteins, starch and dietary fibre from each other. The scientists start by milling e.g. dried peas and beans into flour in a pin mill. Next they run these flours through an air classifier, which separates the protein from the starch and dietary fibre based on weight and size.

“Air classification is not a new technology. It is also used to separate gravel and sand, as in feed production and beta-glucan enrichment. However, this technology has not often been used with beans in Norway. Nofima has carried out a number of studies and tests in order to optimise and remove as much of the starch from the protein as

possible”, says Senior Scientist Stefan Sahlström of Nofima.

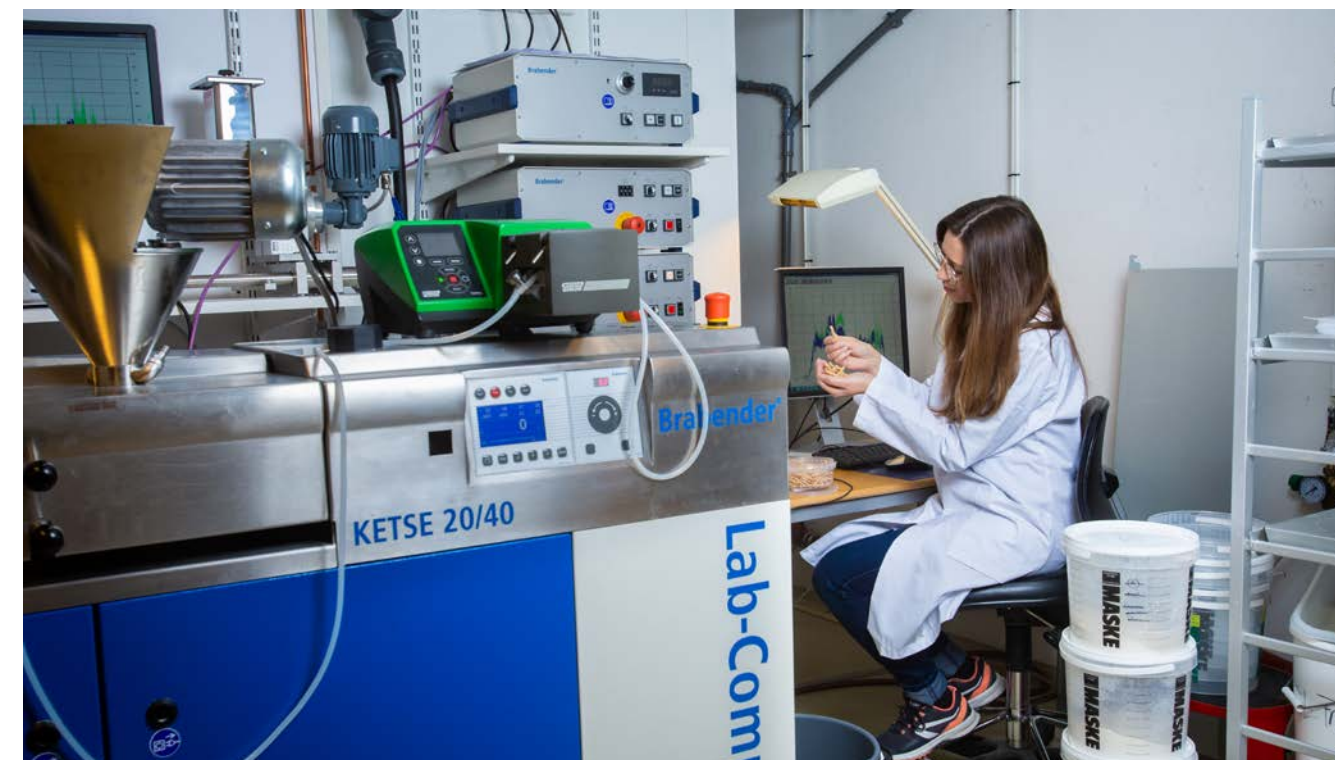
One advantage of using an air classifier is that it can be done at dry conditions not adding water. Nor are any additives required, neither enzymes nor chemicals.

From meal to meat substitutes

The protein fraction – that is, the protein flour, can be used directly as it is in food such as porridge. However, the goal of Nofima’s researchers is to develop ingredients for healthy snacks, bread and meat substitute products.

The extruder is a good tool for this. This is a machine that adds controlled quantities of water, heats, kneads and screws the mass through a channel to a nozzle that shapes the expanded products. The extruder can be used for both wet and dry extrusion.

“In Norway, extrusion technology has traditionally been used by the fish feed industry. The project could help the Norwegian food industry develop good products from Norwegian ingredients”, says Svein Halvor Knutsen.



Postdoc Catia Saldanha do Carmo is analysing the optimum settings for extruders for a number of different factors.



CONTACT:
Turid Synnøve Aas
Scientist
Tel.: +47 71 40 01 37
synnove.aas@nofima.no

FUNDED BY:
FHF – Norwegian Seafood
Research Fund

READ MORE



CONTACTS:
Svein Halvor Knutsen
Senior Scientist
+47 482 99 594
svein.knutsen@nofima.no



Stefan Sahlström
Senior Scientist
+47 970 88 975
stefan.sahlstrom@nofima.no

FUNDED BY:
The Research Council
of Norway (NFR)

PARTNERS:
Eight research partners
and 12 industry partners

World-leading crab research

Nofima is the world-leading interdisciplinary research group for red king crab and snow crab.

“We follow king and snow crab from capture to the global market, and we have a unique network of collaboration partners, says Sten Siikavuopio.

“Nofima’s research focuses on maximizing value from this resource”, says Grete Lorentzen.

The two senior scientists in Nofima is playing a key part in the extensive research into these two relatively new species in Norwegian marine fauna.

The Norwegian Seafood Council’s general strategy states that shellfish should front Norwegian seafood exports and help position Norway as the world’s leading seafood-producing nation. In 2018, export of king and snow crab amounted to NOK 740 million.

Some facts

Here is a brief overview showing the width of our crab research:

Catch: 70 % of the king crab harvested outside Norway is exported alive to the

global market – mainly the EU, USA and Asia. Scientists work with fishermen to develop gentler catching methods – both for minimizing damage to the catch and for better animal welfare. Feed: After years of trial and error, Nofima’s feed technology centre has managed to develop a dry feed tailored for shellfish. Unlike salmon feed, which is consumed right away, shellfish feed needs to be stable in water for longer periods of time without dissolving and it must be consumable. Producing feed pellets which have a highwater stability, the correct texture and good sinking properties are crucial.

Live storage and transport: How should the crab be kept alive after the catch and animal welfare be taken care of during transport? Water quality, temperature, feed access, light, time, and space are key factors.

Genetics: Both king and snow crab moult several times during their growth

period. Because the quality of the meat changes dramatically in the moulting period, stakeholders must be able to determine where in the moulting cycle the crabs are. Scientists have identified the Y-organ and Halloween genes that regulate the moulting cycle.

Fast and accurate

Processing: We have examined how different processing methods, such as heat and high pressure treatment, packaging, and freezing influence the product. The goal is to find combinations that result in a product with optimum quality attributes.

By-products: Utilization of the whole animal is important – both valuable chitin and marine oils can be found in the shells and organs of crabs. At Nofima’s national centre for bioprocessing, experiments can be performed to discover possibilities in total utilization of the by-products.



• Farming

- King crab and snow crab aquaculture is a future perspective

Meat content measurement: The content of meat in the crab legs is one of the most important quality parameter. Such knowledge is important for fishermen, industry, and market, and it is a key for the price of the product. Manual methods are inaccurate, labour and time-consuming. Nofima are together with industry stakeholders developing an instrument for this purpose and it is based on near-infrared technology. This instrument enables a quick and accurate knowledge about the meat content, without causing injuries to the animal. **Market:** Snow and king crab are

especially popular in markets physically and culturally far removed from Norway. What market opportunities and requirements apply? How can we position and differentiate Norwegian crab towards international buyers to create increased value and steady demand?

Management: The management of the crab fisheries sets the condition for the industry’s value creation potential. Regulations on crab fishing are constantly being developed. Nofima analyses how the regulations can

PHOTO SNOW CRAB: LIDUNN MOSAKER BOGE © NOFIMA
PHOTO KING CRAB: NORGES SJØMATRÅD

facilitate the long term profitability and value creation of the industry.

Future research

“Aquaculture of crabs is the future research area. This is a potential supplement to the existing crab fisheries. It will however require intensive scientific and industrial effort to solve the challenges we will face”, says Siikavuopio.

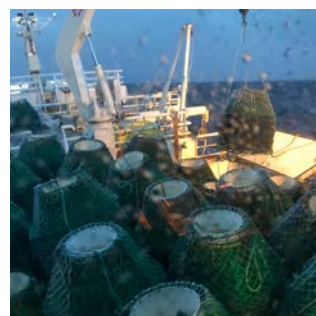


CONTACTS:
Sten Siikavuopio
Senior Scientist
+47 976 98 241
sten.siikavuopio@nofima.no



Grete Lorentzen
Senior Scientist
+47 995 54 336
grete.lorentzen@nofima.no

READ MORE



• Catch

- Bait
- Pots
- Live transport
- Animal welfare



• Feed production

- Starter feed for crayfish and lobster
- Dry feed for king and snow crab



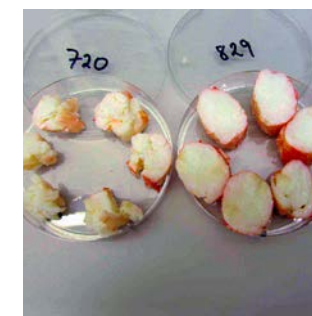
• Live storage

- Water quality
- Water temperature
- Feed
- Time
- Light



• Genetics

- When does moulting occur?
- How is the gene expression affected?



• Processing

- High pressure
- Boiling
- Freezing
- Packaging
- Shelf life



• By-products

- Exploitation of shell and organs for oil and chitin products



• Measurement of meat content

- After catch at sea
- During live holding
- Before export
- In markets



• Market

- 70 % live exported, 30 % exported processed
- Maximizing value creation – including down graded crab
- Different markets for crab

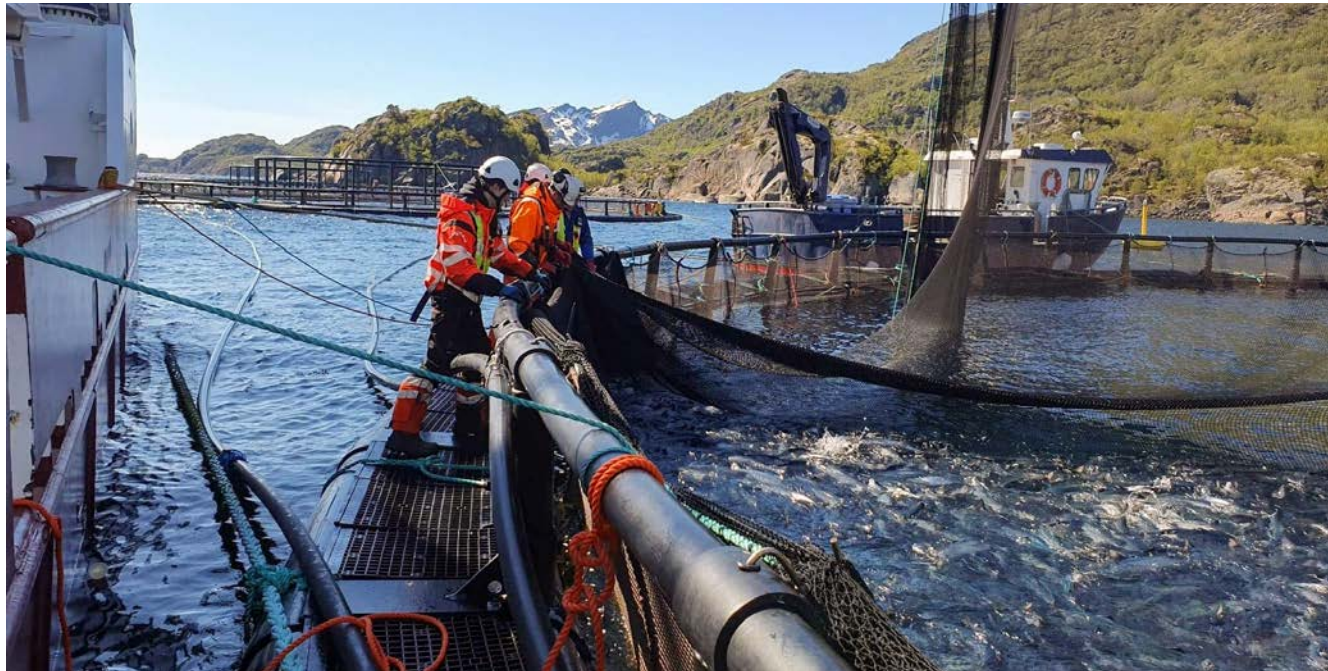


PHOTO: IVAR JOHNSEN © NOFIMA

Voluntary efforts played a key role in the outcome of the algae crisis.

Pulling together in a crisis

Players in the Norwegian seafood industry stand up for each other when it really matters, says a report on algal bloom preparedness in salmon farming.

Over the course of a few weeks in the spring of 2019, toxic algae killed 14 000 tonnes of farmed fish in Northern Norway. Fourteen fish farming companies were hit. Was the preparedness adequate?

The Norwegian Seafood Federation asked Nofima to chart the course of events during these dramatic weeks to find out what the farmers, suppliers and authorities learned from the crisis, and how we can be better prepared for future crises.

The researchers interviewed several fish farmers, scientists and officials to shed light on the matter.

“Essentially, we can say that the emergency preparedness plans and emergency staff of the fish farmers performed well. Even though the capacity to deal with such large amounts of dead fish was insufficient, the affected fish farmers reported that everyone around them mobilized to help out”, says senior scientist Roy Robertsen.

Learning from experience

Algae naturally occur in the oceans. Most types are harmless, yet some can be deadly to fish if they bloom rapidly and in

large amounts, which is what happened in 2019. It was a race against time.

“You can make legislation regulating equipment and procedures. But having people standing up for each other, providing boats and contributing with their knowledge is something you cannot regulate. The collective effort had an enormous impact on the outcome of this crisis”, says senior scientist Kine Mari Karlsen.

The takeaways from this are now used to develop plans for being better prepared for potential new crises in the future.

Researching neighbourliness

The work to map the algae crisis is also part of the project “Aquaculture Management 2030”, where researchers are gaining insights into how fish farmers, public administration and suppliers in different geographical areas cooperate on operations and emergency preparedness.

The results are used by industry stakeholders and the authorities.

Closer to PD-resistant salmon

New insights about fish biology and genetics are bringing Nofima scientists ever closer to salmon with high resistance to PD viral disease.

Pancreas Disease (PD) is caused by what is known as a salmonid alphavirus (SAV). The disease attacks the pancreas and also affects the heart in salmon and causes severe financial losses for the aquaculture industry. Therefore, over the course of a four-year project called “SalmoResist”, scientists have been working to find the specific genes that produce high tolerance or resistance regarding the viral disease. They are now getting close.

“In the past, our understanding of specific genes and what contributes to resistance has been limited. Now, through several different approaches, we have found out more regarding how fish biology works in relation to disease resistance”, says Nofima senior scientist Nicholas Robinson.

Much greater accuracy

Therefore, salmon with the genetic material that makes them most resistant to disease can be selected.

To identify the particular genes, scientists use gene markers. These markers enable them to select broodstock with the desired characteristics.

“The amount of knowledge we have gained so far has enabled us to have much greater accuracy for increasing PD resistance in salmon”, says Robinson.

Important experience

The scientists have infected salmon families and used markers to find genes associated with resistance and clearance of the virus causing PD.

“We were able to determine the map location of the genes and also measure the amount of gene product produced in fish with high compared with low resistance. Controlled infectious propagation of salmonid diseases in water, and the possibility to conduct disease challenge tests on large families of Atlantic salmon, give us a practical model to use in order to investigate genes that influence resistance to this alphavirus”, says Nicholas Robinson.

He believes that the knowledge generated from salmon research can also provide important experience regarding the treatment or prevention of alphavirus disease in other animal species.



PHOTO: JOE URRUTIA © NOFIMA

Nofima scientists are developing more accurate and efficient selection tools for improving disease resistance in salmon.



CONTACTS:
Roy Robertsen
Senior Scientist
+ 47 906 80 275
roy.robertsen@nofima.no



Kine Mari Karlsen
Senior Scientist
+47 472 60 878
kine.karlsen@nofima.no

FUNDED BY:
The Norwegian Seafood
Federation and FHF – Norwegian
Seafood Research Fund



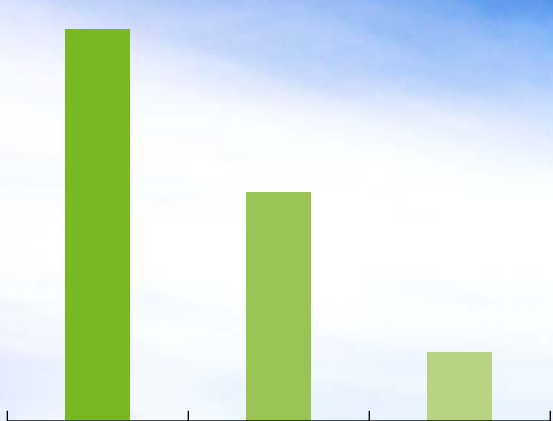
CONTACT:
Nicholas Robinson
Senior Scientist
+61 448984002
nick.robinson@nofima.no

FUNDED BY:
The Research Council
of Norway

PARTNERS:
SalmoBred, Mowi, Salmar,
Roslin Institute, Norwegian
University of Life Sciences
(NMBU), VESO

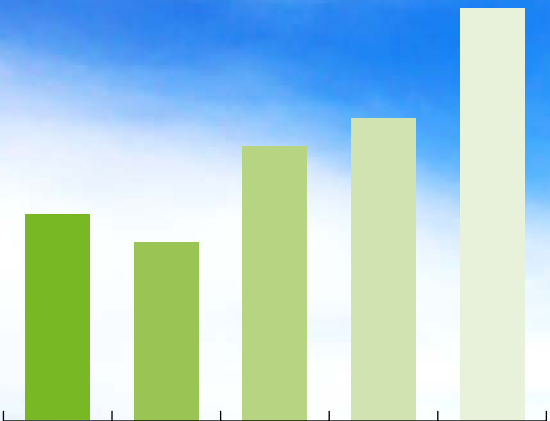
Behind the results

Who owns us



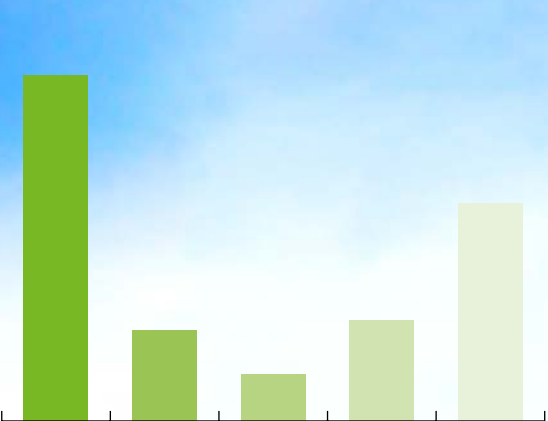
The Ministry of Trade, Industry and Fisheries (NFD)	56,8 %	
Agriculture Nutrient Research Foundation	33,2 %	
Akvainvest Møre og Romsdal	10,0 %	

Who funds the research



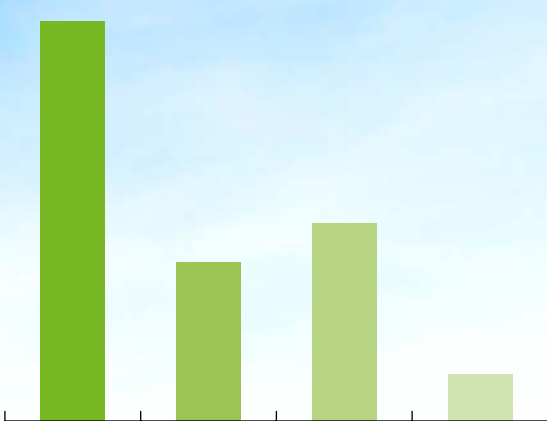
NFD	15 %	
Basic funding from NFR	13 %	
NFR/EU	20 %	
FJM/FFL/FHF	22 %	
Companies	30 %	

Where are we



Ås	168	
Bergen	44	
Stavanger	23	
Sunndalsøra	49	
Tromsø	106	

What are we doing



Scientists and advisers	194	
Laboratory engineers/research technicians	77	
Technical and administrative staff	96	
Managers	23	

The following are our largest funding providers:

THE MINISTRY OF INDUSTRY AND FISHERIES (NFD) is responsible for fisheries and aquaculture management, seafood safety, fish health and fish welfare, the framework conditions for seafood trade and market access for Norwegian seafood. NFD funds Nofima’s research infrastructure.

THE FISHERY AND AQUACULTURE RESEARCH FUND (FHF) manages the funding scheme for industrial research and development work within fisheries and aquaculture to contribute to sustainable value creation and growth in the industry.

THE RESEARCH FUNDING FOR AGRICULTURE AND FOOD INDUSTRY AND PARTNER COMPANIES (FFL/JA) organization finances research and innovation for the entire value chain. The projects should cover key knowledge gaps and ensure good user involvement.

HORIZON 2020 is the EU framework programme for research and innovation. Its goal is to ensure Europe produces world-class science, removes barriers to innovation and makes it easier for the public and private sectors to work together in delivering innovation.

THE RESEARCH COUNCIL OF NORWAY (NFR) is a research policy adviser for the government and the ministries which allocates NOK 10 Bn. annually for research and innovation. The Research Council’s mission is ensure that this funding goes to the best research and innovation projects. The organization is at the forefront in developing research of the highest quality and relevance.

This is Nofima

Nofima has some 390 employees, and a turnover of NOK 623 million in 2018. The research in Nofima is organized into three divisions, each organized in research departments:

Division Aquaculture

- Breeding and genetics
- Nutrition and feed technology
- Fish health
- Production biology

Director Bente E. Torstensen

Division Seafood

- Marine biotechnology
- Marketing research
- Industrial economics
- Processing technology
- Seafood industry

Director Magnar Pedersen

Division Food Science

- Food and health
- Raw materials and process optimization
- Consumer and sensory sciences
- Food safety and quality

Director Camilla Røsjø



PHOTOS: JON-ARE BERG-JACOBSEN, FRANK GREGERSEN AND GRETHE IREN BERGE

Sustainable food for everyone

Excellent research and innovation that contribute to sustainable food production and professional governance of resources from sea and land.



Engaged • Involving • Innovative • Responsible • Sharing



For everyone working with lumpfish and ballan wrasse:
Please find a collection of handy fact sheets on the tools you can use to assess their welfare:

<https://nofima.no/en/project/rensvel>

These fact sheets are based on scientific and practical knowledge and are an introduction to operational and laboratory-based welfare indicators for cleaner fish.

The fact sheets are an output of the «Welfare of Cleaner fish» project RENSVEL, financed by the Norwegian Seafood Research Fund and led by Nofima. The fact sheets are written in partnership with researchers from Nord University and NTNU.





Øyvind Fylling-Jensen
Managing Director
oyvind.fylling-jensen@nofima.no
+47 917 48 211



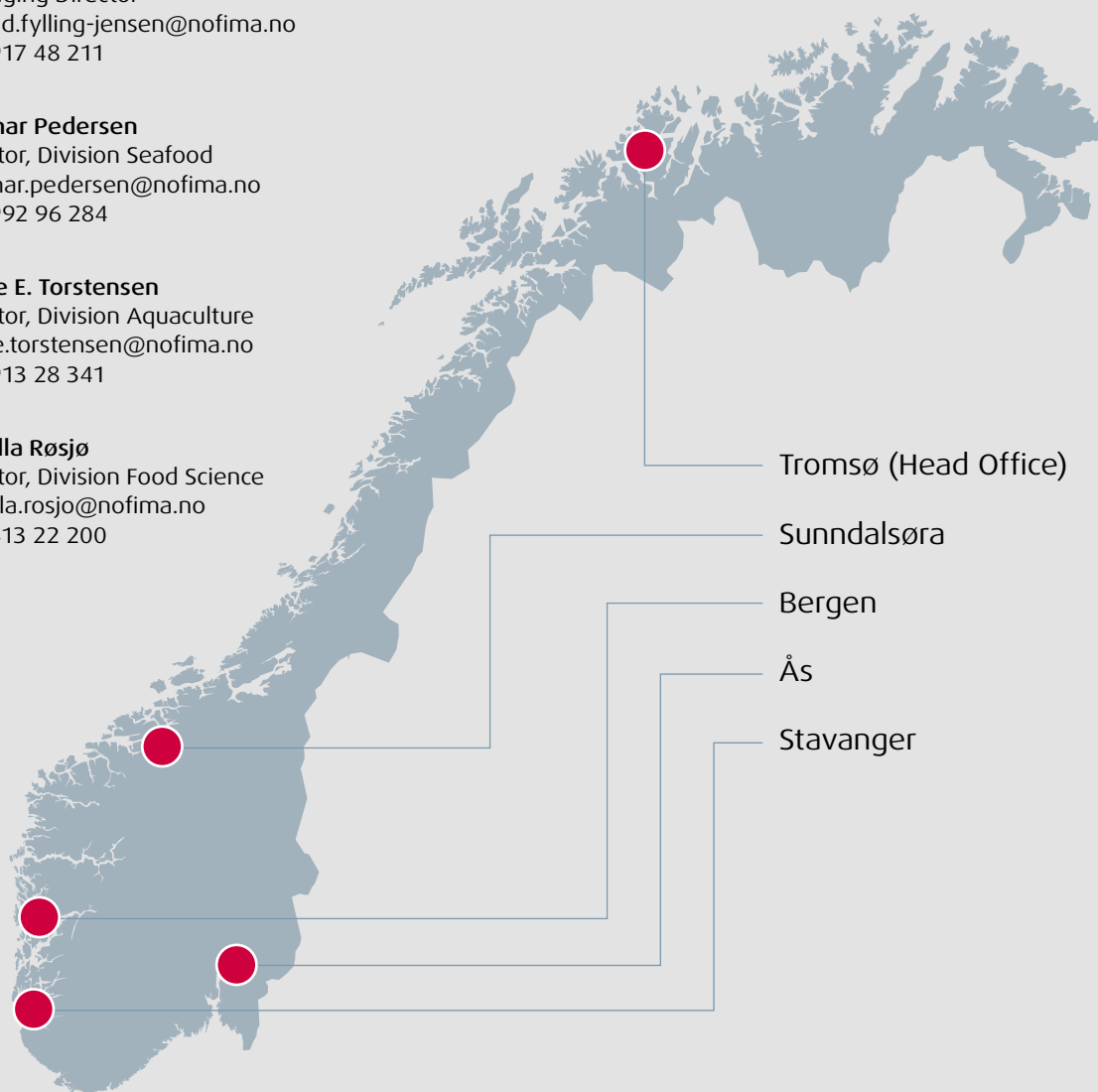
Magnar Pedersen
Director, Division Seafood
magnar.pedersen@nofima.no
+47 992 96 284



Bente E. Torstensen
Director, Division Aquaculture
bente.torstensen@nofima.no
+47 913 28 341



Camilla Røsjø
Director, Division Food Science
camilla.rosjo@nofima.no
+47 413 22 200



Tromsø (Head Office)

Sunndalsøra

Bergen

Ås

Stavanger

Follow us on:



Muninbakken 9–13 Breivika, P.O.Box 6122 Langnes, NO-9291 Tromsø, Norway
Telephone +47 77 62 90 00 | E-mail: post@nofima.no | nofima.no