

Creating value

Project year 2018



Aquafeed Technology Centre (ATC)

ATC is a state-of-the-art innovation centre for research and development in bio-resource processing and feed technology.

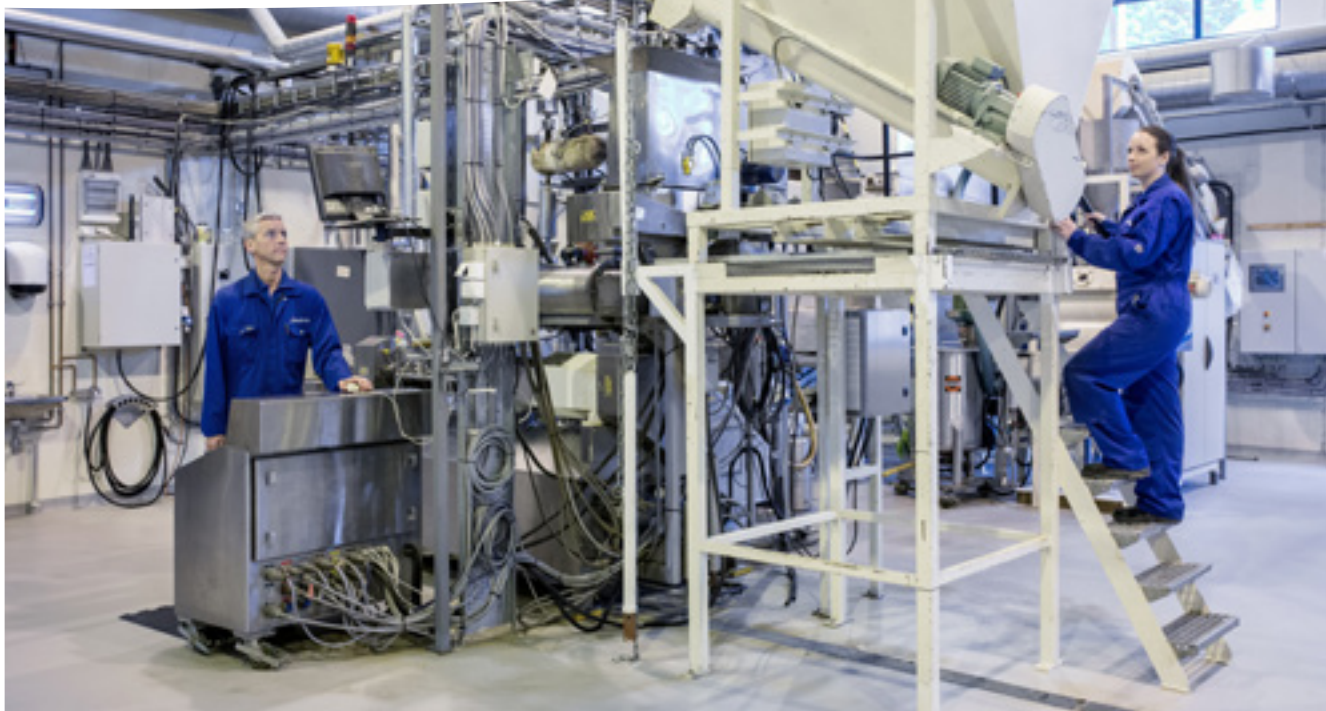


PHOTO: EVIND SENNESET © NOFIMA

ATC is in the process of building up new research infrastructure, and will open at the end of 2019.

Aquaculture is growing globally, and the industry is searching for new and sustainable raw materials to feed fish.

The Aquafeed Technology Centre will address these challenges by offering research infrastructure and expertise within:

- Bioprocessing
- Downstream process technology
- Extrusion and feed technology
- Analytical platforms

ATC is part of the Norwegian Roadmap for Research Infrastructure, and is a collaboration between Nofima (project leader), University of Bergen and Norce.



Contact person: Åge Oterhals, Senior Scientist | +47 55 50 12 74 | age.oterhals@nofima.no





PHOTO: BJØRN ERIK LARSEN - WWW.BEL.NO

Contents

Healthy 10-year-old aiming high	2
Shifting to plant-based	4
Safer transfer to the sea	6
Driver behind local food	7
Varying profitability	8
Cod's sex gene identified	10
Effects of structural policy	12
Know your bacteria	13
Dietary protein-to-lipid ratio	14
Healthier bread with less salt	15
Boosting EU fish breeding	16
Superb cod from hotel	18
Rediscovering old grains	20
Biggest is not always best	21
Food in recycled plastic	22
Fish bones give more red salmon	24
Focus on fish powder	25
Smart tech means better food	26
Losing out on vast sums	27
Web tool for healthy, sustainable food	28
Simulating fishery regimes	29
Knowledge, but no incentive	30
Zinc and omega-3 enhance skin	32
What's in the fish?	34
Sociable lumpfish	35
Food as medicine	36
Facts and figures	38
Nofima's mission	40

EDITORIAL STAFF:

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

GRAPHIC DESIGN AND PRODUCTION:

Lay-out: Krysspress
 Printed by: Lundblad Media AS
 Cover photo: Joe Urrutia
 Translation: Semantix

Published by Nofima AS/Januar 2019
 ISSN 1893-6652 (printed)
 ISSN 1894-4744 (pdf)

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

Healthy 10-year-old aiming high

2018 was the ten-year anniversary of the inauguration of Nofima. Four independent research institutes were merged in 2008 with the ambitions to create a “blue-green food research alliance”. The goals were great: create a world class institute with a clear ownership structure, high academic ambitions, cross-sectoral research, and increased interdisciplinarity.

I am very proud to present this eighth edition of Creating value, which serves as proof of Nofima’s ongoing success. Through increased interaction across disciplinary and geographical boundaries, we create new, innovative solutions with a fundament in research-based competence. Our goal is increased scientific production through conscious, strategic use of the core funding from the Research Council of Norway and through our own strategic research initiatives. We encourage long-term generation of excellent scientific knowledge, with a constant focus on research that benefits and creates impact for the business and public community.

Nofima’s journey over the past ten years has been demanding, and now is a good time to take stock. We have continuously invested in upgrading our infrastructure and have streamlined the organization, ensuring we have a robust economy for future growth. We maintain a firm focus on making sure the research results are used, which we achieve in part through active contact with industrial players.

Nofima has also strengthened its national and international profile. For example, we are doing very well in the EU Horizon 2020 programme. In its work on the upcoming ninth framework programme, Horizon Europa, the European Union is focusing on applied interdisciplinary and cross-sectoral research. Nofima is ahead of the game in this respect.

Last year we started looking at how Nofima could deliver on the United Nations’ 17 sustainable development goals (SDG). This year we have adapted our academic strategies so that they more clearly contribute to solving the major societal challenges. In the big picture, we are a very small player, but anchoring our work in the global SDGs highlights Nofima’s social mission:

“Nofima deliver research-based knowledge that benefits industry, the public sector and society.

By developing and applying evidence-based knowledge, we increase our relevance and contribute to value creation.

This work is reflected in our innovation strategy and our internationalization strategy. Nofima invests continuously in its employees’ competencies through our learning arena. Communicating about our research is also an important part of our work. Næringsnytte is an important element in this respect. In this year’s edition, we present 25 examples of our research in 2018.

We hope you find it interesting!



Øyvind Fylling-Jensen
Managing Director



PHOTO: TERJE MORTENSEN © NOFIMA

Shifting to plant-based

What do Norwegian consumers think about vegetarian food? Nofima researchers are going to find out in a rather creative way.

“When we use so-called projective techniques in focus groups, we learn more about what consumers really think,” explains senior scientist Paula Varela, head of consumer research in the FoodProFuture project.

Typical Norwegian – and French – diets
Young and urban consumers eat more plant-based food than the rest of the population. In this study, the scientists

focused on the attitudes of the average consumer in Norway – and France. However, they included questions that allowed them to select participants who care about health and sustainability.

“We conducted focus groups in Norway and France, because we expected to find interesting differences based on food culture and trends in meat consumption. In Norway, meat consumption is rising steadily, while in

France it is on the decline,” says Paula Varela.

Another interesting point is that despite a lot of similarities in the official dietary guidelines in Norway and France, there are also some key differences. In Norway, fish is associated with a healthy diet, whereas in France, guidelines actively promote the consumption of legumes and pulses.

“Planning and health are important



“This is how one participant chose to group the images,” says sensory assessor Kristine Myhrer, who was in charge of the focus groups.

to both nationalities. However, Norwegians plan their shopping around the meat or fish component, while French people take the vegetables as their starting point. In Norway, health is equated with eating lots of vegetables and fish. The French focus more on nutrition, e.g. that food should not be too fatty," says Paula Varela.

Imagine...

Projective techniques involve the participants being asked to describe how they envisage something, rather than answering questions about themselves. This is often done using activities that make it easier to be objective.

"These techniques, which are borrowed from psychology, are used both in consumer studies and design thinking," explains senior scientist Antje Gonera, who is responsible for the innovation research in FoodProFuture.

The researchers used three techniques – with great success. One was that each participant was asked to photograph four of their dinners during one week. The photos were made into a collage, and the participants talked individually about the meals. The next was to make associations to product images, which they could group at will. The last technique is called third-person association. The participants were asked to describe the types of vegetarian products they believe various stereotypical celebrities eat and why.

Few tempted by meat analogues

"In both Norway and France, most participants in the focus groups express scepticism about vegetarian products made to resemble meat products. They are perceived as unnatural and artificial, highly processed, and not particularly healthy," explains Paula Varela.

Several participants also said that if they were going to have a meat-free meal, they would eat fish or dishes with normal vegetables, or legume-based



Antje Gonera and Paula Varela are researching what it takes to get people to eat more plant-based food.

dishes. Another interesting difference is while the French replace meat with beans and lentils, Norwegians eat legumes as a side-dish to meat.

Meat analogues can nevertheless change eating patterns, particularly for convenience-driven consumers, because they can be used in the same way and do not require any new culinary knowledge.

Knowledge about typical products in vegetarian diets was low. Many people were not familiar with products like hummus, bulgur and quinoa, and many

felt that they don't know how to make a dinner without fish or meat, and that it is more time consuming. In addition, Norwegians are very traditional when it comes to food.

"For Norwegian consumers to eat more plant-based proteins, the products must taste good, have a pleasant texture, and be perceived as healthy. Although environmental awareness is increasing, it is uncertain whether this alone will lead to changes in diet," concludes Antje Gonera.

"You have no idea what's really in the product, and I'm a bit like ... what is it even? There could be all sorts of things in there that I don't want to eat."

Member of the focus group



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



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

FUNDED BY:
The Research
Council of Norway

PARTNERS:
The Norwegian University
of Life Sciences (NMBU) and
Centre for Taste and Feeding
Behaviour (CSGA) France



PHOTO: JON-ARE BERG-JACOBSEN

Scientist Christian Karlsen holds up bacteria taken from salmon and cultivated in Nofima's laboratory.

Safer transfer to the sea

More knowledge about barrier functions in post-smolt salmon can improve fish health and save the aquaculture industry millions.

Post-smolt is a generic term for the time immediately after transfer to sea water. It is estimated that 10–20% of all farmed salmon in Norway die between transfer to the sea and slaughter, of which a significant proportion are lost in the post-smolt phase.

One reason for this is that salmon's barrier functions are reduced in the period after transfer to the sea and take a long time to recover.

"The first period in the sea is a vulnerable phase, as the fish's defence systems are weaker in the first three months. During this period, the fish are especially prone to injuries and infectious diseases. It is therefore important to understand why and how

salmon's barrier functions change and what the industry can do to adapt," says Nofima scientist Christian Karlsen.

Thin skin

Together with his colleague Elisabeth Ytteborg, and other scientists in CtrlAQUA, he has studied how factors such as stress, temperature and treatment during transfer to the sea affect the fish's external barriers.

"The results of the research show that the skin becomes thinner and weaker in the period after transfer, but as the fish adapts to the new environment, the skin stabilizes again," says Ytteborg.

Gentle handling

It is too early to conclude whether it is a single factor or combinations of environmental changes that cause the weakening of salmon's external barriers.

"By increasing knowledge about the sensitive period in the sea, we will be able to suggest how the fish can be protected and handled more gently. Safer transfer of fish will ensure better fish health and fish welfare and will help reduce post-smolt mortality," says Karlsen.

Once the research results are ready, the scientists can start developing new handling methods in collaboration with industrial partners and the salmon industry.



CONTACT
Christian René Karlsen
Scientist
+47 411 47 162
christian.karlsen@nofima.no

Elisabeth Ytteborg
Scientist
+47 900 95 122
elisabeth.ytteborg@nofima.no

FUNDED BY:
The Research
Council of
Norway

PARTNERS:
21 industrial and
research partners
in Norway and
overseas

READ MORE

Driver behind local food

Bakken Øvre farm in Løten is home to the Kildahl family. Both farm and family have been a hub for developing local food in Norway.

Another important player is Stine Alm Hersleth, head of Nofima's competence network for local food in eastern Norway, which helps people who want to start processing farm based raw materials commercially.

"We offer courses and guidance to help food producers learn the relevant skills and technology," says Stine Alm Hersleth.

Products include sausages and other meat products, baked goods, milk and cheeses, processed vegetables, fruits and berries. The portfolio of courses is wide.

"The local food programme is a national network consisting of five regions, with a contact person for everyone – no matter where in Norway they live," explains Alm Hersleth.

Broad knowledge

Her team consists of a sausage maker, a baker, a cook, a jams and jelly expert, a food safety expert, a sensory panel and a whole host of food researchers, who together possess all the knowledge food producers might need.

Just ask Ole Martin Kildahl, the initiator behind Hamar farmer's market. In the 15 years it has been running, turnover has risen from NOK 5.5 million to NOK 72 million.

"There are far more local food producers in Norway now. Most have small farms, an entrepreneurial spirit and are complete foodies," says Kildahl.

A total of 12 people currently work in the company, but more are about to join.

From NOK 3.8m to NOK 15m

"My best advice for meat producers is to start by taking a course with Nofima's master sausage maker. Tom Johannessen can teach you everything you need to know to get started and can also help established producers evolve," says the local food producer.

"If we didn't process the raw materials ourselves, we would have had an annual turnover of NOK 3.8m, as opposed to this year's NOK 15m. This ensures solid value creation and the chance to give more people a job," concludes Ole Martin Kildahl.



Local food maker Ole Martin Kildahl's turnover has quadrupled, partly thanks to advice from Nofima's master sausage maker Tom Johannessen.

PHOTO: WENICHE AALE HÆGERMARK © NOFIMA



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

FUNDED BY:
Innovation Norway, the
Ministry of Agriculture and
Food.

Varying profitability

Ingredients made from marine by-products are often held up as a potential gold mine. But what is the financial reality in the industry?

In a forthcoming Nofima report, the scientists have analysed the profitability of the marine ingredients industry in Norway, with the aim to aid the seafood industry in assessing the potential for additional value creation of the total biomass. The results show that profitability varies greatly.

The marine ingredients industry is an umbrella term for companies that use residual biomass from the fisheries and aquaculture industry to produce ingredients for use in, for example, food and drinks. The ingredients produced come in the form of oil, powder and silage (raw materials conserved in acid). The residual raw materials used vary and can include everything from fish heads and entrails to shrimp and crab shells.

"People talk about the huge potential for value creation from residual biomass. The goal of the analysis was therefore to get an overview of the marine ingredients industry, study profitability, and identify common factors that can help cast light on financial success and challenges," says Nofima scientist Ingelinn Pleygm.

Mapping and interviews

The project started with a mapping of the industry in Norway. This turned out to be surprisingly difficult, according to Pleygm.

"The marine ingredients industry is a made-up term. Most companies operate under a variety of different industry codes. In addition, not all are exclusively engaged in ingredient production from residual marine biomass," she says.

The scientists mapped a total of 61 relevant, active businesses and

conducted interviews with 28 of these. In addition, they compiled and analysed data from public accounting figures and other secondary sources for all 61 businesses.

Varying profitability

The results of the analysis show that profitability in the industry is very fragmented. Over a period of three years (2014–16), almost 40% of the companies had very good profitability, while 25% underperformed. By comparing specific factors between companies, the scientists were able to ascertain the following:

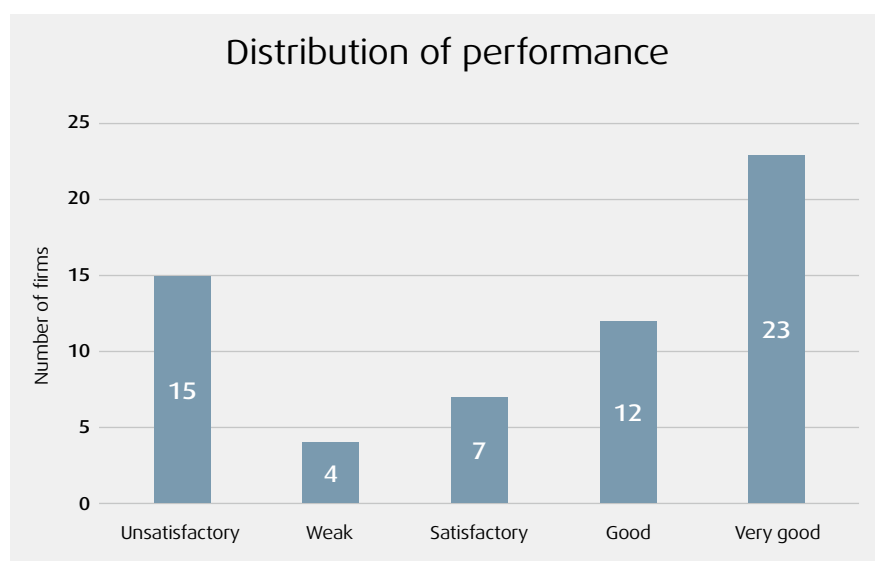
- Businesses that exclusively produce ingredients from residual biomass from whitefish experience satisfactory to very good profitability.
- Production of oil is most common, and businesses that include oil in their production experience better profitability.

- The companies that include powder in their production have slightly weaker results, usually due to market challenges.
- Companies that do not take on the entire value chain achieve better profitability.
- Going from raw material to finished consumer product is more costly and affects profitability, although this does not mean that companies should not try to go it alone on the market.

Common challenges

It was nevertheless demanding to find strong common denominators that explain positive or negative financial results, the scientists admit.

"The data must be handled with some caution, in part because the companies focus on different raw materials, value chains and end products. In addition, several are part of a larger corporation, making the



Are they making money? Number of companies in the Norwegian marine ingredients industry ranked by profitability (average 2014–16).



PHOTO: AUDUN IVERSEN © NOFIMA

Ingelinn Pley (left) and Marianne Svorken have analysed the profitability of the marine ingredients industry in the period 2014-16.

financial figures less precise,” says Nofima scientist Marianne Svorken.

The market is the biggest challenge according to the companies that were interviewed. Many of the companies would like to enter the global market, but find it too large and confusing. Others cited challenges related to access raw materials, supply chain flow, technology, legislation and financing. “This is an industry with a lot of potential, but also with challenges that mean it will take time to create sustainable profitability. So the question then is how long can a company survive without making a profit?” asks Svorken.

“The goal of the analysis was to get an overview of the marine ingredients industry, study profitability, and identify common factors that can help cast light on financial success and challenges.”

Ingelinn Pley, forsker i Nofima



CONTACT:
Ingelinn E. Pley
Scientist
+47 954 64 692
ingelinn.eskildsen.pley@nofima.no



Marianne Svorken
Scientist
+47 922 94 946
marianne.svorken@nofima.no

FUNDED BY:
Nofima. Strategic Institute Initiative.
The Seafood Quality project

Cod's sex gene identified

Using a tiny DNA sample from cod, it is now possible to determine both the sex of the fish and whether it is a coastal cod or skrei.

The breakthrough was recently made by scientists from CIGENE (at the Norwegian University of Life Sciences – NMBU) and Nofima.

Previously, the sex of cod could only be determined in adult fish displaying either eggs or milt. Now it is possible to find out whether a cod is female or male at any time in the fish's life, right from when it is a fertilized egg. The same DNA sample will also reveal whether it belong to the Norwegian coastal cod population or the skrei population living in the Barents Sea. This marks an important milestone in fish research of importance for the management of the wild cod stocks, and also for investigating the impact of pollution and temperature changes on the Norwegian national fish.

Important findings for cod farming

"This research will also have a great impact on future cod farming," says Øivind

Andersen, a senior scientist at Nofima.

Early sexual maturation in male cod has been a major challenge for the aquaculture industry. For this reason, fish farmers only want to produce female cod, which mature much later than males. Now females can be distinguished from males at a very early stage of development, thus profits can be increased significantly once cod farming gets going again.

Resequencing the cod genome

The hunt for the sex gene in cod has been going on for several years through the Aquagenom project, within the BIOTEK2021 programme

financed by the Research Council of Norway. In addition, the Norwegian cod breeding programme has provided data for the research work.

Øivind Andersen explains that the work has been very complicated, as different genes govern sexual development in different fish species.

"We also had to resequence the whole cod genome to identify the region that distinguishes males and females," says Andersen.

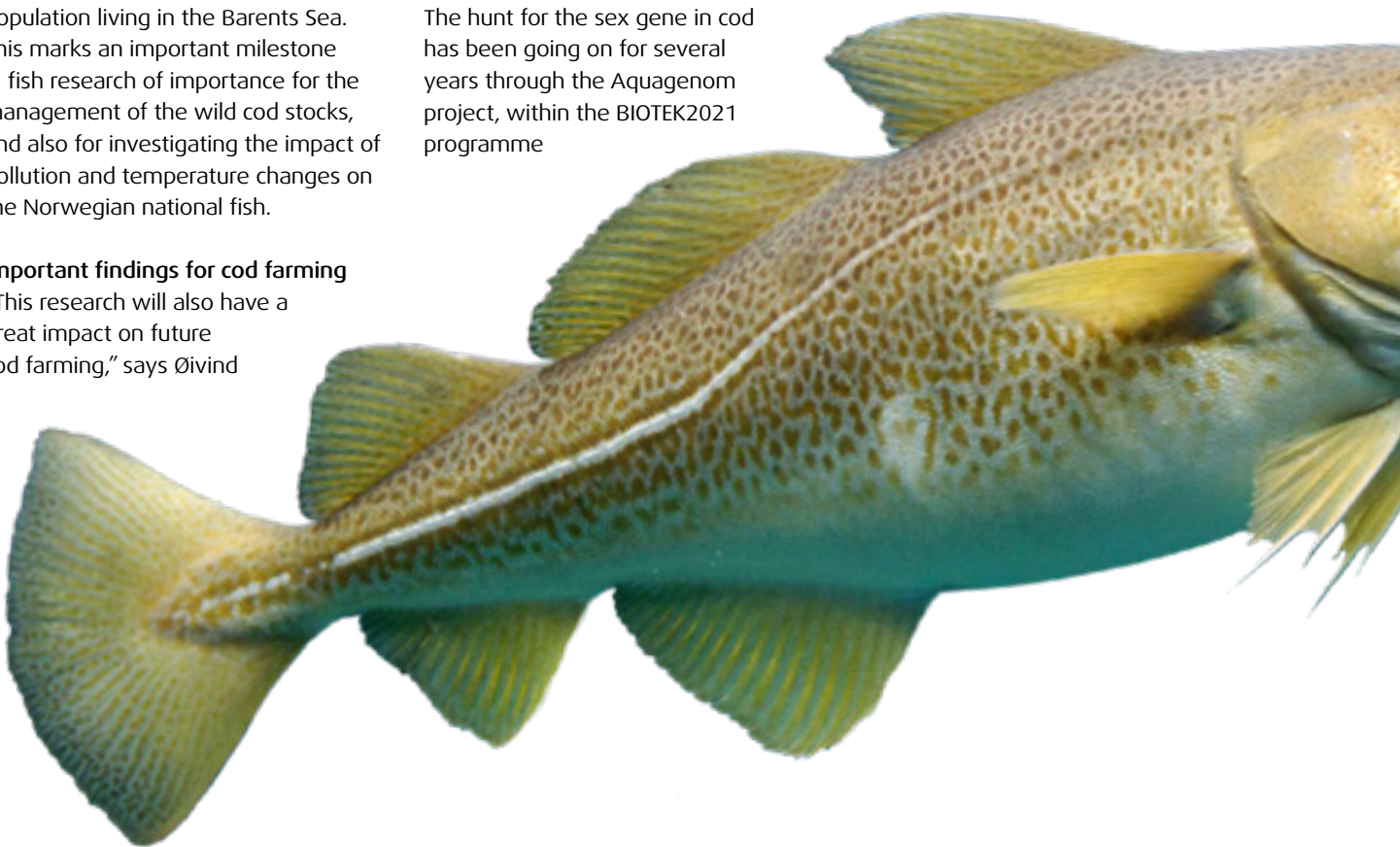


PHOTO FRANK GREGERSEN © NOFIMA

The breakthrough in the joint project between CIGENE at the Norwegian University of Life Sciences (NMBU) and Nofima also means it is now possible to determine the sex of related codfishes.

Oil pollution and climate change

"For example, this tool can be used in the current studies of whiting and effects of oil pollution. It will also be important in ongoing research on how climate change affects sexual development and reproduction of polar cod in the Barents Sea," says Andersen.



// This research will also have a great impact on future cod farming

Øivind Andersen, Senior Scientist Nofima



PHOTO: JOE URRUTIA © NOFIMA.

The hunt for cod's sex gene is finally over. Nofima scientist Øivind Andersen has found it, in a joint project with colleagues from NMBU.



CONTACT:
Øivind Andersen
Senior Scientist
+47 930 60 248
oivind.andersen@nofima.no

FUNDED BY:
The Research Council of
Norway, BIOTEK2021

PARTNERS:
CIGENE (Norwegian University
of Life Sciences – NMBU)

Effects of structural policy

Broad knowledge is needed to understand the consequences of the structural changes in the Norwegian fisheries industry at sea and on land.

From the FHF project “Future effects of structuring on sea and land” much has been learned, but there are still many unanswered questions.

Political challenges

“The background for the project was uncertainty about the consequences of structural measures. We provide knowledge about the underlying driving forces and consequences of structuring. Models that predict the impact of changes in the structuring systems produce knowledge that can be used to adjust the capacity adaptation systems,” explains research director Bent Dreyer.

The project has resulted in two reports – on structuring in the fleet and structural changes in the processing industry. Both reports highlight political challenges related to how, how much and how quickly the fishing fleet should be allowed to structure itself.

The systems work

Important arguments for structuring include overcapacity, poor profitability, and low wages. And structuring works. Changes include fewer vessels and slightly lower capacity, higher operating margins, and higher catch shares for crews. Other aspects are harder to quantify, such as better working conditions and greater job security.

However, there are also challenges:

“In the report we point out how fleet structure and landing patterns impact the industry. Fewer vessels and fewer landings contribute to fewer processing plants. As the vessels become larger, the industry also needs to increase its capacity. This means that while some companies grow, others will find that they cannot keep up in the race for raw materials and will close,” says Nofima scientist Audun Iversen.

The result will be fewer, but larger onshore plants and fewer communities with fish-processing.

“Structural policy thus entails a heavy political responsibility, requiring expert knowledge and conscious political choices,” says Bent Dreyer.



PHOTO: EMIL BREMMES © NOFIMA

The project “Future effects of structuring on sea and land” reveals that structural policy entails a large political responsibility.



CONTACT:
Audun Iversen
Scientist
+47 900 40 615
audun.iversen@nofima.no



Bent Magne Dreyer
Research Director
+47 992 76 715
bent.dreyer@nofima.no

PARTNERS:
University of
Stavanger / IRIS

FUNDED BY:
The Norwegian Seafood
Research Fund - FHF



Birgitte Moen and Annette Fagerlund are working on the latest generation of DNA analysis tools, like this MinION portable DNA sequencer.

PHOTO: JOE URRUTIA © NOFIMA

Know your bacteria

The latest innovation in DNA analysis makes it easier to identify bacteria, allowing better control over product quality.

“By identifying the bacteria on the raw materials and processing equipment, we can locate contamination sources of spoilage bacteria and take actions to prevent problems”, says Nofima scientist Birgitte Moen.

She works with DNA sequencing of bacterial communities, and the methods she uses make it possible to identify bacteria without having to resort to cultivation, paving the way for new possibilities.

For example, the spoilage bacterium *Photobacterium* thrives in cold water and is therefore common on fish. DNA sequencing makes identification of this traditionally hard-to-find bacterium much easier.

Important to know both which and how many

Using DNA sequencing of bacterial communities and classic microbiology, Nofima scientists have mapped the types and number of bacteria found on fish and processing equipment at two fish processing plants.

“When we analyse fresh, processed fish, we find a number

of different bacteria. These bacteria come from the raw material, i.e. the living fish, but also from environments the raw material has been exposed to,” explains senior scientist Solveig Langsrud.

Most bacteria do not affect the taste and smell of the product. The three most common spoilage bacteria for fish are *Photobacterium*, *Shewanella* and *Pseudomonas*. DNA analysis allows you to look at the entire bacterial flora in one analysis, not just the strains that dominate or are cultivable.

DNA sequencing technology for optimal process control

DNA sequencing is developing at a furious rate, and equipment is getting ever smaller, cheaper, faster and more robust, enabling more potential applications in the food industry. However, more research is still needed.

“We need more knowledge to optimize the use of DNA sequencing technology in the food industry,” concludes Birgitte Moen.



CONTACT:
Birgitte Moen
Scientist
+47 922 08 108
birgitte.moen@nofima.no



Solveig Langsrud
Senior Scientist
+47 905 67 218
solveig.langsrud@nofima.no

FUNDED BY:
FFL and TKVDN (Technical Committee for Cleaning and Disinfection Agents for the Food Industry).

PARTNERS:
The Norwegian Seafood Federation

Dietary protein-to-lipid ratio

Scientist Jens-Erik Dessen has studied what farmed salmon should eat in order to optimize growth and health.

Simplified, fish farmers want to get the most out of their inputs – the fish and feed. However, fish farming is influenced by environmental conditions, operating form, smolt quality and infectious diseases – all of which vary widely.

This was the starting point for Jens-Erik Dessen's PhD work, under the supervision of Professor Kjell-Arne Rørvik, which included trials in pens in three very different farming locations along the Norwegian coast.

How protein and fat affects growth

"The experiments lasted up to a year and a half, in order to identify important connections, giving us unique insight into how variables in the environment, feed and fish affect the production," says Dessen.

He has studied at how the protein and fat content in the feed affects growth, feed utilization, health, quality and fat deposition in farmed salmon. This was done to identify good balances in the dietary protein-to-lipid ratio related to different seasons and periods with high risk of viral diseases (pancreas disease).

Three recommendations

He has performed four studies in his PhD and has three general recommendations:

- Smolt transferred to sea in spring require high dietary energy and high protein content during the early seawater phase for optimal growth performance.
- Increased dietary protein-to-lipid ratio could be utilized during the first spring and summer in sea for sites with high risk of pancreas disease outbreaks to improve survival and reduce the accumulation of severely thin diseased fish (runts).
- High fat content in the fish, especially in early autumn, reduces the long-term growth potential.

The trials were performed in small-scale at Averøy Research Station and in large-scale at Nofima's research facilities in southern, central and northern Norway. This was done in order to ensure research that could be of practical relevance for the fish farming industry.



PHOTO: HELGE SKODVIN © NOFIMA

Supervisor prof. Kjell Arne Rørvik has worked on solutions for the industry for 40+ years. In 2019, he will hand the baton over to Dessen.



CONTACT:
Jens-Erik Dessen
Scientist
+47 979 52 768
jens-erik.dessen@nofima.no

FUNDED BY:
Nofima. The small-scale trials were partly funded by the Fishery and Aquaculture Industry Research Fund (FHF) and Havsbrún

PARTNERS:
Blom fiskeoppdrett AS,
Nordlaks oppdrett AS,
Lerøy Midt and BioMar



PHOTO: JOE URRUTIA © NOFIMA

Regarding replacing effects of salt on taste in bread, Mari Øvrur Gaarder and Stefan Sahlström conclude that it is challenging, but possible.

Healthier bread with less salt

Salt reduction is important for public health, especially in everyday foods. Nofima scientists are working to find ways to reduce the salt content of bread.

Together with Norwegian baking industry we have lowered the amount of salt in bread and are working to find more ways to make further reductions. However, we know that salt fulfils several functions,” says Stefan Sahlström, a senior scientist at Nofima.

Salt is not only there for the flavour

Salt acts as a taste enhancer, reduces water activity and increases shelf life. In bread production, salt reduces yeast activity and improves the formation of gluten. A certain amount of salt is therefore necessary to prevent dough stickiness. Stefan Sahlström in collaboration with bakers from Norwegian bake houses and Nofima’s in-house baker performed bread baking trials with varying salt content. “In small scale, it is possible to produce bread without salt, but in large scale, a minimum of 0.18% salt is needed. Without salt the dough becomes sticky and difficult to handle

mechanically. However, too large salt reduction results in tasteless bread that consumers do not like,” Stefan explains.

Taste is the biggest challenge

The scientists have experimented with various types of sourdough bread to see if sourdough can compensate for the negative changes in flavour caused by salt reduction. Wheat, rye, spontaneous sourdough and sourdough produced with specific lactic acid bacteria was tested.

“We found that replacing a part of the wheat flour with a sourdough fermented with specific lactic acid bacteria increase the overall taste intensity of low-salt bread,” says Nofima scientist Mari Øvrur Gaarder.

She adds that with a bread recipe with of 40 percent sourdough taste can be improved, although there are still several technological hurdles to overcome. Further research is required to resolve these challenges.



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



Mari Øvrur Gaarder
Scientist
+47 959 34 352
mari.gaarder@nofima.no

FUNDED BY:
Research Funding for
Agriculture and the Food
Industry (FJM) and the
Research Council of Norway

PARTNERS:
Kavli, Norgesmøllene,
Mesterbakeren, Baker Brun,
Tind, Nortura, Orkla Foods Norge,
SINTEF, Nofima and Animalia



Boosting EU fish breeding

European aquaculture is being taken to the next level through technological advances in breeding of six species in Europe.

The EU project Fishboost started in 2014 with the goal of improving European aquaculture for six species of farmed fish: European seabass, gilthead seabream, common carp, turbot, rainbow trout and Atlantic salmon.

The Nofima-led project will conclude in January 2019. Scientists from 14 research institutions, 11 companies and an NGO have studied a wide range of traits and developed tools and technologies to contribute to more balanced, sustainable and long-term profitable breeding programmes.

Increased interest in fish breeding

"Fishboost has contributed to increased awareness in Europe that breeding is an important part of fish farming," says Anna Sonesson, project coordinator for the EU project.

For example, Fishboost's industry forum at the Aquaculture Europe conference in 2018 was packed out, and Fishboost has held several highly attended workshops.

Knowledge is shared – applications are proprietary

Fishboost is one of the last projects granted funding under EU's seventh framework programme.

High requirements were set for dissemination of findings and large geographical spread in the project.

The partners in the project have agreed that only the parties that find a result or innovation own it, but that knowledge about the result must be shared.

The partners in the project have agreed with EU that only the parties that find a result or innovation own it, but that knowledge about the result must be shared.

"This means that no one else in the

consortium is allowed to exploit your findings," explains Sonesson.

Examples of impacts and results

The goal of Fishboost is to increase the efficiency and profitability of European aquaculture by enhancing all six species through advanced breeding methods.

Many breeding programmes in Europe have only selected for growth and other traits related to production efficiency. Fishboost has demonstrated

Facts about FISHBOOST

- Funded by EU FP7
- Runs from 2014 to January 2019
- Budget of NOK 75 million
- Research on six species of farmed fish
- Partners from nine countries
- Nofima's Anna Sonesson has coordinated the project
- Partners: Ifremer, IMARES, INIA, INRA, Luke, University of Edinburgh, Norwegian University of Life Sciences (NMBU), University of Padova, University of South Bohemia, Wageningen University, Andromeda Group, FMD, FEAP, BMR Genomics, CETGA, Milin Nevez, Geneaqua, Klatryb, LABOGENA, Salmobreed, SYSAAF, VRI and Les Poissons du Soleil.



the potential of also selecting for better disease resistance. For example, the partners have estimated the heritability of the main diseases for the species and mapped the genes behind them.

Fishboost has developed important tools such as gene maps and thousands of genomic markers, which show where on the DNA there is variation between animals. For example, genomic markers are used in genomic selection, which is more accurate than traditional breeding. In the Fishboost populations, accuracy using genomic selection was up to 22 % higher. But the method is expensive. The partners in Fishboost have developed ways to reduce the cost of using this method with the aim to increase the use of genomic selection in European breeding programmes.

Fishboost has also developed better selection and phenotyping methods to increase production

◀ *Anna Sonesson, who is now winding up the Fishboost project after five years, is very pleased with the increased focus on breeding in the EU.*

PHOTO: JOE URRUTIA © NOFIMA.

efficiency. The Norwegian industrial partner Salmobreed sees a potential for knowledge transfer between species:

“Much has been done to develop indirect methods for measuring feed utilization and production efficiency on several of the species in Fishboost. The research done on rainbow trout has a particularly high transfer value to salmon,” says Haavard Bakke, project manager at Salmobreed.

Partners in Fishboost have worked to optimize the design and profitability of the breeding programme when new traits are included in the breeding objective, taking into account different technological levels, reproduction and biology in the species.

The way forward for breeding in aquaculture

“I hope and believe that the industry will make use of this knowledge and that it will contribute to higher quality in existing breeding programmes and stimulate the creation of new ones,” says Sonesson.

Nofima and other research partners have written new applications to continue their work, and Nofima has already been awarded two new EU projects in this field.



CONTACT:
Anna Sonesson
Senior Scientist
+47 930 98 047
anna.sonesson@nofima.no

FUNDED BY:
The EU's 7th framework
programme

PARTNERS:
14 research institutions,
11 companies and one
NGO in Europe

SEE MORE



Superb cod from hotel

Cod from the “Cod Hotel” is a top-quality product, if it is handled properly and not kept too long without feed.

This has been stated by scientist Tatiana N. Ageeva in a PhD on live-storage of cod, as part of the research project Catch.

“Live-storage makes it possible to maintain and even improve the quality the fish had at the time of capture,” says Ageeva.

The Nofima scientist has studied the quality changes in wild-caught mature Atlantic cod or skrei, from it is transferred to sea cages until the marketing. The sea cages for live-storage of cod are also called the Cod Hotel.

“According to Norwegian regulations, wild cod can be stored alive for up to 12 weeks, with an initial four weeks without feeding. We have studied how storage in the cod hotel affects the quality of skrei,” explains Tatiana N. Ageeva.

Spawn in the sea cage

Cod that are stored alive in a sea cage must be fed after four weeks. However, it is difficult to get wild cod to accept formulated feed. If the fish are still fasting after eight weeks, the quality will strongly reduce.

“After eight weeks without feeding, the cod had a lower protein content and a higher water content. Fillets got an atypical white colour and gelatinous texture”, explains Ageeva.

The results showed that the cod should be fed during live-storage in cod hotel. This is important with regard to both the quality and welfare of fish. Scientists have been working to develop a suitable feed, with promising results so far.

The study also shows that mature cod spawn in the sea cages – despite the captivity and absence of feed.



Tatiana N. Ageeva has taken a PhD on live-storage of cod in the research project Catch.

PHOTO: SILJE KRISTOFFERSEN © NOFIMA



Knowledge from Catch may also be very useful in other parts of the seafood industry where high quality and exclusivity are key.

PHOTO: SILJE KRISTOFFERSEN © NOFIMA



Cod from the Cod Hotel is a top-quality product, when handled properly.

PHOTO: FRANK GREGERSEN © NOFIMA

"This leads to a considerable reduction in the fish's weight already at the start of live-storage. The study also found that the absence of feed affects the quality of female cod to a greater degree than males," the scientist explains.

Pre-rigor processing

An extremely relevant issue to ensure the best quality of live-stored cod is the time of filleting after slaughter.

Like everything else that dies, fish also undergo a period of stiffness after death, i.e. rigor mortis. Once rigor sets in, the muscles contract and pull against each other, making the fish stiffen and harden. Such fish is difficult to process without any quality reduction of the final product.

"Fillets made pre-rigor are products of the best quality and have a long marketing time, while fillets processed post-rigor have softer texture and are more prone to fillet gaping during production and thus lose a lot of muscle fluid," explains Tatiana N. Ageeva.

The study she has participated in shows that the pre-rigor time is reduced when the fish have not been fed for a longer time.

The study also covers how the absence of feed affects contraction and drip loss in different fillet products. The

results showed that tails were more prone to contraction and drip loss than loins and whole fillets.

Catch

- The goal of the five-year research project Catch has been to maximize the sustainable value of wild Atlantic cod through capture and live storage.
- Catch has resulted in new knowledge about how to achieve better quality and a longer shelf life, as well as development of considerable new expertise at Nofima and our research partners.
- The project has looked at the entire value chain from catch to consumer and has investigated both fresh and frozen fillet products, as well as dried and salted products.
- Some of the results show how processing and packaging of cod products can be optimized to provide the best quality and shelf life — and how unique purchasing and consuming experiences may increase the amounts of consumers, which are willing to pay.
- The knowledge gained can be of great value for other parts of the seafood industry where high quality and exclusivity are the keys.
- Three scientists have taken their PhD in this project: Morten Heide, Sarah Joy Lyons and Tatiana N. Ageeva.



CONTACT:
Tatiana N Ageeva
Scientist
+47 77 62 92 15
tatiana.ageeva@nofima.no

Geir Sogn-Grundvåg
Senior Scientist
+47 470 29 204
geir.sogn-grundvag@nofima.no

FUNDED BY:
The Research
Council of Norway's
Bionær programme

PARTNERS:
Six research
partners and
eight industrial
partners

READ MORE



Rediscovering old grains

Økologisk Spesialkorn is developing new organic wholegrain products from old grain varieties, based on the results of the Smaskorn project.

The project has generated important knowledge about grain quality and how quality and nutritional content are affected by processing. The different grain varieties studied are Svedjerug (an old Finnish rye rye), emmer wheat, spelt, naked oats and naked barley – all organic.

“The focus in our product development work has been that new organic wholegrain products must taste good and preserve the healthy nutrients,” explains Nofima scientist Ann Katrin Holtekjølén, who has led the research work in the project.

Knowledge about grain quality

The project has analysed grain quality and found quality differences between the special grain varieties as well as within one species of grain.

Grain quality also varies from year to year and in different cultivation conditions. It is important to be aware that these variations in grain quality affect the grain’s processing characteristics and nutritional value, and thus product quality,” says Ann Katrin Holtekjølén.

From farmer to innovative food producer

“The goal is to ensure the nutrients in the grains remain as intact as possible, while preserving the unique flavours and taste properties. We have developed a rapid process with few steps that does just this, providing clear competitive advantages financially and in terms of product quality,” says Ann Katrin Holtekjølén.

She adds that development of prototypes as well as market and consumer surveys and tests are essential for successful product development, as have been central in this project.

“We have great expectations for the upcoming new line of products. We know that many consumers want traditional organic grain products, and it is an important competitive advantage that the healthy nutrients are well preserved,” says Anders Næss, general manager of Økologisk Spesialkorn.

For him, cultivating heritage grains using ecological farming methods is a value choice.



PHOTO: ANDRÉ LOVÅAS © NOFIMA

Ann Katrin Holtekjølén wants to ensure processing and product development do not affect the flavour and nutritional value of grains.



CONTACT:
Ann Katrin Holtekjølén
Scientist
+47 901 27 004
ann.katrin.holtekjolen@nofima.no

FUNDED BY:
The Foundation for Research Levy
on Agricultural Products (FFL), the
Research Council of Norway (NFR)
and Økologisk Spesialkorn

PARTNERS:
Økologisk Spesialkorn



PHOTO: TERJE AAMODT © NOFIMA

Trials in CtrlAQUA showed that both large and small smolt tolerated the transition to seawater. 93% of the salmon transferred to the sea survived.

Biggest is not always best

It seems that the largest smolt do not always perform best in the sea. New research shows that there is still more to learn about salmon.

Researchers in the CtrlAQUA innovation programme are working on the basis of the hypothesis that more time spent in recirculation facilities (RAS) on land will improve the fish's growth and welfare in the sea.

However, RAS represent a new, constructed environment for salmon, where previous knowledge does not always apply. Results from a trial where salmon of different sizes were transferred from RAS to the sea show that the biggest fish not necessarily perform best.

"The question is whether it is most important that the time the salmon spend in the sea is minimized, or whether the overall production is as efficient as possible," says project manager, Trine Ytrestøyl.

Lighting, brackish water and different sizes

Several production regimes have been tested using varying light-regimes, fresh water, brackish water and different sizes on transfer to the sea.

The fish with the best growth throughout life were the ones transferred to the sea at 100 grams after undergoing traditional smoltification with lighting control. The fish that

were 600 grams at the time of transfer had the poorest growth.

Perhaps the most surprising finding was that all the fish tolerated the transition to seawater. The survival rate was not affected by light-regime or salinity in RAS, and a total of 93% of the salmon survived.

Several good production regimes

"It seems that salmon are quite flexible in terms of transfer to seawater, and that when they reach a certain size, they can develop salt water tolerance without lighting control. This paves the way for several different production strategies and greater flexibility," says Ytrestøyl.

The scientist emphasizes that it may nevertheless be an advantage to reduce the time the salmon spend in the sea, in order to reduce the risk of escape and sea lice.

This illustrates that there are still unanswered questions with regard to how large postsmolt should be produced, and how the season and size at the time of transfer affects performance in the sea phase. Research will continue on these issues in CtrlAQUA.



CONTACT:
Trine Ytrestøyl
Scientist
+47 412 29 744
trine.ytrestoyl@nofima.no

Åsa Maria O. Espmark
Senior Scientist
+47 991 60 039
asa.espmark@nofima.no

FUNDED BY:
The Research Council
of Norway (NFR), The
Norwegian Seafood Research
Fund - FHF and partners

PARTNERS:
Research
partners and
industrial partners
in CtrlAQUA

READ MORE
at CtrlAQUA.no



Food in recycled plastic

More plastic needs to be recycled, but recycled plastic cannot automatically be used for food. Researchers are trying to change this.

“To be able to use more recycled materials, we need better sorting systems that can separate both different types of plastic and sub-groups within the different types. It is also necessary to check that hazardous components are not transferred from the plastic to the food,” says Marit Kvalvåg Pettersen, a senior scientist at Nofima.

The majority of households in Norway source sort plastic. Designing better recycling systems must therefore be based on knowledge about the types of plastic in Norwegian households.

Necessary to separate different types of plastic

For seven weeks, 60 households collected all their plastic waste and delivered it to the research project FuturePack. This amounted to roughly 60 kg of plastic. The waste was washed and sorted into five categories: PP (polypropylene), PE (polyethylene), PS (polystyrene), PET (polyethylene terephthalate) and other plastic (either unlabelled or a combination of several types of plastic).

“PP was the largest category, so we chose to concentrate on this and further

sort this type of plastic into subgroups. Another important reason for the focus on PP is that different types of PP are used in different processing methods,” explains Tanja Radusin, a post-doctoral researcher in FuturePack. During the first year of the project, she has concentrated on materials and has been stationed at Norner, which is leading the project.

Migration analysis to check that food stays safe

Materials used in food packaging must be guaranteed safe. The transfer of components from packaging to food is called “migration”. The researchers have compared certain types of recycled plastics with new, virgin plastics. Migration of components must be under defined threshold values.

“We have tested ten different qualities of plastic in harsh conditions and different temperatures to determine whether chemical components migrate from the plastic to the food. As expected, there is a clear correlation between temperature and migration. The higher the temperature, the more migration there is,” says Tanja Radusin.

Seven recycled and three virgin

Migration analyses were performed on seven recycled and three virgin types of plastic. Virgin plastic intended for contact with food is safe, but there were large differences between the recycled varieties.

“Some recycled plastics cannot be used for food packaging, while others seem promising. Based on the tests, we see that more detailed sorting is a prerequisite for being able to use recycled plastic in food packaging,” concludes Marit Kvalvåg Pettersen.

Facts about plastic

There are many types of plastic qualities. The most common main categories found in Norwegian households are described below.

- Polypropylene (PP) comes in both flexible and rigid variants that can also be applied high temperatures. It is used for bottles and packaging for fresh meat and ready meals that are to be heated in a microwave oven. Flexible PP is used widely in packaging for vegetables.
- Polyethylene (PE) occurs also in different varieties, from very soft and flexible to completely rigid. PE can be used in many applications from plastic wrap (bread bags, carrier bags) to bottles, bowls and cups.
- Polystyrene (PS) is transparent, rigid and fairly brittle and has a relatively low melting point. Disposable glasses are often made of PS. PS is also often used for dairy products, such as yogurt.
- Polyethylene terephthalate (PET) is strong, rigid and easy to recycle. Plastic drinks bottles are usually made from PET.

Many products can be made of several different types of plastic. What determines what type of plastic manufacturers choose is what the plastic will be used for, how long it will have to last, and how robust it needs to be.



PHOTOS: WENCHE AALEHEGERMARK © NOFIMA



▲ The sausages Marit Kvalvåg Pettersen and Tanja Radusin tested last just as long when packaged in recyclable plastic as in complex materials.

◀ Eight different categories of PP separated, washed and shredded. The red plastic is from ketchup bottles.



CONTACT:
Marit Kvalvåg Pettersen
Senior Scientist
+47 928 07 951
marit.kvalvag.pettersen@nofima.no



Tanja Radusin
Postdoctoral Researcher
+47 948 60 446
tanja.radusin@nofima.no

FUNDED BY:
The Research Council of Norway and participating companies

PARTNERS:
Norner, the Paper and Fibre Research Institute (PFI), Østfoldforskning, the Department of Chemical Engineering at NTNU and participating companies.)



PHOTO: BJØRN ERIK LARSEN © NOFIMA

Sissel Albrektsen has found that minerals from fish bones make it much easier for salmon to digest and absorb astaxanthin into the flesh.

Fish bones give more red salmon

A mineral-rich ingredient that Nofima scientists have made from fish bones has had unexpected effects.

Salmon fed the new ingredient had much redder muscle. The effect, which was first observed in an experiment with salmon smolt and visible to the naked eye, has been confirmed by chemical analysis.

The colour came from astaxanthin, a pigment that is added to salmon feed to ensure the distinctive red colour. Usually less than 10% of the astaxanthin in the feed is absorbed into the muscle of farmed salmon, mostly due to oxidation of astaxanthin into colourless compounds, but also due to limitations in absorption and transport of astaxanthin into the tissues.

Nofima's mineral ingredient contains minerals extracted from fish bones.

Surprised and very positive

The experiments showed 35% more colour deposition in muscle of salmon fed with the mineral ingredient, and ability to digest astaxanthin increased by nearly 20%. Pigment levels in the blood and liver also increased.

"It is surprising and very positive that a mineral ingredient can affect pigment utilization," says Sissel Albrektsen, a senior scientist at Nofima.

She and her colleagues at Nofima have long researched effective ways to exploit fish bones. They used an acid to extract minerals from the bones of blue whiting. Increased astaxanthin utilization is a very positive side effect with high market value.

Increases digestibility of astaxanthin

Feed containing the phosphorus-rich mineral ingredient was tested on salmon of 1.7-2.5 kg, and compared with salmon that received the same feed containing a common commercial source of phosphorus.

"We believe that the main explanation for the redder muscle is that the salmon digest more of the astaxanthin with the mineral ingredient in the feed," says Albrektsen.

Albrektsen and her colleagues are now going to study how minerals extracted from fish bones can affect intestinal function.



CONTACT
Sissel Albrektsen
Senior Scientist
+47 922 89 743
sissel.albrektsen@nofima.no

FUNDED BY:
The Research Council
of Norway (FORNY)

READ MORE



Focus on fish powder

Nofima and Myre Havbruk AS are working on a product that could enable protein powder from fish to achieve much higher prices.

Fish meal has been around for a while. The real challenge is production of a virtually odourless, flavourless powder on an industrial scale.

In a previous project, Nofima developed a process to make a tasty protein powder from cod backbones. Now scientists and commercial players are working together to scale this process up for industrial use.

Maximizing value

Andre Reinholdtsen from Myre Havbruk is a pioneer within live storage of cod. Using the freshest raw materials, he wants to extract protein from the parts of the fish that are left after filleting.

"We want to maximize the value from live-stored fish so that we can pay the fishermen so well that this kind of fishing is profitable without subsidization," says Reinholdtsen.

Live-stored fish are like line-caught fish in terms of raw material quality, which affects the end product. Hydrolysis is

used to extract protein from the residual biomass. Different hydrolysis parameters are being tested.

"The goal is maximum protein with the best taste. We now want to scale up the results we achieve in the lab for industrial production. We are doing this in the Nofima-run national facility for marine bioprocessing – Bioteq in Tromsø," says researcher Birthe Vang.

Huge benefits for the entire industry

The scientists aim to find out which raw materials, process and infrastructure are best to maximize yield and profits on cod trimmings after filleting.

Fish powder can be used as a dietary supplement and also added to fish soups, fish cakes and other processed seafood products to provide extra protein.

"Processes developed for use of trimmings from whitefish will benefit the entire industry," adds the scientist.



PHOTO: FRANK GREGERSEN © NOFIMA



CONTACT:
Birthe Vang
Scientist
+47 992 37 857
birthe.vang@nofima.no

FUNDED BY:
The Norwegian Seafood
Research Fund - FHF

PARTNERS:
Myre Havbruk AS



PHOTO: JENS PETTER WOLD © NOFIMA

Using near-infrared spectroscopy, producers can measure and control the core temperature of sausages.

Smart tech means better food

Full control of temperature and water content results in better sausages and French fries. This can now be measured in the production line.

In the SmartSensor project, scientists from Nofima and Sintef Digital are developing a rapid measurement instrument for direct use in the production line.

"This instrument will be of great value to food producers, because detailed data will make it easier to handle varying raw material quality, which will reduce waste," says project manager Jens Petter Wold.

Better control = increased profitability

For Nortura, the main goal is better control of the core temperature in sausages. To be entirely safe to eat, sausages must have a core temperature of above 72°C, but if the temperature exceeds 78°C, they can become dry, and profitability decreases. Core temperature is currently measured on a random sampling basis. The new prototype will allow continuous measurement and control.

The water content of potatoes affects what they should best be used for. For example, French fries are best

made from potatoes with a high solids content. Using the SmartSensor technology, Findus can sort the potatoes directly on the production line.

The salmon producer Cermaq wants to see if this technology can measure the quality of whole salmon.

Further advances

The technology in the prototype is based on near-infrared (NIR) spectroscopy and is unique in its ability to measure extremely quickly and to penetrate objects, e.g. salmon skin, without coming into contact with the food.

"Until now, NIR instruments have not been able to measure deep enough inside products with dark surfaces such as salmon and potatoes. Now we are able to combine both speed and depth, providing food producers with huge savings. Today we have a promising prototype that we believe and hope can become a commercial product," says Jens Petter Wold.



CONTACT:
Jens Petter Wold
Senior Scientist
+47 959 79 749
jens.petter.wold@nofima.no

FUNDED BY:
The Research Council of Norway
and participating companies

PARTNERS:
Nortura, Findus, Cermaq,
TOMRA and Sintef Digital

Losing out on vast sums

Unfished quotas and lack of focus on quality mean the Norwegian haddock industry is losing out on vast sums of money – every year.

The quality of haddock is highly variable. The scientists' advice to the Norwegian haddock fisheries is therefore clear: focus on quality to earn big money.

Approx. NOK 72,000

A cautious estimate from scientist Torbjørn Tobiassen shows that improvements in the quality of the raw materials could yield 30% more haddock loin, instead of block products. This could increase earnings on one day's production of haddock fillets by at least NOK 72,000.

"Today there is a price difference of NOK 30 per kilo between haddock block and loin, amounting to NOK 9,600 per tonne of fillet. With a daily production of 7.5 tonnes, the difference is NOK 72,000, which adds up to a lot of money over the course of a year," explains Torbjørn Tobiassen.

Keeping the catch alive on board until delivery, slaughter and pre-rigor processing, can result in a huge improvement in fish quality, ensuring premium products.

NOK 200 million in unfished quotas

In 2017, haddock worth some NOK 200 million were left unfished. The figures for previous years are similar. The scientists believe this is because the quotas have been allocated to the wrong vessel group. Basically, the coastal fleet has been awarded the largest haddock quotas, but it is the off shore fishing fleet that is best equipped and most interested in catching haddock.

"The distribution of the haddock quotas between the vessel groups is not in line with the reality. The growing tendency to favour cod over haddock means large parts of the haddock quotas allocated to the coastal fleet are not being used. In 2017, some 17,000 tonnes of the Norwegian haddock quota north of 62°N were not used," says Edgar Henriksen, a senior scientist at Nofima.

In light of these figures, it is recommended that the distribution of haddock quotas between vessel groups is reassessed.



PHOTO: STEIN HARRIS OLSEN © NOFIMA

Fishing the entire quota and live storage of haddock on board before delivery and slaughter could increase earnings by millions.



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



Torbjørn Tobiassen
Scientist
+47 907 69 321
torbjorn.tobiassen@nofima.no

FUNDED BY:
The Norwegian
Seafood
Research Fund
- FHF

PARTNERS:
Norwegian Institute of Marine
Research, SINTEF Ocean, Båtsfjord-
bruket AS, Lerøy Seafood ASA, Gunnar
Klo AS, Nergård AS and MS Ballstadøy



PHOTO: TOMMY ELLINGSEN © NOFIMA

The goal is safer, healthier foods with a long shelf life. Scientists test innovative food technologies and publish all the results online.

Web tool for healthy, sustainable food

Imagine if we wasted less food, got more foods without allergens and could spend less energy on food production?

Novel food processing technologies can make this possible if manufacturers understand which technologies are appropriate for their business. Today, there is no central place to gather information about which technologies are suitable for different raw materials, processes or applications. Now scientists are developing an online innovation tool that will make it easier to choose the right technology.

Novel food processing technologies

Novel processing technologies can improve the safety, quality and sustainability of food products. These include high pressure processing that extends product shelf-life, preserves food nutrients and reduces food allergenicity; plasma-activated water that inactivates harmful bacteria; and microwave technology that consumes little energy and facilitates food heating. Also, the technologies pulsed electric fields, ultraviolet light and ultrasound are being investigated.

"Novel processing technologies will provide us with safer and healthier foods, thus contributing to public health. Longer shelf-life will reduce food waste. Food production will also be more sustainable, as the food sector will save energy costs, reduce greenhouse gas emissions, and create more jobs as a result of these advanced production systems," says Noriega Fernández.

Research and industry join forces

Nofima is leading the four-year project "iNOBox" where experts at several research institutions, together with food producers and technology manufacturers, will bridge existing knowledge gaps and develop the online innovation tool. The tool will be publicly available, with special focus on food sector players.

The project will also provide training opportunities for young scientists through two PhD and two Postdoc positions and international mobility among research institutions.



CONTACT PERSON:
Estefania Noriega Fernández
Senior Scientist
+47 477 06 088
estefania.noriega@nofima.no

FUNDED BY:
The Research Council
of Norway

PARTNERS:
Seven industry partners,
five manufacturers of
equipment and five
research partners.

READ MORE



Simulating fishery regimes

How do different fisheries affect the marine ecosystem? A new computer tool simulates the consequences of different management regimes.

Together with European research partners, Nofima has developed a decision-support tool for sustainable fisheries management.

“Norway has one of the world’s best fisheries management systems, which is why experience from management here is important to the EU,” says senior scientist Petter Olsen.

Many of the EU’s stocks are overfished. The EU-funded project MareFrame aims to improve the EU’s fisheries management by involving the fishermen more and focusing on the entire ecosystem.

Testing scenarios

A number of research models have been compared, to provide a realistic picture of what will improve fishing and the profitability of the European fishing industry. Seven European sea areas and one area off New Zealand have been modelled.

Now fishermen, fisheries organizations, companies and governments can themselves test different management regimes and see what will happen to the fisheries and the species in the ecosystem.

The online tool calculates what provides the best results

short term and long term. It also calculates how much of a particular species it is profitable to fish to achieve the best possible price.

Clear answers

The researchers have received positive feedback on the tool. Fishermen also become a lot more interested in management issues.

For example, Scottish fishermen thought a large seal population was the reason for depletion of the cod stock. However, the new tool indicated that reducing the seal population would have little effect and indicated other measures to re-establish cod fishing.

“Most of the people we show it to are very enthusiastic. Now we have established a ‘good practice’ for how fisheries can best take care of the entire marine ecosystem”, says Petter Olsen.

The ClimeFish project is refining the tool to also accommodate climate change.



PHOTO: RUNE STOLTZ-BERTHINUSSEN © NOFIMA

Petter Olsen (Nofima) and Michaela Aschan (UiT) have developed a tool to predict the impact of different fisheries and ecosystem scenarios



ILLUSTRATION: MAREFRAME

The EU wants to improve the sustainability of its fisheries. The new tool helps ensure good decisions.



CONTACT:
Petter Olsen
Senior Scientist
+47 906 98 303
petter.olsen@nofima.no

FUNDED BY:
EU

PARTNERS:
28 European research
partners led by Matis,
Iceland

READ MORE





PHOTOS: STEIN HARRIS OLSEN © NOFIMA

CRISP has generated knowledge and solutions, but the government must promote sustainable fisheries.



The prototype of a tank (developed by Optimar AS) for live storage of fish on board vessels was tested with excellent results.



Trawled cod recuperated in the tank, and after six hours 90% were still alive and in good shape.

Knowledge, but no incentive

Eight years of research have provided technological solutions and extensive knowledge about how to ensure top-quality net-caught fish.

The major fisheries innovation project, CRISP is nearing its end. In close collaboration with industrial partners, scientists at the Norwegian Institute of Marine Research and Nofima have developed technology and solutions for more responsible fisheries.

The new technologies developed include acoustic systems to determine fish size, species and quantity prior to catch, systems to monitor catches in purse seines and trawl nets, and an on-board tank for live storage of the catch. The technologies have been developed to enable gentler, more environmentally-friendly fishing.

“Norwegian fishing vessels catch 2.4 million tonnes of fish each year. We have an obligation to manage this natural resource responsibly and sustainably. New technical solutions and extensive new knowledge mean sustainable fishing is now possible,” says research director Heidi Nilsen.

Top-quality trawl fish

Nofima has investigated the effects of the new technologies on the quality of the fish. Scientists compared traditionally caught fish with fish caught using the new systems and found that top quality is possible with trawling if the fish are handled properly.

A new mechanism on the trawl net releases some of the catch into a second, finer-meshed net that provides better conditions for the fish in the trawl, thereby improving quality.

Studies using a specially designed trawl simulator also showed that fish that could recuperate for some hours before slaughter had whiter fillets than stressed fish, which a more reddish fillet colour. In addition, Nofima found that fish that are stored alive in water filled tanks on board for a period after catch have better quality filets than fish caught and stored in the traditional way.

Huge potential gains

Introducing these new technologies will require investments from the industry. Nofima has therefore also assessed the pros and cons of the new solutions. Can these technologies add value, save energy and reduce costs for the companies?

The short answer is yes, but with certain provisos. For example, better fish finder equipment means vessels do not need to travel so far to find fish, hence saving fuel and reducing emissions. Structuring (more quotas per vessel) has already resulted in a significant drop in overall fuel consumption in the vessel groups.

However, the main potential for value adding is in improving quality. Poor quality on landing is generally due to the way the fish are handled during and after catch. The strain in the catch operation leads to overcrowding and stress of the fish. Calculations for the mackerel and herring catch show that some NOK 50 million is lost per year due to impaired quality.

The way the fish are caught and handled impacts the following value chain and the potential for adding value in post-harvest operations. A premium-quality fish can be used in all types of products, and the by-products can be used profitably, whereas a bloodshot, damaged fish has lower value and can be used in far fewer product lines.

Need framework conditions

Several fishing companies have contacted Nofima for advice on how the knowledge from CRISP can be applied on board future trawl vessels. The scientists provide documentation, analyses, and advice, but other factors determine the extent to which the knowledge and technology may be implemented.

“Investments to achieve low environmental impact catch, better quality and more ethical fishing must also result in increased profitability. When the institutional framework favour catch volume over catch quality, and when the market does not reward the quality efforts, companies struggle to justify the investment,” explains research director Bent Dreyer.

The government must therefore adjust institutional framework to prevent inferior quality, promote ethical methods and provide financial incentives for implementing quality friendly innovations.



CONTACT:
Heidi Nilsen
Research Director
+47 997 11 167
heidi.nilsen@nofima.no



Bent Dreyer
Research Director
+47 992 76 715
bent.dreyer@nofima.no

FUNDED BY:
The Research Council
of Norway – Centre for
Research-based Innovation
(SFI) and participating
industry partners

PARTNERS:
6 research
partners and
8 industry
partners

READ MORE



Zinc and omega-3 enhance skin

The skin's barrier function deteriorates when salmon are stressed. Zinc and omega-3 in feed can enhance barrier properties in salmon skin.

Scientists at Nofima have conducted a project to evaluate how different levels of zinc and marine omega-3 fatty acids (EPA and DHA) in feed affect function, barrier properties and wound healing processes in salmon skin.

Different layers have different functions

Skin, gills and intestines, are part of fish's first line of defence against stress factors in the environment. Fish skin provides chemical and physical protection against harmful substances in the water, including parasites, infectious diseases and particles. If the skin is not strong and intact, the fish's protection is undermined. Fish skin consists of several layers that each help strengthen the skin and provide flexibility.

In the feeding experiment, five groups of salmon received feed with different levels of zinc and omega-3 ranging between 100 and 300 mg of zinc and 0.5 and 2 grams of omega-3 fatty acid per kilo of feed. These levels are above and below what is common in commercial salmon feed today. The salmon were studied through smoltification in freshwater, transfer to salt water for ten weeks. The scientists wanted to study how zinc and omega-3 influenced the function, robustness and wound healing processes of the skin, using molecular and histological techniques.

The results of the experiment showed that the various layers are affected by the zinc and omega-3 levels in the feed.

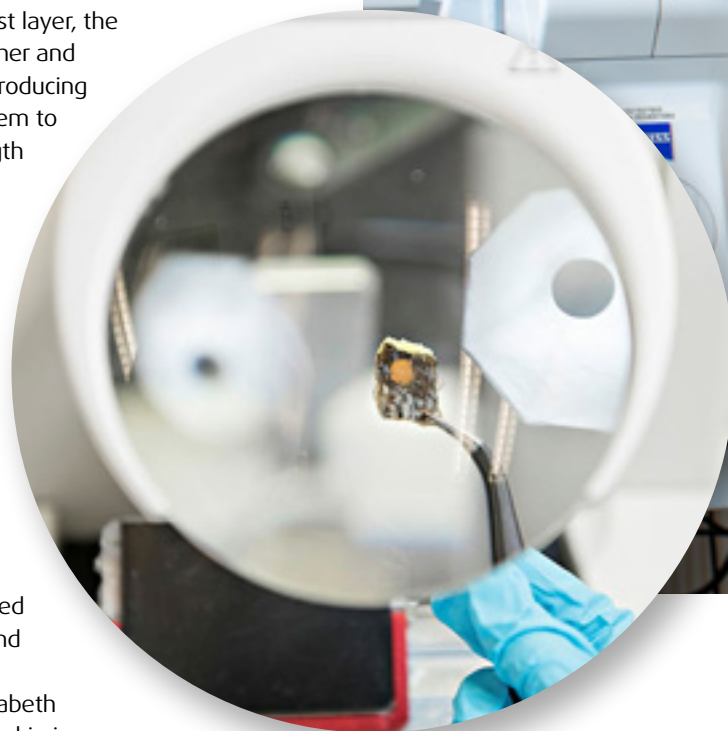
More zinc and omega-3 in periods

The fish that had received higher doses of omega-3 and zinc coped with the transfer to sea water better. While high levels of marine omega-3 strengthened the lower skin layers, through thicker connective tissue and fat layers, high levels of zinc affected the outer layers in that the outermost layer, the epidermis, became smoother and contained more mucous-producing cells. These differences seem to affect the fish's skin strength and ability to withstand external stresses.

The scientists also saw this later in the experiment, when they studied wound healing ability. Wounds on fish that had received high levels of zinc and omega-3 in the feed healed faster than those on fish that had received lower levels. The wounds on the fish that had received the lowest levels of zinc and omega-3 healed slower.

Fish health scientist Elisabeth Ytteborg looks at how fish skin is affected by changes in the environment and finds it interesting to see how different nutrients can have positive effects when the fish is exposed to stress.

"In the experiment, we found that it was difficult to see any change in the fish when the environment was stable; however, when we challenged the fish in the form of salt water exposure or wounds, we could clearly see that the zinc and omega-3 levels in the feed



A sample of salmon skin tissue with a mechanically applied round wound similar to those evaluated in the project.

PHOTO: JON-ARE BERG-JACOBSEN © NOFIMA

have a major impact on the skin health of fish," says Ytteborg.

Knowledge gaps on interaction between nutrients and environment

Enough zinc is important for the skin health, and Ytteborg believes more research should be done on the effect

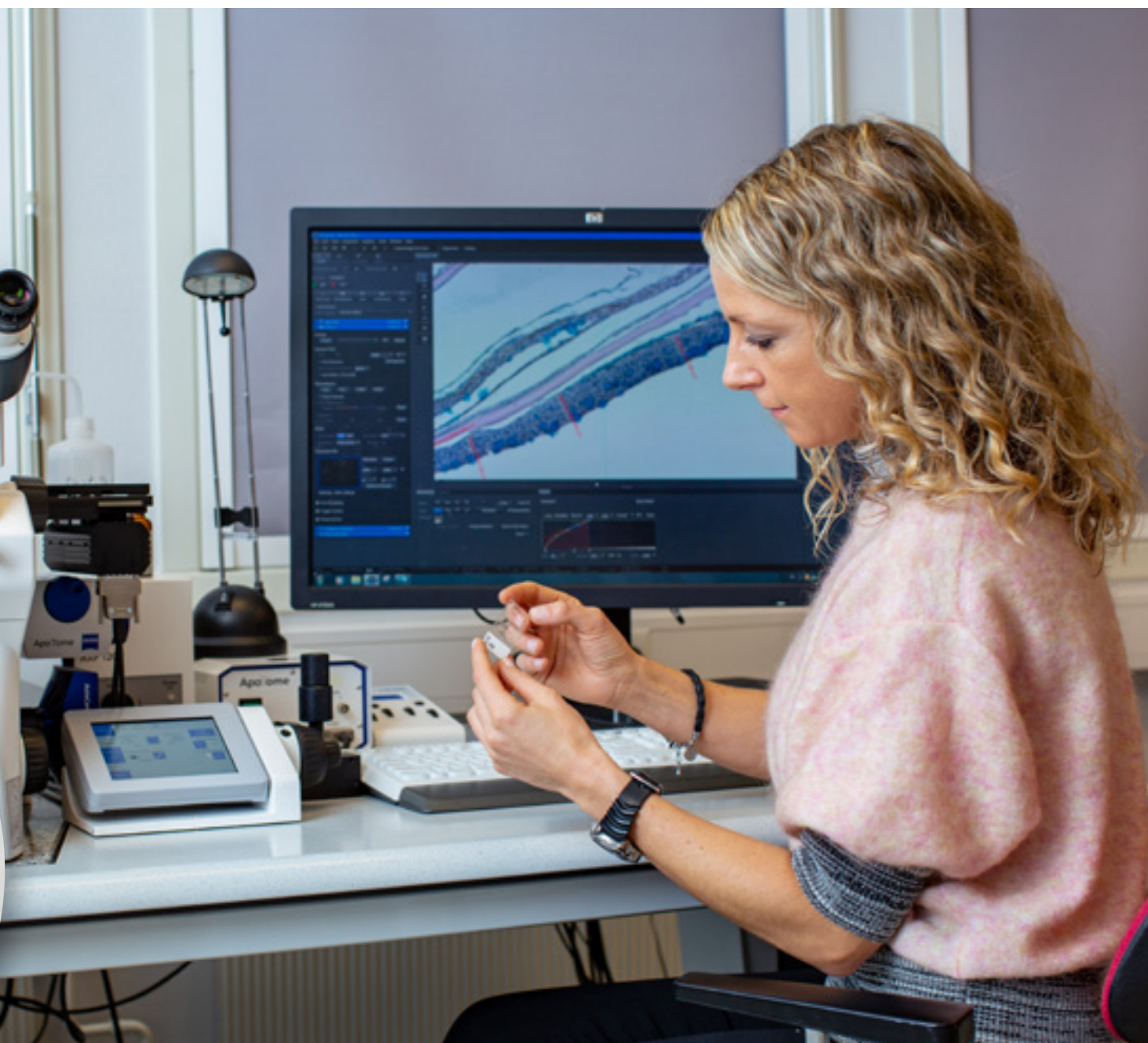


PHOTO: JOE URRUTIA © NOFIMA

Fish health researcher Elisabeth Ytteborg finds it important to look at nutrition in salmon in light of challenges in its surroundings.

of varying zinc and omega-3 levels in feed over time:

"Salmon would benefit from being prepped with zinc and omega-3 before they are transferred to seawater. The same may also apply before they are treated for lice, moved to cold water or other stressful event that we know can

be challenging for skin health. However, we don't know enough about this yet. There are strict restrictions on how much zinc can be used in salmon feed, but what we can continue working on is making the zinc that is allowed more accessible to the fish," said Ytteborg.

There is an upper limit for zinc in

fish feed, current EU regulations allow max. 180 mg of zinc per kilo. Less than 50 % of dietary zinc is absorbed by the fish, and unabsorbed zinc might reach harmful levels when emitted to the environment. Nofima is continuing its research on how salmon could use zinc more efficiently.



CONTACT:
Elisabeth Ytteborg
Scientist
+47 6497 0450
elisabeth.ytteborg@nofima.no



Gerd Marit Berge
Senior Scientist (project manager)
+47 7140 0114
gerd.berge@nofima.no

FUNDED BY:
The Norwegian
Seafood Research
Fund (FHF)

READ MORE



What's in the fish?

Nofima scientists are looking for new ways to identify what fish have eaten using spectroscopy, saving the industry millions.

You are what you eat!

Some things fish eat degrade the quality of the meat, and in the worst case, a whole catch may go to waste. For example, mackerel often eat sea butterflies, whose shells are difficult to digest. Over time, the enzymes produced to digest the shells penetrate the intestinal wall and attack muscle tissue.

"The result is soggy, useless meat – and dissatisfied buyers. To ensure best quality, and avoid squandering scarce resources, fishermen need to be able to promptly identify type and amount of prey the fish they catch have ingested," says Nofima scientist Geir Sogn-Grundvåg.

No objective method

He and his colleagues have analysed the mackerel auction market to find out whether buyers know what the fish they buy have eaten. Generally they do not.

"Fish are bid on unseen, so details about what the fish have eaten is important. Mackerel can contain a lot of small fish, which does not degrade the quality. Or they may have

been feeding heavily on sea butterflies, also known as pteropods" says Sogn-Grundvåg.

Stomach content is currently only assessed on the basis of quantity, not type, and the industry has wanted a more objective method for some time.

Spectroscopy?

Nofima scientists are testing new ways of finding out what a fish has ingested. Using spectroscopic imaging, they want to develop on-board photo boxes to verify type and amount of prey fish have been feeding on, prior to catching.

"The skipper simply takes a picture of a sample from the catch before the net is closed. If the fish have had a bad diet, the whole catch can be released unharmed, and the fishermen can leave the area and fish elsewhere," explains Stein Harris Olsen.

He believes an objective solution would benefit all parties.

"Fishermen will be better able to exploit their quotas, better quality mackerel will be brought to market, and scarce fish resources will not be wasted," he says.



PHOTO: JAN INGE HAGA © NOFIMA.

Contrary to popular belief, the mackerel is not omnivorous. It prefers to feed on small fish and plankton. However, certain food sources can impair the quality of its meat.



CONTACT
Geir Sogn-Grundvåg
Senior Scientist
+47 470 29 204
geir.sogn-grundvag@nofima.no



Stein Harris Olsen
Scientist
+47 776 29 085
stein.olsen@nofima.no

FUNDED BY:
The Research Council of Norway

PARTNERS:
Capia AS

**READ
MORE**





PHOTO: © NOFIMA

Lumpfish are social little worker fish and thrive well in large groups in tanks or pens.

Sociable lumpfish

Lumpfish are cleaner fish used to fight salmon lice. Good feed and the right environment are key for lumpfish to “thrive” at work.

A good sea lice eater is hale and healthy. Companies that produce lumpfish must therefore know what the fish need to thrive, grow and stay healthy – basically: the right feed, enough space, good water quality and minimum stress.

Long way to the food

The Rensvel project aims to find ways of gauging cleaner fish’s welfare and what it needs to thrive and stay healthy. Access to food is important. Lumpfish are not strong swimmers and need to rest. They do this by attaching themselves to the tank wall using a ventral suction plate.

“Because lumpfish like to sit on the tank wall and are not fast swimmers, feed needs to fall down near the tank walls. Most commercial farms use dispensers located in the centre of large tanks, which may be too far away for young lumpfish,” says senior scientist Ingrid Lein.

It has been claimed that lumpfish that grow rapidly become aggressive and “bully” smaller fish. Lumpfish are therefore usually graded by size many times before being

transferred to pens in the sea. The Rensvel project has shown that ungraded lumpfish can live close to their neighbours without any bullying.

“To avoid bigger fish bullying the smaller ones, there must be enough feed for everyone. In addition, the feed pellets must be large enough for the largest lumpfish and small enough for the smallest,” explains Lein.

Plenty of good water

Lumpfish like clean, well-oxygenated, fast-moving water. Because they need to rest every now and again, it is important to provide enough space in the tank for all the fish to be able to find a place to rest.

Crowding is not a problem in itself, as long as the fish get enough of the right food, can find a place to rest and have good water quality.

“Lumpfish are social, thrive in groups, and are not plagued by disease,” says Ingrid Lein.



CONTACT:
Ingrid Lein
Senior Scientist
+47 934 19 441
ingrid.lein@nofima.no

FUNDED BY:
The Norwegian Seafood
Research Fund (FHF)

PARTNERS:
Nord University, the Norwegian Institute of
Marine Research, the Norwegian University
of Life Sciences (NMBU), and the Norwegian
University of Science and Technology (NTNU)



PHOTO: JOE URRUTIA © NOFIMA

Sileshi Wubshet and Rita Lima in front of the vessel used for the production of peptides from chicken carcasses.

Food as medicine

Peptides, which can be extracted from chicken carcasses, may help regulate blood sugar level in the same way as some diabetes medicines.

Everyone agrees that using all the raw materials from chicken, including the carcass, is good for the environment. Now it seems it may also be good for your health. There is growing awareness of the opportunities afforded by making better use of residual raw materials.

Like looking for needles in a haystack

The two Nofima scientists Sileshi Wubshet and Rita Lima are studying residual raw materials from chicken and milk and have identified a number of peptides that appear to have the same effect as some diabetes medications.

It is a laborious process, and the trick is to develop methods that make it possible to identify and extract the exact peptides the scientists are looking for.

"We know that many of the substances in residual biomass have health-enhancing properties, but they are difficult to identify and separate. Out of hundreds of peptides, we have identified 19 that can potentially help regulate blood sugar and manage type 2 diabetes," says Sileshi Wubshet.

Less side effects

There has been a significant increase in the number of people with type 2 diabetes in the past ten years. In Norway alone, some 200,000 people have a type 2 diabetes diagnosis. The disease develops when the cells that produce insulin stop working properly.

This reduces insulin production or means that the body is no longer able to respond to insulin, leading to a rise in blood sugar. Prolonged high blood sugar has many negative health consequences.

DPP4 inhibitors are a relatively new type of diabetes medicine. They help stabilize blood sugar and prolonging the effect of two peptide hormones that promotes the release of insulin. Unfortunately, DPP4 inhibitors also have several negative side effects, such as hypoglycaemia, headache and respiratory infections.

"We have identified peptides in residual raw materials from chicken processing that have the same function as DPP4 inhibitors, and the hope is that they can be as effective – with less side effects," says Rita Lima.

Peptides are molecules consisting of a chain of amino acids. Peptides are basically mini proteins, and the main difference between peptides and proteins is that peptides have fewer amino acids. The first thing the scientists had to do when looking for favourable properties in the residual biomass was to break the proteins down into smaller parts, i.e. peptides.

This is done through enzymatic hydrolysis, a process whereby water and selected enzymes are used to split proteins, making them easier to digest. This also results in changes in the functional properties.

The next step after the peptides had

been separated out was to start looking for peptides with the exact properties the scientists were interested in.

"We separated the peptides from one another on the basis of their chemical and physical properties using chromatography, which makes it possible to both separate and identify substances in very complex samples," explains Rita Lima.

Tests on cells

The scientists have tested these peptides in cell models, with promising preliminary results. Using cell models has several advantages. The models allow the scientists to study everything at the cellular level, making it easier to understand how and why the cells react as they do.

The next step will be to find out whether there are any toxic effects associated with the peptides. Tests will have to be done on diabetic mice to see if the peptides have the same effects on them as they did on the cells. Finally, human trials will have to be carried out.

"The goal is to be able to add the peptides to foods to make them diabetic-friendly," concludes Sileshi Wubshet.



CONTACT:
Sileshi Gizachew Wubshet
Scientist
+47 909 17 126
sileshi.wubshet@nofima.no



Rita de Cassia Lemos Lima
Postdoctoral Researcher
+47 476 77 385
rita.lima@nofima.no

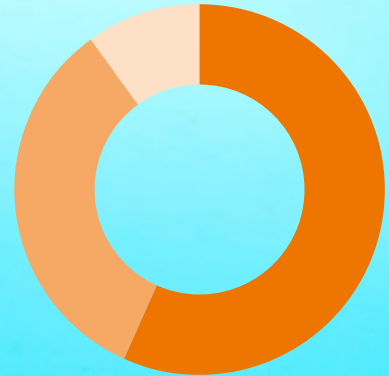
FUNDED BY:
The Foundation for Research
Levy on Agricultural Products
(FFL) and the Research Council
of Norway (NFR)

PARTNERS:
University of
Copenhagen, Denmark
and Norilia, Norway

Facts and figures

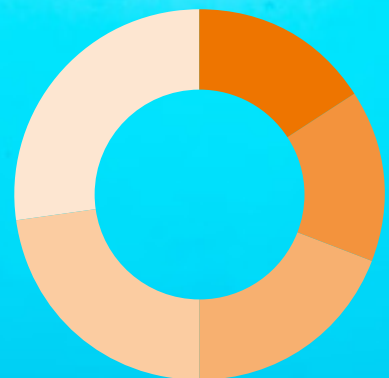
Structure

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



Funders

NFD	16 %	■
Basic funding from NFR	15 %	■
NFR/EU	19 %	■
FJM/FFL/FHF	23 %	■
Companies	27 %	■



The following are our largest funding providers

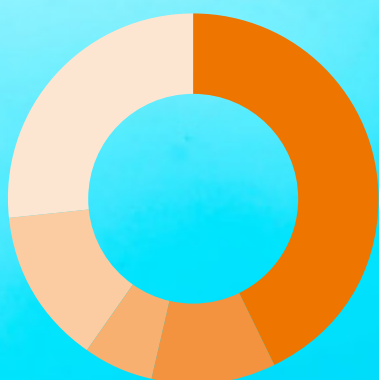
RESEARCH COUNCIL OF NORWAY (NFR) is a strategic organ that identifies priority areas and project/programme managers, allocates research funding and evaluates the research that is carried out.

THE MINISTRY OF TRADE, INDUSTRY AND FISHERIES (NFD) is responsible for the fishery and aquaculture industry, fish health, fish welfare, seafood safety and quality and more.

THE NORWEGIAN SEAFOOD RESEARCH FUND - FHF shall create added value for the seafood industry through industry-oriented research and development. Financed through a levy on all seafood exports.

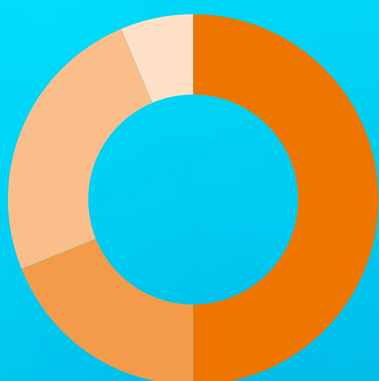
THE RESEARCH FUNDING FOR AGRICULTURE AND FOOD INDUSTRY (FJM)/AGRICULTURE NUTRIENT RESEARCH FOUNDATION (FFL) shall secure an economic basis for research connected to agricultural products that are utilized to produce food and stimulants, as well as feed grain for animals. Financed through a research levy on agricultural products.

THE EUROPEAN UNION (EU) finances several research projects that Nofima either participates in or has project responsibility for.



Geographic distribution of employees

Ås	166
Bergen	42
Stavanger	24
Sunndalsøra	52
Tromsø	103



Employees by function

Scientists and advisers	194
Laboratory engineers/research technicians	73
Technical and administrative staff	96
Managers	24

This is Nofima

Nofima has some 387 employees, and a turnover of NOK 595 million in 2017.

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 © NOFIMA

Nofima contributes to industry and society by performing high quality research and innovations by creating ideas, services and results.

Our work contributes to development of a sustainable and profitable food industry, an effective public sector, creating jobs and knowledge that is to the benefit of the society.



Engaged • Inclusive • Innovative • Responsible



SafeConsume – improving food safety in homes

Every year there are 23 million cases of illness and 5000 deaths caused by food poisoning in Europe. SafeConsume, a Horizon 2020 project with 32 partners from 14 countries, aims to reduce these figures.

To achieve this, consumers must have good food safety and hygiene routines. In this project, we are working with designers and business partners to develop utensils, technology and products that will both help improve kitchen hygiene and reduce exposure to dangerous bacteria.

Read more at safeconsume.eu

Contact:

Solveig Langsrud/-47 905 67 218/solveig.langsrud@nofima.no





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



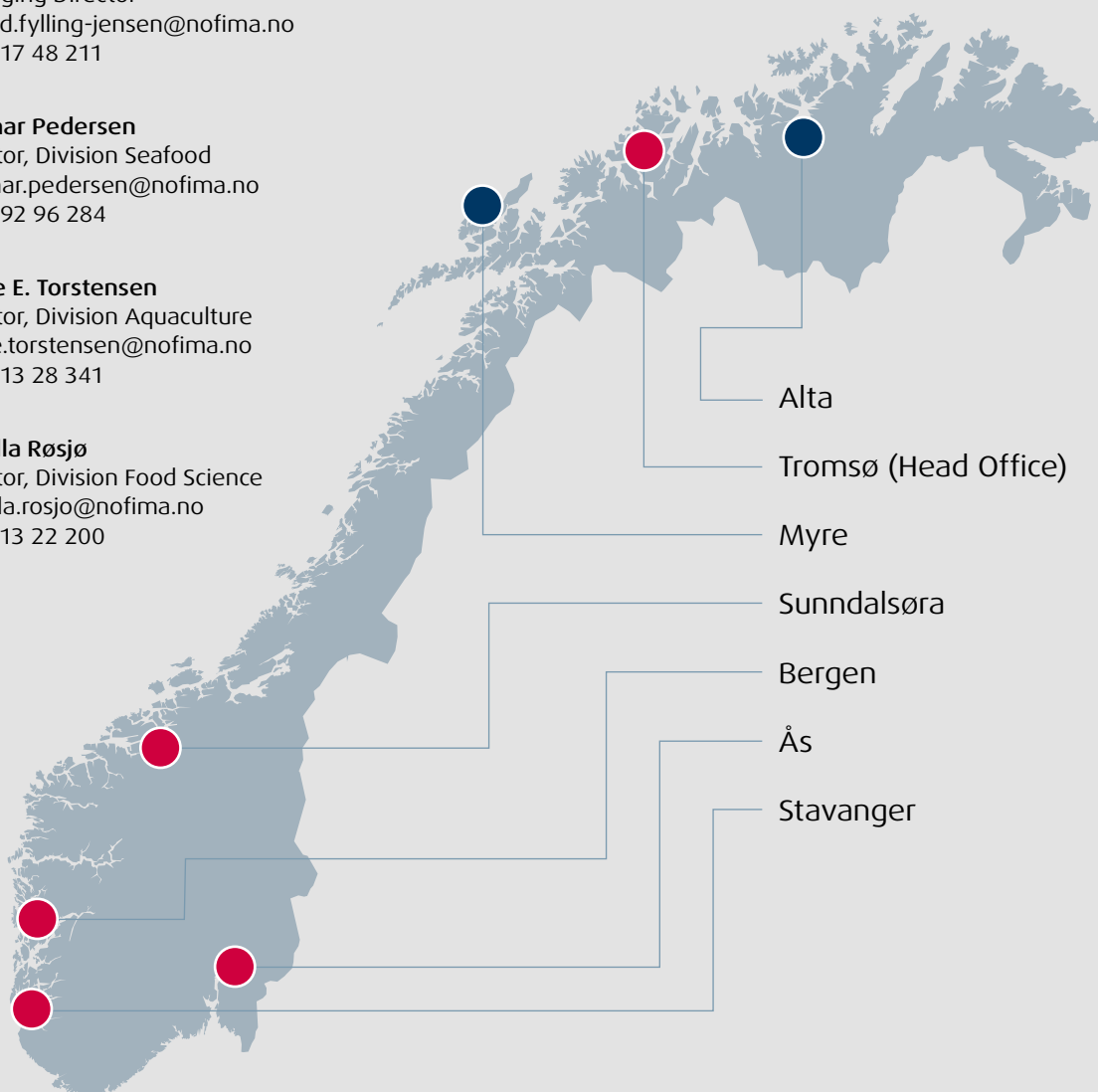
Magnar Pedersen
Director, Division Seafood
magnar.pedersen@nofima.no
+47 992 96 284



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



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