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Aquaculture 2020
Transcending the Barriers – as long as...

The Research Council of Norway | Large-scale programmes

Aquaculture 2020

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A Foresight Analysis

The Research Council of Norway

INNOVATION NORWAY

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Foreword

Aquaculture is one of the seven large-scale programmes established by the Research Council of Norway. Large-scale programmes are an important new initiative towards realising central research-policy priorities and shall be developed through extensive dialogue within and between research communities, users and the public authorities.

In the autumn of 2003 the Research Council invited the aquaculture industry, the research communities and the public authorities to take part in a broadly focused future-oriented dialogue, a foresight analysis about Norwegian aquaculture, Aquaculture 2020. The initiative was received with considerable interest on the part of institutions and individuals. A total of 70 persons took part in four gatherings where some 150 mini-scenarios and five more complex scenarios were developed and one arrived at strategic recommendations and initiatives directed towards research, the public authorities, and trade and industry.

The mini-scenarios and the scenarios in Aquaculture 2020 represent a set of different and hopefully interesting perspectives on the potential condition of Norwegian aquaculture in 2020. The scenarios also attempt to explain that which has taken place along the way.

To carry out this process, the Research Council appointed the following project group:

Rolf Giskeødegård (Project Manager), Research Council of Norway
Magny Thommassen, Norwegian University of Life Sciences/Chairman of Board Aquaculture Programme
Kathrine Angell-Hansen, Ministry of Fisheries and Coastal Affairs
Harald Sveier, Ewos Innovation AS / Norwegian Seafood Federation (FHL) Aquaculture R&D committee
Kjell Maroni, Norwegian Seafood Federation (FHL) Aquaculture / Fishery and Aquaculture Research Fund (FHF)
Svein Hallbjørn Steien, Innovation Norway
Lars Horn, Research Council of Norway
Erik F. Øverland, Research Council of Norway
Lars A. Ødegaard, Research Council of Norway

NIFU STEP was engaged to manage the secretariat function. NIFU STEP also had the role of a professional impetus in the process. From NIFU STEP participants were: Finn Ørstavik and Åge Mariussen. The methodological programme in connection with the Foresight analysis was the responsibility of Erik F. Øverland.

In the report the project group presents the foresight analysis of the aquaculture industry. The report is made up of three parts: Part 1: Analysis and recommendations, written by Finn Ørstavik. Part 2: Process and experiences, written by Erik Øverland. In the Appendixes are the materials produced in the gatherings along with the start-up document and a list of all those who took part in one or more of the gatherings.

The project has been carried out through collaboration between the Research Council of Norway and Innovation Norway. We would like to take this opportunity to thank all those who have taken part in the process and contributed to the creative discussions. Thank you very much! Because of you, long work sessions were made exciting and humorous. We walk away with an impression of many people having been involved and that we have interacted in an exciting arena!

Oslo, september 2004
Project Group

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Analysis and Recommendations





Photo preceding page from left:
Illustration: Making Waves AM
Edelpix
Pia Kupka Hansen
Gunnar Grytås
Norwegian Seafood Export Council

Introduction

The Research Council of Norway has invited resource individuals from the aquaculture industry, from the public sector and from the research communities to look to the future: How will Norwegian aquaculture activities develop? What is required for a positive future development? What types of measures must be carried out within trade and industry, what should the public authorities do – and what can research communities contribute? In this document we summarise the main results from the process. The results are not – and cannot be – scientific answers. But they contribute to directing attention towards many of the most central issues. Through an unorthodox and creative treatment of important questions, the foresight process generates material to work with for all those seeking to find answers for how the aquaculture industry shall succeed in becoming a knowledge-intensive, sustainable and profitable future industry in Norway.

Foresight Aquaculture 2020

Research has played a big part in the aquaculture industry and will continue to play an important role in the future. At the same time, it is clear that research in itself cannot solve all problems. In order to bear fruit, the investment of research must first of all be coordinated with the strategies for business and trade development established in trade and industry, and at the public level. Secondly, research from different fields must be connected and enriched "transversely". Joint action on the part of technological and professional fields such as ICT, materials technology, biotechnology and social and market research can contribute new and important knowledge and strategic solutions for the development of aquaculture.

The contributions of various actors should be correlated; initiatives must be reasonable, not only in terms of own internal developmental logic, but also in terms of the strategies for change and development carried out by others. In this lies both an obligation in the relation between the actors in the industry itself, and also an obligation in terms of keeping a focus directed upon the markets and the development that takes place among consumers, in trade and industry and at the public level in the countries comprising the largest export markets for the Norwegian industry.

It is in recognition of this that the Research Council of Norway has implemented foresight techniques as a tool in the task of developing large research programmes. In such processes, qualified persons from companies, instances of authority and research and education communities work together to try and create visions of the future, of what the situation could be for a given industry in a few years, and how the development can lead us there. Through this work, one can focus upon and develop a dialogue about the future and about what could be expedient future strategies. This creates the opportunity for fruitful collaboration that would not come about on its own within the situation in which the actors find themselves daily.

In 2003 and 2004, the Research Council of Norway carried out a foresight process for the Aquaculture sector. It was entitled "Foresight Aquaculture 2020" and was the first large endeavour of this nature at the Research Council. The process was carried out by a project group of representatives from trade and business, research and government. In order to arrive at the desired transverse connections, the project group that ran the foresight process did a number of things:

- Qualified persons from trade and industry were invited to take part from the very start.

Excerpt from the scenario "Sustainability"

Norwegian aquaculture has today (2020) managed that which few believed was possible. In spite of increasingly obvious climate changes, global warming and high average temperature in the ocean from the Western Norwegian coast all the way up into Helgeland, we have a thriving and sustainable industry, with products that are more in demand than ever. The increase in ocean temperature has for a long time led to, among other things, premature sexual maturity and disease. The extreme weather conditions during the winter season have on the other hand, contributed to the lowering of the average temperature in the ocean during the winter in Nord-Troms and Finnmark. We have witnessed frequent and powerful storms, which have resulted in an increased risk of farm wreck and fugitive fish. Around 2010, the climate changes and question of using resources in a sustainable fashion became a central question in the world's food programme and in fighting starvation – since large areas along the equator were in the process of becoming infertile and parched. It is toward the oceans that the world has now directed its attention. The environment, sustainability, and combating starvation are today at the top of the global agenda, along with new and more long-term environmental challenges that will be of decisive significance in the period leading up to 2050. It has become clear that good monitoring systems and moderate regulations are not enough. One has begun to speak of the melting of the poles, decreasing temperatures and the ceased movement of the Gulf Stream. How can we produce good quality products in a manner that counteracts or constructively addresses this development?

Representatives of research communities were also invited, but not until a little later, and not in such numbers that they would "drown out" the representatives from trade and industry.

- Professionals from adjacent, potentially relevant professional fields and areas of activity were invited to take part. (People from outside the "congregation".) This implied e.g. persons from the food industry, from advertising, from idealistic organisations and areas of technology such as information and communication technology and materials technology.

- The process was focused on all participants using their competence, but that they should simultaneously address freely and imaginatively the future perspectives that were developed. It was a matter of not allowing the thought processes to get locked into fixed truths (and new research results on the situation today) but instead to strive for flexible and imaginative perspectives on the future. There was no requirement for the ideas to be probable, and no proposal was to be rejected on the basis of being "stupid".

In this document the results of this "visionary exercise" are presented. In the following, we present central perspectives and some of the many exciting ideas that were developed throughout the process.

The presentation does not pretend to be a comprehensive or a scientific perspective analysis. The topic is the future, or more precisely, a number of conceivable, alternative futures. The presentation here is intended to contribute to creating a better basis for the programme development work to be done at the Research Council of Norway in 2004 and 2005 for the Aquaculture sector. We therefore focus to a considerable extent also on the effort that will be necessary on the part of trade and industry and the public authorities in order for the research to provide the concrete contribution to industrial development and added-value needed within aquaculture.

The analytical motifs we have developed here shall contribute to situating the thinking about future research investment within a broader context. And previous research efforts, documented for instance in the STEP-report about the innovation system in aquaculture industry from 2002 and in later works,[1]

Excerpt from the scenario "Market With No Frontiers"

The fish farming industry was shaken up by a series of bankruptcies in many of the central companies in 2005-2006. These bankruptcies were due to the mistaken belief that a profitable manufacture of new species could be based on the same process technology as in salmon farming. It proved necessary to develop entirely new concepts for process technology. Only in this way was it possible to realise long-term production planning, large volumes, standardisation of high quality and low unit costs. A large knowledge hole was discovered here which took a long time to climb out of.

Production of farmed cod and niche production of species other than salmon took place through a long-term public investment for the entire period of 2005 to 2020. A significant breakthrough was the establishment of Statfisk in 2005 – based on the Statoil model. Statfisk received 49 percent public capital (NOK 10 billion) from the Petroleum Fund. This strategic measure laid the foundation for the development of a whole new innovation system. Eventually, the large companies realised that their most important competitive advantage was knowledge about the new process technology that they developed in collaboration with Statfisk. This knowledge-driven strategy was the key to their succeeding in establishing themselves with production in many parts of the world, in enterprises run from Norway. A partnership between the universities and the government – organised through Statfisk – was a wholly decisive condition to success.

Effective processes have proven to be the most important of three decisive criteria for survival in the global foodstuff market. All links in the production chain are highly automated and subordinated to regimes for long-term industrial process planning.

The other decisive advantage that made it possible for Norway to maintain its position on the global food article market was the nature-given advantage of coastal regions. The industry has an extremely strong position with regard to administration and area use along the coast.

The third criterion is adaptation to the industry's structure and organisation in relation to the requirements of the global market. The production takes place according to detailed specifications from the food product chains, which are extremely demanding customers. These demanding customers however refrain from integrating the primary manufacturers through ownership. Independent Norwegian manufacturers therefore run primary manufacture and a portion of processing. Their structure and composition is adapted to a market controlled by the buyers. Large-scale operation is thus a criterion crucial to survival.

[1] Aslesen, H.W., Å. Mariussen et al. (2002). The Innovation System in the Norwegian Aquaculture Industry. Oslo, STEP. More recent works include: Ørstavik, F. (2004). Knowledge spillovers, Innovation and Cluster formation: The case of Norwegian Aquaculture. In: Knowledge Spillovers and Knowledge Management. C. Karlsson, P. Flensburg and S. Hörte. London, Edvard Elgar.

have provided valuable assistance throughout the entire period of work on the foresight process. But the process has followed its own design, which was adapted to its own specific themes and further developed along the way. And the results of the process as they are presented here are first and foremost a result of the contributions of the process participants in the context of four gatherings.

"Foresight Aquaculture 2020" has been a pilot project for use of visionary methods in programme development work at the Research Council of Norway. Foresight is now being implemented in a range of other subject areas of the council's activity, to arrive at fruitful long-term connections between societal needs and research-related possibilities. The experiences gained are therefore important beyond the scope of the project group for Aquaculture 2020, and the experiences from the process are therefore documented in greater detail in Part 2 of this report. A table can be found there as well, showing the progress of the process and the main elements of which it was composed.

The foresight process is part of a more comprehensive process whereby research priorities are determined within the Research Council and where industrial actors and instances of authority develop strategies for future investments. The objective is that foresight shall contribute to this, not by enforcing standardised conform solutions, but by developing some shared perceptions about what the future can bring. The idea is that the dialogue started by the foresight process will be continued elsewhere, at a later date, so that the process can serve as a seed for greater awareness and dialogue between different partners in the future. On the basis of this, one will attempt to make the results of the foresight process easily accessible, for industrial actors, organisations and instances of authority. Within the Research Council, the results of the process will be actively used in further programme development work to take place in the area of Aquaculture, and hopefully also in adjacent research fields under the auspices of the Research Council's programme portfolio.

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The development of the aquaculture industry

For several decades there has been a broad consensus that trade and industry, if it is to ensure a high level of welfare, cannot be based exclusively on a simple harvest of natural resources. Fishing, hunting, and agriculture along with the provision of some services and production of some goods can at best serve as supplements to other, more knowledge-based activities. From a range of candidates for the title of "knowledge-based future industry", aquaculture today emerges as one of the most interesting.[2] Aquaculture is misleadingly an apparently simple form of economic activity. In reality, effective aquaculture is an extremely knowledge-intensive activity and an activity with a highly extensive and heterogeneous knowledge base. However, we know that the central knowledge platforms used for the industry are not developed for the industry. This must be better secured in the future, if the industry is to be ensured lead time in an economy exposed to competition. This, combined with the aquaculture industry's basis in Norway's natural resources, implies that aquaculture would appear to have conditions for becoming an internationally competitive and science-based knowledge industry in Norway, and here also in the very long-term. Such an industry can supply primary products (such as fresh and processed fish), and also secondary products (such as technology and competence) to the international markets.

The history of the Norwegian aquaculture industry is to a large degree a success story. A wholly new and large industry has been created, outside of the established primary industries and to a large extent independent of the established industrial community. Farming of salmon proved to be profitable, also when operated on a small scale and in a relatively simple fashion and in the two decades 1965-85, the industry grew as a coastal and regional industry. The fact that operation was relatively labour-intensive was seen as an advantage; the industry should not be "capitalised" and "industrialised" more than was strictly necessary. The more scientific-based knowledge foundation for industrial activity was made a topic of publicly funded research, often through entities in the institutional, university and college sectors, such as Akvaforsk, the National Veterinary Institute, the Institute of Marine Research, Fishery Research, etc. The combination of publicly funded research, local businessmen and openness concerning the results led to significant results in the first 20 years and the industry was made subject to a set of acts, regulations and institutions reflecting this

[2] Farming of fish and other organisms in water takes place in Norway to a large extent in the ocean. We therefore find it suitable to refer to fish farming activities as aquaculture. There is no implicit assumption here that all meaningful fish farming activity will or should take place in salt water.

industry structure: The Raw Fish Act was put into effect for farming, a primary sales monopoly was formed. A license system was established that made it possible to ensure that fish farming took place in small installations distributed across a large number of locations, in local communities along the coast.

In the next two decades, from the middle of the 1980s and up to today, the industry has oscillated between economic success and deep crisis, but the growth in production volumes has continued. Extremely strong growth in the second half of the 1980s was triggered by among other things the release of fry production and a liberalisation of the credit policy. The growth led to a crisis starting in around 1990 where economical difficulties in fish farming activities were heightened by a serious banking crisis. Many banks had large outstanding debts in fishing farming activity, which now saw its existence threatened by historically low salmon prices in the export markets, and by new export-restriction measures implemented in the USA and in Europe. In order to avoid large losses through bankruptcy, the public authorities, finance industry and fish farming industry together saw to a comprehensive structural change of the industry, whereby a small number of extremely large companies emerged. The number of small companies was hereby heavily reduced. [3]

Recent research on the development of the aquaculture industry indicates that for a long time it has been subject to a lack of clarity with regard to the development of long-term framework conditions.[4] This is in part related to challenges in the export markets where the EU among others has implemented measures to check the export of low-price salmon to European countries. But it is also related to the public authorities' efforts for a number of decades being characterised by a sectoral-orientation in relation to the industry, where conflicts appear to have determined the situation more than the ability to find the bottom line and establish consistent and predictable frameworks. The policy has been characterised by different conflicts of interest and different priorities, and one of the consequences of this has been a fragmented knowledge infrastructure that has worked with many projects, which in part have been overlapping and in part have pulled in different directions.[5]
The figure below illustrates this point.

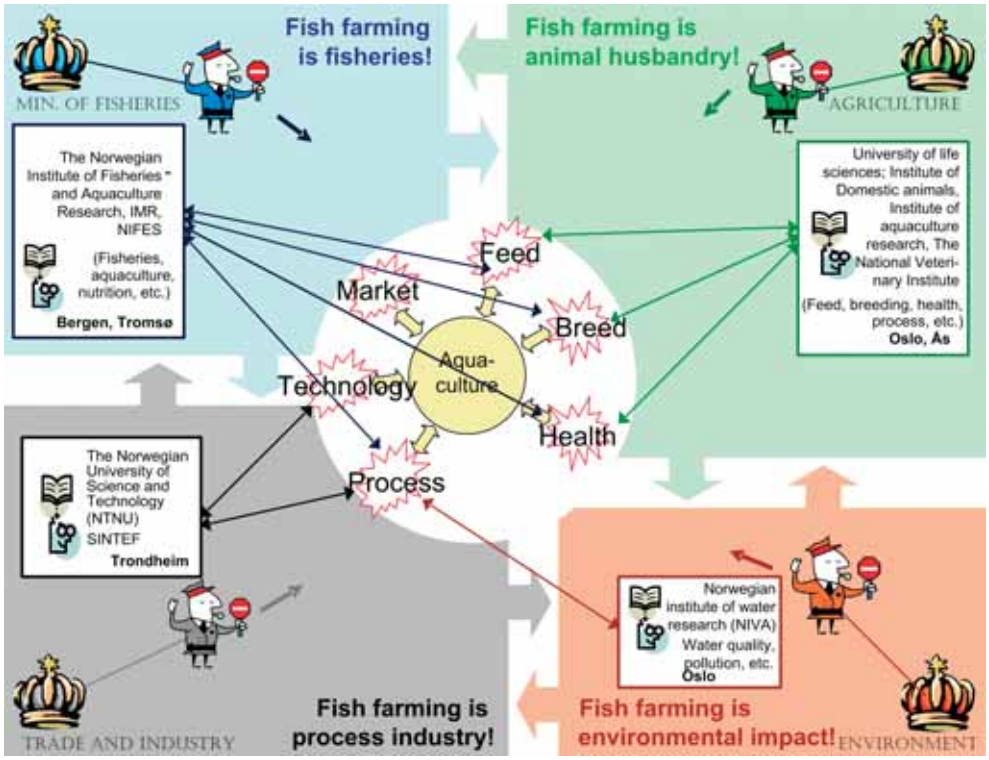

Figure 1: Public authority divided into sectors determines the research system.

[3] Berge, D.M. and O. Bjarnar (1998). Norsk fiskeoppdretts regionale industrialisering: strukturendringer, ledelse og kompetanse i Norsk Aquaculture på 1990 tallet ("Norwegian fish farming's regional industrialisation: structural changes, management and expertise in Norwegian aquaculture in the 1990s.") Molde, Møreforsking..

[4] Ørstavik, F. (forthcoming). Governance of evolving systems: Innovation and sectoral policy conflicts in Norwegian aquaculture. Oslo: NIFU:STEP.

[5] Ørstavik 2004, op. cit.

Excerpt from scenario "A New Industrial Neutrality":
The aquaculture industry has developed in a reality that has become European-ised extremely quickly. Norway becomes part of a reformed and strengthened EU, called the Union of Free Democratic States (EUS). Europe's northern region, which includes the Baltic States, Finland and Iceland, in addition to Scandinavia, is an important part. Nature-given factors result in the region to a certain extent being perceived as marginal to the Union, which stretches from Svalbard in the north to the Mediterranean in the south and from Iceland in the west to Turkey in the east. Nonetheless, Scandinavians play important roles in the political system in Europe and the EUS plays an important role for the industrial development in the northern areas. The content of the term industrial neutrality has been modified from designating a situation where the public authorities play an equal role in relation to all industries, to designating a situation where the public authorities play a neutral role as the transmitter of democratic resolutions with regard to which industries are to receive investment. In the industrial political arena in the EUS, Norway plays a particularly important part within the marine and maritime sectors. Together with Icelanders, Norway-ers (the term "Norwegians" is no longer in use) play a vital role in the administration of ocean resources. This includes fish and other living resources, but also minerals and other valuable materials extracted from the ocean and ocean bed.

Analyses of the innovation system in the aquaculture industry and of the roles of research institutions show that there have been in part serious conflicts and a lack of clarity regarding long-term strategies also within research. Since 1985 industrial interests have been more on the offensive than previously. The "blue-green food alliance" that the Bondevik-II administration established in 2004, indicates however that serious efforts are now being made to transcend the sector boundaries, at least between agriculture and fishery.

The Future Scenarios

The scenario process

The Research Council of Norway invested considerable resources in the implementation of Foresight Aquaculture 2020. In the four meetings carried out, with a point of departure in the former analyses, we first discussed which actors and factors must be expected to have the most relevance to the situation in the aquaculture industry up to 2020. (See table 1.) Seven actors and seven factors were chosen and provided the basis for further work in the process.

In the second gathering, future images were developed for all of these factors and actors. These images were collected in a set of 150 mini-scenarios. These were in turn the raw materials for the next step in the process, where groups constructed complete future scenarios, using the mini-scenarios as an important tool. The group work was set up in such a way that the scenarios would be different in a meaningful fashion. At the same time, they should have key elements in common. To achieve this, everyone addressed the collection of mini-scenarios while at the same time every group was asked to integrate a specific crisis situation into their own scenario. The groups should thus arrive at a picture of a "growth-through-crisis" process, where some serious difficulties were surmounted and the industry – in spite of poor odds – could emerge as successful (thriving) in 2020. The goal was to avoid both wishful thinking and simple catastrophe scenarios, to balance positive and negative elements and to arrive at proposals for constructive solutions with regard to central problems that the industry in many cases had already to a significant extent been touched by.

General about the scenarios

Each scenario should contain a story of how the industry is confronted with at least one profound challenge. Growth in the industry was to take place through overcoming at least one crisis. The project group chose, in light of the scenario work and existing knowledge about the industry, to highlight the following themes:

Table 1: The most important factors and actors expected to influence the development of the aquaculture industry up to 2020.

Factors	Actors
Market	Companies
Feed raw materials	Research, educational and competence communities
Innovation	Industry Organisations
Capital / Ownership	Investors
Development of competence (research and education)	Public Authorities
Sustainable Development (environmental and food product safety)	Advocates
Policy	Consumers/ Customers

The market situation – Because access to the export markets will be decisive to the industry's opportunities for development and because this access has been characterised by unpredictability and uncertainty for many years.

Access to feed raw materials – Because access to adequate feed at reasonable prices can come to be a serious bottleneck in relation to further growth and because administration of marine resources is a large and global challenge.

Development of competence – Because expertise is unevenly distributed in the industry, because the will to invest in research-based innovation has been and remains extremely changeable and because the distribution of responsibility and conditions for action within the knowledge infrastructure have been unclear, creating both uncertainty and conflicts.

Sustainability in added-value activities – Because sustainability and environmental considerations have an increased significance, because climate changes can occur with great repercussions for the industry and because it is not a given that fish farming implies a sustainable allocation of limited resources, such as in terms of energy and protein consumption.

Policy – Because the regulation of the industry has been vital to its development, because the regulatory system has undergone intense modification and has not found its final form, because market access internationally is closely connected with how the industry is administrated by the authorities in Norway, because the political system itself is in the process of being modified and can be heavily influenced should Norway become a member of the EU and because an active government is seen as entirely decisive to large parts of the aquaculture industry, while an industry-neutral government is seen as a necessary condition for healthy economic growth in leading economic and finance policy communities.

Excerpt from scenario "Feed for everyone"

Research has arrived at new and effective feed technology. Advanced biotechnology has developed alternative feed sources, which compensates for limited access to marine fatty acids and ensures adequate protein for feed production. Feed is produced both in Norway and locally near markets around the world. Norway is an active member of the EU, which after big problems leading up to 2014-15 finally manages to guarantee market access for Norway and other member nations, not only in the internal market, but also perhaps to an even greater extent in other parts of the world. The markets are segmented – there are market access agreements between different countries. The Norwegian aquaculture industry has managed to reposition itself and become highly and actively market-oriented. In the international fish farming and aquaculture industry the lack of marine feed has been a considerable bottleneck during virtually the entire period leading up to 2020. There has been an increasingly greater pressure on manufacturers to refrain from using fish to feed fish. As a reaction to this, the original feed-fish is used in a development of marketable and popular food products. It has turned out to be impossible to maintain a satisfactory level of fishing of wild marine species, despite attempts to harvest krill and to establish fishing of other species at lower trophic levels. Harvest at a lower trophic level has contributed somewhat but is far from adequate. Products based on such feed have become a scarce commodity. The feed manufacturers have therefore only been able to produce conventional feed at a very high cost. One has now succeeded in developing viable alternative feed sources, such as single-cell proteins based on natural gas, fat-producing omega 2-algae, higher-elevation land plants that also produce "marine" omega-3-fatty acids, bio-protein and lignin from the woodworking industry.

Excerpt from the scenario "The Aquaculture University"

Norway has strengthened its position as a supplier of seafood to the international market. Salmon is still the girder of Norwegian aquaculture, but other species such as cod, mussels, halibut and scallops are also important. Cod and mussels are volume products, while the other species are niche products for high paying markets. The fish is processed as a semi-manufacture product in Norway and is transported as fillet to the markets. This implies a stable offer of a considerable amount of by-products. Companies have managed to exploit this raw material and the production of semi-manufacture products for pharmaceutical and chemical companies represent a significant portion of the sales volume. Large international groups own a significant number of manufacturing companies, but the Norwegian Petroleum Fund has implemented strategic resources and controls several manufacturing companies in Norway and the market countries. The most significant individual factor for the positive development of the Norwegian aquaculture industry was the formation of the Norwegian Aquaculture University. This took place after a long period of problems in the implementation of knowledge towards industrial activity. The Aquaculture University emphasised multidisciplinary and problem-solving research. This involved an extensive collaboration with basic research communities worldwide. This also contributed to an increased understanding of the significance of research in the industry.

The scenario texts are found in their entirety further below in the report. The contents of the scenarios are presented in a summary on the following pages, in the form of a large table. Here you can read abstracts of the different scenarios (by column) and at the same time compare the scenarios on central points (by row).

Table 2: Summary of the different scenarios

	1 Market with no Frontiers	2 Feed for Everyone	3 Sustainability	4. Aquaculture University	5. A New Industrial Neutrality
Ownership and control	The government has considerable ownership in Norwegian industry, among other things through Statfisk. NUTECO is been nationalised and Norwegian companies own a number of enterprises abroad.	Private capital dominates; foreign capital interests are important, but Norwegian owners, who also control large aquaculture enterprises in the export markets, dominate some companies. Processing companies close to large markets such as the EU are often owned by Norwegian actors.	Active ownership and strong personalities characterise the industry. Ownership is to a large degree foreign, after many years of insufficient capital. The traditional fishery industry and fish farming industry have merged to form one marine industry.	Foreign multinational companies dominate.	Private capital dominates; foreign capital interests are important but Norwegian owners, who also control large aquaculture enterprises in the export markets, dominate some companies.
What kinds of companies?	There is an abundance of companies of different sizes, and they are often relatively specialised. The companies are not integrated towards the consumer markets. Contracting/ supplier companies play an important role in the industry.	Large parent companies with considerable expertise in the entire value chain are dominant. These also have R&D expertise and base their competitiveness to a large extent on proprietary knowledge. A number of the farming enterprises are small, but are run by the large. A series of advanced companies are working on special products from fish raw materials (pharmacy).	Multinational companies with a broad product range dominate the industry. The breeders are primarily small, work in networks and have a joint sales company.	Breeders are often small units and work on contract for large multinational companies. Some independent small companies exist and can experience considerable success.	The significant companies are large with a relatively broad product portfolio. There are fewer service companies providing individual services for small companies. But there are a number of extremely qualified suppliers, of e.g. feed and equipment and these are global actors.
Industry policy/role of government	The government has played and plays an active role as an owner and through formalised joint venture constellations where industry, the authorities and research have joined forces in efforts to build up Norwegian activity and expertise.	Trade and industry have taken over very much of the initiative. Relevant officials are at the EU level. Norwegians and Norwegian communities are important condition providers and decision-makers in the fishery sector. Regulations are function-oriented and stringent, but regulation of the economic development on the basis of regional considerations has been abolished.	The government focuses on financing basic research.	The government has entered as an owner of one of the large companies, but otherwise plays a limited part.	The government plays an active role as a partner in the industry development through trans-sector measures that take the industry actors' needs seriously. But the government does not operate enterprises and the regulations are function-oriented and strict. Regulation of the economic development on the basis of regional considerations has been abolished.
Access to capital	The government has played a crucial role through ownership and acquisitions of foreign interests. Private capital also plays a part and to an increasing extent, as the industry with governmental support over a period has proven viable.	Private investors in Norway have only to a small extent been willing to finance research-based development. Foreign capital dominates but some companies have mainly Norwegian owners.	The Oslo Stock Exchange has become an important source of capital. The Petroleum Fund has been replaced by the Ocean Fund. The fund invests e.g. in the aquaculture industry in Norway and internationally.	Private investors in Norway have only to a small extent been willing to finance research-based development. Foreign capital dominates.	Private capital is dominant and foreign capital has made a definitive entrance. Norwegian ownership interests dominate some central companies and these are multinational companies with owner interests in many countries.

	1 Market with no Frontiers	2 Feed for Everyone	3 Sustainability	4. Aquaculture University	5. A New Industrial Neutrality
Added-value/ production/ new species	Added-value takes place to the largest extent in red-flesh fish. Salmon is extremely important and a global product. Narrow but global product niches provide a basis both for large red-flesh fish production and large further processing activity. A number of new species have been introduced and there is a research driven production of new special products and in the functional food context. Safe fish is an important niche.	Profitable fish farming is operated on a large number of new species, both in Norway and internationally. A steady increase in demand for seafood and extremely good access to advanced and inexpensive feed has made for very large production volumes and added-value. Aquaculture is the largest industry in Norway.	Large export of fresh salmon and farmed cod as fillet. Also a number of other marine species provide revenues. Advanced utilisation of by-products comprises 35% of added-value. Knowledge and technology and advanced administrative models comprise an extremely large portion of the industry's added-value. Knowledge about methods and processes are the most important export product. Cod has emerged as an important farmed product, as have sea urchins, mussels and seaweed and sea tangle products. Norwegian companies are the leading suppliers of salmon roe internationally.	Fresh and frozen seafood, exported predominantly as fresh fillet and semi-manufacture. Advanced utilisation of by-products comprises 30% of added-value. Some further processing in the Norwegian food article industry. Brand names have little importance. Salmon is a main product, but also cod, mussels, halibut, lump-fish, char, scallops and lobster are produced.	Added-value in the fish farming industry on a global scale is two-fold: a volume product market and a market for fresh products. Actors in Norway produce fresh fillet products (particularly salmon and cod) for demanding consumers while other products go into industrial food production. Advanced biochemical products based on by-products from filleting are an important part of added-value.
Transport and logistics	Transport and logistics are advanced and connected to junctures located outside of Norway. These serve as bridgeheads and ensure delivery proficiency also in relation to large customers. Rail and ship are the most important means of transport for long distances. Tracing systems integrate logistics and safety considerations.	Advanced logistics systems are developed, direct sale from manufacturer to consumer through e-trade, simultaneously. Ship and rail are the most important for long distances.	Advanced logistics systems are developed, direct sale from manufacturer to consumer through e-trade, simultaneously. Ship and rail are the most important for long distances.	Actors located in Norway handle logistics and transport. Advanced tracing systems and product information systems based on advanced ICT, intelligent packaging and product identification (Fresh-Track). Rail and ship are the most important long distance transport means.	Advanced, new integrated transport systems make it possible to transport large volumes flexibly and quickly to remote markets.
E-trade	ICT plays a key role in sales and distribution systems.	E-trade is central both for sales to trade chains and directly to the consumers. Just in time and production by customer specification are important.	E-trade is central both for sales to trade chains and directly to the consumers.	E-trade is central both for sales to trade chains and directly to the consumers.	ICT is an important part of logistics and production management systems. Integrated information systems are also used in relation to customers who receive complete information about the products from electronic signatures that are included with the products.

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Competition	Global competition is extremely great on white-flesh fish and mussels. Norway is the world leader in red-flesh fish and a number of advanced functional food products.	Considerable competition from low-price manufacturers of volume products, especially in Asia.	Production of equipment takes place in Asia. Norway leads in concept development and competence. Increasing competition from local fish farmers close to the market.	Strong competition with other species from aquaculture in warmer countries such as tilapia.	The competition is tough internationally especially on volume products of white-flesh fish that to a large extent are nourished on vegetable feed.
Alliances	Strategic alliances with large trade groups that make it unnecessary for Norwegian manufacturers to integrate with the consumer.	Strategic alliances with knowledge-based trade groups.	Extensive sales to large, international trade chains.	Alliances with trade chains and fast food chains, especially McDonalds and Coca Cola. Collaboration also between fish farming enterprises and the supplier industry.	Norwegian companies are vertically integrated, from primary production to trade. Important alliances are established with research communities.
Knowledge regime/ knowledge infrastructure	New companies emerge that are active in different research fields, not least in connection with process. The companies own and protect their core knowledge. University environments are also important but no longer supply to the knowledge commonage. Also the universities protect their results. But the government contributes to basic research and is an important complement to an otherwise more privately-financed research initiatives.	The companies are responsible for much of the knowledge production while the university environments internationally represent the long-term professional development. Different research activities are connected through different types of collaboration.	The public officials have enforced a division of labour in the international knowledge infrastructure. Sector conflicts are solved. Food research is central and takes place in collaboration with public officials and industry actors. Norway is amalgamated.	A multidisciplinary industry-oriented research and education institution owned and financed by the business sector, which collaborates closely with companies and with basic research communities. It has R&D facilities in a number of locations. Part of the institution operates knowledge development and consulting for the administration.	Publicly financed research plays a crucial role but is connected with commercial activities in another way than before. The innovation system has matured so that democratic processes play a more important role for the arrangement of innovative activities. Leading companies are competent and enterprising in the innovation system.
Knowledge placement	Core knowledge in the red-flesh fish sector is situated in Norway.	Basic disciplinary professional knowledge is found internationally, in the university environments. The industry-relevant knowledge and the ability to apply knowledge in aquaculture are found at the leading companies. The industry-relevant knowledge and the ability to apply knowledge in aquaculture are found at the leading companies	40 Norwegian research communities are integrated into five regionally based units. Important knowledge development takes place in the international network.	Some basic, disciplinary professional knowledge is found at the leading universities internationally, the industry-relevant knowledge and the ability to apply the knowledge in aquaculture are found at the Aquaculture University. The companies leave most of the research to the Aquaculture University.	Leading disciplinary research communities internationally play an important part in the basic knowledge development. Process knowledge in particular on salmon, cod and a number of other advanced derivative products is found in Norway.

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Demand for consumption	The food product market is global, but extremely differentiated. Niche products are industrially designed and produced, narrow, global niches provide great production volume for Norwegian manufacturers.	Large increase in the demand for seafood globally. Large demand for fresh, fillet products of salmon and a range of other farmed species. Norwegian fish products are brand name products with a documentable "good production history" and superior quality and the demand is quite great.	Large increase in the demand for seafood globally. Large demand for fresh, fillet products, mussels and sea urchins. Norwegian salmon has become the ocean's "Parma Ham". Demand for products with "good production history" (animal welfare, etc.).	Salmon is a volume product, demand for fresh fillet but also cod, mussels, halibut, lump-fish, char, scallops and lobster. Considerable demand form advanced industry that uses offcuts and remnants from fillet production as input goods.	The demand is two-fold: volume products of white-flesh fish go to consumption and industry food product development and are highly vulnerable to price competition. Fresh fish products based on among other things salmon and cod go to large customer groups with high requirements and significant solvency.
Demand for production	Final manufacture takes place close to the end-user markets, so that the demand for super fresh fillet products is extremely great.	Significant demand from advanced industry that uses offcuts and remnants from fillet production as input goods. Considerable further refinement activity, in Norway and internationally.	Considerable demand form advanced industry that uses offcuts and remnants from fillet production as input goods.	The EU is the domestic market, and here there is full access for Norwegian actors.	White-flesh fish is an important input factor in the food product industry. Remnants from fillet production, mussels, etc. are important input factors in an advanced biochemical industry.
Access to export markets	The market is liberalised globally, but strict supra-national regulations and standards provide a large degree of documentable food product safety.	Norway is part of the EU and plays a central role in the EU's administration of fish resources.	The EU and Russia are the central markets. Norway is part of the EU and plays a central role in the EU's administration of fish resources.		Norway is integrated into the EU, total access to the EU market. Access to other trade blocks more problematic but Norwegian interests represent a significant portion of the tilapia production in Asia.
New emerging markets		China and Russia have become large markets, also for expensive products. America is a large market for low price products. Africa is in the process of becoming a significant market.	China and India are developing rapidly as export markets for Norwegian seafood.	China, India, Russia and Japan are important new markets.	Asia has become a significant market. Africa is on the verge of becoming important.
Product innovation	Norway dominates in the red-flesh fish sector and designs new products all the time that are marketed to the large chains. Special by-product based biotechnological products are an important part of the product development of the Norwegian industry.	R&D has documented seafood's superior characteristics in terms of health and nutrition. Fresh and refined products are developed with an eye towards special markets and application areas and at extremely favourable prices. Special products with special functions have become an important product segment.	Quality classes and documentation systems are introduced and products are sold as brand products on the basis of these.	Customised qualities of fresh fish. New species.	Fresh fish with documentable characteristics is important in the high price segment. Special fresh fish products are designed where e.g. different types of fish are combined in "composite fillets". In the volume market an extensive development of food articles takes place for differentiated markets. Two Norwegian actors have been established as global food article manufacturers.

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Process innovation	Large R&D investments have resulted in completely new process knowledge. This provides far cheaper and more predictable salmon production while at the same time advanced knowledge bases are developed for cod farming and other new, farmed species. Norway possesses a globally speaking superior process technology competence in the red-flesh fish sector.	Effective technology has provided escape-proof installations. Installations are developed that make it possible to operate farming at sea. Area conflicts have contributed to forcing the fish farming installations out into open waters. The installations are remote-controlled and fully automated. Processing takes place with completely new technology in automated processes providing super fish products for large export markets. Advanced logistics are an integrated part of the production processes.	Effective technology has provided escape-proof installations. Installations are developed that make it possible to operate farming at sea. Integrated fish farming (such as salmon and mussels) is a success but area conflicts have contributed to forcing the fish farming installations out into open waters. Fish farming and process management focus on the well-being of the individual fish.	Effective technical solutions based on materials technology, automation, nanotechnology, biotechnology, medicine and ICT has solved most of the problems with disease, escape and traceability and have reduced the labour-intensity and unit costs in production. New technology has made it possible to move installations out of regions with area-use conflicts and out to open sea. Sea ranching and land installations are used for some products.	Process technology and automation have contributed heavily to bringing about a cost-effective primary production in Norway. Considerations are made for food product safety and fish welfare in the new processes.
Feed	New, genetically modified feed products become important for generating enough good feed at reasonable prices.	Gas-based feed production is extremely important and is produced on a large scale on the basis of Norwegian gas resources. Feed is differentiated and specialised in relation to species, product characteristics and markets. Feed is certified at the EU level.	Gas-based feed production is extremely important and is produced on a large scale on the basis of Norwegian gas resources. Feeding of farmed fish with wild capture species is not deemed sustainable, neither species at a lower trophic level.	The feed situation is difficult. GMO has not been able to solve the problem. Marine feed substances at a lower trophic level have become important.	Vegetable feed substances are crucial to volume production of farmed white-flesh fish globally. Norwegian production of salmon and cod is to a large extent based on use of marine feed substances.
Biotechnology	GMO is used in feed and in special applications, but the farmed products in themselves are not genetically modified. Genetic technology has applications e.g. in breeding.	GMO is not used in the value chain.	GMO is not used in the value chain.	GMO has not been accepted, except for in special applications, such as vaccines.	GMO has been used to develop adequate vegetable feed substances. GMO is used in the advanced by-product industry.
Ethics/ Animal Welfare	Animal welfare in production is important and can be documented.	Animal welfare in production is important and can be documented.	Animal welfare in production is important and can be documented.	Animal welfare in production is important and can be documented.	Animal welfare has become crucial and wild fish capture through old methods is perceived as unethical.
Climate and environment		The climate has changed but changes in the ocean temperature have been handled through the moving of installations. While some farming has moved north other species are in production further south.	Significant climate changes. Change in ocean temperature, extreme weather. New and effective environmental monitoring systems make sea-based aquaculture production safe. The ocean is less polluted than before.	No significant climate and environmental changes.	No significant climate and environmental changes but environmental monitoring and administration of marine resources have become important areas where Norwegian competence is world-leading.

Main Themes in the Scenarios

Introduction

The work with the scenarios contributed to making a number of important issues discussion subjects. Some of these have been relevant for a long time and have been a challenge for the industry, the public authorities and education and research communities. It is quite clear that several of them will continue to shape the industry also in the immediate future. Before we move on to a more focused discussion of the research challenges that can come to have important in the future, we will discuss some of these challenges as they are reflected in the results of the foresight process. It is a matter of enduring or structurally conditioned dilemmas, uncertainty related to both human-created and nature-given uncertainties and the need for underlying strategic choices in research prioritising and other measures which the authorities and industry actors can choose to implement.

It is again appropriate to emphasise that the foresight material is not exhaustive and far from a complete perspective analysis. A number of factors were heavily focused upon during the foresight process due to issues of current relevance. An example of this can be the focus on food product safety. A number of other factors that could have received attention have not been as clearly emphasised. This applies to, for example, the significance of new species in future aquaculture. This also applies to the need for sustainable transport and logistics solutions for the industry and the importance of special technologies, such as ICT and materials technology, for the potential development of the aquaculture sector.

The foresight material must be seen as a contribution to an ongoing dialogue about how the industry should be developed in the future and not as a presentation of all of the right answers.[6]

Innovation for added-value and profitability

The modern aquaculture industry in Norway has one dominant product, namely Atlantic salmon. The rainbow trout, which was the most important in the start phase, is still a significant product, but far less important than salmon, both in produced volume and in sales volume value. Both salmon and trout have proven – relatively speaking – to be simple fish to breed through fish farming. Simple equipment and simple care were enough arrive at an increase and profitability. As the scope of the fish farming activity expanded, problems arose, not least in connection with the health of the fish – that had to be addressed using scientific methods to find a solution. Eventually all of the main issues in connection with fish farming – health, breeding, process management, technical equipment, feed and market development – came to be dependent upon contributions from higher education and research.

Through the structural change that has occurred over the past 10 years, a number of groups have emerged of a size and with a resource base that can make it easier to address advanced developmental challenges. They also have the possibility to assess the relation between own core competence and future activity strategy in another manner than small actors. Putting into use their own research in a systematic manner to bring about progress requires significant resources and the ability to carry risk.

But it appears to be a problem in the industry that also the large fish farming companies have too limited a capacity to use biological knowledge and advanced technology to develop more modern, scientifically based and industrial operational forms. Actors continue to operate on the basis of practical knowledge, as this has been developed over the course of a number of decades of fish farming in relatively small installations and in a situation with relatively limited requirements with regard to documentation and safety. It could appear as if part of the structural change that has taken place has not been deep enough. Large groups can be, organisationally speaking, simple holding companies with first and foremost economic- and administration-oriented management. The operation takes place locally in a number of departments that possess practical knowledge in terms of the fish farming activity. Operations thereby take place more or less as they would have had they still been locally owned and the large-scale benefits one manages to derive become therefore also quite limited.

The small fish farming actors have to a large extent been obliged to confine themselves to a focus on primary production. They have sold their product to traders at the "spot price" (current market price) and they have not to any significant effect had to worry about the fish and about the buyers beyond this. The orientation towards primary production has been about acquiring efficient operati-

[6] See Part 2 of the report where the foresight methodology is described in more detail. An account of the results from a questionnaire on the participants' opinions of the first part of the process is given there.

ons, about buying the feed that gives the best growth for the money, and operating in a manner that is cost effective and provides a basis for positive earnings year-round. Equipment, smolt, feed and veterinary services have often been purchased from actors whom the breeders have known and trusted. New solutions and new input goods have first been introduced when others have demonstrated that these actually function and provide better profitability for the operation.

How then can the future come about? A recurring feature in the scenarios is that one visualises a large and successful industry that sells its products globally. Salmon will be a main product like today, but the industry will also produce and sell new products based on other species and advanced special products based on raw materials from the fish. Some envision that salmon or red-flesh fish are the main product and that first and foremost it is a matter of sales of fresh fish fillets, accordingly, much like today (Aquaculture University, Market With No Frontiers), while one in A New Industrial Neutrality envisions white-flesh fish (cod) expanding parallel to salmon and that fish processing in Norway gains a much greater importance. Fish is in this scenario an important input product in a significant and advanced Norwegian food industry specialised in marine brand name products.

But what kind of companies make up the industry and who produces the advanced knowledge needed to bring about an industry of the nature envisioned? In the scenarios there is a distinction between those who believe in an industry where also small companies manage to handle the challenges they encounter and remain important in the industry, and those who believe that the large group will come to dominate the industry in the future. There is also some disagreement about the degree to which Norwegian ownership will be maintained in the industry without direct governmental intervention.

In Market With No Frontiers, the industry is made up of a multitude of companies of different sizes and specialised in different parts of the value chain. They are not integrated towards the consumer market but, on the other hand, many of the companies have strategic alliances with trade chains in the large markets. All of the companies appear to play a more active role in carrying out research and the universities, that are still public, are also extremely important to the industry, although they no longer deliver their products to a "knowledge commonage", but protect the results they produce legally and earn money by selling rights of use. Also the many companies that do their own research protect their results and knowledge has become more of a commodity. The focus of the industry is on primary production, but insufficient attention to end-markets and limited understanding for the need for product innovation and conscious market development are counteracted through alliance building.

While other scenarios choose the middle road and envision an industry of some large groups and some small enterprises that in some way or another are run by these, the scenario A New Industrial Neutrality goes all the way and foresees an industry where the large companies are completely dominant. Here the integrated companies control many links in the value chain; they are involved in processing and food production, while they also control the fish farming itself through an advanced, scientific knowledge base. There are a number of specialised suppliers to the industry, but these too are large and deliver their products globally. The innovation system is primarily composed of the companies themselves and of leading communities from the research and education sectors that receive public funding but that have other framework conditions than previously and that in addition to being engaged in professional development in international competition, are responsible for both education and a training programme where the public authorities and industry are customers.

In the scenario Sustainability there is a focus on the marine industries, fishery and aquaculture, moving closer to one another and eventually merging in a single marine industry. To succeed in the future the wild fish industry and the Norwegian aquaculture industry find that one must first and foremost think with a value-chain orientation and market-orientation. New marine fish farming species (such as cod) meet wild fish in the same markets. The fisheries are not able to able to provide delivery of fresh quality products year-round due to seasonal changes and limitations in wild fish capture. This problem is remedied through cooperation with the aquaculture industry's actors.

In all the scenarios, the situation is turned around in 2020, in the sense that the industry no longer lacks a good grasp of the market problems, that it has learned to focus adequately upon product innovation and it is willing to implement significant portions of its surplus on research tasks and innovation. All in all, we have before us an industry that has become an advanced knowledge industry and that is not confined to selling individual qualities of fish in bulk abroad. The focus on increased ear-

nings and profitability is no longer synonymous with a focus on growth. This has contributed to giving the industry a strong competitiveness. It has also strengthened the position of the industry in that it sells more advanced products at higher prices so that dumping allegations and imposition of fines on Norwegian aquaculture products are no longer an issue. The trend where salmon was becoming a less and less expensive and less of a quality product has also been turned around, even on the Norwegian domestic market.

In this way the five scenarios developed in connection with the foresight process accordingly reflect an acknowledgement that something must be done and a number of central things must be done in ways other than they have been done before: it is not enough to produce large volumes of salmon and to export them as gutted fish. The customers have with time become both competent and demanding and fish must not only be good quality, it must also be safe, it must be possible to supply it in large quantities at given points of time and it must be of a quality that is suited to the market and the planned use. The aquaculture industry must address many more links in the value chain, it must have an understanding of the markets and the market dynamic and it must manage to supply an assortment of different products. At the same time, the primary production must be carried out in the most cost-effective manner possible, since the competition from other nations and alternative products is increasing.

The industry must have the ability to operate effective product innovation for global, dynamic and differentiated markets. Part of what is needed can be to generate new fish farming species in such a way that it becomes possible to operate a cost-effective aquaculture activity on species other than salmon and trout. Another important condition can be that one manages to establish processing operations that are profitable. Norway is still expected to have wage costs at a high level on an international scale, and a development of the processing dimension of aquaculture activity will depend upon a radical ability to automate the processes or to produce extremely advanced special products.

The technological development in areas not associated with standard equipment industry, such as ICT, materials technology and nanotechnology must be exploited within aquaculture. And the market understanding and market development must be connected with product and process innovation so that the industry definitively abandons its bulk and spot-sale strategy.

Long-term ecological and social sustainability

The aquaculture industry is based on a systematic strain upon nature and is fundamentally dependent upon the conditions that nature imposes upon aquaculture activities. If it should prove that we are entering a period of rapid and unpredictable changes in local climate conditions, this represents a significant challenge for the aquaculture industry.

At the same time, the aquaculture industry itself is a challenge in relation to nature: the industry puts a strain on the natural environment in different ways through its activity, among these, through emissions of nutrient salts. Fugitive farmed fish can have a negative effect on wild stock; the location of fish farming installations can occupy attractive coastal areas, etc.

In the scenarios there are different conceptions of the meaning of climate changes. In Sustainability and Feed for Everyone the scenarios foresee significant climate changes, with a change in ocean temperatures and more weather of the type which we today regard as extreme. One has been able to meet these changes through relocation and technology development. Installations are moved north and out to open sea, or in the ocean. It is now a precondition that equipment and technology are more robust, that advanced positioning systems and dynamic anchoring systems are available and that automation of production on a large scale has made it possible to operate remote controlled installations. In addition, one sees in several scenarios that in the future there are monitoring systems for the environment that make it possible to predict changed water conditions and to compensate for such changes by movement or other adjustment of parameters that control the processes of the automated installations.

The sustainability issue has clearly also an important social aspect. The aquaculture industry is dependent upon the social processes related to the public authorities', and society's management of environmental issues and themes connected with long-term sustainable development. When environmental impact gradually becomes integrated into the individual actor's costs through a goal-oriented development of the regulatory system, based on the principle that "the polluter pays", this changes the framework conditions for fish farming activities. When considerations for food product safety and animal welfare lead to new and somewhat stringent requirements for the design of installations, process, and hygiene, this also implies new framework conditions and new challenges for the actors in the industry.

In the foresight process it was almost unanimous when it came to assessment of the market significance of animal welfare: regardless of what one might feel about the fish's ability to feel pain and regardless of whether it is a moral problem if one can say that humans are cruel to fish, there is agreement that it will be completely crucial for the industry that fish farming is carried out in a manner that makes it possible to document that the fish are fine and that extermination is done in a manner whereby the fish do not suffer.

Food safety is another theme where there is widespread agreement: Everyone perceives the tendency to require documentable product characteristics and explicit product history as something more than a passing trend. The future aquaculture industry must be organised in such a way that tracing and quality assurance are an integrated part of production and not something one tests through spot tests on goods for sale.

In addition, two further sustainability-related matters emerge as being of particular importance: the issues in relation to feed and the transport problem.

It is not a given that it is ecologically expedient, in other words sustainable in the long-term, to feed fish with marine species that in themselves contain valuable proteins which can be used as food for humans. Stock analyses and ecological administration models can provide indications that a continued acceleration of the aquaculture activity, in the form as we know it today, will run into obstacles: the feed substances known today and that provide good feed, are limited. Presumably significantly more cannot be extracted than is extracted today, without this threatening the stability of the stocks over time.

Will the aquaculture industry have the possibility to acquire adequate and inexpensive feed, should the global expansion of demand for fish farming products have continued strong growth? In some scenarios it is not a certainty that this problem will be easy to solve. In A New Industrial Neutrality, one envisions a segmentation of production, where a high price segment is based on traditional, natural and expensive marine feed raw materials, while a larger volume segment, where prices and quality are lower, is based on alternative feed, primarily vegetable, produced in the agriculture sector and adapted to the needs of fish through advanced genetic modification of the feed organisms. The idea of genetically modified vegetable raw materials becoming important is also found in Market With No Frontiers. In Feed for Everyone one is more radical: here it is envisioned that the feed problem is solved through the use of natural gas. It is assumed that production of feed from gas will provide a first class feed at a reasonable price, and that this will make it possible for the industry to continue its strong growth (measured in production volume) without having to resort to advanced genetic technology solutions. Wholly corresponding ideas are found in the scenario Sustainability. In Aquaculture University on the other hand, one envisions the feed situation as difficult. One assumes that marine raw materials from lower levels of the food chain in the ocean (lower trophic level) will be a new important source of raw materials for feed.

Also on the transport side one sees challenges. However, here most of the scenarios are relatively conservative with regard to the physical flow of goods: one envisions a traditional logistics system, controlled from abroad or in Norway, that is based on trucks for short distances and primarily on trains and ships for long distances. A New Industrial Neutrality distinguishes itself here by envisioning an extensive technological change in the transport sector, where new energy-economic and pollution-free transport solutions combine the effectiveness of mass transport with the flexibility of individual transport. None of the scenarios foresee transport and logistics placing serious obstacles in the way of the industry's expansion in Norway. On the other hand, all the scenarios envision a future where information technology systems become an integrated part of the production and distribution activities and where such systems provide great benefits in terms of efficiency, product quality, documentable food safety and a new capacity to deliver to specified orders, just-in-time.

Ownership, control and access to capital

We have seen how the aquaculture industry grew from below: the impetus during the early years came from local entrepreneurs who saw opportunities to create a supplementary income by starting up farming of trout and salmon. The public authorities intervened here from the very start, by giving financial support and advice for establishment of enterprises. In different ways the public authorities have continued to play an entirely vital role in the industry's development up to the present day.

A recurring theme in the scenarios is the opinion that how government chooses to carry out its role becomes extremely important for the future of the industry. And in general, all see the need for the government playing an active and constructive part

in terms of the industry. But the scenarios are far from identical with regard to those factors to be emphasised and the type of governmental role envisioned as being necessary or desirable.

The public authorities are significant in practical terms for all important aspects of the aquaculture industry's situation. The themes in the scenarios with the most explicit focus on the role of government are about ownership, control and access to capital, market access abroad and research and technology development. We will look more closely at how the scenarios address these themes in the following.

The foresight process for aquaculture took place in a period that was characterised by the fact that the industry had been through, and remained in, considerable financial difficulties. Concentration into larger entities had not succeeded in compensating for historically low salmon prices and several of the actors, including some of the largest, found themselves in a situation where bankruptcy could not be ruled out as an option. It is therefore not without reason that the capital situation within the industry was a prominent theme.

The difficulties in creating new capital for investments were considerable and these had been compounded by the public administering agency's being to a continually lesser extent capable of compensating for this. In the scenarios, the government's involvement, or lack of involvement, plays a key role in the development.

In the Market scenario, the government has taken on a very active role as an owner: Stafisk has been established, but a large actor who had previously been in foreign control, is now nationalised. Through governmental involvement and support, also private actors have acquired confidence that the industry will survive in the long-term and have become involved with capital, in addition to what the government has contributed. Public investments have accordingly triggered rather than restrained private investments.

In the other scenarios, private actors and private capital play a much more central role. In Feed for Everyone large and competent Norwegian companies dominate and set the tone and the Norwegian public authorities have become less important, while the authorities at the EU-level have become far more important than today. In the three other scenarios, foreign owners are extremely important and this is frequently perceived as a result of the Norwegian government having failed in its task with regard to ensuring Norwegian ownership for central actors. Foreign private owners enter instead, when private capitalists in Norway do not dare to invest and the government refrains from investing for political and ideological reasons. The picture is somewhat more nuanced in the scenario A New Industrial Neutrality. Here the government has played an active role in the industry without directly taking part as an owner. One has found new ways of supporting the industrial development and has succeeded in drawing in Norwegian ownership interests. The overall picture is thus more mixed: some Norwegian companies are large and have large ownership interests in aquaculture worldwide. On the other hand, foreign interests also have ownership shares in the aquaculture industry in Norway..

Market access

The Norwegian aquaculture industry is above all an export industry. It is clear in all the scenarios that without this international dimension, the Norwegian aquaculture industry cannot in any feasible way be a success. All presume that the authorities do an active and effective job of integrating Norway into the global trade system. In all the scenarios, Europe is regarded as a domestic market and all four scenarios that say something explicit about Norway's relation to the EU state that Norway is a member in 2020 and has been one for more than ten years. One exception is Market With No Frontiers. Here one envisions global markets and open trade independent of a Norwegian connection to the EU. But also other markets become important and all mention the large populations of Asia as extremely important export markets with strong purchasing power in the future.

Research and technology development

In Market With No Frontiers the public authorities pay an equally active role in research as they do when it comes to ownership and securing access to capital. Through concrete investments where research, trade and industry and the government have taken on joint responsibility, new commercially viable industrial activity has been created. The public authorities have contributed as well in long-term financing and to the organisation of a research and education system that is such that long-term development of knowledge of relevance to industry is found in the university institutions, which are themselves actively commercialising their results and they are adept at exploiting their non-tangible rights. On the other hand, the companies themselves are also better informed about research and development

and collaborate on the development of knowledge with the relevant university communities.

Feed for Everyone and Sustainability have similar ideas and envision a concentration in a small number of regionally connected education and research institutions that are internationally competitive. In these scenarios one can sense that the institutions have changed in character and resemble more hybrids between traditional universities (which are oriented towards higher education and professional development according to internal disciplinary development criteria) and strong research institutions (which are not fundamentally oriented toward the basic professional development according to disciplinary criteria only, and which actively address problem-solving in relation to their principals).

The scenario Aquaculture University envisions a development in a somewhat different direction: here an institution with clear similarities to the large research institutions of today, with a clear user-orientation and trade and industry representation in management of the enterprise, will be a vital complement to the activity in the more traditional discipline-oriented university communities. In this scenario, the companies to a large degree refrain from carrying out their own research and product development and leave this instead to the Aquaculture University.

In A New Industrial Neutrality there are as well ideas about active policy with regard to innovation to a greater extent than previously being formed through democratic mechanisms. Investment in

sustainable aquaculture has in this scenario a great legitimacy because the choice of this industry as a special area of investment has taken place democratically.

In all, the scenarios provide pictures of a government that prioritises contributing to the development of the fish farming industry and a government that steps up when individual actors in the industry find themselves to be powerless: this pertains to relatively simple issues such as financial support in periods of decline, more complex problems such as regulatory systems and industry policy or supra-ordinate factors such as international relations and Norwegian integration in supranational economic and political systems such as the EU. And this pertains to the government's possibilities to shape the innovation system in the aquaculture industry, and to the interaction that to a certain extent is already in place but which could have been better, between industry actors, instances of authority and teaching and research communities.

Central Research Challenges

The aquaculture industry has emerged through an interaction between private actors, researchers and public authorities. Local entrepreneurs propelled the development forward. They sought out professional advice abroad as well as in Norwegian administration. Many establishments took place with public economic support, for example through the Regional Development Fund. Scientific research was seriously mobilised when the industry had become large enough for disease and other operational problems to be perceived as problems of a certain regional, and gradually also of national significance.

Although the culture of the industry, especially within the fish farming activity, has been characterised by a strong belief in the importance of purely practical knowledge, one has also understood the need for research with regard to central questions. This pertains, for instance, to disease: actors have experienced serious crises in connection with the outbreak of disease and the need for basic research on fishery biological issues has been clear.

Figure 2 illustrates that research has become increasingly more important to the aquaculture industry: First of all, scientific knowledge has gradually acquired an increasingly more vital importance on all main fronts for the development of enterprises and knowledge. Secondly, as the industry has become increasingly more advanced and the underlying knowledge bases more analytical (i.e. less comprised of purely practical knowledge), integration between the different areas of knowledge has also increased. Scientific methods and documentation make it possible to handle this increased complexity in an expedient fashion.

Research has generated essential findings and has played a decisive role in the aquaculture industry's development. Simultaneously, the challenges for research remain great. The investment must by far surpass putting out fires in crisis situations. We have a need for a broad and reinforced investment within traditional research fields, such as biology, technology, etc. While there is a need for knowledge-based enterprises in charge of a profession-based problem solving when problems require quick solutions, we still have a need for long-term research that aims at creating results intended to have a commercial significance in the long run.

A wholly central theme in the foresight process was to specify which research challenges, within the different scenarios anticipated, would be the most central in the future. We shall present the results of

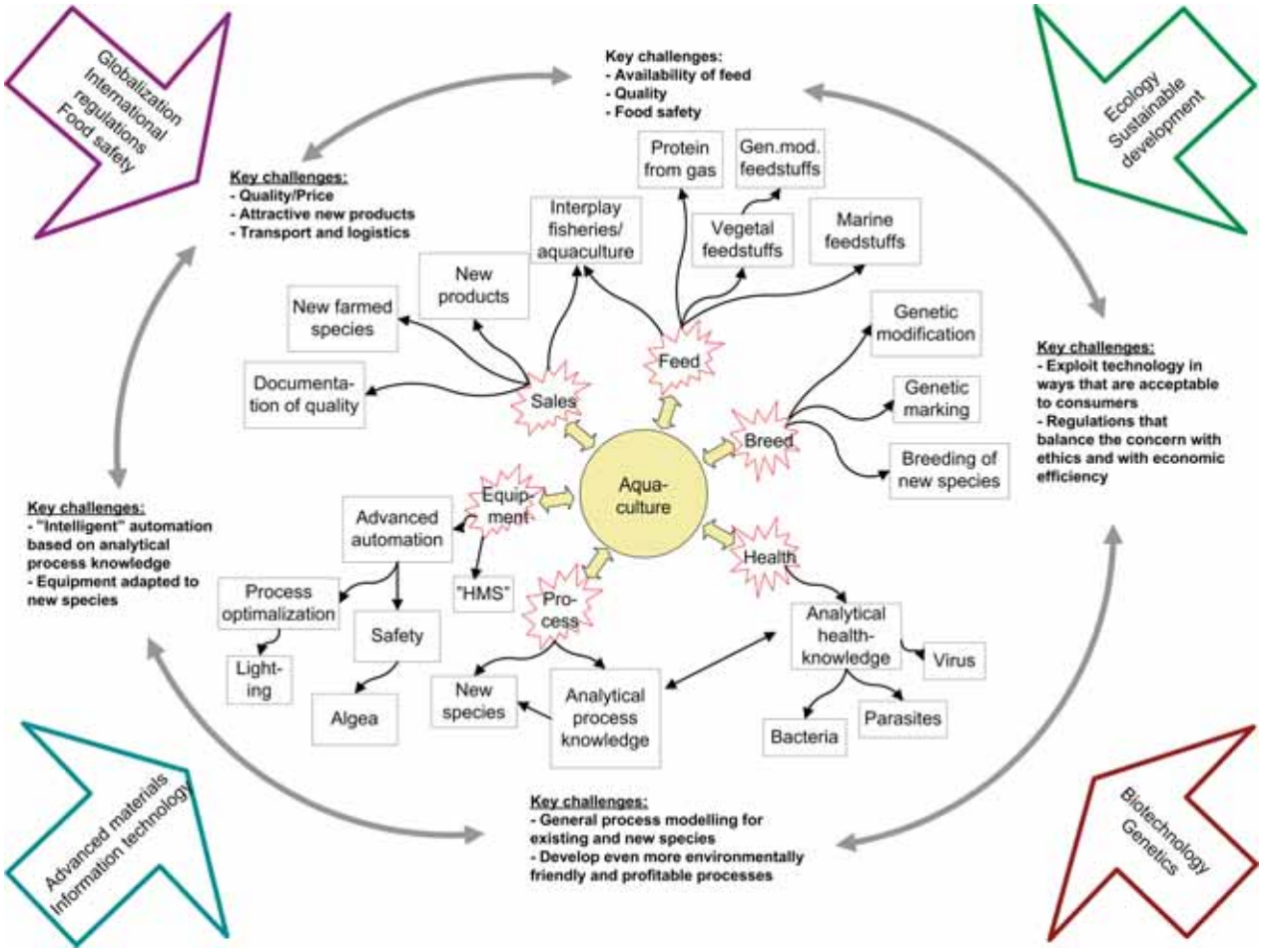

Figure 2: Developmental fronts and research challenges

this work in the following and will see that the seminar participants addressed all of the developmental fronts and the research themes presented above.[7]

It is important to note that the work in the process was not intended to lead to a full consensus with regard to priorities and choices in terms of which research challenges are the most important, what should receive the greatest investment and where investments should be made first. The project group for the foresight process presents a number of views and assessments on page 28. In the final analysis, it must nonetheless be the case that concrete choices and priorities must be made in the programme development work to take place at the Research Council, subsequent to the foresight process and of course also in the strategy development which companies and research communities will be responsible for in the future.

Process Innovation

In the scenarios the overriding problem that emerges is that the production costs of fish farming activity are too high. Despite ongoing efficiency measures and rationalisation, price competition from countries such as Chile force Norwegian breeders to come up with increasingly more cost-effective methods of operation. Nonetheless, in the scenarios, one moves past the traditional and simple perspective of process development and efficiency. Research that can lead to rationalisation is viewed in a broader perspective in all the scenarios. Process development must take place in such a way that important considerations other than short-term profitability are addressed. Market orientation will be increasingly more important also on the side of process. For instance, should animal welfare become an important criteria for consumers and the public authorities in the future, it is crucial for fish farming to be

[7] The list of central research challenges that emerged was extensive but only to a limited extent systematic. In the following we have only given a simple presentation. More specific challenges, referred to here as themes, are listed under a number of more general challenges. These general challenges we have then listed under three different headings, namely, Process Innovation, Product Innovation and Sustainability.

Table 3 Examples of research challenges connected with process innovation

Research Challenge	Theme
Development of operational models	
	New fish farming concepts
	Large-scale operation vs. small-scale operation
	Basic biological process knowledge; fish biology, farming environment, limit selectors
	Knowledge about and indicators for animal welfare
	Infection assurance
	Telemedicine
	Sea Ranching
	Land-based installations
	Integrated sea farming models (poly-cultures)
	Interaction between species
	Climate and environmental monitoring systems
	Resource monitoring and administration based on ecological models
	Area-use planning, area-use management
Farming technology and equipment	
	Automation and process management
	Instrumentation
	Robot technology
	Advanced ICT applications
	Installations for open water
	Cage technology constructions
	Anchoring systems
	Dynamic positioning
	Feeding regimes
	Escape-proof installations
	Exploitation of materials technology and nanotechnology
	Alternatives for use of chemicals
	Water treatment, purification
	Alternatives for fouling prevention
	Recycling
Fish health and health problems for other species	
	Diagnostics
	Vaccines
	Biopharmacology
	Bacteria diseases, viruses, production ailments
	Breeding
	Knowledge of genetic technology options
Total utilisation of raw materials	
	Advanced by-products
	Bio-prospecting
Food Product Safety	
	Tracing systems in production and logistics for the entire value chain
	Information systems connected to production and the products
	Effects of use of genetic technology.

carried out in a way that gives the fish's needs and well-being a central focus. Slaughter must be done in as gentle a manner as possible. All the scenarios address such factors.

Food safety is important today and all the scenarios clearly state that this will be even more important in the future. This imposes strict hygienic and systematic requirements upon the farming and refining processes. It also imposes great requirements on feed and medicine. And it imposes requirements for an extensive control of the products put on the market. Tracing systems providing information about the product, its ingredients and its origin are of great importance. In several scenarios, such as A New Industrial Neutrality one envisions a development of advanced information systems together with the tracing systems; systems that give the buyer information both about what they buy and how what they buy can be used.

In the scenario Sustainability as well as in Feed for Everyone there is an emphasis on the need for development of advanced production equipment, which among other things can make possible relocation of activities out into more open waters. In the scenarios one envisions that climate changes can occur that will make relocation necessary. In addition, one foresees that area-use conflicts and local environmental impact can lead to it being expedient to move enterprises away from some of the sites in use today. Regardless, new equipment technology, new materials, advanced robot technology and automation along with environmental monitoring systems and biological process knowledge will make possible large-scale operation of fish farming in a totally different manner than we see today.

In all of the scenarios a continuous improvement of process technology and continuously improved basis knowledge about the processes and biology involved in fish farming are envisioned. Research in these areas and active innovative endeavours, leads to greater profitability and continued strong competitiveness for Norwegian aquaculture activities.

Investment in all of the areas will potentially have a favourable effect upon costs in the industry in the long-term. But it is not the case that one can expect the investment in these areas to provide immediate economic gains for individual actors. It is thus clear that it is not only necessary to carry out research on these things; the investment must be implemented in a broader context, where the industry's developmental strategy is coordinated with the public research efforts. (The same can be said for almost all of the challenges we highlight in the following.)

Further, it is clear that the contents of the research work, beyond the headings, will be potentially highly divergent within different scenarios. As an example, the view of the localisation challenge does not correspond in all of the scenarios. Some expect that fish farming must be moved out to sea, others that a large portion of the farming will take place on land.

If one views the aquaculture industry's primary challenge as a cost problem, there is clear agreement that cost reducing process development must have a central position. This is reflected in table 3. As we have already mentioned above, it is however not the case that reduced costs in themselves are sufficient. New requirements from consumers, from idealistic organisations and from the public authorities make it necessary for the aquaculture industry to adapt the way in which it solves its problems. In the event, to mention one quite dramatic example from one scenario, there should be a total prohibition of nutrient salt emissions into the ocean, this will have extremely great repercussions for the fish farming industry and will have a large and direct significance upon which research investments will be meaningful to pursue in the future, also with regard to process development and automation.

Product Innovation

What should take place in the area of process depends of course also to an extremely large extent on what happens in relation to added-value in the industry; what one earns money on in the future. A general theme in the scenario process was that the aquaculture industry must become more market-oriented, more engaged in acquiring and exploiting knowledge about end-users and more proactively involved in relation to the development here. In Market With No Frontiers, Norway will do especially well with red-flesh fish. But for all of the scenarios there is in general little room for doubt about the question of expansion of product range. First of all, everyone is preoccupied about our producing many more farmed species than salmon in the future. Cod and a (varying) number of other species are expected to become commercially viable. Secondly, one has in the scenarios a clear ambition that eventually increasingly more processing will take place in Norway.

All in all, considerations with regard to price-competition driven process rationalisation in terms of salmon are weighed against the opportunity we have to acquire a lead through product innovation.

Tabell 4: Eksempler på forskningsutfordringer knyttet til fremtidig produktinnovasjon

Research Challenge	Theme
New fresh fish product	
	Customise product quality to markets geographically
	Customise product quality to customer groups
	Customise product quality to industrial applications
	Market regional features
	Commercialisation of new species
	Development of fish products e.g. functional food, health research, nutritional research
Quality fresh products	
	Methods for primary processing
	Refrigeration
	Packaging, special gas combinations instead of air
	Alternatives to fresh in sense newly slaughtered
New processed products	
	Methods and technology for automated primary processing
	Aquaculture products as input goods in the food industry
	Product development of products for "global production line": global niche products
	Designer products
	Medicinal, food article and technical products from fish raw materials
	Bio-prospecting
New species	
	Development of methods for primary production (table 3)
Packaging	
	Keeping qualities
	Packaging with special features for retail trade
	Recycling
	With ICT for traceability and information
	New materials; nanotechnology applications
Market	
	Market understanding geographically and industrially
	Standard development
	Brand building processes
	Strategies for market access

Information systems and tracing have already been mentioned and can certainly be characterised both as a product and process innovation. In the scenarios however, a number of other product innovations are addressed that one anticipates will be completely decisive to the future of the aquaculture industry. This pertains to both creating new varieties and qualities of products based on salmon and to creating commercial products on the basis of other species. It is also anticipated that a series of advanced products of a technical and medical nature will be created, based on remains from fillet production and that this both will increase profitability in the industry and make the industry more sustainable in the sense that all raw materials from the fish will eventually come to be commercially exploited.

In table 4 we have listed the examples of research challenges related to product innovation that emerged through the scenario work.

Sustainability

Sustainability in relation to ecological and social fac-

Tabell 5: Eksempler på forskningsutfordringer knyttet til behov for bærekraft

Research Challenge	Theme
Effect of feed	
	Development of customised product qualities
	Feed's effects on fish and interaction with other factors in the farming environment
	Outline characteristics of different feed substances
	The fish's needs during different life phases and under different conditions
	Feed as functional food for fish
	Feed as functional food for humans
Feed substances from new sources	
	By-products from other industrial processes
	Protein from gas
	Vegetable feed-substances, agriculture production
	GMO
	Opportunities in connection with extracting resources from the ocean at a lower level in the food chain
	Purification technology
Feed for new species	
	Nutritional needs
	Fat metabolism
Feed additives	
	Colour
	Medicine
Technology	
	Feed production
	Out-feeding systems for farming installations
	Transport and logistics
Forvaltningskompetanse	
	Ecologically-based administration and monitoring of marine resources
	Harvesting models
	Environmental monitoring
	Integrated administration of wild fish and fish farming industry
	Nature and area-use administration

tors is of a general importance to the aquaculture industry. We have addressed this above in connection with animal welfare issues. In the scenarios from Aquaculture 2020 a conviction that sustainability will acquire extremely great importance for the industry in a number of ways, finds expression. First, climatic factors and possible climate changes are pointed out as one of the overriding factors that can impose wholly vital parameters on the development of the industry. Second, there is a broad consensus that the principles for sustainability will continue to hold force and will gain an increasing significance for consumer behaviour, for governmental behaviour and for the framework conditions that will come to be in effect for the aquaculture industry in the future.

This finds expression in a number of ways in the different scenarios, but common for all is a focus on the following themes:

- Access to feed and administration of feed raw materials
- Application of advanced biotechnology in breeding, process and product development
- Transport systems and logistics
- Administration of marine resources

The issues connected with feed have a special and direct significance to the industry because the access

to adequate feed at reasonable prices can be a serious bottleneck to continued growth in the industry in coming years. The feed problem is complex, because it is connected with the general and global administration of marine resources, because it is dependent upon the interaction between different species in the ecosystem in the ocean and because it depends upon ethical problems connected with administration of protein resources. The feed problem also pertains to a large degree to the technical solutions one decides to employ in genetic technology and to what degree such technical solutions prove to be socially sustainable (politically acceptable) in the long-term.

Table 5 contains examples of central challenges connected with such questions, as these emerged throughout the scenario work.

The Project Group's Summary and Recommendations

A foresight process is a mechanism that generates new ideas about the future. The process has a value of its own in that qualified people meet in a common forum and talk together about the future in a manner that makes it possible to look up and think more in the long-term. It also provides an opportunity to be less constrained by the current situation than one usually is. The competence the participants possess makes the ideas relevant and interesting. Still, a foresight process cannot deliver complete answers. The foresight material provides a basis for reflection and can offer helpful impulses both for the commercial actors in the industry, for governmental actors and for researchers. The primary intention of this document is to communicate as effectively as possible the wealth and abundance of ideas and arguments generated by the foresight process to all involved in the work of forming the future of Norwegian aquaculture.[8]

The project group has followed the process at close range and has in the collaboration with its secretariat (NIFU STEP) and representatives from the project group for foresight work at the Research Council (CREATE) attempted to give it direction and to make it as productive as possible. The process has given the members of the project group a wealth of possibilities to reflect upon the situation of the aquaculture industry for their own part and the group wishes by way of conclusion to pass on some of its own views and evaluations.

The situation of aquaculture today

The modern Norwegian aquaculture industry has thus far been a great success. The commercial investment has to a large degree been carried out outside of and independently of established industries. The aquaculture industry has wished to stand on its own two feet and its representatives have, through active collaboration with research and with the public authorities, achieved a large degree of independence. Outstanding results have been achieved.

The project group "Foresight Aquaculture 2020" is of the opinion that Norwegian aquaculture will also have great possibilities for success in the future. The industry can be an innovative, knowledge-based export industry of great significance to Norwegian society and for the Norwegian economy far into the future. But this will not happen as a matter of course. Only if one invests consciously and long-term and if one effectively tackles the central challenges with which aquaculture will be confronted, will the industry be able to develop in this way.

Norwegian aquaculture has to a large degree developed through crises. Biological, technological and political issues that have arisen along the way have represented great challenges. But most of these have been solved effectively and all have been handled in such a way that the industry has been able to continue its growth. Along with commercial and political measures, also advanced biological research has played a crucial role.

The main challenges that the industry will be faced with in the future need not be essentially different from those challenges confronted earlier. But there is reason to expect the occurrence of a significant displacement, in terms of which challenges are the most central. The project group will in particular emphasise the market challenge and the challenges in relation to ecological and ethical sustainability as especially important hereafter.

Need for cooperative action

Cooperation between industry, research and public authorities is decisive to our being successful in creating a future-oriented aquaculture industry. Advanced research has during critical phases in the history of the aquaculture industry been closely connected with strategies for enterprise development among the companies. Collaboration in constellations, where companies, public authorities and research

[8] At the same time, the report represents a simplification and a systematisation so it becomes difficult to see a lot of the creativity that unfolded throughout the process. It is therefore recommended that interested parties read the complete scenarios and mini-scenario texts found below in this report.

communities take part will also be entirely crucial in the future.

The project group is of the opinion that the "Foresight Aquaculture 2020" process that the Research Council of Norway implemented in 2003 and 2004 is an important initiative that should be carried on. It should be the beginning of a process, not a one-time event. Corresponding dialogue processes should also take place in other contexts and both the government and companies should be involved in these types of "conversations about the future".

One of the goals that a foresight process can contribute to reaching is a "broad coordination" of innovation and research efforts, across disciplines and technological fields. One must in the future manage to exploit technologies and knowledge from other areas than those that have traditionally been applied within aquaculture. The aquaculture industry must be a demanding customer not only in relation to the biological and technological research communities, but also in relation to communities developing new materials and equipment, communities and enterprises that can develop advanced automation and information technology systems for production management, distribution, as well as sales, and in relation to social science communities (who can contribute to the ongoing work of strengthening the industry and contribute to market knowledge that trade and industry depends upon). Investments in research must be followed up with tools that contribute to capitalising on knowledge.

The seeds of such a co-operation can be sown through the manner in which one works in the large-scale programme areas in the Research Council of Norway but significant results can only come about through long-term projects and conscious use of research and development contracts, under private as well as public direction.

Only through active cooperation can the innovation system in the industry function well. And only by the development of strong companies with ties here in this country can this innovation system provide a basis for maintaining a Norwegian industry and a long-term, profitable production of aquaculture products. It is essential that leading actors, those with the greatest will and ability to work strategically and long-term towards forming the future of the industry, have their management functions located in Norway. The project group thinks it probable that a significant Norwegian ownership is a condition for making this possible.

Biotechnology

Modern biotechnology contributes with knowledge and methods that are used in a range of areas within aquaculture, such as breeding, fish health and diagnostics, refining processes and environmental monitoring. In the breeding work, the molecular genetic methods contribute in an increasing degree towards shifting the focus from individual genes to the entire genome (genomics). This contributes to developing methods that are time and labour saving and which make the selection more effective. Methods that make it possible to study thousands of genes simultaneously open for new possibilities to identify genes than can be used in pathogenic studies Molecular biological methods where defined genes/functions in host animals "blaze up" have proven to be effective tools in studies of the significance of individual factors for virulence. In the feed context, biotechnological methods can be used, for example in work with the evaluation of feed-substances and to specially adapt processes for breaking down anti-nutrient substances and modification of nutrients. The use of enzymes opens up new possibilities in the refining industry. The research communities must be stimulated to implement new molecular biological methods and develop "tools" that can contribute to propelling research and innovation forward.

Materials technology – nanotechnology
In the area of materials it is said that a technological revolution is just around the corner. Throughout the world major investments are being made in research on the new possibilities offered through nanotechnology. In brief, nanotechnology is about developing techniques for controlling nature's smallest building blocks, atoms and molecules. Innovations connected with materials are often an important element for innovations in other areas and here the development can contribute to technologies and solutions that can have a large significance for aquaculture's further development. New construction materials based on nano-structures that are much stronger and lighter than today's materials and that also reduce fouling problems can become standard aquaculture constructions. New material combinations can result in lighter packaging, which will simultaneously increase the keeping qualities of the product and reduce environmental problems in connection with transport and distribution. Likewise, simple sensors that can improve traceability of products from the fish farming installations up to the consumer. Further, nanotechnology can provide new types of catalysts to produce proteins based on natural gas for all or parts of the process. Aquaculture must become a demanding customer, both by being an important user of new possibilities and by contributing so that the investment in the area can include themes that are relevant to aquaculture.

Information and communication technology - ICT
The ICT sector is experiencing a furious development and is contributing with new solutions and products that are quickly put to use in all parts of society. Within aquaculture, the development has gone in the direction of use of ICT-based solutions, such as in monitoring and control tools for the production processes in the marine phase, during the transport and distribution phase and as important tools in the work with statistics, monitoring and modelling. Biomass measurements, feed and feeding, feed-loss control, product control, logistic systems and transfer of quality and traceability data are examples of areas using somewhat advanced ICT systems in today's aquaculture. Aquaculture must be involved in the research in this area and contribute to the development including solutions and methods that can be useful for the further development of aquaculture.

Trade & Industry

Norwegian salmon is today exported to more than 100 countries and in large volumes. Nonetheless, the project group thinks that the Norwegian aquaculture industry can only become truly groundbreaking in the future if one succeeds in developing a more advanced market understanding and more differentiated strategies in relation to the market than what we have today. The concentration one has traditionally had on primary production and spot sales by way of middlemen to a foreign purchasing system can be a potential underdevelopment trap.

The investment made to develop other strategies is extremely valuable. But more of us must ask the questions who is going to buy and consume and what will they want to buy in the future. More of the production must be based on methods and products taking as a point of departure the answers one finds to these questions. It is not enough to state that one sells "fresh high quality salmon".
It is necessary to:

- Prepare to develop different products and different qualities for global, dynamic and differentiated markets, preferably in interactive collaboration with the customers.
- Focus on and have an analytical understanding of end-user markets but also an awareness of industrial applications of the products derived from fish farming.

Another market orientation in the industry will involve not only covering an existing demand for aquaculture products by producing as much as possible as inexpensively as possible. A more advanced strategy stipulates that one actively addresses trends in the markets, finds solutions for new requirements and needs that arise and builds the knowledge right into the marketing of the product in the form of smart solutions – "extended products". It is important to understand just what, in reality, is being demanded: i.e. what does the buyer emphasise when they chose to buy aquaculture products. One must not only follow the market. To ensure a high competitiveness in the industry in the long-term, it is also important to play a proactive role in relation to the markets and to take part in shaping their development.

Market orientation presupposes innovation
That greater attention must be directed towards the

market does not mean that there is less of an emphasis on the need for product and process innovation. On the contrary: innovation is a condition for a proactive market management. Innovations that exploit new nano-, bio-, materials and information technological possibilities to produce more effectively and correctly, to provide traceability and to bring about new products will be completely crucial. The point is that technology is not a goal in itself, but a tool for addressing (and hopefully also stimulating) needs and trends in the market.

There is a tradition of thinking efficiency and profitability in the aquaculture industry and the restructuring that has taken place in recent years where the number of small, independent actors has dropped, has to a large degree been mobilised to promote companies' ability to operate lucratively. Unit costs are reduced, while one has at the same time worked at improving delivery proficiency in relation to large customers.

There is a need to move on with process development and it will be vital that actors in the industry, in addition to carrying out short-term measures to reduce costs, also think long-term and invest in more radical development in the future. There is a need to further develop a scientifically grounded process technology. This can be best realised through a coordinated investment in key technological and scientific fields. Radical process innovation of the type required will take a long time to develop and call for considerable resources.

Coordinated research efforts

Leading Norwegian companies today spend large sums on research. Through the Fishery and Aquaculture Research Fund (FHF) the fish farming industry invests an annual NOK 30-40 million in R&D initiatives directed towards aquaculture. This investment is very important and should be further developed. It is however not only a question of the willingness and ability to invest in research. It is equally a question of using funding in the right manner and that the investments are based on a strategic coordination with industry activities.

The companies have a number of things to take into consideration. Investments in long-terms development must be balanced against the possibility to maintain profitable operations also in the short-term. Owners must be patient, without being uncritical of ongoing development activities. The potentially system-altering development of entirely new solutions and new knowledge that research can contribute is a crucial condition for the industry's competitiveness in the long-term. But it is easy to misstep and one can incur large costs when projects do not turn out as expected. If the industry is to succeed in the long-term there is a need for both high level competence among the actors and for their collaboration in expedient fashions. The competition consideration must be balanced against what can be achieved through collaboration.

Wild fish and fish farming

The aquaculture industry can be groundbreaking if it manages to commercialise a large number of new species and operate a differentiated production in such a way that aquaculture and traditional fisheries become complementary and not primarily rival activities. If a large amount of resources are to be invested in bringing about new species for commercial production, it must be on the basis of the opinion that over time it will be possible to develop a sufficient market.

- Will the new products hold their own in the competition, price-wise and quality-wise and in light of the patterns of demand one can anticipate in the future?
- Can the importance of new species change should the wild fish industry and fish farming industry join forces and establish a joint industry that aims at delivery assurance and quality in the large markets?

Regardless, should one manage to develop special fish qualities and to standardise and document the quality of the fish, this will bring about important new possibilities. In general, one can develop the activity around sale of fresh products based on sustainable solutions to get large volumes of fresh seafood out to the end-users in a way that is customer-oriented in relation to quality, safety, delivery competence and price. Packaging, logistics, consumer information and documentable safety through tracing systems are natural parts of this.

Trade and industry cannot solve these tasks alone. The public authorities and publicly financed research communities must play important roles.

The public authorities [9]

The public authorities play many and vital roles in

[9] The representative from the Ministry of Fisheries and Costal Affairs has chosen not to take a stand on the group's recommendations to the authorities. The representative however regards it as both important and correct in terms of process that the group otherwise was free to bring up relevant and constructive recommendations to the government.

relation to the aquaculture industry. The project group will in this context only point out a few key issues of importance.

For Norwegian aquaculture the international market is entirely crucial. The public authorities must take upon themselves as their very first task the ensuring of access to the large markets through trade policy and through the policy that otherwise regulates Norway's relation to its surroundings. It is decisive to ensure effective mechanisms that connect the development of the Norwegian export industry with the development in international markets and the international production activity in the aquaculture sector.

The regulatory system, the administering agency and the policy carried out in terms of the industry have played a vital role in the development of the industry and will also do so in the future. It is important to have an active and engaged business policy and to work with developing an administering agency that serves as a conscious and qualified partner in the innovation system – and accordingly something entirely other than a support system for companies that do not manage to hold their own against the competition.

Make the necessary modifications

While the policy earlier had a primary focus on local and regional distribution of small-scale enterprises, the regulatory system in the future should be based on a more dynamic understanding of how local activities can be maintained. It is important to make the necessary modifications so as to enable companies in the industry to develop, to facilitate their becoming qualified and competitive international actors with the possibility for operations on a larger scale. Investment in production on a larger scale with new technology can provide large benefits and large gains in terms of both company and social economies.

Feed remains a key factor with regard to possibilities for continued profitability and growth in the industry. A considerable investment must be made to ensure access to adequate feed and the feed issue is one central example of an area where there is a need for trade and industry, the public authorities and research communities to cooperate to tackle future challenges. But the public authorities must assume the supra-ordinate role in relation to administration of marine feed-resources and in relation to development of potentially new raw material sources. Here there is also a need for investment from research communities that have not traditionally speaking directed their activities towards the aquaculture industry, such as the oil and gas research communities.

Ethics and sustainability

In general, the public authorities efforts must seriously take into consideration the need to make the industry's activity sustainable, both in an ethical and ecological sense. For the aquaculture industry to become a groundbreaking industry in the long-term, the project group thinks it imperative to take as a point of departure that ethical questions will be of increasing importance in the future. In a welfare society one can expect to receive continually enhanced attention regarding the way in which we treat nature. Should the aquaculture industry for instance have an image of being cruel to fish, this will be a serious problem.

The question of whether aquaculture is reasonable management of natural resources is wholly decisive in relation to evaluating whether an activity is sustainable. If marine organisms that could be suitable for human consumption are under-exploited through use as a source of protein in aquaculture feed, it may be that a continued acceleration of aquaculture is in fact not sustainable. That would be the case if salmon, through industrially produced feed, consumed organisms that could be directly used as first class food for humans.

The more traditional question connected to the two-sided relationship between environmental impact and aquaculture is also central. Aquaculture reaps great benefits from a clean natural environment and requirements must also be imposed so aquaculture does not in significant ways have a negative impact on its surroundings.

Production and innovation

Finally, we repeat that the public authorities must make a serious contribution to making collaboration between different instances of authority, research and industry possible. The basis for a viable and significant aquaculture industry in Norway in the future is that the industry is not just a production system: it must also have access to a strong innovation system. This innovation system can clearly not be limited to Norway but must have solid roots here. We must have some strong Norwegian companies and research communities and Norwegian aquaculture interests must be represented at the level of the public authorities and in the administering agency, whether the relevant executive bodies are in Norway or in the EU.

Research

Biological and technical research has played an important role for aquaculture and it is important to continue with this investment. Research is a demanding activity, in particular research that is closely connected not only to discipline-specific issues but also to possible practical applications of new methods and new knowledge. Researchers need framework conditions that make it possible and interesting both to pursue issues within the disciplines and simultaneously to direct research towards themes and problems that have a practical relevance. It is obvious that the public authorities have a decisive role in relation to defining framework conditions, roles and relations in the innovation system and to make the necessary arrangements to ensure dialog, constructive collaboration and an expedient division of labour. But also the communities themselves and the aquaculture industry companies can contribute to a good future development.

Different roles

In general, the public research efforts must be directed towards solving problems that are vital to companies' being able to solve their problems in a competitive manner. This endeavour must first and foremost be relevant in relation to goals that can serve to set the course for the development of the industry and which can be crucial in the long-term. Research communities and industry must collaborate, complement and exploit one another, but not merge or converge to a type of hybrid enterprise that both operates commercial activities, long-term knowledge development and education simultaneously. In a well-functioning innovation system, the actors play different roles and collaboration has value precisely because the actors are genuinely different.

To carry out research in such a way that it is both relevant for long-term industry development and for the professional development is – as stated above – no simple task. Transversal dialogue and mobility are key mechanisms. Strategies for development must be created through dialogue and through concrete collaboration in goal-oriented developmental investments. "Foresight Aquaculture 2020" is such a step in the right direction that has constituted a forum for dialogue about long-term goals and trends.

International Research Collaboration

The research communities must have framework conditions that make it interesting to address the added-value processes that take place in the aquaculture industry, while they must simultaneously have framework conditions that make it possible to carry out knowledge development and "knowledge documentation" (publication) in ways that are competitive within an international research context. This is also vital if the communities are to be attractive in international R&D collaborations. The latter is of particular importance if Norway wants to be an active partner and mobilising force in the development of a European Research Arena (ERA). Aquaculture is long-term biological production, which means that also research projects will often take a long time. Allocations for research must take this into consideration through long-term stability based on evaluation along the way.

With regard to more specific research priorities, the project group does not wish to go into detailed proposals. This is left to the programme work to be later carried out by the Research Council of Norway.

Correlation with the industry's challenges

In general the project group wants to emphasise that the aquaculture industry's possibility to transcend barriers in the long-term will also depend upon research communities focusing on the challenges connected with ecological and ethical sustainability and with the need for a more differentiated market strategy in the aquaculture industry. The research efforts must have as a point of departure that it will in the long run be meaningful in relation to the industry's work in developing markets and in responding to requirements posed by the market. The investment must, in short, be directed towards making the aquaculture industry competitive when requirements are imposed upon products and processes based on overriding ethical and ecological considerations.

Challenges connected to product innovation are clearly central. Research in connection with product development for global and differentiated markets cannot be carried out by the companies alone, although the companies must obviously play a key role. General knowledge and method development (the basic tool kit) for food articles and food production can be advantageously developed within or in collaboration with public research communities in Norway or abroad.

Coordinated investment

With regard to basic biological and technical knowledge connected to farming of existing and new species, this is an area where distinguishing betwe-

en process and product innovation is not such an easy matter. This is one of the areas where the project group views it as vital that the investment be coordinated – not so competition is ruled out but so one avoids the parallel development of research infrastructure, fragmentation of communities and unnecessary duplicate work.

In any case, general biological process knowledge and process technology are of fundamental importance if one is to have a hope for the aquaculture industry becoming groundbreaking in the future. All requirements imposed, whether these are ecological requirements, ethical requirements or more basal requirements for attractive products at the lowest possible price, can only be met if one manages to develop optimised production processes. Biological research must, together with different types of technical research, contribute to making possible production where economic efficiency does not come at the cost of considerations for the fish's (fish farming organism's) health and welfare, or have a negative impact on the natural environment.

Feed situation

Biological and technical research will play a decisive role not least in relation to questions about access to feed. There is in general a need today for an ecological administration of marine feed resources. But research will also be able to contribute more radically, by ensuring that completely new types of feed raw materials become applicable in aquaculture. One is now, for example, capable of creating a single-cell protein from gas. It will be interesting to find out if this can be exploited commercially in fish farming. Further, it is expedient to look into how vegetable raw materials can be exploited and if products from agriculture can be used in the Norwegian aquaculture industry. Another very central question is how genetic technology can provide new opportunities with regard to exploitation of different feed raw materials.

Interdisciplinary investment

In general there is a great need for information about and analysis of the trends and forces that form the markets and aquaculture activity internationally. Social research has an important role to play, along with the other biological scientific research and the technology development required in the Norwegian aquaculture industry hereafter.

A sensible use of social research can also contribute to creating a basis for the dialogue-based strategy development process that is necessary in order to develop a groundbreaking, future aquaculture industry.

Part 2
Process and Experiences





Photo preceding page from left:
Illustration: Making Waves AM
Edelpix
Pia Kupka Hansen
Gunnar Grytås
Norwegian Seafood Export Council

Point of Departure

The point of departure for Aquaculture 2020 was the ambition to realise another, more open and creative process in the work of planning a new, large-scale research programme. It was about opening the boundary surface between the Research Council and the surroundings in such a way that more legitimacy is created on the part of those effected by the Research Council's prioritising and that one generated more new and exciting ideas in the planning phase. Thinking ahead in a systematic and professional manner, foresight, through effective dialogue between central actors in the field became a key tool for bringing this about.

The use of the scenario form to discuss future possibilities often contributes to strategy work being more creative, inducing greater involvement and yielding more thoroughly considered evaluations. Precisely because one works out alternative future visions not in the form of predictions but as alternative possibilities and threats that one must prepare for, a scenario process contributes to one's being "compelled" to think beyond one-dimensional, linear and virtually "predictable" expectations of what the future can bring. The scenario form is a demanding work form, which poses a number of requirements on the tools and methods involved in the process, on organisation and implementation. This part of the report goes through the most important process measures and points out both experiences and key dilemmas that arose along the way. The goal is for the reader to gain an impression of how we proceeded and that she hopefully can learn something about how such processes can be organised and carried out. The project group (see Foreword) has been responsible for the programme and design of the project.

The main benefit from using foresight in the planning processes is the creative aspect. By inviting a series of resource individuals to think together systematically about future development opportunities one opens up a creative space. Previous planning processes often moved too quickly to the conclusions and did not allow for this type of creativity.

Just as with more conventional planning processes involving, for instance, long and extensive discussion rounds, the foresight process can also involve a lot of work in periods. The advantage of implementing foresight is that one then gets the possibility to construct more consistent and comprehensive input, often within a significantly shorter time period than what is frequently common in more conventional planning processes. At the same time, we have the opportunity to bring out a greater breadth and vitality in the proposals. From experience we know that involvement and dialogic processes demand both time and resources. Foresight processes, where different dialogue-based seminar and conference techniques are implemented, can contribute to improving the efficiency of the boundary surfaces between the Research Council and the surroundings. Instead of many individual meetings, one gathers a large number of persons for 1-2 days and comes away with perspectives that are significantly more unified and comprehensive than if one had arranged a long series of meetings with different actors, whose input must in turn be edited and tailored to a comprehensive context later.

Foresight and dialogue

Foresight is a designation for a set of measures, methods and techniques for the future's "diagnostics". We find the most frequently applied definition of foresight in the FOREN-network's manual for regional foresight in EU, (FOREN 2003).
Here it states:

Foresight is a systematic, participatory, future intelligence gathering and medium-to-long-term vision building process aimed at present-day decisions and mobilizing joint actions.

The foresight tradition has at its disposal a range of tools and methods. The most central of these are scenarios, Delphi studies, expert and layman panels, relevance trees and dialogue-based techniques (Øverland 2003). The combination of foresight and dialogue is clearly something that is becoming more and more common and in terms of method, it is the dialogue-based future method that characterises the Research Council's investment. To many outsiders, both "the future" and "the dialogue" are things "everyone" masters and the conception that process knowledge is not knowledge equivalent to other knowledge such as technical knowledge remains widespread. Now the world is not so simple! Process knowledge is a knowledge industry in its own right. This also to a large extent applies to knowledge about how to achieve creative future conversations and good dialogues. On the dialogue side, we find in Norway a long tradition for application and development of different dialogue-based techniques in so-called action research, preferably as represented by the National Labour Research Institute in Oslo, parts of SINTEF (IFIM) and Rogaland Research. Central persons in the project group have a background from

one or more of these institutions and brought this type of thinking into the process. In particular, tools such as search and dialogue conferences (Eikeland, 1992; Pålshaugen, 1993; Engelstad, 1990; Quale, 1990) have been sources of inspiration here.

On the scenario and foresight side we have been inspired by former works in the EU Commission (so-called shaping actors, shaping factors see Neumann & Øverland 2001; Ringland 2000), Michel Godet (2001), the government's scenario project Norway 2030 and what is called perspectivist scenario building (see Øverland, ed. 2000; Øverland, 2001; Neumann&Øverland 2004). Here one has further developed the foresight thinking so that it can be positioned in relation to the ongoing emergence of so-called post-positivist scientific theory and method. In addition, one has developed a unique position within the foresight tradition, which emphasises the distinction between the scenario future discourse and the subsequent/parallel strategic discourses. The philosophy is in short that there are different ways of talking to one another when we a) discuss what CAN happen (scenario/foresight mode) and when we b) discuss what we WANT and BELIEVE will happen (strategic prioritising mode). In addition, perspectivist scenario building (Neumann&Øverland op. cit.) points out the significance of emphasising different points of view or perspectives in the different scenarios.

The scenarios in "Aquaculture 2020" vary thus also between different main perspectives (market, feed, sustainability, education and research system, policy). Although the scenarios are to address themes and situations that appear in all the scenarios, they can vary in the angle they take on these factors.

Scenario methodology is one of the most central tools within foresight and as you have already noticed we at "Aquaculture 2020" have chosen to use scenario methodology (see Øverland 2003; Kees van der Heijden, 1996). The gatherings were set up according to scenario methodological criteria and criteria for good dialogues.

A brief history of foresight

Foresight and dialogue, or systematic future-oriented discussion with central actors within a professional field, industry or sector, represents a long, international tradition. Particularly over the past 40-50 years this method has been used in a range of different contexts, from military problems with industrial challenges to society's well being. In recent years, and particularly in Europe, foresight has been connected with research and innovation policy and with planning of large research endeavours (Salo 2003). Countries such as Finland, Germany, the Netherlands, Great Britain and Spain, to name just a few, have implemented this method. The future programme (www.futur.de) under the direction of the German Ministry of Research and Education has scenarios, Delphi studies (extensive surveys) and other foresight tools as part of their activities. The objective of these activities is to continuously develop good prioritising of future research themes and areas. The EU is underway with the establishment of an arena for future-orientation within ERA-Net (The European Research Area). In addition, the EU is using such tools in both policy development and in preparation of the 7th Framework Programme for Research.

When we implement this tool in our own planning, it is because we want new perspectives on what we should conduct research on in the upcoming period. At the same time, we want to develop a more robust boundary surface between the Research Council and its surroundings. What could be better than taking part in dialogues about future possibilities and limitations about what can take place and to subsequently look at what we should prioritise in the long view? To avoid the classical positioning discussions that are so common in such contexts, we have accordingly invited people from the industry, researchers and other resource persons to discuss what can take place in the aquaculture sector in the next 15-20 years, to subsequently bring to light important, necessary and dynamic priorities.

Organisation, roles and assignments

A total of some 70 persons took part in the different gatherings. A project group was established, made up of five resource persons from outside of the Research Council and three persons from the Research Council. Two of these were the Research Council's experts on marine research while one contributed with expertise within foresight, scenario building and dialogue methodology. The project manager for the Research Council's CREATE-initiative also took part throughout more or less the entire process. In addition, two persons were hired in from NIFU STEP to take care of some of the writing and the ongoing documentation work. These were contracted on the basis of their professional expertise in the field. The professional expertise was the criteria and not any knowledge they might have had about foresight and scenario building, as such. NIFU

STEP's role was also to contribute to analyses of the developed material along the way.

Within the project group there was a clear division of tasks. NIFU STEP was responsible for the ongoing secretariat work and proposals for analyses of material. The CREATE person was responsible for the design of the process, in other words to provide input which the project group then discussed and developed jointly. Those from the Research Council who were not part of CREATE had the ongoing project manager responsibility and responsibility for grounding the process internally at the Research Council. The Research Council employees (sometimes with assistance from other colleagues) and persons from NIFU STEP also functioned as group secretaries at the gatherings. The external members were group leaders and they led the group work at all of the gatherings. The groups varied somewhat from gathering to gathering. The project group had a collective responsibility for preparing the gathering in terms of practical details and methodology. No two such processes are exactly the same. The scope, design and choice of measures/tools are to a large degree dependent upon theme, timeframe, type of participants and the type of end product one envisions.

There is an important distinction between a so-called scenario-oriented time perspective of 15-20 years on the one hand and a strategic perspective of 2-4 years on the other. The long-term perspectives shall have a stimulating effect on the decisions made here and now about research prioritising and initiatives carried out in the next 2-4 years. As such there is no contradiction between the long-term and the more short-term.

Expert group or broad future-oriented dialogue?

The project group was early on aware of how important it was both to develop the professional insight and ensure a broad dialogue. The challenge was to bring out interesting and qualified perspectives, at the same time as one involved a large number of actors and criteria for a good dialogue. This was especially a challenge at the gatherings themselves, at which between 50 and 70 participants were to come to an agreement on some selected perspectives to continue working with. This was a challenge regardless of whether one worked with scenario constructions or with initiatives and prioritising. Regardless the conclusion was that it could not be a matter of either/or between expertise and broad participation, but rather all of the above.

Within the international foresight tradition a continuous dialogue takes place about the challenges and dilemmas connected with how to apply, understand and evaluate the results from the foresight processes. This discourse also has great relevance for the work of "Aquaculture 2020". A central dimension here is as we saw above the relation between experts and other actors. Variation in expectations for the outcome is also a theme in this sense. Are we first and foremost interested in content or are the dialogue, the arena and the process also crucial? In our case, the question of how foresight perspectives shall be made operational and effective in relation to the choices one is faced with today, in other words, made relevant to the daily work of implementation and development of an Aquaculture Programme, had a prominent position!

All of this leads up to a number of central process-related problems, which we in one way or another addressed underway during the process. Some of these were:

- What should the criteria be for participation?
- Who should be invited at which phase of the project?
- What do we want from the process? Scenarios? Strategies? Process competence?
- What should the relation be between creative brainstorming and analytical problem solving?
- When in the process shall one dare to think the original thoughts and be open for the big surprises?
- When should the vision and perspectives be given "a dose of reality" with an eye towards bringing about what we want to have happen, accordingly the chiselling out of strategic recommendations and prioritising?
- What type of dialogue shall we invite the participants to?

Role of the project group

The project group discussed and took a stand on all of these questions. There was early on agreement about dialogue and learning being central dimensions of the process. Such an ambition involves of course a commitment and made participation in the project group something much more, both more interesting and more demanding than ordinary participation in a standard investigative committee. One could have prepared for a process where an external facilitator came and stated in detail what one should do at all times and where the participants, including those in the project group respon-

sible for the process, could lean back and arrive at a set table.

Such a programme is inconsistent with first and foremost two things. First, all learning, also process learning must involve a somewhat intense experience of "finding oneself in deep water", where one now and then hits one's head against the wall in pure despair. Learning without resistance is poor learning. Secondly, the term "dialogue" should also include dialogue about process-related means and methods, not only thematic. The arena for the process-related dialogue was first and foremost the project group. This applied to both the entire project group and the smaller internal work group made up of the Research Council's representatives and 1-2 participants from NIUFU STEP who met somewhat more frequently. It was in the project group's discussions that we found the answers to the questions above and to the process-related challenges that arose along the way.

The Group Leader and Secretary Function

Particularly challenging were the group leader role and the secretary function in the group work at the gatherings. Most had no previous experience with such processes, something which for some caused a large amount of uncertainty. One of the reasons for this was the group's experience of the process' openness, not just in terms of results, but also in terms of process and that it was an experience whereby the path to be followed appeared only upon each step, without clearly defined goals. The group leaders handled this in a very constructive and creative if divergent manner, where some were obviously more at ease in their role than others. For many reasons it is neither desirable nor possible to establish teams with experienced foresight people to take on such roles. Purely in terms of resources it is difficult and one must also ask oneself if it is even expedient. In order to avoiding repeating processes and the content perspectives being infinitely repeated, it is a clear advantage and almost a condition that those who play a central role in the implementation are people with a special competence in the field and with a strong grounding and legitimacy. This grounding and legitimacy is more important than having to take a round or two regarding how one shall do things. The dialogue and the learning mean involvement of central actors from the field in which one is operating. It is also an open question whether it is possible to prepare such group work in ways that will safeguard you from all eventualities. The experiences from the Aquaculture process speak against this. Even on those occasions when we went through the group leader role and designed a tentative programme for the group work in advance, it turned out that the individual group leaders quickly found their own way of doing things in other words, a way that worked for them. If one had had an experienced foresight team, there is a lot that speaks for the situation not having been very different. A good foresight process should, in other words, involve the project owners/representatives in an intimate and thorough manner in order to arrive at maximum learning and engagement.

With regard to the group secretary function, two things were decisive. One was that the person in question should have the ability to formulate things with a basis in the discussions, discussions that could proceed quickly and be somewhat complex. The other was that the secretary had some knowledge of the marine field and of the aquaculture industry in particular. The latter was however not a must in that insufficient knowledge here was compensated for through close collaboration between the secretary and the group leader who comes from the industry. We saw this especially during gathering 3 and in the scenario construction subsequent to this.

Secretariat function

Two persons from NIFU STEP took part as the project secretaries. Their role was first and foremost to document the results of the process, including the discussions in the project groups and the ideas, thoughts and perspectives of the participants in the gatherings. The secretary role also to a great extent included an analytical and problem-identifying perspective. The discussions in the project group/secretariat moved at all times back and forth between the concern over having included all aspects, whether these were sufficiently relevant to research, etc. and how open and inviting one should be. This is of course a fine balance and an analytical and investigative attitude progressed considerably further in wishing to create guidelines for the discussions in the gatherings in advance. In particular between the third and fourth gatherings we had a lengthy discussion on the designing of the group tasks. Some went so far as wanting to prescribe for the different groups which scenarios they should develop and went quite far in defining frameworks, themes, main perspectives and tentative headings for each of the different scenarios. There was however due resistance to this, without one daring to fully relinquish all definitions to the groups themselves (see Group Tasks gathering 3, below). The result was a small but creative compro-

mise. In a survey regarding why certain foresight processes were successful and others not, done by the scenario specialist Kees van der Heijden (1996) he comes to a crystal clear conclusion: the main reason why some foresight and scenario processes were, relatively speaking, highly successful lies first and foremost in managing to refrain from succumbing to the temptation to supply too many thematic guidelines before the workshops. It would appear as if Willy Brandt's famous words "wir müssen mehr Demokratie wagen" also apply to scenario processes. After the fact it is clear that we were wise not to decide too much in advance but rather to relinquish the arena to the participants themselves. This can make for a lot of follow-up work, but it is significantly smarter to carry out the analysis after the fact rather than before such processes!

What criteria for participation did we have and what type of dialogues did we invite the participants to take part in?

The main criteria for participation were persons with some type of connection to the aquaculture industry or from communities expected to have significance for the development of the industry in the long-term. We placed a great emphasis on finding persons who could not be said to be part of "the congregation" in the field. We also made it a point to include persons from the entire value chain. Persons from environmental organisations, marketing communities and the finance sector were also invited. All were invited on a personal basis. The condition was that none represented anything but themselves and their own experience, wealth of perspectives and knowledge at the point in time at which the gatherings were to take place.

The dialogues shall be both future-oriented and creative. In order to achieve this, we developed a kind of foresight philosophy that is in accordance with general principles within foresight thought. We can summarise these briefly under the heading "the art of thinking ahead":

- Future-oriented discussions are fun! (In other words, it is up to us!)
- Nothing is too stupid or too improbable (childishness is allowed!)
- Let others' contributions instigate new thoughts in you – and present them!
- Do not discuss what is right or wrong.
- It is better to get off track than to get stuck in a rut.
- Nobody is an expert on the future! ("The expert" that is you!)

These points were to remind us of the first commandment of every scenario, namely that the future cannot be "identified" through traditional methods and techniques, such as prognoses and extrapolations. At the same time, it indicates how important it is to focus on the abundance and allow for somewhat "crazy" whims so as to avoid falling into the dreariness of probability conservatism.

Who was invited and to which phases of the project?

We were very conscious about focusing on the aspect of industry in the first gathering. The experience of the aquaculture industry and research planning in this sector was that the researchers appeared to dominate the discussions and the arena. Without explaining the reasons for this something which is clearly related to level of education, time-flexibility and the general conjuncture situation of the industry we agreed not to invite the researchers to the first gathering, as a means of counteracting precisely this tendency. The researchers who were present were however those who were already a part of the project group and the project secretariat. In the second gathering we increased the participants by approximately 20-30, of which many came from the research community. The list of participants is found in one of the appendixes at the end of the report.

The relation between creative brainstorming and analytical problem solving

Every single scenario-based strategy or planning work process must find a balance between the creative phase, where new ideas and surprising perspectives can be expressed and the phase where one poses the question of where one actually wants to go and what we now finally should go with. When in the process shall one dare to think the original thoughts and be open to the big surprises? When should the vision and the perspectives be subjected to "a dose of reality" with an eye towards making happen what we WANT to have happen, accordingly, the chiselling out of strategic recommendations and priorities?

These two central questions were in "Aquaculture 2020" connected to the different phases of the project. Although we had a discursive and analytical approach throughout, it was in the beginning important that this approach not become too dominant in relation to the need to bring out the creative and unconventional ideas.

"Aquaculture 2020" was made up of four gatherings in all, with some work before and after the gatherings.

Table 1: The main elements in the process

Gathering	Date	Participants	Goal	Work Form	Result	Follow-up work
1	Nov. 27, 2003	Approx. 20	To discuss which factors and actors will shape the aquaculture industry throughout the next 20 years.	Group work and plenary discussion.	5 pairs of unsystematic lists of factors and actors.	Combination, arrangement and grouping into two lists of 7 main factors and 7 main categories of actors.
2	Jan. 21-22, 2004	Approx. 60	Develop ideas about what will happen and how each of the actors and factors will influence the development of the next 20 years.	Work in 7 groups of 7-8 persons, each works with 2 pairs of actors and factors and creates at least 5 mini-scenarios for each.	Approximately 150 mini-scenarios.	Rewriting and completion of the mini-scenarios, development of a mini-scenario matrix.
3	March 16, 2004	Approx. 40	Construct scenarios on the basis of the 150 mini-scenarios.	Work in 5 groups. Each gives a description of the situation in the industry in 2020, and creates a credible story about the development up to 2020.	5 different scenario documents describing 5 different problem situations that have been resolved and where the industry in 2020 despite difficulties is able to function well.	Rewriting and completion of the scenario texts.
4	April 22, 2004	Approx. 30	Develop recommendations and proposals for research topics and make recommendations for which measures the authorities and industry actors should implement.	Work in 3 groups.	3 different documents with proposals and recommendations	Rewriting of one document containing the work results of all of the groups. Development of a comprehensive summary report.

Gathering 1 November 27, 2003
Gathering 2 January 21-22, 2004
Gathering 3 March 16, 2004
Gathering 4 April 22, 2004

The main elements of the process are summarised in the table on the next page.

The participants were invited to take part in all four gatherings, where the gatherings should build successively upon each other. We emphasised the importance of maintaining continuity from gathering to gathering and that the participants should be present throughout. The first three gatherings were dedicated to foresight work, in other words, to different stages of scenario construction while the last went a step further and developed points of view on strategic recommendations for future research priorities. Here we moved across the scenarios and used scenario perspectives for what they were worth in terms of coming up with unconventional, meaningful, new and interesting research themes and areas. The result of this is a central part of this report (cf. Part I).

These gatherings have been arenas for dialogue and reflection about challenges and opportunities facing the aquaculture industry. That the results were carried on from gathering to gathering contributed to the learning process being cumulative to the greatest possible extent. It was the project group's task to design the programme for each gathering, work on and develop the material from the gatherings before the next gathering and to organise the

practical process. The members of the project group functioned as group leaders and secretaries in the gatherings themselves, in accordance with the descriptions above.

Start-up memorandum

Before we started with the first gathering we developed a start-up memorandum to create a kind of kick-off and some food for thought before the process. It was important that this memorandum did not have a format that "told" the participants what is important and what one should focus upon. Instead of trying to provide a diagnosis of the situation today, we sought to bring out professional dilemmas, paradoxes in the field and any disagreements between different actors in terms of what the challenges are now and the trends to which we are exposed.

The start-up memorandum, or the paradox memorandum as it was also called, is found in one of the appendixes at the end of the report.

Gathering 1

- Dialogue about trends, influences and agents of change (factors&actors)

Radisson SAS Airport Hotel, Gardermoen. 27.11.2003 10 AM – 4 PM.

Programme

10:00 – 10:30 AM	Welcome. Presentation of the work with large-scale aquaculture programme at the Research Council. Lars Horn, Research Council of Norway
10:30 – 11:00	Presentation of the foresight methodology and plan for work ahead with Foresight Aquaculture. Erik F. Øverland, Research Council of Norway
11:00 – 12:30	Group meeting with coffee
12:30 – 1 30	PM Lunch
1:30 – 2:30	Presentation of group works in plenary assembly
2:30 – 2:50	Coffee break
2:50 – 4:00	Plenary discussion. Compiling of the results from the group work.

The themes we discussed at this gathering were first and foremost which factors, trends, and developmental features influence us today and will do so in the future, in other words, so-called factors, and which actors can be perceived as being able to influence the aquaculture industry in the years ahead. More traditional scenario processes and particularly extrapolation and prognoses have an ugly tendency to under-communicate the possibilities one has to influence future development. One has too great a focus on external factors, trends and other influences that "wash over us" so to speak. It is therefore important that also the actors whose decisions and choices can have a great significance for the future of the industry are explicitly addressed in the process. This is something of the main idea behind the so-called "shaping actors – shaping factors" perspective of Cellule de prospective of the EU Commission (Bertrand&Pench, 1996), which this project is also inspired by.

The assignment that was discussed was broken down into two parts and both questions were answered by all of the groups.

1. Which factors can influence the aquaculture industry over the next 20 years? Make a list of the factors you think can have a great significance. Give a reason for why you think this is important (bullet points).

2. Which actors (decision-makers, institutions, companies, instances of authority, etc.) can be perceived as influencing the development of the aquaculture industry up to 2020? This need not be actual actors of today but also possible future actors who it is presumed will have a great importance in the time ahead. Make a list of the most important actors and give a reason for why.

The experiences from gathering 1

The discussions were both engaged and lively. The main impression is nonetheless that one did not fully "take off" in terms of unconventionality and imagination with the themes discussed. This was not such a surprise in that we in this gathering discussed factors and actors today and in the future and did not address the scenario construction itself. One assessment one should make is whether one needs an entire gathering/day to discuss such factors and actors. One possibility for the future is to connect these directly with the development of the mini-scenarios (cf. Gathering 2).

Gathering 2

– Development of mini-scenarios

Radisson SAS Airport Hotel, Gardermoen.
21-22.01.2004

Day 1 Programme

3:00 – 4:00 PM	Welcome. Orientation about Foresight Aquaculture and gathering 2.
4:00 – 5:30	Group work. Factors and actors updating of existing materials.
5:30 – 6:00	Break
6:00 – 6.15	Introduction to group work with mini-scenarios
6:15 – 7:30	Group work - mini-scenarios
8:00	Dinner

Day 2 Programme

8:30 – 9:00 AM	Experiences from day 1
9:00 – 12:00	Group work mini-scenarios
12:00 – 1:00 PM	Lunch
1:00 – 3:00	Group work – mini-scenarios
3:00 – 4:00	Wind-up. Summary. Experiences. Further work.

Here so-called mini-scenarios were developed for the respective actors and factors. Mini-scenarios are texts of about 1/3-1/2 a page and treat specifically an actor's or a factor's possible future. All of the seven factors and seven actors from the first gathering were subject to mini-scenario development. We chose to give the groups two actors and factors on the basis of which up to five mini-scenarios were developed. The point of this exercise is first of all to arrive at a broad span in the range of ideas and to challenge the participants to think of an abundance of future possibilities. Psychologically (and also methodologically speaking as it were) one always has a tendency to make the future one-dimensional. There is one most probable future. The logic here however departs from this and encourages and virtually "compels" the participants to exit from their mental boxes and mobilise several possible developments for one and the same phenomenon. Choosing five such developmental tracks further contributes to creativity and imagination development. The work was based on the perspectives that were discussed in the former gathering and in the introductory group work of gathering 2, where we had repeated some of what we did in gathering 1. For each of the actors and factors a set of mini-scenarios were developed that in the next gathering were used in the construction of the five scenarios for the future Aquaculture industry.

The assignment text read as follows:

1. The group shall produce a minimum of 5 mini-scenarios about how the situation will be in 2020 for the assigned actors and factors (cf. table above). Use the standard from the examples reviewed. The mini-scenarios should be respectively different and each should have a consistent/coherent structure. Give each of the mini-scenarios a descriptive heading. The group reporter writes a text of approximately a 1/3-1/2 page for each mini-scenario on a computer (cf. distributed document). 1-2 sentences from each of the mini-scenarios are written down in a flip-over format with a view towards later plenary presentation.

Experiences from gathering 2

The experiences from this gathering were very positive. There was a very energetic pulse in the discussions and people more or less reached the goals of the gathering in formulating the texts for the mini-scenarios. The imaginativeness and creativity here emerged in full force. Immediately after the gathering we had a wealth of material that could serve as an extensive idea-bank for the remainder of the process. We also learned how expedient it was to use a PC with a live-feed video projector in the group work itself. This enabled the entire group to be able to see at all times what was written and one could discuss specific formulations of the respective mini-scenarios. Those we had invited, in addition to those who had taken part in gathering 1, also expressed a strong wish to take part in the rest of the process, something which we regarded then and there as positive.

Gathering 3

– Scenario construction

Radisson SAS Airport Hotel, Oslo.
16.03.2004 10 AM – 4 PM.

Programme

10:00 – 10: 20 AM	Welcome. Presentation of four scenario sketches for the Aquaculture Industry in 2020. Lars Horn, Research Council of Norway
10:20 – 10:30	Introduction to the first group assignment. Erik F. Øverland, Research Council of Norway
10:30 – 12:30	Group work I Situation scenarios (with coffee)
12:30 – 1.30 PM	Lunch
1:30– 3:30	Group work II Developmental Scenarios
3:30 – 4:00	Plenary discussion. Compiling of the results from the group work.

Here we first described the situation of Norwegian aquaculture in 2020. We called these situation scenarios. We assumed that we have a thriving industry at this time but that it faces and has faced some significant challenges. Based on the discussion about factors (gathering 1), the project group came up with five main perspectives for scenario constructions. This was to ensure a broad range of themes and differences between scenarios. We also asked the groups to take as a point of departure a specific challenge (significant difficulty) related to these main perspectives, cf. main perspectives and challenges on the following page.

The work was started by going through the mini-scenarios, where one attempted for each actor and each factor to produce one or more mini-scenarios that fit with the scenario constructed.

How does the aquaculture industry look? What are the special features of the industry in this scenario? In addition to these main questions, there was a focus on the following questions:

1. What products are produced and who buys the products?
2. Where does production take place, where are the markets located and how does transport occur?
3. What kinds of companies are important in the aquaculture industry in Norway and what do they do?
4. How important are new farmed species?
5. What is the role of the government (or supra-national authorities) in the industry and how is the industry regulated?
6. What role does foreign ownership play in Norway and Norwegian ownership abroad?
7. Who develops new knowledge, where does knowledge development take place?
8. Is there a lot of openness around key knowledge or is the core knowledge privatised and protected by patents, etc.?
9. Are genetically modified organisms (GMO) important for the industry? If yes, in what way?
10. Are there trade restrictions that are of significance to the aquaculture industry?
11. ...and other questions that the group thinks are central!

The group itself found a name for the scenario they constructed. We were also careful about emphasising that the mini-scenarios were to be an aid and that they should not be a straightjacket. The groups were encouraged to cut and paste from the mini-scenarios and bring in new perspectives if they wished.

Main Perspectives and Challenges

Main perspective: Market

Challenge: New species
In the international fish farming and aquaculture industry species other than salmon and trout dominate in 2020. Fish from warmer latitudes that eat vegetable feed provide good, healthy and popular products. This production can be carried out in large volumes and at low unit costs. The production takes place relatively close to large consumer markets.

Nonetheless, the Norwegian fish farming industry thrives in 2020.

Main perspective: Feed – resources

Challenge: Lack of marine feed
In international fish farming and aquaculture activity the lack of marine feed is a serious bottleneck in the entire period up to 2020. It turns out to be impossible to maintain a sufficient level of wild catch of marine species despite efforts to harvest krill and establish capture of other species at a lower trophic level. The feed manufacturers can thus only produce conventional feed at a very high cost. Products based on such feed are not good quality.

Nonetheless, the Norwegian fish farming industry thrives in 2020.

Main perspective: Competence development

Challenge: Society rejects use of genetically modified organisms
Limited access to marine feed raw materials makes it interesting to use genetic technology to develop variants of bred species that can eat other feed. At the same time, genetic technology can be used to develop raw materials other than marine for feed. The research investment is goal-oriented and comes up with good solutions. However, the opinion is unilaterally negative regarding use of genetically modified organisms in feed and it turns out that there is not sufficient demand for products based on modified genetic materials.

Nonetheless, the Norwegian fish farming industry thrives in 2020.

Main perspective: Sustainable development

Challenge: Climatic and environmental problems change Norway's nature-given conditions for aquaculture.
Considerable climatic changes take place in the period up to 2020. Environmental pollution increases while at the same time increasingly more stringent requirements are imposed for clean and safe food, both on the part of the public authorities and the consumers. Considerable incidences of heavy metals, radioactive materials and other toxic substances in 2020 make for serious problems for fish farming along the Norwegian coast.

Nonetheless, the Norwegian fish farming industry thrives in 2020.

Main Perspective: Policy

Challenge: Liberalisation and industry-neutral policy
The leading research and industry policy in Europe and in Norway is run according to the principle that public authorities must have a distanced and as neutral a role as possible as a regulator and controller of research and industry activities.

Nonetheless, the Norwegian fish farming industry thrives in 2020.

Experiences from gathering 3

Before gathering three we developed a set of guidelines for the procedure of the group work with a particular focus on the roles of the group leader and the secretary. This procedure is described in the following:

Guidelines for scenario construction

– Some basic steps in the group leader/group secretary's work

The list of actors and factors created in gathering 1, the mini-scenario gathering and the mini-scenario matrix comprise the basis for the scenario building. This will be distributed to /sent out to participants in/before the meeting. The group problems will be distributed at the meeting.

A visualisation of what the group assignment consists of can take as a point of departure the mini-scenario matrix. (See illustration below.) The point is to connect one or more squares (mini-scenarios) in each column (for each factor and actor type) with an adjoining and plausible story. We are not looking to create the most probable scenario but they are to be unconventional: by this we mean that they shall:

– Be thought-provoking
– Be logically consistent
– Contain an element of surprise

Group work

The point of departure that is outlined in the group assignment is expressed through two/three mini-scenarios (in group 1 this is the market + one elective "crisis" from another factor/actor). It is important to explain this with the ambition of creating different scenarios and that one shall address at least two types of problems/crises/challenges. An example of such a starting point is marked off in the matrix (the mini-scenario space with a thick frame/ orange colour). Each group is free to choose their starting point, but will also receive a proposal for a starting point.

The groups in other words take as a point of departure either the text proposed or another that they develop themselves and elaborate on this. When the first starting point has been determined, we move on to the mini-scenarios/matrix to find suitable mini-scenarios that will fit with the chosen scenario starting point. In the table below the mini-scenarios chosen are marked in blue.

Mini-scenario matrix	F1	F2	F3	F4	F5	F6	F7	A1	A2	A3	A4	A5	osv
Mini-scenario matrix													

The groups otherwise have complete freedom to create new mini-scenarios or change the existing mini-scenarios (by re-writing, cutting-and-pasting a cross-section of mini-scenarios or editing in another fashion). We will work with the situation scenario until we achieve a more or less consistent picture of the situation in 2020 (but for no longer than 1.5-2 hours or corresponding with what we have specified for group work 1). In group work 2 it is important to elucidate the strategic choices made, who has made these and the repercussions these have had for the development of the individual scenarios. Here it is good to work according to the questions. Try to be concrete, in other words, use statements such as "in 2008 the Ministry of Fisheries, the Ministry of Agriculture and the Ministry of Trade and Industry were merged. This led to a new way of thinking about innovation policy measures in terms of former primary industries, fishing, aquaculture, agriculture, etc. that are unprecedented in recent times...first...secondly,...etc."

Summarised:
Assignment One (situation 2020)

- With a point of departure in the perspective chosen by the group, such as new species become increasingly more dominant, the group goes through the matrix of mini-scenarios and the mini-scenarios for each factor and actor that are relevant to the group's future perspective is marked off. In purely practical terms this is done by displaying the mini-scenario matrix on the overhead and marking off choices as the group discusses. This part of the work takes about 30 minutes.

- The group now starts the task of constructing the main features of the situation in 2020. Start by finding out which products dominate the market for Norwegian aquaculture and what the most important markets are – who are the buyers? The next element is what kind of companies are important in the industry. Then fill in the entire picture and use the questions in problem 1 in this work (about 90 minutes – the secretary will then have an element description). The questions are important clues and also signal the themes we want the group to address. They are of course not exhaustive.

- Write an introductory paragraph – what is the scenario about (see the outline – written as a group, about 30 minutes). The point is to clarify the scenario (the secretary has an introductory text about a page long). Give the scenario a heading that can incite interest and attention and/or hook the reader.

Assignment Two – Development up to 2020

- Here comes the story about (elective text)...use elements from the mini-scenarios for inspiration. There are to be drafts (secretary) of what different actors have done along the way (about 90 minutes).
- Create an analysis or diagnosis of why what happened, happened main elements (about 30 minutes).
- Take an explicit point of departure in the questions of assignment 2 the research, the industry and the public authorities adapt the development story in relation to these questions (about 60 minutes).

After 3rd gathering: Group leader and secretary are responsible for writing the scenario. Possibly in collaboration with 1-2 group members. The scenario is sent to the rest of the group for a brief period for comments.

The primary tasks of the group leader:

- Structure the work in relation to the group assignments and outline for the scenarios
- Watch the time
- Stimulate the dialogue
- Ensure that everyone is heard
- Maintain an analytical stance – it is important to give reasons

The task of the group secretary in the gathering is to:

- Assist the group leader
- Write down the main elements

It however turned out that in spite of the extensive planning of the group work and review of the functions that the group leaders chose different ways to carry out the work. The secretaries now worked primarily with a pc connected to a screen but the depth of the texts also varied somewhat. The challenge is to produce text sequences there and then that exceed merely copying the different relevant mini-scenarios. The goal is for the scenarios to serve as consistent and comprehensive texts. It was also pointed out that too little time was spent on the developmental scenarios. Although one will always run out of time in such processes, this is an important lesson to take along. In that it is in the development strategies that the strategic choices and consequences of these can be made visible, it is also important to provide sufficient time to think this through in an expedient manner. Now the development tracks, in other words, the development from today up to 2020, were a central part of the discussions throughout, also during the discussion of the situation scenarios. It is however nonetheless important to have the time to address this point explicitly and in a thorough manner.

Gathering 4

- Strategic recommendations and measures

Radisson SAS Airport Hotel, Gardermoen.
22.04.2004 9:30 – 17:00

Programme

09:30 – 10:00 AM	Welcome and introduction of the day's group work.
10:00 – 1:30 PM	Group work
1:30 – 2:30	Lunch for all participants
2:30 – 4:30	Group work
4:30 – 5:00	Summary and brief presentation of two examples from the day's work from each group.
	Winding up.

Here we discussed what possibilities and challenges we can see outlined in the scenarios. Which of these can be solved by R&D measures, what kind of R&D measures would this then involve and who/what are the influences behind / causes of this?

Experiences from gathering 4

Here we worked with a cross-section of the scenarios and looked for interesting research topics, input to what the public authorities should do and which responsibility the industry itself had. This worked reasonably well, although many had the feeling of not having "caught everything" or that there were things of importance that were not included. This feeling of not having "caught everything" is in terms of process psychology a feeling that is difficult to avoid. On the one hand this is a good sign, in that it attests to both engagement and thorough consideration of the relevant issues and problems. On the other hand, this feeling should not be the dominant feeling in that it also reflects a situation where essential perspectives are in fact missing.

Summing up of Experiences

Through the foresight process in aquaculture we feel that we have achieved a relatively acceptable consensus regarding important perspectives and priorities. Everyone involved has experienced the process as both stimulating and very exciting. It has also been in part very strenuous. Some of this must be due to the fact that "Aquaculture 2020" is the first foresight project the Research Council of Norway has been responsible for directing, so there are good opportunities for making more efficient parts of the process when foresight is to be carried out in other areas. In addition, it is quite clear that most of the participants have experienced the process as both positive and interesting. A seminar exercise, carried out by three students from the Institute of Business Administration who also took part in large portions of the process, documents in a good way the participants' views on the process contents and form (Project Assignment in Master of Management Programme/Scenario learning 2003/2004 MAN 21271).

More than 90% of the participants found the process to be extremely interesting and more than 60% were also of the opinion that the project was important for the aquaculture industry's future. It also turned out that the group leader function is very important and an even greater focus on/review of the group leader role before the scenario processes was recommended. The importance of having good group secretaries who used tools making what they write accessible to the group in the course of the discussion was also pointed out. This was however followed up to a large extent, in that the group secretaries for longer segments of the process used laptop computers connected to a live-feed video projector. In this way the entire group could follow what was written and comment upon this "online". Although the study was carried out before the project was concluded, it provides an extremely good report of the atmosphere and a good picture of how people experienced the process. Such attitudes have now also found expression later in the process, most recently now in the work with completing the final report.

An open virtual process was also carried out along the way, where all those who wished could take part with input over the Internet. This contributed mostly to comments of a more corrective nature. In this foresight process engagement and enthusiasm were generated first and foremost in the encounter with other people.

Good processes shall also contain a reasonable portion of self-critique. One of the most important lessons is perhaps the importance of daring to relinquish the arena to the participants and not to be so worried about the participants' not discussing "the right things". In the project group we have had discussions about how much we should "control" the thematic focus. Even though the project group's conclusion was clearly in the direction of not wanting to provide too much guidance, we could perhaps have done even better here. Particularly the

discussion before gathering 3 (the scenario construction) is an example of this.

In addition to these process-related results we have produced a range of perspectives that in all probability would not have been made visible through more conventional methods.

Challenges along the way

The most central challenges along the way can be summed up by the following points:

- Know what one shall do when.
- Have the group leader role and secretary role defined in a good and comprehensible manner.
- Do not succumb to the temptation to analyse and discuss the process "to death". Develop a genuine dialogue where the participants feel they are taken seriously.
- Find a good transition from the creative phase to the discussion of future prioritisations and strategic recommendations.
- Include perspectives from "others" besides the established research communities within the aquaculture field, e.g. from technology communities, marketing, etc.

What we were good at

- Awakening interest and enthusiasm
- Getting the participants talking and engaged in the dialogues
- Generating a significant amount of written material
- Good situation-specific analysis afterwards

What we can improve

- Be clearer about the roles earlier in the process
- Provide more time for work with the development scenarios
- Make some of the discussions more efficient before the gatherings
- Dare to leave more to the participants (cf. paragraph above)
- Combine the material from the gatherings with a more comprehensive analysis of the field as such
- Do better in inducing other sectors to be heard in different phases of the process

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Appendixes





Contents:

Photo preceding page from left:
Illustration: Making Waves AM
Epelpix
Pia Kupka Hansen
Gunnar Grytås
Norwegian Seafood Export Council

The aquaculture of the future – start-up memorandum

In the foresight process for aquaculture we want to trigger discussion and reflection. We want to look ahead, evaluate alternative directions the development may take and look at the opportunities Norwegian actors have to shape the future of the industry. The central aspect of a foresight process is not to decide what is probable or to calculate what the future situation will be, should the trends we observe today continue to have an influence into the perceivable future. The goal is to use creativity and imagination, along with the participants' own knowledge about the aquaculture industry (and other industries) to create alternative images, probable as well as improbable, of how the future might be and how we might wish for it to be.

A significant investment has already been made in the analysis of the development of the aquaculture industry and to understand the situation of the industry today. In relation to handling the future, such analyses can when seen in isolation appear somewhat retrospective. But it is important to learn from history and the experiences gained.

In the following we have created some text fragments that indicate a few of the many important challenges that are central for the aquaculture industry today. We pose some questions for which it is not yet easy to find a clear or unambiguous answer. We present them as a source of inspiration and as basis for further reflection and discussion.

Should actors be open about core knowledge and new technology?

The aquaculture industry was originally propelled forward by entrepreneurs who, through practical experience and experimentation, produced equipment and fish farming methods that functioned well. They used knowledge and tools that they thought were interesting and experience from other industries was extremely important. The culture in the emerging industry was characterised by openness and a willingness to help one another.

Norwegian fish farming companies have correspondingly carried knowledge along with them abroad and established fish farming on the basis of technology developed in Norway while supplier companies have launched their products on international markets.

A number of companies have worked at protecting their special knowledge through patents, registered designs or secrecy, because they view their own core competence as a crucial competitive advantage.

Openness with regard to knowledge and technology can lead to innovation in an industry because news spreads fast. At the same time, openness can be "naive" in the sense that actors in a competition situation lose competitive power in relation to others by sharing their best ideas with others. Norway as an aquaculture nation can perhaps lose its leading position should individual actors export key knowledge to realise for themselves short-term financial gain.

What does the development of the aquaculture industry really create in the long run? What adaptations should be carried out so self-interest and common good will coincide in the long-term? What types of actors will lead the industry in the future and what are the conditions for their being able to manage in the international competition?

Is there enough innovation and is the innovation progressing in the right direction?

The aquaculture industry is said to be an innovative future-oriented industry. At the same time, there are some sceptics also within the industry itself who claim that the industry is not innovative, or that it is far from being innovative enough. It is claimed that one even within the large groups to far too great an extent hangs on to established practice and that the key added-value processes still are based on practical animal technician knowledge, where it should be based on a much stronger scientific knowledge base. It has also been claimed that the industry is too introverted, preoccupied with optimising established processes and that it lacks imagination and drive with regard to acquiring knowledge and technology from other industries and establishing radical new solutions.

How will this be in the future? Will important problems – such as with disease – eventually be handled in a good way by an industry that functions more or less the way it does today or will the actors have to invest in other ways than today, with regard to innovation? Can knowledge and technology from other industries come to create significant changes in the aquaculture industry in the long view?

Will we have other types of actors in the future aquaculture industry?

The grounds for central group formations in the aquaculture industry have been explained as based

on the wish for realisation of economies of scale and the building of market power through control over the production side, but evidently to a lesser degree the wish for greater strength so as to be able to carry out development projects and innovation. Through license legislation and on the basis of regional policy and environmental policy considerations, production has taken place on a small scale in small installations scattered along the coastline.

Will the future aquaculture industry be characterised by companies that prioritise and function in ways that differ from today's large and small companies? Will we find the current division of roles between fish farmers, suppliers and research communities in the aquaculture industry in 15-20 years?

Shall products from the aquaculture industry be brand-name products on the grocery store shelves or should the industry endeavour to produce a bulk-based input product for, primarily, foreign food production?

The question of what kind of basic product salmon really is (e.g. can salmon be regarded as a domestic animal) can have suppressed another important question: for which kind of food article production can aquaculture provide a basis? Norway has proud industrial traditions in the process industry sector and has even longer traditions as an exporter of fish. On the other hand, one finds the agricultural sector and the strangely Norwegian lack of an export-oriented food article industry. Agriculture is also engaged in standardised production, but on a small scale and for a rather closed domestic market.

The activity within aquaculture seems to a rather large degree to have been formed in keeping with this historical starting point. Salmon and trout have been exported as bulk products, in large quantities and in standard qualities.

Will the future aquaculture industry be able to turn this image upside down? Will new industries such as agriculture and the food article industry be in a position to take part in fish farming? Can we envision the development of an export-oriented food industry in Norway, in the same manner as in Denmark, but based on raw materials from aquaculture?

Will aquaculture be sustainable in relation to the environment in the long-term?

Access to suitable feed substances from the ocean is limited. The net result is salmon and trout farming as a consumer of food resources for humans, not a manufacturer. Political processes, not least in international forums, can lead to regulatory and political changes that will make it, economically speaking, crucial to organise production and consumption in sustainable ways.

Will considerations for environmentally-friendly aquaculture lead to profitability in the aquaculture industry being placed under increasing pressure? Can other areas of knowledge and new technologies besides those that are today used in aquaculture come to create substantial changes in this area? Can the entire concept of intensive fish farming turn out to be unsuccessful for the aquaculture industry? Can it be that "sheep on mountain pastures" will prove to be a more correct metaphor for what aquaculture should be about than "cows in a pen"?

Will intensive aquaculture in the future be able to continue to deliver attractive products?

Closely connected to environmental sustainability is the question of market attractiveness. It seems to be necessary to use new knowledge and new technologies to arrive at larger production volumes and new efficiency gains in order to achieve continually more rationalised production. It can be relevant to generate genetically modified species both as farmed species and as feed organisms.

Will such a development, should it be, technically speaking, successful, create the basis for a vital industry or will it on the contrary result in fish farming products' losing their reputation for being healthy and natural and in this way undermine the industry's possibility for success in the market for food articles for end-users in the long-term?

New development based on increased market knowledge?

Today's aquaculture industry is, as pointed out earlier, to a large extent oriented around production and around improving and making efficient production. The market side, contact with the end-user markets and actively working towards developing new products in collaboration with end-users has been little emphasised.

Will the future aquaculture industry have to base itself on direct contact with end-users and more competence about the end-users' needs than the aquaculture industry's actors of today? Can a viable aquaculture industry also in the future base itself on sales via intermediaries and without product development

strategies established on the basis of advanced competence on the consumers and the development of consumption patterns? What kind of changes can be expected in the industry, if this is not the case?

Will the public authority "troll" explode when exposed to the light of day?

The framework conditions for the aquaculture industry are developed in a political system divided into sectors. The instances of authority in different areas influence the framework conditions for the aquaculture industry based on the considerations that are important within each area of competence. Regulations can have paradoxical effects. They can be sensible, seen in the light of some considerations but extremely unfortunate seen in relation to others. Today's government is working on developing a more comprehensive innovation policy and is trying to change the administration so that collaboration with the industry becomes simpler and more constructive and better suited to achieving a positive industry development in the future.

Will the aquaculture industry of the future have another relation to the public authorities than the industry does today? Will the public authority level look significantly different than it does today? What type of development could be desirable?

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Mini-scenarios



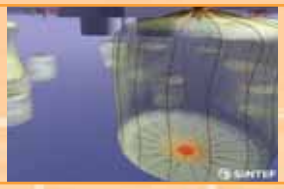


Photo preceding page from left:
The Norwegian Seafood Export Council
Illustration: Jon Solberg
SINTEF
Photo Disk
K.J. Merok/Matforsk

Factors

Market

Safe food in an unsafe world

Continued period of scandals in the meat industry. We have unfortunately experienced several environmental scandals that have created new uncertainty on the part of the consumer. Scientific documentation shows that farmed fish is safer to eat than wild fish. Norway has consistently managed to document that Norwegian farmed fish has been and is pure and healthy. We lead the world in classification of fish and fish-product quality. The industry is unified behind a national marketing of farmed products with a national branding programme and this programme has received international acceptance. Norwegian salmon is the ocean's "Parma Ham". The coastal waters are clean, the problems with pollution have been reduced, radioactivity from Russian vessels and sunken/dumped reactors are not a problem. The fish farming industry functions well within the new and strict international tolerance levels for extraneous matter that have been established.

"Norwegian salmon is the ocean's "Parma Ham"."

New fish farming species from other latitudes dominate

Competing species from warmer regions have come to stay. Tilapia has ousted the traditional Norwegian farmed fish. Other countries succeed in their fish resource administration and ensure in this way a sustainable and extensive harvesting and manufacture of wild fish and wild fish products. Other countries protect their fish and the trade regime has progressed away from the liberalisation that was the trend 20 years before. Norwegian food culture has become more American-ised and Norwegians are to a large extent eating their way into poor health. The aquaculture industry has adapted and has a smaller production volume than previously. Specialisation of companies is strong. Air transport from the East and America is central. We export feed competence and are simultaneously global leaders in fry production. We have by 2020 developed some Norwegian brands that are used for marketing internationally.

New focus on the domestic market

The fishery industry has in 2020 focused on the domestic market in a completely different manner than previously. It is no longer all about simple food-fish production for export. Norwegians have become fish feinschmeckere. The Norwegian chefs are international fish pioneers. The Norwegian consumers have become demanding fish customers. Fresh fish is available throughout all of Norway. Previously the postulate was that a fresh fish is noble and that it in reality cannot be refined. Now a significant portion of the added-value in the industry is connected with production, distribution and sale of refined products. The actors in Norway have recognised that one must succeed in the sale of refined products in Norway before one can manage to market refined products abroad.

"Norwegians have become fish feinschmeckere."

Global market for fresh and cleaned, de-boned fish

Norwegian aquaculture operates in a world market and sells large volumes of high quality fresh fish. The marketing is based on the product being a pure product from a pristine nature. The industry has an extremely well developed logistics system all the way to the consumer. There are frequent deliveries, often several times a day. The manufacturers have closer contact with the sales link towards the consumers. Production takes place on the basis of global contracts and sale of salmon occurs to a large extent to multinational sales and distribution companies such as "Ahold".

Force of gravity scenario

Norway is primarily a supplier of fresh, unprocessed fish and the Norwegian fish farming industry is the world's most efficient manufacturer of fish. But Norway is located too far away from the markets. The petroleum economy characterises the Norwegian population and the cost level is too high. The large multinational companies dominate and want to operate the production and marketing of all fish close to the end-users (consumers). They build up their own brands. The production of refined products is by order, and takes place close to the customer. All further processing takes place outside of Norway in 2020.

We process fish only where it can by done by machine. No refining or adding of substances is done as there are still duties imposed on such refined products. We therefore export only fillet and round fish. We also process remnants and make special products from this in Norway.

"...the Norwegian fish farming industry is the world's most efficient manufacturer of fish.

Foto: KJ. Merok/Matforsk

”Norwegian Crown”

The Norwegian aquaculture industry exports fresh semi-manufacture products according to customer-specifications abroad, where products are further processed. Norway has developed an extremely high level of competence within food article technology and product development. A few regional slaughterhouses are in operation. Operations are around the clock so that the capital costs are low. The fish are cut up according to specifications from different customers. Norway is a brand product supplier. By-products are processed in Norway. They are used in the pharmaceutical industry and the oil and meal industries, while swim bladders are exported to China. The industry has developed an advanced technology and an advanced system of distribution. End processing takes place close to the consumers. Production is extremely efficient and only a very short time passes from the time of slaughter to final packaging. Norway is one of the world’s largest suppliers of "semi-manufactured" fish.

The Bonanza scenario

“In 2020 the industry is profitable and stands on its own two feet.”

We are in the EU and sell large quantities of round and processed fish and fish products. Eastern Europe and China demand farmed fish in large volumes. Fish are recognised as being the healthiest food product one can consume in the daily diet. The world population is growing even more rapidly than previously and there is an ever-increasing demand for fish. The government’s entering as a large-scale owner in periods has solved the capital problem in the industry. In 2020 the industry is profitable and stands on its own two feet. The industry is perceived as an environmentally-friendly industry and meets all the central requirements posed by international customers. We have problems meeting the large demand. The consumer is preoccupied with good health and is therefore willing to pay a high price for the fish.

Natural trade - the new common currency

The new trend in 2020 is natural trade. This will become the new global currency, experts predict. Goods are traded for goods and this will make the euro, dollar and yen to an increasing extent superfluous. In 2020 already 10% of all food sale is organised by way of such trade agreements. As an example, all fruit and vegetables imported to Norway are paid for by deliveries of Norwegian seafood, especially aquaculture products (salmon, farmed cod and oysters). Dairy products and meat are "exchanged" for seafood deliveries to/from Denmark and Germany. Nature-given conditions and nature-given production capabilities become more and more essential to how food is produced. The UN has already set up a special council that stipulates the equivalent value of different food products. More and more countries join this council or follow the recommendations of the council. The downside thus far has been an ongoing increase in disease problems in connection with increasingly larger areas with intensive monocultures. A countermove against this is the introduction of disease-resistant genetically modified organisms (GMO). The Norwegian-owned GenTec AS has patented genes from cod, salmon, oysters and sheep and anticipates a dramatic revenue increase from extensive sales of licenses.

Foto: Torbjørn Tandberg/Samfoto

Arab countries and salmon

The Norwegian fish-farming sector has experienced a formidable development and has continuously penetrated new markets. In 2020 fish farming products are distributed in areas which 20 years previous were completely inconceivable. Control of production and new developments within biotechnology have led to being able to distribute farmed fish in up to 30°C transport temperatures. This is made possible through a feed development where natural additives in the feed arrest the enzyme activity and oxidation of the dead fish. (Example: inhibitive cultures such as lactic acid bacteria oust/kill pathogenic bacteria.) Norwegian patents! In addition, kosher-approval is introduced as a part of the Norwegian standard. High temperature distribution and kosher-approval have led to enabling the distribution of Norwegian salmon in markets without refrigerated/frozen good distribution. Lerøy salmon is reported distributed by camel in Ethiopia.

Norwegian grocery store chains reopen the European market

In the period from 2004 up to Norway’s becoming a member of EU in 2016, an ongoing deterioration of the situation for Norwegian actors in the fishery industry occurred. Up until FISHPACK opening its new central facility in Oslo last year (2019) there has also been a cool relation between the Norwegian fishery industry and the Norwegian commodity trade chains.
Both because the chains have felt snubbed by the industry compared to the Asian markets but also because it has not been possible for the chains to invest in fresh seafood before FISHPACK opened. This new model opens up for completely new possibilities with regard to

supplier collaboration, logistics and marketing. When WHO presented its report on the connection between ocean temperature, fish health and human health, the demand for Norwegian farmed fish increased once again in Europe. As an aid in the marketing work in Europe, the Norwegian fishery industry is finally receiving solid assistance from the Norwegian grocery store chains. These see that by negotiating together with their European sister-chains they achieve far better prices than they do on their own. This ensures the Norwegian fish farming industry large volumes at acceptable prices and both sellers and buyers win. Norwegian fish farmers expect large gains from this new alliance and expect that Norwegian salmon will again be a favourite on the European market.

Animal welfare requirements revolutionise the fishery industry

The large international animal welfare organisations have achieved a significant response to the allegation that traditional fisheries are cruel. This has led to a readjustment of the fisheries, to live up to the market's requirements for more humane fishing methods. For a number of years during the period before 2020 there has subsequently been a dramatic decrease in the access to feed raw materials from the fisheries. The aquaculture of today is therefore almost exclusively based on vegetable raw materials. The welfare requirements have also gained full force within the aquaculture industry and fish farming methods and handling and slaughtering processes have been completely altered. This has also had significance for the administration and regulation of the industry. Among other things, the requirements for maximum permitted space have been replaced by a regulation of maximum permitted production.

"The aquaculture of today is therefore almost exclusively based on vegetable raw materials."

Free Choice

Due to an increased need for penetration of existing product segments, the Norwegian aquaculture industry has been obliged to carry out a large amount of product development. It is years since the consumers have been able to and wanted to identify which part of the fish they were eating. Seafood-based food articles are now in 2020 found in all kinds of variations, whether it is a matter of a wide variety of extruded portions, finger food sold at petrol stations, or diverse kinds of sandwich spreads. Through successful product development, the aquaculture sector's actors have succeeded in getting fish-based products into most product segments. There is "free choice" with regard to which seafood products the consumers want to eat. Only 20 years ago this was completely unthinkable! An important aspect of the development that has taken place is that all further processing has been moved outside of Norway and takes place close to end-users. Norway for its part has established a new industry based on the by-products, which there will be an abundance of as long as the most important export product in the traditional fishery and fish-farming industry remains trimmed fillets of fish meat. This advanced residual product-based, processing industry is among other things the supplier to the world's largest taste and ingredient group delivering additives to the food article industry worldwide.

Foto: Eksportvalget for fisk

Diversification and product development

The Norwegian salmon industry has from 2003 and up to 2023 experienced an ongoing development where one has at all times worked towards generating new products. Product development and customised products have come about to a large degree with a point of departure in the development that has taken place within adjoining industries such as ICT and logistics. Now all salmon produced in Norway is pre-rigor filleted. It is transported to large, predominantly Norwegian-owned processing companies that have facilities centrally located in Europe. In the Czech Republic, refined products are produced on customer-demand. Customers served include everything from large supermarket chains to individual households. The customer makes purchases over the Internet. The orders are automatically fed into the production system. Distribution takes place in collaboration with a company, a spin-off from DHL that delivers refrigerated products to the customer's door. The system is a further development of traditional door-to-door logistics. Fresh products dominate trade in Europe and DHL's distribution system has been highly influential in Norwegian salmon's gaining considerable market access in the American fresh food market. The Norwegian salmon industry has proven to be extremely adaptable to the development in the market and is now able to deliver to specifications, all the way down to the level of the fatty-acid profile of the salmon. Ecological products based on unique feed regimes have been possible since 2017.

Feed raw materials

Foto: Eksportvalget for fisk

Vegetable raw materials dominate

The breakthrough for vegetable raw materials is due to:

- A dramatic decrease in wild fishing
- Customers no longer accept the use of fish as feed
- Vegetable feed is easier to make and far more inexpensive
- Relevant plant species have been genetically modified and are now suitable as feed raw materials for fish
- The EU has approved vegetable feed and the feedstuff has gained a central position in a safe food programme
- Vegetable feed can be produced by processes that use very little energy

Raw materials based on natural gas dominate

- Gas as a raw material represents better use of the gas resource, which is not a renewable resource (increased total added-value)
- One is able to produce polyunsaturated fat from gas, after the right micro-organisms have been found in the ocean
- Gas implies that GMO is not necessary in the value chain
- Gas is no longer used as an energy source (incineration) but is preserved as a future resource in food production
- The EU has accepted the gas-based feed in its safe food programme

Marine raw materials dominate

- There is significantly greater access to marine feed raw materials because one has begun fertilising the ocean
- One has begun cultivation of mussels as fish feed
- Harvesting in 2020 takes place at a lower trophic level (algae, bacteria, krill, etc.)
- Technology has solved the pollution problem with toxins in mussels and the method has been accepted by the EU

Animal raw materials dominate

- The problems of disease transmission through feed have been solved
- Genetic modification of tame fish has made it possible for the important species to consume non-marine animal feed
- The EU has accepted the solution
- The fish farming industry has become a large-scale consumer of cheap raw materials from agriculture

"People will not eat fish fed on fish."

Production is based on flexible exploitation of more raw materials

- Amount and composition is balanced so that the productive effect of fish farming is optimised
- The feed problem is solved without use of genetically modified organisms

The aquaculture industry experiences a serious feed scarcity

- A breakdown has occurred in the supply of adequate marine feed (excessive over-fishing in previous years)
- Other fish species with other feed requirements have taken over
- There is a general problem with raw material access for feed production
- The industry actors have not achieved acceptance of alternative solutions:
  - GMO research is forbidden
  - People will not eat fish fed on fish
  - The marketing investment has been by far inadequate.

Former feed raw materials processed directly into food products for humans


Foto: Stein Johnsen/Samfoto

In large segments of the rich world a perception that all fish must be allowed to live in peace spreads. Economic and emotional forces and strict food safety requirements lead to our ceasing fish capture. Children and young people who in 2004 said in consumer surveys that they did not like fish have become adults and passed on their dietary preferences to their children. "Functional food" based on marine ingredients leads to people no longer needing to eat fish for health reasons. Fish farming has been reduced to a minimum. There is however complete acceptance for the capture of animals at a lower trophic level and systems and international agreements have been established for sustainable harvest of krill and plankton. Methods that make it possible to produce meat with a point of departure in marine feed substances such as krill have also been established. Also different vegetable products supplemented with krill extract and other marine raw material additives are consumed as seafood along the same lines as other marine products. Norwegian companies take part in all of this and, all in all, this comprises significant Norwegian industry activity.

Vegetarian salmon only: "All Green Salmon"

All salmon that is farmed in 2020 is fed vegetable feed. Vegetable raw materials are safer and more economical than marine raw materials. One has found extremely good solutions that make marine products now superfluous. The only marine product used is an adhesive that is produced from alginate. Fish diseases cannot be transmitted through the feed. Brazil has become a large and important manufacturer of vegetable feed raw materials to Norwegian and international fish farming. Only 10% of the raw material is now produced in Norway. In the transition to use of vegetable feed part of the problem was with deficiency diseases, but that has now been overcome. Norway has found an economic means of exploiting waste heat in the production of algae and phytoplankton. This provides the basis for production of alginate and valuable components used in the production of fish feed and in the pharmaceutical industry.

Single cell protein – "Salmon in Oil"!

Salmon is produced in 2020 in large new offshore installations. The feed is produced from gas from platforms. The feed is so good that cages are no longer needed: the fish is affected by the feed and remains by "its" platform of own volition. This is a conditioned response; smell and taste signals are sent to fish belonging to a specific installation. Gas becomes fish feed. Hydrocarbon in the methane gas and nitrogen in the air are used to produce single-celled protein on the platform. Pipe trenches that were formerly used for oil transport are now used to transport salmon to processing facilities in Europe (salmon in oil).

"Salmon is produced in 2020 in large new offshore installations."

Global food shortage opens for GMO in 2015

The global food shortage opens for GMO. Food is produced cost-effectively as cell culture released from the production animal or from selected production animals. Increased knowledge leads to acceptance of such production. Food production is in the hands of a few. Feed costs a fraction of what it cost 20 years ago and the fish grows much more rapidly. GMO provides taste differentiation, increased storage capacity, and different types of "functional food". It is easier to produce such functional food from aquaculture products because marine animals are more plastic than land animals or other "historically authentic" products. The public authorities and politicians lack the ability and will to inhibit the development through regulation. The supply side (manufacturers) and the demand side (consumers) both work in the same direction and the market becomes the dominant force in the development.

"The global food shortage opens for GMO."

The industry development stops due to feed shortage


Foto: Kerstin Mertens/Samfoto

Danish pig production and commercial breeding of pets ousts Norwegian fish production. The financing and knowledge do not exist to find alternative resources to the marine raw materials for fish feed. The pet industry can pay handsomely for the feed and as such seizes control over large portions of the available marine feed resources. Also the Danish manufacturers of pork buy up a lot of marine feed and portions of the most valuable marine raw materials are used directly as human food. The production costs of fish farming go up. The prices of aquaculture products increase, production drops and the demand for salmon goes down. Fish farming becomes a mini-industry.

Innovation

Production costs per kilo salmon: NOK 9

The market demands production costs of marine species to be less than NOK 9. In our most important markets GMO is now accepted, but productions ethics have become an important factor. (Hutch housing is now abolished; all cows must be free-range animals.) With the help of GMO the fish farming industry has developed species that live on food and organisms from a lower level of the food chain, while at the same time it maintains a low feed-factor. The fish must live in freedom and the schooling instinct as well as birth place coding, reduced susceptibility to stress, etc. have been coded in. (Undesirable characteristics are done away with or significantly reduced.) This results in the farmed fish returning to its "home" after a given period. The fish are collected together in large quantities and shipped to Norway for further processing. Further, the health of fish can be followed up individually. Some in the school are equipped with electronic chips that provide information about where the fish is, health and well-being. This makes it possible to follow-up the fish and implement preventive measures when necessary.

Norwegian aquaculture triumphs with sustainable production methods

Norwegian aquaculture tops the list of industries that have developed sustainable methods for food production. The quotas for wild fish harvest have been radically reduced. Large demand for seafood, particularly white-flesh fish, has created a general rise in prices on fish and seafood products. On the basis of this the aquaculture industry has developed new and intensive farming of lumpfish, cod and haddock, among others. Also the mussels industry has become big. Fry production is controlled; reproduction of fish is effective. The industry is sustainable on the force of its ability to operate without polluting, to optimally exploit resources and to avoid disadvantageous interaction with natural wild fish stock. A diversification of fish farming forms has taken place, new alliances have been created between traditional industry and aquaculture, and intensive farming is carried out parallel with "sea ranching". A significant product differentiation has occurred that has contributed to making it possible to utilise absolutely the entire fish in production.

Foto: K.J. Merok/Matforsk

Technological breakthroughs makes processing possible in Norway

Technological breakthroughs result in 95% of all salmon produced in Norway, Scotland and the Faeroe Islands being processed in Norway. The technological development in other sectors (such as the auto industry, pharmaceutical and materials industry) has been adapted and exploited within the bio-marine sector. Particularly robot and automation competence from the international auto industry have made it possible to depart completely from use of manual labour within processing. Norwegian R&D communities have managed to develop a leading position internationally in the field. It has also been possible to protect the technological advances from competitors. Increased production costs in former low-cost nations along with an increase in demand for fresh products have contributed to this development. In particular the Norwegian research and industry communities have been proficient in implementing Internet technology and have generated new logistic systems that make it simple to deliver fresh fish products to consumers' doorsteps. A national monopoly has been formed in this sector. A total exploitation of by-products (held back in Norway when the processing takes place here) has led to increased profitability within processing and has contributed to centralisation of the processing industry in Norway. Scottish and Faeroe Island salmon and trout are therefore processed in Norway.

Norway is a super power in feed production and export

"There is a broad public consensus against using human food as feed."

Norway has developed into one of the world's 5 leading manufacturers and exporters of feed. But there is a crisis: in 2020 there are large limitations on the access to feed. There is a broad public consensus against using human food as feed; NGOs have made this into a banner-cause. The difficult feed situation has put the industry in a deep crisis. Environmental toxins in caught fish for feed have also become a serious problem. (Retention of toxic substances in the food chain.) This has provoked a change and large technological and biological breakthroughs are about to take place. Harvesting and cultivation of feed is knowledge-driven and has led to the development and breakthrough of a 4th generation feed processing industry in Norway. Feed products for functional food have brought new market possibilities. Feed licences provide considerable revenues for the government and the Norwegian public authorities contribute to industrial development in poor countries with particular growth conditions for algae. This is first and foremost based on conversion of natural gas.

Viagra salmon – and the revolution in functional food

The functional food market grows. A fourth generation of salmon is developed. R&D has shown that marine food in general has extremely good health effects and in addition medicinal qualities are coded in that make the fish even more attractive. Strong alliances are formed between large pharmaceutical companies and the food industry. This makes possible the breeding of fish that can have hundreds of different characteristics and that can be adapted to special medical needs and provide significant preventive health effects. Norwegian research leads the international knowledge development and documentation in the field.

"Strong alliances are formed between large pharmaceutical companies and the food industry."

Breeding makes possible effective sea ranching

- Environmental and infrastructure costs become too great for traditional farming and a feed problem develops
- A shift in research occurs from growth to exploitation of migratory characteristics
- An effective influence upon migratory fish species takes place at receiving and feeding locations along the coast
- One breeds/feeds large quantities of fish that come back for slaughter
- The conflict with administration of the natural resources is solved

Development of escape-proof offshore installations

- Zero release of fish
- Money allocated by the public authorities to test out different solutions
- Area-conflicts force the fish farming industry out into open waters
- Larger demands are placed on technical installations
- Hydro (at Yara) has returned to fish farming
- The natural competitive advantages in Norway are weakened, but gains are realised in the technical sphere

Foto: Eksportutvalget for fisk

25% of the Petroleum Fund is spent on the commercialisation of new species

- This leads to innovation/investment/capital for establishment of new fish farming species
- Capital is no longer a bottleneck
- Great acceptance by the Norwegian population for fishery and aquaculture being something we are going to live on (after the oil)
- The innovation investment is controlled and coordinated
- People stay in the industry – and important competence and experience stay within the business sector
- Aquaculture is an attractive workplace

"Aquaculture is an attractive workplace"

Innovation system

- Innovation has become a subject at school
- The Norwegian fish farming industry controls the world market through knowledge development instead of being the largest in production volume
- Public measures stimulate innovation
- The government contributes with seed capital
- An innovation model is established for the aquaculture industry, which is intended to commercialise new fish farming species. This model is followed and one has managed to establish a goal-oriented aquaculture industry

Capital / Ownership

Success for Statfisk in Asia

Stafisk was established in 2005 with 49% public capital (NOK 10 billion) from the Petroleum Fund. The company's goal was to take on the same role in the aquaculture industry as Statoil, which is now shut down, had in the oil industry. The capital was invested in Norwegian equipment companies and in the development of halibut farming, salmon farming, lumpfish and intensive lobster production. In addition, Statfisk quickly formed a unifying market mechanism for the promotion of Norwegian seafood, in particular directed towards Asia. Great success was in particular realised in the export of cultivated mussels. The large population explosion in Asia has resulted in an interest for local, intensified farming. This has led to large export of equipment to these installations in Asia, but at the same time, the export of aquaculture products to the same markets has experienced a complete lapse, as these markets are now self-sufficient. Statfisk states in a commentary that they for a number of years have been looking at the possibility of expansion in seafood export to Africa, which now comprises a 13% share of the world market.

Foreign capital unwanted

After the WTO negotiations broke down completely in 2005, world trade has to an increasing degree been characterised by protectionism. Norway introduced as early as the subsequent year (2006) a total prohibition of foreign ownership interests in the Norwegian aquaculture industry. During the initial years this led to a large capital deficiency and a negative development, especially for new fish farming species. Active investment on the part of the government through Innovation Norway however, reversed this trend and the industry is now (2020) in a strong but simultaneously vulnerable position. This is due to the fact that 70-80% of the production of the large fish farming species (salmon, trout and cod) is manufactured under license for the two large global conglomerates, Global Food and Magasuga.

Foto: Per Eide/Samfoto

Coastal municipalities have a good economy due to aquaculture ownership

The municipality of Fredrikstad invested in 2004 in mussel cultivation to clean up the municipality's ocean areas. The mussels turned out to be well suited as a feed raw material for cod and the municipalities have earned well on the investment. In 2010 the Norwegian Parliament passed a resolution that the municipalities should have 49% ownership of all fish farming companies in own waters. The surplus has resulted in a good economy for the coastal municipalities. It is nonetheless more and more difficult to induce private interests to invest in fish farming due to political horse-trading, as to whether the surplus is to be spent on municipal initiatives, pension obligations or for reinforcing fish farming companies (day-care centres or fish).

Active ownership and strong personalities inform the development

The fish farming industry in 2020 is still informed by strong personalities and active ownership but now in combination with an active and qualified investor community. The Oslo Stock Exchange has become an important source of capital and with its adjacent broker community is a world leader in the marine bio-production sector.

Interest organisations support safeguarding their funds but seldom play an active ownership role.

Norway – Homeland of ...?

"Just about everything has gone wrong in the a quaculture industry in Norway."

Just about everything has gone wrong in the aquaculture industry in Norway. There has been little goal-oriented investment because the new brown-red political alliance has run the country since 2005. Money has been spent on objectives that have not been very future-oriented; investment decisions have been made on the basis of weekly polls. The Petroleum Fund has been scraped to the bottom. What remains of competition-exposed industry has been bought up and is owned by Chinese interests. Innovation Norway has been shut down and the website address has been changed from invanor.no to no.invanor.

The Petroleum Fund is replaced by the Marine Fund

An industry fund financed by revenues from oil, energy, fish and biotechnology has indicated four main areas for innovation and investment: Aquaculture and marine biotechnology, Energy, ICT and Culture. The value increases by 10% per year after good combined investments are made in Norway, Russia and Eastern Europe.

The investments are distributed evenly between investments in Norway and connected investments abroad to support and supplement the Norwegian activity. China and India are in 2020 the foreign investment areas with the strongest growth.

Intangible rights abolished – open access to knowledge and technology

2018: The EU abolished IPR (Intellectual Property Rights) within important areas due to the development within technology and communication (ICT). Private investors became less willing to finance knowledge development but they focus more on service and product development. A shift away from added-value based on rights and towards added-value based on new solutions and new technology has taken place.

One does not earn interest on knowledge/solutions but added-value on use of knowledge and solutions. There is a new vitality in the public efforts to stimulate and take responsibility for central knowledge communities (universities, colleges, basic research).
Knowledge has become much more accessible. There is a large potential connected with the use of newly developed knowledge.

"Knowledge has become much more accessible."

GMO is a central tool

After intensive R&D for the past 30 years, GMO has become vitally important to the aquaculture industry. Protection of intellectual property rights has become even stricter than previously. Ownership in the industry is in 2020 connected directly to the proprietors of key intangible rights. These are to a large degree large international actors (who have purchased the rights) who are experts in administrating such rights.
Monsanto is an important global actor in the roe market.
Production is carried out through franchising.

An extensive privatisation of knowledge communities has taken place. Research to a large extent is done in closed environments that attract the best talent and it is difficult for others to compete, even with considerable public efforts promoting open research.
Information about what is taking place in the industry is inadequate and inaccessible and the consumers' real power is significantly reduced.

Foto: Eksportutvalget for fisk

Competence Development (research and learning)

Internationalised knowledge sector and the north/south conflict lives on

The government realised in 2008 that the aquaculture industry had to be injected with considerable capital and competence if it was going to be able to take over after an oil industry that was adding less and less value. In 2020 a national network university is established where students can choose subjects independent of location. Universities are an international force in teaching and research. They attract international top expertise. Marine-science alliances are established with the largest and most esteemed professional communities in the world. In the EU Norway has received the leading responsibility for development of research and teaching in the marine sector. Basic research is led from Norway and under the direction of the Norwegian segment of the ERC (European Research Council).

Trade and industry carry out knowledge production

Key industry actors are in 2020 highly dissatisfied with the public R&D strategy. Large public allocations to different research programmes such as SFF, FUGE, etc. have not had the anticipated results in the form of commercialisation and industry development. The industry takes the initiative itself for a total reorganisation, User-run innovation projects are gathered and create the stem of a user-run research and education institution with a semi-public and semi-private financing structure, but predominantly run by user interests. The new organisation has its own technology transmission departments. The large actors have own departments at the institutions to enable them to respond quickly in implementing new technology. The institution has its own education programmes, which the users use to update their employees. There is also a start-up and commercialisation unit, where design protection and patent rights are taken care of and where the government and industrial actors jointly finance the activity, through among other things different means such as seed capital and start-up grants. The investment represents a fully-integrated tool concept.

Foto: Jørn Areklett Omre/Samfoto

"McDonalds has become the industry's largest customer"

Alliances with international brand builders – the Coca Cola effect

Norwegian research communities and companies have been obliged to give up ambitions of developing national or company in-house advantages within brand building. In a global food product industry it has therefore been necessary to enter into alliances with global suppliers of processed food products. A contract has therefore been formed with the Coca Cola Company for marketing and distribution worldwide. This in particular pertains to use of CC's refrigerator concept for sales in stores. This is a part of CC's new strategy to penetrate schools and day-care centres and to build a positive image. Since users/consumers consume a larger and larger percentage of meals through fast-food chains, it has been necessary to enter into a contract (exclusive) with McDonalds. This is an initiative that was also made by McDonalds in order to acquire alternative products besides meat (Mad Cow Disease has made unilateral investment in meat extremely risky.) McDonalds has become the industry's largest customer and a long-term strategic cross-ownership has been established.

Reform "Competence 2012" an impetus

Aquaculture has become the most difficult study programme to get into: the grade requirements are a 4.0 average. This attracts the best minds nationally and internationally. The aquaculture industry has become knowledge intensive and the wage leader for employees with higher education. Aqua Studies has become the leader, after "Competence 2012" which emphasised the industrial subjects. Competence communities within Aqua Studies connected to R&D and education (framework conditions) have become an important location factor for the foreign pharmaceutical industry. There is an active interaction between trade and industry and international industry, thanks to the competence reform. Norway is the most attractive host country. In aquaculture and in the supplier industry, there is an essential cluster dynamic and actors have a remarkably high absorption capacity with regard to new knowledge and technology from other industries. The aquaculture industry leads in the cluster and has been developed into a "demanding cluster". It has been developed into a large competence-based international cluster with the management located in Norway. The generic platform of biotechnology is a key girder in the development.

The reorganised research space – and the demise of industrial neutrality

In the election of 2009, a banner cause was a change in the focus on use of oil revenues and the Petroleum Fund. Trade and industry gains complete acceptance for the use of funds to develop future-oriented growth sectors. Marine industry is one of the most important. There are 3-4 prioritised areas, everything else must compete for general funding and the government takes on no particular responsibility. The real prioritising moves away from industrial neutrality as a principle. This becomes an obvious necessity because the export earnings were nearly halved; crisis was a fact; the focus was placed on research within the prioritised areas (Finland Phenomenon).

Five million tons in fish farming production annually

Large companies that are leading competence and innovation forces have come to set the tone in Norwegian fish farming. This has led to a considerable prosperity and growth in the industry with an annual production of 5 million tons of fish farming products. Salmon is still the dominant species with 2 million tons. Different species, cod, halibut, tunny, shrimp, lumpfish, haddock, mussels, sea cucumber, hagfish are farmed and comprise the rest. Farmed fish has become "in-food" for large segments of the population internationally. The production percentage of processed fish is increasing.

"Farmed fish has become "in-food".

The industry does not only produce fish for food but also extracts biochemical substances. Innovation Norway has not received resources to take part and is no large participant in this. The impetus is large companies where knowledge and innovation are important elements. Transport by boat has increased somewhat. Due to climate changes that have led to higher winter temperatures, the fish matures more quickly. Good roads to Eastern Europe open this up as a new market. Goods are transported against return transport costs in the right direction. The immigration policy has been slackened; Norway acquires more manpower for the farming of these products. This is a result of goal-oriented innovation. The feed question has been solved.

All fish exported fresh

Customer demands lead to the necessity of including an aroma component in the product. This and the short distance to large markets have contributed to all fish being exported from Norway fresh (not alive) and not frozen. Chile has taken over the majority of the export of fro-

zen fish that is processed in China. Norway takes the fresh market. Development of new competence is an important condition and the competence communities had a wealth of resources for this work. The quality of fresh fish is customised because there is quality assurance the entire way. Niche products are developed because the distance from the main market has changed. Controlled maturing processes after slaughtering are included as part of the distribution chain. Intelligent registration in packaging has been developed that shows a quality indicator and deviance if something has gone wrong along the way.


Foto: K.I. Merok/Matforsk

Fish farming offshore

Because of the area-shortage in the coastal zone and to avoid national jurisdiction and restriction, fish production is located out on an offshore facility. The fish farming installation is established outside the 2000 km mark and is either anchored in the bed or self-propelled and self-positioning. The installations are self-sufficient, self-supporting on ocean current-, solar- and bio-energy. The installations produce a series of different species and a quality improvement of the fish is achieved (pollution-free environment). Boats that come with feed take with them products back to the market. New materials technology and ICT result in the installation being unmanned, remote controlled via satellite. Only under special conditions is there a crew on the installations.

Erosion in Norwegian research

It has become unprofitable for the individual to invest in many years of education in Norway. Brain drain manifests itself because foreign competence communities provide better conditions for research and for industrial operation. Marine investment is taken out of the Research Council's areas of investment. The Research Council invests primarily in free basic research. The remaining aquaculture researchers lack competence, they travel in flocks and do not contribute to innovation. The industry's reputation becomes in time so bad that nobody wants to research in the aquaculture industry. The development of competence in the industry is reduced and the production declines. Meanwhile, reduced use of fish in society results in increased costs in the old age welfare services and the health care sector.

"...unprofitable for the individual to invest in many years of education..."

No Free Lunch

The free distribution of research findings came to an end in 2015. The results of publicly financed research become private property because the education institutions are permitted to patent and in other ways protect their new findings. Sale of knowledge is intended to contribute to financing research. The development of knowledge is self-financed. Patenting of own findings gives the individual researcher greater power with regard to propagation. "No free lunch, no free knowledge." Knowledge has become more privatised and simultaneously, that which already exists in the way of research results is distributed better. The precise, scrupulous information however must be paid for; free information is imprecise and not to be trusted.

"No free lunch, no free knowledge."

Sustainable Development (environment and food safety)

Global warming leads to warmer waters along the Norwegian coast

Warming has provided possibilities for the farming of new species and we have now many more species in fish farming (oysters have become a standard part of the production). Warmer water has led to new disease problems, but these have been solved through research in fish medicine and other research, and through health considerations being taken seriously in the administration's regulation of the industry. It has grown too warm for farming of salmon in Western Norway – and the centre of gravity for this part of the industry is now in North Norway.


Foto: Stein Johnsen/Samfoto

Global warming creates a decline in the industry

- The work of producing new species has not been successful (technology, market, administration).
- Fish health problems increase (disease, algae)
- Health considerations not included in government administration
- Salmon and cod fade, particularly in North Norway due to conflicts with the wild fish industry

The Gulf Stream turns around: local cooling in Norway

A radical drop in ocean temperatures creates ice problems in the fjords. Salmon farming is moved south and west. Western Norway survives on farming of exclusive arctic species. The country's wise men search for a solution...

Increased area conflicts

"A prohibition has been imposed on fish farming in a number of large areas."

A prohibition has been imposed on fish farming in a number of large areas. Fish farming is moved out to sea, in large and capital-intensive installations owned by external actors. We have solved the problems of extreme weather conditions through technology development and new transport solutions. This has had positive effects on the environment in the fjords (marine oligotroph). Solutions for farm wreck and the fugitive fish problem have been found. Integrated fish farming (such as salmon with mussels) of several species in the fjord regions and along the coast is successful, due to the great efforts of veterinary medicine and other research in collaboration.

Large environmental problems from a radioactive leak

Adaptation through laying down of feed, water purification in closed installations, vegetable and gas-based feed sources are important. Laying down of feed on land or in closed installations. Certification and control systems are developed, approved by the EU and aquaculture products are accepted in the markets as safe food.

Success and growth compound environmental problems

Emissions and other impacts on the ecosystems of nutrient salts, chemicals, pathogenics, fugitive farm organisms, etc. have measurably negative effects in Norwegian waters on the water environment and on wild populations. The industry takes the problems seriously. The installations must be out at open sea or up on land. Researchers monitor the problems. Mussel farming is used as a purification system for nutrient salts. The fugitive problem is solved.

Foto: Per Eide/Samfoto

Environmental changes have given the Norwegian mussel industry a boost

Increased emissions of nutrient salts from Europe and fish farming lead to the blossoming of algae. Mussel installations are used to a large extent as purification facilities in areas with a particularly high nutrient salt or algae concentration. The temperature of the ocean has gone up 1.5 degrees. Other fats are used for fish feed.

Marine raw materials from lower trophic level

"All wild fish catch goes directly to human consumption."

- All wild fish catch goes directly to human consumption
- Still not access to enough feed substances that can replace wild capture fish
- Farming of feed organisms. Mussels are sold to Asia
- Harvesting of natural zoo-plankton
- Cultivation of marine micro-organisms (reactor mentality) using CO_2 and light, nutrient salts connected to CO_2-generating power plant
- Utilisation of krill from the Arctic and Antarctic oceans
- The problem of krill autolysis is solved
- Favouritism of species at a lower trophic level such as herbivore species: tilapia, carp, mussels, abalone, sea urchin, crab

Climate change makes fish farming difficult in some regions

"The industry must move fish farming activities on land."

- Short-term scenario: Global warming, higher mean temperature in the ocean. Leads to increased mortality, increased problems with advanced sexual maturity and disease
- Increased extreme weather leads to greater risk of wreck/fugitives. This means reduced access to good locations and struggles over these
- Long-term scenario: Melting of the poles. The temperature drops, the Gulf Stream halts, increased problems with ice.
- The industry must move fish farming activities on land
- Norway loses most of its nature-given competitive advantages
- Farming of salmon increases in the Mediterranean
- Norwegian companies are moved out of the country, such as to Chile where there are still good conditions for fish farming

Aquaculture production has preferential access to use of coastal zone


Foto: K.I. Merok/Matforsk

- The industry's rights are upgraded
- One gains abundant access to areas to the detriment of other activities
- Virtually free licenses – the value of a license is depreciated
- Many new establishments take place
- There is a dramatic increase in production
- Increased conflict between actors and in relation to other interests
- Increased focus on aquaculture in coastal zone planning
- Stricter environmental and ethical requirements
- Larger variety of species in production
- Concentration of licenses on fewer and larger locations. It becomes significantly easer to establish joint locations
- Stricter health/distance between sites requirements

Harvest of wild fish the most sustainable exploitation of marine production

- Feeding farmed fish with wild fish and the corresponding energy loss is not regarded as sustainable
- The industries must find other feed resources
- Harvesting at a lower trophic level at the cost of the higher level is neither considered to be sustainable
- Fish farming must base itself on vegetable proteins, gas, and algae and the exploitation of by-products
- Shift towards species adapted to accepted feed types
- Shift towards herbivore fish and shellfish
- Strong decline in traditional fish farming in Norway
- Much of the activity is relocated to Chile, where similar limitations have not been introduced
- The coast party takes the side of the aquaculture industry and we get an increased polarisation and debate

"Strong decline in traditional fish farming in Norway"

Requirement for short-distances becomes dominant

- Climate considerations and transport liabilities become more important in the large markets
- Energy and transport costs increase dramatically
- We experience a shift from air and auto to boat and rail
- There is a focus on high-speed solutions that still allow transport of fresh fish
- Increased focus also on products that do not tolerate a longer transport time and larger volume
- A reorganisation of the logistics system is carried out adapted to the new situation
- There is significantly more competition from small farmers with market proximity

Policy

National capital in the fish farming industry

Capital has been the largest scarcity factor in the industry. One of the national capital funds has entered as a large owner in one of the largest fish farming companies. The Trondheim study's capacity gauge is achieved through strong national investment in the company, designed according to the same model as Statoil. 60% of the capital is in the biomass that has a life cycle of 15 months. National industry policy has actively followed-up the trade & industry policy within the fish farming sector.

De-regulated fish farming industry

The political regulation of the industry is abolished. There is no licensing requirement. The industrial neutrality policy is approved. Norway is part of the EU. The EU has given the fish farming industry priority in the form of support for R&D to produce safe and healthy food. Norway is the country in Europe that still has the conditions for operating fish farming. The other countries do not have the area due to competition from other industries. The Ministry of Fisheries, the Ministry of Agriculture and the Ministry of Trade and Industry have merged into one Ministry of Industry.

Industry organisations are internationalised

The industry organisations are international and the Norwegian actors are direct members of the international organisations.

Foto: Eksportutvalget for fisk

Marine sector receives national priority

Norway has made a choice and prioritised the marine sector as one of three main sectors. The national measures are directed towards these three sectors. The distinction between traditional fishing and fish farming is erased. The food industry has on the basis of increased outside competition focused more on marine products than on agriculture products and particularly for export. Innovation Norway and the Research Council have merged to arrive at an even greater coordination of the administering agency. The national R&D communities have a focus on the prioritised industry sectors.

Norway part of the EU

New directives have come into effect after Norway became part of the EU. The role of the Directorate of Fisheries has been toned down. The environmental requirements which were formerly different between Norway and the EU countries are abolished. EU research has become even more central for the fish farming industry.

Norway outside of the EU

"Norway becomes a tax paradise for the marine sector."

Norway becomes a tax paradise for the marine sector. Foreign companies receive tax concessions by investing in Norway and to invest in Norwegian marine R&D. Norway has gained solutions at the WTO-level with free-trade agreements. Norwegian national capital has established companies in the EU that process fish and are active owners in multinational companies.

Aquaculture collaboration EEA – Japan/ Russia

A vital collaboration has been established between the EEA and Japan/Russia in relation to international policy, trade and foreign policy, and research policy directed towards the aquaculture industry.

"Meat products are out, seafood is in."

- Norway leads in Arctic products
- Every region takes their products onto the global market, also markets where they compete with one another
- Coordinated R&D collaboration
- Norway has vital know-how, especially on Arctic products
- Meat products are out, seafood is in
- The health and environment aspect is extremely important

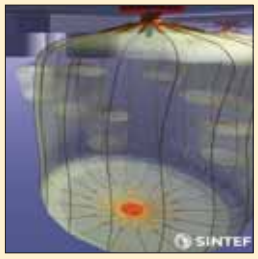


Foto: Sintef

Research-policy Norway in 2020

Norway has developed as a knowledge society

- 4% of the GNP is invested annually in R&D
- Companies invest up to 10% in research in addition to public investments
- Project activities enhanced through Centres of Excellence together with public authorities and industry actors
- There is a conscious investment in reaching explicit goals
- "The free idea" is favoured with less than 20% of the allocations to research
- Norway is an international leader within the 4 topics we invest in – of which one topic is within aquaculture, which holds great attraction for the best researchers, also internationally. The final decision was made in 2006.

Norway – Europe's aquaculture nation

- Gabrielsen stepped down in 2004; we have since had a hard-hitting industry-focused innovation and research policy
- Aquaculture is chosen as an investment area in the Research Report of 2005
- Aquaculture is a central theme in a new and comprehensive innovation policy
- Norway became a member of the EU in 2007
- Coordinated administering agency for R&D and commercialisation
- Adapted framework conditions for investing in aquaculture; that means that Norway is attractive internationally also for the EU. Norway is a production nation for the EU. No dark clouds

Coordination of national and international policy


Foto: Photo Disk

- Traditional regional policy has been phased out, primarily due to a lack of consensus in the regional commission report
- But the public authorities monitor the environment and set the social framework. Otherwise there are no hindrances. The industry policy has been replaced by R&D policy and Norway has a Centre of Excellence within studies of primary- and by-products from marine resources in aquaculture. This provides the basis for development of functional food, development of new medicines and for Norway being able to foster an internationally leading ingredient industry
- Norwegian aquaculture production has a niche character in 2020
- Fishery resources that are well managed – a great asset
- The salmon industry is large due to systematic comprehensive thinking (breeding, environment, feed/nutrition, tending), in the long-term based on large experiential databases. The Fishery and Aquaculture Research Fund (FHF) allocates NOK 3 million per year for 15 years. And the salmon industry is very competitive.

The non-competitive Norway: the last oil

The focus in financial policy has been on the oil revenues and future retirement costs. The solutions chosen are focused on dividends from interest on earned incomes. The yield curve showed the need for increased interest rates in Norway. The average interest rate in Norway has been 3% above the international interest rate.

Price increase as a basis for the currency and interest policy was in 2005 reduced from 2.5% annually to .3% annually. The Norwegian krone strengthened 5% annually. The export industries were for the most part discontinued. Norwegian production is made up of protected industries based on national purchasing agreements. Wild catch resources are sent frozen directly to the EU/the consumers. Fishing vessels are registered at the Norwegian International Shipping Register (NIS) and one has the same schemes as the shipowners industry. The fishing vessels are manned by Asian crews. Large aquaculture activity (with different types of fish products) takes place along the coast. The production is out-sourced. All input factors arrive refrigerated in Norway. Norway is the only EEA member.

The competitive Norway

Focus as in the scenario "The non-competitive Norway". The solutions one chose were focused on revenues from future increased added-value. The interest level was maintained at an international level. We imported a price increase. The focus was on currency stability and has changed from being trade-weighted to competitor-weighted stability. The export revenues from traditional industries increased by 2% annually from 2003. Aquaculture is an important export industry. Increased immigration.

The investment strategy for the Petroleum Fund is connected to industry development in Norway. The Petroleum Fund owns considerable portions of the distribution channels for seafood and participates actively in the connection between distribution in the markets and added-value in Norway.

Wild fish versus fish farming – the added-value coast

Wild fish and aquaculture go hand in hand and contribute to one another's success. Increased knowledge about interaction gave in 2007 a completely new image of the relation between fishery and aquaculture. Research shows that the aquaculture activity contributes to an increased amount of nutrients for fry, which increases the benefits from wild production by 100%. This has contributed to an increase in wild fish stock along the coast. Catch fields lie in the fish farming regions, bio-production has increased. The Sea Ranching Act has been expanded and Norway has an environmentally-friendly marine industry.

"Wild fish and aquaculture go hand in hand."

The peace-making role

Norway is a member of the EU, division of labour is controlled and out-sourced by the EU. This has led to Switzerland and Finland taking over as the leading developers of technology and new innovations. Sweden has culture, Spain/Portugal/Scotland/Iceland have fish, Norway has PEACE and conflict resolution. The funding is distributed as 50% regionalised and 50% centralised initiatives. The significance of national borders is reduced, the nation state is weakened, the level of democracy has increased and there is increased regionalisation.

Norway is part of three regions: the Barents, North Sea and Baltic Sea Region.
A net controlled/virtual parliament plays a central role and the different levels of administration are spread throughout Europe.

Actors

Companies

Multinational companies with a broad product range dominate the industry

After several years of limited access to equity capital, the Norwegian aquaculture industry is to a large extent owned by companies with headquarters and owners outside of Norway. A few multinational companies dominate the market. 20% of the companies in the industry represent 80% of the production. The key groups specialise in 5-7 different farmed species and all have a well-developed marketing system. Products based on by-products comprise approximately 35% of the sales volume. Research activities are purchased on the international market, because among other reasons, Norwegian researchers have become too costly compared with (and in competition with) foreign researchers. Fish farmers work predominantly on a contract basis for the multinational companies.

Foto: K.J. Merok/Matforsk

Norwegian-owned integrated companies with national ownership shares

A large Norwegian company has a dominating position in the industry. It has been difficult to acquire capital and the government has purchased ownership to ensure that the company competence remains in Norway. The company is vertically integrated and the feed sector is an integrated part of the company's production activities. Feed production to a large extent is based on marine raw materials and comprises as such a natural part of the aquaculture activity. It is considered to be strategically important to have control over feed production as well as fry production. Special Norwegian competence is used in this integrated company but a part of the competence is sold to foreign enterprises, in Norway and abroad.

Small and medium-sized companies in networks

The industry is made up of many small companies that work together according to a cooperative model. The companies and organisations are owned from below and upward. Norwegian salmon and other farmed species are of a high quality and are manufactured according to approved standards and in well-defined qualities. The industry is characterised by a large abundance of products; a number of niche products have been established after a lot of trial and error. Cross-ownership and use of joint technology is common. Joint sales companies are established and research is focused on reinforcing the manufacturing side in relation to the market.

Food fish production located close to the consumer

"Norwegian salmon has an even greater prestige than today"

Environmental deteriorations in the ocean, along with new manufacturing methods in fish farming have resulted in the Norwegian coastline no longer being a nature-given advantage for the aquaculture industry as it was previously. In 2020 innovation has been based on scientific knowledge about breeding processes and new technology has made it efficient, safe and profitable to operate food-fish production in land-based installations, where re-circulated water and artificial light provide an optimal and safe environment for growth. Production and slaughter are in this way located close to the large markets and this has led to fish of a high quality and safety and greatly reduced transport costs. Effective logistics and process management ensure that "catch of the day" fresh fish is delivered to all large markets. Traceability is very good and is an integrated aspect of production and distribution. Very few farming installations remain in Norway. Norwegian actors have earned a lot of money from sales of the competence developed by the fish farming industry leading up to 2010.

Foto: K.J. Merok/Matforsk

Slaughter and packaging at the same location

The aquaculture industry is strong in Norway. Consumption packaging in 2020 takes place to a much larger extent in the same place where the food-fish is produced and slaughtered, namely, in Norway. Wages are still high so we are not competitive when it comes to manual production. But the tariff barriers before the large markets, such as the EU, are gone. Technological innovation has made possible a capital-intensive, little demanding automated production, which results in ready-for-consumption Norwegian products becoming competitive outside of Norway. In 2020 manufacturers know much earlier what the salmon is to be used for and who will buy and this has made possible a development of new product segments and products tailor-made to different types of buyers. Specialised niche-companies can deliver special products to different customers and the quality can be of such a nature and of such a level that price/"performance" is satisfactory for a large range of customer groups. Norwegian salmon has an even

greater prestige than today and has become a protected brand along the same lines as Parma ham was 25 years ago. The framework conditions for aquaculture have been significantly improved and we compete successfully with pork export from Denmark. Chile and Norway continue to have the best parameters for fish farming and the natural farming conditions remain vital to the aquaculture industry's production capacity and profitability. Chile has suffered a series of serious setbacks over a 10-year period due to fish disease.

National strategic companies have revolutionised Norwegian aquaculture

The company Protein AS has in the course of the past 20 years revolutionised Norwegian aquaculture. The company was established as a strategic investment based on Cermaq, which reinvested surplus from Chile in Norwegian salmon production. At the same time, the Norwegian Parliament approved the allocation of NOK 6 billion to strategic subsidiaries for the development of Norwegian cod farming, lumpfish, and sea ranching of scallops. A unique combination of oil capital and raw materials has made this possible. Among other things, a 400 km pipeline has been built to enable use of natural gas in feed production, The result was an incredible tenfold expansion of salmon production, 300,000 tons cod, 20,000 tons high-priced lump-fish and export of 10 million large, living scallops packaged in a modified atmosphere. The strategic companies are now private, Norwegian-owned and have paid back 3 of the 6 billion that the government contributed (as agreed). Oysters and halibut have now also shown a positive development, based on private initiatives and knowledge from research performed in the strategic companies.

Norwegian breeders own EU refiners

Norwegian breeders form binding collaborations and create their own sales organisation. These create key logistic centres in France and Poland. Through market dominance they attain extremely favourable feed contracts, which lead to a large reduction in feed purchases. Increased surplus is used to invest (buy upward) forward along the value chain, towards the refiners. Through increased competitiveness – centralised warehouses – they oust the non-owned refiners. The company's strategy is concentration in all links and efficiency.

AS Altifisk is Norway's third largest manufacturing company

AS Förogfix, Norway's largest feed and smolt company continues its integration strategy and growth philosophy having a few years before taken over AS Fiskeproduksjon, which has factories in France, Germany and the UK. Now Förgofix purchases the Danish logistics company AS Rettfram, which is Europe's leading logistics company for fresh seafood, and establishes AS Altifisk. AS Altifisk becomes the first Norwegian fully-integrated company in the aquaculture sector and controls 60% of the Norwegian fish farming industry from feed to the table. Strong forces have for more than 20 years worked towards the establishment of such a company but the EU has constantly had objections because Norway is not a member and the EU wants to protect its own fish farming industry. Now the establishment is a fact and it is anticipated that other Norwegian fishery companies will collaborate closely with Altifisk, not least in terms of logistics, sales and marketing. Altifisk's chairman of the board, Stein Bit reports that the company is looking closely at the existing possibilities for commercial collaboration and emphasises that an affirmed objective is to keep the company in Norwegian hands.

"...the EU wants to protect its own fish farming industry."

Norwegian food-fish production in the hands of one

The revolutionary environmental organisation "No Death" (the organisation works for all animals being allowed to die of natural causes) in 2015 bought up all of the food-fish licenses in Norway. This was made possible after the licensing-hold was abolished in 2010. "No Death's" philosophy is to convert the food-fish installations into recreational centres where foreign tourists can go diving together with the salmon. The salmon is harvested only as dead fish (from accidental or natural causes) and "No Death" harvests the salmon for the unique anti-carcinogenic substance for which they have a global patent. This anti-carcinogenic substance gives "No Death" significant economic growth.

Key phrases:

- Production only at a few locations
- Most fish farming installations are shut down
- The salmon slaughterhouses are torn down
- Widespread development of a tourism infrastructure in connection with the few remaining installations

Foto: Fredrik Naumann/Samfoto

"Recreational centres where foreign tourists can go diving together with the salmon."

Status-quo in the basic structure

No large changes! The current ownership structure is maintained in that the salmon price is stabilised at an acceptable level and gives a marginal return on the equity capital. Innumerable attempts to abolish the licensing-hold have not succeeded. This has led to the structure on the ownership side remaining in place. An individual MO – manufacturers organisation – has been formed and there are strict production regimes. The only possibility for maximisation of profit has been to establish centralised marketing and sales. 70% of the limited companies that do not have a stock exchange listing have entered collaborative agreements with Lerøy.

The aquaculture industry today (2020) is primarily made up of the mergers:

- Marine Harvest + Pan fish – Pan Marine ASA
- Fjord + Cemaq – Max Fjord ASA
- Lerøy + independent fish farmers – Lerøy ASA AISF
  (Lerøy Association of Independent Salmon Farmers) in collaboration with Lerøy

Research, education and competence communities

Foto: Photo Disc

Privatisation of knowledge

As owner of a large pharmaceutical company, Røkke establishes a marine technology research centre (focused on aquaculture) in Tromsø. The purpose of the centre is patenting and exploitation of genes in marine organisms that have a large earning potential. This applies to bio-medicinal and biotechnological products. This initiates the farming of marine organisms for bio-medicinal purposes. Another patenting area is new feed types.

Large-scale operations and group control

Norwegian aquaculture is controlled by large, international food product groups with internal research units. Their control is based on superior systems for logistics, market contact and control of a superior, patented feed technology. Most of the applied research is privatised, while the government concentrates on financing basic research. Extensive collaborations have been established between the research-based aquaculture industry and the universities.

Organisation of research

The government and the Research Council have established a national division of labour between the R&D sector in Norway and abroad. This has created larger, more interdisciplinary environments, qualified to address composite, complicated problems and assignments. This was brought about through the geographically virtual collaborative forms connecting the Norwegian institutes. Both the industries and the public authorities have gotten past the territorial and sector conflicts between the fishery and agriculture sectors. The result is better-organised Norwegian research with good international connections and an effective collaboration between industry and research.

Foto: Eksportutvalget for fisk

The Norwegian aquaculture industry the most efficient in the world

A key tool for achieving this result has been a heavily public-financed research system and an administering agency that has effectively contributed to transmitting new technology and new knowledge into the industry.

Success for the Norwegian Aquaculture University

The Norwegian Aquaculture Industry has after many years of effort patented an immunity stimulating vaccine for fish farming. The vaccine protects against 10 out of 12 of the most serious diseases in fish farming which implies that farmed cod can now be certified for trade within the EU.

"Researchers from all parts of the world study marine biology in Norway."

The Swedish Academy establishes a new Nobel Prize in biology

The objective of the prize is better global exploitation of resources and food production. As an internationally recognised pioneer nation, Norway has been asked to award the prize along with the Peace Prize. Researchers from all parts of the world study marine biology in Norway.

Norway is depleted of researchers

Through integration of the European Research Arena (ERA) the central Norwegian research institutes within the field of aquaculture received marginal positions. What once were suc-

cessful communities for Norwegian aquaculture research have been depleted of the best researchers and the most gifted students, as everyone is running to the central European institute in the south of France. After aquaculture research disappeared, the aquaculture industry has lost its competitiveness, and is heavily diminished.

Norway's greatest export product = knowledge

It has grown too expensive to manufacture goods in Norway. The fish farming industry in Norway has a more experimental focus. It pays for breeders to produce knowledge at their installations instead of fish. Knowledge has always been inexpensive in Norway and knowledge is now the country's most important export product. This applies to knowledge about salmon but to an even greater extent is connected to production of marine fish and especially marine hatcheries and fry production. Norwegian companies own and operate hatcheries all over the world. In addition, Norwegian companies have a leading position in supply of salmon roe thanks to patented improved characteristics. The Research Council modified its prioritising, became a foundation and now works exclusively with competence development for aquaculture. 30% of the Petroleum Fund's dividends are put into the knowledge industry. This contributed to the companies' eventually taking on a greater responsibility for innovation and in-house research.

"...knowledge is now the country's most important export product."

The fish farming companies have given knowledge a position in Norway. The competence communities in Norway have safeguarded royalties and patents. Norway also owns large portions of the fish farming industry abroad. Norway has succeeded in the link between the market and knowledge development. There are Norwegian interests throughout the entire value chain.

Knowledge exists all the way to the ready-for-sale product. The mentality is from the market backwards and it is global.

2020= 0 Escape from fish farming installations

In 2012 all installations received fish farming certificates and are type approved. Further development led to all installations in 2020 being totally escape-proof. New materials technology detaches fish farming from old limitations. New methods for dimensioning, design and choice of materials make installations escape-proof. New seine concepts and customised surfaces are implemented leading to zero fouling. Condition monitoring methods make possible timely component replacement. This development is realised through an interdisciplinary collaboration between biological and technological communities where also collaboration with materials technology is important. Experience from space technology and knowledge from space research provides new materials. Self-reparation processes, self-correction of errors are an effective part of this new technology. In Norway aquaculture has become a demanding customer for materials development.

"...all installations in 2020 being totally escape-proof."

Antidote for food poisoning

Foto: Photo Disc

Biotechnological research is the basis for this new development. The expression "you are what you eat" has definitely lost its validity. One goes from prophylaxis to therapy. Membership in the EU enables free flow of most everything. The doctrine of safe food was abandoned because research has come up with effective antidotes that can be taken in pill form. It has become in fact economically and politically impossible to produce safe food. On the other hand, consumers are able to rid themselves of the toxic substances that the food may contain. Children from the prosperous segment of society are vaccinated against food poisoning. Poor countries cannot implement this prophylaxis, leading to greater contrasts between north and south. The fish can be produced close to the markets. The fish is also fed pills or vaccines so it stays healthy enough to be swallowed. The fish farming industry produces very inexpensively and with good profits, often in drainage water from oil and other heavy industry where fish farming has been introduced as a purification measure before emission. The only restriction is the requirements imposed on the fish's health and well-being.

"The principle of a neutral industrial research and industrial policy disappeared."

Norway made its bet and won

The principle of a neutral industrial research and industrial policy disappeared after the parliamentary election in 2005. An annual NOK 20 billion was invested in innovation-based industry development within aquaculture. Tax exemption programmes and Aquacasino (Laks Vegas) that are run offshore also mean significant capital injections to the industry. More money means more research; advanced foreign researchers are brought in from abroad to the newly established aquaculture university. This university has set up satellite universities in many countries. The result of a fusion process of many competence sectors in Norway leads

to the best minds giving Norway a leading global role. This national investment has given Norway total dominance on a global scale in international fish farming.

Problem of salmon lice abolished

Through research on breeding and new vaccines, a protection from salmon lice has been discovered for farmed salmon. Natural selection in wild salmon leads to resistance to salmon lice.

Industry organisations

All power to the companies

"...the international large companies see the possibilities for establishing technology development under more private direction.

Price collapse and a downward trend in the industry in 2008-2010 are followed by a total collapse/depression, over-production, price reductions, betrayal of confidence in large consumer groups, etc. Another collapse occurs simultaneously, namely within the public knowledge policy and technology development. But the possibilities in Norwegian aquaculture are still present. Now it is the international large companies that see the possibilities for establishing technology development under more private direction. This also enables the emergence of international manufacturer organisations (MO), run by these multinational companies. As the first link, production control has been implemented, but experience results in the building up of a stronger management of the MOs' competence. The focus is directed towards competence, research, and raw materials access. The multinational companies are in charge of the entire international aquaculture regime.

All power to the green

In the years before 2020 clear market growth and an organisation of green organisations took place. This includes consumer organisations, grocery chains that operate with a green profile, and protest organisations such as GreenPeace. Animal Protection Organisations (NGOs) are also important. This has occurred as a result of the formation of a balance between food product supply and population growth. A coordinated organisation of these movements has created a significant instance of power, which the Norwegian aquaculture industry has had to contend with. This pertains to animal welfare, use of beach areas, escape of farmed fish, pollution (chemicals, feed remains, medicine). This has led to a significant price-hike on finished products. Attending to all of these considerations has also contributed to the development of new and price-increasing concepts for fish farming. The positive health effects of salmon remain and a stable, well-paying market has been developed.

European organisations dominate

The Norwegian Confederation of Trade Unions (LO), the Confederation of Norwegian Business and Industry (NHO) and the industry organisations of today have merged with the corresponding EU organisations. They have changed their focus from a concentration on wage and working conditions to professional and industrial development. They have great power and influence in the EU system and are initiators of change in acts and regulations. LUBC is established to develop the local and national marine industries, and LUBC is also connected to the corresponding EU organisation.

"Anarchy reigns."

Special interests and conflicts in Norway

Anarchy reigns. We have wallowed in prosperity and are not able to join forces on any strategic choices or create a consensus for anything. The industry organisations battle over money and positions. There is significant splinter activity; green waves meet with blue, red. The yellow organise (north-south organisation in global production). Norway fights at home and behaves like the angel of peace out in the world. The consequences are that added-value is low; the public sector grows since all special interests are to have their home, and a career in lobbying is the most promising. The Norwegian School of Management and the Norwegian College of Business Administration wrangle over giving the best lobbying courses. The Research Council is still developing DocuLive.

Norway a member of the EU

Norway becomes a member of the EU in 2010. This has led to free market access for processed fish products for a market of 3-400 million consumers. This has also offered access to more resources for R&D objectives so it has been possible to realise prioritised projects, which have

generated breeding of new species, new processed products, biochemicals, etc. EU-membership has led to the national marine resources becoming part of the EU's joint resources. Administration and management of these resources is located in Norway, which creates a competence centre of gravity in the region. Increased demand for fresh, processed products has led to new alliances between European supermarket chains and Norwegian coastal groups that take care of all processing. Production of fabricated consumer products in Norway has also led to valuable by-products not being sold outside of the country. Industry based on these raw materials has finally obtained stable raw material access.


Foto: Eksportutvalget for fisk

Large groups administrate the majority of Norway's marine resources

"The industry is controlled by a few actors."

- Partial abolishment of ownership restrictions
- International food giants are the largest owners
- Norwegian Seafood Federation (FHL), EFF, the Norwgian Raw Fish Organisation are weak or non-existent
- The licensing system – political control of quotas and area is carried out through time-limit licenses
- Groups acquire market quotas allocated by the government. This leads to a greater focus on added-value per unit (quality instead of quantity)
- The industry organisations are weakened
- Strong brand goods are established
- Greater stability, more secrecy with regard to information
- The industry is controlled by a few actors

"Many coastal communities collapse..."

FHL Aquaculture is proactive and run on the industry's terms

- Stronger FHL (The Norwegian Seafood Federation)
- Expanded influence in control of the research investment
- More applied research with industry influence
- Small actors obtain greater influence on decisions in the organisations
- The most important actors with regard to setting terms in the industry are the largest and medium-sized members of FHL
- FHL becomes the government's collaborating instance in the formation of aquaculture policy (assumes role as fish farming directorate)

Industry organisations talk politics – Party of Progress as supporting player

- Fish farmers complain about competition-restricting conditions
- PoP promises to lighten the acts and national restrictions
- FHL gets a PoP dominated board
- PoP constitutes the government
- Leads to power being shifted from courts and councils to companies
- One envisions strong growth in aquaculture with less market, environmental and ownership control
- Aquaculture becomes the most important industry with strong concentrations
- Many coastal communities collapse, area conflicts increase (fishery/recreation)
- Large oscillations in the economy, many bankruptcies (the growth cannot be controlled, but follows the market)

"The environmental quality of the products is high."

WTO promotes aquaculture in the 3rd world


Foto: Dag Jenssen/Samfoto

- WTO removes trade restrictions on the 3rd world
- Removes direct and indirect subsidies in the current industrialised nations
- The World Bank supports establishment and the transfer of knowledge to the 3rd world
- Quick growing tropical farmed species are heavily increased as a part of total and global fish farming production and as a share of protein consumption in Asia, Latin America and Africa, which leads to increased export to western markets at low prices
- The environmental quality of the products is high
- The products are perceived as politically correct and at the same time, exclusive
- Strong competition for fish farming

Serious resource conflict between FHL and the Norwegian Fisherman's Association (Fiskarlaget)

A serious conflict has arisen between FHL and the Fiskarlaget regarding area, fishing resources and market access

- Norwegian Raw Fish Organisation obtains control of all primary trade of all marine farmed fish
- Heavy restrictions on when farmed fish can be traded to avoid competition with the wild fish trade
- FHL gains very little opportunity to develop offshore-farming and controls restrictions on area expansion on the coast
- Fiskarlaget contributes to political scepticism towards a foreign-owned fish farming-industry which increases the pressure on the wild fish resources out of fear of losing national control of these resources
- Fiskarlaget opposes the farming of new species that are already caught wild
- The fish farming industry hits the wall with regard to area, feed and market access
- The wild fish industry controls the development on its own terms

Investors

Norwegian Raw Fish Organisation in interaction with the oil industry

"All the fish and water are ozone-treated to avoid the spread of diseases and parasites."

After the large oil catastrophe in 2006 with the blow-out at Frigg, which killed most of the fish stocks in the North Sea, the oil industry had to carry out drastic measures to develop new goodwill. Together with the Norwegian Råfisklaget, great sums were invested in the building of production installations for the production of fry for both sea ranching and standard fish farming. Parts of the fisheries are completely re-built for capture of live fish, which among other things, are exported by plane to Asia in containers irrigated with oxygenated freezing water. Especially in China, which has a population of 2 billion, this has been a great hit. All the fish and water are ozone-treated to avoid the spread of diseases and parasites and WHO approved the method in 2017 as the safest method for transport of live seafood.

Environmental organisations however are working very actively to bring this to an end, based on the view that this is wasting energy resources.

Financial investors in the cod industry

After Norway became a member of EU in 2008, financial investors in Europe have extracted large gains from Norwegian cod farming. After the breakthrough in fry production in 2003/2004 this segment of the Norwegian aquaculture industry has been extremely profitable but since the surplus is milked away by investors, the development has stopped, also due to a lack of R&D efforts. The adventure in the north, with investments from both Russian capital interests and from the regional funds of the EU has also had a catastrophic development. Special interests/the indigenous population demanded rights on the planning, production and profits and the large facilities in Finnmark and Troms that were built up to 2015 are now inactive. Norsk Kjøtt and Tine, which because of the EU membership lost their customer-base in competition with European manufacturers, are in the process of gaining a stronger position as owner of an installation for farming of rainbow trout for export to Asia.

Icelandic trawler company controls Norwegian cod farming

After having for a long time bought up international quotas for cod fishing, the Icelandic fishery company "Toske Heimat" has bought up 60% of Norwegian cod licenses. The farmed cod is an important supplement to wild fish and ensures the fleet and the Icelandic fish industry activity in low activity periods in the fisheries. The Icelanders slaughter and package the cod onboard their vessels, which has led to a considerable reduction in activity for the Norwegian fish industry.

Foto: Eksportutvalget for fisk

Farmers and fishermen – hand in hand

Norsk Kjøtt, Tine and Norwgian Raw Fish Organisation's investment company Marinvest have established the investment company Produsentinvest and are buying up fish farming companies on a large scale. The objective is to be an active industry developer within all the important sectors of Norwegian food production. A prioritised area is building successful brands in sea-food equivalent to Jarlsberg and Terrina. Simultaneously, Produsentinvest wants to ensure Norwegian companies a foothold in the fast-growing Asian markets. Through the establishment, Norwegian farmers and fishermen now jointly control also the large manufacturers and exporters of Norwegian food products to the EU and USA and thereby some 60% of all Norwegian food product manufacture. Produsentinvest wants to build Marian into the international seafood brand and it is therefore anticipated that several fish farming companies will further question the value of the Norwegian Seafood Export Council and the Norway-brand.

The government active through the Aquaculture Fund

- The government develops new species
- The price of feed is high
- The government wants out

Due to extremely high costs in connection with the development of new species, the government forms a national aquaculture fund. The fund is to the guide the development forward until commercialisation is made possible. The form of the Aquaculture Fund is that of the current seed-programme but the profile for investments is 10/90 private/national. The government has hereby been willing to carry a significant part of the burden of generating new species. The developmental costs have become considerably greater than anticipated at the time of establishment of the fund. In 2020 commercialisation of new species is a reality and the government wants out. Because of global warming, the regions around north-west Russia have not been iced over for the past five years. This can make fish farming possible as far north as Novaja Semlja and has led to Russian oil companies (those operating oil extraction in the Barents Sea) viewing the Norwegian development with interest and buying the government's shares at a heavily reduced price.

Development calls for great resources

Advanced technological products take time to develop and require capital.
Investors only operate venture funds and mutual funds – and counteraction of such is a large and difficult task. Some are speculative and are willing to enter at an early phase. But this assumes that the aquaculture industry is attractive and in possession of R&D communities with specialised competence (Centres and Networks of Excellence – Gold Coast). These must be a part of a global / regional R&D network and must be working on projects which the investors can believe in. The public sector must take responsibility for both contributing with "patient" capital, allowing long-term thinking and predictability. The public sector must also take responsibility for building up the R&D communities needed. A large R&D fund will be a key tool.

"Advanced technological products take time to develop."

Cluster-investor – the investor of the future

The investors of the future require public investments and public contributions to research in new and promising areas. Market plans must be in place; one must have thought through a comprehensive strategy for the development one initiates and not just be myopically concerned about specific technical or knowledge-related problems.

The investors take the development tasks seriously; they invest heavily where reduced risk can be expected and if it is clear that those who actually put in risk capital will have possibilities to derive later gains. With goal-oriented sound projects, it has proven possible to realise a longer timeframe with investors than what was formerly common; 2-5 years.

Foto: Per Eide/Samfoto

The Aquaculture Fund – interaction between the public and the private

- Public framework conditions (tax-related, etc.)
- 50/50 public and private capital
- Modifications that will make it expedient to join forces in a large, target investment
- A condition is that the public sector has already contributed to financing basic research
- The fund may also be regional

The splintered investor community

- Private investors are key
- Finance capital for the average Norwegian has since 2003 increased from approximately NOK 500,000 to NOK 2 million. This type of investor comprises approximately 25% of available investor capital.
- Reserve capital: Low risk willingness
- Institutional investors: banks, insurance companies
- Public reserve, mutual funds, venture funds (public/private)
- Majority of the concept-development funding comes from private (angels) and will be highly focused on added-value benefits. Here there is a great willingness to assume risk.

Public Authorities

The Ministry of Food – a simpler Norway

"We are a reference nation on marine food resources."

Ministries of Industry LD and FID are integrated with industrial funds in the Ministry of Food NMF (the Norwegian Ministry of Food). The Ministry of Food has total responsibility for fjord/earth to table in Norway (in other words, the entire value chain). At the same time official forums have been established between the Ministry of Health and the Ministry of Food to ensure research on food as medicine and health effect. The political structure in Norway has been changed to five regions (counties/municipalities) and the administration of these is carried out locally. The Food Inspectorate has been further simplified. The Norwegian Ministry of Food has acquired international administrative responsibility for marine resources in the EU. Research on and documentation of seafood done in Norway determines the EU regulations. We are a reference nation on marine food resources.

Foto: Hvide Bang/Samfoto

The industry is destroyed by pollution

Increasing public costs, expensive tariff settlements, costly social reforms, pension programmes all remain unsolved problems. At the same time the oil revenues are dropping. (Iran/the Middle East are stabilised, the value of the dollar drops, etc.) Many unfortunate and simultaneous circumstances lead to a collapse of the established economy. The government transfers the costs to a successful aquaculture industry and increases the taxation on the industry. This leads to the industry itself not having the financial backbone to invest in preparedness and further development. Or: The public sector has neglected to drive forward long-term developmental projects, so the industry is run in an extremely traditional manner. In this situation a serious pollution accident occurs where oil tankers run aground at Mongstad or large oil tankers collide or atomic waste is released into the ocean after a ship on its way to Russia runs aground on the coast of Western Norway. The demand collapses and the production terms in the south are destroyed overnight.

Post EU – regionalised policy

"The Nordic region has appeared as a reliable and good supplier of seafood.

An expansion of the EU to continually new areas in Europe, North Africa and western parts of Africa has accumulated/generated internal regional and ethnic conflicts. This has led to a regionalisation (split) of the European Union into a number of larger and less autonomous entities. This had led to the Nordic region comprising a considerably large domestic market. Beyond this, unlimited market access has been acquired to some regions and more limited access to others. Together with Russia and Iceland the Nordic region has managed to retain sovereignty over marine resources. The Nordic region has appeared, in the eyes of other paying industrialised markets such as the USA and Japan, as a reliable and good supplier of seafood. These markets have emerged as large buyers of more processed Norwegian products. This has more than compensated for the insufficient market access one now has to the EU for processed products.

Aquaculture gives growth and prosperity

Norway has taken innovation policy seriously. There is a new paradigm in the social economy and political science, a new generation in the industry and in the public sector. The break with a so-called industrial neutrality policy is obvious and the focus is on the aquaculture industry through a "simpler Norway". This has contributed to aquaculture in 2020 emerging as the most financially strong industry in Norway. It provides the basis for large national revenues; we have a close partnership between the actors (Trippel Helix); trade & industry, the public authorities and the university and college sector have joint strategic visions and plans of action in both the short and long-term. They function well in a good dynamic collaboration and as demanding customers with clear requirements with regard to one another's delivery proficiency. National leadership has become a sought-after position – professionalism is high at all levels.

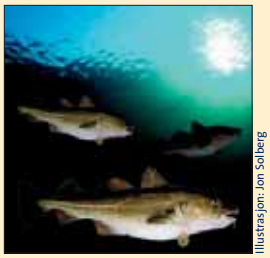
International authorities focus on energy

"International energy crises have resulted in a depression."

International energy crises have resulted in a depression and the need for a powerful transformation in traditional production. This is reinforced by environmental activists and developing countries, who think that it is now the developing countries' turn to exploit the global resources. The so-called 1st world must spend capital on the development of new work methods and there is danger of war. The aquaculture industry is in crisis, people are hoarding food that can be stored; the demand for marine products with limited keeping qualities has

radically dropped. Intensive research is being done on developing marine dried products with a shelf life of at least 2 years and with 0 energy investment (solar and wind power have now seen a definitive breakthrough).

Norwegian salmon gets BSE – cod farming has a breakthrough


Illustrasjon: Jon Solberg

Prions mutate and spread to marine animals. Salmon farming is affected as the disease spreads through the feed and through the water environment. R&D resources for generating alternative feed resources do not arrive in time. Due to a lack of new feed resources, the waste from fish farming as well as poultry waste and maybe even slaughter waste are used as feed for fish. The "better safe than sorry" principle was abandoned earlier and there was a complete lack of control. The EU waste directive for animal by-products was not good enough. The disease was also transmitted to humans and in large markets several thousand fell ill after having eaten salmon and many die. R&D funding is poured in and control is acquired over the problem. A Norwegian delegation headed by the king travels to important countries to publicly apologise for what has happened. All remaining salmon must be slaughtered and the salmon production must start from the beginning with a point of departure in the gene banks that have been established. The occurrence however leads to a breakthrough in cod farming.

Norway – the eternal raw material manufacturer

Norway is in 2020 still not part of the EU. All European countries are in, except Norway, Switzerland and Liechtenstein. (a) Norwegian interests have managed to acquire significant ownership in refining facilities and chains in the EU. Profits are good. The industry has taken responsibility and is banking on R&D. A number of species are farmed in Norway using new, cost-effective methods. (b) Norwegian interests have not managed to obtain ownership in refining installations in the EU. Breeder price approximates production costs. China has become the new market for raw materials from Norway. China has become the great refining power. Russia and China have become the new market. But due to this narrowing of the market, the industry has great problems achieving further expansion and eventually loses its competitiveness and fades away.

"The control system and the public certification of salmon established in Norway are applauded in the EU."

Salmon = the healthiest and safest food

Through long-term investment and strategic collaboration Norwegian R&D communities have developed methods and systems that provide the basis for enabling complete control over all seafood production. This provides a foundation for the implementation of strict control of feed resources and production. We have defined health characteristics in seafood and control of the finished product. The Food Inspectorate is an important participant in the implementation of this and has contributed to resurrecting Norwegian salmon as a quality product. The control system and the public certification of salmon established in Norway are applauded in the EU.

Only three fjords allowed fish farming


Foto: Edelpix

It has become simpler and cheaper to travel and people are willing to pay handsomely for special holiday trips. The public authorities in Norway show a considerable interest in the tourist industry. This is based on several persons from the tourist industry having key political positions. In the USA a president is elected with roots in Hardanger and this also has repercussions for the expansion of the tourist industry in Norway. Reports stating that farmed fish oppress wild fish and other species in danger of extinction have resulted in the public authorities and the consumers becoming more sceptical about fish farming. Recreational fishing is an important aspect of the profiling of Norway in international tourism and has taken over coastal Norway. Tourist trade based on sport fishing eventually becomes extremely profitable and other activity must retreat. A conflict of interest develops over area-use and farming is only allowed in a few fjords. In the three fjords mussels, scallops and algae in particular are cultivated. Other fish farming is moved offshore. New materials and constructions have contributed to solutions where floating elements for farming of mussels are integrated parts of floating bridges. Profitability in the mussels industry has led to the fish farming companies contributing to large floating bridge projects. Toll money contributes to yield on the capital. In the Hardanger Fjord several large floating bridge installations have been established according to this principle.

"Tourist trade based on sport fishing eventually becomes extremely profitable."

The Truman Doctrine inhibits growth

Strict industry requirements lead to the public authorities' "better safe than sorry" principle in administration being abandoned, although there is no basis for a knowledge-based adminis-

tration. The industry however does not listen to the surrounding world and does not adapt to the new requirements. Salmon lice and fugitive salmon are growing problems, but the industry operates nonetheless as before. The conflicts increase; the industry does not pick up on signals from society before it is too late. The public authorities must finally step in and press through new administration systems based on the "better safe than sorry" principle. Strict requirements for zero-emissions lead to regulations from the public authorities taking over. The Norwegian salmon capital flags out and relocates to Chile, with support from the Norwegian Pension Fund.

The industry dies because residents move away

"People move to the big cities in the south."

The public authorities do not succeed in carrying out IT investments in the north, the building of broadband, roads, communication and school systems stops. Public expenses go solely to health and pension. The basis for abundance in trade and industry falls away. The industry does not purchase local services any longer, does not feel obliged to maintain local industry activity. The industry cluster idea is not well received. Coastal Norway is levelled. The coastal areas are vacated. People move to the big cities in the south and to Southern Norwegian coast.

Opinion formers

Opinion formers

The Crown Princess of Norway begins studies in marine-biology in Tromsø. "This is a fantastic signal," states the headmaster at the University of Tromsø. Talented young people from all over Norway apply to Norwegian aquaculture studies.

The media controls public opinion with regard to food product safety

Aggressive media companies use Norwegian researchers' disagreement, uncertainty and lack of answers about Norwegian fish farming being dangerous to the health as a means of attracting readers and viewers. They receive assistance from the nature conservation organisations. Researchers and environmental administration are in conflict. The researchers meet this pressure by focusing more on preparedness research. The public authorities, the research community and industry have developed a professional and coordinated information service, which works actively to establish research-based, international systems for food product standards that are accepted as a legitimate guarantee of food product safety and control.

Foto: Trym Ivar Bergsmo/Samfoto

"...showing beautiful images of contented farmed fish in a beautiful environment."

Public opinion moves towards support for farming and against fishing

The fish farming industry has adapted to the market's and media's demand for "happy fish" and has developed a technology for fish welfare with large enclosures that give farmed fish a good and natural life with sufficient space, clean water, good health, a sensible and varied diet, an optimal variation of species, with mussels as a "natural purification system" – and a slaughtering process that takes place within the scope of international standards for the killing of humans. The new fish farming technology is adapted to the media and tourists. Visually attractive television segments showing beautiful images of contented farmed fish in a beautiful environment are often contrasted with the capture of wild fish that are placed under a great strain due to the unnecessary suffering this practice imposes on the fish. Many in the media equate wild fish capture with whaling, which was completely prohibited ten years ago. In order to distance itself from the stigmatised wild-fishing industry, the fish farmers have also produced clean feed sources other than captured wild fish (production of gas-based marine feed for closed systems without environmental toxins).

Competing industries pull the rug out from under Norwegian fish farming

An alliance of manufacturers of competing meat products, the media and green organisations receive public support for a prohibition against fish farming.

Lidl chooses Norwegian aquaculture products

Lidl chooses Norwegian aquaculture products as the basis for all of its fishery products. Quality, reliable delivery and ethics were the deciding factors, Lidl states. Other important factors are large changes in the transport system and improvements in the organisation of the trade, with an emphasis on traceability and "Just in Time", where the warehouses control the outtake from cages.

Farmed fish has gained a health food status

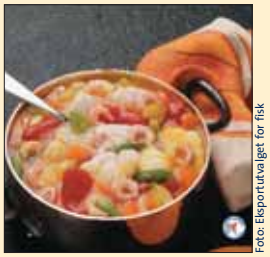


Foto: Eksportutvalget for fisk

- FHL Aquaculture influences the choice of topics for R&D and invests in R&D activities
- Research on functional food (aquaculture research focuses on medicinal themes)
- The media informs ("you and your life" journalism dominates)
- WHO recommends (heart and vascular diseases)
- Customers buy (alliances between the aquaculture industry and the health institutions, e.g. Fjord Seafood/Rikshospital University Hospital)

Cod Fisheries in the northern Atlantic Ocean are phased out

- Excessive over-fishing in combination with unsuccessful administration of resources
- Europe's university for marine resource management is located in Tromsø
- The universities recommend a five-year fishing suspension (2014-2019)
- Animal welfare organisations: a strong position in society
- Public support for ethical methods of capture in addition to sustainable development of the fisheries (fishing methods are phased-out)
- The EU Parliament, Norway and Russia follow the recommendations of researchers and take into consideration environmental organisations' requirements
- Exception: Coastal population and indigenous population
- The consequence is a change in the conditions of competition between fishery and aquaculture. Aquaculture acquires a stronger position.

"The universities recommend a five-year fishing suspension."

The Western Norway region and North Norway region in a trade war

The war is about the right to use the brand name "Fjord Fisk". The regions Western and North Norway have been at the forefront of a debate that finally ended up in court over the rights on marine products for the companies of the respective regions. The populations in the regions have however gotten so worked up over their politicians' opinions in this campaign that a "civil trade war" has developed. The solution is a regionally independent collaboration between the fish farming companies.

"Norway has chosen to focus on environmental quality as a sales argument."

The environmental organisations have received complete backing on fish farming

- After many years of struggle, the industry has entered into a partnership with the environmental organisations.
- An environmental certificate has been established for fish farming (ECC).
- Norwegian farmed salmon is sold with an environmental certification at a high price
- Fish from 60% of the competition are not certified and uncertified products are sent for 50% of the price, but Norway can still not compete on price due to the cost level and has therefore chosen to focus on environmental quality as a sales argument.
- Certification involves requirements for sustainable resource management, which limits feed access for farming, but increased credibility in the market results in fish farming acquiring a larger portion of marine feed to the detriment of meat production.
- Norway holds its own in the battle against cheaper manufacturers and against the meat industry. This is a battle for both the market and for feed resources.
- The environmental organisations create confidence in the industry on the condition that the industry meets the environmental requirement (certification) but this costs a lot of money.

The Daily Newscast broadcasts a positive segment about the fish farming industry every day

- The fish farming industry earns money and is financially interesting
- The fish farming industry spends a lot of money on PR and media consultants to bring about the news coverage
- The fish farming industry is presented on the news about trade and industry along the same lines as oil & gas, shipping, IT. This leads to an increased awareness and pride on the part of Norwegians (from Eastern Norway).
- Taxi drivers speak positively about the industry.
- The fish farming industry has increased its budget ten-fold for marketing and related services.
- The fish farming industry is a recurring topic on BBC World News

"Taxi drivers speak positively about the industry."

Consumers/Customers

Foto: Bjørn Røslett/Samfoto

The demanding customer

Customers are much more concerned about how the fish has been raised, what it has eaten and whether or not it has been raised under proper conditions. Extermination methods are important because the buyer is concerned about the fish suffering, both while it is alive and in the moment it is slaughtered. Animal welfare in production has become an important basis for the reputation of aquaculture products and welfare is a part of the production standard for the brand name in use. Customers are more politically aware and are often organised in consumer organisations. These organisations give customers a voice in relation to the public authorities and other actors, so it is not only purchasing behaviour in the stores that is decisive for the aquaculture industry. E-trade of fish has developed from being a curiosity (sale of farmed fish products as gift articles) to a common means of buying fish as a grocery product.

GMO as the consumer's best friend

"Better, healthier and cheaper food products through the use of GMO."

The consumer's antagonism towards GMO is gone. Genetically modified farmed species are popular commercial products and genetically modified organisms are used on a large scale in feed production. One can now produce better, healthier and cheaper food products through the use of GMO. In a situation with a growing population and in a world of many poor and undernourished people, the environmental organisations have realised that there is a moral obligation to exploit the possibilities GMO represents in terms of sustainable food production. Farmed species are fed in a more differentiated manner than previously, on the basis of GMO feed and the bottlenecks that were important before in relation to harvesting of marine feed substances are longer decisive. Norway has been a pioneer nation in the research of salmon and cod genomes and is using the knowledge to develop specialised feed for different products in consumer-demand. Examples of this are functional food and fish that also people suffering from allergies can eat.

Norwegian Fish House

An international chain of centres for the distribution, sale and catering of Norwegian aquaculture products has been established. A centre of fast food, gourmet fish restaurants and fish shops has for example been established in all cities in the USA with a population of more than 500,000. These centres are extremely important customers for the Norwegian aquaculture industry and they have come about through financing from among others the public authorities in Norway and from the industry itself.

Logistics functions are an integrated aspect of the centres' operations and imply that the Norwegian aquaculture industry itself controls and operates the central logistics system upon which the industry depends. Sales from the centres are thus both retail and wholesale. Local actors wishing to sell aquaculture products or who wish to use them in their own production will therefore be customers of these centres and not industry actors in Norway. The industry has formed an alliance with IKEA and other international groups on the sale of fishing rights based on Norwegian products in the groups' restaurants and cafeterias.

Foto: Eksportutvalget for fisk

Salmon has become everyday food for large new customer groups

"There is a focus on health and proper food."

While the EU, Japan and the USA up to 2010 were the largest consumers of salmon; China and Russia have taken over this position in 2020. Large spending-power developments have characterised these markets and there is in general an increased focus on health and healthiness. Distribution based on use of newly constructed high-speed railroads through Russia to China lowers costs. The demand is great for both expensive products (such as fillet) and cheap products such as heads, forcemeat and belly flaps. Salmon has become a part of the daily diet in these large markets.

By-product buyers become the main customers

In 2020 the aquaculture industry has learned to put the entire fish to use, also the blood. The main product shall not carry the cost. Through innovation, new knowledge and new technology the industry has developed a series of valuable special products based on the fish farming industry's primary production. The by-products are in fact so valuable that sales of products based on what was formerly by-products provide higher revenues and more profitability than the sales of the traditional food products such as fillets and gutted fish. The demand and willingness to pay for the new products is high. This has implied that the unit costs for

the aquaculture industry have on the whole been significantly reduced. The production costs for the traditional food have thus gone down and profitability also in this sector has improved. In several Asian countries young people eat manufactured products, such as a new type of fish-burger made of by the bone offcuts.

The consumers of the future are vegetarians

In 2020, the consumers are vegetarians. There can be a number of reasons for this. MCD broke out for real in the USA and in the period 2004 – 2010 one million people died. Within the fish farming industry there was a focus on environmental toxins in carnivorous fish and ethical issues in connection with production. This also had consequences for the wild fish industry. Ethical issues in connection with line fishing, seine fishing, harvesting of non-sustainable resources and extermination are central. From 2005 we obtain an industrial reorganisation of fish farming activities, in part through national duties, from traditional fish farming to seaweed and sea tangle production.

IPR provided the basis for the large Norwegian industrial locomotives to take part in the development. Yara and Statkraft continued Hydro's Mariculture programme (fertilisation of the ocean) – under governmental directive. Statkraft was made responsible for cleaning up consequential damages caused by the power network development; mineral deficiency. Yara produced a special mineral fertiliser for this purpose, which contributed to increased stability in the marine environment. Strategic investments within bio-ecology made possible the commercial utilisation of natural flourishing growth of algae (e.g. brown algae).

The Kyoto Agreement laid the foundation for international resolutions on CO_2 emissions. This was leading up to 2010 a hindrance for the Norwegian oil and gas industries. Statoil had at the same time become a superpower within the field of biotechnology and managed to exploit spin-off technologies from the oil and gas industries. Statoil was also a mobiliser and key actor within the new aquaculture. This contributed to commercial production of microalgae based on ten of the country's gas power plants (commercial production of single cell protein and marine fat).

The Gastronomic Institute played a central role in the development and education of new nutritional precepts. This made the farming of fish superfluous.

Through the European Marine research programme linked to large Norwegian actors, Norway became a superpower in marine research and innovation.

The future consumer is a slow food customer

Consumers are well-informed and emphasise factors such as health and ethics in their choice of food. Consumers in the age-group 0-60 years in the industrialised nations reduce their consumption of chicken dramatically, replacing it with cheap, health-promoting aqua products from developing nations.

The population over sixty (a growing part of the population with buying-power) puts a greater emphasis on culinary enjoyment – both at home and out.

Fresh fish products and combination products are popular because important consumer groups are on the look-out for new culinary experiences.

Communication about country of origin and a "good manufacturing history" become key sales arguments.

Prospects for a significantly longer lifetime put a focus on easily digested products, and on health food. Health food products have however decreased as a portion of the trade segment and have been replaced by proper food. (One knows for instance that one kilo of salmon is equivalent to NOK 200 in health food products.)

In 2020 we have the communication consumer

The consumer pattern has changed. Communication companies and the media rule. Direct communication between the manufacturer/refiner and the consumer through communication companies is vital. Shopping malls are on the way out. Less travel and physical movement in people's everyday lives. Chains that make preferences/differentiate with own brand name are also on the way out. Labelling and differentiation in the way of origin and history are important. Deliveries take place from warehouses or restaurants to the customer. Weekly menus. There is a focus on health and proper food.
Nutritional intake in the form of tablets based primarily on marine products. Consumer organisations have become important advisors on nutritional matters.

New markets eastward

The nearby market regions in the east have acquired the same standard of living as the EU (Russia and Eastern Europe). The consumers demand exclusive products. They want mussels, salmon and sea urchins to eat with champagne. Demanding customers who are both price and quality conscious.

Within aquaculture, the market focus is also further east. Norwegian export of salmon has increased from 30,000 tons to 300,000 tons. China and India have emerged as importer nations with an annual increase in GNP of 8%. China is a significant impetus to the world development.

The new customer groups in Eastern Europe, China and India have other preferences than the western customers. The western customers are primarily preoccupied with health while the customers in the east focus on enjoying life in their new welfare society. In the western countries there is a focus on by-products.

"The house of the future has no kitchen."

World competence centres

Norwegians want to live in cities. In 2020 we have only ten large cities in Norway. Depopulation in parts of Norway instigates international questions regarding Norwegian sovereignty over these land areas. Production of aquaculture products has dropped dramatically. Norway is a world-leading provider of R&D competence, technology, consulting services and food product safety in the marine sector. We want to provide comprehensive aquaculture packages for abroad, with sales to Norwegian-owned as well as foreign owned companies that manufacture in other countries. IPR becomes key to going global.

Seafood trade controlled by the large multinational chains

Large food product chains are crucial and buy only customised products with product declarations specifying the nutritional ingredients the aquaculture product contains. They demand documentation of the effects of seafood as functional food. In addition, the requirements for ethical, sustainable production and slaughtering are strict. Norway is made up of very few actors who manage to satisfy these requirements (such production is expensive). Wild capture fish is regarded as an extremely exotic/exclusive product and not for the poorer customers. The main reason for this is political pressure leading to far too high quotas in previous years.

Foto: Ole Åsheim/Samfoto

Proper nutrition: "Big Brother" knows best

The industry is made up of large companies. Great health problems in the form of obesity, etc., due to an unhealthy lifestyle are common. The government receives the bill for poor nutrition and must take control of the population's health condition. Schools, day-care centres and other institutions integrate the health dimension and become responsible for proper nutrition of children, young people and the elderly. Great health problems, combined with insufficient manpower, lead to the employer assuming responsibility for proper nutrition on the part of employees, both privately and at the workplace.

The house of the future has no kitchen. Meals are eaten out. "Grazing." Finger food is consumed socially, together with the family. Seaweed and sea tangle products and other new products based on healthy seafood are popular. Good tastes are combined with what is healthy thus attending to the needs of people looking to enjoy life.

Scenario:
A New Industrial Neutrality





Photo preceding page from left:
Norwegian Seafood Export Council
Illustration: Jon Solberg
SINTEF
Photo Disk
K.J. Merok/Matforsk

A New Industrial Neutrality

The fish farming industry has developed in a reality that has become European-ised extremely quickly. Norway has become part of a reformed and strengthened EU, called the Union of Free Democratic States (EUS). Europe's northern region, which includes the Baltic States, Finland and Iceland, in addition to Scandinavia, is an important part. Nature-given factors result in the region to a certain extent being perceived as marginal to the Union, which stretches from Svalbard in the north to the Mediterranean in the south and from Iceland in the west to Turkey in the east. Nonetheless, Scandinavians play important roles in the political system in Europe and the EUS plays an important role for the industrial development in the northern areas. The content of the term industrial neutrality has been modified from designating a situation where the public authorities maintain the same attitude in relation to all industries, to designating a situation where the public authorities play a neutral role as the transmitter of democratic resolutions with regard to which industries are to be invested in. In the industrial political arena in the EUS Norway plays a particularly important part within the marine and maritime sectors. Together with Icelanders, "Norwayers" play a wholly decisive role in the administration of ocean resources. This includes fish and other living resources, but also minerals and other valuable materials extracted from the ocean and ocean bed.

In spite of its, in some respects, marginal position and its tough climate, the northern region plays an important economic role and has a varied trade and industry. A completely key element in the economic picture is advanced industries based on knowledge-intensive harvesting and further processing of the renewable natural resources of which the region has an abundance (not least, forests and fish). The Norwegian public authorities report on the northern regions from the autumn of 2003 ("Towards the North!") played an important part in this development.

The global development within the area of energy as well as within transport and logistics has made it possible for Norwegian actors to deliver raw material based fresh products (different seafood products are particularly important) to all of Europe in an extremely cost-effective manner. Metal and mineral products from power-demanding industries are sold all over the world and are transported effectively and in environmentally-friendly Norwegian-owned vessels equipped with wholly new and environmentally-friendly propulsion systems. Norwegian companies have narrow but global niches in the maritime market in fields such as navigation and automation. Ships and propulsion systems are however almost exclusively built in Asia.

Industry Poilcy

The industry policy is oriented towards industrial neutrality but not in the same way as 20 years earlier. The government does not take on the role of chief-referee by on the basis of subjective opinions favouring individual actors or sectors to the detriment of others in concrete competition situations. The government now plays a neutral role but without industry policy becoming indifferent with regard to trade and industry and industry development. The public officials play a key role in concrete initiatives for the development of trade and industry activity and respond effectively when initiatives and investments are made in established or emerging industries. The measures implementation is complex and new indirect measures that in different ways support innovation endeavours have become important. In particular, work is being done to ensure that policy and political tools are cross-sector consistent and that funding for industries and enterprises is based on guidelines with a point of departure in priorities and choices made democratically. The development of society is to a much greater extent than previously a subject of public debate and is more

[1] The term "Norwegian" has gradually disappeared from Norwegian daily language use and in 2020 the expression is no longer permitted.

democratically run than was formerly the case. There is "equality among the industries", in the limited sense that the public authorities base their investments on open criteria and make their choices on the basis of priorities for which there is democratic support.

Industry policy and the aquaculture industry

In 2020 the public authorities play a particularly active role in relation to industries based on principles for a long-term sustainability and on Norway's nature-given premises. This is a contributing factor to Norway having world-leading expertise and a great commercial effectiveness in the area of aquaculture internationally. Norway plays a central role in the marine sector in the EUS. The aquaculture industry emerges as a winner within the framework of the new, industrial neutral policy.

The aquaculture industry in the entire EUS region is controlled by function-related health, ethical and environmental requirements, etc., while the detailed, specific and descriptive regulations that characterised the industry when it was young have been phased out. The actors compete and everyone has the right to establish enterprises if they wish and where they wish as long as they can document that the functional requirements defined in the legislation are met. The "free market forces" function, in the sense that the licensing policy is gone. European companies have the right to establish themselves and in the marine sector Norway is an attractive host country, not least due to the advanced competence communities found here and due to the economic terms that are in force for foreign establishment in Norway.

The policy is in general directed towards making the innovation system functionally proficient. In Norway, as in the EUS in general, it is such that some 4% of the GNP is spent on research and development. Public incentive programmes are general and often of an indirect nature but not industry neutral in the strictest sense. There is a general perception throughout the population that production that meets strict requirements for animal welfare, low consumption of non-renewable resources and seamless interaction with natural ecosystems as well as considerations for human beings' social and health needs, should be favoured. Part of the former Petroleum Fund has been allocated to a European fund for sustainable innovation and development and this plays an important role, among other things, in the marine and aquaculture industry.

Ownership

Private capital dominates the industry. Norwegian aquaculture is to a large extent internationalised. The aquaculture industry, which includes sea-based fish farming activity, submarine mining activity, etc., is made up of companies that to a large degree are owned by foreign interests. In the aquaculture sector, particularly Icelandic companies play a central role.

Within the EUS the companies are only minimally dependent upon national borders. Leading companies produce many places in the union and have rather large product portfolios. But the aquaculture industry extends beyond the EUS. For example, an extremely significant manufacture of tilapia takes part in Asia and a large company with headquarters in Ålesund controls more than 30% of the total tilapia production globally.

The competition policy in 2020 is fully oriented towards ensuring competition on a European and global scale. In correlation with this, ownership restrictions and monopoly situations within some of the Union states are no longer regarded as being any problem.

Competence and markets

Norwegian knowledge communities, especially communities in this company and at the Institute for Omnivorous Fish Farming Species at the Norwegian Aquaculture University, are global competence leaders on breeding, farming and elementary processing of this species. Competence with regard to farming of species for food is divided into two segments. On the one hand, one has competence on volume production of species that are extremely effective in the production of high-grade protein. On the other hand, one has extremely comprehensive competence on the production of the farmed species cod, salmon and trout, which have the longest traditions here in Norway. (Commercial farming of Atlantic salmon has gone on for more than 50 years.)

The two types of production and the two markets are very different. In the volume market, price and continuous quality are crucial. The fish is used as an inexpensive and healthy fresh product and is sold over the counter worldwide. It is used to a large extent in fast food products as well as in industrially produced food products (prefabricated food) so the fish in reality is far more important as an input good in industrial food production than as a fresh food product in the grocery trade.

Cod, salmon and trout are produced for a far more demanding market. The entire industry has developed special production techniques, and of

course, full traceability in production and there are strict cleanliness requirements for feed and production processes. The fish is used almost exclusively as a fresh product and is sold directly to the consumer, to manufacturers of prefabricated food products and to restaurants. The greatest volume of this fish is sold to the population's large middle class. A smaller segment, an elite group of people with spending power, is the target group for especially advanced fresh products. Among these, combination fillets are made (the pieces are called zebra-fish by children) where fish meat of differing textures and colours are put together in decorative portions. A specially developed format with stars proves to be an enormously popular sales item at the Union's 10-year anniversary in 2020.

Norway also has a considerable production of mussels. This portion of the industry is in a position in the middle because mussels are both used as feed and for human consumption. Traceability and purity of the end-product is extremely important, but the product is not primarily a high-price product although certain species such as oysters and scallops are high-price and are used almost exclusively as fresh products and sold to restaurants and as fresh food products in grocery stores. For salmon, trout and cod freshness, environmental-friendliness, healthiness and safety are decisive sales arguments. With regard to certification, all food products are subject to detailed requirements for traceability and documentation.

Quality systems and classification are integrated into all food production also in that portion of the aquaculture industry focused on low-price production of volume products, such as tilapia.

In connection with the traceability systems special information systems have been developed making it possible through use of an ordinary personal information terminal[2] to retrieve detailed information about production, transport and possible application areas of the sales products.

Mussels are important because the production is part of an integrated part of other marine-based fish farming production. Mussels are part of a concept for poly-culture that has proven to be extremely effective.

When it comes to the relation between production and market, it is first and foremost in the high price segment for salmon, trout and farmed cod that production's proximity to the consumer is an important sales argument. This has primarily historical reasons (see below) and can be said to be "culturally determined". Due to new energy systems, there is no longer any point with regard to ecological sustainability in breeding fish near end-users. Nonetheless, it is in the high price segment regarded as exclusive that products are local; produced and packaged in the local community and both extremely fresh and of superb quality. Fish farming installations are, as described in the development scenario, automated, flexible and safe in 2020. The installations are escape-proof with the exception of in extreme situations such as when installations are hit by vessels or submarines. There is no longer any uncontrolled release of farmed fish.

Processing

Primary processing of volume fish in the low-price market takes place to a large degree close to production: this includes cutting, de-boning and packaging. Advanced processing is carried out under the direction of integrated food product groups and is to a large extent based on advanced process competence, as well as detailed knowledge of the consumer markets. The production therefore takes place under the direction of a small number of companies, but the production capacity is distributed to the large markets. Food production of this type also takes place in Norway but this is not a large operation. On the other hand, there is significant processing activity in the high price segment. Ready-made dishes are produced with medium-term keeping qualities for the European market and two Norwegian companies emerge as integrated companies that both have control and competence within fish farming while they also have excellent market knowledge and high penetration power as actors in the marketing of fresh, ready-made food products.

Some niche manufacturers have managed to develop an extremely knowledge-intensive niche production of special products based on by-products from processing activities that otherwise take place in aquaculture-based food production. Production based on by-products is an important part of the total economic added-value.

In the production carried out for the world market, market competence is crucial and the development has made Norway a leader in this area. Delegations come to Norway all the time that are interested in learning how a small region such as ours can manage to develop products for so many foreign cultures. One of the impressions they have is that immigrant groups and the multi-cultural character of Norway

[2] Previously known as a cell phone.

and the Norwegian companies hold a great significance in this context.

Structure of the industry

Aquaculture, wild fisheries and processing comprise the backbone of a quite comprehensive industry cluster along the Norwegian coast. There are a number of heavy-weight supplier enterprises in Norway that are research-intensive and in possession of advanced competence that is in part proprietary, in other words, protected through brand names and patents as well as through secrecy. Intensive development activity is carried out, aimed at maintaining the lead in competence, where both private companies and public research and education communities are involved. Effective systems are established where scientific publications are coordinated with protection of rights so that the scientific development on the whole is promoted through close collaboration with private actors. Access to resources and focus on crucial research fronts are promoted through such alliances, while publication is only to a small extent delayed. The central actors however use some resources on protecting their rights; the scientific knowledge development thus takes precedence over the general private exploitation of results in commercial contexts.

As mentioned in the section about ownership above, the industry is nonetheless to a large extent internationalised and owners being Norwegian descendents is no longer an important criterion and a decisive factor for whether an activity is recognised as an important part of the economic added-value activity taking place in this country. The aquaculture industry is, like Norwegian culture in general, more European than it was 20 years ago.

Trade and industry are on the whole an important impetus for the development of knowledge, within the framework of a well-oiled innovation system. There is a close collaboration between knowledge sectors and trade and industry. A de-politicisation has taken place in research, not least in terms of regional-policy considerations. At the same time, a predominant portion of the total knowledge development takes place abroad. "Bringing home" knowledge is a given aspect of all development work that has as an objective establishment of new knowledge and to contribute to innovation and it is common – and a prioritised task at Innovation Norway, and other places – to work towards persuading foreign companies with leading competence to establish knowledge-intensive enterprises in Norway.

Some of the key knowledge is protected through patents, etc. in some industry sectors. Among other things, with regard to fish health we have leading knowledge (breeding, biotechnology). But there is a large pool of common knowledge, built through publicly financed research activities, that is open and available to all those with the ability to use it.

A good portion of the leading competence and the strategic competence development takes place through close dialogue between advanced suppliers and demanding users. Development, certification, patenting and pattern protection provide the basis for competitive advantages with a certain longevity. Many of the most advanced suppliers and the customers are found in Norway and this contributes to strengthening competitiveness in Norwegian industry.

Genetic modification

Volume production globally takes place to a large extent on the basis of vegetable feed raw materials. The high price segment that characterises the activity in Norway has therefore access to first class marine feed raw materials at a reasonable price. It is not the case that genetically modified organisms (GMO) are a vital condition for the industry. Certain applications of GMO have proven to be viable and this has proven to be important in the processing of special products. This processing takes place to a large degree on the basis of remains from food production based on farmed fish and other farmed species. Genetic modification provides among other things the possibilities to develop customised special substances that are used in the pharmaceutical industry and as ingredients in functional food.

On the other hand, GMO freedom is a wholly central sales argument in the segment of Norwegian industry delivering high price, fresh, farmed products for consumption.

The economic and political development from 2005 to 2020. What happened?

In spite of sceptics' grim predictions, the European Union continued to develop both culturally and economically after the first constitution was passed in the summer of 2006. A European Union of Free Democratic States became a reality in 2009 and the first direct election of a European president took place in 2010. In 2007, earlier than most had predicted, Norway joined the Union, after the situation in Norway became precarious. New member nations imposed stricter requirements, which led to continually greater financial pressures for Norway, without market access in any way being guaranteed. In the referendum held after a successful negotiating

result with the EUS in 2006, 66.9% of the population voted yes for membership.

The European Union continued to develop into becoming a continually more closely integrated economic entity. The development was accelerated through corresponding development of supra-national political and economic systems in America and Africa. At the same time, China and Russia were to an increasing extent becoming more and more marked by prosperity and a type of democracy and openness that formerly had been the hallmark of Europe and the USA.

In the decade from 2010 to 2020 the economic world order was clearly defined by block divisions. Russia and Europe functioned to an increasing extent as a single economic unit; China gained a central role in Asia and became the power centre in an alliance where India and Japan contributed to making this the indisputably largest and most powerful of the blocks. North and South America comprised a third unit while Oceania and Africa had close ties to both America and Asia without belonging to any of the blocks.

In general the development was characterised by increased freedom of trade, but first and foremost within the blocks mentioned. The situation between blocks was unclear, the development ambiguous. Especially Africa established special trade regulations in an attempt to finally bring about a positive economic and social development on this continent.

Industrial neutrality – but in a different fashion

In the industry political and general political debate after 2005 it became quite soon clear that conventional perceptions about "industrial neutrality" were unsuitable as a basis for a future-oriented policy. Ideas about such a simple neutrality were recognised as naïve and unrealistic as soon as one acquired a clear understanding of which types of different roles organisations and institutions in fact play in the development processes taking place in a society. In the policy, "Industrial neutrality" was eventually (this was particularly clear after 2008) regarded as an outdated concept that attested to former times' understanding of economic activity as an inevitable process where individual actors at almost any cost must try to win hegemonic power at the sacrifice of all others. "Neutrality" is in this perspective a condition to ensure that the government and public authorities refrain from taking dictatorial power as well as to prevent other, private actors from winning corresponding absolute power.

As one gradually came to understand that development takes place through evolutionary processes where different actors for shorter or longer periods work together in fruitful constellations and in this way realise future possibilities more through active dialogue than through fighting against one another, the concept of industrial neutrality gained another significance. The government and the public sector are part of many different constellations and contribute constructively to the work taking place towards developing new solutions in all important areas of society (innovation). In such an image, neutrality does not involve the government and public sector staying away from concrete efforts to build society through competence development, technological development and industrial development, but that the government and public sector behave as representatives for all members of society: the government's most important role consists of ensuring a coherence in relation to acts, regulations and rules that is such that different interests and different activities are connected with one another in an effective manner and in a manner that is in harmony with the opinions which in a democratic fashion determine what one shall achieve and how the future society shall be.

Objectives for maximum growth and maximum economic profitability were gradually replaced by a wish for collaborative action based on dialogue and on a gradual development of viable and sustainable solutions, where democratic mechanisms play an important role in choosing which future is in fact desirable.

The political development after 2005 moved generally in the direction of an increased emphasis on dialogue, more faith in actors' willingness to create meaningful enterprises and less faith in maximum economic profitability as a universal indicator of an enterprise's sustainability.

Industry development in the northern region

Within this context the northern region of the EUS after 2010 received to an increasing extent support for a policy that prioritised the economic enterprises that could be based on natural resources and nature-given advantages and which emphasised industrial neutrality according to the post-2005 debate. The public authorities committed themselves to the development of industries and enterprises. They did so not with the intention that individual actors or groups should acquire hegemony, but with the intention of making it possible to combine different

investments in coherent manners and to ensure that reunified societal prioritising was the basis for the choices made in relation with the direction of the development.

Investments were made not least in the way of knowledge-intensive harvesting of wild fish stocks and active development of a high-technology aquaculture. Old regulations and regulatory forms were phased out in the years leading up to 2010. From 2006 great amounts of resources were poured into research that could provide systematic knowledge about how fish and fish stock interact with their surroundings and what it would take to bring about a fish farming situation that provides for both the welfare of the fish and sustainability in relation to the natural surroundings.

The public research investment was to a large degree based on large-scale interdisciplinary programmes. In this way research areas such as materials technology, ICT and biotechnology were witness to research activities that both were oriented in relation to world-leading professional developments and active problem-solving. In aquaculture, which was one of several areas of investment, materials were developed that resulted in wholly new types and qualities of cages and equipment, and production equipment that provided clean processes, the likes of which one had never seen before.

Trade and industry were at the new millennium undergoing strong reformations. An ICT industry well-informed in telecommunication and Internet technology established in the first decade of the new millennium the basis for strong growth between 2010 and 2020. Leading cellular phone system developers in Sweden and Finland merged with a software manufacturer in Norway that had acquired a wholly dominant position within the development of a user-interface for information management and control of processes based on the Internet infrastructure. The company headquarters were located in Oslo in 2010 but had a large amount of activity in Norway, Sweden, Finland, Germany, China and the USA.

Telenor invests in a big way in information systems connected to tracing in food production and this eventually gives every consumer completely new opportunities to acquire information regarding how the products they want to buy are manufactured, which characteristics they have and how they can be prepared.

Agriculture in Norway has in time even less importance than previously, as the southern parts of the union eventually acquire a steadily increasing significance as effective manufacturers of fruit, vegetables and meat for the European market.

In general, a revolt takes place against the intensive animal production where animals are treated as things instead of living creatures. Animal welfare becomes more and more important as does animals being exterminated in ways that are neither frightening nor painful. This provides new opportunities and new challenges for agriculture. The farmers recognize the development in time and lay down completely new guidelines for the running of central companies such as TINE and PRIOR. A new investment takes place where TINE is equipped as a globally competitive food manufacturer and where niche products based on special production techniques and strict requirements for animal welfare are central.

In contrast to the development in agriculture a number of energy-demanding process industries continued to develop positively because the energy prices all over the world eventually levelled out. The liberalisation of the energy market therefore did not prove to have any long-term negative effect on the competitiveness of the process industries. At the same time, raw material access in this industry was revolutionised by new activities that harvested resources from the ocean in completely different ways than before. As access to new petroleum resources eventually decreased appreciably, commercial actors focused on harvest of other mineral resources from the sea bed. The deep-sea technology that had been developed for the petroleum industry acquired new applications in submarine mining operations and the process industry and metallurgical industry had their hands on a new link in the value chain.

A significant increase in energy prices occurred. This proved to make eventually possible a development of new energy technology that had dramatic effects and which made the world's energy consumption much less of a problem than it had been previously. New technologies were developed which extracted energy from easily accessible raw materials such as small reactors where the fusion of light atoms produced large quantities of energy without creating negative side-effects and without producing noxious waste substances. Such reactors were mass produced after 2014.

In the transport sector this created a development that would have been impossible to predict. In the years following 2005 a relatively rapid increase in transport-related costs took place. Road haulage costs increased the most quickly, because the negative effects of road haulage were priced into the

road-users' budgets through wholly new technical and legal systems for road pricing. This shifted the transport of fish to train and boat from road and air, and promoted a development where manufacturers located close to the consumer markets acquired considerable competitive advantages. Short distances therefore became an important sales argument comprising part of the consumers' basic preferences.

However, after 2009 the development of a new energy technology took place, which turned this picture upside-down. New energy sources, new materials and new information technology made it possible to establish integrated systems for individual and collective transport, where vehicles with the help of a computer-operated infrastructure could connect to and disconnect from high speed transport streets (a technology which we in formerly familiar terms could refer to as a hybrid of a ski lift and a moving sidewalk, on a large scale) connecting the large population centres in Norway and in Europe.

The development within fisheries and aquaculture

The production of salmon and trout, and later of cod, for demanding customers was the point of departure for the development that shaped the fish farming industry as it came to be in 2020.
Profitability problems in the years 2002-2004 put the industry to an extremely tough test. With a starting point in the knowledge and the prioritisations that were the most traditional in the industry the focus was yet again placed on trying to reduce the costs of production through innovation. One was obliged to attempt to succeed in developing a production system that was so effective that Norwegian salmon and trout could compete in price with fish produced in countries such as Chile.

Central private investors and the public authorities were convinced that it was necessary to invest in cost effective primary production in Norway. An investment was made in the period 2005-2009 involving a reunified effort where industry actors and industry organisations, research communities and the authorities all took part.
The political environment developed a horizontal innovation policy that to a large extent came to replace traditional regional policy. Traditional processing policy was replaced by a focused innovation policy that provided the basis for the dynamic development of a number of important places in the outlying regions.

Targeted researched efforts were publicly financed. Norwegian actors played an important role in the EU's 6th framework programme, not least in the marine sector. Our position by the time of the 7th was even stronger. The Research Report 2005 contributed to creating the momentum that proved decisive to acquiring results, not least in that the report clarified in a new and constructive fashion which role publicly financed research institutions and universities would play in the Norwegian innovation system.

The biomarine forum cooperated in bringing about a more constructive collaboration between different actors in the industry, by focusing on profitability problems and the drying up of capital in the industry. Old jealousy and sector interests between agriculture and fishery are broken down because the actors see that they must stand united in order to not lose out in a new global reality. The industry focuses on establishing a future-oriented innovation system. Central industry actors meet profitability problems and the strong price competition actively.

The industry develops strategies for promoting products and markets. The fish farming and supplier industries collaborate to reduce the costs: the supplier industry achieves success through close interaction with that which eventually becomes demanding and competent customers.

The result of the investment was new production techniques and not least a wholly new and systematic knowledge of what is needed to make the fish farming process controllable in the same manner as industrial processes had been controllable for a long time (such as within the chemical and metallurgical industries).

Process improvements and cost reductions give the industry room to breath up until 2008 and made possible more future-oriented investments which more actively focused on new products and new markets, when the European market seriously opened up. In this endeavour, TINE and PRIOR came to play key roles.

New equipment, new software and new installation design were the result. Salmon and trout were produced in fully-automated installations where the fish received individual follow-up and attention. Electronic systems were developed which gave fish farmers total knowledge about every single fish and about the entire farmed stock in an installation and the installation became flexible in the sense that it was not dependent upon special geographic factors and neither upon a permanent anchoring in the sea bed.

The development was so successful that the opinion eventually shifts to fish farming's advantage

and against the fishing of wild fish which is perceived as more brutal than the aquaculture activity in connection with fish farming.

Key events

2006 A common European constitution is passed

2006 (Norway) Old regulations and regulatory forms are phased-out in the years leading up to 2010

2007 Norway becomes a full-fledged member of the EU earlier than expected

2008 Technology actors (ICT, Biotek, etc.) began the system-oriented development of cross-over technologies that will create strong growth up to 2020

2009 EU changes name to the European Union of Free Democratic States (EUS)
Development of new energy technology starts for real

2010 The first direct election of a European president

2011 The northern region of EUS finally receives support in the EUS for an industry policy that emphasises economic enterprises that could be based on natural resources and nature-given advantages

2012 The block division of world politics begins

2014 Deep-sea technology from the petroleum sector receives support also in an aquaculture context (sea bed mining)

Scenario:
Market with no frontiers





Photo on preceding page from left
Norwegian Seafood Export Council
Illustration Jon Solberg
SINTEF
Photo Disk
K.J. Merok/Matforsk

Market with no Frontiers

Norwegian manufactured fish as good, healthy food – strong position worldwide

Marine products have the hegemony over land-based products within an integrated global market for food. The integration has brought with it:

- A global food culture where standardised marine products are produced in extremely large volumes.
- Large chains have a dominant position worldwide.
- Within given global standards – that guarantee global food safety through traceability and documentation – an intense price war is taking place between primary manufacturers.
- Within this mass market a distinction is made between white-flesh and red-flesh fish.
- The fish farming industry in Norway is specialised in primary manufacture with a particular emphasis on red-flesh fish. Here Norway is a world leader, based on a unique process competence and maximum exploitation of local, nature-given advantages.
- Norway is the red-flesh fish "production capital" of Europe.
- Norwegian companies in addition operate fish farming in all other parts of the world, based on the companies' superior internal knowledge-bases within process management and technology.
- We have a large niche production of seven other species (many types of white fish and shellfish). On the integrated global market, narrow niches can provide large volumes.
- Cultivation, local processing and exports of these products benefit from a dense integration with wild capture fish and shellfish.
- The innovation processes within the niches have the same characteristics as in other design-based industries, such as textiles and furniture. Besides creativity based on in-depth familiarity with the consumers' unique food culture, a given price – carefully adapted to market requirements – and requirements for standardisation and safety of large volume deliveries, are also important in the niches.
- Based on the large production volume of red-flesh fish and in niches, a significant extraction of biochemical components and functional molecules from by-products is carried out. This manufacture takes place in separate, specialised biotechnological companies.
- An important explanation for the success of the global integration is global institutions regulating world trade and ensuring food safety and open access for everyone, everywhere.
- Another significant explanation is a global, well-integrated transport system for frozen food products. Because of strict CO_2 regulations – making air transport too expensive – transport with refrigerator vessels plays a significant part.
- Refrigerator and transport technologies have proven to be an important research front.

The road leading to this success was long and full of thorns. The fish farming industry was shaken by a series of bankruptcies in many of the central companies in 2005-2006. These were due to the mistaken belief on the part of some that a profitable manufacture of new species could be based on the same process technology as salmon farming. It proved necessary to develop entirely new concepts for process technology that made it possible to realise long-term production planning, large volumes, standardisation of high quality and low unit costs. A large knowledge hole was discovered here which took a long time to climb out of.

Production of farmed cod and niche production of species other than salmon were built up by taking the highest price products to the best paying markets. This was carried out through a long-term government investment for the entire period of 2005 to 2020. A significant breakthrough, which had a decisive significance to later developments, was the establishment of Statfisk in 2005 – based on the Statoil model. Statfisk received 49% public capital (NOK 10 billion) from the Petroleum Fund. This strategic measure laid the foundation for the development of a whole new innovation system. Eventually, the large companies realised that their most important competitive advantage was knowledge about the new process technology that they developed in collaboration with Statfisk. This knowledge-driven strategy was the key to their succeeding in establishing production in many parts of the world – production controlled from Norway. A close partnership here between the universities and the government – organised through Statfisk – was a wholly decisive condition to success.

The red-flesh fish manufactured is slaughtered in Norway. Most is filleted. Further processing is carried out along the lines of ready-to-heat dishes, but much of the processing of products takes place abroad.

Effective processes have proven to be the most important of three decisive criteria for survival in the global food market. All the links of production are highly automated and subordinated to regimes for long-term industrial process planning.

The second decisive advantage that made it possible for a high-cost country like Norway to maintain its position on the global food market was the nature-given advantage of coastal regions. The industry has an extremely strong position with regard to administration and area use along the coast.

The third criterion is adaptation to the industry's structure and organisation in relation to the requirements of the global market. The production takes place according to detailed specifications from the food product chains, which are extremely demanding customers. These demanding customers however refrain from integrating the primary manufacturers through ownership. Primary manufacture and the Norwegian portion of processing are therefore run by independent Norwegian manufacturers. Their structure and composition is nonetheless adapted to a market controlled by the buyers. This adaptation to the large chains has led to large-scale operation becoming a criterion crucial to survival. Primary manufacturers must be of a certain size in order to be an interesting collaborating partner for the multinational food product chains.

The explanation for why Norway has competitive and effective processes within raw material production is its competence within the core fields of breeding, health, operations, slaughter and feed. This competence is unique in a global context. The competence is controlled by large Norwegian primary manufacturing companies that own and operate industrial fish farming production in many countries. The competence is built up and further developed by an effective national innovation system, which gives Norway a leading global position in knowledge development. The success of this innovation system is based on two factors, in part that research in Norway is run cost-effectively – in a country where the research labour force is cheap on a global scale, and in part in the successful interaction between public and private actors that materialised after the great crisis.

The global food product market

The world food market is integrated but at the same time, highly differentiated. The integration has brought along with it a global food culture, where marine products hold a dominant position. This global mass market exists however parallel to a series of national and regional cultures and tastes. This combination of integration and differentiation implies that small niches can provide large volumes, while at the same time we have extremely large mass markets. Within the given quality standards price and delivery proficiency are important competitive criteria. The price competition between primary manufacturers is extremely great – and has mobilised great advances in process technology efficiency.

The consumer market is controlled by large sales entities (chains). The chains own the large brands. Norway exports to the best paying markets all over the world (USA, China, India, etc.). Within the global mass market, the "global consumer" is unschooled. She has no idea about the different types of fish, but can distinguish between fish according to the colour: red-flesh fish and white-flesh fish.

Niche markets for "designer food" can be large. The niche products are no longer what they once were. They are no longer a craft – created by chefs – we speak instead about industrial design, adapted to different consumer groups. This industrial design process creates the basis for niche products of a large volume. Here the relation between price, quality and form are important factors ("IKEA design" of the price tag first, then adaptation of the product range).

With a few small exceptions, the niche product is accordingly not above the requirements for efficiency and large-scale production. Seen from the position of a small raw material supplier such as Norway, small global niches can thus offer large volumes. Farmed cod (together with wild fished cod) is such an industrially-produced niche product, which is sold:

- 80 % as ready-to-heat
- 20 % as unprocessed fillets

There is only a small amount of export of gutted fish.

The most important functions to take place in the processing in Norway is cutting up and de-boning. What was previously a cost problem – high wage costs – has been solved through robot technology and automation. The fish goes from the sea to the consumer without any human contact. The process industry creates jobs first and foremost through its support industries, which develop the effective solutions.

There is accordingly extensive production in Norway of processed, ready-to-heat products, but much of the final processing takes place also within the chains abroad – who understand the local taste ("styling" in the store).

Safe fish is an important niche. The integration of the global food market is based on a complex system of international and regional (EU) institutions that ensure that the products traded are safe to eat. These institutions' standards and procedures for quality assurance and control are implemented through chain-specific standards.

In the global logistics system that connects Norwegian fish farming with the markets some "hubs" are important. The hubs are nodes in the transport systems where transport flows are gathered, controlled and directed towards the products' final destinations. Through "the hubs" many small contributions are gathered to serve large deliveries to the chains. They are not located in Norway.

The fish from the manufacturer is shipped by semi-trailers to "the hub" – and from there onward out into the world. Regional transport on the European continent takes place by train, while refrigerated vessels cover longer transport distances. Air transport is not used because of the CO_2 regulations.

Large volume and many niches

Formerly the relation between Norwegian primary manufacturers and the chains abroad was informed by a certain tension and rivalry. Norwegians attempted to buy their way into the chains – and some chains attempted to acquire control of the primary manufacturers. These mistakes are now history. An effective division of labour has come into force with which both parties are satisfied.

Norwegian manufacturers no longer have any ambitions of being integrated into the consumer market, which is now dominated by the large chains. Correspondingly, the chains are not interested in expanding into the production area. They instead carry out their control through a well-regulated market where the chains have an extremely strong position. It is a large challenge for the raw material manufacturers to adapt to the chains' requirements. In order to do so, the raw material manufacturers must have an advanced knowledge of the markets that the chains serve. The industry is deeply marked by a price competition. The commercial orientation towards efficiency, long-term planning that ensures delivery proficiency in relation to

extremely large contracts and adaptation to the chains' and the global institutions' quality standards is very strong.

Process innovations that make production efficient ensure a long-term perspective in planning of production and a uniform quality have become a new area of knowledge with an extensive research investment. It is this field of knowledge that is the Norwegian industry's and the Norwegian innovation system's most important competitive advantage globally. This knowledge comprises an important part of the large, Norwegian primary manufacturers' closed knowledge bases. The primary manufacturers compete with one another over the development of new knowledge in this field.

The unique global specialisation in efficient production of red-flesh fish has also made it possible for the large Norwegian primary manufacturers to establish themselves in several countries around the world. This expansion builds upon the unique Norwegian competence: nobody can deliver red-flesh fish so inexpensively, with such a large degree of delivery proficiency and in such volumes as the Norwegian manufacturers.

In these markets a differentiation has taken place in large volumes and in many niches. Because the niches are global – they are large – seen from the position of a small raw material manufacturer such as Norway. Here a considerable amount of product innovation activity takes place. The product innovations are in part the domestication of several species – in part new variants based on existing raw materials. The variants are developed through industrial product design processes that are reminiscent of other cultural industries such as the fashion and furniture industries. In this area the Norwegian manufacturers are the mobilising agents in relation to the chains: Norwegian manufacturers launch new designer products – which they market to the chains. This means that knowledge about the food products' design – grounded in an understanding of different niche consumer requirements – is an important field of knowledge within niche production.

The large volume within primary manufacture has in addition provided the basis for extensive research-driven production of by-products that are developed through biotechnological research. Marine organisms are exploited to an extensive degree as a source for new biotechnological products.

Red-flesh fish remains the most important – Norway dominates here globally. We also have important niches with:

- cod
- lumpfish
- halibut
- mussels
- lobster
- crab
- oysters

White-flesh fish and shellfish are however extremely vulnerable products, due to competition from foreign new species. Another important niche sector is functional food based on marine organisms, such as mussels, sea tangle, sea urchins, etc.

The government invests heavily and long-term

The great crisis led to everything except salmon disappearing. The reason was clear: a competitive process for production of cod could not be based on a copy of salmon. After this expensive lesson had penetrated, the government initiated a heavy, long-term investment in a closed partnerships with a few, private industry actors. The objective was to ensure the development of new process technology that would make the new niche products profitable.

The principles for this partnership between the government and the large companies was:

- The government assumed the risk.
- The knowledge hole that could ensure new process technology was extremely deep. Totally new and radical solutions had to be found in several areas.
- The investment was long-term – with the aim of profitability over a ten year period.
- The government was also actively involved with the organisation of new marketing (product design, export) of the new niche product.

The investors who entered into the partnership with the government could benefit from public investments and public contributions to research in a number of new and promising areas. The overriding perspective in this new endeavour was however propelled by the industry's need for wholly new processes. The more "near-sighted" specialisation in specific solutions that characterised the research operated investment of the previous century had to give way to comprehensive and market-driven industrial strategies. Market plans must be in place; one must have thought through a comprehensive strategy for the development initiated and not only be myopical-

ly interested in specific technical or knowledge-related problems.

The investors take the developmental tasks seriously. They involve themselves heavily if reduced risk can be anticipated and if it is clear that those who in fact invest risk capital will have the option to extract values at a later date. With goal-oriented, good projects it has proven possible to achieve a longer timeframe with investors than was usual previously; 2-5 years.

Through the partnership with the government a new type of knowledge-driven company emerges. This is a large process operator with prominent own research departments. For these companies, knowledge was a decisive competitive advantage. This involved that the "open common knowledge" which had characterised the Norwegian innovation system in the last century was replaced by a national innovation system where large portions of the core competence was protected internally in the large companies. At the same time, the innovation system was more differentiated than ever – and the support industries that supplied specialised technological modules also held a strong position.

Free distribution of research findings came to an end in 2015. The results of publicly financed research become individual property, because the educational institutions are allowed to patent and in other ways protect their new findings. Sale of knowledge is intended to contribute to financing the research. The knowledge development has thereby gradually become more and more financed by private actors. An important part of this privately financed research takes place at universities and external research institutions, with part government financing and organisation.

Knowledge becomes more privatised. Patenting of own findings and results gives the individual researcher and the groups hiring researchers more power with regard to propagation. "No free lunch, no free knowledge." At the same time, that which already exists in the way of research results is better distributed. The scrupulous, precise information you must however pay for; free information is imprecise and not to be trusted.

A differentiation has taken place within the innovation system. While in 2005 one had open, common knowledge, there is now a distinction between one common knowledge sector – which the public authorities and companies share – and where the public authorities are central actors and a closed sector – which is closest to the commercial activities of the large companies. Despite this privatisation of the knowledge base, the contact between the large fish farming companies, universities and national research financing authorities more close-knit than ever before.

The government's role in the new innovation system is:

- To finance extensive basic research through the universities,
- To ensure education of researchers and qualified personnel in the companies,
- To safeguard and contribute to the interaction between the research in the universities and research in the industry, according to a triple helix model,
- Continued openness regarding basic knowledge and where the government is involved.

This implied that the entire research investment in the field grew but with a continually expanding privately financed share. In 2020 the financing of the fish farming industry's research was at the OECD average for advanced knowledge economies – with a 20% public and 80% private share.

After the great crisis – when the industry was rebuilt, they came in as investors in biochemical products and functional foods.

Genetic technology is used to select for natural breeding. Feed products that are genetically modified are also used. However, no genetic modification of farmed salmon is carried out. The niche products are natural products and the fact that they are natural is an important sales advantage in the market.

The global food market is open. The large chains and international organisations operate institutionalised systems for food safety, which involve a widespread control of production.

The development up to 2020

The cod farming industry was hit by several bankruptcies in central companies in 2006. The production costs for farmed cod were still too high to enable competition with other white-flesh fish. The bankruptcy was due to the economy and insufficient control of the process – and not insufficient basic knowledge in biology.

Simultaneous to the large set-backs in the cod production, farmed salmon retained a continued large market share and emerges as a well-established industrial volume product. For a while it appeared as if only salmon could be Norwegian primary production due to a capital drought.

We managed to rebuild once again the production of farmed cod and niche products of species other than salmon by taking the most costly products to the best paying markets. This occurred though a strong, controlled and long-term governmental investment in the period 2007 to 2020 in collaboration with a few private actors. The government assumed the risk so that the actors one invested in received adequately long-range terms and thereby time and opportunity to develop a sustainable industry from the ground up. Here considerable knowledge development took place.

The process was studied and the development was supported by competence built up in the Aquaculture University's department for industrial organisation and innovation research.

The research contributed to rationalising and making efficient the production processes while simultaneously discovering new biotechnological products based on by-products. As a raw material manufacturer, Norway is dependent upon sustainability with regard to environment, animal ethics, society and economy. Research provides the basis for food safety, traceability, etc. all of which support the chains' control system. Investments were made in research on industrial organisation, logistics and market research. Research on transport, packaging, keeping qualities and automated production.

The industry developed logistics systems in collaboration with transport companies. Eventually the Norwegian salmon manufacturers began taking over control of red-flesh fish production other places in the world, on the basis of the Norwegian manufacturers' superior process industry competence. We invested abroad based on our specialisation in production.

As a part of the large investment, the government established a new specialised and interdisciplinary aquaculture university. The objective of this university was to ensure the basis for an advanced national knowledge of industrial production of fish. The university contributed significantly to the subsequent success.

The public authorities operate an active cluster policy to develop large-scale "hubs". NUTEKO is bought up in 2010.

Another part of the large national investment was the establishment of Stafisk. Stafisk was established in 2005 with 49% public capital (NOK 10 billion) from the Petroleum Fund. The company's goal was to be to assume the same role in the aquaculture industry as Statoil, which is now shut down, had in the oil industry. The capital was invested in knowledge development and technological development in Norwegian equipment companies and in the development of halibut farming, salmon farming, lumpfish and intensive lobster production. In addition, Statfisk quickly formed a unifying market mechanism for the promotion of Norwegian seafood, in particular oriented towards Asia. Great success was in particular realised in the export of cultivated mussels. The large population explosion in Asia has resulted in an interest for local, intensified farming. This has led to large exports of equipment to these installations in Asia, while at the same time a virtually total collapse occurred in the export of aquaculture to these same markets, which are now self-sufficient. Statfisk states in a commentary that they for a number of years have been looking at the possibility of expansion in export of seafood to Africa, which now comprises a 13% share of the world market. An industry fund financed by revenues from oil, energy, fishing and biotechnology has identified four primary areas for innovation and investment: Aquaculture and marine biotechnology, energy, ICT and culture.

The value increases by 10% annually subsequent to good combination investments in Norway, Russia and Eastern Europe. The investments are equally distributed between the investments in Norway and connected investments abroad, to support and complement the Norwegian activity. China and India are in 2020 the foreign investment areas with the strongest growth.

Key events

2005	Establishment of Statfisk
2006	A series of central companies go bankrupt
2007	The long-term governmental investment starts (- 2020)
2010	NUTEKO is acquired
2020	China and India have the greatest growth in the world.

Scenario: Sustainability





Photo preceding page from left:
Norwegian Seafood Export Council
Illustration: Jon Solberg
SINTEF
Photo Disk
K.J. Merok/Matforsk

Sustainability

Continual climate changes and advanced environmental monitoring – have revolutionised the industry

The aquaculture industry produces "green" and the products taste good! Norwegian aquaculture has today (2020) managed what few believed was possible. In spite of increasingly distinct climate changes, global warming and high average temperatures in the ocean (July– November) from the coast of Western Norway all the way up into Helgeland, we have a thriving and viable industry, more ecological, with products that are more in demand than ever. The increase in ocean temperature has for a long time led, among other things to premature sexual maturity and disease. The extreme weather conditions during the winter season has on the other hand, contributed to the lowering of the average temperature in the ocean during the winter in Nord-Troms and Finnmark. We have witnessed frequent and powerful storms, which have resulted in an increased risk of farm-wreck and escape. About ten years ago, the climate changes and question of using resources in a sustainable fashion became a central question in the world's food programme and in fighting starvation – since large areas along the equator were in the process of becoming infertile and parched. It is toward the oceans that the world has now directed its attention.

The environment, sustainability, and combating starvation are today the dominant agenda, along with increased attention to new and more long-term environmental challenges in the period leading up to 2040 and 2050. It has become clear that good monitoring systems and moderate initiatives are not enough. One has begun to speak of the melting of the poles, decreasing temperatures and the ceased movement of the Gulf Stream in the near future, and not least, how can we produce good quality products in a manner that counteracts or constructively addresses this development?

Totally new systems for environmental monitoring, mapping and preparedness have been developed in the EU and in the rest of the world. Between 2005-2010 a number of farm-wrecks and accidental close calls with freight tankers along the Norwegian coast took place. This resulted in heated debates, large media segments and crisis maximisation, in Norway, the EU and in the USA. Risks in connection with increased transport of oil/gas along the Norwegian coast led to our finally in 2011 acquiring a preparedness system along the entire coast, which the fisheries and aquaculture industry could live with. Well-developed systems for environmental monitoring, along with outstanding multi-stock administration models that have functioned extremely well since 2010, have made possible total market confidence in Norwegian sea products. Through long-term work with bio-prospecting and a conscious investment in utilisation, commercialisation and coordination with biotechnology, Norway has in the past five years managed to build up a significant expertise within these areas and the marine biotechnology industry is thriving.

We are a large exporters of knowledge within marine sustainability (special competence within management and implementation of administration models, food safety), Norwegian researchers are leaders within marine environmental research, fish health and breeding work and we are well on the way to becoming a large and central actor within new energy forms (oceanic heat, wave power, environmentally-friendly gas power). We export competence and technology for NOK 40-50 billion annually. Together with different fish products, the aquaculture industry in total represents a sales volume of more than NOK 100 billion on an annual basis.

The climate changes led to the industry having to relocate the fish farming installations on land or to move the companies and fish farming activities, one example being to Chile. If we look back at the past 10-15 years, we see that it was in this time period that we laid the foundation for an aquaculture industry that does not only sell fish as a main pro-

duct, but knowledge and technology about how one can develop and operate aquaculture regionally adapted to local climatic considerations and with a minimum of transport costs. The Chinese saying that one shall not give away fish or reveal a fishing spot but instead teach how one designs and develops good fishing spots in harmony with nature and the idea of locally situated and robust knowledge – becomes a mantra for Norwegian aquaculture.

The perception of what nature is and what it means to be in harmony with it has however changed radically. Sustainability is ensured first and foremost through new technology and growth, not through protection and museum-making. This becomes an increasingly clearer strategy for Norwegian aquaculture in the years leading up to 2020, which had many consequences, not least for a close collaboration between 30-40 Norwegian research communities, fishery and aquaculture industries and the Norwegian public authorities. We have today one unified marine industry. The most important thing that happened was a modified thought model for how one produces knowledge and a shift in the organising perspective for the aquaculture related research. This is first and foremost what sustainability is all about.

Some things are the same but...

Seafood has globally become a more and more important source of protein both for large new populations and as a health food. It is a new era for cod in Nordland and northward. The long coastline provides differentiated possibilities. Increased production of refined products in Norway, high-quality fillets (Grade-A fillets) and by-products. There the dominance is still with an advantage in fresh goods with a main emphasis on the new EU and Russia – 70-80% of our Norwegian fish production goes there. This imposes large requirements in the way of increased productivity, fish health and logistics. But compared to the situation in 2004 there is also very much that is different in 2020.

Climate changes

Climate changes and the question of using the resources in a sustainable manner has become a completely central question in the world's food product programme and in combating starvation since large areas along the equator are in the process of becoming unproductive and parched. The world has turned its attention towards the oceans. The environment, sustainability, and combating starvation are the dominant agenda in 2020, along with increased attention to new and more long-term environmental challenges in the period leading up to 2040 and 2050. It has become clear that good monitoring systems and moderate initiatives are not enough. One has begun to speak of the melting of the poles, decreasing temperatures and the ceased movement of the Gulf Stream in the near future and the temperature dropping in the Polar Regions.

Norwegian aquaculture is in 2020 also dominated by increasingly more distinct climate changes that have led to global warming in some regions, and high average temperatures in the ocean (July–November) along the coast of Western Norway all the way up into Helgeland. The increase in ocean temperature has for a long time led, among other things to premature sexual maturity and disease, while it has also had positive effects for the environment in the fjords of Southern Norway (marine oligotroph). The extreme weather conditions during the winter season have on the other hand contributed to the lowering of the average temperature in the ocean during the winter in Nord-Troms and Finnmark. This has led to increased problems with ice. Frequent and powerful storms have resulted in an increased risk of farm wreck and escape. The access to well protected sites has been reduced and a vehement battle is taking place over these.

To sea

Fish farming has been moved out to sea or become land-based in large, capital-intensive installations owned by external actors. We have solved the problems of extreme weather conditions through technology development and new transport solutions. Solutions for farm wreck and the escape problem have been found. Integrated fish farming (such as salmon with mussels) of several species in the fjord regions and along the coast is successful, due to the great efforts of veterinary medicine and other research in collaboration.

Harvest of wild fish is regarded as the most sustainable exploitation of marine production. Breeding farmed fish with wild fish and the corresponding energy loss is not regarded as sustainable. The industries must find other feed resources. Harvesting at a lower trophic level at the cost of the higher level is neither considered to be sustainable.

Raw materials based on natural gas

In "Sustainability", raw materials based on natural gas dominate. Gas as a raw material represents better use of the gas resource, which is not a renewable resource (increased aggregate added-value). One is able to produce polyunsaturated fat from gas, after the right micro-organisms have been found in the ocean. Gas implies that GMO is not necessary in the value chain. Gas is no longer used as an energy source (incineration) but is preserved as a future resource in food production. The EU has accepted the gas-based feed in its safe food program. Salmon is produced in 2020 in large new offshore installations. The feed is produced from gas from platforms. The feed is so good that one no longer needs cages: the fish is influenced by the feed and stays by "its" platform on own volition. This is a conditioned response, smell and taste signals are sent to fish belonging to a specific installation.

Gas becomes fish feed as the hydrocarbon in the methane gas and nitrogen in the air are used to create a single-cell protein produced on the platform. Pipe trenches that were formerly used to transport oil, are now used to transport salmon to processing facilities in Europe (salmon in oil).

Escape-proof offshore installations are developed providing zero release of fish. Money is allocated by the public authorities to test out different solutions. Area conflicts force the fish farming industry out into open waters. Larger demands are placed on technical installations and Hydro (at Yara) has returned to fish farming. The natural competitive advantages in Norway are weakened, but gains are realised in the technical sphere.

The new market – safety, communication, nutrition and culture

Scientific documentation shows that farmed fish is safer to eat than wild fish. Norway has consistently managed to document that Norwegian farmed fish has been and is pure and healthy. We lead the world in classification of fish and fish-product quality. The industry is united behind a national marketing of farmed products with a national branding programme and this programme has received international acceptance. Norwegian salmon is the ocean's "Parma-ham". The coastal waters are clean; the problems with pollution have been reduced.

The nearby market regions in the east have acquired the same standard of living as the EU (Russia and Eastern Europe). The consumers demand exclusive products. They want mussels, salmon and sea urchins to eat with champagne and are demanding customers who are both price and quality conscious.

Norwegian aquaculture sells large volumes of high quality fresh and cut and de-boned (A-grade fillets) fish, primarily for further processing within the EU. The marketing is based on the product being a pure product from a pristine nature. The industry has an extremely well-developed logistics system all the way to the consumer. There are frequent deliveries, often several times a day. The manufacturers have closer contact with the sales link addressing the consumers. Production takes place on the basis of global contracts and sale of salmon occurs to a large extent to multinational sales and distribution companies such as "Ahold".

Customers are much more concerned about how the fish has been raised, what it has eaten and whether or not it has been bred under proper conditions. Extermination methods are important because the buyer is concerned about the fish suffering, both while it is alive and in the moment it is slaughtered. Animal welfare in production has become an important standard for the reputation of aquaculture products and welfare is a part of the production standard behind the brand names in use. Customers are more politically aware and are often organised in consumer organisations. These organisations give customers a voice in relation to the public authorities and other actors, so it is not only purchasing patterns in the stores that are important for the aquaculture industry. E-trade of fish has developed from being a curiosity (sale of farmed fish products as gift articles) to a common means of buying fish as a grocery product.

Fresh fish products and combination products are popular because important consumer groups are on the look-out for new culinary experiences. Communication about country of origin and a "good manufacturing history" become key sales arguments.

Prospects for a significantly longer lifetime puts a focus on easily digested products and on health food. Health food products have however decreased as a trade segment and have been replaced by proper food. (One knows for instance that one kilo of

salmon is equivalent to NOK 200 in health food products.)

In 2020 we have the communication consumer. The consumer pattern has changed. Communication companies and the media rule. Direct communication between the manufacturer/refiner and the consumer through communication companies is vital. Shopping malls are on the way out. There is less travel and physical movement in people's everyday lives. Chains that make preferences/differentiate with own brand name are also on the way out. Labelling and differentiation in the way of origin and history are important. Deliveries take place from warehouses or restaurants to the customer. Weekly menus. There is a focus on health and proper food. Nutritional intake in the form of tablets based primarily on marine products.

Consumer organisations have become important advisors on nutritional matters. Seaweed and sea tangle products and other new products based on healthy seafood are popular. Good tastes are combined with what is healthy thus attending to the needs of people looking to enjoy life.

Active ownership and a separate Marine Fund

Active ownership and strong personalities characterise the situation in 2020. The fish farming industry is still characterised by strong personalities and active ownership but now in combination with an active and qualified investor community. The Oslo Stock Exchange has become an important source of capital and with its adjacent broker community is world-leading in the area of marine bio-production. Interest organisations support safeguarding their funds but seldom play an active ownership role.

The Petroleum Fund is replaced by the Marine Fund in an industry fund financed by revenues from oil, energy, fish and biotechnology and has indicated four main areas for innovation and investment: Aquaculture and marine biotechnology, Energy, ICT and Culture. The value increases by 10% per year after good combination investments are made in Norway, Russia and Eastern Europe. The investments are distributed evenly between investments in Norway and connected investments abroad to support and complement the Norwegian activity. China and India are in 2020 the foreign investment area with the strongest growth.

Clearer role division

The industry organisations are international and the Norwegian actors are direct members of the international organisations. Innovation Norway and the Research Council have merged to arrive at an even greater coordination of the administering agency. The national R&D communities have a focus on the prioritised industry sectors.

As owner of a large pharmaceutical company, Røkke establishes a marine biotechnology research centre (focused on aquaculture) in Tromsø. The purpose of the centre is utilisation of genes in marine organisms that have a large earning potential. This applies to biomedicinal and bio technological products. This initiates the farming of marine organisms for biomedicinal purposes. Another patenting area is new feed types.

The government is concentrating on financing basic research. The research is organised in international networks. The government and the Research Council have established a national division of labour between the R&D sector in Norway and abroad. This has created larger, more interdisciplinary environments, qualified to address composite, complicated problems and assignments. This was brought about by the geographic virtual collaborative forms that connect the Norwegian institutes.

Conflicts that provided learning

Both the industries and the public authorities have coped with the territorial and sector conflicts between the fishery and agriculture sectors. The result is better-organised Norwegian food research with good international connections and an effective collaboration between industry and research. Knowledge is now the country's most important export product. This applies to knowledge about salmon but to an even greater extent is connected to production of marine fish and especially marine hatcheries and fry production. Norwegian companies own and operate installations all over the world. In addition, Norwegian companies have a leading position in supply of salmon roe.

We export also knowledge about how it can be done

We are a large exporters of knowledge within marine sustainability (special competence within management and implementation of administration models, food safety), Norwegian researchers are leaders within marine environmental research, fish health and breeding work and we are well on the way to becoming a large and central actor within new energy forms (wave power, environmentally-friendly gas power). We export competence and technology for NOK 40-50 billion annually. Together with

different fish products, the aquaculture industry in total represents a sales volume of more than NOK 100 billion on an annual basis. The research and development activities are rooted in Norway along with the concept development. All production of the technology itself however is done abroad, to an increasing extent in China and South Asia, which have become important markets for Norwegian knowledge in this field. The benefits of the experience from developing and managing large, complicated projects in the offshore sector are now making themselves apparent. We have knowledge and we know how we can combine it in regionally-rooted development projects. The ability to work in dialogue with local authorities and interests in developing more robust, situated knowledge about solutions becomes decisive. Norwegian development communities have in the last decade worked actively at developing such work forms. To a large extent one has cashed in on Norwegian working life research and the experiences from regional development programs.

The Ministry of Food

The Research Council modified its prioritising, became a foundation and has research, technology development and innovation directed towards complex development processes and systems as its main focus. In the globalised world Norway had to choose to be good at something. Food, with a main emphasis on seafood, nutrition and environment has become such a chosen area, along with energy and related technology areas.

EU-membership has led to the national marine resources becoming part of the EU's joint resources. Administration and management of these resources is located in Norway, which creates a competence centre of gravity in the region. The Research Council is part of the joint European research infrastructure for aquaculture.

The industry ministries LD (Agriculture) and FID (Fishery) are integrated with industrial funds in the food ministry – NMF (the Norwegian Ministry of Food). The Ministry of Food has complete responsibility for fjord/earth to table in Norway (in other words, the entire value chain). At the same time, official forums have been established between the Ministry of Health and the Ministry of Food to ensure research on food as medicine and health effect. The political structure in Norway has been changed to five regions (counties/municipalities) and the administration of these is carried out locally. The Food Inspectorate has been further simplified. The Norwegian Ministry of Food has received international administrative responsibility for marine resources in the EU. Research and documentation of seafood done in Norway determines the EU regulations.

Aggressive media companies use Norwegian scholars' disagreement, uncertainty and lack of answers about Norwegian fish farming being dangerous to the health as headlines to attract readers and viewers. They have received assistance from the nature conservation organisations. Researchers and environmental management are in conflict. The researchers meet this pressure by focusing more on preparedness research. The public authorities, the research community and industry have developed a professional and coordinated information service, which works actively to establish research-based, international systems for food product standards that are accepted as a legitimate guarantee of food product safety and control.

Multinationals dominate

Multinational companies with a broad product range dominate the industry. After several years of limited access to equity capital, the Norwegian aquaculture industry is to a large extent owned by companies with headquarters and owners outside of Norway. A few multinational companies dominate the market. 20% of the companies in the industry represent 80% of the production. The central groups specialise in 5-7 different farmed species and all have a well-developed marketing system. Products based on by-products comprise approximately 35% of the sales volume. Breeders work predominantly on a contract basis for the multinational companies in networks off small and medium-sized companies. Joint sales companies are formed and research is directed towards creating strength on the side of manufacturing in relation to the market. The company's strategy is concentration in all links and efficiency.

What happened? Globalisation, demographics and climate

Contemporary analysts in 2020 all agree that there are three fundamental forces that have been crucial to the development of the past 10-15 years: globalisation, the demographic world development and the climatic changes. There is however a large amount of disagreement regarding how the interaction between them has shaped the society and the conditions for the industry activity in Norway for Norwegian aquaculture activity. Individual events are however referred to as having contributed to

engaging people and the political debate and thereby shaping the actions of central actors. The individual events we mention are random. It could just as easily been others but with the same effect. They become common observations that create debate and actions, both of which illustrated the development and shape the future.

Several large farm wrecks

Between 2005-2010 a number of farm wrecks and accidental close calls with freight tankers along the Norwegian coast took place. This resulted in heated debates, large media segments and crisis maximisation, in Norway, the EU and in the USA. Risks in connection with increased transport of oil/gas along the Norwegian coast led to our finally in 2011 acquiring a preparedness system along the entire coast which the fisheries and aquaculture industry could live with. Well-developed systems for environmental monitoring, along with outstanding multi-stock management models that have functioned extremely well since 2010, make possible complete market confidence in Norwegian marine products.

Beneficial research

Research shows that the aquaculture activity contributes to an increased scope of nutrients for fry, which increases the return from wild production by 100%. This has contributed to an increase in wild fish stocks along the coast. The fishing area is located in the farming areas; bio-production has increased. The Sea Ranching Act has been expanded. Through long-term work with bio-prospecting and a conscious investment in utilisation, commercialisation and coordination in relation to biotechnology, Norway has in the past five years managed to build up a significant competence within these areas and the marine biotechnology industry is thriving.

Boycotts, conflicts and development

The expanded EU and Russia are our most important markets (60-70%). Norwegian and Russian authorities resumed in 2008 large-scale seal hunting on the East Ice to minimise large populations of sea mammals in the region, as the stocks have become completely out of balance. There is a seal invasion inward towards the Norwegian coast that also exceeds the problems experienced in 1987-1988. This leads to an escalation of non-governmental organisations and a lot of negative media attention. The Norwegian aquaculture industry is on thin ice, but after this action is eventually positively received. The Norwegian public authorities, with sound support from own and international researchers, finally get through to the NGOs with sustainable administrative models within the marine sector. The environmental organisations develop confidence in the industry while in exchange the industry fulfils the environmental requirements (certification), but at a high monetary cost. Norwegian bureaucracy within the marine sector sees great possibilities internationally and The Norwegian Model becomes a leading standard in administration of the Atlantic Ocean and eventually in collaboration with other coastal nations, also worldwide. The government makes further investments in goal-oriented R&D in the field, and this becomes a large export item.

Aquaculture under scrutiny

Aquaculture is an area subjected to scrutiny because climatic considerations and transport pressures become more important in the large markets. Energy and transport costs increase dramatically and we experience a shift from air and auto to ship and rail. There is a focus on high-speed solutions that still allow transport of fresh fish, and an increased focus also on products that tolerate a longer transport time and larger volume. A reorganisation of the logistics system is carried out adapted to the new situation, which implies significantly more competition from small farmers with market proximity.

IPR disappears – free flow of knowledge available for use

Non-tangible rights are phased out at the end of the period. There is to be fully open access to knowledge and technology. In 2018 the EU abolished IPR (Intellectual Property Rights) within important areas due to the development within technology and communication. Private investors became less willing to finance knowledge development but correspondingly focus more on service and product development. There is a new vitality in the public investment to stimulate and take responsibility for key knowledge centres (universities, colleges, base research). Knowledge has become much more accessible. The new development however is that the knowledge development becomes international and is organised in networks. Marine-science alliances are formed with the largest, most esteemed professional communities in the world.

New Research System in Europe

The European common arena for research has been continually developed to meet the research competition from the USA and not least from countries

such as China and India where enormous private companies eventually channel funds at the American level into research and development. The government understood in 2008 that the aquaculture industry had to be injected with considerable capital and competence if it was going to be able to take over after a petroleum industry that was becoming increasingly less value-added. In the EU Norway has received the leading responsibility for development of research and teaching in the marine sector. Basic research is led from Norway and under the direction of the Norwegian segment of the ERC (European Research Council).

We have seen that the need for increased knowledge about the ocean became a central societal impetus for research. The conservation thinking was abandoned as basis for an active attitude towards resource administration and resource utilisation. The dialogue between the strong research communities and society accelerated and the universities were to an increasingly stronger extent run through a broad social dialogue and strategic investments. Within aquaculture research there was a reduction from 30-40 communities down to four regional communities, which in practice comprised an Aquaculture University in a European context. The view of knowledge production changed radically and what in 2005 were viewed as research activities restricted to research institutions, are in 2020 a part of the general knowledge development in the companies. There is at all times a focus on inadequate areas of knowledge such as marine sustainability and dynamics, multi-stock research, marine climate, flow factors, algae, information systems and market knowledge. The current infrastructure of aquaculture research is completely reorganised to reflect new knowledge needs. The nation becomes less important to the benefit of the regions and the international collaboration.

A new thought model

The Norwegian aquaculture industry moved away from the reigning intensive industrial mentality in production in the period 2005-2010 and changed to more well-being oriented farming where communication with the fish played an essential role. The industry imposed requirements on the public authorities for new monitoring regimes and more controlled production and requirements for a more differentiated utilisation of the fish. The industry established apprentice-networks and carried out transmission of information to the general public. The industry invested continually more in bio-products as a market for Norwegian aquaculture and a unique long-term strategy was developed for the industry's own BIOR&D in 2010. This is seen in connection with a breakthrough in 2006 in terms of thinking utilisation of the entire fish. The connection between aquaculture and wild fishing became central and created a good basis for continuous delivery in the market.

In 2014 a separate industry organisation was formed in Europe for marine sustainability-based special competence within management and implementation of administrative models and food safety, fish health and breeding work. The companies that became members had extremely divergent backgrounds, but specialised in regional fish farming installations around the world, both on land and on water. We export competence and technology for NOK 40-50 billion annually. Along with different fish products, the aquaculture industry as a whole represents a sales volume of more than NOK 100 billion per year.

Social consciousness raising, investments and marketing

The public authorities increased the research connected to documentation, knowledge-development and social consciousness-raising eight- to tenfold and invested in all a total of NOK 1-2 billion per year on aquaculture research and industrial aquaculture development. 50% of these funds went to research and development projects in international networks. From 2010-2020, NOK 50 billion from the Petroleum Fund is spent on share investments in companies working with food product distribution in Europe. This was done to ensure the share of Norwegian food products in Europe. The launch of the Olympics in Tromsø in 2014 as an Aquaculture Olympics put a focus on Norway as a knowledge and technology supplier for regional installations adapted to local conditions and healthy monitoring and administrative systems. The impetus in this development was regional in Norway, not least because the licensing fee went to the municipalities to stimulate the ripple effects of the aquaculture industry and to develop industry in local communities. This regional stimulation strongly contributed to developing vital knowledge and culture-creating environments with sustainability in the global economy.

Key Events

2007 The oil tanker Scuko Valdez runs aground at Hordaland. Contributed to bringing about a breakthrough and focus on sustainability and monitoring systems

2008 The EU wanted to have the Petroleum Fund in the structural sense

2009 Parliamentary election in Norway – an election about Norway's role in the global economy. Specialisation parties receive a clear majority

2009 A political awareness surrounding Norwegian seal policy in 2010 led to a boycott of Norwegian salmon which resulted in the industry learning to communicate with the surrounding world

2010 Climate changes and the question of whether to use the resources in a sustainable fashion became a central question on the world's food product programme and in combating starvation

2011 The cod in the North Sea collapse.

2011 A preparedness system for environmental monitoring was launched along the entire coast

2012 "Fish well-being" was launched as a concept in 2012 and echo sounder research became a research field

Scenario:
Feed for everyone





Photo preceding page from left:
Norwegian Seafood Export Council
Illustration: Jon Solberg
SINTEF
Photo Disk
K.J. Merok/Matforsk

Feed for everyone

Economic, environmental and feed production crises – contributed to a revitalisation of the fish farming industry and the development of non-marine feed alternatives.

The access to feed is both effective and good. Feed is also inexpensive. The feed costs are between 20-30% of the production costs on average for all fish farmed species. Research has generated a new and effective feed technology. Advanced biotechnology has developed alternative feed-sources that compensate for limited access to marine fatty acids and ensure sufficient proteins for feed production. Feed is produced both nationally and locally close to the markets around the world.

Norway is an active member of the EU, which after large problems up to 2014-2015 finally managed to guarantee market access for Norway and other member nations, not just in the internal market but perhaps to an even larger degree in other parts of the world.

The markets are segmented, with market access agreements between different countries. The Norwegian fish farming industry has managed to reposition itself and has become actively market-oriented. In international aquaculture activity, the lack of marine feed has been a significant bottleneck for almost the entire period up to 2020. There was an increasingly greater pressure on the manufacturers to not use fish to feed fish. As a reaction to this, the original feed fish was developed into sales-worthy and popular products directly for food. It has proven impossible to maintain a satisfactory level of wild fishing of marine species, despite attempts to harvest krill and establish capture of other species at a lower trophic level. Harvesting at a lower trophic level has contributed somewhat, but is far from adequate. Products based on such feed became a scarce commodity. Therefore the feed manufacturers could only produce conventional feed at an extremely high price. One has now succeeded in developing viable alternative feed sources, such as single-cell proteins based on natural gas, fat-producing omega-3 algae, land plants at a higher elevation that also produce "marine" omega 3 fatty-acids, bioprotein and lignin from the woodworking industry. On the market side, there have been a series of challenges, as the market today (in 2020) is segmented and characterised by a range of new species and products. Much of this was the response to the great industry crisis that slowly developed starting in 2006, reaching its climax in 2012.

In addition, it turned out that the environment up to 2010-2013 was effected by a range of environmental toxins such as dioxins, hormone imitators, pesticides, brominated flame retardants, pcb's, hopper suspensions and heavy toxins. In addition, two accidents caused great pollution problems. Especially exposed were areas such as the North Sea, the Baltic, and the Polar Regions (Barents Sea). The herring has returned to Iceland and the Norwegian ocean was not exposed to this in the same way. Herring and blue whiting were good alternatives in the food sector. A significant creativity in the research investment managed however to solve these challenges by developing purification technology and simultaneously compulsory follow-up of international agreements (Timbuktu protocol of 2016) ensured that emissions were reduced. Politicians have by and large compounded the problems for the industry and continually imposed hindrance upon hindrance to development of the industry (non-industry-friendly policy). Nonetheless, we did it!

The feed problem is solved

The aquaculture industry is thriving, not because there are no problems, but because one has managed to solve the somewhat large problems that arose during recent years. Particularly feed access became a large problem. But there now appears to have been a happy solution through the successful investment in alternative feed sources. "Against all odds" as some might say. In spite of the fact that the public authorities not only have ignored the industry but also imposed hindrance upon hindrance to the industry's being able to develop, the industry is today thriving in more ways than one. The exaggerated industrial neutrality policy and the counter-productive distribution and regional policy for a long time sent industry actors to increasingly higher levels of frustration. That one has nonetheless succeeded is not confirmation of industrial neutrality's excellence but must be seen in the context of Norway's incorporation and engagement in Europe and the industry's active positioning in the world market. Where Norway, in many ways, fell through, Europe and the international organisations came through!

The aquaculture industry today is characterised by investment in both high price products and in large volume bulk markets. Raw materials from gas have gained penetration and dominate now feed production to a large extent. One has succeeded in producing polyunsaturated fat from gas, not least because micro-organisms have been found in the ocean that make this possible. Of most interest is perhaps that the EU accepted this feed through EUSecure – the European system for safe food. The aquaculture industry is today built up around clear alliances between traditional industry and aquaculture. Aquaculture itself is characterised by great intensity, large stock increase, product diversification and an extremely high utilisation of the entire fish. Distribution based on use of a newly constructed high-speed railroad through Russia to China and on specially built vessels to Europe over the northern sea-route (Barents Sea) among other routes, diminishes transport costs where long distance transport is necessary.

Products, species and consumers

Made in Norway is an internationally recognised brand, not just in Europe but more or less all over the globe. Norwegian manufacturers do not only invest in salmon and trout as they did at the end of the last century and during the first decade of this one, new species have also arrived. In the high-price segment the most important products today come from species such as cod, king crab, halibut and char. One has particular success with the so-called "diet salmon". It has spread like an epidemic into the world market during recent years and today comprises more than 34% of the total market. Also the consumer pattern has changed. Communication companies and the media are in control. Direct communication between manufacturer/refiner and consumer through communication companies is crucial.

In the bulk market it is first and foremost tilapia, carp, spiked dogfish and sea cucumber that dominate. These are cultivated in large volume in warmer regions. The Norwegian fish farming industry controls large portions of the production internationally. Typical consumer groups in the high price segment are the heavily expanding middle-class in China and Russia. Eating expensive, health-promoting fish has status. Americans, who have traditionally represented the most important high price consumers, are to an increasing extent oriented towards low price products.

We also observe an increasing market growth in Africa, but in particular with products from the low-price segment. Morocco is one of the largest consumers of spiked dogfish. In addition, increasingly more tilapia, carp and sea cucumber are produced locally, close to the markets, in other words, in Mozambique, The Ivory Coast, Nigeria, Egypt and South Africa. Also in Southeast Asia low price products dominate and Norwegian interests are great in, for instance, tilapia production.

In Western Europe things are as they have always been, some expensive, some inexpensive while to an increasing degree there is an emphasis on functional fish farmed products, particularly in Eastern Europe. Typical products in the high-price segment are fresh fillet, a series of smoked products such as warm/cold smoked salmon, ready-to-heat composite products, sandwich spread and a large and varied selection of functional products. In the low-price segment we find in particular gutted fish, canned products, forcemeat products and frozen products. In addition fillet types from tilapia, carp and spiked dogfish are typical low-price products.

Technology and Research

The industry today derives great benefits from the technological development within other sectors (the auto industry, pharmacy, materials). Newer technology developed in other sectors is accepted, transmitted and exploited within the bio-marine sector. Especially robot automation competence from the

international auto industry has made it possible to remove all manual labour from processing. Norwegian R&D communities have therefore managed to develop a leading position internationally in the field. It has also been possible to protect the technological advances from competitors.

The feed production is comprised to a large extent of protein production based on natural gas. Norway leads the development in this field and has invested considerable research resources in further developing feed-manufacturing technology. This has in itself become a large export product for Norwegian enterprises. In addition, large quantities of feed raw materials based on this technology are exported. We have also developed technology systems for feed-fat production based on algae and oats.

Special products used to add taste, colour, vaccines and health benefits are an enormous area of growth where different characteristics are adapted to different customer groups and markets.

Increased production costs in low-cost countries and an increase in demand for super-fresh products based on pre-rigor filleting has contributed to this development. In particular the Norwegian research and industry community have managed to implement advanced Internet technology combined with new logistics systems to deliver fresh fish products to the doorsteps of consumers. E-trade of fish has developed from being a curiosity (sale of fish farming products as gift items) to a common way of buying fish as a grocery. A national monopoly has been developed in this sector. A total utilisation of super-fresh by-products with wholly unique characteristics (held back in Norway as the processing takes place here) has given increased profitability within processing and contributed to centralisation of the processing industry in Norway. Scottish and Faeroese salmon and trout for the northern European market are therefore processed in Norway.

The functional food market is growing. Through R&D it has been shown that marine food in general has extremely good health effects and also medicinal characteristics are fed in which make the fish even more attractive. Strong alliances have been formed between large pharmaceutical companies and the food industry. A typical example of this is Haframed, originally from the former Hafslund. This makes possible fish that can have hundreds of different characteristics, which can be adapted to special medicinal needs for preventive health effects. Norwegian research and documentation leads the international knowledge development in this area.

This development has led to not only the well-known European chain Lidl but also the most belligerent competitor Euro-REMA choosing Norwegian aquaculture products as the basis for all their fishery products. Quality, delivery assurance and ethics are crucial, say the spokeswomen from Lidl and EuroREMA. Both Lidl and EuroREMA are important actors in the new functional food segment. Both chains today have own research institutions, in fact some of the largest and best in Europe. Particularly biotechnology with world-leading competence in use of proteomics and metabolimics for development and control of farmed fish' unique functional characteristics, health/welfare and market economy/social science receive a strong focus in this research.

Other important factors that contribute to Lidl and EuroREMA's positive attitude towards Norwegian aquaculture products are the large changes that have been made in the transport system and basic improvements in the organisation of trade with an emphasis on factors such as traceability and "just-in-time" principles, where the department stores control their out-take from the market.

Animal welfare is the most important

The customers, and that includes both the bulk market and the high price market, are extremely concerned about how the fish was raised, what it has eaten and whether it has been raised under proper conditions. Good exterminations methods are regarded as extremely important because the buyers are concerned about whether the fish suffers, both while alive and in the moment it is slaughtered.

Animal welfare in production has become an important basis for the aquaculture products' reputation and welfare is a part of the production standard that lies in the brands in use. The customers are very politically conscious and most of them are members of consumer organisations. These organisations give the customers a voice in relation to the public authorities and other actors, so that in 2020 it is not only purchasing-behaviour in the stores that is important to the aquaculture industry.

The large international animal welfare organisations have achieved considerable penetration for the fishing methods of yesterday being cruel. This led to a restructuring of the fisheries so as to live up to the market requirements for more humane fishing methods. This was one of the reasons for the dramatic drop in access to feed raw materials from the fisheries a mere decade ago, which in turn is the reason why the current aquaculture almost exclusively is based on protein and fat from micro-organisms cul-

tivated on gas, and vegetable substances. The welfare requirements have also hit with full force within the aquaculture industry and fish farming methods and treatment and slaughtering processes have been completely modified. This has also had significance for the administration and regulation of the industry. Among other things, the requirements for maximum allowed area-use have been replaced with a regulation of maximum allowed production.

While the EU, Japan and the USA up to 2010 were the largest consumers of salmon China and Russia have conquered this position in 2020. A large purchasing power development has characterised these markets and there is in general a greater focus on animal welfare and health. The demand for expensive products (like fillet) and cheap products such as heads, forcemeat and belly flaps is large. Salmon has become a part of the daily diet in these large markets.

The entire fish "at work"

In "Feed for Everyone 2020" the fish farming industry learned to utilise the entire fish, also the blood. The main product shall not carry the cost. Through innovation, new knowledge and new technology, the industry has developed a series of valuable special products based on the fish farming industry's primary production. By-products based on super-fresh (1/2 – 1 hour) raw materials are in fact so valuable that sale of products based on what formerly were by-products, in part provides higher revenues and better profitability than the sale of traditional food products such as fillets and gutted fish.

The demand and willingness to pay for the new products is great. This has meant that the unit costs for the aquaculture industry on the whole have become significantly lower. Production costs for the traditional practices have thereby gone down and profitability also in this area has improved. In several Asian countries young people eat processed finished products like a new type of fish-burger made of bone offcuts.

Labelling and differentiation in the form of origin and history are important. Delivery is carried out from warehouses or restaurants out to the customers according to weekly menus. The focus is on health and functional and proper food.

Norway is an active member of the EU, which guarantees market access in other parts of the world. The situation is characterised by segmented markets, with market access agreements between different countries. The USA is a growing bulk market. The Norwegian fish farming industry has succeeded in repositioning itself and become extremely active in its market-orientation. The food product technology is extremely advanced in Norway in 2020. The Norwegian fish farming industry produces low-cost products such as tilapia, carp and spiked dogfish for African and Asian markets. These are manufactured in other parts of the world such as Bangladesh, the Philippines and Brazil.

Within aquaculture the market focus is also on the Far East. China and Russia have entered the arena as importer lands with an annual increase in GNP of 8%. China is a decisive impetus in the world development. The new customer groups in Eastern Europe, China and Russia have other preferences than the Western customers. The Western customers are mainly concerned with health while the customers in the East have a focus on the good life in their new welfare society.

The Norwegian salmon industry has from 2003 and up to 2023 gone through a continuous development that has been propelled by product development and customisation. This has been possible due to development that has taken place within adjacent industries, IT and logistics. Today pre-rigor all salmon is filleted in Norway. It is transported to large Norwegian-owned processing companies centrally located in Europe. In the Czech Republic refined products are produced on customer-demand. The customers served include everything from large supermarket chains to individual households. The customer makes purchases over the Internet; this is automatically fed into the production system, which produces customised products according to customer specifications. Distribution takes place through a further development of DHL, which now delivers refrigerated products to the customer's door. The system is development of the traditional door-to-door logistics. Fresh products dominate the trade in Europe and DHL's distribution system has been highly influential in Norwegian salmon gaining considerable market access in the American fresh food market. The Norwegian salmon industry has proven to be extremely adaptable to the development in the market and is now able to deliver to specifications, all the way down to the level of specified functional connections, anti-oxidants, bioactive slimming fatty acids and the newly discovered rejuvenation peptides. Ecological products based on unique feed systems have been common since 2017.

Multinational branding

The large multinational companies dominate and will operate the production and marketing of all fish

close to the consumers. They build up their own brands in close collaboration with the Norwegian fish farming industry. The production of refined products is by order, and takes place close to the customer. Eastern Europe and China demand farmed fish in large volumes. Fish is recognised as being the healthiest food product one can consume in the daily diet. The world population is growing even more rapidly and there is an ever increasing demand for fish. The capital problem has been solved by the government for a period becoming a large-scale owner. The industry is profitable and stands on its own two feet. The industry is perceived as an environmentally-friendly industry and meets all the requirements posed by international customers. We have problems meeting the large demand. The consumer is preoccupied with good health and is therefore willing to pay a high price for the fish.

Global warming brings new opportunities

Global warming has resulted in making the emergence of new species possible also on the domestic market. We obtain many more species in the national fish farming production (oysters have become an important part of the production). Warmer water led to new disease problems for a long time, but these have been solved through research and because health considerations have been taken seriously in the administrative regulation of the industry. It has become too warm for salmon farming in the coastal waters of Western Norway – and the centre of this industry segment is now out to sea in North Norway.

Fish farming has been prohibited in several large areas. Due to area scarcity in the coastal zone and to avoid national jurisdiction and restrictions, fish production has been relocated to offshore installations. The fish farming installations are established beyond the 2000 km mark and are either anchored in the bed or self-propelled and self-positioning. The installations are self-supplying, self-sufficient on energy through ocean currents, solar and bio-energy. The installations produce a range of different species and a quality improvement of the fish is achieved (pollution-free environment). Boats bringing feed bring the products with them back to the market. New materials technology and ICT enable unmanned installations, remote-controlled via satellite. Only in special circumstances is there a crew on the installations. We have solved the problem of extreme weather conditions through technology developments and new transport solutions. This has had positive effects for the environment in the fjords (marine oligotroph). Solutions for wreck and fugitive fish problems have been found.

Increased emissions of nutrient salts from Europe and fish farming result in flourishing algae growth. Mussel installations are used to a large degree as purification facilities in areas with particularly high levels of nutrient salt or algae concentration. The ocean temperature has increased by 1.5 degrees.

A few large companies dominate the Norwegian aquaculture industry

A few, large companies define the knowledge and technology development. In addition there is a multitude of different operations and manufacturing companies. The large companies control the operation and manufacturing companies and hereby control the markets.

The forwarding industry is marked by a new special competence in the area of equipment technology. The production of this however takes place often locally, outside of Norway. There is a particular emphasis on bringing down wage costs through automation of the processing segment and in parts of the production process (e.g. remote controlled feeding).

A development of refrigeration technology has taken place that makes possible significantly longer keeping capacity for fresh products and longer shipping distances. This has had a great importance to the development of the new markets, particularly towards Southeast Asia.

The aquaculture industry is strong in Norway. Consumer packaging in 2020 takes place to a much greater extent where the food fish is produced and slaughtered, namely, in Norway. Wages are still high, so we are not competitive with regard to manual production. Technological innovation has made possible a capital-intensive, non-labour demanding, automated production that makes ready-to-eat Norwegian products competitive abroad. In 2020 manufacturers know far earlier what the salmon is to be used for and who will buy it and this has made possible the development of new product segments and customised products for different types of buyers. Specialised niche companies can deliver special products to different customers and the quality can be of such a nature and at such a level that price/"performance" is satisfactory for a wide range of customer groups. Norwegian salmon has an every higher prestige than it does today and is protected by brand in the same manner as "Parma ham" was many decades ago. The framework conditions for

aquaculture have been improved significantly and we compete successfully with the pork export from Denmark. Chile and Norway remain the countries with the best fish farming conditions and the natural parameters are still crucial to the aquaculture industry's manufacturing ability and profitability. Chile has suffered several serious setbacks over a ten-year period due to fish disease.

Success despite absence of an innovation policy

Norway became a member of the EU in 2008. This has resulted in free market access for processed fish products for a market of 300-400 million consumers. This has also offered access to more resources for R&D purposes so it has been possible to realise prioritised projects, which have in turn procured breeding of new species, new processed products, biochemicals, etc. EU membership has implied that the national marine resources are made part of the EU's joint resources. Norway comprises a competence centre for the sector and has responsibility for the administration and control of these resources. Increased demand for fresh, processed products has led to new alliances between European supermarket chains and Norwegian coastal groups that attend to all processing.

Production of finished consumer products in Norway has also led to valuable by-products not being sold outside of the country. Industry based on these raw materials has finally obtained a stable access to raw materials.

The WTO has removed trade restrictions in relation to the 3rd world. There are neither any extensive direct and indirect subsidies in the traditional manufacturing nations (such as Norway). The World Bank supports establishment and transmission of knowledge in the 3rd world while fast-growing tropical farmed species are rapidly expanding as a share of the total and global fish farming production and as a portion of the protein consumption in Asia, Latin America and Africa, which results in increased export to Western markets at lower prices.

Ownership restrictions are suspended

After several years of limited access to equity capital the Norwegian aquaculture industry is to a large extent owned by companies with headquarters and owners outside of Norway. A few multinational companies dominate the market. 20% of the companies in the industry represent 80% of the production. The key groups specialise in 5-7 different farmed species and all have a well-developed marketing system. Products based on by-products comprise approximately 35% of the sales volume. Research activities are purchased on the international market, but the Norwegian researchers remain inexpensive compared with foreign researchers. Breeders work predominantly on a contract basis for the multinational companies.

Former institutions like Norwegian Seafood Federation (FHL), EFF or the Norwegian Råfisklaget have completely disappeared, replaced by international institutions and systems. The license system is such that quotas and area-use policy are politically controlled through licenses limited in terms of time, something that has at times been a large – and some might say unnecessary – hindrance to the development of the industry. The groups are allocated market quotas by the governments of the respective countries, based on supra-ordinate principles fixed by the EU. This has led to an increased focus on added-value per unit (quality instead of quantity). Greater stability, more suppression of information.

Knowledge development takes place internally in the companies

We have large, mobile, relevant, basic research through shared knowledge banks/pools. But most of the knowledge development for product development, etc. takes place at the companies, in-house. Economic theory is today something else entirely from what it was in the period before 2004. Endogenic growth theory, innovation policy perspectives and a renewed interest for classical theorists such as Ricardo, Sraffa and Schumpeter have begun to define the professional debates. This contributes to a much better interaction between companies, research and knowledge organisations than was the case up to 2014-2015 when the great trade reform within economics was carried out.

In 2020 a national network university has been formed where students can choose subjects independent of location. Universities are international forces in teaching and research. They attract international top expertise. Marine science alliances have been established with the largest and most heavyweight professional communities in the world. In the EU Norway has received chief responsibility for developing research and teaching within the marine sector. Basic research is led from Norway and under the direction of the ERC (European Research Council); Norway has been given this role within aquaculture. Central industry actors have long been dissatisfied with the public R&D strategy. Large

public investments in different research programs such as SFF, FUGE and others have not brought about the expected results in the form of commercialisation and industry development. The industry itself takes the initiative for a total reorganisation; user-controlled projects are changed over to a user-controlled research and education institution with a split public/private financing model, but controlled by users. The new organisation has own technology transfer departments, where the large actors have own divisions at the institution in order to enable rapid implementation of new technology. There is a separate education program, which users can utilise to update their employees and a start-up commercialisation unit has been established. The government/industry actors attend to protection and patenting by joint financing through different seed-capital and start-up initiatives. A fully-integrated concept.

Large companies that are leading competence and innovation impetuses have set the tone in Norwegian fish farming. This has resulted in considerable progress and growth in the industry with an annual production of 5 million tons of farmed products. Salmon is still the dominant species with 2 million tons. Different species, cod, halibut, tunny, shrimp, lumpfish, haddock, mussels, sea cucumber, and hagfish, are farmed and comprise the rest. Farmed fish has become "in-food" in large population groups internationally. The production share of processed fish grows. The industry does not only produce fish for human consumption, but also extracts biochemical substances. Innovation Norway has not received resources to take part and is not an important participant in this. The active forces are large companies where knowledge and innovation are important elements.

Little openness regarding key knowledge

Little openness. Large companies set the agenda. As owner of a large pharmaceutical company, Røkke establishes a marine technology research centre (focused on aquaculture) in Tromsø. The goal of the centre is patenting and utilisation of genes in marine organisms that have a large earning potential. This applies to bio-medicinal and biotechnological products. This provides the trigger for farming of marine organisms for bio-medicinal purposes. Another patenting area is new feed types. Norwegian aquaculture is controlled by large, international food product groups with internal research units. Their control is based on superior systems for logistics, market contact and control of a superior patented feed technology. Most of the applied research is privatised while the government concentrates on financing basic research. Extensive collaborations are established between the research-based fish farming industry and the universities.

The government and the Research Council have established a national division of labour between the R&D community in Norway and abroad. Larger and more interdisciplinary communities have been formed that can take on complex, complicated tasks and problems. This is achieved by way of geographic virtual collaborative methods that connect the Norwegian institutes. Both the industries and the public authorities have surmounted territorial and sector conflicts between the fishery and agriculture sectors. The result is better organised Norwegian research with good international connections and an effective collaboration between industry and research.

The Norwegian Aquaculture University has after many years of effort patented an immunity stimulating vaccine for fish farming. The vaccine protects against 10 of the 12 most serious diseases in fish farming, which implies that farmed cod can now be certified for trade in the EU.

EU a mobilising force behind the phasing out trade restrictions

Norway is a member of the EU. New directives have come into effect after Norway became part of the EU. The role of the Directorate of Fisheries has been toned down. The environmental requirements which were formerly different between Norway and EU countries are abolished. EU research has become even more central for the fish farming industry. We have a EU that has large problems after two radical expansions in 2004 and 2008 (where Norway became a member). The political coordination has failed and the EU contributed to growing confusion and problems for the industry for a long time. But after the reform in 2015 it began to play another tune. The EU became a mobilising force for reforms in the national industry and innovation policies, which served to rectify the situation in 2020.

The industry organisations are international and the Norwegian actors are direct members of the international organisations. The traditional regional policy has been phased out, mainly because of a lack of consensus in the regional commission's report. But the public authorities monitor the environment and stipulate social frameworks. Otherwise, it is full steam ahead. The industry policy is replaced by R&D policy and Norway has obtained a Centre of

Excellence within studies of primary- and by-products from marine resources in aquaculture. This provides the basis for development of functional food, the development of new medicines and for Norway being able to foster an internationally leading ingredient industry. Norwegian aquaculture production in 2020 is niche-defined.

How did "Feed for Eveyone" become possible? What happened?

In the entire period from the beginning of the new millennium up to today (2020) the public authorities shined in their ignorance and made it in part very difficult for the fish farming actors. Particularly around 2003-2005, when the industry experienced its worst crisis ever, many felt totally forsaken by the government. The markets in Europe became less and less accessible and sales dropped radically. In the beginning of 2004 the sales volume had decreased so much that it corresponded with the level from 1978. A slap in the face for all involved parties. Although the government did not appear to lift a finger, there were others who began to take action.

For many, also in coastal Norway and North Norway, it was clear that Norway had to become part of the EU. Early in 2004 "The Coast in EU" was established, led by Centre Party mayor Ronald Rindestu. Rindestu was perceived as being virtually a traitor, particularly by the members of his own party, the Centre Party. But eventually even large numbers of the Centre Party's constituents and representatives had their eyes opened to the fact that the road into the EU is and should be the only navigable road for Norway in general and for the fish farming industry in particular. In March 2004 a survey was carried out which indicated that 42.2% of the population in a selection of coastal municipalities would have voted yes, while 45.5% said no to EU membership. In 1994 the corresponding figures in the same municipalities were 20.3% yes, and 51.7% no. This was such a remarkable change that it was something much more than more or less superficial fluctuations. Norwegians were in the process of European-ising their identity. This trend proved to continue so that in the referendum in the EU spring 2007 the result was a solid YES to Norwegian participation in the European Union. 63.4% voted yes, while 36.6% voted no. The opinions of Norwegians had gone through a silent revolution.

In 2008 Norway also became a full-fledged member of the EU. This membership would later prove in many ways to be what rescued the industry from the crisis that arose in the period 2008-2012. Membership could by far compensate for the national government's servility and lack of understanding and willingness to get the industry out of the crisis and invest in individual industries.

Crisis

Between 2008 and 2012 public expenditures increase. We experience a costly tariff agreement, costly social reforms and pension challenges pile up. At the same time the oil revenues drop, because for among other reasons, Iran/the Middle East are stabilised. This also contributes to the value of the dollar further decreasing (In 2012 1 Euro = 1.65 dollar). Many unfortunate circumstances at the same time place a great pressure on the Norwegian economy. The government transfers the costs over to the individual citizen and the established industries. Particularly vulnerable is the aquaculture industry, which also is made victim of a radical increase in industry taxation. At this point the industry has no financial backbone to invest in preparedness and further development. At the same time, it becomes clear that the public sector has neglected to drive forward long-term developmental projects. The situation reaches a climax in 2011 when two oil tankers run aground at Mongstad followed by atomic waste being released into the ocean after a ship on its way to Russia runs aground on the coast of Western Norway. The demand collapses and the production terms in the south are destroyed overnight. For the fish farming industry this was paramount to experiencing the fall of the iron curtain, Chernobyl and the 1929 crash of the stock exchange all at the same time.

As Europeans we became strong

The industry however did manage a resurrection. There were several reasons for this. The increasing investment in research was of importance. Another important contribution to the resurrection was participation in the regional investments in the EU, in the 6th, 7th and 8th framework programmes and that the EU in fact was able to guarantee full market access to the entire Euro-region, as well as to large parts of the world market otherwise. The industry therefore began slowly to get to its feet again after 2012. The EU was also an important contributor in the sense that the relevant industry-ecological research results from the entire EU-region were made available to the European fish farming industry. One of the first things that was done was to improve management of increasingly greater requirements for the environment, "humane" production routines and traceability. In addition to the

other reasons for the crisis, the poor handling of these challenges was a contributing cause to the industry's almost being obliged to pull in its oars around 2011-2012. The industry strengthened its grasp in the collaboration with the EU.

The industry really had to take responsibility, as the public authorities did not appear to be doing so. With the help of active involvement and use of an international structure of measures and means, many industry actors succeeded in compensating for the inadequate industry and innovation policy for the aquaculture industry. In the midst of all of this, research was crucial.

The research was crucial

There is an expression that says: "necessity is the mother of invention". This also how we can characterise the situation following 2010. The Research Council, parts of the official activity and the industry joined forces, thanks to the innovation policy foresight of the fish farming industry 2012-2013 (based on a corresponding review in 2004). After 2012 these actors all pull together and propel forth a development in spite of politicians' vacillations and lack of focus. The condition for this was that the aquaculture industry was regarded as an attractive collaborating partner with R&D communities with special competence (Centres and Networks of Excellence – "Gold Coast") by external communities such as the EU.

Research in relation to the equipment industry, feed production and the biological production orientation has held a central position during the entire period, but received a serious boost around 2013-2014. Society-oriented research also became increasingly important. Some of the areas the research was directed towards in particular in this period were:

Basic biological research (organisms, etc.)

- Health and disease
- Parasite issue
- New species for farming (domestication of species)
- Breeding and genetics
- Environmental monitoring and knowledge about organisms' environmental requirements
- Characteristics of special products and bioprospecting (e.g. functional food)
- Product quality control
- Food safety (what will this involve in the future?)
- Genetically modified politicians!

Research on feed production

- Selection and refinement of relevant organisms for feed production
- Technology development oriented towards feed production
- Pre-processing of raw materials for feed productions (enzyme treatment, etc.)

Research oriented towards equipment industry

- ICT
- Material- and nanotechnology
- Biotechnology
- Genetic technology

Society-oriented research

- Market research
- Economic research
- Social science research (area-use, GMO, interaction between different industry sectors, such as wild capture fish / fish farming)

Eventually, the fish farming industry acquired such a good reputation that even the Norwegian Crown Princess begins studies in marine-biology in Tromsø. Ingrid Alexandra is brilliant and begins her studies three years earlier than is usual. "This is a fantastic signal," states the headmaster at the University of Tromsø at the opening of the new Aquaculture programme August 15, 2019. Talented young people from all over Norway apply to Norwegian aquaculture studies. In 2020 one of the professors, who is also a breeder, receives the EU Innovation Prize, one of the finest distinctions in Europe.

Key Events

2007 Referendum for EU membership (63.4% yes, 36.6% no)

2008 Norway becomes a full-fledged member of the EU

2009 The European aquaculture programme MarineResearch was launched with considerable funding and Norway became a key actor in this programme, despite the fact that the industry began to experience strong crisis tendencies

2010 Public expenditures reach an historical high

2011 Two oil tankers run aground at Mongstad Russian atomic waste spreads into the ocean after a shipwreck on the Western Norwegian coast

2012 Central actors such as the Research Council, some official activities and industry actors join forces and begin to work towards the same goals

2013 The large innovation policy foresight exercise for aquaculture is concluded

2014 Large research investment in equipment, feed production and biological production

2015 The trade reform within economics is carried out

2016 The Timbuktu Protocol is signed

2017 Ecological products based on unique feeding regimes

2018 Ingrid Alexander begins studies at the new Aquaculture Programme in Tromsø

2019 A central representative from the Norwegian fish farming industry receives the EU's innovation prize

Scenario:
The Aquaculture University





Photo preceding page from left:
Norwegian Seafood Export Council
Illustration: Jon Solberg
SINTEF
Photo Disk
K.J. Merok/Matforsk

The Aquaculture University

Establishment of the Norwegian Aquaculture University – a success in the work of industry-oriented R&D

Norway has strengthened its position as supplier of seafood to the international market. Salmon remains the girder in Norwegian aquaculture, but other species such as cod, mussels, halibut, lobster and scallops also assert themselves. Cod and mussels are volume products while the other species comprise niche products for high-paying markets. The fish is processed to a semi-manufacture product in Norway and transported as fillet to the markets. This implies a stable offer of a significant amount of by-products. The companies have managed to exploit this raw material and the production of semi-manufacture products to large pharmaceutical and chemical companies comprises a significant portion of the sales volume. A large number of production companies are owned by large international groups, but the Norwegian Petroleum Fund has contributed with strategic funding and controls several of the production companies. After heavy environmental taxes were imposed on lorry transport much of the transport out of the country is done by rail. Large tranship terminals have been established in Narvik and in the vicinity of Gardermoen. The Norwegian manner of shipping seafood is internationally recognised.

Norwegian membership in the EU from 2008 has contributed to stabilisation of the EU market, which is now regarded as a domestic market for Norwegian seafood. The most significant individual factor for the positive development of the Norwegian aquaculture industry was the formation of the Norwegian Aquaculture University. It came about subsequent to long-term problems with implementing knowledge in industry activities. The Aquaculture University emphasised multidisciplinary and problem-solving research. This implies a widespread collaboration with basic research communities worldwide. This also contributed to an increased understanding for the meaning of research in the industry. The large companies hired own people to work with R&D strategies. This commitment on the part of the industry involved a stronger focus on basic research and research oriented towards the administrative needs of the public sector. The Norwegian university communities became subsequently international leaders within a range of areas connected to aquaculture. The administrative sector acquired a basis from which to carry out research-based administration.

The "Better safe than sorry" principle is now only used in exceptional cases. This attracted international attention and led to Norway receiving responsibility for administration of the EU marine resources as early as in 2014.

The aquaculture industry's research institution: Ten-year anniversary in 2020

In March 2020 the aquaculture industry's research institution the "Norwegian Aquaculture University" celebrated its 10-year anniversary. The research institution has already succeeded in becoming the largest and most reputable institution of its kind in Europe. It attracts researchers from a number of countries and has extensive collaborations with large international research communities all over the world. Multi- and interdisciplinary research and collaboration with the best basic research communities are key factors in the institution's activities. This has contributed to creating a unique environment that produces research-based solutions providing a basis for further development of the industry. The institution now has a central role in the development of the aquaculture industry in Norway. The first years in particular were characterised by some trial and error, but from the very start it was clear

that the collaboration between biological and technological competence would be important in terms of meeting the industry's expectations for this investment. It was also clearly a contributing factor to the institution's being established on the Trondheim Fjord, a short distance away from the technological community in Trondheim and with good communication to the formidable biological communities in Bergen, Tromsø and Oslo/Ås. Large parts of the activity are operated as a virtual university where the students study over the Internet, through tele-lectures, and at the same time actively take part in work at the fish farming companies. Marketing, economy and relevant social science competence is brought in from other universities with such specialised competence. The institution also brings in other specialised knowledge where it can be found and adapts it to the objectives of the industry. In this way one has been able to implement and adapt knowledge that is developed within automation, materials technology, biotechnology and medicine, which has led to effective solutions for problems such as escape, fouling, traceability. Aquaculture is regarded as a demanding customer in relation to several of these spheres. The large companies have transferred much of their formerly scattered R&D activities to own departments at the institution to enable rapid implementation of new technology and they have their own education programme that is used to update their own employees. Special solutions are patented in collaboration with industry actors.

There is also a start-up and commercialisation unit that attends to design protection and patent rights. In the anniversary year the institution emerges as a well-run research institution. The location on the Trondheim Fjord includes offices for management, offices for researchers, laboratories and outdoor installations. A regional unit was recently established in proximity to Bodø, where what remains of the former halibut endeavour are included. Work is being carried out to establish a unit close to Stavanger. This shall be based on the former Norconserv, among others.

Product development will receive a central place at the unit near Stavanger. The institution is owned by the industry. It has an annual basic grant from the industry, in that large portions of the industry's research fund are allocated to this purpose. The institution also receives funding from the government, through various initiatives such as seed-capital and start-up grants. In addition it has revenues from implemented research projects. The administration has found it to be expedient to have a separate department focused on obtaining and coordinating administration-oriented knowledge. After many years of effort, the health and welfare institute at the University received a patent for an immunity stimulating vaccine for fish farming. The vaccine protects against 10 of the 12 most serious diseases in fish farming, including salmon lice. This has been important for the breeding of cod and has generated good revenues for the institute.

Public investments have failed!

Around 2008 it turned out that public investments such as the Centre for Outstanding Innovation and Big Programme, etc. did not contribute to the anticipated innovation in the industry. Multidisciplinary and long-term research was not prioritised and the industry continued to struggle with considerable problems in connection with escape, area-shortage, health, feed and production of new marine species in fish farming. The knowledge development within fields such as automation, biotechnology, materials technology, medicine and genetics were significant in the period, but one had not succeeded in utilising this knowledge in solutions from which the aquaculture industry could benefit. All of this created great frustration in the industry. The criticism from the industry increased and the public research funds were gradually heavily influenced by political decisions. This contributed to the long-term investment being neglected, little focus on the prioritised areas and the funds were thinly spread all around. It was now decided that an increasing portion of the universities' incomes was to come from sources other than public funding. This led to the universities being propelled towards research that can provide revenues in the form of patents and rights. The best people at the universities became preoccupied with research and had little time to teach. The teaching system did not intercept the creative people and the universities' role as a place of learning crumbled. Administration-oriented research was minimised. Institutions wishing to operate interdisciplinary research and knowledge development acquired large problems. Private knowledge increased.

The scope of knowledge is enormous and easily available but on the other hand it is hard to gain access to the exact knowledge. The large public investment from 2005 forward led to many young people applying for education within aquaculture. In a few years, "Aqua Studies" was among the most popular among applicants to universities and colleges. Due to a limited implementation capacity in the

industry and almost no jobs, the results were not carried on into industry development. There were many gifted researchers, newly educated students and teachers who did not find jobs in Norway and had to work at other things or they moved to other countries. A considerable brain drain from the industry takes place.

Uncertainty in Norwegian research communities

Also in other areas things occur that create problems for the fish farming industry in Norway. New and better-adapted technologies and production systems led to a significant increase in the production of tilapia and other species from warm countries. The species became popular in the EU and other important markets for fish and eventually created significant problems for sales of Norwegian salmon. A scarcity of alternatives to the traditional marine feed substances led to an increase in the price of feed and the production systems for salmon had not managed to intercept and utilise the opportunities that the development within automation and materials- and nanotechnology had generated. Aggressive media companies use the disagreement between Norwegian researchers, their uncertainty and lack of answers to questions about whether Norwegian farmed fish is dangerous to the health, as headlines to attract readers and viewers. They receive assistance from the nature conservation organisations. Researchers and environmental administration are in conflict. This leads to Norwegian salmon competing poorly in the markets.

Central industry actors reorganise industry-oriented research

Central industry actors who were extremely dissatisfied with the public R&D strategy took the initiative as early as in 2007 for a total reorganisation of industry-oriented research. The industry-oriented research was concentrated and formed the stem in the user-controlled research and education institution the Norwegian Aquaculture University, which was established in 2010, financed by funding from the industry and the public sector, but mainly run by user-interests. Quite early on there was agreement about establishing the new institution on the Trondheim Fjord. An emphasis was then put on proximity to the sizeable technology community in Trondheim and good communication with the important communities in Tromsø, Bergen and Oslo/Ås.

It became clear very soon that this initiative would contribute to innovation and new gains in the aquaculture industry. The special interaction between practical work in the fish farming companies, remote learning both from the Aquaculture University and other institutions and research with a strong industry orientation, under the direction of the commercial research units at the university, provided the basis for goal-oriented problem solving. It has led to solutions contributing to more cost-effective production. A range of the industry's environmental problems is solved and the institution carries out important work with regard to market understanding and market access. The investment represents a fully-integrated measures concept and attracts international attention.

Increased competence provides the basis for research-based administration

The growth in the industry-financed research is significantly larger than in the publicly financed research. The industry brings in special competence where it can be found and adapts it to own objectives. The industry has been able to implement and adapt knowledge that is developed within automation, materials technology, biotechnology and medicine. This has led to effective solutions for problems such as escape, fouling and traceability. Self-repairing seines give automatic notification of escape-risk. Seines equipped with nano-robots prevent the formation of biofilm. In the most modern markets there are small computers in people's jewellery or wristwatches used to trace information about the product. The companies' special interests are patented. Private investors focus however most on service and product development and are less willing to finance knowledge development. The publicly funded research is to a considerable degree oriented towards competence development and towards administration needs. Regional and global research networks are of great importance to the development.

After the Norwegian research communities to a larger degree focused on acquiring knowledge about administration needs, important changes took place in administration. Initiatives are now generally implemented according to knowledge-based administration, and the "better safe than sorry principle" is used only in exceptional cases in the administration of the Norwegian aquaculture industry. The Norwegian public authority system, which administrates marine resources, has been made efficient and simplified and has received international administrative responsibility for EU marine resources. In return, Norway had to relinquish fishing quotas in the Barents Sea to the EU. This led to

large problems in relation to fishery interests and the fishermen's organisations. However, Norwegian shipowners are now in the process of buying up several of the most important EU shipping companies that have quotas in the Barents Sea. The public sector is contributing with change-over funds for these initiatives.

The universities' work with competence led to the Norwegian communities developing a significant international competence in a series of areas of relevance to aquaculture. In 2020 two large international aquaculture conferences will take place in Norway, one in Tromsø and one in Bergen, both with considerable international participation. The Norwegian universities that have Aqua Studies have become attractive to foreign researchers.

The product range has increased

Competition from products from warmer countries is significant. Tilapia is produced in a number of countries in Asia, Africa, in the Mediterranean countries and in Central America. The products are in demand by large markets such as the EU, the USA, Asia and Russia. After Norwegian communities succeeded in finding new cost-effective production methods for salmon, salmon is again competitive in the markets. In Norway approximately 1 million tons of salmon are produced annually. Salmon is still the girder in Norwegian fish farming. Long-term research has shown that marine food in general, and salmon in particular, has extremely beneficial health effects. Strong alliances have been formed between pharmaceutical companies and the food industry and a series of different health characteristics are coded into the salmon. One product has the designation "Viagra Salmon".

Cod has also become a significant farmed species in Norway. Annually approximately 200,000 tons are produced and production is growing. Cod is a familiar and highly treasured species in Europe, including Russia and most of the production is sold fresh or as frozen fillets to these markets. A company in Sunnmøre has in recent years had good experiences with making clipfish from farmed cod. The clipfish is now being tested in the bacalao markets in Portugal and Brazil. But here the competition from wild capture cod is great.

The mussels industry has picked up and Norway exports annually some 100,000 tons of mussels. Most goes in bulk to the EU but some is processed and included in ready-to-eat products. In addition, halibut, lumpfish, char, scallops and lobster are produced in Norway. These species are produced in smaller amounts, but they are sold to high-paying markets all over the world. Norwegian sectors are involved in the work of developing special products from these species.

Utilisation of by-products has contributed to the development of an industry that supplies semi-manufacture products to chemical and pharmaceutical industries. Industries based on this raw material have finally found a stable access to raw materials. The production based on utilisation of by-products comprises 35% of the sales volume. The company Byssus in 2012 received the patent for an incredibly strong glue based on substances extracted from the "byssus" or filaments from mussels. The glue is used among other things as a replacement for screws in the new space shuttles transporting tourists to the moon. Byssus was in 2016 the winner at the Tokyo stock exchange.

Markets and transport

Norwegian research communities and companies have had to give up ambitions on developing national or company-specific advantages within brand building. In a global food product market it has been necessary to form alliances with global suppliers of processed food products. An agreement has therefore been formed with the Coca Cola Company for marketing and distribution worldwide. This in particular pertains to use of CC's refrigerator concept for sale in stores. This is a part of CC's new strategy to get into schools and day-care centres and to build a positive image. Since users/consumers consume a larger and larger percentage of meals through fast-food chains, it has been necessary to enter into an agreement (exclusive) with McDonalds. This is an initiative that was also made by McDonalds in order to acquire alternative products besides meat (Mad Cow & Pig Disease have made unilateral investment in meat extremely risky.) McDonalds has become the industry's largest customer for seafood from Norway and a long-term strategic cross-ownership has been established.

The customers demand that the aroma component in the product is retained. This and the short distance to large markets have contributed to most of the fish being exported fresh or imitation-fresh from Norway. Development of new competence is an important condition and the competence communities had a wealth of resources for this work. The quality of fresh fish is customised, because one has control the entire way. Niche products are developed because the distance from the main market is different. Controlled maturation processes after

slaughter are incorporated as a part of the distribution chain. Intelligent registration in packaging has been developed that shows quality indicators and deviance if something has gone wrong along the way. Signals from the packaging are sent electronically to the virtual tracing and documentation system Fresh Track, developed and patented by researchers at the Norwegian Aquaculture University.

After several referendums, Norway became part of the EU in 2008 and access to the EU market in 2020 is stable and satisfactory. The EU is regarded as a domestic market for Norwegian seafood. The EU and Russia are the most important markets for Norwegian fish farming and take more than 50% of the production. Also other large, but more remote markets, such as China, India and Japan are important markets. Heavy environmental taxes were imposed on lorry transport in the EU. This led to much of the lorry transport of large amounts of Norwegian seafood becoming too expensive. A decision was made to ship by rail. The railroad companies were re-outfitted and Narvik and Gardermoen were established as importance junctions for railroad transport. Most of the salmon and cod are now shipped fresh or as frozen fillet and transported by trailer and rail to the markets in Europe and Russia. Most transport to the more remote areas is frozen goods by boat. Some is also transported by air, such as super-fresh products to high-paying markets.

Large companies dominate – but there is also room for the small

After several years of limited access to equity capital, the Norwegian aquaculture industry is to a large extent owned by companies with headquarters and owners outside of Norway. A few multinational companies dominate the market. 20% of the companies in the industry represent 80% of the production. Products based on by-products comprise approximately 35% of the sales volume. Breeders work predominantly on a contract basis for the multinational companies. In 2012 however one of the national capital funds went in with strategic funds on one of the largest fish farming companies designed according to the same model as Statoil. 60% of the capital is in the biomass, which has a life cycle of 15 months. In addition to owning and operating fish farming installations, they have also established themselves in Norway with some of their refining companies, which first and foremost manufacture fillets for transport and further processing closer to the end-user. There are also large installations for processing of by-products, which now comprise a significant resource. The "little fish farmer" still however has a place and in 2020 one of the smaller companies was selected as Norway's most successful company, both economically and innovatively with its special combined operation of rainbow trout, mussels, oysters and lobster in the same system.

New materials and production technology give robust and better adapted installations

Intense fish farming at sea is the most important form of production for the "volume species". With use of modern materials and high level of automation, installations and production technology have been developed that make it possible to safely place large installations in more exposed locations. The fish farming installations established in the most exposed locations are either anchored to the bed or self-propelled and self-positioning. The installations are self-supplying, self-sufficient from energy through ocean currents, solar and bio energy. The installations produce a range of different species and a quality improvement of the fish is achieved (pollution-free environment). Boats bringing feed bring the products with them back to the market. New materials technology and ICT enable to a very large extent unmanned installations. The production itself is remote-controlled via satellite, monitored by a security crew on the installations. Only in special circumstances is there a crew on the installations.

This has resulted in less pressure on the areas in the most densely populated regions. There are however also installations on land where part of the production takes place. Water treatment and recirculating are important elements of this production form. Also in this area new technology is implemented. Farming of lobster and scallops is popular and spreading. Development of methods for effective influence of individuals through breeding has led to sea ranching being used for large portions of this production. A considerable amount of the doubts about this form of production disappeared when equipment was implemented which resulted in there no longer being a need for divers for tending and harvesting.

Preferential rights on use of coastal zone – increasing consumption of ready-to-eat dishes

Aquaculture production has received preferential rights on use of the coastal zone, particularly in the areas from Nordland and northward. There are however strict environmental and ethical require-

ments for the installations and operations and stricter requirements for health and distance between the sites. The industry is struggling with creating a good understanding for this in its own ranks. There is a concentration of installations at fewer sites and joint sites are common. Many coastal municipalities have introduced a municipal tax on fish farming, which implies significant annual revenues for these municipalities. There is an increasing consumption of ready-to-eat dishes, which are produced near the large markets. Extensive use of food cosmetics results in other quality requirements for the raw materials in many of these products. Presentation of goods is emphasised, and traceability and keeping quality indicators are important. There are strict requirements imposed on packaging. It shall present the product, fit into the chain and meet requirements for refrigeration, keeping qualities and environment. The materials in the packaging are produced from genetically modified products and can be implemented after use for the production of feed used for other production animals.

Customers impose large demands on products

Customers are concerned about how the fish has been raised, what it has eaten and whether or not it has been bred under proper conditions. Extermination methods are important because the buyer is concerned about the fish suffering, both while it is alive and in the moment it is slaughtered. Animal welfare in production has become an important standard for the reputation of aquaculture products and welfare is a part of the production standard behind the brand name in use.

Customers are more politically aware and are often organised in consumer organisations. These organisations give customers a voice in terms of the public authorities and other actors, so it is not only purchasing patterns in the stores that are decisive for the aquaculture industry. E-trade of fish has developed from being a curiosity (sale of farmed fish products as gift articles) to a common means of buying fish as a grocery product. Through the use of modern ICT the industry has in collaboration with international research communities developed systems that enable the consumer to retrieve electronic information directly from the product. In recent years this reading system has become "common property". In addition to transmitting information about the product, it can also transmit pictures from the installations and those who work there.

The growth in industry-financed research is significantly greater than in publicly-financed research. The industry brings in specialised knowledge from where it is found and adapts it to its own objectives The industry has been able to implement and adapt knowledge that is developed within automation, materials technology, biotechnology and medicine. This has led to effective solutions for problems such as escape, fouling, and traceability. Aquaculture is regarded as a demanding customer in relation to several of these spheres. The companies' special interests are patented. Private investors however focus mostly on service and product development and are less willing to finance knowledge development. Publicly financed research is to a significant degree oriented towards the administration needs. Regional and global research networks are important to the development.

GMO – yes, but in a new way

The first years after the year 2000 several studies concluded that the access to marine feed substances would be the largest challenge for continued growth in Norwegian aquaculture. The Research Council of Norway developed an action plan on the subject and eventually significant amounts were allocated to research on alternative feed substances. A parallel investment in biotechnology made it interesting to use genetic technology to develop variants of farmed species that can eat other feed. At the same time, genetic technology was implemented to develop feed raw materials other than marine. The research investment was goal-oriented and good solutions were found. However, the opinion has been unilaterally negative regarding use of genetically modified organisms in feed and there has not been sufficient demand for products based on modified genetic materials. Many ask whether the earlier investment in GMO has been wasted. Researchers at the Norwegian Aquaculture University have in recent years consciously focused on knowledge and objective information. This has opened up for the use of GMO in treatment of certain diseases and GMO-manufactured vaccines have been implemented. Marine feed products are taken from the lower trophic levels in the ocean, such as krill and other plankton. A number of feed products also come from mussels. For a period a good deal of single-cell protein is also used, produced with a point of departure in gas. The fatty-acid content however is still a problem. Trials have been done with several vegetable oils but it does not appear as if this can be done without use of feed substances based on use of GMO. The large companies have finally gotten together in an attempt to solve this problem and the researchers at

the Aquaculture University are very confident about finding technical solutions.

At the same time, continuous work is being done with information on the subject. There is an extensive collaboration in the field with large food universities in Japan, the USA and China.

Establishment of the Norwegian Aquaculture University – A success in the work with industry-oriented R&D. What happened?

In the period leading up to 2008, the research communities were fraught with mutual competition and division. Recommendations that were made regarding the blue-green food alliance were not followed up. Instead came a series of initiatives in connection with the election campaign before the Parliamentary Election that resulted in the establishment of 10 new competence centres along the coast from Bergen to Tromsø. It became evident eventually that at the very end of the election campaign a promise was made for three further competence centres in Finnmark alone. The building of the competence centres was time-consuming and costly and led to increased competition over limited public funds. Well-established and internationally recognised research communities were at risk of losing public backing and being split up. The considerable resources necessary for establishment of the 10 competence centres resulted in the work on many important tasks demanding interdisciplinary collaboration not being commenced. It also led to making the innovation processes difficult and the opinion manifested itself that publicly financed industry-oriented research was not satisfactory, and that it did not contribute to the development of the aquaculture industry. For the industry this was a big problem.

Knowledge development in many important areas such as feed resources, parasite problems, production technology, deformations, area-use, new species in fish farming, product development and market access virtually came to a halt in Norway. The growth in the industry-financed research was significantly greater than in the publicly financed research. Thanks to increased investment from the industry and increased collaboration with foreign research communities, the research could continue in a number of areas. The industry's organisations continued to point out the difficult situation and had several meetings with leading cabinet ministers and with the Prime Minister, but this did not lead to solving the problem. Eventually it became clear that the industry itself would have to address the problem with a view to coming up with a solution. This was however also difficult in that the large industry actors had different perceptions of the matter and were only to a small extent interested in research-strategy work. In a meeting where all the influential industry actors took part, there was however a consensus for establishing a separate research institute that should have the task of carrying out industry-oriented research and development. After tough discussions with the Ministry, an agreement was reach that large portions of the industry's research fund should be used for operation of the institution.

From scattered to concentrated ownership

From 2005 the salmon prices were good. The companies earned well and there were several large international companies that wanted to buy up the Norwegian fish farming companies. Many sold and a few large international companies eventually dominated the Norwegian fish farming industry. The Norwegian Petroleum Fund brought in some money, but the funds were scattered and did not provide a basis for a strategic influence. This led to a lot of media attention and the guidelines for a couple of the largest funds were changed so they also could utilise strategic funds. In the course of 2008-2009 a couple of the funds entered with strategic financing and became the dominant owners in two of the largest companies. This played a big part in the establishment of the Norwegian Aquaculture University, which occurred just afterwards.

The industry-oriented research was intensified

In a study from 2006 it was shown that in spite of interesting and important results from research the results had not led to lower production costs in the industry as was anticipated. This led to the innovation system and industry-oriented research coming under serious public scrutiny. Only after the Aquaculture University was established did this research take off. With a basis in previously established competence and knowledge, a range of industry problems were solved and quickly implemented in the industry. One of the first problems addressed was coming up with an escape-proof installation.

Through an intense collaboration between the technological and biological communities and use of new materials and methods, one came up with an installation and operational form that was estimated to be 99% escape-proof. This contributed to solving the conflict of interests on area-use and the

large environmental problem that fugitive fish represented. Production of the new species was still not a success. A large amount of knowledge had accumulated in the research communities and in individual companies but it was only after the implementation department at the Aquaculture University took hold of the problem that the development began to make serious headway. This led to a large interest in developing new species for farming and was successful with species such as cod, halibut, mussels, lobster and scallops.

With the entrance of new species in fish farming new disease problems also arrived. With a basis in formerly established fundamental knowledge, effective measures were eventually developed against the diseases causing the greatest amount of fatalities. An important step forward in this work was that vaccines based on GMO were allowed. The Norwegian research communities, with researchers form the Norwegian Aquaculture University leading the way and in collaboration with large international communities, made an important investment in the task of creating an understanding for GMO-based solutions.

The research made strong contributions with knowledge about markets, market power and market access. This contributed to richly populated areas such as China, India, Pakistan and Indonesia becoming important markets for Norwegian seafood in 2020. Detailed knowledge about society, culture and culinary traditions resulted in one being able to customise products for the different markets and seafood from Norway is a preferred product in many important markets. The customers' demand for information about the products was finally taken seriously and the systems that are established for transport, logistics, packaging, monitoring and information are referred to as "the Norwegian way".

The industry is heavily involved in research

The industry's involvement in industry-oriented research would prove to have an extremely great importance for the continued development. It implied that the industry to a much greater extent than previously assumed a research-strategic role. It also implied that the industry and especially the large actors understood the advantage of being involved in research and of utilising research results. Positions were created for employees who could contribute with implementation and communication with the research institutes.

Equipment requirements increased and in the equipment industry one realised that the smaller companies could meet the requirements of the large companies. A series of fusions were carried out that provided the basis for larger, and more effective companies. The collaboration between fish farming companies and the supplier industry was developed and contributed to a quicker development of expedient equipment in all areas.

The public authorities on the offensive with investments in research and development

When the public authorities and the political system finally understood the problems with implementing knowledge in the industry, conditions were modified so as to facilitate increased involvement on the part of industry. Guidelines for the use of the industry's research fund were changed and could be applied as a basic grant to the Aquaculture University. A very correct and important decision was also made when the Petroleum Fund was spent on strategic acquisitions in large international companies that formerly had acquired control over large parts of the Norwegian aquaculture industry. The investment in competence generating research and research oriented towards administrative needs proved to be a must. The Norwegian basic research communities became international leaders in a series of aquaculture sectors and the administration achieved international status as the EU's instance for administration of marine resources.

Key Events

2005	Good salmon prices
2006	Greater attention to the innovation system and industry-oriented research
2008	Norway became a member of EU
2009	Establishment of 10 new research and college centres between Bergen and Tromsø
2012	The company Byssus receives patent on incredibly strong glue based on substances extracted from filaments (byssus) from mussels
2012	One of the national capital funds went in with strategic funding to one of the largest fish farming companies designed according to the same model as Statoil
2014	Norway receives responsibility for administration of the marine resources in the EU
2016	Byssus becomes winner at the Tokyo stock exchange
2018	"Viagra salmon" is launched and achieves great success

Strategic recommendations and initiatives
List of participants





Photo preceding page from left:
The Norwegian Seafood Export Council
Illustration: Jon Solberg
SINTEF
Photo Disk
K.J. Merok/Matforsk

Strategic recommendations and initiatives

Non-prioritised list of challenges and initiatives one can anticipate meeting in the future in the context of the different scenarios. Developed during gathering 4.

Opportunities and challenges	Research and education	Trade and Industry	Public Authorities
Primary challenge and opportunity:			
Development of an innovative (dynamic), internationally-oriented, sustainable and profitable aquaculture industry in Norway	Relevant development of competence in interaction with trade and industry and the public authorities	Development of internationally-oriented, profitable, strong-growth and knowledge-based added-value processes	Development of framework conditions that make sustainable solutions profitable and that make it expedient for the individual actor to choose solutions that are favourable in relation to common values. Active interaction with industry actors and others regarding concrete strategies and investments.
1.Main challenge: **Process innovation for profitability, sustainability and market adjustment**			
• **Knowledge-based process development, automation, equipment (technology)**			
Profitability in primary production is a basic precondition for being able to utilise research	Costs in the value chain Profitability in daily operations Remove cost drawbacks that Norwegian actors have Industrialisation of processing segment Distribution Total utilisation of the fish	Meet international competition by choosing competitive products. Focus on innovation: implement available technology Develop new technology. Develop business concepts that are capable of exploiting these advantages.	Optimal resource administration Research in relation to the most significant bottlenecks
Knowledge of production Added-value based on intellectual rights	Develop equipment for marine industry in a long-term perspective (as good at this as at manufacturing fish!) Research ambition!		
Organisation of optimal (large-scale / small-scale) operation	Administrative problems and issues Practical solutions Infection assurance Technology		
Innovation in processes	Combine R&D from a number of disciplines ICT from the automotive industry R&D for utilisation of entire fish		

Opportunities and challenges	Research and education	Trade and Industry	Public Authorities
New fish farming and harvesting technology	New fish farming concepts Land-based, fjord or offshore farming. New materials, new constructions, design, costs		
Automation	Robot technology Process management Efficiency Animal welfare		
Nanotechnology	Operational application		
New materials	In sea-based installations Strength Automation Escape proofing		
Process technology efficiency, price, delivery proficiency. Robot technology. High wage costs	Robot technology Automation Materials technology Nanotechnology IT/artificial intelligence	Structures that ensure utilisation of capacity in aquaculture/fishery industry. Development of a stronger equipment industry that can produce the new process technology for niches where the Norwegian equipment industry has an advantage. The new technology must be implemented Information processing as a basis for process − management Access to equity and risk capital	License and industry policy that make an optimal structure possible Public authorities must ensure basic knowledge and operate using an active innovation policy.
Automated and remote-control installations dominate the industry	Telemedicine Instrumentation Materials technology Climate research	Ditto	Develop national centre for aquatic telemedicine
Effective primary production competition	Knowledge of the whole in the food chain and critical control points Quality	Experience databases and bench-marking systems Documentation of efficiency for new technology Communicate developmental needs/bottlenecks	Framework conditions that give maximal competitiveness. Provide opportunities to test new technology “Midwifing” to get started with new species.
Fish health in focus due to productivity and ethics, animal welfare	Efficiency vs. animal welfare in processes Ethics Diagnostics, biology, biopharmacology		

Opportunities and challenges	Research and education	Trade and Industry	Public Authorities
Vaccines	Marine species IPN ILA GMO Lice		
Fish farming out into exposed areas	Marine knowledge Technology		
Joint-localising of species/poly-cultures Area-utilisation	Interaction between species	Test and exploit possibilities	Knowledge of acceptable water quality Ecosystem understanding and monitoring Health, food safety Design of regulations (joint-operations, polycultures, etc.) Allow possibility for testing.
Alternatives to the use of chemicals - Use of chemicals prohibited	Alternatives for fouling prevention measures − biological and technological Anti-parasite measures − biological, technological / water treatment, parasites biology and proliferation Area-planning	Alternatives for fouling prevention measures − biological and technological. Anti-parasite measures − biological, technological / water treatment, parasites biology and proliferation Area-planning	Alternatives for fouling prevention measures − biological and technological. Anti-parasite measures − biological, technological / water treatment, parasites biology and proliferation Area-planning Regulate and follow-up the prohibition
Complete knowledge of fish's environmental requirements - Climate changes	Modelling tools − fish farming environment Fish biology knowledge Technology that addresses this knowledge Analysis/monitoring tools	Fish biology knowledge Technology that addresses this knowledge	Modelling tools − fish farming environment Fish biology knowledge Develop oceanographic models
Water quality	Limit values new species Water treatment Emission-purification environment Recycling Process management and monitoring		
Nutrient salt emissions prohibited - Local and national environmental requirements	Increased feed exploitation Feeding technology Choice of location Purification technology Online monitoring	Increased feed exploitation Feeding technology Choice of location Purification technology Online monitoring	Regulate and follow-up the prohibition

Opportunities and challenges	Research and education	Trade and Industry	Public Authorities
Traceability	How to communicate the history? Technological requirements and possibilities in relation to customers (Information systems, competitive tendering, traceability, product documentation, product information, chip on fish pieces provides information about preparation of fish, automatically transmitted to kitchen stove)	Ability to address competitive tendering: from offering to tendering. Ability to deliver fish in large volumes over time, “just in time”.	Information infrastructure/ broadband Ensure that we participate in the European standardisation work.
Escape does not occur Biological abundance Economic − image	Wreck-proof installations Unbreakable materials Interactions between wild/farmed fish − area-planning, HES/operational routines Land-based installations	Wreck-proof installations BAT-implementation	Regulation BAT research
Traceability, food safety, quality environment	Identify applied system Adapt the systems to fish farming Implementation	Implement existing possibilities and develop documentation for “the lifetime” System for information availability	
Good animal welfare Market Economy Self-interest	Fish’s nutritional needs Communication manufacturer and consumer (knowledge to market) Transmitter in correlation w/ needs of fish Identification of well-being	Code of conduct Best practice Communicate with the consumer and the fish Perception of fish welfare Technology that addresses welfare Use of antibiotics	Outline needs of the organism Develop regulations Document well-being limits Well-being factors Bonus programmes Communicate with the fish
Fish welfare	Physiological welfare indicators Market significance Transport and extermination	Proactive attitude	
Ethics are important to the consumer	Welfare documentation Production systems		
The conscious consumer/the demanding trade chains	Documentation Traceability Labelling History told by those selling Systematic production		

Opportunities and challenges	Research and education	Trade and Industry	Public Authorities
Adapt production to markets	Market models, economic production models Adapt product to market		
• **Feed**			
Feed technology from “seed” to finished product	Technology in relation to the different links in the value chain; not only input to feed but also the surrounding technology.		
Feed substances from new sources	Are there interesting by-products from other industrial processes? (e.g. breweries) Protein, oil, etc. Find and document good characteristics of new feed substances; designer feed. Develop synthetic feed. Marine feed substances at lower trophic levels; e.g. copepod and krill Bacteria		
New feed types	Based on natural gas By-products. Marine biotechnological methods and process development. Development of value chain for these Fish farming as a means of transforming gas to food Agriculture, agriculture technology and new feed		
Abundant access to sustainable proteins - Raw material access from the traditional fisheries disappears	Research to derive single-cell proteins from algae and gas Research on vegetable proteins Research on how to obtain acceptance for GM protein Research for better utilisation of existing vegetable protein-sources (effect of anti-nutrient substances) Harvesting at a lower trophic level Health effect on fish Interaction with micro-nutrient substances	Feed and fishery industry must make the problem visible. Must research a lot (average growth of 0.25% annually) and commercialise amply. The industry must promote synergies between different disciplines and industrial spheres.	The public authorities must finance basic industry-oriented research. Develop good partnership-models for research financing and activity between trade and industry and the public authorities. Establish a new administrative system for lower trophic level (e.g. krill). Establish programmes and criteria for public approval of by-products.

Opportunities and challenges	Research and education	Trade and Industry	Public Authorities
Genetic modification and feed production	Effect on fish and humans	Consumer trends Perception of risk Product development	Basic knowledge Labelling and certification system Limit setting
Effective development of feed for new species - Ongoing production of new species that require feed	Fat metabolism and deposit in fish Nutritional needs related to metabolism rate	Fat metabolism and deposit in fish	Fat metabolism and deposits in fish Nutritional needs related to metabolism
Functional food − fish - Use of antibiotics prohibited - Vaccines produce too many side effects	Immunity stimulants Outlining of fish's immune system Total focus/research on phase between healthy fish and sick fish = "foolish fish"	Immunity stimulants Outlining of fish's immune system Total focus/research on phase between healthy fish and sick fish = "foolish fish"	Outlining of fish's immune systems
The fish utilises the feed better - In 2020 the feed factor was approx. 3 measured as dry matter - In 2020 this was down to 1.5 - Abundant access to sustainable fatty acids - Farmed fish are a safe food product - Increased focus on clean food requirement for documentation	A more effective fish is bred Biological value of feed increases Feeding regimes and technology are improved The fish's protein metabolism is controlled through the feed Research on health consequences of contaminants and identification of these Purification technology Raw material sourcing	Implement quality criteria for "clean food" Research on commercial consequences of basic research in the field Purification technology Raw material sourcing	Develop tools for understanding of the fish's protein metabolism Develop "clean food" criteria New fish species and breeding strategies − genomic research Remove feed quotas in kilos Research and documentation of health consequences of contaminants and documentation of these
Focus on food safety/security - Consumer requirements - Consumers	Psychology (social communication) Environment Traceability and control systems Human, health Documentation & communication Analysis techniques − online type	Psychology (social communication) Traceability and control systems Analysis techniques − online type	Psychology (social communication) Documentation & communication of limit values Crisis preparedness/management Standards for traceability and control systems
New sources of marine fatty acids Scarcity of existing sources Knowledge of alternative sources Approval	Human health − optimise Mixing of terrestrial and marine Ditto for fish GMO Non-GMO Terrestrial and marine	Better exploit positive health effects in marketing	Basic research Health studies

Opportunities and challenges	Research and education	Trade and Industry	Public Authorities
Alternative feed sources (protein) Scarcity and price Knowledge of alternatives offers new opportunities Acceptance of alternative sources Environmental focus	Process technology, "baggage" (toxins, etc. health effects, fish and humans) Identify sources (GMO – non-GMO)	Product development	Basic knowledge, etc. Ecosystem understanding Technology Nutritional knowledge
New feed sources	Gas Mussels Plankton		
More effective use of marine raw materials and by-products for feed and other applications Scarcity and high price Hunt for valuable components	Outline positive (specific) effects Process technology Extract and refine feed substances and desired components	Connection with global market actors/ other industries Make by-products available Document effects of products	Basic research on contents of marine organisms Document effects
More effective feed production Energy consumption Costs Other feed measures Environmental focus	New processes (innovations) Develop existing techniques Energy efficiency in processes Process management (ICT, materials technology)	Develop new processes	Risk minimisation
Proper colour at low cost Market requirements Economy Health effects	Develop alternative sources Availability intake and deposit in fish Health effects	Develop new products Document effects Exploit breeding possibilities	Health effects in humans, positive or negative
Production costs of feed	How to reduce production costs? Purification of feed oils: Environmental impact in the oil Development of new, inexpensive technology Also vegetable oils. Genetically modified organisms: suitable for farming		
Inexpensive proteins, fish meal substitutes	Technology and genetic modification and quantitative breeding GMO with proper amino acid profile What is the proper profile? Disease-resistance. Feed adapted to different types of products		

Opportunities and challenges	Research and education	Trade and Industry	Public Authorities
Designer products / feed for different species and special qualities	Basic research needs Genetic modification, needs of salmon in growth phase. Specifications other than those currently in use, based on trout. Need for all relevant species, also an international issue.		
2. Main challenge **Product development for global, dynamic and differentiated markets**			
• **New species/ New characteristics in generic products**			
New species Phasing in Think value chain Trickle-down structure Market orientation Zero premium	Trickle-down development Research on structural elements surrounding new species Research on pilot phase, small-scale		
Standardised products of a high quality	What distinguishes Norwegian from foreign products (Danish pork) Locate market for such products (Parma) Market regional characteristics (Finnmark)		
Focus on products other than salmon - Climate changes	Species' biology Market acceptance/product development Fish's health Sustainable feed resources		
Effective breeding	Production data Molecular biology combined with breeding	Long-term investment, criteria for what shall be bred vs. protection of rights More comprehensive breeding thinking Implement opportunities to customise material Implement molecular biology methods	Basic research that ensures basic knowledge Long-term investment Transmission of knowledge/exchange of experience
Niche products other species	Market and species knowledge	Product and market development Production technology	Market access and regulatory system Listening posts Risk management

Opportunities and challenges	Research and education	Trade and Industry	Public Authorities
Differentiate fish in terms of different Applications Customer needs Purchasing requirements	Breeding Feed adaptation Farming conditions Process adaptation (aromatic components)	Identify possibilities and develop new products Documentation	Listening posts and research Approval schemes
Functional food − human - Increased focus on health-related additional effects of food products	Health research Intake and storage of functional substances − fish as carriers	Intake and storage of functional substances − fish as carrier Health research	Develop control systems
Demanding market: traceability, purity - Crisis, allergy toxins - Consumers	Food safety Welfare research Culture research	Ditto	Ditto
Functional foods Customer needs Health	Effects How to create the entire value chain Attend to characteristics throughout process Risk − benefit	Product development Collaboration with other, more specialised food industry	Basic knowledge basic research Good framework conditions (Documentation requirements) Marketing possibilities Regulations that ensure market access Risk analysis based on multidisciplinary competence Risk capital
• **New refined products**			
Product tailoring - Increased demand for niche products	Intake and storage of additives − fish as carriers Identification of natural components such as colour/vitamins	Intake and storage of additives − fish as carriers Identification of natural components such as colour/vitamins	
How to find niche products for production in Norway? - Consumer chains, market, public authorities	Market research More biological research Production strategies	Market research Production strategies	More biological research Develop a distinct innovation policy with clear priorities
Exploit global niches Volume, price Advanced market knowledge Exporters	Market knowledge Market research Market communications Cultural understanding Trends	Identify niches Transform market knowledge in new products Learn market communication	Education Cultural understanding on the part of public authorities Active use of external system

Opportunities and challenges	Research and education	Trade and Industry	Public Authorities
Niches Designer products Purchasing systems Organisation Location of hubs Price/Brand "Parma Ham"	Market research Consumer research Market-based customising of fish products Different products for different markets (quality, size, taste, packaging, history of production site, process, etc.) Safe production		
The fish's components, utilise entire fish	Constituent parts and benefits	Product innovation	
• **Packaging**			
Keeping qualities	Packaging Refrigeration chain Aroma		
Packaging to ensure Quality Product profiling Logistics Environmental requirements		Product development Packaging requirements from the aquaculture industry Packaging industry implements new technology and adapts to needs of the demanding customers	Schemes that stimulate re-use Basic knowledge
3. Main challenge: Development and implementation of profitable, environmentally and socially sustainable solutions in processes and products			
Alternative energy forms	Energy needs and sustainability requirements in entire value chain Climatic gasses		
• **Transport and logistics**			
More effective logistics	Flow of goods HUBs are organisation Integration auto/boat/rail	Collaboration with proficient suppliers of transport services; organise integrated transport systems	Infrastructure development Coordination of wild capture fish and fish farming; transport needs levelled

Opportunities and challenges	Research and education	Trade and Industry	Public Authorities
Effective logistics CO2 regulation Just in time Environmental fees Logistics and transport requirements	Market Transport ICT Transport economy Environmental effects Life-cycle analysis Packaging materials	Develop new environmentally-friendly transport system that promotes Norwegian products' competitiveness	Environmentally-friendly and effective infrastructure Prioritise that which promotes the Norwegian industry's long-term added-value Broadband
Transport systems	Tailor transport to suit the individual product		
Environmental problems, expensive energy, transport costs more, minimal transport requirements	How is the competition situation effected? How are the transport solutions affected? Refrigeration technology reduces Norwegian advantages		
• **Ethics**			
Strict environmental, health, and ethics requirements for the industry - Crisis examples - Consumers, consumer instances	Info-systems Health research Environmental research Ethics research Basic philosophical research - Buddhism or GMO (compatible?)	Health research Environmental research Save key data and fact bases Communication to develop confidence and legitimacy Follow up BAT	Establish an electronic infrastructure throughout the entire country Stimulate ethical, philosophical and religious reflection upon key developmental traits (what is natural? What is artificial? Critique of critique) Bring out crucial facts Establish requirements for BAT (best available technology)
The industry is not dependent upon genetically modified fish - Atrocity image of technology development - - Applies to "everyone"	Research on alternatives Preliminary studies Disclosing deception	Ditto	Must find effective tracing methods for GMO and look at possible consequences of GMO Make the public database fact-based and rational
• **Resource administration**			
Proper harvesting of resources	Harvesting models Interaction in harvesting of different species Administrative competence as an export commodity		
Battle over coastal zone	Wild salmon vs. farmed Protection interests Area-use Multi-use		

Opportunities and challenges	Research and education	Trade and Industry	Public Authorities
Better stock and resource administration to meet the requirement for a sustainable development	Ecosystem based stock administration Interaction of wild fish / farmed	Impose requirements and follow regulations	Responsibility
Climate changes Adaptation	Monitoring of ocean climate Adaptation of feed solutions Adaptation of technology		Monitoring of ocean climate
Climate changes	Documentation and consequence analysis (Historical data and prediction models) Analysis of effect on nature		
Environmental monitoring systems	Development of key parameters, adequate indicators System for registration and analysis Total models for analysis of environment; describe the environment's condition. Statistics, sensor technology, etc. Local and global factors, also factors such as increase in algae growth		
Sustainable utilisation of resources	Other feed resources Gas as a basis for feed production Feed influences the fish − and provides the foundation for new operational concept Bio-prospecting Biotechnology Gene technology Shellfish, seaweed, sea tangle, blue whiting		
Area use Conflicts due to climate changes	Escape-proof installations	Technology development	
Good systems for environmental monitoring - Complete confidence in Norwegian sea products implies good environmental documentation	Analysis method − online Effective traceability systems Research on information systems (real time) Limit values, knowledge base (External environment, consumers)	Implement BAT, deliver data and document	Outline biological abundance in the ocean and develop indicators for how to measure this Satellite monitoring Better ocean map
- 4. Main challenge: Organisation of the industry as a production, marketing and innovation system			

Opportunities and challenges	Research and education	Trade and Industry	Public Authorities
Regulations' effect on cost	Adequate regulations in relation to special feed and different species. Not cost-controlled beyond that which is completely necessary. Better safe than sorry is expensive.		
Innovation: create the unborn	Basic marine research, bio-prospecting Innovation systems: R&D to industrialise systems. Master Plan Knowledge from other segments of aquaculture		
Increased social awareness: The needs and political goals of the industry	Inquiry Competence Consequence and risk analysis Mechanisms for transforming scientific analyses into political actions (more precise decision-making tools)		
Industrial organisation	Interaction between industrial actors	Implement this knowledge	Knowledge about industrial organisation and development (evolutionary theory)
Integration of wild fishing and farming	Market analyses Application technology, biology, feed		
Large, foreign trade chains dominate	How shall Norwegian suppliers gain access to these? To what degree will the consumers determine product range? Requirements for market organisation in the fish farming industry?		
Industrial organisation and competitiveness	What have the successful done? Empirical studies	Initiatives to develop new practices Find answers to a situation where the "polluter must pay"	Knowledge about status other places
• **Organisation of knowledge infrastructure ("common knowledge")**			
Added-value orientation in research Long-term social strategy with expectation of growth Prioritising requirements Short term bottleneck	Social research: how to guide R&D in Norway in this direction?	**Define and prioritise** short term bottlenecks and long-term strategies / challenges	Use of foresight-type methods (open and inclusive processes) Long-term political and economic priorities in innovation and industrial policy
Establishment of Aquaculture University			

Opportunities and challenges	Research and education	Trade and Industry	Public Authorities
Knowledge sharing creates basis for specialisation Increased awareness of connections	Pedagogy Research development Process development	Define needs and initiate modulation of	Prioritising of interdisciplinary knowledge development Participation in international forums, Initiate knowledge networks
Global knowledge market for marine sustainability	Knowledge about innovation (innovation research) Fundamental knowledge Multidisciplinary Innovation policy		
Organisation and lifetime learning within aquaculture business sector	How? Who? Applicable competence Openness Innovation organisation Use of Internet		
• **Governance principles: the government's role in relation to trade & industry**			
Industry structure – regulations, framework conditions Freedom of profitability adjustments	Value chain optimisation for optimal structure in the industry Capital, ownership, companies		Norwegian competitiveness in general (currency, interest)
Industry policy controlled by public debate - Welfare development - Democracy - Consumers and opinion	Mentometer system democracy Fish and democracy inquiry Welfare development Social Economic		Fish and democracy inquiry Ensure that all have a mentometer system surgically implanted into the organism Develop quality criteria for democratic participation
Statfish is established - the government wants revenues			
Requirements for governance and legislation methodology to ensure coordinated governing and formation of regulations, sector coordination	Co-management	Involvement	Identification and adaptation
• **Internationalisation**			
Globalisation of aquaculture industry World leading Parallel to oil/merchant fleet	Biological globalisation Industrial organisation		
Norwegian actors' position Control the industry? Control to develop Norwegian advantages?	Need for Norwegian research lead		

Opportunities and challenges	Research and education	Trade and Industry	Public Authorities
The industry is globalised - Small world - Internationalising	Social economy Research on global institutionalisation (which global institutions do we need?)	Increased collaboration over national borders also for trade sector organisations	Make necessary adjustments and preparations for widespread residency abroad and increased language and cultural understanding Research on global institutionalisation (which global institutions do we need?)
Global food chains dominate - EEA and localisation	Keeping qualities Market knowledge Sales systems and channels Transport and logistics	Market knowledge Sales systems and channels Transport and logistics Keeping qualities	Ensure market access (e.g. the EU as a guarantor of market access in other parts of the world) Prevent boycotts Basic knowledge on keeping qualities
The industry is characterised by international ownership	Social economic research		
The industry is characterised by international competition	Competition policy		
Export of equipment	Development of advanced equipment	Further develop strong niches Connection with other trade sectors and knowledge spheres	Innovation policy
Global integration processes	Political science, integration processes, changes in world trade		
Knowledge about international decision-making processes	Research on policy processes and policy systems	Involvement and participation Proactive strategies	Knowledge about possibilities for influence Listening posts Systems for knowledge transmission to trade and industry
Non-tariff bound trade restrictions	Competition-based trade restrictions Market access and policy Quick documentation to ensure safe food upon importation into another country		
Other types of trade restrictions. A global trade culture?	Social anthropology Trade culture, what advantages can we obtain?		

Other: (remnants)

Opportunities and challenges that require R&D investment Cause/impetus/need	R&D needs	Challenges for trade and industry. What needs to be done?	Challenges for the Public Authorities. What needs to be done
Utilise entire fish Environment, added-value, costs	Bio-prospecting, what shall we look for?	Product development Equity capital Collaboration with other industries	Risk capital Basic research of marine species Documentation of effects
GMO to more than… Ingredients Input factors Follow-up of bio-prospecting	Knowledge about ingredients associated Effects on fish and humans		Publicly financed knowledge preparedness
Feed free of environmental toxins Market requirements Health Environmental aspect	Measuring methods Purification technology Tolerance Traceability − system Real and experienced risk	Know what they have and what they do New purification technology Documentation	Development of measuring methods and monitoring Regulatory system Environmental protection Public **independent** financing
Change in settlement pattern − how can we organise the industry	Technology adapted to new population patterns		
Wrecks, pollution	Reduce impact Knowledge of impact on organisms Influence on human health, safe seafood		Threat research Threat picture Prevention Preparedness
Norway is best in primary production - Government subsidies - The industry (profitability) and the government (policy)	Production processes Health, environment, ethics Info systems	Production processes Profitability Technology Develop a healthier, cleaner fish than competitors in low-cost countries Utilise offshore technology	Infrastructure in the cities and everywhere else Low NOK exchange rate and low interest rate Area-management and access “De-museum-isaton” Stimulate increased work immigration Change the tariff system (phase out LO?)

Increased stock of predators - Climate changes and access to food	Passive predator rejection The predators' biology/stock modelling Area-planning		
Social challenges become important!	Ditto		
Resource administration is important	Ditto		
Problems with feed, the market, area, coastal zones, process, quality, breeding, parasites, competition, consumer preferences, pollution, etc. - No overriding research and coordinating policy - Fragmented industry and market conditions beyond Norwegian control - Brain drain from Norway - Self-interest on part of central industry actors	Research on feed, the market, area, coastal zones, process, quality, breeding, parasites, competition, consumer preferences, pollution, etc. Energy sources, Materials technology, Logistics, ICT, Biotechnology "cross-over dishes" (food development) collaboration with agriculture (lamb and cod)	Be an active innovation policy contributor	Establish an overriding research and coordination policy Facilitate establishment of knowledge-based trade & industry Be an innovation and new-founding helper
The Aquaculture industry is established with all of its facets.			

Other – what the industry should do:

- Develop the ability to find and develop the right products.
- Implement market knowledge.
- Cultural change: focus on quality and product rather than volume. Away from the spot culture.
- Patient owners.
- Avoid industrialising unfinished concepts.
- Development contracts for several years that address the competition legislation but encompass several companies and types of activity.
- Develop companies with organisational strength and the capacity to manage the value chain and strategic issues. The ability to choose core business and specialise.
- With absorption ability in relation to advanced research knowledge and the ability to relate to research investment proactively.
- Learning network, lecture auditing systems.
- Brand building, quality standards and quantity control. Real co-financing in development projects.
- One must learn to balance collaboration and competition, secrecy and transparency.
- Avoid having small companies survive hand-to-mouth as clients of the administering agency system.
- Realism regarding complexity and costs.
- The industry must be able to assume ownership of research. Contribute to solving the non-trivial problem of disconnecting long-term research from commercial business development.
- The industry cannot allow itself to be run by its surroundings.
- The industry must put itself in the driver's seat.
- The large don't need it, the small can't do it. The medium-sized companies that only think of costs…

Other – what the public authorities should do:

- Master plan for value chain based introduction of new species. Innovation support based on credible innovation system/ developmental strategy/value chain.
- Framework conditions for capital access for activities that have been unprofitable for a long time. Conditional support for strong companies. Conditions for support to companies must be changed.
- Or "Dutch treat", Development contracts for several years that address the competition legislation but encompass several companies and types of activity.
- Spearheaded, strategic, basic research investment, carried out in a reorganised research system.
- Manage to distinguish between innovation in established enterprises and in wholly new enterprises.
- Activity regulation that provides possibility of organic growth but is simultaneously effective in relation to other societal needs (e.g. environmental considerations).
- Distinguish between efficiency in the production system and the innovation system.
- Organise conditions for applications for research funding that are suitable for trade and industry. Easy to decide yes or no.
- Industry policy: Significant level of ambition in relation to industry development. Simplistic perceptions of industrial neutrality must be replaced by a policy founded on knowledge about how development happens.
- An administering agency that is predictable and comprehensible. Simple procedures for establishing projects. Clear organisational structure. **True** joint financing.
- A proper commercialisation unit so that everyone is not obliged to start up their own pilot operation. Avoid regional or sector overlapping, where many similar activities are run in tandem.
- The administering agency does not succeed in coordinating; has often said yes far too many times.
- The administering agency must contribute, along with the industry organisations, towards arriving at comprehensive thinking and coordinated strategies in time, but also transversely in the trade sector.
- A whip and a carrot oblige the industry to work cooperatively; the business sector works together on strategy, organisation, etc. Longer than FHF.
- Scope of aquaculture programme must be adapted to the users; if it becomes broader it must also become larger in terms of total costs. Do not spread too thin in terms of too many researchers and investigators.
- The aquaculture programme should be designed consciously, closer to the market than previously. Include broader groups in the strategy work. Look at the communities, e.g. in biotechnology that have knowledge and can contribute to the process.

Foresight AQUACULTURE 2020

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AQUACULTURE is one of the Research Council's large-scale programmes that shall join and reinforce aqua-culture-oriented research activities. It addresses among other things the professional initiatives "Fish Health", "Feed resources for fish farming" and "Cod in Farming".
The large-scale programme builds upon the findings of "AQUACULTURE – production of aquatic organisms" (*HAVBRUK-produksjon av akvatiske organismer*) (2000-2006).

The programme shall contribute to:

- Further development of the salmon industry
- Development of new farmed species
- New forms of fish farming in sustainable production
- Further development of relevant supplier industries

Foresight analyses have been carried out for Aquaculture 2020 as a basis for the new plan of action in force in 2006.

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AQUACULTURE – a growth industry

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Large-scale programmes are an important tool at the Research Council towards realisation of prioritised central research policy. They shall provide enhanced knowledge in the long-term national sense, with an eye towards stimulated innovation and increased added-value or generate knowledge that contributes to solving prioritised social challenges.