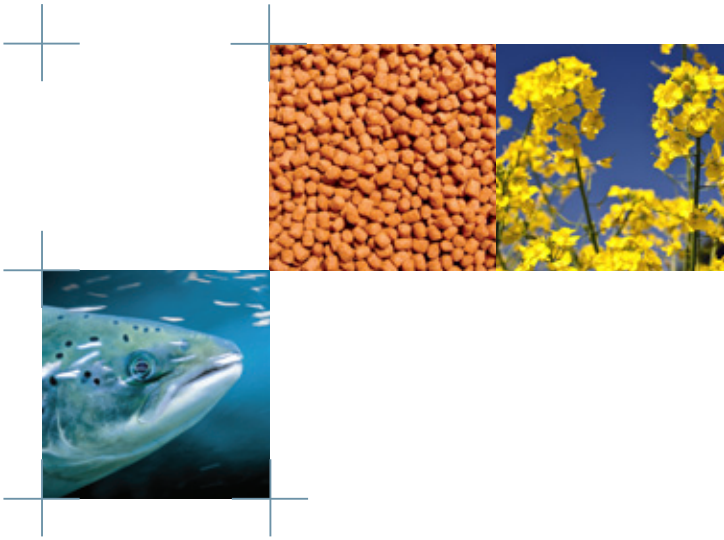
The Research Council of Norway

Work Programme for the HAVBRUK programme

Approved by the Division for Strategic Priorities
Vision: Norway – the world's leading aquaculture nation

Large-scale Programmes
Aquaculture – An Industry in Growth (HAVBRUK)



Large-scale Programmes

The RCN initiative to meet national research priorities

Forskningsrådet

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Vision: Norway – the world's leading aquaculture nation

Aquaculture – An Industry in Growth (HAVBRUK)

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1 Summary

This work programme lays down a cohesive framework that explains why it is important to conduct activities within the overall thematic area encompassed by the programme Aquaculture – An Industry in Growth (HAVBRUK), how these activities will be structured, and what is expected to be achieved. The work programme establishes the formal structure and focus of the HAVBRUK programme and provides guidelines for R&D players seeking funding under the programme. This work programme is a revised version of the work programme for the entire programme period, 2006-2015.

Norway is currently the world's leading producer and exporter of salmon and rainbow trout and an important global supplier of knowledge, technology and equipment for aquaculture. It is the Government's vision that Norway shall become the world's leading seafood nation, and aquaculture is a key component of Norwegian seafood policy. The willingness and ability of state and industry players to invest in research and development have been critical for developing Norwegian aquaculture into what it is today. Norwegian aquaculture researchers are at the forefront of the research field, and Norwegian aquaculture research groups are highly visible, with a strong international standing. Norway is therefore well-equipped to exploit the wide-ranging commercial, social and research opportunities that are emerging within the aquaculture sector.

The potential for growth in aquaculture production may be realised both by boosting production of existing and new production species and by increasing the value of aquaculture products. However, production must not cause undesirable environmental effects, and further growth in production must go hand in hand with competence-building and development of environment-friendly biological and technical solutions.

The HAVBRUK programme is the Research Council's most important funding instrument for aquaculture research. The primary objective of the programme is to acquire knowledge to achieve economically, environmentally and socially sustainable growth in Norwegian aquaculture as well as to enable Norwegian research groups to develop knowledge at the international forefront. In this way the programme assists in maintaining and further developing Norway's position as the world's leading seafood nation.

The HAVBRUK programme has a long-term perspective and a broad sphere of responsibility, and employs a wide array of the Research Council's project types and strategic measures to achieve its objectives. By supporting strategic research, applied research and user-driven research, the programme will generate new expertise to help to ensure that:

- Norwegian aquaculture is environmentally sustainable and promotes well-functioning coastal communities;
- Norwegian production fish are healthy and production satisfies the most stringent requirements for animal welfare;
- Feed and feed ingredients used in Norwegian aquaculture are derived from sustainable sources and yield safe and healthful seafood;
- Norwegian aquaculture encompasses a diversity of species;
- The Norwegian aquaculture industry is the world's foremost in development and use of environment-friendly technology;
- Norwegian production fish are robust and tolerant to changes in environmental and production conditions.

During the 2011-2015 period, the HAVBRUK programme will place priority on the following thematic areas, which are also of relevance for more long-term priorities for aquaculture research:

- Sustainable seafood production
- Healthy fish
- Feeds of the future
- Other production species
- Environment-friendly aquaculture technology
- Genetics and selective breeding

The HAVBRUK programme attaches importance to cooperation across company and institutional boundaries as well as to promoting international participation in research projects. The Fishery and Aquaculture Industry Research Fund (FHF), Innovation Norway and the regional research funds are important partners in collaboration.

The HAVBRUK programme works to achieve the objectives set out in the Government white paper on research, *Climate for Research* (Report No. 30 (2008-2009) to the Storting), the Government's *Strategy for an Environmentally Sustainable Norwegian Aquaculture Industry* (Ministry of Fisheries and Coastal Affairs, 2009), the Ministry of Fisheries and Coastal Affairs' *Research Strategy 2011-2014*, and the strategy of the Research Council for the 2008-2012 period, *In the Vanguard of Research*. The programme is an integral component of the Research Council's Focus on the Arctic and Northern Areas initiative.

2 Background

2.1 Strategic perspectives

Norway has access to some of the world's most productive ocean areas as well as a coastline, infrastructure and traditions that provide unique opportunities for aquaculture activities. Over the past 40 years, the Norwegian aquaculture industry has developed into the world's leading producer of salmon and rainbow trout. The industry contributes substantially to upholding value creation in Norway with respect to exports, employment and settlement patterns in coastal areas.

The aquaculture industry is one of Norway's most internationally-oriented industries. Over 90 per cent of the fish produced in Norway is exported, providing a basis for many food-industry jobs, particularly in the EU. Norwegian equipment suppliers have a sizeable home market and target international markets as well. Norwegian aquaculture researchers are at the forefront of the research field, and Norwegian aquaculture research groups are highly visible, with a strong international standing.

It is the Government's vision that Norway shall become the world's leading seafood nation (cf. Proposition No. 1 (2010-2011) to the Storting, Ministry of Fisheries and Coastal Affairs). Aquaculture activities will play a vital role in realising this vision. Today, more than one-third of all seafood in the world is a product of aquaculture, and this proportion is expected to increase. According to the Food and Agriculture Organization of the United Nations (FAO), the growing global demand for seafood can only be met by boosting aquaculture production.

The Norwegian aquaculture industry is currently in a very strong position and is well-equipped to exploit the wide-ranging commercial, social and research opportunities that are emerging. As an exporter of salmon and other seafood products and a supplier of knowledge, equipment and technology, Norway has a firm foundation for maintaining and enhancing its leading position.

Aquaculture production is knowledge-based and has its origins in the primary industries. The willingness and ability of state and industry players to invest in research and development have been critical for Norwegian aquaculture. The potential for growth in aquaculture production may be realised both by boosting production of existing and new production species and by increasing the value of aquaculture products. This will require a significant, long-term effort.

The aquaculture industry must respond to steadily increasing knowledge requirements from the market, society and the authorities alike. The market is calling for accurate, detailed information about the products, society is calling for information about the impacts of production on coastal areas, and the authorities in every country are issuing more stringent stipulations relating to product documentation. Greater attention is being focused on the need to ensure safe and healthy seafood and environmentally, economically and socially sustainable production. Cf. *Strategy for an Environmentally Sustainable Norwegian Aquaculture Industry*, Ministry of Fisheries and Coastal Affairs, April 2009, and *Environmental report for Norwegian aquaculture with an emphasis on statistics and facts for 2008*, Norwegian Seafood Federation (FHL), August 2009. Further growth in Norwegian aquaculture production must go hand in hand with competence-building and development of environment-friendly biological and technical solutions.

A major proportion of the public funding for aquaculture research is channelled through the Research Council. The HAVBRUK programme is the Research Council's most important funding instrument for aquaculture research. The programme attaches importance to achieving

cooperation across company and institutional boundaries as well as promoting international participation in research projects.

As an integral component of the Research Council's Focus on the Arctic and Northern Areas initiative, the HAVBRUK programme encourages the submission of project proposals of possible significance to the expansion of aquaculture activities in the northern areas. Although aquaculture is well-established in these areas, there is great potential for new industry because there is extensive area for production available. An expansion of aquaculture activities in the north may open up many new possibilities, but more research is needed to ensure that these opportunities can be exploited constructively.

The HAVBRUK programme has a long-term perspective and a broad sphere of responsibility that encompasses strategic research, applied research and user-driven research, giving it significant value-added and weight. The Fishery and Aquaculture Industry Research Fund (FHF), Innovation Norway and the regional research funds are important partners in collaboration.

2.2 Scientific perspectives

Today, Norwegian research groups are at the international forefront in a number of aquaculture-related areas. Key research areas include nutrition, genetics, fish health, technology and interactions with the surrounding environment. Norwegian research efforts have been crucial in turning Norway into an international leader in seafood production, and Norwegian researchers also make important contributions to generating knowledge to further develop aquaculture activities in a global context.

According to a study by the Norwegian Institute for Studies in Innovation, Research and Education (NIFU STEP)[1], independent research institutes accounted for 54 per cent of the aquaculture research conducted in Norway in 2007, universities and university colleges accounted for 15 per cent, and trade and industry for 32 per cent. Investment in aquaculture research totalled NOK 930 million in 2007.

A wide range of research institutions receive project funding under the HAVBRUK programme. In the initial phase of the programme, the following institutions received the largest amount of funding: the Norwegian Institute of Food, Fisheries and Aquaculture Research (Nofima), Institute of Marine Research, National Veterinary Institute, National Institute of Nutrition and Seafood Research (NIFES), SINTEF Group, Norwegian Institute for Nature Research (NINA), Akvaplan-niva, Norwegian School of Veterinary Science, Norwegian College of Fishery Science, University of Bergen, Norwegian University of Life Sciences (UMB), Bodø University College, Norwegian University of Science and Technology (NTNU), and University of Oslo.
Communication and cooperation between the research community, industry and the government administration are highly important to all stakeholders, and the HAVBRUK programme will continue to employ funding instruments that reward cooperation and communication activities. Several large international companies in the areas of feed, vaccines, technology, selective breeding and production have established research activities in Norway. During the period, more than 20 companies received support under the programme in the form of funding for user-driven research projects.

Advancements in fields such as biotechnology, information and communication technology, and materials and nanotechnology have opened up new opportunities for aquaculture. It is vital to help to develop methods and technology of relevance for the Norwegian seafood industry as well as to

[1] Ressursinnsatsen innenfor marin FoU og havbruksforskning 2007 ("Investments in Marine R&D and Aquaculture Research, 2007", Norwegian only). Report 10/2009. NIFU STEP.

employ them in research, industry and management. According to the UN Intergovernmental Panel on Climate Change, there may be changes in the global climate that can have an impact on aquaculture activities. It is essential to generate knowledge to predict these effects in order to plan and implement relevant measures.

More and more, aquaculture production is affecting – and being affected by – other aspects of society. Competition for use of the best land and sea area in coastal areas is becoming tougher due to conflicts of interest between an expanding aquaculture industry and other user groups. Social science-based knowledge will play a critical role in achieving socially sustainable growth of the aquaculture industry. According to the 2009 report on the mid-term evaluation of the Large-scale Programme initiative (*Sats på forandring*), efforts must be strengthened to incorporate social science and humanities research into the Large-scale Programmes. High-quality, impartial international research is called for in a number of areas, for example with regard to amendments to international regulations.

As the result of the efforts of the HAVBRUK programme and other instruments at the Research Council (the Centres of Excellence (SFF) scheme and the Centres for Research-based Innovation (SFI) scheme), knowledge platforms on topics such as deformities, vaccines, feed, technology, sea lice and early life stages of cod have been established during the initial five years of the programme. This type of expertise is crucial to the further development of Norwegian aquaculture and must be continually enhanced.

The HAVBRUK programme has published a number of reports on relevant topics. These reports have formed the basis for many of the scientific priorities set out during the period and comprise part of the basis on which the HAVBRUK work programme has been revised. A list of reports is found in an attachment to this work programme.

Research in areas such as industrial processing, logistics, transport, and industrial and trade policy are the sphere of responsibility of other programmes at the Research Council, particularly the Research Programme on Nature-based Industry (NATUROGNAERING) and the Food Programme.

3 Objectives of the programme

Vision: Norway – the world's leading aquaculture nation

Primary objective

- To acquire knowledge to achieve economically, environmentally and socially sustainable growth in Norwegian aquaculture.
- To enable Norwegian research groups to develop knowledge at the international forefront.

Secondary objectives

The programme will fund both basic research and applied research activities as a means of generating new knowledge and innovation that ensure that:

- Norwegian aquaculture is environmentally sustainable and promotes well-functioning coastal communities;
- Norwegian production fish are healthy and production satisfies the most stringent requirements for animal welfare;
- Feed and feed ingredients used in Norwegian aquaculture are derived from sustainable sources and yield safe and healthful seafood;
- Norwegian aquaculture encompasses a diversity of species;
- The Norwegian aquaculture industry is the world's foremost in development and use of environment-friendly technology;
- Norwegian production fish are robust and tolerant to changes in environmental and production conditions.

Sphere of responsibility

Research activities carried out under the programme are to be relevant for species that are currently being produced in Norway or that may be produced in Norway in the future. The focus of the programme is on the value chain for aquaculture production as well as on parts of the value chain for sea ranching and catch-based aquaculture. The programme's sphere of responsibility extends to the market for lightly processed products.

Priority production species for the HAVBRUK programme

- *Highest priority will be given to salmon and rainbow trout;*
- *Of the new species for commercialisation, priority will be given to cod;*
- *Funding may also be allocated to research projects on other species where the aquaculture industry or the government administration is involved.*

Target groups

- *The aquaculture industry, including the supplier industry, various customer groups and other stakeholders;*
- *Research environments in Norway (e.g. universities, university colleges, independent research institutes and private institutions);*
- *The authorities – as they are responsible for resource management and for laying the foundation for industrial development;*
- *Educational environments offering research-based training targeted towards the aquaculture sector.*

4 Priority research tasks

a) Thematic priority areas

The most important task of the HAVBRUK programme is to acquire knowledge to maintain and enhance Norway's position as the world's leading seafood nation. During the 2011-2015 period, research activities under the programme will primarily focus on the following thematic priority areas:

Thematic priority area 1 – Sustainable seafood production
Thematic priority area 2 – Healthy fish
Thematic priority area 3 – Feeds of the future
Thematic priority area 4 – Other production species
Thematic priority area 5 – Environment-friendly aquaculture technology
Thematic priority area 6 – Genetics and selective breeding

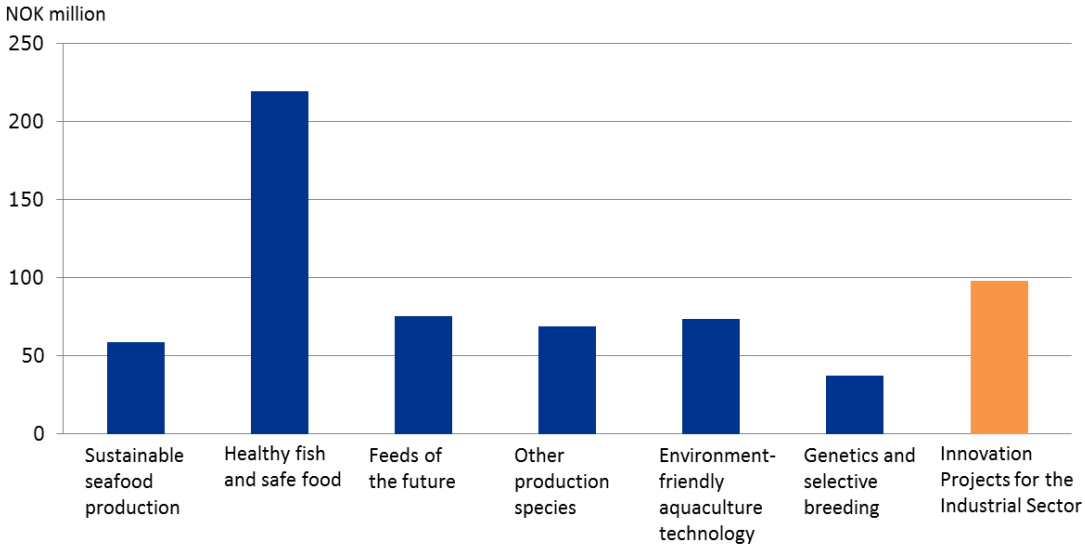
These thematic areas address the key priorities of the HAVBRUK programme for the period and may also be of relevance for more long-term priorities for aquaculture research. The vision, challenges, programme priorities and environmental relevance of each thematic area are described in greater detail in Attachment 1.

The Government's *Strategy for an Environmentally Sustainable Norwegian Aquaculture Industry* describes the challenges related to the development of sustainable aquaculture. Several of the thematic priority areas in this work programme encompass research that may help to solve the challenges identified in the strategy document. In this way the HAVBRUK programme is an important tool for refining and implementing the strategy.

Social science research, research related to the northern areas, research on climate effects and research on utilising genomic data are not listed as individual thematic areas, but instead extend across, and will be considered an integral part of, the other thematic areas under the programme.

During the first five years of the HAVBRUK programme, focus was placed on strategic basic research targeted especially towards the areas of fish health and animal welfare and quality. The figure below shows the distribution of funding among the new thematic priority areas for the 2006-2010 period.

Figure 1. Allocations under the HAVBRUK programme for the 2006-2010 period.



Implementation

Although the programme seeks to cover all of the thematic priority areas, the level of activity within each area will vary depending on the directions provided by the allocating authorities, the strategy and guiding principles set out by the Research Council and the strategic decisions taken by the programme board. The scientific priorities for the HAVBRUK programme will be specified in annual funding announcements, which will also provide the annual budget parameters. The programme will assess the need for research related to the climate and the northern areas and social science and humanities research on an ongoing basis.

b) Strategic priorities

An international evaluation of Norwegian biological research from 2000 concluded that aquaculture research was not sufficiently grounded in high-calibre basic research and that this would pose an obstacle to genuine innovation and ongoing advancement within the industry. Ten years later, researchers and industrial players still concur with this conclusion. In the next five years the HAVBRUK programme will continue to place priority on basic research within the thematic priority areas.

The HAVBRUK programme employs a wide array of the Research Council's project types and strategic measures to achieve its objectives. In addition, the programme uses targeted measures such as knowledge platforms and promotes collaboration within and between projects. New strategic measures may be designed and special initiatives launched under the programme, in cooperation with other programmes, when relevant.

The use of applied research project types, such as Knowledge-building Projects for Industry and Innovation Projects, serves to establish links between academia and industry, thereby promoting industrial development. The programme will place special weight on maintaining a productive dialogue with the industry with regard to priorities as well as on close cooperation with the regional research funds, Innovation Norway and the Fishery and Aquaculture Industry Research Fund (FHF) with the aim of establishing user-driven innovation projects. The programme board assesses which application types to employ on an ongoing basis.

The HAVBRUK programme emphasises that research of high international calibre will enable Norwegian research groups to be more successful in attaining funding under general and strategic funding schemes and in international competitive arenas for basic and industry-oriented research. The programme will provide support for long-term competence-building and education of research fellows. A designated funding scheme for younger researchers has been established to help them to acquire good research management skills and achieve international excellence. There is also a need for personnel with doctoral-level training for jobs in industry.

5 International cooperation

International research cooperation is essential for solving the challenges facing the aquaculture industry. Norway must have research groups that hold a high international standard and are viewed as attractive partners for cooperation that can take on leadership roles in international research initiatives. To this end, the HAVBRUK programme will encourage cooperation between Norwegian research groups and international players that are at the forefront of their field.

International cooperation on projects will be a key component of programme activities. When allocating project funding, special weight will be given to projects that incorporate international cooperation which enhances project quality. The programme will also work to enable a greater number of Norwegian researchers to benefit from research and study periods abroad, and correspondingly enable more international researchers to spend time at Norwegian institutions.

The white paper on research, *Climate for Research*, and the allocation letters from the ministries set out guiding principles for international cooperation. North America, Chile, China, Japan, Russia and the EU are important partners for research cooperation under the HAVBRUK programme. The programme participates in two ERA-NETs[2], cooperates with India on research on fish and animal vaccines and has close contact with the European Aquaculture Technology and Innovation Platform (EATIP). In the next several years the programme will also consider participating in new joint research initiatives within the EU framework, such as the Joint Programming Initiatives (JPI) on the oceans and food.

[2] The ERA-NET scheme facilitates the realisation of the European Research Area. As per 2010 the HAVBRUK programme is a partner in the ERA-NETs EMIDA (Emerging and Major Infectious Diseases of Livestock) and EraSME (Small and Medium-sized Enterprises and Research Organisations).

6 Communication and dissemination activities

The HAVBRUK programme has drawn up a communication plan for the entire programme period that sets high targets for communicating with and disseminating research results to the programme's various user groups. The communication plan is a strategic tool for achieving programme objectives.

The communication plan encompasses both activities under the auspices of the programme and support for or participation in events and measures organised by others. The plan includes the following main elements:

- marketing the HAVBRUK programme as a funding instrument and part of the Research Council's Large-scale Programme initiative to the government administration, in political circles, to trade and industry and the research community;
- communicating research needs and disseminating results from aquaculture research to the industry and the government administration in a manner that makes new knowledge accessible and easy to apply;
- international marketing and dissemination activities;
- public-oriented dissemination measures to generate and maintain positive interest in aquaculture research;
- communication activities targeting children and young people to foster interest in aquaculture research.

The programme prepares an annual activity plan specifying communication and dissemination tasks for that year.

7 Budget

The HAVBRUK programme was launched as a Large-scale Programme in 2006 and is planned to be concluded in 2015. As of 2011, the Ministry of Fisheries and Coastal Affairs and the Norwegian Fund for Research and Innovation (the Ministry of Education and Research) are the primary sources of funding to the programme. The programme budget for 2010 is NOK 123 million. Industry also provides project funding via the Fishery and Aquaculture Industry Research Fund (FHF) – this comprised a total of NOK 17 million in 2010.

Zero-growth budget

Funding source	2010	2011	2012	2013	2014	2015	TOTAL
Ministry of Fisheries & Coastal Affairs	102 850	102 850	78 850	78 850	78 850	78 850	
Ministry of Agriculture & Food	1 500						
Fund for Research & Innovation	19 000	19 000	19 000	19 000	19 000	19 000	
TOTAL	**123 350**	**121 850**	**97 850**	**97 850**	**97 850**	**97 850**	**509 250**

In connection with the launch of the research cooperation initiative between Norway and India[3] in 2007, the HAVBRUK programme was granted an earmarked allocation of NOK 20 million per year. This Norwegian-Indian research cooperation is planned to be concluded in its current form in 2011. If the programme's budget is reduced by NOK 20 million per year from 2012, this will have negative consequences for the research conducted. The programme has followed a policy of awarding larger-scale grants early on in the programme to ensure that allocations are used during the programme period. The result of this is that grants to new projects are smaller at the end of the programme period. To avoid having research groups reduce their competence-building activities, the programme will continue its efforts to secure further growth in allocations.

Aquaculture is dependent on continuity in research. Indications of whether or how research within the HAVBRUK programme's thematic priority areas will be continued must be given well before the programme concludes in 2015. This will help to ensure that research groups and talented younger scientists maintain interest in aquaculture research. The programme is planning to issue three or four new funding announcements as from 2011. Given a zero-growth budget, the programme will allocate a total of NOK 170 million to new measures under these funding announcements. The budgetary parameters and scientific priorities for the allocation of project funding will be specified in the individual calls for proposals.

[3] Research cooperation between Norway and India on fish and animal vaccines.

8 Coordination with other related instruments at the Research Council

The HAVBRUK programme attaches importance to cooperation with other research programmes at the Research Council and shares interfaces and areas of overlap with several programmes. Figure 1 illustrates areas of overlap with the most relevant programmes. The HAVBRUK programme also seeks out collaboration with strategic instruments such as the Centres of Excellence (SFF) scheme, the Centres for Research-based Innovation (SFI) scheme, the SkatteFUNN tax deduction scheme, the Programme for Regional R&D and Innovation (VRI) and the regional research funds.

Collaboration with other programmes and instruments at the Research Council takes the form of joint planning activities, joint funding announcements and project co-funding.

Figure 2. Areas of overlap between the HAVBRUK programme and the most relevant programmes at the Research Council.

9 Organisation

The programme board of the HAVBRUK programme is appointed by and reports to the Research Board of the Division for Energy, Resources and the Environment. The programme board will strive to achieve programme objectives by implementing the activities available to the programme, in accordance with the intentions and objectives of the overall strategy for the Research Council, guidelines from the Executive Board of the Research Council and the Research Board of the Division for Energy, Resources and the Environment, and the approved work programme. The programme board's activities shall at all times be in compliance with the overall principles and guidelines for the establishment, operation and conclusion of research programmes as set out by the Research Council.

The programme board acts on behalf of the Research Council and reports to the Research Board via the Executive Director of the division.

The programme administration is responsible for carrying out the day-to-day tasks of the programme and consists of a programme coordinator assisted by personnel with scientific and administrative expertise. The programme administration carries out the administrative functions of the programme and the programme board and facilitates the implementation of the programme board's decisions.

Processing of grant applications

Researcher Projects and Knowledge-building Projects for Industry are normally assessed by a panel of international referees that convene for discussion and assess the grant proposals in accordance with Research Council guidelines. Innovation Projects are assessed by a national referee panel. When assessing grant applications, consideration will be given to the scientific merit of the grant proposal, the relevance of the grant proposal relative to the call for proposals and the programme's primary and secondary objectives, the relevance and benefit to society, the authorities and industry of the grant proposal, and the substance of the grant proposal in relation to relevant ongoing projects.

The HAVBRUK programme board is responsible for final approval of grant allocations on the basis of recommendations submitted by the programme administration.

Attachments to the work programme

Thematic priority area 1: Sustainable seafood production
Thematic priority area 2: Healthy fish
Thematic priority area 3: Feeds of the future
Thematic priority area 4: Other production species
Thematic priority area 5: Environment-friendly aquaculture technology
Thematic priority area 6: Genetics and selective breeding

List of scientific reports published by the HAVBRUK programme

Thematic priority area 1: Sustainable seafood production

Vision

Norwegian aquaculture is environmentally sustainable and promotes well-functioning coastal communities.

Challenges

Norwegian seafood production must not cause any unacceptable impact on the environment. Interbreeding of escaped production fish can contribute in the long run to weakening the genetic makeup of vulnerable wild stocks. This issue, together with the spread of parasites such as sea lice, are two of the most critical environmental challenges facing modern aquaculture. Furthermore, the discharge of pollution in the form of waste feed, faeces and inorganic nutrients must not exceed the local environment's sustainable limits. Waste nutrients can be recouped as a resource for the production of such species as phytoplankton and seaweed, providing a basis for integrated aquaculture.

Sustainable seafood production brings value creation and positive ripple effects throughout local communities. Satisfactory framework conditions and sound resource management systems lay the best foundation for achieving this sustainability.

Priorities of the HAVBRUK programme:

- Quantify the genetic impact of escapes;
- Contain the spread of genetic material from production fish;
- Utilise aquaculture waste as a resource;
- Develop effective resource management systems;
- Build up an industry that creates value and positive local ripple effects.

Cooperation with the Oceans and Coastal Areas programme (HAVKYST), the Programme on Nature-based Industrial Development (NATUROGNAERING), and the programme Norwegian Environmental Research Towards 2015 (MILJO2015) is relevant here.

Thematic priority area 2: Healthy fish

Vision
Norwegian production fish are healthy and production satisfies the most stringent requirements for animal welfare.

Challenges
Intensive cultivation is a strain on fish welfare and increases the risk of disease outbreak. This is particularly true of aquatic animals. Sub-optimal environmental conditions and poor feed quality are additional stressors on the organisms' health and well-being. Due to the lack of effective vaccines against fish diseases caused by intracellular agents (viruses, parasites, certain bacteria), combating these diseases poses a major national challenge. Knowledge about fish health, fish welfare and humane killing methods is vital for maintaining and expanding seafood production.

Priorities of the HAVBRUK programme:
- Disease prevention;
- Understanding virulence factors of major infectious agents;
- Knowledge about pathways of infection/spread of disease/infection models;
- Understanding the lifecycles of the major parasites;
- Effective vaccines against fish diseases caused by intracellular agents.

Environmental relevance
Infectious diseases and parasites, sea lice in particular, are the most serious environmental problems currently facing the aquaculture industry; diseases and parasites are transmitted between farmed fish and wild stocks. High concentrations of naturally-occurring pathogenic agents and parasites may accumulate at intensive production sites, and lead to infection in wild stocks. Furthermore, production can increase the pressure of infection by agents and parasites not previously existing at a site. Combating such agents and parasites may involve the use of chemicals and antibiotics which can entail negative impacts on the surrounding environment, including the development of resistance to treatment methods.

Thematic priority area 3: Feeds of the future

Vision

Norwegian seafood is safe and healthful, produced on feed and feed ingredients satisfying the nutritional requirements of the fish and derived from sustainable sources, without weakening the reputation or competitiveness of the industry.

Challenges

The major production species in Norway – salmon, rainbow trout and cod – have a need for high-quality protein that must be provided through their feed. Species with high lipid content in the flesh such as salmon and rainbow trout are good sources of omega-3 fatty acids in the human diet. Fishmeal and fish oil are still important ingredients in feeds for several production species. Production of these ingredients, however, is based on wild fish catches – resources with natural, seasonal fluctuations. In all likelihood, fish catches cannot be increased sustainably. Access to fish oil is particularly critical. The feed affects fish health, welfare and normal development as well as product quality. To enable the industry to increase production of salmon, rainbow trout and cod, more knowledge is needed about feed ingredients and the formulation of feed composition, and about the relationship between feed composition and fish health, fish welfare, and the normal development of fish that yield healthful, safe and well-accepted products.

Priorities of the HAVBRUK programme:

- Basic nutritional physiology;
- The role of feed in fish health;
- Safe, healthful aquaculture products;
- The role of feed in the discharge of faeces, inorganic nutrients and undesirable substances;
- Consumer attitudes and social acceptance of new feed ingredients.

Environmental relevance

Ingredients for fish feed have traditionally been based on fish stocks that are now being harvested to their fullest possible extent. The development and use of new sources of feed ingredients, however, will reduce the industry's dependence on fishmeal and fish oil. Optimal utilisation of nutrients in fish feed will reduce organic pollution in the environment.

Thematic priority area 4: Other production species

Vision
Norwegian aquaculture encompasses a diversity of species.

Challenges
Norwegian aquaculture is based on intensive production of primarily salmon, but also rainbow trout. Relevant authorities have expressed a desire for more diversified aquaculture in terms of species as well as production practices. New production species will encounter all the same challenges that salmon production has faced: health, production technology, feed and nutrition, selective breeding, framework conditions and markets.

Priorities of the HAVBRUK programme:
- Further developing cod production;
- Advancing production of other species of commercial interest;
- Multi-trophic aquaculture;
- Framework conditions;
- Markets and profitable production.

Environmental relevance
Biological delousing using cleaner-fish will reduce the use of chemicals. Multi-species aquaculture can help to limit the dispersal of waste by utilising it as a source of nutrients in the production of lower trophic-level species.

Thematic priority area 5: Environment-friendly aquaculture technology

Vision

Norway's aquaculture industry is the world's foremost in development and use of new environment-friendly technology, ensuring profitable, sustainable production in a healthy production environment that is tailored to climatic conditions.

Challenges

Modern open-cage technology has been a major factor in the growth of Norwegian aquaculture. However, the use of this technology entails a number of weaknesses, including infectious diseases and parasites, escapes, pollution from waste feed, and conflicts between coastal-area user groups. Insufficient knowledge about aquatic environments can lead to problems concerning the health, well-being and growth of production fish. There is a need both for refining current technology and for developing alternative systems of production; new materials, technologies and experience from other industries could prove valuable in this respect. Technology development and knowledge of aquatic environments will be key components in selecting the most suitable production sites in terms of production environment as well as environmental challenges. Advances in aquaculture production, which must take place within the environmental restrictions deemed acceptable by society, will require research-based knowledge relating to production technology.

Priorities of the HAVBRUK programme:

- Technology, systems and production methods that are safe and limit pollution to acceptable levels;
- Optimal adaptation to local environments;
- New technologies for modelling and monitoring;
- Understanding the environmental requirements of production species and adapting to climate change;
- Efficient, profitable and market-oriented production.

Cooperation with the MAROFF programme may be relevant on certain topics within this thematic priority area.

Environmental relevance

Improved technology will help to safeguard fish health and welfare by minimising escapes and the release of genetic material, and by limiting the spread of infectious agents and dispersal of feed waste, faeces and organic nutrients.

Thematic priority area 6: Genetics and selective breeding

Vision
Effective selective breeding makes production fish robust and more tolerant to changes in environmental and production conditions.

Challenges
Greater production profitability can be achieved by using fish selected through effective breeding programmes. Refining the methodologies of these programmes for different species will be important. Variable conditions in the environment and in production – such as changes in temperature or currents, variations in feed ingredients, and new market demands – require hardy, adaptable farmed fish. The genomes of both salmon and cod are now sequenced, which opens opportunities for the aquaculture industry and researchers. The genomic sequences are especially useful in selectively breeding for desired traits that would otherwise involve a difficult and lengthy process using conventional methods.

Priorities of the HAVBRUK programme:
- Further develop selection methods for new and existing traits that make fish hardy and adaptable;
- Develop methodologies for effective selective breeding programmes;
- Develop methodologies for using genomic information;
- Map genes that control important traits.

Cooperation with the Programme on Functional Genomics in Norway (FUGE) will be particularly important for developing methods and technologies.

Environmental relevance
Selective breeding to increase fish resistance to disease and parasites will reduce reliance on administering medicines. Improved feed efficiency and feed utilisation will reduce pollution from waste and lead to better utilisation of natural resources.

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