



AN R&D STRATEGY FOR
A MARINE NATION OF SUBSTANCE

HAV21

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Preface

The HAV21 strategy committee herewith submits its proposal for a national marine research and development strategy – HAV21.

The ocean plays a central role in life in Norway. The ocean has been the most important transport route in and out of the country, and is an integral part of our history and our economy. The ocean is the origin of much of our national value creation and the basis for the shipping, seafood production and offshore industries. The ocean provides jobs for coastal populations and is the lifeblood of dynamic local communities. Norway's beautiful coastline attracts tourists from around the world, and provides the Norwegian people with a place for relaxation and recreation.

The ocean, however, is vulnerable, and must be managed and used in a manner that will also allow coming generations to benefit as well. It will take knowledge to achieve this, and it is essential that we choose the right focus for our research. We believe that marine research is one of the most important fields in which Norway can invest.

The HAV21 strategy encompasses the full breadth of the marine sector, from fjord to table and from ocean floor to plate, and it has been rewarding to have an opportunity to work within this framework. In the course of our process we have witnessed wide-ranging consensus emerge across industries and management areas on fundamental prerequisites such as the need to ensure clean and healthy oceans and the importance of knowledge. We have confirmed that

the various segments of the marine sector are co-dependent, and that marine research, management and industrial development maintain a high standard in Norway.

We have also noted tremendous commitment on the part of the people around us, in the form of scientific input submitted during the process. Affiliated working groups have drawn up independent reports as part of the HAV21 strategy project. These reports form a vital part of the basis for the strategy committee's recommendations.

We would like to take the opportunity to thank everyone who has contributed with enthusiasm and ideas, making it possible to present the HAV21 strategy as an integrated R&D strategy for the marine sector as a whole. We hope this will be an important contribution to the further development of Norway as a marine nation.

Oslo, 7 November 2012



Liv Monica Stubholt

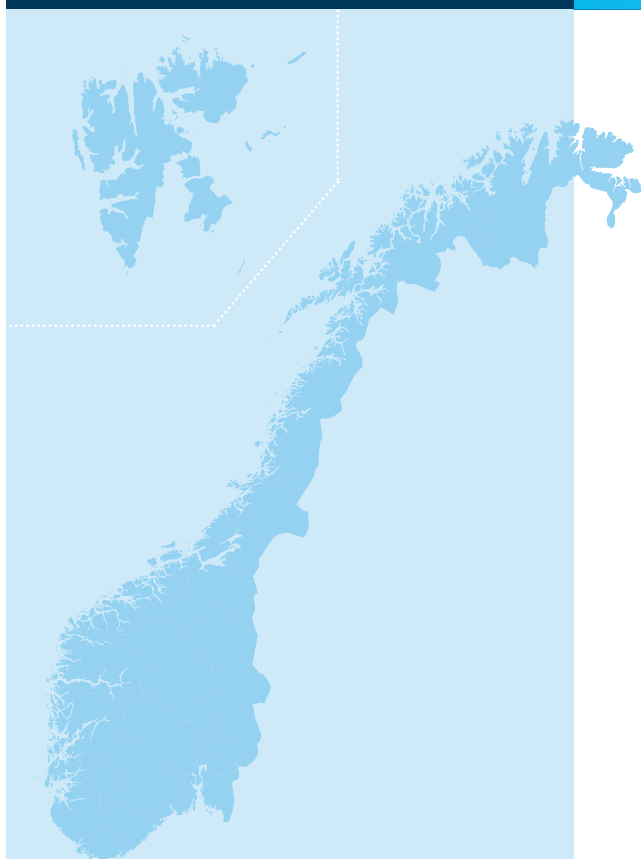




An R&D strategy for a marine nation of substance

Norway's leading position as a marine knowledge nation entails special responsibilities in a global context, and it is essential for the country to invest in targeted, integrated marine research activities. The HAV21 strategy report sets out recommended priorities to enable Norway to achieve its industrial and political objectives for the marine sector.

SUMMARY AND CONCLUSIONS



Norway holds a prominent global position in marine research, management and industry. The marine industry is one of Norway's most complete industries, along with the maritime and offshore industries. The common denominator for all of these industries is the ocean. Moreover, Norway has a well-functioning management regime for regulating marine activities, including unique integrated management plans for specific sea areas. It is prudent for Norway to continue investing in the marine sector – a sector in which it excels.

The HAV21 strategy committee was established in autumn 2011 by the Ministry of Fisheries and Coastal Affairs on behalf of the Government to draw up a proposal for an integrated research strategy for the overall field of marine science. The committee's mandate is to identify the knowledge needed and recommend how it should be developed. Knowledge, however, is of little value unless it is placed within a specific context. Thus, the HAV21 strategy report also addresses questions pertaining to what needs to be done to obtain the best possible research and development activities from investments in marine research. The report identifies major knowledge needs and points out that both the private and the public sectors need to boost investment in research and development if ambitions are to be achieved and opportunities fully realised.

Historically, the ocean has played a key role in Norway's development as a nation, and it will continue to do so in the future as well. The ocean and its resources are being used increasingly intensively for a variety of purposes, and more and more, political, social, industrial and resource management-related objectives and interests are competing with one another. Thus, the use and conservation of the benefits provided by marine ecosystems must increasingly be weighed against each other. The question is how. We need more knowledge to find the answers.

Anticipated climate change will lead to major changes in the functioning and productivity of marine ecosystems in the future. As the use of coastal and marine areas increases, so does the complexity of research questions relating to their use and conservation. While a longstanding dialogue culture already exists in many of the marine

THE NORWEGIAN COASTLINE

KILOMETRES

Coastline, mainland (incl. fjords and bays)	28 953
Coastline, islands	71 963
Total	100 915

For comparison, the length of the equator is 40 077 km

279 Norwegian municipalities have a coastline

Total of 239 057 islands and 81 192 skerries in Norway

Source: Norwegian Mapping Authority



Photo: Shutterstock

sector's arenas, there is still room for improvement. The more effective the consensus and/or cooperation achieved, the greater the gains for the marine sector and society at large. The HAV21 strategy committee recommends expanding the interdisciplinary, cross-sectoral approach to research, management and industrial development.

The overall recommendations set out in the HAV21 strategy report are based on the standalone reports submitted by the four working groups in the areas of management (including basic research), fisheries, aquaculture and food, respectively (available in Norwegian only).

The HAV21 strategy committee has based its recommendations on the assumption that the current significant investment trend in marine research will continue to be a national priority and will be followed up by all of the relevant ministries: the Ministry of Fisheries and Coastal Affairs, the Ministry of Education and Research, the Ministry of the Environment, the Ministry of Foreign Affairs, the Ministry of Trade and Industry, the Ministry of Petroleum and Energy, the Ministry of Agriculture and Food, and the Ministry of Health and Care Services.

THE HAV21 STRATEGY COMMITTEE'S RECOMMENDATIONS

Funding of research and development

Norway takes a broad-based approach to and conducts a considerable amount of marine research and development. Nevertheless, new knowledge is needed in order to further develop marine industrial activities and management, and both the public and the private sectors need to step up investment in marine research and development significantly. The strategy committee recommends that consideration be given to increasing private sector funding by increasing the proportion of the overall fee levied on seafood exports (which is comprised of a market fee and a research fee) that goes to R&D, or by raising the overall export fee.

Social and legal perspectives, management and use

Research-based knowledge must be included in the basis for national and international legislation and regulations on the use and conservation of marine resources, industrial activity and traffic in coastal and marine areas. Many Norwegian acts and regulations are intertwined and have elements in common with international regulations and treaties. Knowledge and harmonisation are needed to improve the efficiency of decision-making processes. The strategy committee recommends strengthening research on legal perspectives of marine questions, and establishing an interdisciplinary research project on future principles for and organisation of marine and coastal management.

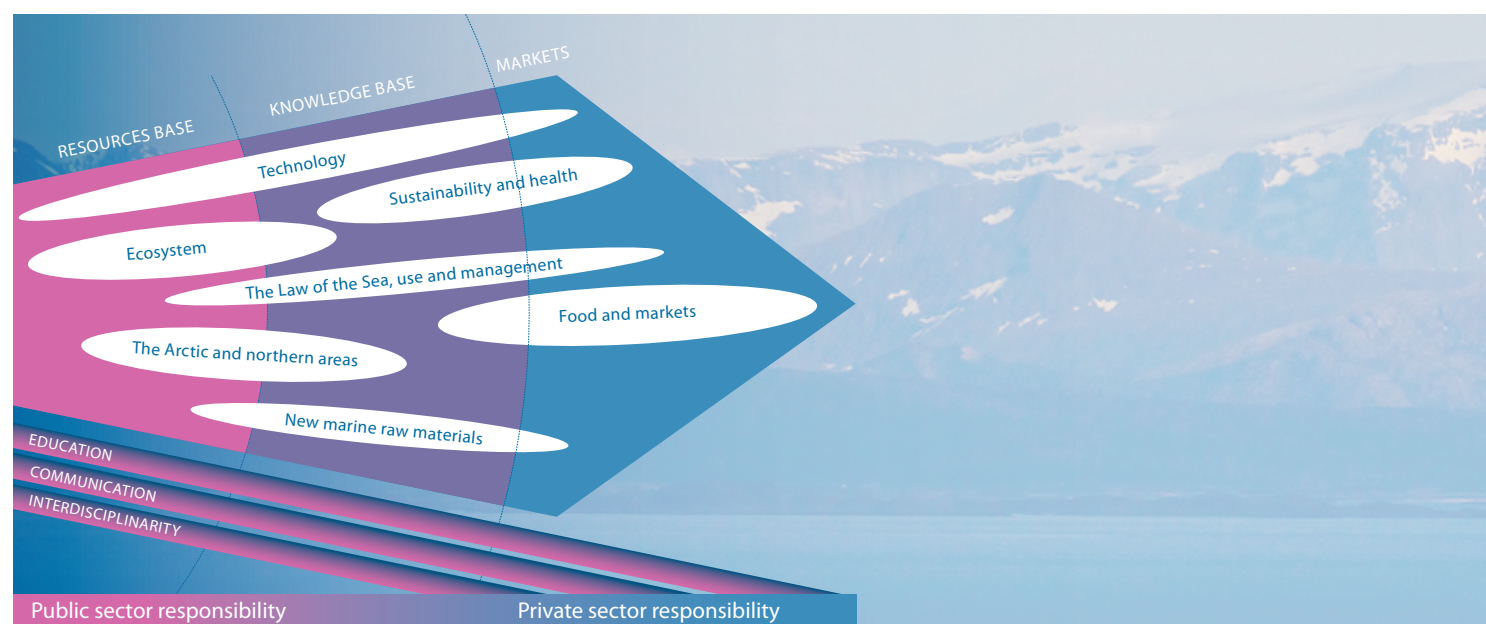
Knowledge about the ecosystem

Clean, thriving oceans are fundamental to the marine industries. The strategy committee recommends funding long-term research to obtain better understanding of marine life and processes, with focus on drivers of change: impacts of climate change, acidification, harvesting of biological and other resources, pollution and other anthropogenic activity.

Norway has a long history of using advanced marine infrastructure, research vessels, research stations, buoys, satellites, seabed installations, planes and models for gaining insight into and monitoring the ecosystem. The strategy committee recommends ongoing investment in infrastructure to ensure efficient data collection, effective monitoring and optimal prediction at various time scales.

The Arctic and northern areas

The geopolitical, security policy and strategic significance of the Arctic and northern areas is growing. Success in managing and using resources in these areas, balancing considerations relating to local communities and understanding the role of this region for global climate development will require knowledge from technology and the natural sciences, social sciences and the humanities. Marine research in the Arctic and northern areas must be intensified in keeping with the Government's High North Strategy.



HAV21 strategy committee's overall recommendations

Harvesting and cultivating new marine raw materials

Cultivation of marine raw materials for use in fish feed, energy production and human consumption may become a new, important growth industry along the Norwegian coastline, in part due to the projected scarcity of traditional marine feed ingredients for use in the aquaculture industry. The strategy committee recommends that research to shed light on potential opportunities and knowledge and technology needs is conducted, and that a strategy relating to new marine raw materials is drawn up.

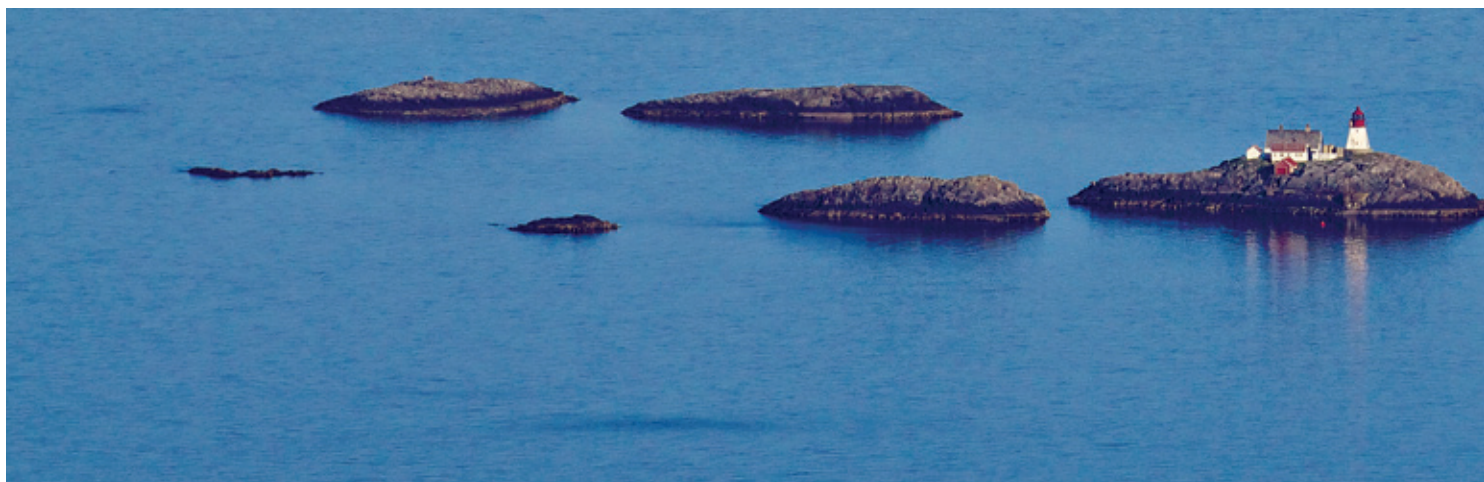
Fish health and sustainable, safe and healthy seafood

Reducing the incidence of fish disease is essential to maintaining the profitability, sustainability and good reputation of the aquaculture industry. Product-conscious consumer groups are demanding that seafood is produced sustainably under healthy conditions and that the quality of the seafood can be documented objectively and reliably by public authorities with the help of research-based systems and methods. The establishment of effective zones or production areas is a key measure in this context.

Documenting the relationship between seafood consumption and human health is important both for the Norwegian market and for marketing seafood at home and abroad. The strategy committee recommends continuing high-calibre research on fish health and sustainable seafood production, as well as investing in research to document the sustainability and quality of the seafood produced.

Food and markets

Norway already exports seafood on a large scale, and there is still tremendous potential for expansion. Further development is dependent on knowledge about markets and consumers. The strategy committee recommends building a market research community of high international standard to better understand the impact of changes in existing markets and the challenges posed by new ones. The objective is to develop better knowledge about product development, competitive conditions, marketing and distribution channels, brand-building and changes in consumer behaviour.





Technology

New technology is essential to promoting thriving coastal communities and addressing new and existing environmental challenges. Innovations in technology will also provide a basis for launching new and further developing existing marine industrial activities. The strategy committee recommends investing in technology for the fisheries and aquaculture industries that draws on expertise in technology development from the maritime and offshore sectors and incorporates components from biotechnology, nanotechnology/materials technology, and information technology.

Interdisciplinary research

Solving problems and making the most of opportunities is growing more and more complex and is increasingly contingent on knowledge combined from many fields. The strategy committee recommends that research projects are organised to include interdisciplinary and cross-sectoral dimensions to address new challenges relating to management and industrial activity.

Education and training programmes

Meeting tomorrow's challenges will require a great deal on the part of industry and the research community, and competition for the most highly qualified personnel is tough. Research careers in the marine sector must be made more attractive. Permanent researcher positions must be established at universities and university colleges, with particular focus on post-doctoral positions to create greater stability for younger researchers. The independent research institutes should become more involved in education and training programmes.

Communication activities

Research results must be communicated actively to the public administration, trade and industry and public at large, as well as within the research community itself. The strategy committee recommends that research projects set aside time and resources for communication activities to ensure that the research being conducted is relevant and the results are disseminated and put to use.

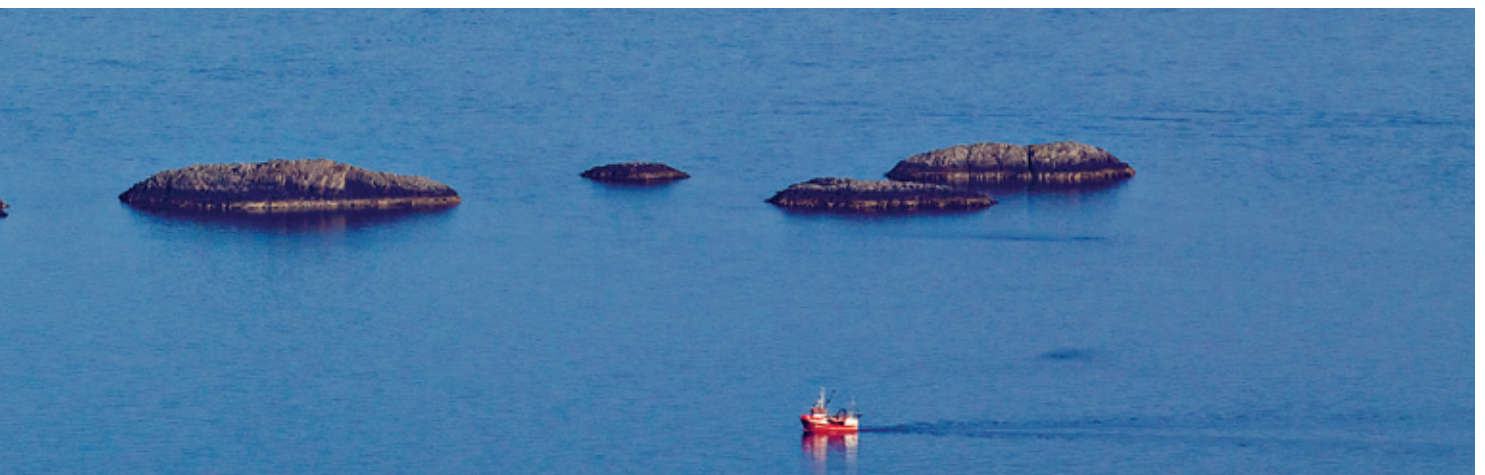


Photo: Shutterstock

NORWAY – A MARINE NATION OF SUBSTANCE

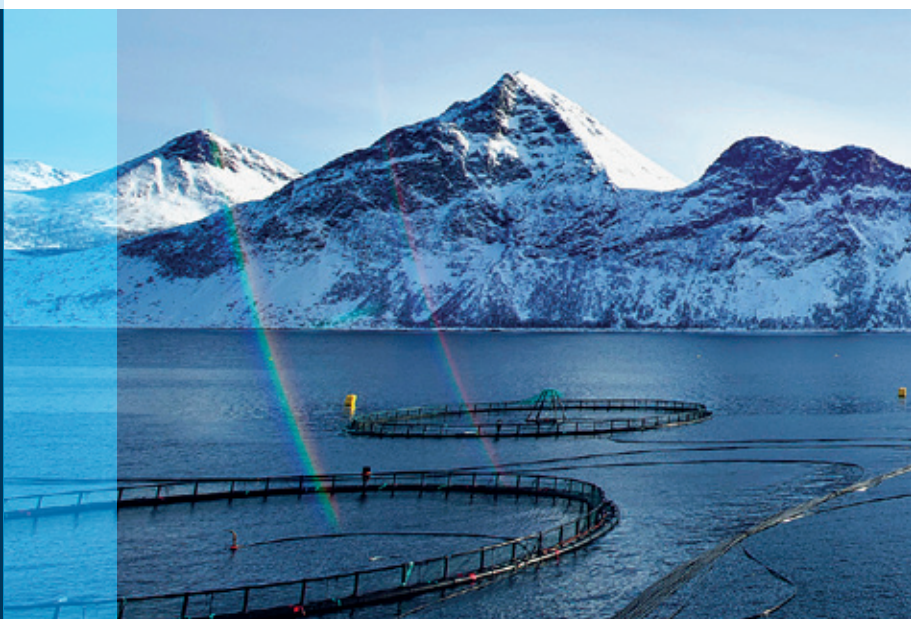


Photo: Tommy Olsen

The HAV21 strategy project

The HAV21 report sets forth an R&D strategy for the marine sector, a sector in which Norway today leads the way in knowledge development in many fields. The strategy is based on the high-quality, broad-based research and development activities conducted throughout the country, which are part of a long tradition that is expected to continue. The future of the marine industries is very promising, with one of the best platforms for growth in Norway.

The HAV21 strategy is intended to promote cohesive thinking and concentrated focus in marine research and development:

- at the overall level by means of a general report;
- at the scientific level by means of four designated reports in the areas of management (including basic research), fisheries, aquaculture and food.

Export of fish and fish products

2.3 million tonnes of seafood was exported in 2011

Export value, fisheries	NOK 22 billion
Export value, aquaculture	NOK 31 billion
Total	NOK 53 billion

Source: Norwegian Seafood Council



Photo: Norwegian Seafood Council/Johan Wildhagen

The working group reports identify areas in which new know-how is needed. It must be assumed that access to funding for R&D and infrastructure will be a limiting factor in the years to come, so it will be essential to establish priorities. This entails deciding which research areas and types of infrastructure are to be given primary focus or relatively greater weight. It also involves identifying knowledge needs in a logical sequence to prevent activities from becoming too fragmented.

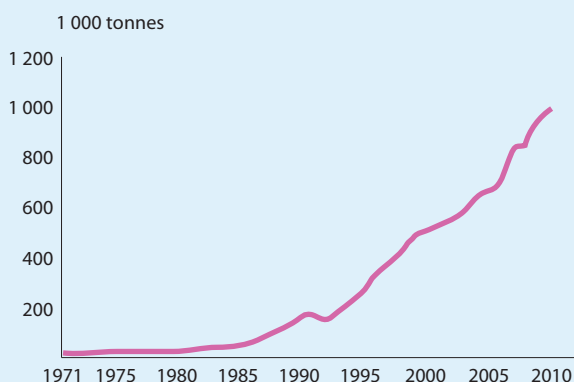
The HAV21 strategy report points towards the research and knowledge that will be needed to develop the marine sector in the direction that will fulfil the Government's vision of a Norway that is the world's leading seafood nation, that keeps the oceans clean and thriving for coming generations, and that carries out integrated, ecosystem-based management of sea areas.

Realising this vision means setting ambitious objectives, including to:

- achieve a position in the forefront in sustainable management, harvesting and profitable production of seafood as well as in full utilisation of biomass;
- achieve a position in the forefront in the quality of the products it provides;
- achieve a position in the forefront in innovation in all segments of the value chain, from fjord to table;
- facilitate value creation along Norway's entire coastline.

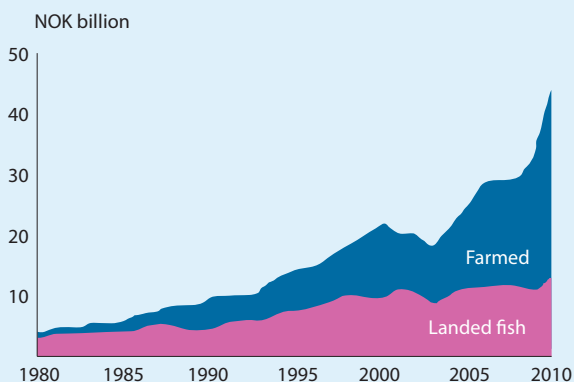
More knowledge is the key to realising the Government's vision.

Fish farming. Salmon and trout, amount sold

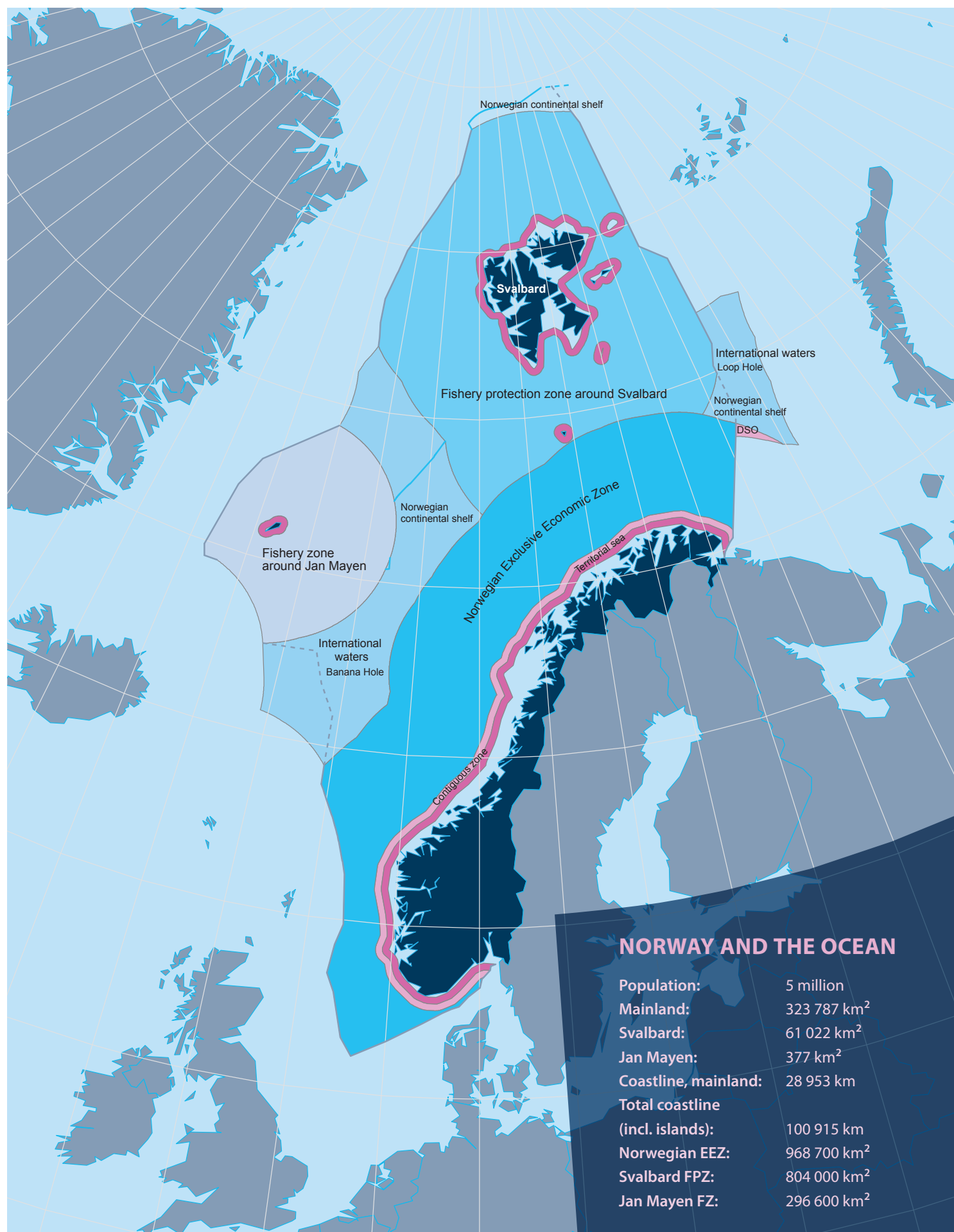


Source: Statistics Norway

Value of farmed and traditionally landed fish



Source: Statistics Norway



Source: Norwegian Mapping Authority

The HAV21 strategy will help to achieve these objectives by identifying the competencies and technology needed to develop Norway's position as a leading international supplier of seafood, marine equipment and marine services. The strategy will also help to further develop a knowledge-based fisheries and marine management system with international transfer potential and a research and development system that enhances the marine sector's international standing. To ensure future recruitment to the research and industrial spheres, the strategy seeks to increase the appeal of marine R&D as a career choice for younger students. The aim is to encourage knowledge and technology development that can provide a basis for thriving coastal industry and communities.

The HAV21 strategy committee has formulated its recommendations based on the following assumptions:

- The world needs to produce more food, and available coastal and marine areas must be used for food production – both in Norway and globally.
- Favourable framework conditions must be put into place to enable industry to grow.
- All activities must be carried out in keeping with the principle of sustainable development, i.e. development that meets the needs of the present without compromising the ability of future generations to meet their own needs, and must have wide-spread acceptance throughout society.
- Seafood production is energy-efficient compared with other types of animal food production and it is also an efficient means of producing animal protein.
- The markets for seafood, technology/equipment and services are changing radically as a result of, and there is a growing need to adapt management principles in response to, the competition for resources; market-related, political and social shifts; and the emergence of new science and technology.
- Local and global markets have varying capacity to pay for Norwegian products and services. Norway is a high-cost country, and the HAV21 strategy must promote high value creation to safeguard industrial activity and jobs in Norway.
- The structure of Norwegian society, with established cooperation between trade and industry, the research sector and the public administration, is a competitive advantage and must be preserved.

Comprehensive research activities of consistently high quality are essential to generating relevant, up-to-date knowledge about the marine environment. This research field is exceedingly complex

and incorporates a variety of disciplines, with overlapping boundaries between different subject areas, sectors and types of research (from basic to applied research and innovation). This calls for an integrated approach that will open up opportunities for greater cooperation and efficiency.

Maintaining a strong international standing will require more expertise in many areas. Included here is knowledge that will be of major strategic significance to the competitiveness and innovation capacity of the marine sector and knowledge on topics of geopolitical and/or security policy significance to Norway. Experience has shown that international cooperation promotes quality in research while strengthening the economic muscle needed to carry out the projects. It goes without saying that such cooperation must be continued and expanded. But at the same time, it is in Norway's national interests to seek to excel in certain key research areas, without losing its ability to master activities across the entire research chain.

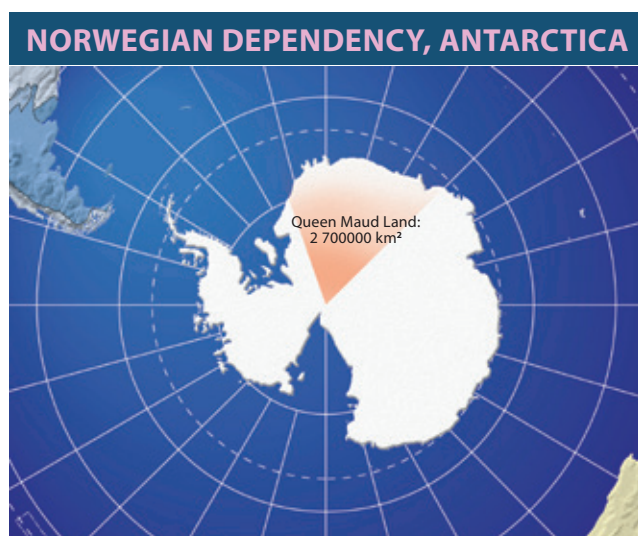
The HAV21 strategy shares an interface with other national research strategies, including the Martim21 and Klima21 strategies. These three strategies are intertwined to a certain degree, and there are advantages to viewing them together. The Maritim21 strategy is central, as it deals with maritime technology and knowledge needs of critical importance to the marine sector. The Klima21 strategy is focused on issues relating to the climate system and climate change that must also be addressed by the HAV21 strategy.

The marine sector and the world at large

Norway is a major power in several areas of marine research and development. In the spheres of industrial development, management, and research and development, the country is most widely known and respected internationally in areas that revolve around the ocean: the offshore, marine and maritime sectors. The increasing global interest in the Arctic region, with its petroleum, mineral and fisheries resources and potential for seasonal shipping activity, must be addressed through wide-ranging, long-term knowledge-building. This is also important in light of the role of the Arctic and northern areas in climate development and the significance of the region to industrial and social development in Norway.

Norwegian marine research must be international in terms of its approach, quality and ambitions. The fundamental processes that explain and regulate marine ecosystems are the same around the world, even though there are major regional differences in the character, structure and dynamics of the ecosystems. Many marine ecosystems extend into the territorial waters of several countries and/or international waters, and many of the species and resources harvested are shared by more than one country. A number of countries harvest resources in Norwegian waters, and Norway engages in extensive and still expanding fisheries and aquaculture activities in other parts of the world.

Norway must seek a key role in expanding the global knowledge pool and generating new understanding of marine ecosystems, biological diversity and processes. It must also aspire to a position at the international forefront in basic as well as applied research. This will only be achieved through close cooperation with leading international research groups. Norwegian research for mapping, understanding and managing marine resources must be developed in an international context and integrated into the EU's research systems and research funding schemes. In the European context, Norway has taken the initiative to establish the pan-European Joint Programming Initiative for Healthy and Productive Seas and Oceans (JPI Oceans) to further strengthen European cooperation on marine research.



Marine research is resource-intensive, so international cooperation on infrastructure and competence-building is vital. In Europe, a major effort is underway to link together marine data collection and management systems in the individual countries to make the data openly accessible. Likewise, new marine observation posts are being established that will be connected in a European and global network. For Norway, marine research stations, observation posts and collection of environmental and scientific data are essential, particularly in connection with the increasing interest and activity in the Arctic and northern areas. Norway must aspire to be a major player in technology development and marine data management; however, effective monitoring of the oceans can only be achieved through international cooperation.

Norway has substantial global influence when it comes to management principles, protection of ecosystems, and fisheries and aquaculture practices. In the EU and globally, Norway has a strong voice in developing policies and management principles and promoting marine research and development. Norwegian industrial players in the marine sector have established a world-wide presence. The value of transferring management principles and industrial activities to other countries and ocean areas is very high, and may result in major environmental and economic benefits around the globe.

Global demand for food

The world's population is expected to grow to 9 billion by 2050, before tapering off. This growth will entail major challenges in terms of protecting the environment and securing an adequate supply of energy and food. According to the United Nations Food and Agriculture Organization (FAO), in 2009 fish made up nearly 16 per cent of the animal protein consumed by the global population on average. The proportion of fish in people's diet is increasing, and seafood will play a larger role in tomorrow's world, where all possibilities for food production will need to be put into use. At the same time, care must be taken to avoid stripping the ocean of

its resources or damaging its capacity for resource renewal. There is every reason to believe that development will become increasingly knowledge-intensive and that Norway can play an influential role by providing knowledge-based management principles that facilitate the use and conservation of resources.

The HAV21 strategy does not specifically address the role of Norway's marine research and development strategy as a component of development cooperation. It is obvious that access to equipment, services and research-based knowledge can and should be a part of the effort to support industrial development and resource management in countries with limited research resources. There is significant potential for expanding Norway's efforts in this area, and a separate overall strategy for this should be drawn up.

The potential of the marine sector

The ocean is the common denominator for Norway's three most important industries: the marine industry, the maritime industry and the offshore industry. All three have their roots in Norway's longstanding tradition in navigating the seas and utilising marine resources. They are also complete business clusters; that is, they have all the key elements (industrial, R&D and management activities) needed to maintain their vitality, challenge and encourage one another, and grow in an international context.

It is worth noting that all three sectors have internationally leading industry, R&D environments and public authorities, enjoy large-scale international exposure, and export knowledge, products, equipment and services to global markets.

A key success factor for all three industries is that they are supported by competitive management regimes and have established recognised management principles based on thorough knowledge of marine ecosystems. There is also a certain amount of valuable exchange of technology and knowledge between the three industries, and together they form Norway's strongest industrial base.

Key figures 2011

Fishing and fish farming's share of GDP: 0.7 per cent

FISHERIES:

Norwegian fishing vessels supplied **2.3 million tonnes** of fish and crustaceans

Catch value: NOK 15.9 billion

No. of persons with fishing as their main occupation: 10 235 persons

No. of fishing vessels: 6 252

FISH FARMING 2010 (EXCL. CRUSTACEANS):

Norway sold **1 017 711 tonnes** of farmed fish

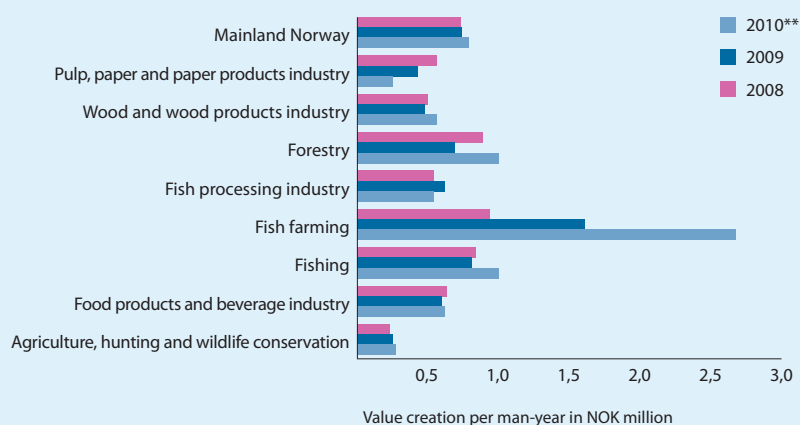
First-hand value: NOK 30.7 billion

Employment: 5 333 persons

No. of escaped farmed fish: 387 000

Source: Statistics Norway

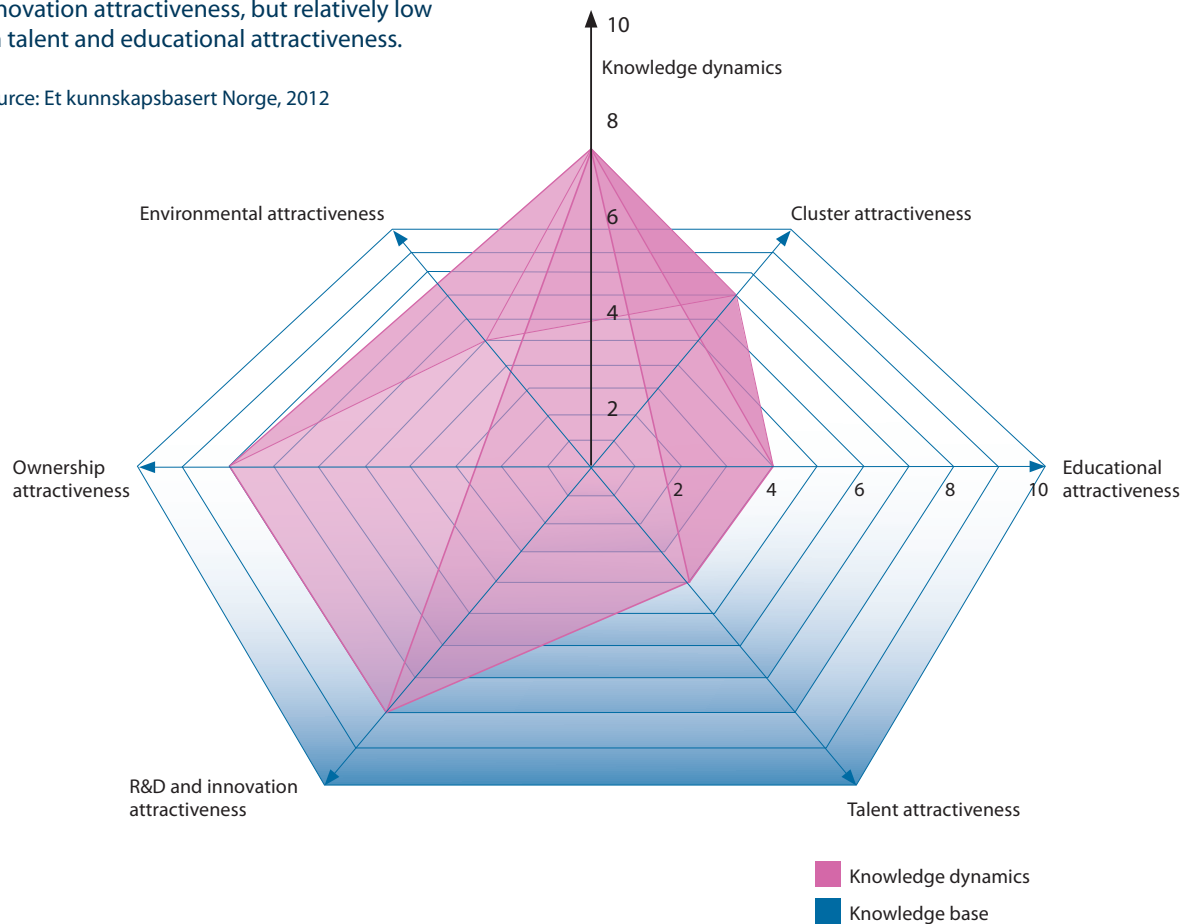
Value creation per man-year in selected industries (in NOK mill.)*



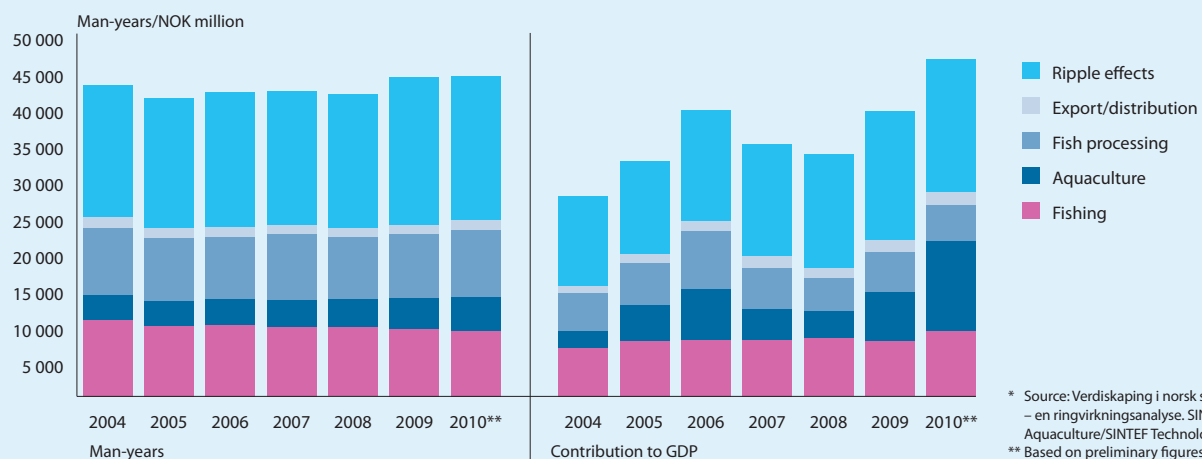
Strategic analysis of the Norwegian seafood industry

The industry scores high on R&D and innovation attractiveness, but relatively low on talent and educational attractiveness.

Source: Et kunnskapsbasert Norge, 2012



Marine sector. Man-years + contribution to GDP (in NOK mill.)*



* Source: Verdiskaping i norsk sjømatnæring 2010 – en ringvirkingsanalyse. SINTEF Fisheries and Aquaculture/SINTEF Technology and Society
 ** Based on preliminary figures from the national accounts, 2010



Photo: Jostein Fossnes/Fete typer

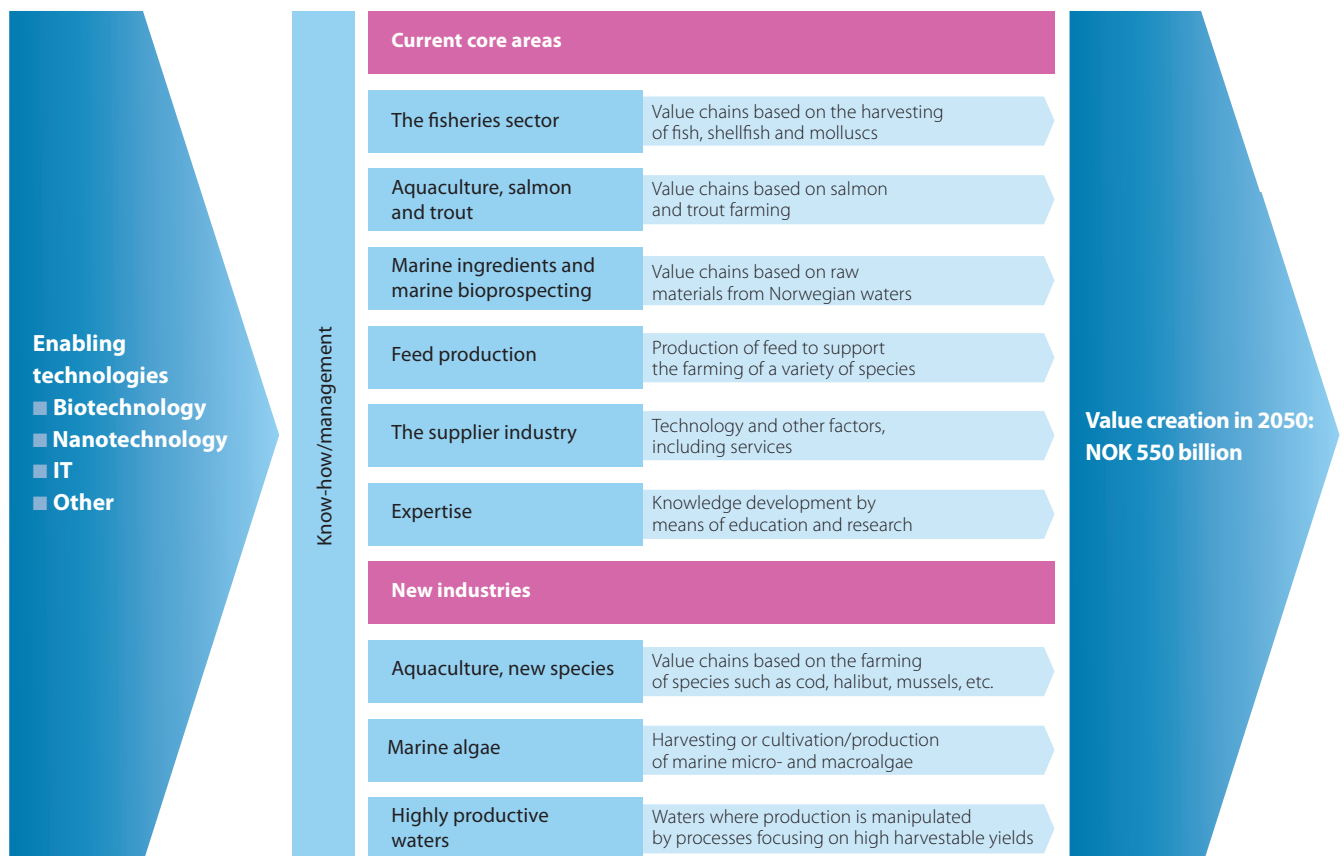
A number of major reports and white papers that have been drawn up identify and discuss the industrial strengths and growth potential of the marine industries, the framework on which they are based and their impact on society:

- In a 2012 report entitled *Et kunnskapsbasert Norge* (“A knowledge-based Norway”, Norwegian only), Professor Torger Reve et.al. point out that the marine sector is one of Norway’s three most complete industries, together with the offshore and maritime sectors.
- The follow-up report *Value created from productive oceans in 2050* (2012) published by the Royal Norwegian Society of Sciences and Letters and the Norwegian Academy of Technological Sciences identifies development trends and estimates the turnover potential of the marine industries at NOK 550 billion in 2050, compared to approximately NOK 90 million today.
- SINTEF Technology and Society and SINTEF Fisheries and Aquaculture prepared the report *Betydningen av norsk sjømatnæring 2004–2010* (2012) (“The national importance

of the Norwegian seafood industry, 2004–2010”, Norwegian only) on commission from the Norwegian Seafood Research Fund (FHF). The report analyses the fisheries and aquaculture industries’ ripple effects in society, and estimates that the fisheries-based value chain, including ripple effects, encompasses 24 200 man-years, while the aquaculture-based value chain encompasses 21 100 man-years.

- Report No. 12 (2001–2002) to the Storting: Protecting the Riches of the Seas emphasises that future generations must also be able to harvest the abundance of resources the ocean has to offer.
- The integrated management plans for the Barents Sea and the Norwegian Sea, respectively, and the forthcoming integrated management plan for the North Sea and Skagerrak, describe the importance of these sea areas for industry and society at large, as well as ways to optimally facilitate value creation, production and coexistence within an environmentally sound framework in the years to come. The management plans also identify key knowledge and research needs.

MARINE SECTOR VALUE CREATION IN 2050



The value creation potential for the marine sector as illustrated in the report *Value created from productive oceans in 2050* published by the Royal Norwegian Society of Sciences and Letters and the Norwegian Academy of Technological Sciences (2012).

Together these reports document future opportunities for the marine industries and provide a persuasive argument for increasing investment in marine research and development.

Industrial development and framework conditions

Public regulatory regimes may have different aims and may both promote and restrict value creation and innovation capacity in trade and industry. Effective management of the ocean and its resources is a prerequisite for sound industrial development. The marine industries are multifaceted and operate under framework conditions that are subject to what at times is close political scrutiny as well as considerable regulation development.

To be effective, regulations must be rooted in a knowledge-based understanding of the ecosystem, and critical limits and limits for resource extraction must be set. Only legislators and the public administration can fully safeguard the common good, including the demand for sustainable development, and Norwegian

regulatory practice has generally been a competitive advantage for the marine industries and knowledge-building in Norway. However, shifts in markets, technology and political agendas occur quickly, making it crucial to incorporate industry and the public administration into knowledge-building activities.

Follow-up of management systems is based on research and systematic acquisition of know-how. This, too, will require increasing involvement in and contribution to new understanding on the part of the many stakeholders that use the ocean for commercial purposes.

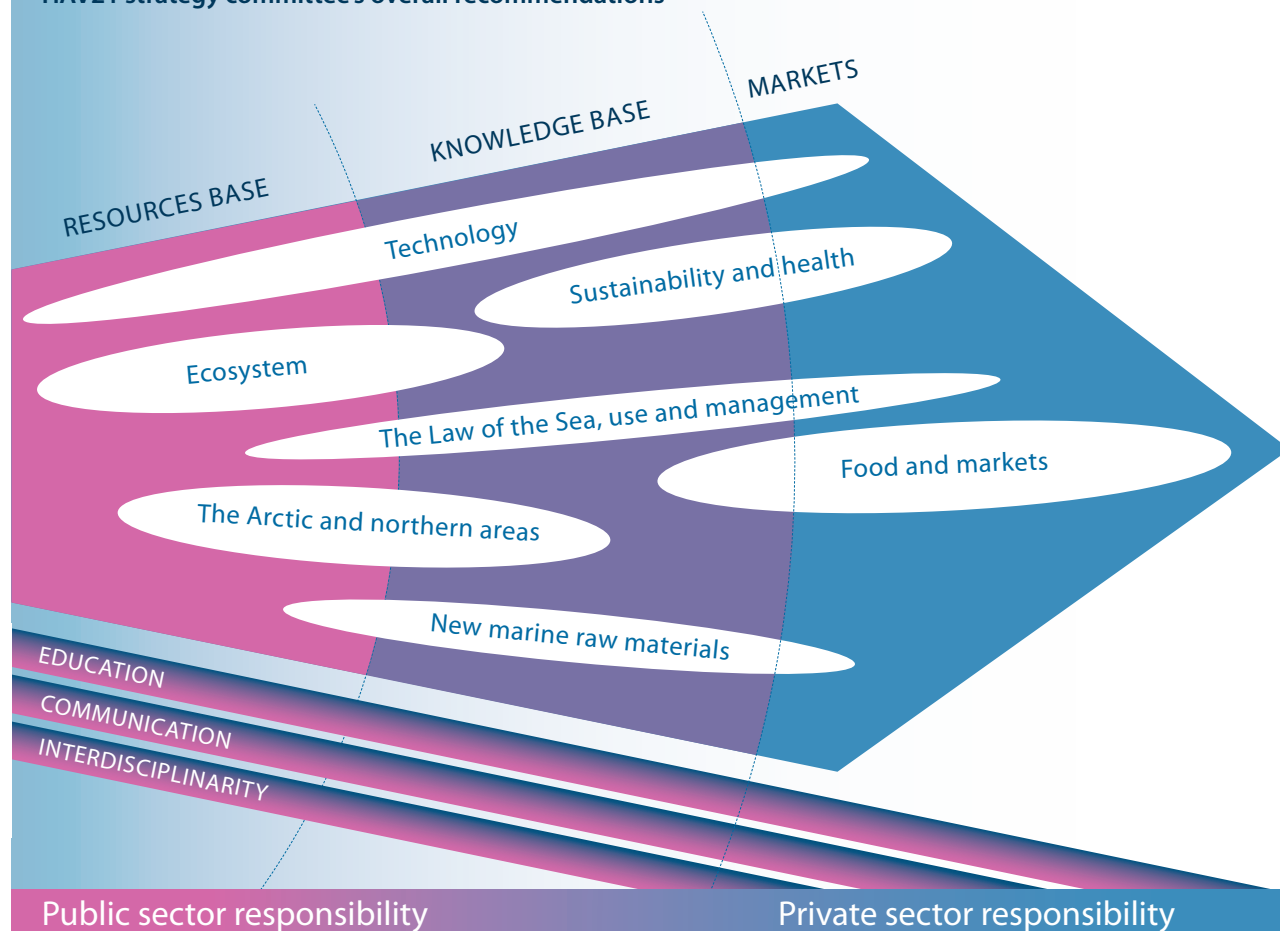
In its recent evaluation of the Research Council of Norway, the consultancy group Technopolis recommends enhancing cooperation between research and industry. The HAV21 strategy committee believes that there is great potential for such cooperation in marine-related industrial activities.

RECOMMENDATIONS – PROMOTING STABLE GROWTH AND EXPANDING OPPORTUNITIES



Photo: Sverre Jarild

HAV21 strategy committee's overall recommendations



Norway currently employs a broad-based approach to marine research and development, and it must be continued. This provides the point of departure for the HAV21 strategy committee's recommended priorities for the years to come. The presentation of priority areas does not imply any internal ranking.

The strategy committee's recommendations are based on the reports submitted by four working groups in the areas of management (including basic research), fisheries, aquaculture and food, respectively. The working groups have operated autonomously, and their proposals, recommendations and priorities represent their independent views. The strategy committee has found the reports to provide a well-considered, useful basis for further planning and priority-setting in the individual areas, and has integrated them into its overall recommendations. Certain recommendations have been addressed within several working groups, such as giving priority to understanding the ecosystem and to cross-sectoral cooperation. For more detailed descriptions of research questions and scientific priorities, please refer to the individual reports (in the Norwegian version only).

Funding of research and development

Norwegian research and development activities span a wide range, including research infrastructure and monitoring systems, and are both publicly and privately funded. According to a 2011 report published by the Nordic Institute for Studies in Innovation, Research and Education (NIFU), entitled *Ressursinnsatsen til marin FoU og havbruksforskning* ('Resource investment in marine R&D and aquaculture research', Norwegian only), just over NOK 2.8 million was invested in marine research and development in 2009. Trade and industry accounted for NOK 0.67 billion of this amount, or 24 per cent of overall investment.¹ NOK 1.32 billion was allocated

to aquaculture research (46 per cent of overall allocations to marine research), of which the industry contributed NOK 0.53 billion, or 40 per cent.

The HAV21 strategy committee finds that considerable knowledge is needed to further develop industrial activities and management regimes. The cost of meeting these needs far exceeds existing public and private sector budgets. The public administration and industry must take responsibility together for constructively distributing tasks in order to expand marine knowledge and infrastructure.

Research for the public administration is primarily a public responsibility. However, many of the challenges relating to the use of coastal and marine areas require a unified, coordinated research effort between the industry and the public authorities. Public funding should be used to secure higher education and research across a broad spectrum, enhance basic knowledge about the ecosystem, ensure monitoring of the status of the oceans and management of coastal and marine areas, and, in addition, to lay the foundation for industrial development. The industry should contribute by collecting data and making equipment available for use in research and development.

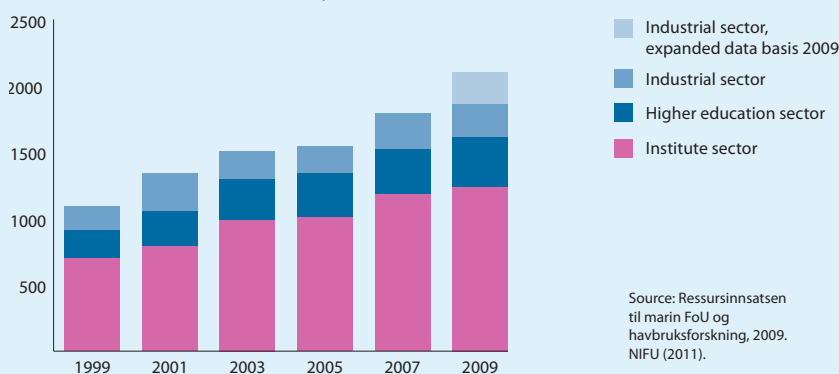
The marine sector consists of a large number of companies of widely divergent sizes, only a few of which have the capacity to carry out research and development. Thus, there is a particular need to develop joint solutions that ensure that all types of companies take part in funding research and development on shared objectives. At present such research is funded with the help of a research fee that is levied on exports of fish and fish products.² Assuming that broad-based involvement is a prerequisite for further knowledge-building and industrial growth, it is vital to establish incentives to increase R&D activity in trade and industry.

¹ NIFU's figures for investment on the part of trade and industry may be too low due to inadequate reporting or because certain companies have not been included. New figures will be presented in 2013.

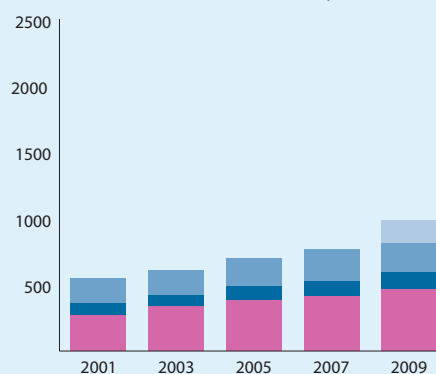
² Exports of fish and fish products are subject to a fee of 1.05 %, of which 0.75 % is a market fee and 0.3 % is a research fee.

Resource investment in marine R&D

R&D expenditure for marine R&D 1999–2009, by sector of performance
NOK million (in constant 2000 basic prices)



R&D expenditure for aquaculture R&D 2001–2009, by sector of performance
NOK million (in constant 2000 basic prices)



THE STRATEGY COMMITTEE RECOMMENDS:³

- Given the sizeable need for knowledge, public and private investment in marine research and development should be increased significantly.
- Private sector funding should be increased in one of two ways:
 - either by increasing the proportion of the overall export fee that goes to R&D,
 - or by raising the overall export fee.

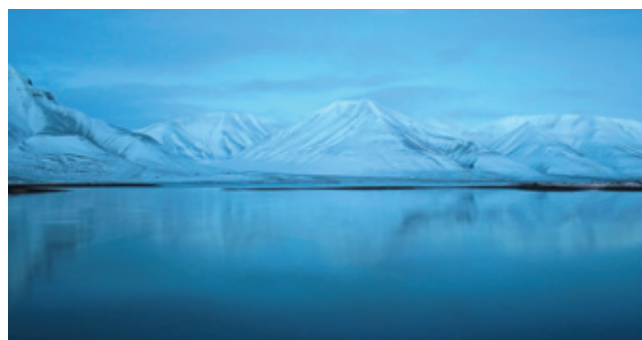
PRIORITY AREA – SOCIAL AND LEGAL PERSPECTIVES, MANAGEMENT AND USE

Photo: Thomas Wiborg

The Law of the Sea

Norway is an international heavyweight when it comes to management of coastal, sea and polar areas (both north and south). Much of the Norwegian statutory framework is linked to and shares an interface with international regulations and treaties. More knowledge and harmonisation are needed to optimise the efficiency of decision-making processes. Norwegian management principles are respected and have high transfer value to other areas. Interest in the Arctic and northern areas is growing, nationally and internationally, due among other things to the region's biological, mineral and petroleum resources. Climate change is affecting both the amount and migration patterns of biological resources,

which opens the door to increased human activity and transport, but also gives rise to new management-related challenges.

Escalating competition for use of land and sea area in coastal areas and growing interest in the Arctic and northern areas underscore the need to view all of these issues in the same context. At the same time, legal research on marine questions is not well organised as a field in Norway. There is little continuity in planning and many activities receive only short-term funding. The management and use of Norway's coastal, sea and polar areas must be founded on a sound legal basis. Although Norway has some of the world's most modern legislation in this sphere, there is still a need to evaluate, systematise and modernise regulations and practice related to the Law of the Sea, resource utilisation and management of coastal and ocean areas.

THE STRATEGY COMMITTEE RECOMMENDS:

- Legal research relating to coastal and ocean areas, including the polar areas, should be systematised and organised as a specifically-defined initiative to safeguard Norway's management and industrial interests.

Use and management

Norway's marine and coastal areas represent enormous value for the fisheries and aquaculture industries, for other industrial purposes such as petroleum and shipping activities, and for leisure activities, and these areas must be managed soundly. Use and management involve an entire complex of scientific, technological, industrial and social science-related problems all in need of solutions that can adequately accommodate divergent considerations. Management agencies, counties and municipalities all have responsibility for marine and coastal areas and are responsible for fulfilling different objectives. A scientific basis for political decisions and better structures for coordination between the players involved would lead to considerable benefits.

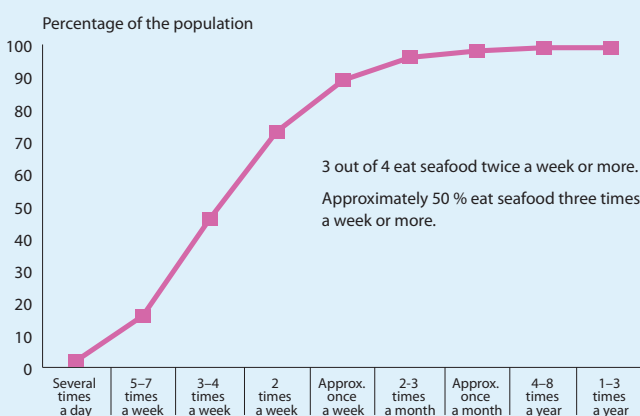
New principles for the organisation of marine and coastal management and the links between them can create a foundation for more efficient and integrated management, with a focus on value creation

Household consumption of seafood in Norway, 2011

Kg per person per year

	Round weight	Product weight
Purchased	28.0	16.1
Caught by consumer	0.5	0.4
Gift	0.4	0.2

Source: Norwegian Seafood Council/GfK Norge AS/Flesland Markedsinformasjon AS

Seafood consumption frequency in Norway, 2011 (all meals)

Source: SCI 2011 Norwegian Seafood Council/TNS Gallup AS

within clear biological limits and overall benefits to coastal communities. Developing a system that can satisfactorily balance these interests, while taking into account dynamics (rapid changes in the ecosystem itself and relevant stakeholders) and democratic processes and transparency will be a major challenge in the next 20 years.

THE STRATEGY COMMITTEE RECOMMENDS:

- Issues relating to sea/land use in marine and coastal areas should be identified with the aim of optimising future regulation and management. An interdisciplinary research project on management principles and future organisation of marine and coastal management should be launched.

PRIORITY AREA – KNOWLEDGE ABOUT THE ECOSYSTEM

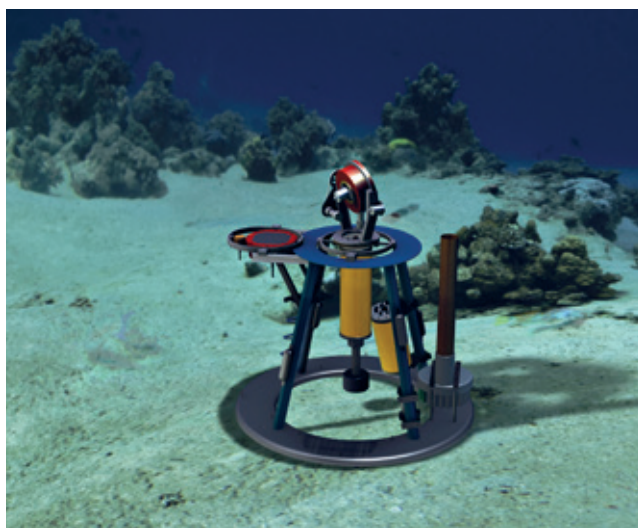


Illustration: Glynn Gorick/Institute of Marine Research

Knowledge about the ecosystem and changes taking place there should be the basis for all activity, use of resources, innovation and industrial development at sea and along the coastline. Long-term basic and management-oriented research is essential to safeguarding national interests and contributing to the global knowledge pool.

The integrated management plans for the Barents Sea, the Norwegian Sea, and soon the North Sea and Skagerrak (2013), provide a detailed description of ocean ecosystems. However, a similar description of coastal ecosystems is lacking, as is information about the links between the coastal and marine environments.

Ecosystems are complex, and are affected by many factors. Ecosystem-based management entails integrated management of nature and natural resources, and it is human activity that must be regulated to ensure that the cumulative effects of the various pressures do not exceed the critical limits of the ecosystem. The

concept of ecosystem-based management is discussed in the white paper *Protecting the Riches of the Seas*; the objective is to achieve sustainable use of ecosystem resources and goods, while maintaining the ecosystems' structures, functioning and productivity. More knowledge about the cumulative effects of various factors is needed to form a basis for effective implementation of ecosystem-based management in practice.

Ecosystem services is the collective term for benefits and services from natural ecosystems and on which human welfare and well-being depend, but to which it is difficult to assign an economic value. Greater attention must be paid to these benefits, as human activity is steadily encroaching on the natural environment. This is also essential for sustainable management of biodiversity and ecosystems, and represents important input to the work of the Intergovernmental Panel on Climate Change (IPCC) and the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES).

Thorough basic research in a range of disciplines will form the foundation for effective applied research for management, harvesting and industrial development. Conversely, questions and knowledge generated by applied research may give rise to new perspectives in basic research. Norway must be able to offer educational programmes of high international standard in the marine disciplines, at all levels across a wide array of subject areas. Effort must also be made to facilitate the dissemination of research results so that the knowledge generated can be put to use.

Marine research is dependent on infrastructure for data collection and management to gain insight into and monitor the ecosystem. Norway has a long history of using advanced marine infrastructure such as research stations, laboratories and testing facilities, as well as ship, seabed, satellite and aircraft-based observation and monitoring systems. Observations are fundamental for modelling and prediction of ecosystem dynamics. There is extensive international cooperation in this area. Marine infrastructure and data collection and management are costly, and new and more efficient solutions must be sought to cut costs and improve quality. This is primarily a public responsibility; however, the fisheries, aquaculture and petroleum industries ought to do more to make the data they have collected more accessible for research purposes.

THE STRATEGY COMMITTEE RECOMMENDS:

- The broad approach to marine research must be continued and implemented in ecosystem-based management. Greater emphasis must be given to obtaining knowledge about the key drivers of change: impacts of climate change, acidification, harvesting of biological and other resources, pollution, other anthropogenic activities and the cumulative effects of various pressures.
- Ongoing investment in and coordination of marine infrastructure must be maintained and viewed in an international perspective in order to improve the quality and efficiency of data collection and monitoring.

³ Arne E. Karlsen, Managing Director of the Norwegian Seafood Research Fund (FHF), abstained from the discussion and deliberations on the research fee, which is FHF's income base.

PRIORITY AREA – THE ARCTIC AND NORTHERN AREAS



Photo: Cecilie von Quillfeldt

The rapidly growing national and international interest in industrial activity in the Arctic and northern areas, the significance of these areas for climate development and the increase of geopolitical interest in the region all dictate a need for a coordinated, well-planned, interdisciplinary research and technology development initiative targeting the region. In addition to the integrated management plans for the Barents Sea and the Norwegian Sea, there are strategies for polar research and there is important research infrastructure located on Svalbard.

Although there is already considerable research activity in the Arctic and northern areas, the strategy committee believes that marine research in and on the region needs to be expanded. Many of the strategy committee's recommendations in other HAV21 priority areas comprise elements of the focus on the Arctic and northern areas without being explicitly identified as such. Prioritisation of the northern areas in this context will help to boost marine research overall.

There is markedly less knowledge and understanding of fundamental physical and biological processes in the Barents Sea and the Arctic than for the areas further south. Due to the ice cover and limited accessibility in winter, there is little data on the physical and biological conditions during that season. Ongoing climate change and ocean acidification, increased interest in Arctic shipping and petroleum resources in the region, and the vital role of the Barents Sea and the Arctic areas as nursery grounds for commercially important fish stocks all point to a pressing need to quickly expand the knowledge base.

It is essential to study how changes in air and ocean currents will affect the introduction of pollutants, how the composition of environmentally hazardous substances that put pressure on Arctic ecosystem will evolve, and how cumulative environmental stress factors, including climate change and ocean acidification, will affect species and ecosystems. An increased level of activity and resource utilisation will involve an expansion of industrial development, infrastructure, transport systems and energy supply. Research is needed to determine the ramifications of this for coastal communities and indigenous peoples.

There are a number of unresolved issues relating to the Law of the Sea and the geopolitical situation in the region. Interest in this area is on the rise, not least from the Asian growth economies. Sustainable management and future industrial activities will need to be based on new knowledge. This involves both mapping of the current status prior to the launch of new activities and research and technology development on and for companies in the relevant areas. A good overview of national and international research activities in the northern areas is essential to ensuring the best possible basis for targeting future research activities in and on these areas.

THE STRATEGY COMMITTEE RECOMMENDS:

- Marine research in and on the Arctic and northern areas should be made a national research priority. Developments in this region should be addressed in a broad-based initiative for research and development in science and technology, social sciences and the humanities.

PRIORITY AREA – HARVESTING AND CULTIVATING NEW MARINE RAW MATERIALS



Photo: Janne K. Gitmark, NIVA

Cultivation of marine raw materials with different areas of application may become a growth industry along the coast, but a broad-based approach is needed to analyse the growth potential and potential environmental impacts.

The marine feed ingredients currently used in fish feed will become increasingly scarce, particularly for fish that eat feed containing fish. Research and development have led to the formulation of vegetable feed ingredients that can replace marine ingredients. This has not reduced the quality of the fish, and the salmon has remained an important dietary source of omega-3 fatty acids. Globally, an increasing proportion of food production will have to come from the ocean. In all likelihood the aquaculture industry will grow substantially in the coming decades. More feed ingredients will have to come from the production of marine micro- and macroalgae, for example. Mussels cultivated for industrial purposes may also have considerable potential as a source of marine protein and lipids.

Marine raw materials can also help to meet the demand for renewable energy. Cultivation of micro- and macroalgae for use as energy, for example in the form of biofuels, may lead to sustainable, competitive production in Norway, as well as provide important by-products such as protein and mineral supplements for

feed and fertiliser. Restoring seaweed forests may help to improve fish recruitment and increase bioproduction along the coastline. The development of new technology is essential to realising this potential.

There may also be new potential in the production of food/medicine/dietary supplements based on bioactive components in micro- and macroalgae, cf. bioprospecting.

THE STRATEGY COMMITTEE RECOMMENDS:

- The public agencies within the research and innovation system and private stakeholders should cooperate on launching an R&D project to analyse potential opportunities and knowledge and technology needs, develop a framework for a knowledge base, and draw up a strategy for sustainable harvesting, cultivation, technology development and use of “new” marine and vegetable raw materials in fish farming, energy production and for other purposes.

PRIORITY AREA – FISH HEALTH AND SUSTAINABLE, SAFE AND HEALTHY SEAFOOD



Photo: Marine Harvest

Fish health

To remain productive in the long term, aquaculture activities must be sustainable in a broad sense. The growing focus on food safety in large segments of the market for Norwegian seafood poses a challenge to Norwegian aquaculture and seafood exports.

Ensuring good fish health and low incidence of disease is an overall objective of the aquaculture industry, regardless of whether the aim is food security, food safety, animal welfare or profit. Disease prevention is therefore a priority area for all aquaculture production.

The spread of disease (including sea lice) is a serious problem and a limiting factor for continued growth in the Norwegian aquaculture industry. Much greater focus must be placed on preventive measures and obtaining knowledge about the underlying causes of loss-inducing diseases and factors that influence their spread. The establishment of effective zones or production areas is a key measure in this context. Technology will also have an important role to play here.

The aquaculture industry is seeking to reduce its loss percentage. Identifying which losses can be attributed to operations and production conditions and which can be attributed to disease is essential.

Unbiased, knowledge-based documentation of important characteristics of Norwegian seafood, such as sustainable catch and production, fish health, food safety and traceability, is critical to the industry's reputation and market acceptance. Documentation is also important for satisfying the requirements of any certification schemes and for marketing purposes. Thus far, Norway has been very restrictive with regard to genetically modified (GMO) fish and use of GMO feed ingredients. Nevertheless, there is a need to stay up-to-date on developments in this area.

The public authorities must still have primary responsibility for basic research and documentation, while the industry must take responsibility for research on market-related activities, traceability, packaging and logistics.

THE STRATEGY COMMITTEE RECOMMENDS:

- Research on disease prevention in fish must be continued and expanded. Knowledge on division into production zones, area use, types of operations, spread of infectious agents and causes of losses provides a vital basis for decision-making for both the management authorities and the industry. Basic and applied research is also needed on infectious agents, defence mechanisms and vaccine technology.
- Research to document the sustainability and quality of Norwegian seafood throughout the entire value chain must be continued and maintain a high standard.
- Research on and competence-building within the field of genetic modification should be carried out at the general level to enable Norwegian research groups to follow developments relating to GMO fish and GMO feed ingredients.

Seafood and human health

The food we eat affects our health throughout our lifetime. The challenge is to achieve a balanced diet that promotes normal growth and development and good health. The positive health effects of seafood consumption must be documented better. More insight is needed into the ways in which seafood consumption can prevent lifestyle diseases, beyond the documented positive effect of omega-3 fatty acids on cardiovascular disease. Research needs to be conducted on other important topics as well, such as how seafood affects physical and mental performance and cognitive abilities. This includes research on consumer understanding and how to influence consumers.

For dietary advice to be reliable it must be based on documentable effects. This will require the further development and harmonisation of methodology for measuring health effects with the use of both food consumption and modelling trials, including animal trials. In addition, the level of documentation needed to form a basis for dietary advice must be clarified. Positive health effects must also be weighed against the risks associated with consumption of seafood contaminated with, for example, heavy metals. Basic research and documentation here should primarily be a public responsibility.

THE STRATEGY COMMITTEE RECOMMENDS:

- Research to document the quality characteristics of seafood is vital for marketing and sales, and must be continued. The relationship between seafood consumption and human health is very important from a public health perspective and must be documented better.

PRIORITY AREA – FOOD AND MARKETS



Photo: Sverre Jarild

The Norwegian seafood industry has enormous development potential, and can, under the right conditions and with effective knowledge-building, deliver a vastly greater amount of seafood to the global food market than it does today. Such dramatic market growth is dependent on a detailed understanding of the market, thorough identification of market drivers and trends, good insight into marketing and distribution systems, retail chains and novel distribution outlets, and understanding of brand-building for seafood as well as of factors that influence consumer choices at the end of the value chain. Knowledge about market access, trade policy and trade barriers as well as cultural conditions in the various markets is crucial to further expanding the markets for Norwegian seafood.

At present, market and marketing research activities in Norway are fragmented and the field is not properly equipped to meet the future demands of the seafood industry. Continued advances in export markets will depend on the existence of a dynamic international research community for market and distribution research, brand-building and consumer behaviour in Norway. The aim must be to increase the number of qualified personnel for both research and industry-based activities to enable the Norwegian seafood industry to hold its own with international distribution and brand-name companies.

If Norway is to succeed as a seafood supplier in a large-scale international market, the industry must have access to relevant scientific and research expertise. Unlike most Norwegian industries, which are active in raw materials and industrial markets, the seafood industry is one of a very few that operates in international consumer markets.

THE STRATEGY COMMITTEE RECOMMENDS:

- An initiative should be launched for market and distribution research, brand-building and consumer behaviour in relation to seafood in order to establish a research community of high international calibre.

PRIORITY AREA – TECHNOLOGY



Photo: Sverre Jarild

The objective of Norwegian fisheries and aquaculture policy is to achieve the longest, broadest value chain possible in the marine sector. This entails fully utilising marine raw materials from catch and production, including residual raw materials, until they reach the consumer or are transformed into industrial products.

Ongoing technology development is vital to safeguarding the environment, safety and profitability of the aquaculture, fisheries, fish processing and marine ingredients industries and activities associated with bioprospecting. Marine technology, supplemented with technology from the maritime and offshore sectors, biotechnology, ICT and nanotechnology/materials technology, can support the further development of lucrative, environment-friendly industrial activities in Norway's coastal and marine areas. This will also open up opportunities for increased export of technological equipment. Cooperation between the private and public sectors on prototyping and pilot testing of new concepts, such under the DEMO2000 programme for the petroleum sector, is part of this picture.⁴

THE STRATEGY COMMITTEE RECOMMENDS:

- Industrial players, equipment suppliers, the research community and the public agencies in the research and innovation system should establish a joint initiative for, and enhance coordination of, research and technology development for the fisheries and aquaculture industries that utilises enabling technologies and relevant expertise from the maritime and offshore sectors.
- Within the field of bioprospecting, priority should be given to identifying potential applications and creating links between research and industry.

INTERDISCIPLINARY AND CROSS-SECTORAL RESEARCH



Photo: Shutterstock

The kind of knowledge needed in the marine sector has become increasingly more complicated and interdisciplinary in nature, and this must be reflected in the research conducted. More and

⁴ The DEMO2000 programme provides support for the qualification and pilot testing of new technology for use on the Norwegian continental shelf. The funding is intended to enhance the industry's own technology development activities and is awarded to projects of high relevance and significant socio-economic benefit.

more, complex, interdisciplinary research and development is required to solve large-scale challenges and fully realise existing potential. It is crucial to consider whether the knowledge system is appropriately organised on an ongoing basis. The strategy committee has not assessed the structure of the research system, but points out that it is essential to concentrate research activities in communities of adequate size to prevent fragmentation.

Access to funding for research and development is limited at any given time, and to make the most of available resources, research and development should to a greater extent be directed towards solving complex problems. The public agencies in the research and innovation systems need to focus their efforts on organising research activities under larger-scale projects or platforms with more participants. The same advice applies to independent research institutes and universities and university colleges, both internally and between the institutions. Comparable strategies for other sectors, such as the Maritim21 and Klima21 strategies, are closely linked to the HAV21 strategy and also demonstrate the need to carry out more synthesised research and development.

THE STRATEGY COMMITTEE RECOMMENDS:

- The research community, the public administration, trade and industry, and the public agencies in the research and innovation system should seek to solve challenges using interdisciplinary and cross-sectoral projects involving science and technology, social sciences and the humanities. Technology development efforts should draw upon Norway's extensive knowledge base in the offshore and maritime sectors.

EDUCATION AND TRAINING PROGRAMMES



Photo: Nicolas Tourrens, BI

To meet tomorrow's challenges the educational programmes for marine researchers must be of top international standard. Tough competition from international research environments underlines the need to concentrate research and educational activities in fewer locations in Norway to ensure high quality and avoid establishing new, fragmented R&D groups.

It is essential to recruit younger researchers as they will be in closer alignment with the attitudes and processes that will be shaping the future. Students should be involved in research activities at an early stage of their education to generate interest in and boost recruitment to research. The aim must be to train independent, creative, constructive researchers with a good understanding of basic disciplines, good contact with researchers at the international forefront and a clear interest in making a difference in the research community of tomorrow. Working in teams should be encouraged, particularly in the form of multi-/interdisciplinary projects, and a stay at a research institution abroad should be mandatory for all doctoral students.

It is today's and tomorrow's students who will be taking research to the next level and solving future challenges. In terms of gender balance, there are more women than men being trained in the field in Norway. The current age distribution in certain marine disciplines, however, is somewhat skewed. It is vital to the future of Norwegian marine research that the country trains and recruits younger researchers of top international calibre. This will require stepping up new recruitment rapidly within a relatively short time perspective. Although the number of students at the master's and doctoral levels has risen sharply in the 1990s and 2000s, the best and the brightest must be inspired to embark on a career in research. The lack of permanent researcher positions is a problem. The independent research institutes should become more involved in educational and training programmes in order to link researcher training more closely to the needs of the public administration and the industry.

THE STRATEGY COMMITTEE RECOMMENDS:

- Norwegian universities should offer a thorough basic education in marine disciplines. National distribution of tasks should be established on the basis of the respective institutions' areas of strength, both in terms of basic marine disciplines and applied disciplines relating to management, fisheries, aquaculture and food. Increased investment in permanent researcher positions and more post-doctoral positions will make a career as a researcher more stable and attractive.

USE OF RESEARCH RESULTS – COMMUNICATION AND DISSEMINATION ACTIVITIES



Photo: Jon Solberg

In general, researchers must become more adept at disseminating knowledge and research results and communicating with the users of the research as well as the public at large. Communication and dissemination activities are pivotal to ensuring that the public administration and trade and industry can apply knowledge and as a basis for informed social dialogue. Training in communication and

dissemination should be a key component of researcher education programmes and should be incorporated into all courses of study, particularly at the doctoral level. Researchers need communication skills and experience, as well as knowledge about available dissemination channels and arenas for research-related dialogue.

Publication of research results in widely-read scientific journals is vital. It is important that Norwegian researchers excel in areas in which Norway has strong national interests, and that quality comes before quantity. In addition, research results must be conveyed in a manner that enables the public at large to understand the significance of the research being conducted. It is also important to disseminate research-based knowledge to the public to increase general knowledge about and importance of the ocean.

Both the public administration and trade and industry need to improve their ability and capacity to implement research results and research-based knowledge. At present, research is not adequately utilised in industry and management because, among other things,

plans and systems for communicating results are lacking. Communication and contact with industry must be integrated into project plans from the outset, and time and resources must be set aside for this purpose. Effort should be made to facilitate dialogue between research institutions, equipment suppliers, industry players, the public administration and the public at large as early as possible in the project, not least to ensure that the research activities are relevant and that the R&D results will be of practical use to industry and the public administration. User participation and communication and dissemination plans should be required in new projects, when this is relevant. Consensus on project objectives is an important basis for the dissemination process.

THE STRATEGY COMMITTEE RECOMMENDS:

- Training in communication and dissemination should be a mandatory component of doctoral programmes. Research projects should have a plan for dissemination and communication with users from start-up, and end-users should be involved in the research process to the greatest possible extent.



Photo: Sverre Jarild



SUMMARY

Photo: Cecilie von Quillfeldt

The Norwegian economy is based extensively on value creation linked to the ocean, marine resources and maritime opportunities. There are also significant management challenges relating to the ocean, with regard to the climate, the environment and resource use. Both value creation and management must be based on knowledge generated in an array of subject areas and by specialist groups. This must be reflected in the research conducted.

Effective management of the ocean and its resources is a prerequisite for sound industrial development. The marine industries are multifaceted and operate under framework conditions that are subject to what at times is close political scrutiny as well as considerable regulation development.

It is the job of the legislators and public administration to safeguard the common good, including the demand for sustainable development. In Norway there is constructive dialogue between all of the players in this area, which is a competitive advantage for Norwegian marine industries and knowledge-building and should be further developed. Shifts in the market, technology and political agendas occur quickly, making it crucial to incorporate trade and industry and the public administration into knowledge-building activities.

The HAV21 strategy report confirms that a research-based foundation must be laid for sustainable management of unique ecosystems and biological diversity, and of marine resources harvested or cultivated by Norwegian industry in Norwegian waters. Norway should also contribute to the global knowledge pool for management activities outside Norwegian waters.

The HAV21 strategy committee proposes a range of measures to help to ensure that Norway develops the competencies it needs. The strategy committee recommends that a plan for implementation of the HAV21 strategy is drawn up.

Although the HAV21 strategy is an R&D strategy, it cannot be separated from the day-to-day reality in which the industry and public administration operate. Some of the strategy committee's recommendations for R&D priorities will have a direct impact on the framework conditions for industrial development and may provide opportunities for cohesive thinking, cooperation and increasing efficiency.

The marine sector is one of Norway's strongest sectors internationally, along with the maritime and offshore sectors; all of these have the ocean as the common denominator. Although the HAV21 strategy has been drawn up at the request of the Ministry of Fisheries and Coastal Affairs, on behalf of the Government, the strategy committee would like to emphasise that all of the ministries in the reference group (the Ministry of Fisheries and Coastal Affairs, the Ministry of Education and Research, the Ministry of the Environment, the Ministry of Foreign Affairs, the Ministry of Trade and Industry, the Ministry of Petroleum and Energy, the Ministry of Agriculture and Food, and the Ministry of Health and Care Services) fully support the strategy. If the ambitions articulated in the HAV21 strategy are to be achieved, all of the ministries must use the strategy actively when setting priorities and in their affiliated research and management systems.

STRATEGY COMMITTEE

Title	Name	Institution
Senior Vice President Strategy	Liv Monica Stubholt (chair)	Kvaerner ASA
Managing Director	Tore Nepstad	Institute of Marine Research
Director General of Fisheries	Liv Holmefjord	Norwegian Directorate of Fisheries
Professor	Torger Reve	BI Norwegian Business School
Fisherman	August Fjeldskår	
CEO	Alf-Helge Aarskog	Marine Harvest Group ASA
CEO	Åse Aulie Michelet	Teres Medical Group AS
Director General	Harald Gjein	Norwegian Food Safety Authority
County Governor of Nordland	Hill-Marta Solberg	
President (CEO)	Unni Steinsmo	SINTEF
Professor	Olaf Styrvoid	University of Tromsø
Director	Christina Abildgaard	Research Council of Norway
CEO	Arne Karlsen	Norwegian Seafood Research Fund
Professor	Helge Drange	Bjerknes Centre for Climate Research/University of Bergen
CEO	Nina Jensen	World Wide Fund for Nature
Senior Advisor	Cecilie von Quillfeldt	Norwegian Polar Institute
Director	Yngve Svarte	Norwegian Directorate for Nature Management
Director	Signe Nâmdal	Climate and Pollution Agency

WORKING GROUP: MANAGEMENT (INCLUDING BASIC RESEARCH)

Title	Name	Institution
Research Director	Geir Hønneland (leader)	Fridtjof Nansen Institute
Professor	Bjørn Hersoug	University of Tromsø
Manager	Einar Lystad	Norwegian Oil and Gas Association
Consultant engineer	Ingvald Riisberg	Climate and Pollution Agency
Research Director	Reidar Toresen	Institute of Marine Research
Specialist Director	Peter Gullestad	Norwegian Directorate of Fisheries
Senior Advisor	Knut Baar	Norwegian Coastal Administration
Secretary General	Maren Esmark	Nature Conservation Society
Professor	Anders Elverhøi	University of Oslo
Senior Advisor	Lars Johansson	Norwegian Directorate of Health
Senior Advisor	Ingrid Bysveen	Norwegian Directorate for Nature Management
Professor	Peter M. Haugan	University of Bergen
Professor	Trond Amundsen	Norwegian University of Science and Technology

WORKING GROUP: FISHERIES

Title	Name	Institution
Senior Advisor	Jan Henrik Sandberg (leader)	The Norwegian Fishermen's Association
Research Director	Vegar Johansen	SINTEF Fisheries and Aquaculture
Principal Scientist	Arill Engås	Institute of Marine Research
Product Advisor	Kjell Ramberg	SIMRAD
Director	Helge Hammersland	Scantrol
Professor	Michaela Aschan	University of Tromsø
Principal Scientist	Geir Ottersen	Institute of Marine Research
Managing Director	Lars Olav Lie	Liegruppen
Director R&D Fishery technology	Rita N. Maråk	Norwegian Seafood Research Fund
Senior Advisor	Aase-Merethe Remøy	Innovation Norway

WORKING GROUP: AQUACULTURE

Title	Name	Institution
Chief Operating Officer	Einar Wathne (leader)	Cermaq ASA/EWOS
Director R&D Aquaculture	Kjell Maroni	Norwegian Seafood Research Fund
Group Technical Manager R&D	Olav Breck	Marine Harvest ASA
Sales Manager	Torild Lohne	Sævareid Fiskeanlegg
Director R&D	Edel Anne Norderhus	Pharmaq
Project Manager	Marianne Waage Fougner	Statoil ASA
Director	Olai Einen	Nofima
Deputy Director	Roar Gudding	Norwegian Veterinary Institute
Head of Research Group	Geir Lasse Taranger	Institute of Marine Research
President	Karl Almås	SINTEF Fisheries and Aquaculture
Head of the Marine Programme	Karoline Andaur	World Wide Fund for Nature
Technical Manager	Harald Sveier	Lerøy Seafood Group ASA

WORKING GROUP: FOOD

Title	Name	Institution
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Director R&D	Berit A Hanssen	Norwegian Seafood Research Fund
Director, market information	Egil Ove Sundheim	Norwegian Seafood Council
Director	Morten Hyldborg Jensen	Aker Seafood
Sales Manager	Arnt Olav Aarseth	Brødr. Aarseth
COO	Gunnar Domstein	Norway Pelagic ASA
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The working groups' recommendations

- summary of the overall priorities

The working groups for management (including basic research), fisheries, aquaculture and food have drawn up independent reports with recommendations for their respective areas. These reports are based on input received during the strategy process.

SUMMARY OF THE WORKING GROUPS' OVERALL PRIORITIES

The reports of the individual working groups in their respective areas set out the groups' overall priorities, recommendations and suggestions for enhancing R&D activities. These reports are available as separate attachments (in Norwegian only). Below is a summary of the overall priorities of the working groups.

MANAGEMENT (including basic research) – priority knowledge needs and research topics to strengthen R&D activities

As a trend-setting marine nation, Norway is dependent on wide-ranging marine research and technology development activities. Recognising that this research area is extremely broad and complex, the group has discussed topics that should be given relatively greater weight without this undermining the current broad-based approach.

■ Knowledge about the ecosystem

- Knowledge about the ecosystem and changes affecting it is fundamental to all activity and use of resources in ocean and coastal areas. Maintaining basic research activities in the long term is critical if Norway is to safeguard its national interests, contribute to the international knowledge pool and be a global player. Norway must be able to offer educational programmes of high international standard in the marine disciplines, at all levels across a wide array of subject areas. Effort must also be made to facilitate the dissemination of research results so that the knowledge generated can be put to use.

■ Anthropogenic impacts

- Knowledge about anthropogenic impacts on the ecosystem, such as pollution, land appropriation, ocean acidification, harvesting and greenhouse gas emissions, is vital to regulating human activity. There is a particularly great need to study the interaction between several of these pressures to determine their cumulative environmental effects.

■ The Arctic and northern areas

- A dramatic rise in national and international industrial activity in the Arctic and northern areas, the significance of these areas for climate development, and the increasing geopolitical interest in this region calls for coordinated, well-planned, interdisciplinary research and technology development activities.

■ Technology

- Consistent, long-term focus on developing new technology for operationalising research results is important as a general rule, but is especially critical for marine areas, as the marine environment is not easily accessible and visible to the public at large.
- Maintenance of established and development of new time series and new monitoring and mapping technology are essential for responsible management and industrial activity.
- New catch technology must be developed to improve the selective properties of fishing gear, reduce energy consumption, minimise damage to the seabed and promote fish welfare.

■ The Law of the Sea and social science-based research

- Activities in coastal and marine areas are regulated by a large number of international treaties, laws and directives that are intertwined and overlap one another. Studies are needed to shed light on how these are implemented, how they hinder planning and cooperation in management, and how they complicate industrial activities.
- Tougher competition for land and sea area in coastal areas and growing interest in the Arctic and northern areas make it even more important to view all of these aspects in context.

FISHERIES – priority knowledge needs and research topics to strengthen R&D activities

■ Understanding of the ecosystem

- Basic knowledge is needed about the ecosystem, including the impacts of climate change, ocean acidification and pollution on the ecosystem, the mutual influence of variations in the species through harvesting and natural mechanisms, and the ways in which the fisheries industry should be adapted to a marine environment in flux. There is a need for ecosystem-based management models that build on the experience of both the management authorities and fishermen.

■ Clean oceans and fjords

- Knowledge is needed about the effects of foreign and environmentally hazardous substances, marine disposal sites for the mining industry and protection of areas for food production.
- A real-time monitoring system for fjord and coastal areas should be established.

■ Safety at sea and HSE

- The challenge is primarily to establish effective routines to safeguard health, safety and environment (HSE) on board vessels, as well as to develop new equipment, etc. to improve safety.

■ Land/sea use and coexistence

- Increasing competition for use of land and sea area in fjord, coastal and marine areas calls for knowledge that can lay a foundation for satisfactory coexistence among various stakeholders, including the fisheries, aquaculture, tourism and shipping industries.
- Coordination of regulations that affect each other can facilitate use and conservation.

■ Industry-oriented technology programme

- A joint, coordinated, industry-oriented technology programme needs to be established for the Norwegian fisheries and aquaculture industries, in which industry players and equipment suppliers take part. Focus should be placed on resource and environment-friendly production and harvesting, among other things.

■ Alternative catch methods

- Catch methods that focus on the end-product, thereby boosting profitability, need to be developed.

AQUACULTURE – priority knowledge needs and research topics to strengthen R&D activities

■ International perspectives

- Knowledge must be generated as a basis for Norwegian export of fish and aquaculture equipment and services.
- International cooperation is needed to ensure competence-building in Norway.
- Norwegian aquaculture expertise must be adapted to help to secure the future global food supply.

■ The ecosystem – clean fjords and coastal environments

- Knowledge about the production and tolerance capacity of fjord and coastal areas is needed.

■ Multi-use of fjord and coastal areas

- Growing use of fjord and coastal areas for various purposes and activities will require the use of an integrated approach to address research questions.
- More specific and more flexible regulations are needed for industrial activities in fjord and coastal areas.
- Studies on legal protection of fjord and coastal areas in relation to food production are needed.

■ Technology

- A technology initiative should be launched to advance technology development. This should combine technologies and knowledge from the marine sector with comparable technologies and knowledge from the maritime and offshore sectors as well as encompass enabling technologies such as ICT, nanotechnology and biotechnology.
- The industry needs joint pilot testing facilities and various types of infrastructure. The industry, the R&D community and the public administration should collaborate on mapping the need for and funding such facilities.
- Biotechnology within the areas of genomics and processes will play an increasingly important role in the future.

■ Documentation of fish health and seafood

- Unbiased documentation of fish health and seafood with regard to sustainability, food safety and traceability is essential to the industry's reputation, market acceptance and marketing. The authorities must continue to have the primary responsibility for documentation, provide adequate funding and organise activities in a manner that withstands criticism.

■ "New" marine raw ingredients

- Knowledge about new feed sources that can supplement fish protein and fish lipids must be obtained. There is potential for harvesting lower trophic-level marine organisms, as well as for cultivating micro- and macroalgae.

■ Basic research and education

- Links between basic research groups, applied research groups and aquaculture infrastructure should be strengthened.

■ Organisation and infrastructure

- Research groups should be encouraged to submit proposals for interdisciplinary and cross-sectoral projects instead of individually-based projects in response to funding announcements issued by research funding bodies.
- The public authorities and the industry should collaborate on drawing up a national strategy and plan that provides an overview of all types of aquaculture infrastructure needed by the industry to advance development and obtain more funding.

FOOD – priority knowledge needs and research topics to strengthen R&D activities

■ Seafood and health

- Research is needed on: documentation of the health effects of seafood as part of a balanced diet, consumer understanding, lifestyle diseases, and physical and mental development in and health effects for individuals in various stages of life.

■ Technology

- Environment-friendly processing technology needs to be developed, including automated production lines for processing all types of raw materials.
- A pilot village – a "fish factory for the future" – should be created to develop processing technology that can ensure the future of processing activities in Norway.

■ Full utilisation of raw materials

- Marine raw materials have many areas of application, and utilisation of these materials is dependent on technology (see above) and logistics that involve suppliers and purchasers of the raw materials, their geographical location and the profitability of each segment of the value chain. An analysis that looks at the flow of raw materials, technology and profitability in context is needed.

■ Global framework conditions

- Trade policy factors determine the degree of access that Norwegian seafood products have to global markets at any given time. Knowledge about global framework conditions for the seafood industry and in relation to brand-based and reputation-based value optimisation is needed. Knowledge about factors relating to the WTO, FAO, etc. that influence the global market situation is also needed.

■ Bioprospecting

- Basic knowledge and mapping of bioactive components in marine organisms is expanding. A regime for intellectual property rights should be introduced. The application opportunities vary widely, and specific applications should be selected for testing and upscaling.
- Importance should be attached to establishing links between research groups and industry players at an early phase.

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This publication may be ordered at
www.forskningsradet.no/publikasjoner
or green number telefax: +47 800 83 001

Cover photo: Shutterstock
Design/illustrations: Fete typer
English translation by Victoria S. Coleman and Carol B. Eckmann

Oslo, March 2013

ISBN 978-82-12-03175-3 (pdf)
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