The Research Council of Norway

Work programme

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Programme
Marine Resources and the Environment – MARINFORSK

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1 Summary

The Research Programme on Marine Resources and the Environment (MARINFORSK) is the Research Council of Norway's most important thematic initiative in the field of marine research, and encompasses research on both ocean and coastal areas. The programme is designed to provide the government administration with a sound knowledge base and promote increased value creation based on marine resources, with sustainability as an underlying principle throughout. The programme will also be a key instrument for implementing the Research Council's Research Strategy for the Arctic and Northern Areas.

More knowledge is needed about marine ecosystems and how they are affected by climate change, pollution and other anthropogenic factors. The problems involved are often highly complex, and addressing them will require an integrated approach, both nationally and internationally.

Large marine ecosystems often extend across territorial boundaries and into international waters as well. The ecosystems of the Barents Sea, the Norwegian Sea, and the North Sea and Skagerrak are no exception.

The MARINFORSK programme is divided into four areas which comprise the programme's main thematic priorities:

- **Marine ecosystems** is targeted towards increasing understanding of the structure and function of and change in these ecosystems to facilitate long-term, sustainable management of Norway's marine areas.
- **Pollution and other effects on ecosystems** is aimed at generating knowledge about the extent and effects of pollution and other anthropogenic factors on the marine environment.
- **Sustainable harvesting and value creation** is concentrated on expanding the knowledge base for ecosystem-based fisheries management and sustainable value creation based on the harvesting of marine resources.
- **Management and societal perspectives** addresses the challenges facing national and international coastal and marine management regimes as a result of climatic and population change processes.

The MARINFORSK programme will collaborate with other programmes and funding instruments at the Research Council. The relevant forms of cooperation are defined in this work programme. This will increase both the impact and the scope of activities and promote inter- and multidisciplinary cooperation and network-building.

The programme targets the Norwegian research community in addition to users in the public and private sectors. The programme's thematic priority areas will encompass the entire spectrum from curiosity-driven to problem-based research and innovation activities.

The MARINFORSK programme will work to raise the general level of knowledge about marine and coastal marine life. This knowledge is to be relevant and applicable, which means it must reach users and the general public alike. Thus the programme will attach importance to knowledge sharing, science communication and dissemination activities.

2 Background

2.1 Strategic perspectives

Norway's leading position as a marine nation and 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. Clean and healthy oceans and coastal areas are a prerequisite for sustainable value creation based on marine resources. The MARINFORSK programme succeeds the Oceans and Coastal Areas Programme (HAVKYST), and is the Research Council's primary marine research initiative. The programme is policy-oriented and will help to expand the knowledge base needed for the authorities to promote increased marine value creation with sustainability as an underlying principle. The programme will be a key instrument for implementing the Research Council's Research Strategy for the Arctic and Northern Areas.

The programme is intended to meet the need for in-depth knowledge about marine ecosystems and the changes that occur in them as a result of climate change, pollution and other anthropogenic pressures. Such knowledge is also fundamental to long-term management and sustainable use of marine resources. Future value creation based on the use of resources from the oceans and coastal areas is dependent on a good environmental status and rich biodiversity. Addressing the complex issues we are facing will require an integrated approach, both nationally and internationally. The HAV21 national marine R&D strategy sets out recommended priorities to enable Norway to achieve its industrial and political objectives for the marine sector. The strategy report has been a key background document in the design of the MARINFORSK work programme. In addition, the Research Council's Miljø21 strategy on environmental R&D (in Norwegian only) has been an important supplement in relevant areas.

The Norwegian Government's Long-term plan for research and higher education 2015–2024 sets the course for research and education policy for the next 10 years. The plan has three overall objectives: to enhance competitiveness and innovation in Norway; to tackle major social challenges; and to develop research communities of outstanding quality. These objectives provide a guiding framework for marine research. The seas and oceans comprise one of the six long-term priority areas in which the Government plans to expand allocations to research and higher education.

Meeting tomorrow's challenges will require investment in education, training and recruitment of a new generation of marine researchers. The MARINFORSK programme will contribute significantly here by funding positions for doctoral students, post-doctoral research fellows and researchers. Norwegian marine research must be international in terms of its approach, quality and ambitions, as the fundamental processes that explain and regulate marine ecosystems are universal. In addition, many marine ecosystems extend into waters under the jurisdiction of several countries and/or areas beyond national jurisdiction. Norwegian marine research must therefore be further developed in an international context, and, not least, coordinated with the EU's research systems and research funding schemes. The programme will facilitate increased Norwegian participation in keeping with the Government's objective to increase success in achieving funding under Horizon 2020.

Norway is one of the countries that took the initiative to establish, and continues to play a key role in, the European Joint Programming Initiative Healthy and Productive Seas and Oceans (JPI Oceans), whose purpose is to coordinate the national research activities of the participating countries in the marine sector. The MARINFORSK programme will contribute actively to setting the agenda for JPI Oceans and will take part in joint activities.

The MARINFORSK programme targets Norwegian research institutes, universities, university colleges and other research environments, in addition to users in the public administration, trade and industry, and society at large. The programme will encompass basic research, applied research and innovation activities of relevance to the ocean and coastal areas, including curiosity-driven and problem-based research. Researchers in other fields, the public administration, trade and industry, and the general public will all be key users of the programme's research findings. One of the programme's aims is therefore to generate relevant, applicable knowledge. Further, the programme will seek to disseminate and utilise knowledge and results in the best possible manner.

2.2 Scientific perspectives

The MARINFORSK programme will help to expand the national knowledge base and generate a better understanding of marine ecosystems, biodiversity and processes. This will help to maintain Norway's position at the international forefront in basic as well as applied marine research, as well as provide a basis for continued value creation based on marine resources.

Global change processes, both climate- and population-related, together with their accompanying changes in the demand for renewable and non-renewable natural resources, make national and international marine management a challenge. Climate change is occurring faster and will have the most marked impact in the Arctic and northern areas, resulting in major changes in the functioning and productivity of Arctic marine ecosystems. The Arctic sea ice is receding, leading to growing global interest in the Arctic region, with its petroleum, mineral and fisheries resources and potential for seasonal shipping activity. Increased human activity in the polar regions, combined with other pressures, will affect the total load on the ecosystems. Changes in the ecosystems will affect the types of organisms dominating the coastal and marine environment, which will in turn affect the structure of the ecosystems and the potential for harvesting and utilising marine bioresources. Hazardous substances and loss of biodiversity, together with climate change, are the three greatest threats to environmentally sustainable development in a global context.

As the use of coastal and marine areas increases, so does the complexity of questions relating to their use and conservation. This presents management challenges within and between sectors and industries. Comprehensive research activities of consistently high quality are essential to generating relevant, up-to-date knowledge about the marine environment.

The MARINFORSK programme will generate new and better knowledge about the ocean and coastal zone, and provide a basis for more integrated management regimes and increased value creation based on marine resources. There is escalating competition for use of land and sea area between various industrial, environmental and outdoor recreation interests. There are also complicated and at times overlapping legislation and regulatory systems relating to the coastal zone. More knowledge is needed to deal with conflicting interests and ensure more integrated and effective management.

The development of technology, methods and models for ecosystem-based management and sustainable value creation is essential. A key area of focus involves anthropogenic impacts resulting from long-range and local pollution, acute pollution incidents and seepage from marine disposal sites, e.g. in connection with mineral extraction or polluted sediments. Other important areas include the long-term effects of discharges to sea from petroleum activities, changes in species distribution patterns, the spread of alien species, the environmental impacts of fisheries and aquaculture activities, and the effects of changes in sea and land use.

It is vital that environmental management is ecosystem-based. This is an overarching principle that must be reflected in research whose aim is to establish a basis for future environmental

management regimes that take into account ecosystems, effects on ecosystems and related societal perspectives. An ecosystem approach is one of the key instruments set out in the Government objective to achieve integrated management of Norway's marine areas. The MARINFORSK programme will lay the foundation for the targeted, research-based development of an ecosystem-based marine management regime in Norway.

3 Objectives of the programme

Primary objective

The MARINFORSK programme will generate knowledge about marine ecosystems and the impact of anthropogenic pressures.

With cutting-edge knowledge, the programme will strengthen the basis for sound, effective management processes and sustainable value creation based on marine resources.

Scientific secondary objectives
The MARINFORSK programme will:

- increase understanding of the structure and function of and variation and change in marine ecosystems;
- generate knowledge about the extent and effects of pollution and other pressures on marine ecosystems;
- expand the knowledge base for sustainable harvesting and value creation based on marine resources;
- acquire insight into management and societal perspectives related to marine ecosystem services and marine areas.

Strategic secondary objectives
The MARINFORSK programme will:

- provide funding for basic and applied research of high scientific quality and relevance to the programme;
- further develop outstanding research groups and foster the development of a new generation of marine researchers;
- encourage cross-cutting research internally in the programme and externally in cooperation with other programmes and activities, when this creates added value;
- encourage national and international collaboration on projects;
- draw international attention to Norwegian research groups and their contributions;
- promote dialogue with the users of the research, the public administration, and trade and industry on the programme's priorities and results through active, targeted communication activities;
- work to ensure that research results are applied by making data and research findings accessible.

4 Priority research tasks

4.1 Thematic priority areas

The MARINFORSK work programme is divided into four areas which comprise the programme's main thematic priorities. The overview below shows these with their respective priority focus areas.

4.1.1 Marine ecosystems

Structure
Function
Variation and change

4.1.2 Pollution and other effects on ecosystems

Hazardous substances and litter
Petroleum activities
The mineral industry
Aquaculture
Other pressures
Combined environmental effects

4.1.3 Sustainable harvesting and value creation

Harvesting levels
Environmental effects, harvesting patterns and catch technology
Monitoring methodologies and resource control
Ethical capture and killing methods

4.1.4 Management and societal perspectives

Marine ecosystem services
Management of marine and coastal waters
Management challenges in light of climate and environmental change
Ecosystem-based management

The following section describes the four thematic priority areas, in light of research needs and areas in which the MARINFORSK programme will give priority to seeking new knowledge.

4.1.1 Marine ecosystems

Norway's marine areas range from coastal ecosystems to ecosystems far out at sea, from the temperate ecosystems along the southern coasts of Norway to ice-covered Arctic areas. They

encompass ecosystems in the seawater and on the seabed, and in shallow and deep waters. These ecosystems comprise the seabed, water column, ocean currents and organisms at all levels, including their genetic structure.

Good information about the structure, function, variation and changes occurring in ecosystems is critical for knowledge-based management, and is fundamental for all activities taking place in the ocean and along the coast – including utilisation of resources, innovation and industrial development. Long-term basic and management-oriented research is also essential to safeguarding national interests and contributing to the global knowledge pool.

Marine research is dependent on infrastructure for data collection to gain insight into and monitor the ecosystems. It is this data that forms the basis for modelling and predicting ecosystem dynamics. Marine infrastructure and data collection and management are costly, and new and more efficient solutions must be sought to cut costs and improve quality.

The thematic priority area *Marine ecosystems* is targeted towards increasing understanding of the structure and function of and variation and change in these ecosystems to facilitate long-term, sustainable management of Norway's ocean and coastal areas.

Focus areas for research

a) Structure: Marine ecosystems encompass organisms and their abiotic environment. Organisms range from microorganisms to whales, so a wide range of methodical approaches is needed to map and understand the diversity of nature types, species diversity and intra-species variability. Knowledge about the species and their biology and distribution, from the shoreline to deep waters, is essential to solving a number of challenges relating to Norway's management of marine ecosystems. Our understanding of the structure of marine ecosystems remains severely limited by observation methods, and it is necessary to take part in technological development to make progress in this field.

Research is needed on:

- knowledge about the biology, ecology and distribution of species and functional groups;
- knowledge about the existence of different habitats and nature types, and how they affect the distribution of organisms;
- development and use of new methods and technologies to generate more knowledge about the structure of the ecosystems, ranging from genetic to biological diversity.

b) Function: The marine food web is complex, and more concerted effort is needed to understand the relationships between ecosystem components. The fundamental processes that explain and regulate marine ecosystems are the same around the world, even though there are major regional differences in the response and dynamics of the ecosystems. More research is needed to identify, understand and quantify key processes in the respective ecosystems by combining field data, experimentation and modelling.

Research is needed on:

- mechanisms that regulate population dynamics of species that are currently harvested commercially, and knowledge about how species affect one another;
- core processes within marine ecosystems related to functional groups of organisms, the food web and biogeochemical cycling of substances in and between trophic levels, ocean

circulation, spatial distribution, and different transition zones (e.g. pelagic-benthic, ice edge-open waters, land-water);
- mapping and understanding the processes in marine ecosystems not related to fisheries or aquaculture but nonetheless important for ecological processes and biodiversity.

c) Variation and change: Marine ecosystems are dynamic and constantly changing due to natural and anthropogenic factors, particularly in Norway's northern sea areas. Research is essential to understanding the driving forces of change, for instance in order to distinguish between natural fluctuations and pressures from human activity as well as gain insight into impacts. Long time series in Norwegian waters should be used as a basis for better understanding ocean climate variations and their effects. The coastal and marine environment is affected by global environmental changes such as ocean warming and ocean acidification, and inter-annual atmospheric and oceanic variability. This has an impact on hydrography, biological production and distribution of organisms at all trophic levels as well as freshwater runoff from land and the resulting inputs of nutrients, organic pollution and murkier coastal water.
Global warming could cause changes in species distribution patterns, while increased oceanic transport around the world can facilitate the spread of alien species into Norwegian ocean and coastal areas. Changes in one or more ecosystem components may have major impacts on other parts of the food web.
For more on the effects of human activity on marine ecosystems, see also the thematic areas *Pollution and other effects on ecosystems* and *Sustainable harvesting and value creation*.

Research is needed on:
- the drivers and impacts of variation and changes in ecosystems' structure and functioning;
- potential impacts of changed species distribution patterns and increased alien species distribution;
- how changes in ecosystem components may escalate into trophic cascades;
- impacts of climate change and ocean acidification on individual organisms and marine ecosystems.

4.1.2 Pollution and other effects on ecosystems

Proper management of ocean and coastal areas depends on knowledge about the extent and impact of pressures from human activity. Many different components of the marine ecosystem are involved: from air, water, sediments and shoreline to different ecological niches and habitats, and from microorganisms and primary producers to fish, marine mammals and seabirds. Research on the effects of human activity on marine ecosystems also involves enhancing knowledge about how to safeguard environmental quality and food safety. The objective is to prevent pollution and other pressures from causing damage to health, reducing quality of life or weakening the natural environment's capacity for self-renewal.

Research on discharges and their ecological impacts should strive to generate the knowledge needed for developing national and international regulatory frameworks. Overarching research questions include establishing indicators and threshold limits for hazardous substances, organic matter and nutrients and creating classification systems for ecological status.

Research under this thematic priority area is aimed at generating knowledge about the extent and effects of pollution and other anthropogenic factors on the marine environment, including the environmental impacts of petroleum activities, mineral extraction and aquaculture. Ecological impacts of fisheries are encompassed under the thematic priority area *Sustainable harvesting and*

value creation and the impacts of climate change are under the thematic priority area *Marine ecosystems*.

Focus areas for research

a) Hazardous substances and litter: Although levels of hazardous substances remain high and are increasing in certain ecosystems, the levels of several hazardous substances have declined as a result of international agreements and regulations. New chemicals are being continually introduced, however, and many of these may prove to have unintended properties. Society needs to know more about the sources, spread, extent and impacts of hazardous substances in marine ecosystems. More knowledge is also needed about how the extent and effects of hazardous substances are affected by climate change, hydrology, precipitation and biogeochemical cycles. Hazardous substances are a global problem, and Norway and the Arctic receive long-range transboundary pollution transported by air and ocean currents. Norwegian conditions such as low temperatures and large seasonal variations affect uptake, transport and effects in marine food webs. Knowledge about extent, accumulation and effects is essential to national and international regulations and treaties on chemicals.

Research is needed on:

- identifying and documenting extent and effects of new hazardous substances and their degradation products in the marine environment;
- local vs. long-range transported emissions, and transport of pollution from fjords and coastal waters to the open sea;
- the extent to which pollutants taken up by and accumulated in organisms are transferred up through food chains and metabolised into degradation products;
- effects of hazardous substances on their own and in combination (cocktail effect) at the organism, population and ecosystem levels;
- the ecological relevance of pollution studies by generating greater insight into interactions between extent and effects of hazardous substances and ecosystem structure and functioning;
- long-term effects of pollution and how ecosystems recover after pollution pressures are reduced;
- continued development of models for the spread of local and long-range pollution transported via air and ocean currents, including risks to the marine environment and food safety posed by pollution in the short and long term;
- the amount, origins and composition of marine litter, including plastic waste and microplastics, and their effects on marine ecosystems.

b) Petroleum activities: The Norwegian petroleum industry can affect marine ecosystems through operational discharges, acute spills, phasing out of offshore activity, waste treatment and seismic surveys. These pose the risk of discharging heavy metals and other hazardous substances and constitute a threat to ecosystems, fisheries, the aquaculture industry and nature-based industrial activities (for research needs related to seismic surveys, see Chapter 4.1.2 e)). In general, it is important to study effects at the individual, population and ecosystem levels alike.

Research is needed on:

- identifying the composition and long-term effects of unknown groups of substances in produced water, incompletely characterised components in discharges and process

chemicals; more insight is needed into long-term effects on both pelagic and benthic organisms.
- the effects of accidental discharges into the open sea and coastal waters, particularly in the Arctic.
- how response and sensitivity to pollutants from petroleum activities vary among species and life stages.
- the environmental impact associated with phasing out offshore activities.
- the physical impact of petroleum activities on the seabed, such as sedimentation and physical installations on the seabed.

c) The mineral industry: Mineral extraction both offshore and onshore can lead to significant occupation of areas and deposition of large quantities of fine minerals processing waste and various chemicals into the marine environment. More knowledge is needed about the spread of minerals processing waste and associated chemicals, and their impact on ecosystems as a whole and on individual species and populations.

Research is needed on:
- how mineral extraction in coastal areas and at sea and any associated minerals processing waste deposits affect the marine ecosystem;
- empirical data and reliable models for calculating chemical, physical and biological processes related to minerals processing waste deposits in both the operational and clean-up phases, and for calculating the spread of mining waste/tailings and contaminants.

d) Aquaculture: It is important to expand basic knowledge of the impact of aquaculture on marine ecosystems. Intensive cultivation and selective breeding of species for aquaculture change the genetic makeup of production populations. Aquaculture may lead to undesirable ecological interactions with other organisms in the ecosystem in various ways, for example through the spread to the natural environment of organic matter or escaped production organisms. In addition, residual medicines and antifouling substances for net-cages can also affect the ecosystem and parasites can be spread to wild stocks.

Research related to wild salmon, including the marine stage of the wild salmon life cycle of, lies within the scope of the Programme for Environmental Research for a Green Transition (MILJØFORSK). Thus this type of research will not be funded by the MARINFORSK programme on its own.

Research is needed on:
- discharges of organic matter and nutrients from aquaculture activities and their environmental impact on pelagic and benthic ecosystems;
- discharges of medicines and antifouling substances and their effects on the marine environment;
- the effects of aquaculture activities on wild marine species.

e) Other pressures: Stressors beyond those outlined in the above points include pressures such as inputs of nutrients and organic carbon, changes in salinity, UV radiation, oxygen depletion, noise, hydropower development in river systems and other changed land use. We need to know more about how the different drivers of change function individually and in combination. (See below under f) Combined environmental effects.) Ecological impacts of fisheries are encompassed

under the thematic priority area *Sustainable harvesting and value creation* and the impacts of climate change are under *Marine ecosystems*.

Research is needed on:

- the qualitative and quantitative effects of eutrophication on marine ecosystem structure and functioning;
- the effects of inputs of nutrients and organic matter in coastal waters, and transport and dispersion models for organic matter and nutrients in coastal waters;
- the effects of noise, e.g. seismic surveys, offshore wind farms and ship traffic, on marine organisms, particularly on fish spawning migration and spawning grounds;
- how hydropower developments in river systems affect the ecology of fjords.

f) Combined environmental effects: The different anthropogenic drivers of change most often involve complex interactions, known as multistressor impacts. Understanding how these drivers interact with one another requires multidisciplinary approaches within discipline-based environmental research as well as interdisciplinary approaches incorporating social science-based knowledge.

Research is needed on:

- how the combined interactions between multiple drivers of change – such as climate change, pollution, fisheries, aquaculture and other anthropogenic drivers – affect marine ecosystems; this kind of knowledge must also be incorporated into ecosystem modelling.

4.1.3 Sustainable harvesting and value creation

It is important to strengthen the knowledge base for ecosystem-based management of fisheries and sustainable value creation from the harvesting of marine resources. Throughout Norway's history, its fisheries have played a critical role in the development and settlement of the coastal areas, and remain a cornerstone of the country's economy and social development. The fisheries rely on renewable biological production and are thus fundamentally dependent on clean and healthy oceans. This sets the fisheries industry apart from most other industries that utilise marine areas (petroleum recovery, mineral extraction, shipping, etc.).

Fisheries activities affect marine ecosystems beyond the stocks of fish targeted for harvesting. In the context of ecosystem-based fisheries management, socially optimal utilisation of joint marine resources will not necessarily coincide with economic profitability in the short term. Activities under the MARINFORSK programme in this area will target research seeking to mitigate the harmful environmental impact of harvesting in addition to research on the scope and effects of fisheries activities.

Focus areas for research

a) Harvesting levels: Norway's fish resources are well on their way to being fully exploited. It is still possible to increase value creation based on sustainable harvesting, however, by assessing the development of the various stocks in connection with one another to harvest optimal quantities of each stock. To this end, continual monitoring of marine resources in the ocean and coastal zone is essential to provide a basis for estimating stocks and offering guidelines.

Research is needed on:

- cost-effective methods for mapping and monitoring marine resources, both commercially important stocks and resources with limited potential economic returns.
- further development of management strategies and rules for harvesting commercial stocks, in order to adapt fisheries to changes in climate and the marine environment, among other things; research related to effects on multiple stocks and applied research on the bioeconomy will also be needed in this context.
- the potential for and impact of harvesting species at lower trophic levels (such as copepods) and harvesting other, less-exploited species.

b) Environmental effects, harvesting patterns and catch technology: It is possible to enhance value creation and reduce the negative ecological impacts of harvesting by improving the harvesting levels of individual stocks. Bioeconomic multistock modelling will be an important tool for clarifying whether harvesting will be profitable on the basis of the resource base, density, availability, catch costs and market conditions.

Research is needed on:

- the impact of fisheries activities on marine ecosystems, habitats, species and stocks.
- how to refine technologies and methods to improve both product quality and species/size selectivity as well as reduce discards, unwanted bycatches, bycatch mortality rates and negative impacts on vulnerable benthic habitats.
- how to refine existing catch technologies and initiate research on new, more environment-friendly catch technology; these technologies must also fulfil requirements relating to profitability, including catch- and energy-efficiency.
- the relationship between resource bases, regulations, harvesting methods and patterns, reception, industry, logistics, markets and overall value creation.
- possible negative impacts on the genetic makeup of fish stocks, and how this may affect optimal catch levels.

c) Monitoring methodologies and resource control: Norway's status today as a global leader in segments of the marine and maritime sectors could not have been achieved without cooperation and knowledge transfer between fishermen, equipment suppliers and R&D institutions. The goal of developing ecosystem-based fisheries management brings a new and greater demand for data and information for the fisheries industry, the research community and management authorities. This information must be collected in the most efficient way possible.

Research is needed on:

- knowledge, technology and instruments for identifying species, quantities and size of individuals before and during catch operations;
- how to improve technology and methods for determining actual catch levels, measuring both quantity and species composition;
- technology and methods to facilitate more effective, risk-based resource control.

d) Ethical capture and killing methods: Thus far, limited focus has been placed on fish welfare and other ethical aspects of catching and killing processes in fisheries. More knowledge is needed about the relationship between harvesting and fish welfare from an ethical perspective and in terms of sustainable value creation. Ethical capture and killing methods must also be viewed with an eye to developing new catch technologies.

Research is needed on:

- the relationship between harvesting and fish welfare both from an ethical perspective and from the perspective of quality and value creation;
- knowledge, technology and methods for preventing the loss of nets and other fishing gear, which can continue killing fish long after being lost (a problem known as ghost fishing).

4.1.4 Management and societal perspectives

Global change processes, both climate- and population-related, lead to changes in demand for biological, chemical and geological resources. This presents challenges for national and international marine management. Climate change is opening up opportunities for expanding shipping and petroleum activity. Climate change and ocean acidification will also bring about changes in the types of organisms that dominate the marine environments of different regions, which will lead to changed harvesting patterns. Increased human population pressure leads to a greater demand for food production in and from the oceans and eventually also for extraction of minerals and other resources from the seabed. In addition, with higher population come more pollution and a greater demand for renewable energy, which in turn can increase pressures on the ocean and coastal areas.

All these changes pose management challenges within and between sectors, and create a pressing need for a wide-ranging knowledge pool. The desire for sustainable utilisation of resources in the marine environment requires ecosystem-based management with an integrated approach. The challenges are fundamentally multidisciplinary or interdisciplinary, and will require insight from the natural sciences and social sciences alike.

Focus areas for research

a) Marine ecosystem services: Marine environments contribute a wide range of ecosystem services, but currently there is only a limited overview of what these comprise. Mapping of ecosystem services in the ocean and coastal zone as well as estimates of their scope and value are important for understanding connections and finding a balance between different activities in the marine environment. It will be important to take this knowledge into consideration in the management of coastal areas and management plans for marine areas. These efforts require knowledge from both the natural and social sciences, in addition to local ecological expertise.

Experiential knowledge, relevant observations and data from the fishing fleet should be applied as a cost-effective supplement to conventional research and management data.
For resources near the coast, sport fishing comprises a large and growing proportion of catch levels. In this context knowledge is needed to support development of ecosystem-based fisheries management and to help in mapping important marine ecosystem services.

Research is needed on:

- the scope and value of marine ecosystem services;
- how to balance ecosystem services, and the management-relevant knowledge needed to do this;
- knowledge and methods for collecting, treating and distributing environmental and catch data from the fishing fleet;
- the extent and development of recreational and tourism fishing.

b) **Management of marine and coastal waters:** The coastal zone is the part of the marine environment most exposed to human pressure. These areas are subject to increasing competition with regard to settlement and industry, exposure to discharges, disposal sites, sea transport, fisheries, aquaculture, renewable energy infrastructure, tourism and recreational activities. Melting ice and ocean warming will cause sea levels to rise, causing problems for coastal communities.
While the management plans for the ocean areas (Barents Sea, Norwegian Sea and North Sea) are by and large ecosystem-based with an integrated approach, the challenges in the coastal zone are more complex and planning systems more fragmented. This complicates coastal zone management and increases the potential for both commercial and management-related conflict. It also complicates legislation, which is sector-based with different geographical scope. Research questions addressing rights to and ownership of marine resources will be of relevance in this context. It is important to develop effective and practical systems for weighing these interests. These systems must pay due regard to the wide range of interests and perspectives, the dynamics (rapid changes in the ecosystem itself and of the relevant stakeholders) as well as the need for democratic processes and transparency. Comparative studies of spatial management, nationally and internationally, will be valuable. It will also be useful to examine legal aspects relating to an integrated and more coordinated approach to marine value in the coastal areas.

Research is needed on:

- mechanisms and obstacles for integrated use of land and sea area and other resources under management today;
- interactions between and impact of various interest groups.

c) **Management challenges in light of climate and other environmental change:** Changed environmental conditions present management challenges and require the revision of legal and management tools. Climate change affects the established distribution of natural resources and areas among various national and international interests, which leads to social and economic consequences. Research targeting adaptive management in light of environmental changes is essential for tackling these kinds of social and ecological upheavals. There is also a major need for research on the Law of the Sea regarding, for instance, issues of safeguarding national rights associated with changes in migration patterns in fish stocks and other relevant environmental changes, as well as new challenges relating to e.g. mineral extraction and production of renewable energy.

Research is needed on:

- societal processes that have an impact on the design of management tools, including knowledge about the relationship between research and policy design;
- whether existing management tools function as intended;
- the Law of the Sea with respect to safeguarding national rights in an international perspective.

d) **Ecosystem-based management:** Ecosystem-based management is a broad concept, and there are many areas where this concept needs to be further developed. Given Norway's long coastline and vast ocean areas, there is a need for more cost-effective monitoring and further development of current indicators, among other things.

Research is needed on:

- developing robust, sustainable, productive strategies for management of marine ecosystems, including strategies that take into account that marine systems are in a state of flux and are changing;
- further developing indicators along with associated threshold limits and reference values;
- methods for expressing combined environmental effects in ocean and coastal areas;
- new, cost-effective methods for mapping and monitoring marine biodiversity.

4.1.5 Strategic priorities

Research within the thematic priority areas of the MARINFORSK programme will help to ensure sound management processes and sustainable value creation based on Norway's marine resources.

Researcher projects will be the key funding instrument employed by the programme, but *knowledge-building projects for industry* and other funding instruments will also be employed when relevant. To promote recruitment and network-building, the programme may issue funding announcements for establishment of national-level graduate researcher schools, establishment of networks or mobility grants. The programme will also fund a significant number of doctoral candidates, post-doctoral research fellows and researcher positions.

The MARINFORSK programme will work to comply with the Research Council of Norway's policy on gender balance and gender perspectives in research and innovation. The programme will attach importance to achieving a good gender balance among project managers as well as encouraging younger researchers to take on project management responsibilities. The programme will take steps to strengthen gender perspectives in marine research, when this is relevant.

The MARINFORSK programme will bolster Norwegian research groups, and work to take advantage of opportunities in areas where Norway has competitive advantages and can contribute significantly to advancing the international knowledge front in the field of marine research. At the same time, the programme will attach importance to increasing international cooperation, both via the EU system and through bilateral cooperation with other countries when this is relevant to achieving the programme's strategic objectives (see also Chapter 6).

The Research Council is seeking to fund more projects based on bold, innovative ideas. In certain cases funding announcements will be open to high-risk projects.

There are plans for cooperation with other Research Council programmes and funding instruments in relevant thematic areas. Such cooperation may take the form of joint funding announcements or other measures such as establishing meeting places or communication activities (see also Chapters 5 and 7). The MARINFORSK programme will further develop the Research Council's role as a meeting place. It also aspires to cooperate with related programmes to create arenas for discussion, not least of topics that may be divisive or where there is major disagreement among scientists. The programme will also facilitate dialogue between groups whose paths traditionally do not cross. In addition, the programme will seek closer dialogue with the Norwegian Seafood Research Fund (FHF) on relevant topics.

This work programme can and should be revised during the programme period to ensure that the programme has the most appropriate scientific and operational focus at all times and promotes the greatest possible scientific and societal relevance.

The Research Council has issued a policy on open access to research data. Better access to research data will enhance the quality of research in that results can be validated and verified in a more

effective manner and datasets can be used in new ways and in combination with other datasets. The MARINFORSK programme will follow up the open access policy, and this may entail measures such as requiring projects to include a data management plan.

5 Cross-cutting cooperation with related funding instruments

The Research Council works to promote integration and effective coordination between its thematic research programmes. Thus the MARINFORSK programme will seek binding cooperation with other Research Council programmes. The programme will also serve as a hub for Research Council research on the oceans and coastal areas and will be a driving force for this type of research.

In general, there is widespread interest in expanding cooperation between research programmes at the Research Council. There is growing recognition that knowledge needs may extend across several programmes and some extend beyond the framework of the programmes themselves. There may also be inadequate focus on certain research questions given the current programme structure.

In the years ahead, the programmes will employ a more open and flexible structure that facilitates different forms of cooperation. A selection of potential instruments is described below, but others may be of relevance as well.

5.1 Relevant forms of cooperation

Role as funder

- The programme may contribute funding to another programme's funding announcement.
- Programmes may collaborate scientifically and/or financially on a targeted funding announcement with a restricted thematic focus.
- Programmes may collaborate on larger-scale funding announcements with a broad thematic focus.
- Co-funding may also extend to more innovative, higher risk and/or ground-breaking projects.

Role as a meeting place

- Develop joint communication and meeting place activities to promote more integrated, synthesised and targeted communication with user groups.
- Attach greater importance to developing arenas for dialogue and discussion on important social issues. Together the programmes can direct focus towards key issues and knowledge areas, also where there are contradictory or conflicting interests at play. Such measures may facilitate a better shared understanding and help to mitigate conflict.

Role as advisor

- Develop scientific and strategic cooperation between programmes to strengthen the Research Council's advisory role, for example in budget and planning processes, and to promote sustainable thinking and lend greater weight to the Council's advice.

Role as an international driving force

- Increase cooperation between programmes on international activities and boost mobilisation for participation in international efforts.

5.2 Related funding instruments

The MARINFORSK programme shares an interface and areas of overlap with a number of other programmes, centre schemes, open competitive arenas, infrastructure initiatives and other Research Council instruments (see the list in the box). The most important partners for cooperation are the BIONÆR, MAROFF, PETROMAKS 2, POLARPROG, KLIMAFORSK, HAVBRUK2 and MILJØFORSK programmes.

Relevant partners and related activities

- BIONÆR – Research Programme on Sustainable Innovation in Food and Bio-based Industries
- BIOTEK2021 – Research Programme on Biotechnology for Innovation
- ENERGIX – Large-Scale Programme for Energy Research
- HAVBRUK2 – Large-scale Programme on Aquaculture Research
- KLIMAFORSK – Large-scale Programme on Climate Research
- MAROFF – Innovation Programme for Maritime Activities and Offshore Operations
- MILJØFORSK – Programme for Environmental Research for a Green Transition
- MILPAAHEL – Research Programme on Environmental Exposures and Health Outcomes
- NANO2021 – Research Programme on Nanotechnology and Advanced Materials
- PETROMAKS 2 — Large-scale Programme for Petroleum Research
- POLARPROG – Polar Research Programme
- INFRASTRUKTUR – National Financing Initiative for Research Infrastructure
- JPI Oceans – Joint Programming Initiative for Healthy and Productive Seas and Oceans
- SFF – Norwegian Centres of Excellence Scheme
- SFI – Centres for Research-based Innovation Scheme
- PROFORSK – Programme for the profiling of research
- FHF – Norwegian Seafood Research Fund

6 International cooperation

The Research Council encourages the use of international cooperation to the greatest possible extent when expedient for achieving programme objectives. Opportunities for cooperation under the EU Framework Programme for Research and Innovation, Horizon 2020, must be explored each time international cooperation is relevant. Other forms of international cooperation must also be assessed in keeping with the Research Council of Norway's strategy on international cooperation.

Extensive international research cooperation is essential for achieving the objectives of the MARINFORSK programme. The programme will assess the need to develop incentive measures to encourage active participation of Norwegian research groups in international arenas for cooperation and competition. This applies to research cooperation at the Nordic, European and global level, as well as bilateral cooperation with selected countries.

The framework for international research cooperation will be established in keeping with the Research Council of Norway's strategy on international cooperation. The MARINFORSK programme will promote international marine research by means of joint funding announcements with relevant national and international programmes.

Key arenas for research cooperation include Horizon 2020, the Joint Programming Initiative Healthy and Productive Seas and Oceans (JPI Oceans) and other European cooperation platforms (particularly the ERA-NET scheme), as well as large-scale global programmes such as Future Earth under the International Council for Science (ICSU) and the Belmont Forum.

Experience has shown that international cooperation promotes quality in research while strengthening the economic muscle needed to carry out the projects. International cooperation in the field of marine research must be continued and further developed. A 2013 bibliometric analysis commissioned by the Research Council showed that Norwegian marine research is in the international forefront. The MARINFORSK programme will work to maintain this position.

The MARINFORSK programme will help to maintain and further develop marine research groups that measure up to international standards and are viewed as attractive partners for cooperation with the capacity to take on leadership roles in international research activities. This will require publication in international peer-review journals, high citation frequency and a visible presence in international research arenas (e.g. active participation in international conferences, EU-funded projects, recruitment and network-building activities).

7 Communication and dissemination activities

Communication activities under the MARINFORSK programme are to draw attention to the Research Council's marine research initiatives. The Research Council's communication strategy underlies the programme's communication activities targeting researchers and other users of the programme.

The programme will also pave the way for more and better dissemination from the projects, which is primarily the responsibility of the researchers and institutions. The MARINFORSK programme will view dissemination activities as a crucial element in achieving the programme objectives and this will be reflected in the funding announcements and project follow-up.

Objectives

Communication activities under the programme will:

- improve dialogue between the research community, the public administration, trade and industry, and society at large, and give a more visible profile to how the programme creates added value by covering key knowledge needs, answering key environmental questions and providing a foundation for future policy design, innovation and sustainable social and industrial development;
- strengthen user participation in scientific development;
- highlight the strategic role of the Research Council in marine research;
- promote targeted communication in cooperation with related funding instruments and research groups;
- ensure an adequate number of high-quality grant proposals in response to the programme's funding announcements and to those of relevant international activities.

Target groups

- The research community;
- Decision-makers at various levels;
- Trade and industry, and business organisations;
- Interest organisations;
- The general public;
- The media.

Main principles

- Cooperate with related programmes/funding instruments to communicate with and disseminate results to various user groups at the overall or thematic level;
- Cooperate on international instruments to give a more visible profile to Norwegian participation in international research efforts;
- Cooperate with research groups to publicise good examples of research results;
- Cooperate with user groups;
- Facilitate targeted communication efforts under the projects and follow up the activities;
- Recycle texts and other material that have already been produced by disseminating them through more channels.

Instruments

- Provide meeting places for different target groups, from broad-based conferences on topics relevant to the public debate to dialogue meetings and purely scientific conferences/meetings;
- Use the press/media, including the national media, scientific media and the Norwegian-language popular science website forskning.no;
- Use the Research Council's own channels, including English-language channels and social media.

Based on this, the programme will provide input to the Division for Energy, Resources and the Environment's annual communication plan for marine research.

The division administration will determine the communications-related tasks for which the programme administration will be responsible. Responsibilities will be distributed in dialogue with the programme administration.

8 Budget

The MARINFORSK programme is funded by allocations from the Ministry of Trade, Industry and Fisheries, the Ministry of Climate and Environment, the Ministry of Petroleum and Energy, the Ministry of Education and Research, and the Norwegian Oil and Gas Association. The total budget for 2016 is NOK 100 million.

Given a zero-growth budget, the programme will have a budget totalling about NOK 1 billion for the period 2016–2025. The MARINFORSK programme has identified research needs in existing areas where activities should be continued, in addition to research needs in new areas. The funding required to address all of these needs significantly exceeds the zero-growth budget, and thus a substantial budget increase is called for. Identified needs should be incorporated into the Research Council's annual input to the national budget, in keeping with the follow-up of the priorities set out in the Long-term plan for research and higher education 2015–2024.

The programme's long-term budget will incorporate funding set aside for the following:

- cooperation with other programmes and activities at the Research Council, roughly 10–15 per cent;
- international cooperation, roughly 10 per cent.

9 Organisation

Programme board

The MARINFORSK programme board is appointed by and reports to the Research Board of the Division for Energy, Resources and the Environment. The programme board is responsible for achieving the programme's objectives as set out in this work programme, using the specific instruments available. Activities are to be carried out in accordance with the Research Council's strategies and guidelines, and reflect the guidelines from the Council's Executive Board and the Research Board of the Division for Energy, Resources and the Environment, and the guidelines from the funding ministries and other funding sources. The programme board acts on behalf of the Research Council and reports to the research board via the executive director.

Programme administration

The MARINFORSK programme administration is responsible for carrying out the day-to-day tasks of the programme, performing the administrative functions of the programme and the programme board, and facilitating the implementation of the programme board's decisions.

10 Follow-up and evaluation

The MARINFORSK programme will follow the development of the programme towards achieving its stipulated scientific and strategic objectives.

With regard to the scientific secondary objectives, analyses of the project portfolio will show the extent to which the programme is funding research that addresses the knowledge challenges described in Chapter 4.

The strategic objectives will be followed up and assessed regularly, both qualitatively and through the use of statistics and analyses. Information on the strategic role of the MARINFORSK programme, the manner in which the programme is being implemented, the actions taken and work methods selected, and the collaborative platforms developed will be set out in the programme's annual report. Furthermore, the programme board will assess the programme's performance achievement on an ongoing basis and introduce new concrete measures in the programme's action plans, funding announcements and communication activities.

The portfolio analyses will provide a statistical basis on, among other things:

- national and international cooperation;
- user participation;
- relevance for management practices;
- commercial relevance and involvement of industry actors;
- recruitment;
- gender balance and gender perspectives.

The MARINFORSK programme is an open-ended programme, and the members of the programme board are appointed for a four-year period. Towards the end of this period the programme board will consider the need for an evaluation of the programme, or segments of the programme, in light of the changes that have emerged and the challenges facing the programme.

After 10 years of operation, the need for a major revision of the knowledge base should be assessed.