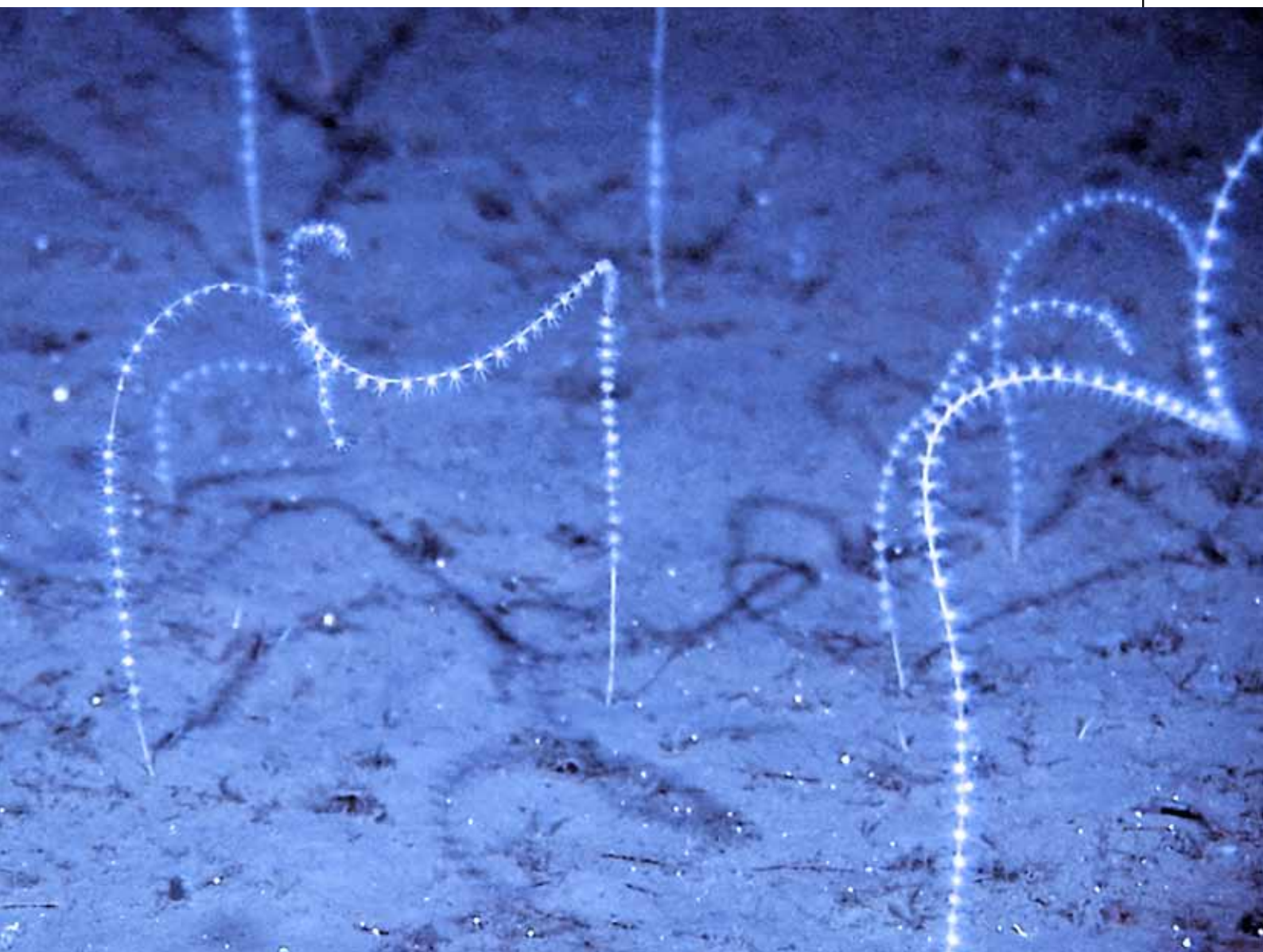
NORWEGIAN MINISTRIES

National strategy 2009

Marine bioprospecting – a source of new and sustainable wealth growth

Joint project between the Norwegian Ministries of Fisheries and Costal Affairs, Education and Research, Trade and Industry and Foreign Affairs



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Cover photo: New horn coral Photo: ©Mareano

Family: *Chrysogorgiidae*

Species: *Radicipes sp.*

The research programme, **MAREANO**, maps life along the Norwegian coast and has found species that have never previously been seen. One of these is the horn coral *Radicipes sp* that was found at a depth of 900 metres during a voyage in the north-west of the Barents Sea. *Radicipes sp* rises up from the clay bottom like long, spiral-noded pigtails (hence the English name «Pigtail coral»). The coral can be up to 70 cm high and has polyps on just one side of the trunk. Corals may be important sources of new substances for the development of medicines against cancer, infections and other illnesses. Possible uses could also include dietary supplements and cosmetics.

Helga Pedersen
Minister of Fisheries and Costal Affairs

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Helga Pedersen Photo: Scanpix, Tora Aasland Photo: Stig Weston,
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Preface

Since the dawn of civilization, mankind has utilised biological materials from plants and animals for a variety of purposes. A familiar example is pharmaceuticals, of which a significant proportion is based on substances derived from nature, primarily from terrestrial sources. Even though the oceans cover more than 70% of the Earth's surface, and their biological evolution began several million years before that of the land, the abundance of marine organisms has still not been adequately explored.

Norway manages large oceanic areas, where there are probably more than 10,000 species, of which few have been studied. Some of these live in extreme environments, in Arctic waters where temperatures are low, and light conditions vary, or in oil reservoirs under high pressure and in high temperatures, while others live along the coast and fjords where there are high concentrations of species. It is reasonable to assume that several of these marine organisms have properties that can be used as basis for different products and processes within a number of industries.

Marine bioprospecting is a process that lies at the forefront of industrial production. It involves the collection of materials from the sea, categorisation and analysis to research and development. Marine bioprospecting provides opportunities to utilise genetic material from the sea in a sustainable manner. It is about doing something new in order to create future wealth. The power of globalization increases international competition, and we must therefore strive to invagorate and safeguard our competiveness in order to maintain our high standard of living.

The Government is promoting the first national strategy on marine bioprospecting. This strategy facilitates better utilisation of our marine resources. The Government will invest in infrastructure and research that stimulate a broad spectrum of opportunities for wealth growth. The strategy is included in the Government's innovation policy for making Norway innovative and sustainable, and in the Government's strategy for the marine sector, «Sustainable seafood – alpha and omega». The High North is important because of its access to unique Arctic marine organisms, marine industries as well as expertise and infrastructure within research. The potential in relation to the development of knowledge and wealth growth makes marine bioprospecting an important focus area within the Norwegian Government's Strategy for the High North, and particular mention of this is made in «New Building Blocks in the North».

Norway has a long tradition of marine harvesting and has developed a high level of expertise within the marine sector and biotechnology. This gives us an advantage with regards to compiling and describing a broad range of marine organisms. A lot has been done already, but we still face many challenges that require commitment from the Government.

The strategy has been prepared by the Ministry Fisheries and Costal Affairs, the Ministry of Education and Research, the Ministry of Trade and Industry and the Ministry of Foreign Affairs, in collaboration with the Ministry of the Environment. Expert statements and input from the university sector, the research institutes, industry and commerce, the capital market, commercialisation stakeholders and support structures have been obtained. We wish to sincerely thank everyone who was involved in this.

Sagaskjeret 2006, Biological diversity © Marbank Photo: Sten-Richard Birkely

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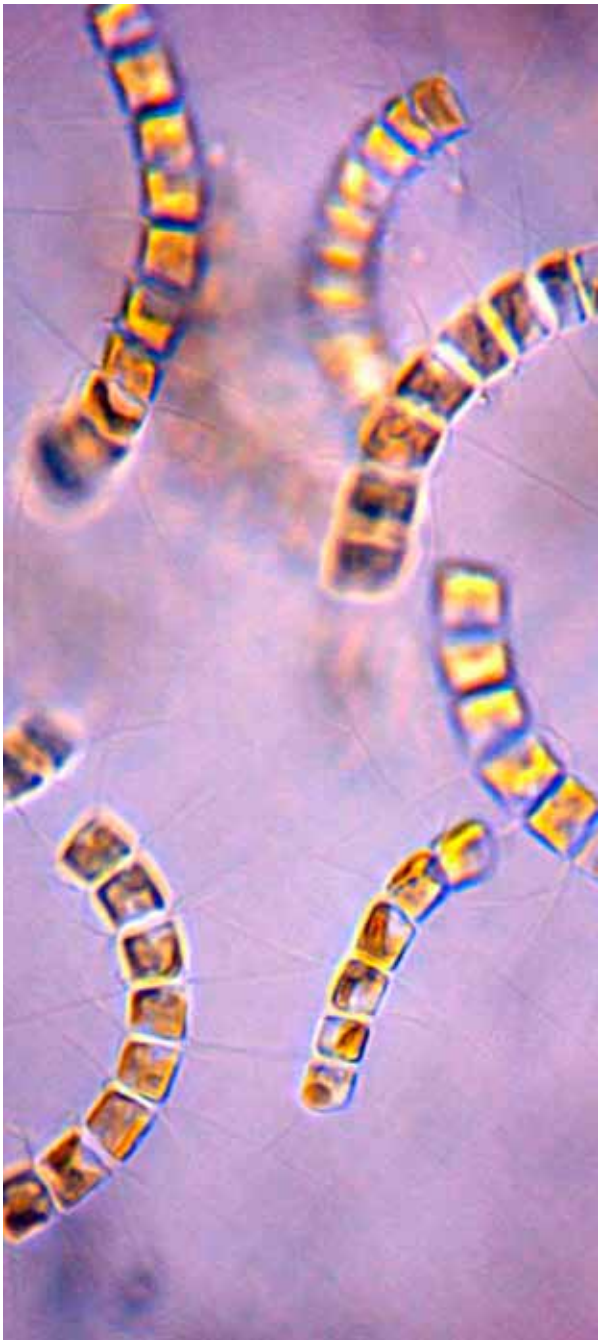
1. Summary



Phytoplankton, *Chaetoceros socialis,* under algal bloom in Norwegian waters in spring ©MabCent-SFI

Marine bioprospecting can be described as a systematic search in marine organisms from the sea, along the coast and from the fjords, from the seabed or from oil reservoirs beneath the seabed. This may include all kinds of organisms; microorganisms like bacteria, fungi and viruses and larger organisms such as sea plants, shellfish and fish.

The purpose of marine bioprospecting from a business perspective is to find components, compounds or genes that may be included as components in products or processes. There is an extensive range of uses/applications. Relevant areas of application may include medicine, processing industries, including oil and gas, food, feed, and biofuels. The course of commercialisation from research results based on marine bioprospecting is often presumed to be long-term, multidisciplinary, venture intensive and demanding on business expertise. National and international collaboration are essential. The Government will stimulate increased wealth growth from marine bioprospecting in collaboration with industry and research institutions.

The Government's vision is "Marine bioprospecting – a source of new and sustainable wealth growth". The Government will facilitate a targeted and national commitment to marine bioprospecting. This commitment is an important part of the Government's High North Strategy and is included in the Government's innovation policy and in the strategy for the marine sector, "Sustainable seafood – alpha and omega". A rich biodiversity, including unique Arctic resources, established marine businesses, the growth of biotechnology-based industries combined with a good infrastructure and research expertise form a good basis for success. The Government commitment will pass through established schemes and support structures.

The Government will:

- Ensure proper and sustainable search and extraction activities in accordance with national requirements and international legal principles. Regulations will be made concerning these activities, with statutory basis in the Norwegian Marine Resources Act and the Norwegian Nature Diversity Act.

- Regulate marine genetic resources and make them more accessible to researchers, industry and international stakeholders. There will be better collaboration and coordination of marine collections through the development of a national network for marine biobanks and marine mapping authorities. Marbank in Tromsø will be developed further as the national marine biobank.

- Strengthen research on marine bioprospecting. Research funds will primarily be channelled as a specific commitment to the Research Council of Norway's FUGE (Functional Genomics) programme, which will contribute to the development of national research expertise and infrastructure, including the development of a marine biobank network. This commitment will be designed to facilitate interaction with other relevant programmes in order to stimulate business development. International research collaboration will be prioritised. MABIT, an industry-focused R&D programme within marine biotechnology in Northern Norway, will be further developed to enhance industrial development in the north.

- Strengthen the management system for commercialisation of research results. The commercialisation of research results related to marine bioprospecting are not significantly different from the commercialisation of other research results. The broad range of market opportunities for marine bioprospecting makes it appropriate to use general policy instruments with regards to commercialisation. The FORNY wealth creation programme is currently an important commercialisation instrument. Schemes that contribute to confirming the potential for commercial applications (means of verification) will be stengthened. Increased collaboration and specialisation should be encouraged between the various commercialisation stakeholders to meet the need for adequate business expertise.

- Strengthen bioprospecting activities in the High North by giving priority to the collection of marine organisms from the northern ocean region and through the further development of infrastructure and research activities.

The strategy has a 10–15 year perspective. The initiatives must be interpreted in a dynamic perspective however, and must not be regarded as a completed action plan for the next 10-15 years. The priorities of the various initiatives, the order of implementation and the pace of progress will be assessed on an ongoing basis and will appear in the Government's annual budget presentation to the Storting. The priorities within this area will need to be adapted to the Government's other focus areas and will depend on the budget for that particular year.

Large deep-sea pens of the *Umbellula encrinus* species at a depth of 1,010 metres ©IMR

2. The Government's vision

The Government's vision is:

«Marine bioprospecting – a source of new and sustainable wealth growth»

The Government will stimulate research and business development in strategic areas with high potential of wealth growth, and where Norway has a good opportunity to assert itself in an international competition. The Government will through this targeted focus on marine bioprospecting, secure new and sustainable growth. The aim is to release the potential for wealth growth within marine bioprospecting. This initiative underpins the Government's High North Strategy and will contribute to increased activity in and for the High North. This initiative forms part of the Government's innovation policy and the Government's strategy for the marine sector, "Sustainable seafood – alpha and omega".

There are various significant reasons why the Government is considering marine bioprospecting as a strategic focus area for Norway:

- Norway has jurisdiction over large ocean areas that provide access to a large number of different marine organisms.
- Marine organisms from Norwegian waters may have unique properties that have great potential and a wide range of uses/applications from a business perspective.
- Norway has developed infrastructure for data collection and research to develop futher.
- Norway has excellent stakeholders within several relevant research areas.
- Bilateral research agreements and EU research programmes promote collaboration with several relevant foreign researchers.
- The results of marine bioprospecting may be used by existing companies and as a basis for new activities within different sectors such as processing industries, food, feed, health and energy.

Taking samples at Langnes Beach ©MARBANK Photo: B. Igeland

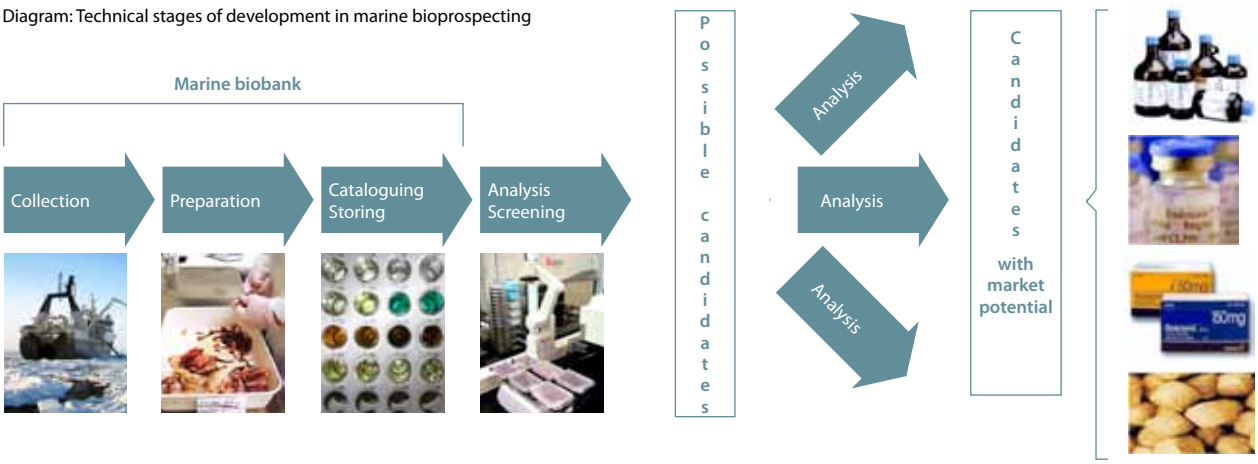
3. What is marine bioprospecting?

Marine bioprospecting can be described as targeted and systematic search for components, bioactive compounds or genes within marine organisms. This may include all kinds of organisms; microorganisms like bacteria, fungi and viruses and larger organisms such as sea plants, shellfish and fish. The marine organisms may come from the sea, the coast, the fjord, the seabed or oil reservoirs beneath the seabed. The result of the bioprospecting could be a purified molecule that is produced biologically or synthetically, or the entire organism. Bioprospecting can also be carried out on land and in freshwater organisms[1].

The purpose of marine bioprospecting, from a business perspective, is to find components, compounds or genes that may be included as components in products or processes. Marine bioprospecting, therefore, is not an industry in the traditional sense, but it may procure different compounds that may be used in many different industries.

Marine bioprospecting makes exploitation of bioactive compounds from marine organisms possible. Collection and extensive analysis/preparation of the collected material is necessary before the substance is suitable for further development to an end product or product component. The various phases within marine bioprospecting can be illustrated using a simplified model (see diagram below) that shows the development from collection of marine organisms, preparation, categorisation, storage and analysis to creation of a substance, i.e. marine genetic and biological material with the potential for further use. Different biotechnology methods are used during this course, cf. appendix 1 – Clarification of concepts.

Diagram: Technical stages of development in marine bioprospecting



The technical stages sketched in the diagram above may be regarded as part of a value chain. Value chains are seldom linear however. In practice, there is normally extensive interaction between the different phases until end product. The projects may be market-based or technology-driven, or they may be a combination of both. As with biotechnology generally, commercialisation related to marine bioprospecting is long term, multidisciplinary, capital-intensive and risky. In relation to these elements, there will be considerable variations according to the proposed range of uses, e.g. the development costs for products for human medical treatment will generally be considerably higher compared to others.

[1] With terrestrial prospecting the material comes from land and with limnistic prospecting the material comes from freshwater.

4. Opportunities and challenges

The Government is convinced that Norway's long coastline and our maritime zones provide major opportunities with regards to access to resources and biodiversity. We have an infrastructure and a research community that enable us to collect and identify a wide range of marine organisms. A combination of the national expertise that has already been built up within the marine sector and biotechnology provides Norway with a good basis for focusing on marine bioprospecting.

4.1. Access to resources and biodiversity

Humans have traditionally searched for natural bioactive substances that can be used in medicines and for other purposes. It has been asserted that over 65% of medicines used today are based on natural substances, most of which are derived from the biodiversity found on land. The biodiversity that can be found in the sea has not been explored to the same extent despite the fact that the sea covers more than 70% of the Earth's surface. The evolution of the marine environment started several million years earlier than that of the land, and the marine biodiversity is thought to be greater than that found on land.

Up to this point in time, little is known about the molecules and genetic properties of the marine species. This applies particularly to organisms from cold waters. Up to now, research has mainly concentrated on life forms from tropical and temperate regions. In the future, we will probably see a shift in focus to mapping biological material from northern waters. In addition, there is also increasing interest in life at sea, as products isolated from marine organisms tend to be more bioactive than equivalent bioactive compounds isolated from land.

There are probably more than10,000 species in Norwegian waters,[2] of which we have little knowledge. These are species that live in Arctic waters where temperatures are low and levels of salt, light and nutrient conditions vary. They can also be found in oil reservoirs and are subject to high pressure and high temperatures, and along the coast and fjords where the species have to develop special properties to survive in an area where there are high concentrations of species and man-made pollution. This varied and extensive biodiversity gives rise to expectations about marine organisms with unique biochemical properties and chemical compounds that can be used for a variety of purposes.

4.2. Range of uses/applications

In relation to future economy related to biotechnology, also called "the bioeconomy", the OECD estimates[3] that the industrial application of biotechnology will be of great significance until 2030. It is estimated that biotechnology-based output could account for approximately 35% of the output value of chemicals and other industrial products. Correspondingly this will be 80% for pharmaceutical and diagnostic products and 50% for agriculture/food. Within the biotechnology area generally, industrial processes could be the largest sector with 39%, while agriculture/food and health is estimated at 36% and 25% respectively. The OECD believes that the development of improved microorganisms that can produce an increasing number of chemical products in one and the same process will increase. Some of these will be based on genes that are mapped and identified through bioprospecting. This gives perspectives in relation to the Norwegian focus on marine bioprospecting.

Biotechnology contributes to products and processes that are essential to the quality of life in a modern society. Medical treatment today is totally dependent on biotechnology. At the same time one sees a strong global trend where biotechnology is integrated within many industrial areas. When working with the implementation of the strategy, it is important to note that marine bioprospecting can form the basis of products and processes that have a wide range of applications. This may include, for example, new medicines, ingredi-

[2] http://www.artsdatabanken.no

[3] "The Bioeconomy to 2030: Designing a Policy Agenda", OECD (2009)

ents for flavourings and nutritional content in food and animal feed, enzymes and microorganisms for improving food/animal feed, industrial processes related to the production of textiles, degradation of cellulose and use connected with the petroleum industry, environmental initiatives and renewable energy.

In Canada, biobased production makes up 6.4% of GDP, which is equivalent to approximately NOK 450 billion[4]. 37 % of this comes from medical industries. Similar figures can be seen in a number of other countries, including the USA, UK, Germany, France and Japan. A national focus on marine bioprospecting will stimulate not only the medical industries, but it should also help to develop Norway towards a knowledge-based sustainable bioeconomy. The Government sees marine bioprospecting as a central area for developing Norway as an important nation within bioeconomics and as a means of developing knowledge-based workplaces connected to traditional sectors like aquaculture, agriculture and forestry.

The role of marine bioprospecting in such a development can, for example, be to explore and use knowledge about enzymes and microorganisms for the industrial utilisation of biomass. It will be possible to create high-value bulk products and fine chemicals from renewable sources using processes that require less energy and create less pollution of the surrounding environment. Local advantages based on proximity to raw materials will facilitate the creation of new jobs in the regions, including in Northern Norway. It will also be possible to create synergies with the oil and gas industry, where biorefining will enable improved utilisation of fossil hydrocarbons. Biotechnology has already been established as a strategic element within a number of oil companies including StatoilHydro.

Vacuum filtration of marine extract ©Marbank

[4] BIOTECanada, The Canadian Blueprint, 2009 with reference to William Pellerin and D. Wayne Taylor, Measuring the biobased economy: A Canadian perspective. Journal of Industrial Biotechnology, December 2008, 4(4) 363-366

4. 3. Legal framework

There is currently national legislation and several international conventions that are relevant to marine bioprospecting activity. The main regulations are enshrined within the Norwegian Marine Resources Act, the Norwegian Nature Diversity Act, the U.N. Convention on the Law of the Sea (UNCLOS) and the Convention on Biological Diversity (CBD).

4.3.1. International legal obligations

No legally-binding definition of the concept "marine bioprospecting" exists. This creates challenges with regards to achieving international consensus on an international framework for the utilisation of genetic and biological material.

UNCLOS lays down basic obligations and rights for administration by coastal authorities of the waters for which the coastal authority has sovereignty and sovereignty rights. Foreign marine research should be facilitated, however, and the marine environment should be protected in line with the obligations of the convention.

One of the main aims of the CBD is a fair and equal division of the advantages when using genetic resources, including suitable access to genetic resources, cf. appendix 1 – Clarification of concepts. It is the countries themselves that decide whether they will allow access to genetic resources within their national jurisdictions, whether prior consent is required and also whether there are any conditions connected with the extraction. The conditions that are set for those who are given access to genetic resources shall aim to achieve a fair and reasonable distribution of either monetary and/or non-monetary gains that may be generated from their use.

Central provisions of The Convention on Biological Diversity:

- States shall, as far as possible, facilitate access to genetic material (Articles 1 and 15 [2]).
- States may require prior consent and set conditions for allowing access to genetic material and shall ensure that similar requirements that are set by other countries are respected (Article 15).
- States shall take appropriate measures in order to achieve a fair distribution of the benefits that result from taking and using genetic material (Articles 1 and 15 [7]).
- The aim of the states is to establish research collaboration between the host country and the country that supplies the genetic material, which is the subject of the research (Article 15 [6]).
- States shall request a fair distribution of the advantages obtained through use of traditional knowledge of genetic material (Article 8 [j]).

According to Article 8 (j) of the CBD, the states shall as far as it is possible and appropriate, and taking into consideration its national legislation, respect, preserve and maintain knowledge, innovations and practices of indigenous peoples and other local communities that represent traditional lifestyles that are of significance for viable preservation and use of biological diversity. Similarly, the States shall promote a wider use of these with the consent and participation of the holders of this knowledge, application and practice and encourage a fair distribution of the benefits that arise from the utilisation of such knowledge, innovations and practices.

4.3.2. National legislation

According to existing legislation, the search for and extraction of marine genetic material is regulated by Regulation of 30 March 2001 regarding foreign scientific marine research in Norway's inner waters, territorial waters, economic zone and in the continental shelf. The Regulation requires permission from the Norwegian Directorate of Fisheries for such activity prior to carrying out marine research.

A framework was set up through the Norwegian Marine Resources Act, which came into force on 1 January 2009, governs all harvesting and other utilisation of wild marine resources and their associated genetic material within national jurisdictions. The Norwegian Marine Resources Act provides rules regarding the administration of these resources, including rules on extraction, how harvesting is carried out and on controls. The Norwegian Nature Diversity Act, which came into force on 1 July 2009, contains similar regulations regarding genetic material generally, and rules regarding genetic material in public collections and measures to support the legislation in countries that supply genetic resources, etc.

Both laws emphasise that genetic material from nature is a common resource that belongs jointly to Norway and that is administered by the Government. The utilisation of genetic material shall be subject to the granting of access to the community, including an emphasis on a fair and equitable distribution of benefits arising from utilisation of the genetic material.

Marine bioprospecting is specially regulated in the Norwegian Marine Resources Act § 9 and § 10. The provisions provide the legal basis for drawing up regulations where the Government can request permission to search for and extract marine genetic material and the Government can request a share of the benefits that result from this activity. Regarding permits for searching and extracting marine genetic material, further conditions, pursuant to the Norwegian Marine Resources Act, may be put in place to the effect that agreements would need to be signed with the public authorities ensuring that the community receive a share of the benefits that may be generated by the utilisation of Norwegian marine genetic material. Such an agreement will normally be required in order to ensure effective enforcement of the conditions. The legal authority of the Norwegian Marine Resources Act § 9 and § 10 has not yet been used.

Patented inventions based on material found during marine bioprospecting, will be regulated for by the Norwegian Patents Act. The Norwegian Employee Invention Act may also be applicable, while the production and use of genetic material based on material found during marine bioprospecting will be covered by the Norwegian Gene Technology Act if genetically modified organisms are included. The extent to which genetic material from Norway may be patented abroad is regulated by the legal framework within the respective countries.

4.3.3. Contractual provisions

As international and national legislation do not adequately protect all conditions connected to the use of biological material from a marine biobank (cf. Chapter 4.4. Marine biobanks and other collections of marine organisms), agreements called Material Transfer Agreements (MTA) are entered into. Such agreements regulate different conditions for using the biobank material such as the right to apply for immaterial rights, rights of disposal, exclusivity and any restrictions on use or application.

Hose Stars *Gorgoncephalus sp* (Gorgon's Head) ©MabCent

4.4. Marine biobanks

Several collections of marine organisms currently exist among various private and public stakeholders within Norway. The collections vary in relation to the degree of preparation and systematisation of material.

A biobank is characterised by the fact that it has procedures in place for collection, determination of species, storage and preparation of materials in the field via receipt and preparation in a separate laboratory for cataloguing, chemical preservation and long-term storage. Precise characterisation and extraction of, among other things, genetic information is vital for the further use of the material. In order to be stable and reproducible, the biological material must be of high quality. The biobank must base its activities on international, scientific and technically-accepted methodology. A part of a biobank's ordinary activity is to systematise information about the material so that it can be used in research and development or in routine investigations. The collection in a marine biobank will typically include biological material from marine microorganisms such as bacteria, viruses, plankton, algae, sea plants as well as fish and sea mammals.

Many of the collections of marine organisms and material are connected to universities and institutes. Marbank in Tromsø has particular species from Arctic waters. SINTEF and NTNU have microorganisms from the Trondheim Fjord. The University of Bergen has microorganisms that were collected from the coast and fjord regions. Private companies also have separate marine biobanks, and there are several collections that are connected to different projects. A more detailed overview of existing marine biobanks and collections from various mapping authorities can be found in Appendix 2 – Overview of existing marine biobanks and collections from marine mapping authorities.

Several of the marine biobanks will be defined as public collections under the Norwegian Nature Diversity Act, § 59, i.e. a collection of genetic material that is managed by or on behalf of the Government, and where any access is subject to particular conditions.

Marbank in Tromsø is a marine biobank that collects, catalogues and stores materials from areas along the Norwegian coast, around Svalbard and in the Barents Sea. Marbank was established in 2005 following an initiative by the University of Tromsø, the Institute of Fisheries and Aquaculture, Norwegian Polar Institute and the Institute of Marine Research. The biobank has built up a collection of approximately 750 different species of benthic fauna in addition to a rapidly-expanding collection of microorganisms. The collection includes samples of marine microorganisms, plankton, algae, inverte-brates and also samples from fish and marine mammals. Samples are collected during their own expeditions and in close collaboration with other institutions.

mareano
collecting marine knowledge

MAREANO is a mapping programme managed by the Norwegian Institute of Marine Research in close collaboration with the Geological Survey of Norway and the Norwegian Hydrographic Service. The aim of the programme, which started in 2006 in connection with the Plan for the Barents Sea, is to gather information about depth conditions, soil conditions and fauna in the sea bed. MAREANO shall continue these mapping activities in 2010 as part of the follow-up on knowledge requirements in connection with "The Plan for the Norwegian Sea". The programme which is financed by the Ministry of Fisheries and Coastal Affairs, the Ministry of the Environment and the Ministry of Trade and Industry, has a budget of NOK 51.5 million in 2009. Key services include the database, **mareano.no**, which shows, among other things, the vulnerability of the eco-systems that are found, important nature types, and environmental conditions. MAREANO has two annual mapping expeditions, and the expeditions are open to experts searching for benthic materials.

The Norwegian Government assumes that the many Norwegian collections of marine organisms provide a sound basis for utilisation, while at the same time there are challenges in relation to the availability of collected materials and coordination between the stakeholders engaged in collecting and mapping activities. The current fragmented system with fairly well organised and less coordinated marine biobanks and various mapping projects needs to be better coordinated in the future. Knowledge development assumes not only that the different stakeholders cooperate, but also that they collaborate with other relevant stakeholders nationally and internationally. Increased international collaboration will be important for future wealth growth within this area in Norway.

4.5. Research

The Government believes that more activity within marine and biotechnology research and innovation in recent years is a good basis for releasing the potential for wealth growth from marine bioprospecting. Infrastructure, skilled research community and the ability to carry out high-quality bioprospecting-based research have been developed in Norway. Norway has several research vessels connected to institutes and universities that are used to collect marine biological material.

Expertise and infrastructure have been built up through various strategic investments in university colleges and through the Research Council of Norway.

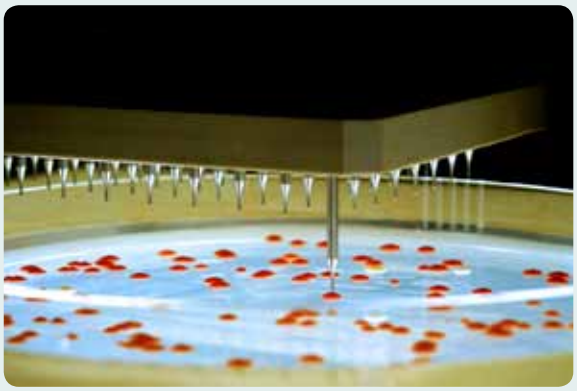
The marine biobank, Marbank, and the analysis platform Marbio were set up in Tromsø, as well as a Centre for Research-based Innovation (SFI), MabCent. The research community and the industry stakeholders collaborate on long-term investments, including the industry-focused programme MABIT (an industry-focused R&D programme in marine biotechnology in Northern Norway). Considerable expertise and infrastructure have been built up in Trondheim through systematic marine bioprospecting work at NTNU and SINTEF. Bioprospecting activities are also in progress at universities and institutes in Bergen and in the Oslo region.
Norway today has high-quality research and innovation environments in different areas within medicine, life sciences, aquaculture and petroleum-focused activities.

MabCent - Centre for Research-based Innovation with a focus on marine bioprospecting

The Centre for Research-based Innovation (SFI) is a scheme, the purpose of which is to strengthen innovation through a focus on long-term research in close collaboration with research companies and prominent stakeholders within the research community. The scheme was set up in 2006 and is managed by the Research Council of Norway. Each SFI has a total annual budget of approximately NOK 20 million. The initiative is based on a joint effort between public authorities and private companies. 50 % of the funding comes from the Research Council of Norway, while the host institution and the partners in the SFI consortia have to provide the remainder.

The University of Tromsø (UIT) is the host institution for MabCent, and Biotec Pharmacon ASA, Lytix Biopharma AS and Pronova Biopharma ASA are corporate partners. MabCent's activities are related to bioprospecting with a special focus on molecules and genes from the marine benthic fauna of the Arctic and Subarctic regions that may provide medical benefits. Even if only about 20% of the collected material is analysed, MabCent believes that interesting findings have already been made. These will be further investigated in the search for effects that regulate the immune system or type II diabetes or that inhibit cancer and bacteria. "New" antioxidants and enzymes with a range of different possible uses are being investigated.

The bioprospecting work under the auspices of MabCent has already shown that the northern waters contain organisms and compounds that have a number of interesting properties that were previously unknown or that had not been described. As MabCent only analyses a limited number of medical activities, the same material could probably turn out to contain compounds with a greater potential than what is tested for today.

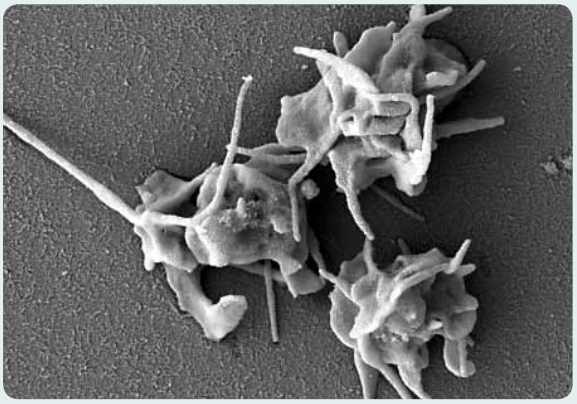


NTNU and SINTEF

The bioprospecting work in Trondheim is primarily connected with marine microorganisms. Work in this area in recent years has involved the search for cultivable micro-organisms that produce commercially-interesting compounds. In some of the work there has been a focus on anti-microbial compounds, anti-cancer compounds, colourings and unsaturated fat. It is not possible to cultivate a significant number of marine micro-organisms in the laboratory. Genes from these non-cultivable microorganisms may be a source of interesting biomolecules. NTNU and SINTEF have therefore worked to develop new effective techniques for expressing such genes in cultivable microorganisms.

The main part of the work at NTNU/SINTEF has been connected to studying the actinomycete bacteria from the Trondheim Fjord. The main objective is to find compounds that can be developed into new medicines. A collection of 10,000 bacterial isolates has been established. NTNU and SINTEF are collaborating closely with the University of Bergen and Gause Institute of New Antibiotics in Moscow in this work. One of the compounds that was discovered is now undergoing further development as a new cancer drug for leukaemia at Biosergen AS.

In connection with the bioprospecting work at NTNU and SINTEF, an advanced technology platform for cost-effective process development has been set up. The technology platform takes care of all steps within microbial bioprospecting from the isolation of strains, high-capacity analysis, cultivation, production, purification and elucidation of structures.



The University of Bergen

The marine bioprospecting work at the University of Bergen (UiB) is mainly connected with the Department of Biomedicine. They are searching for new substances against cancer, in particular acute leukaemia, drugs to prevent and treat blood clots and chemotherapy, all of which are based on marine bacteria, marine algae and polar organisms. The research work related to marine bioprospecting at UiB is based on extensive collaboration with other Norwegian and foreign universities and research institutes (Helsinki, Geneva and Bremen).

The Government believes that it is important that the Norwegian research and innovation community works closely with stakeholders outside of Norway. An extensive Norwegian-Swedish collaboration has been established within marine bioprospecting between the University of Tromsø, NTNU and Umeå University. In addition, good bilateral collaboration with research groups at universities and institutes in UK, USA, Denmark, Russia, Belgium, Spain, China and New Zealand, as well as multilateral collaboration within the framework of EU activities. Closer collaboration with Japan is also being considered.

The Functional Genomics (FUGE) research programme under the auspices of the Research Council of Norway, has been important for the development of basic knowledge of marine bioprospecting. FUGE has assisted in the development of technology and analysis platforms and the development of national networks with expertise and infrastructure within genetic technology and biotechnology research. The Government believes that is important that building capacity within the Norwegian research and innovation system assists in strengthening expertise connected with marine bioprospecting. This competency requirement ranges from basic research, preparation for the search activity, going on expeditions and collecting biological material, via systematisation, sequencing, sample preparation and pretreatment of these, further research and development on the basis of the findings to different types of business expertise.

FUGE currently has ten national technology platforms. The platforms ensure a high level of expertise and advanced technology within central technology areas. The technology platforms are mainly organised as a network and currently include 6 universities and 25 research institutions. The platforms are important to bioprospecting work, and all Norwegian researchers and companies can avail of the services provided by the platforms. This provides national, regional and local accessibility and is an effective utilisation of our research resources. The technology platform, Norstruct, for example, is essential for bioprospecting work in the Tromsø area.

Dissection ©Marbank

4.6. Industry and commerce

Biotechnology business development mainly occurs under the auspices of established companies. These are companies that have generally carried out extensive research themselves and have significant collaboration with universities and research institutes[5]. Lately, several new biotechnology-based companies with backgrounds in marine resources have also occurred in Norway. The companies, which are predominantly entrepreneurial companies that originated from the research community, also have formal collaboration with universities and institutes. All Norwegian universities have collaboration projects within biotechnology with the business sector, and the number of collaboration projects has almost doubled in the last five years[6].

[5] SkatteFUNN database.

[6] Source NIFU-STEP, report 14, 2009.

BIOTEC PHARMACON

Biotec Pharmacon is one of the pioneers among the Norwegian biotech companies. An international supplier of enzymes contacted Biotec Pharmacon. They wanted to have a cold-active enzyme for medical analysis related to the detection of viruses and bacteria developed. Biotec Pharmacon had already found an enzyme in cod liver that may have the desired properties, and commenced a research project in collaboration with the University of Tromsø. Cod UNG, a product based on an enzyme from cod liver, was developed, which is currently the most expensive Norwegian export item in terms of price per unit of weight. Cod UNG is included in a method that has a broad range of application within the research and diagnostics market.

MAREALIS®

Marealis AS is a company that is working on developing new bioactive reagents based on the residual raw materials from the production of cleaned prawns. Based on the special properties of the prawn proteins, Marealis is developing a product, which, at a laboratory phase, is showing a very positive effect on raised blood pressure. Marealis will carry out several clinical experiments in collaboration with a clinical research institution, to document the antihypertensive effect of the product. Marealis and its partners in the R&D work, Nofima Marin and the University of Tromsø, have established a collaboration with an international marketing partner in the further development of launching a product on the market.

PRONOVA BIOPHARMA

Pronova BioPharma is a pharmaceutical company that works actively on, "R&D on Drug Discovery". In short, "R&D on Drug Discovery" is concerned with the identification of new chemical substances that fulfils particular predefined biological criteria and may potentially be optimised. It is important to have several parallel strategies to identify such chemical starting points. Pronova BioPharma works actively with marine bioprospecting in the fields of cardiovascular disease, metabolic disorders and chronic inflammation. Pronova Biopharma does not do this primarily because it is a Norwegian company with "marine ancestry", but because the company feels that it has unique chemical starting points that can differentiate it from its competitors.

4.7. Industrial development and commercialisation of research results

A common feature of the biotechnology business activity is that there is a considerable need for research-based knowledge. This is generally developed in clusters through close collaboration between stakeholders within the research community, biotechnology companies, other businesses and associated business environments, which can provide the necessary business expertise and capital.

It is important that a research-based focus on marine bioprospecting is followed up by measures to increase wealth growth within the business sector. This will involve the recruitment of industrial experts and the establishment of strategic alliances between companies, knowledge clusters and regions at a national and international level. The Government emphasises the regional and national focus in an international context in order to gain added value through international networks and collaboration.

Biotechnology-based business development mainly occurs either where the research results are used by existing companies or where the stakeholders within the research community themselves use their research results commercially. Patented research results can be licensed out or can form the basis for their own business development.

When commercialising research results from marine bioprospecting, it is important that agreements are set up between the relevant stakeholders in order to contribute to predictability and secure the interests of the various stakeholders. Rights and obligations regarding materials from a biobank and the rights of universities and research institutes in connection with the commercial utilisation of research results, should be assessed in relation to existing legislation and guidelines.

4.7.1. Commercialisation activities at universities

Most universities have created Technology Transfer Offices (TTOs) alone or with other stakeholders to contribute to the commercialisation of their research results. Thus today there are established commercialisation stakeholders who are closely linked to the most prominent publicly-funded research institutions in Norway. The assignment of the TTOs is to support the universities in the transfer of technology and the commercialisation of research results. The TTOs are financed through the FORNY programme of the Research Council of Norway.

The FORNY programme

FORNY is a collaboration programme between the Research Council of Norway and Innovation Norway. The main aim of FORNY is to contribute to increased wealth creation by setting up new companies, and using new technology in existing industries. The programme finances the development of business ideas from research results and assists the realization of ideas that have business potential and lead to financial gain. The programme allocates funds early in the commercialisation process, before seed capital and venture capital are available. Through the TTOs, FORNY has assisted in the commercialisation of ideas from publicly-funded research institutions throughout Norway.

The research institutions and their TTOs have a central role to play in relation to marine bioprospecting and the associated commercialisation. The TTO system has not been evaluated so far, but this will be discussed in a new evaluation of the FORNY programme[7]. Some weaknesses have been revealed. In line with the analysis, the Government considers that the TTO system has significant development potential. The TTO system was established fairly recently, and it still needs more time to further develop the system in a positive direction.

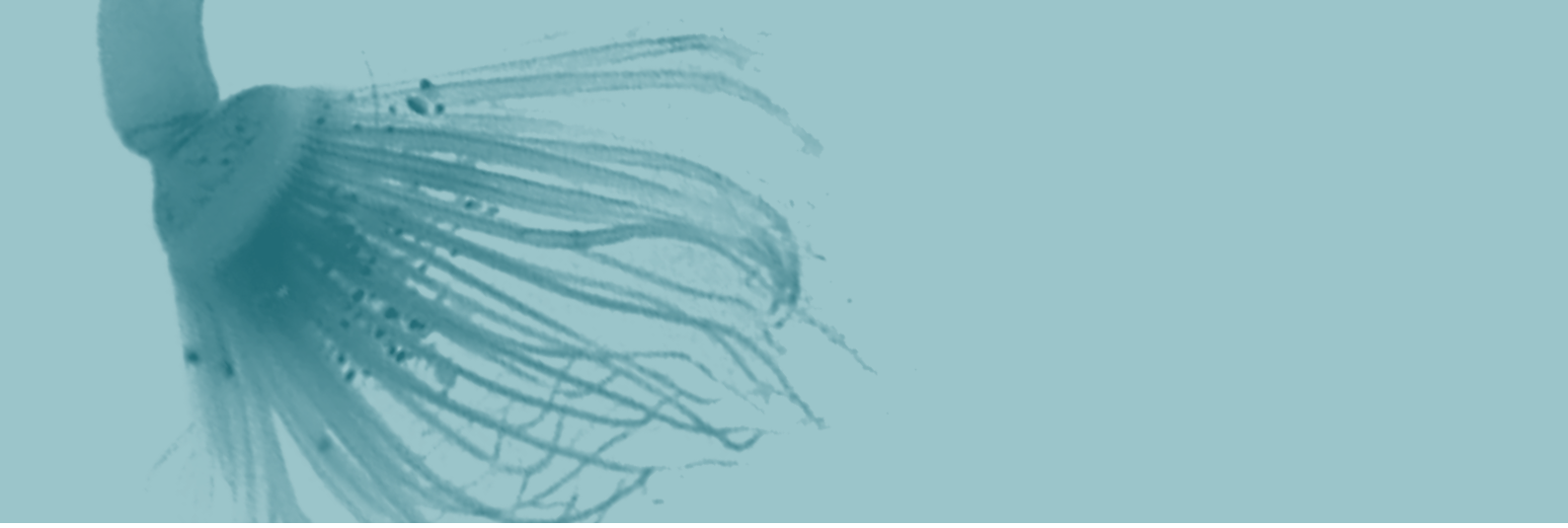
Commercialisation of marine bioprospecting results will not differ greatly from commercialisation of research results from life sciences generally. There is a broad range of applications, and the volume of marine bioprospecting results that may be commercialised will not be such that it is practical to develop separate commercialisation centres for this activity.

The Government believes, however, that there is a need to strengthen and utilise the various commercialisation stakeholders' expertise through increased collaboration and specialisation among the TTOs. The experience that can be drawn from the FORNY programme thus far would also indicate that there is a particular need to strengthen the "means of verification" within the programme, i.e. the means of confirming the potential for commercial application of the technology or the project concepts within universities and research institutes. These will be important considerations on which to base the design of a new FORNY programme.

The most important contribution that the universities and research institutes will make to the bioprospecting-based business development will not solely be through commercialisation in the form of patents, licensing and new start-ups. The importance of the role as a developer of knowledge and collaboration partner for established companies is just as important.

Sandy mud flats with a large hydroid that probably belongs to the *Corymorpha* genus at 1,040 metres ©IMR

[7] NIFU-STEP, report 19/2009 : *Between entrepreneurship and technology transfer: Evaluation of the FORNY programme*



4.7.2 Capital

Biotechnology businesses are generally long-term and capital intensive. A well-functioning capital market is essential for securing all phases of a company's development. Active, long-term and competent ownership, where the owners are directly involved in the development of the company, has been shown to have a major positive impact on unlisted research and technology-based start-up companies.

Access to venture capital is a recurring theme in discussions about innovation in Norway. But, as in many other OECD countries, this often leads to a discussion between, on the one hand, entrepreneurs who cannot access capital from stakeholders who are willing to participate in their projects, and, on the other hand, venture capitalists who do not find sufficiently attractive projects in which to invest. Relatively speaking, the Norwegian venture capital market is small. Still, the growth in venture capital investments has been comparatively large. On the whole, there does not appear to be a lack of venture capital, according to the OECD[8].

The Government has been proactive in strengthening access to capital by Norwegian businesses. In 2008 the Government created a new public investment company, Investinor AS, with total assets of NOK 2.2 billion. Investinor will first and foremost invest in companies that are in an early growth phase. Investments shall be made on a commercial basis and on the same terms as for private investors. Funding of NOK 500 million is earmarked for the marine sector, including marine bioprospecting. Investinor has recently made its first investment, of NOK 30 million, in a marine bioprospecting company.

The Government has contributed to the establishment of several seed capital funds, and capital for Argentum was increased by NOK 2 billion in 2009. Argentum, which is an investment company that was created by the Government in 2001, participates with minority shares in specialised investment funds for active ownership.

The Government believes that these measures to improve access to capital help create good opportunities for investments related to marine bioprospecting. The extent of instruments allowed by the budgets of the Research Council of Norway and Innovation Norway will, to a large extent, also be customised and relevant to bioprospecting-based businesses in a growth phase.

The Government has proposed a number of initiatives for 2009 in the Bill to the Storting no. 37 regarding changes to the state budget for 2009 with initiatives for work that will encourage continued investment in research and innovation thereby facilitating the development of new business activity. The investment in industry-focused research was increased by a total of NOK 165 million for this year. Research and development contracts from Innovation Norway are being increased by a total of NOK 65 million. The SkatteFUNN scheme has also proved to be very useful for research-based SMEs, and has been strengthened by raising the threshold for tax deductions for both internal R&D and R&D purchased from an approved research institution. A total of NOK 150 million was put into a newly-established scholarship scheme that will assist several new start-ups. This year, Innovation Norway has had its lending limit for nationwide innovation loans increased from NOK 300 million to NOK 1.4 billion in the revised budget for 2009.

An independent business tax relief was also approved, where companies are allowed to reverse losses of up to NOK 20 million annually in 2008 and 2009 against profits for the previous two years. The scheme is estimated to provide a tax relief of NOK 4.5 billion annually; a total of around NOK 9 billion for these two years. Loss of income to the State is uncertain, however, as it will depend on the development in the deficit, which in the current economic climate is difficult to estimate. The tax relief corresponds to increased taxable income in the future, as the companies will then have less deficits to carry forward against subsequent profits.

[8] OECD (2008) OECD Reviews of Innovation Policy: Norway

The rabbit fish (or rat fish), *Chimaera monstrosa*, at 315 metres ©IMR

5. Government initiatives

Investment in marine bioprospecting is an important part of the Government's plans for building knowledge and the development of industry and commerce, particularly in the High North. The importance of marine bioprospecting as an investment area with significant business development potential is stressed in both the White Paper on Innovation, St. meld. no. 7 (2008-2009) "Norway – An Innovative and sustainable Norway", the White Paper on Research, St. meld.no. 30 (2008–2009) "Climate for Research and the Strategy for the Marine Sector, Sustainable seafood – alpha and omega", a strategy document submitted by the Norwegian Ministry of Fisheries and Coastal Affairs on 14 May 2009.

Through a strategic focus on infrastructure, research, innovation and commercialisation, the Government will develop skills, excellent research institutions, and stimulate coordination and synergy to release the potential for wealth growth from marine bioprospecting. Norway has several strong research institutions that are relevant to bioprospecting. The range of possible uses, the need for collaboration between various research groups and the necessity for international oriented approach suggest that this should be a national strategy. The Government also particularly wishes to strengthen bioprospecting activities in and for the High North.

The strategy should encourage the various user groups to use marine biological material for research purposes, for documenting biological diversity and also for commercial use. The stakeholders may come from Norway or other countries.

The Government will establish regulations relating to the search for marine biological material, facilitate the strengthening of Marbank as a national biobank and improve the overview of existing and new collections. Increased collaboration and coordination between marine biobanks are central elements of the strategy. The Government presumes that research, innovation and commercialisation are mainly based on established policy instruments and structures.

The Government will facilitate the development of an appropriate national structure and expertise to ensure that there is adequate capacity to analyse marine bioprospecting material.

5.1. Preparation of regulations

Regulations connected with the search for and extraction of marine organisms as well as a sharing of the benefits are required. The Government will specify this in the regulations to the Norwegian Marine Resources Act, § 9 and § 10. With the new regulations the Government will facilitate research and business development related to marine bioprospecting. The Norwegian Nature Diversity Act will form part of the legal basis, and the Norwegian Nature Diversity Act and the Norwegian Marine Resources Act will work side by side in this area. According to Bill 52 to the Odelsting (2008–2009) regarding the Act relating to the management of biological, geological and landscape diversity (the Norwegian Nature Diversity Act), it is planned that the regulation and utilisation of genetic material be founded on common regulations under the two aforementioned laws.

Regulations pursuant to the Norwegian Marine Resources Act § 9 shall be drawn up to secure control of the search and extraction activity that is started in Norwegian waters. This ensures control of where such activity takes place, and it lays the foundation for the community to reap the benefits that may eventually be generated through utilising our common resources. Furthermore, this will be important to ensure that wild marine resources or vulnerable marine areas are not damaged by the extraction.

The Government believes that the search and extraction activity should not be permitted before the administrators have obtained information about where the extraction will take place, its purpose and scope. The Norwegian Directorate of Fisheries will handle applications for permits to search for and extract marine genetic material, and it will enter into agreements connected with utilising material with the applicants. A registration system that provides an overview of collected material will be set up. The administration of this system may be added to

the appropriate centre, e.g. in connection with a national marine biobank. Regarding permits for search and extraction activity, terms may be put in place pursuant to the Norwegian Marine Resources Act § 10 that agreements have to be entered into with the public authorities, which ensure that the community receives a share of the benefits that may be generated by the utilisation of marine genetic material from Norwegian waters. This may include, among other things, access to knowledge, relevant information and sample parts from Norwegian marine genetic material. Such agreements may also contain provisions regarding the sharing of financial gains. This enables the community to benefit to a greater extent from the utilisation of marine genetic material. These provisions should be clear so that predictability in relation to commercial utilisation is secured. The Norwegian Nature Diversity Act also has the legal authority to impose conditions regarding the utilisation of marine genetic material, cf. § 58, in line with the objective in § 57.

One of the purposes of the regulation is to help to make activities in Norway attractive to researchers, research groups and companies and to collaborate with the national marine biobank.

5.2. Infrastructure, research and innovation

The Government will promote the development of infrastructure, basic research and applied research to facilitate innovations related to marine bioprospecting.

5.2.1. National marine biobank

The Government will promote Marbank in Tromsø as the national marine biobank. The main purpose of further development of a national marine biobank is to facilitate the availability of marine organisms for research purposes, documentation of biological diversity and commercial utilisation.

The Government will strengthen Marbank to ensure that the biobank can offer various services, from collecting, making characterised biological samples available, to research assistance and storing materials collected for others. Marbank needs to have a well-developed database and an Internet-based information service to ensure easy availability about the bank's materials to various users. The national biobank must be based on appropriate procedures and the experiences of biobank activities in other countries.

The Government will ensure that Marbank can have users or clients from R&D institutes, administration and industry and commerce. The Government will ensure that the guidelines governing the use of material from Marbank are developed and clearified in order to improve predictability. Such guidelines will deal with several factors such as immaterial rights, possible differences between research and commercial utilisation of material, right of ownership and rights of disposal, the right of disclosure, etc. The guidelines must also deal with possible restrictions on access to the biobank material. In addition to restrictions on stored amounts, access may be subject to entering into agreements with users (in the form of Material Transfer Agreements, for example). This also includes immaterial rights, import and export regulations, ethical and security conditions, (e.g. to ensure that the material is not used to prepare material that is harmful to humans, animals and the environment, as in biological warfare).

The Government believes that the national biobank should be publicly owned. The Government will consider various organisational and financial options for the activity.

5.2.2. National network and database

A better overview and availability of collected marine biological material in Norway is crucial for expanding utilisation of the material. This can be obtained by better collaboration and coordination, e.g. by encouraging the establishment of one or more stakeholder networks with well-established marine biobanks and those who have

more or less systematised collections of marine organisms. The aim is to exchange and systematise information about collections of marine organisms well as to provide more opportunities to gain access to biological material.

The Government will facilitate the establishment of a new database that gives an adequate overview of existing and newly collected materials. Another goal is the development of appropriate procedures for collecting, cataloging, building up and storing samples within the entire network. Private biobanks can opt for inclusion in the national network.

The Government will ensure that adequate resources are made available to handle collections of a wide range of different organisms, to maintain sample collections and to have knowledge and expertise regarding procedures for collecting, processing and preserving material. Making samples available and analysis activity will be included as part of the initiative.

The Government will encourage the establisment of a national division of work regarding collection, storage, analysis and data handling to facilitate better utilisation of expertise and capacity and to achieve critical mass and synergy effects. Marbank will be assigned a coordinating role.

When establishing approval procedures, registration systems, biobank activity, collaboration and coordination of networks, a combination of direct grants and competitive grants, which also covers the biobank's external activities and development requirements, will be required.

The Government will arrange for a national infrastructure of marine biobanks based on quality and expertise in operating biobanks. The network should be connected to relevant international networks in order to gain access to and to participate in the development of modern biobank activity.

5.2.3. Research vessels

The Government has commenced work on the possible procurement of a new ice-class research vessel. A new vessel could contribute to an increased collection of material. In addition, it may be relevant to consider investing in equipment for taking samples from great depths.

5.2.4. Prioritised collection areas

The Government believes that it is important to build further on our existing knowledge of marine organisms, whether they originate from coastal areas, fjords, the sea, the seabed or oil reservoirs beneath the seabed. Interesting findings that already exist today should be followed up.

In expanding the national marine biobank further, the Government will prioritise the collection around two main themes: Arctic aquatic biodiversity and extreme habitats.

These areas have been selected as particularly interesting to explore, because organisms that live under extreme conditions often develop special systems for survival. Organisms that live in cold waters, for example, can develop effective defence mechanisms that may be useful in different contexts among others medical treatment. Another example is that organisms from drilling wells living off oil can possibly be used to search for and extract oil more effectively. This has also been recommended by several expert groups, including the expert committee for the High North. Setting priorities in this way will contribute to increased focus and activity in and for the northern areas of Norway. If it is relevant to use the traditional knowledge of the Sami and other local inhabitants when collecting material, this shall be done through dialogue. Marine bioprospecting may also raise ethical, social and legal issues, e.g. in relation to international conventions and regulations. These issues will be assessed as part of the initiative.

5.2.5. Analysis, expertise and building capacity

There shall be an investment in research and innovation preparing for analysis activity focused towards a wide range of applications.

Connections with medical, industrial and other analysis activities will contribute to improved utilisation of biobank material. The Government whishes to encourage national coordination and division of work, where appropriate in regard to effective utilisation of material.

5.2.6. International collaboration

Competitiveness within the areas of research, business development and capital is necessary when developing high-technology products. The existing research expertise, biobank activity, analysis capacity and other infrastructure are generic and not limited to specific niches. The initiative will therefore be open to all research groups and business shareholders within Norway as well as their international partners.

5.2.7. Organisation of research effort

The Government prepares to further develop research and innovation in relation to marine bioprospecting through the existing support structures of the Research Council of Norway. Research on marine bioprospecting will basically be organised as a commitment witin the national FUGE programme. FUGE has established the basis for important tools for facilitating national and international networks, national coordination and sharing of work and R&D projects, through a strategic building-up of expertise and technology platforms. A high degree of user-driven research projects and enhanced collaboration between the research-based biotechnology companies and the public research system is desirable.

Research related to ethical and legal issues will be included in the initiative. The industry-focused programme within marine biotechnology, Mabit, shall be continued and further developed to encourage marine bioprospecting activities in Northern Norway.

To ensure the commercialisation perspective throughout the entire value chain close collaboration between the research commitment and the instruments such as the FORNY programme and other relevant instruments is required.

5.3. Commercialisation

The commercialisation of bioprospecting faces the same challenges as the commercialisation of other ideas and projects within biotechnology research. This applies to the utilisation of the research, the development of new companies as well as the out-licensing of research results to existing companies.

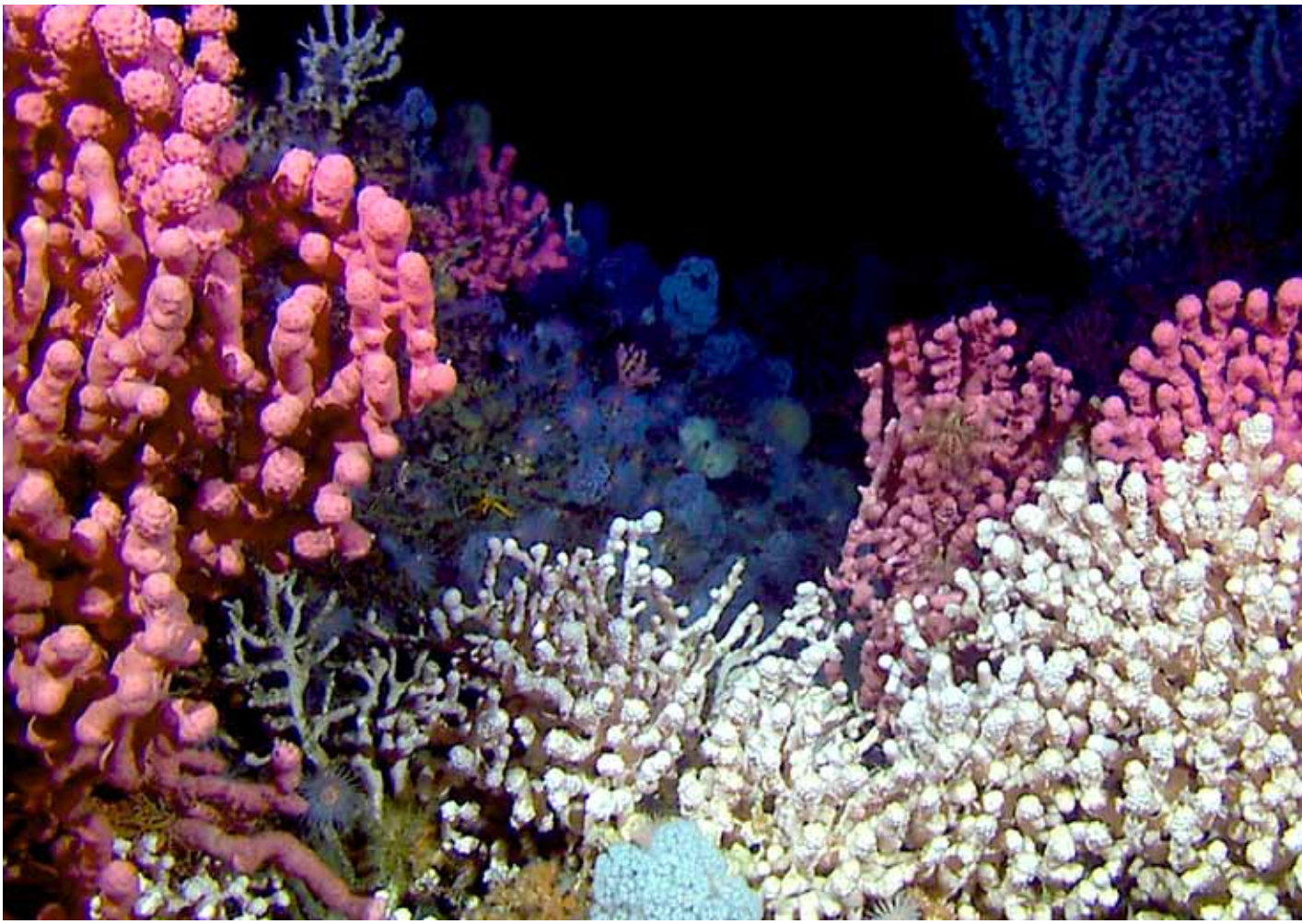
The Government believes that the best way to facilitate increased commercialisation and business development from the results of marine bioprospecting is through proper utilisation of established instruments and schemes and through the further development of these.

5.3.1. The FORNY programme and the TTO structure

The Government prepares to establish a new FORNY-programme based on the experiences gained from the TTO structure and the results of the FORNY programme. There will be a particular need to develop instruments that facilitate a closer formalised and organised national collaboration between the current TTO units. Instruments contributing to ensure better commercialisation expertise through specialisation, sharing of work and interaction between the individual TTO units will also be assessed. At the same time, it will be important to enhance the quality of the project during the commercialisation phase. The Government will strengthen the means of verification within the FORNY programme. The new FORNY programme shall be adapted to Innovation Norway's corresponding commercialisation instruments.

5.3.2. Seed capital fund

Available and adequate capital as well as skilled asset management with a high level of expertise have been important components in the development of many strong biotechnology companies and clusters. The Government will look more closely at the challenges that were highlighted in the evaluation of the existing seed capital funds.



Coral Forest with bubblegum coral, *Paragorgia arborea*, and rice coral, *Primnoa resedaeformis*, coral reef at 214 m ©IMR

Appendix

Appendix 1: Clarification of concepts

Biological resources are described as genetic resources, organisms and parts of these, components or other biotic parts of eco-systems that are of real or potential benefit or value to mankind.

Genetic resources are described as genetic material of real or potential value. Genetic material is any material from plants, animals or microbes, regardless of origin, containing functional units of heredity (cf. the Norwegian Marine Resources Act)

Genetic material that is used in the new Norwegian Nature Diversity Act instead of genetic resources because the concept appears to be more neutral, regardless of the value or the resource the material constitutes.

Arctic aquatic biodiversity denotes biodiversity in the ocean regions around the Arctic.

Extreme habitats denote organisms that reside in extreme conditions, i.e. that live in very cold (in icy waters) or in hot surroundings (hot springs) or under high pressure (in oil wells).

Biotechnology is technology using microorganisms, plant and animal cells or parts and models of these to produce or modify products that may be used for different purposes (e.g. in medicine, agriculture, the marine sector, environmental issues, energy and other industrial purposes), to alter plant and animal properties and to develop organisms for specific purposes. Modern biotechnology includes genetic technology.

Genetic technology involves techniques that permit hereditary material (DNA) to be isolated, characterised, taken up in living cells, reproduced and expressed. Genetic technology enables the transfer of genes across biological species' borders. The concept is often used synonymously with "modern biotechnology".

Appendix 2: Overview of marine biobanks and marine mapping authorities [1]

There are several marine biobanks in Norway today as a result of systematic collecting and research activity.

Mareano is a national marine mapping programme with interdepartmental financing. The participating institutions are the Norwegian Institute of Marine Research (nature types, biodiversity, marine natural resources and environmental toxins), the Geological Survey of Norway (bottom conditions, sediment and environmental toxins) and the Norwegian Hydrographic Service (seabed and depth conditions — national administrator of the terrain and ocean-depth data). All three institutions are responsible for facilitating communication within their respective subject areas. The southern Barents Sea including Lofoten will be the first areas that are mapped. MAREANO and Marbank have developed a good collaboration where Marbank participates in MAREANO expeditions to collect materials.

[1] The Government's expert groups for the High North, The committee's work group for marine bioprospecting, Marine bioprospecting – small molecules with a big future?, February 2008.

Coastal zone plans are designed under the auspices of the Norwegian Directorate for Nature Management and only include mapping of nature and habitat types. The activity is receiving interdepartmental funding. The participating institutions are NIVA, the Norwegian Institute of Marine Research and the Geological Survey of Norway. Extensive collaboration with the local authorities. Does not map species, but the nature type overview may be useful in relation to knowing where to search for different species. All data is entered into the Norwegian Directorate for Nature Management's nature database.

A proposal on Marine protected areas containing many different nature types has been prepared. The majority of these areas will contain habitats and species that are also found in other sites. However, it has been suggested that there are some particular nature types that may contain special species, e.g. Framvarden in Sørlandet, which is an anoxic fjord. When the motion for the protection plan has been carried out, a thorough mapping of the areas should be carried out. Unknown species may emerge during the mapping, as several marine nature types have not been studied in detail. Different types of business activities can take place in the protected areas, as long as this do not interfere with the purpose of the protected areas.

The Norwegian Biodiversity Information Centre systematises existing data from museums, the Norwegian Institute of Marine Research, the Norwegian Directorate for Nature Management, NIVA, the Norwegian Polar Institute and private stakeholders. The Norwegian Biodiversity Information Centre will provide important information regarding the Red List of Threatened Species.

The University Museums possess systematic expertise and have a statutory responsibility for sample material.

The Norwegian Petroleum Directorate's sample collection contains information about species and a multitude of grab samples obtained by the oil companies along the entire Norwegian shelf. Includes data from both the North Sea and the Barents Sea. Akvaplan-niva and Det Norske Veritas Foundation are the largest suppliers.

The Norwegian Marine Data Centre is a division of the Norwegian Institute of Marine Research. Its main task is to collect, quality assure and store all marine environmental and fisheries data and to make this data available for research. Data from MAREANO is included in the Marine Data Centre.

Marbank supplies R&D institutions and industries that carry out basic and applied research on marine biomolecules with material from marine organisms. Marbank's main objective is to collect and store biological material from areas along the Norwegian coast, around Svalbard and in the Barents Sea. The biobank supplies material from marine microorganisms, plankton, algae, vertebrates and invertebrates. The biobank collects material on its own voyages and from voyages made by others and has a close collaboration in the field with the University of Tromsø, the Norwegian College of Fishery Science, the Norwegian Institute of Marine Research and the Norwegian Polar Institute, among others. The sample collection consists of three sample types for each specy — fixed tests for taxonomic determination and documentation, aqueous and organic biochemical extract for analysis of bioactive compounds, as well as genetic material. All data regarding collected and prepared material is stored in a database (NAPIS). Marbank also has a database of biogeographical distribution and biological/ecological observations of available species that are of particular interest to bioprospecting.

Marbio is an analysis platform with partly-automated equipment for bioactivity analysis (cancer, antibiotics, inflammation, diabetes, antioxidants and enzymes and inhibitors), which is closely connected to Marbank.

There are several stakeholders **within the Tromsø area** with activities in relation to marine bioprospecting. The main stakeholders are the University of Tromsø, Nofima, Norut, the Norwegian Institute of Marine Research, the Norwegian Polar Institute (marine resources), Akvaplan-niva AS (marine resources) and a number of industrial stakeholders such as Biotech Pharmacon ASA, Lytix BioPharma AS, Calanus AS, Probio ASA and others. Tests are carried out for bioactive substances for medical purposes (cancer, diabetes, antimicrobial activity), bioingredients and various industrial purposes.

In the Bergen area bioprospecting-related research/activities are carried out by the University of Bergen, the Norwegian Institute of Marine Research and Nofima. This activity includes collecting and researching biological material from a number of organisms (algae, cyanobacteria, bacteria, extremophiles and Archaea) or marine raw material. Tests are carried out for bioactive substances used as biocatalysts in industrial processes, and for medical purposes, including as raw material for anti-cancer drugs. The University of Bergen has collections from the individual research groups. The industrial interest is significant.

In Trondheim bioprospecting activity takes place at NTNU and SINTEF. The focus is on marine microalgae, seaweed and bacteria. The collectionconsists of several thousand isolates from rare bacterias. Tests are carried out for bioactive compounds for medical and industrial purposes. International collaboration has been established with Russia and Switzerland.

In the Oslo area there are a number of industrial stakeholders within marine bioprospecting such as Aker biomarine and Pronova Biopharma. There is also marine bioprospecting-related activity within the university sector.

StatoilHydro has stocks of over 5,000 isolates collected in the course of drilling. The organisms demonstrate great potential for better utilisation of the oil reservoirs as well as more eco-friendly drilling.

Published by the following Norwegian Ministries:
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