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## Innovation in the Nordic marine sector

- Nordic cooperation can increase efficiency in funding for innovation and intensify innovation capacity
- Policy recommendation



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<b>A report initiated by:</b> Nordic Innovation Centre (NICe), Nordic Fisheries Cooperation, Nordic Atlantic Cooperation (NORA)		
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<p><b>Abstract:</b> The aim of this report is to examine innovation instruments and systems that are available in the Nordic Marine Sector; to consider the strength and weakness of the Nordic countries, and to suggest how to enhance innovation and competitiveness of the marine industries through Nordic cooperation. The marine sector in this context is broadly defined, encompassing both primary producers in aquaculture and fisheries, processing industry and support industry delivering technology and services. Innovation is also broadly defined; covering both radical and incremental innovations, commercial, technological, and organisational innovations.</p> <p>It is evident that the Nordic countries have different strengths and weaknesses regarding innovation in the marine sector, as Norwegians for example can be considered experts in aquaculture and vessel design, while processing of seafood has been the most advanced in Iceland and marketing in Denmark. This should be taken advantage of by encouraging each country to focus on what they do best and at the same time to enhance collaboration to increase exchange and development of expertise between the Nordic countries. By stimulating such a development it is possible to foster a dynamic entrepreneurial environment which in selected areas may be able to churn out innovations and ensure competitiveness on a global level.</p> <p>The technological status, competitive strength, and interests for Nordic cooperation have been considered for the main subsectors of the marine sector. Among those, four subsectors have been identified as being the most promising, in terms of innovation opportunities. These are: Fishing gear, aquaculture, processing and traceability, and marine biochemicals. These subsectors have been analysed and suggestions are made on how to facilitate innovation through enhanced Nordic cooperation.</p> <p>Available funding for innovation projects on the Nordic level, as well as in each of the Nordic countries, has been examined; and suggestions are made on how to increase their effectiveness through better focusing, information sharing and cooperation.</p> <p>There seems to be an untapped potential for innovation in expanding existing and developing new forms of cooperation amongst governmental agencies, research partners and industrial partners on a Nordic level. Suggestions are made on how this can be achieved by 1) Sharpening existing instruments through focusing of available resources 2) sharing of information, facilities and equipment, 3) cooperating in projects and funding and 4) Capitalising on and exploiting the different competences available in each of the Nordic countries.</p>		
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## **Executive summary**

### **Objectives:**

The focus of this report is on the innovation opportunities facing the Nordic marine sector. The paramount issues are:

- How existing national and Nordic innovation systems support the innovative capacity in the marine sector
- The competitive strength and weakness of the marine subsectors in the Nordic countries
- How these systems can capitalize on Nordic strength and be made more efficient and effective through improved Nordic cooperation.

### **The study has worked towards these objectives through:**

- Collection and review of available key documents and public information on the status of the Nordic marine sector and various innovation systems
- Participation and *observations at the Innovation in the Nordic Marine sector - Nordic cooperation Conference*, held in Reykjavik, Iceland on May 12<sup>th</sup> 2009,
- Consultations and discussions with the reference group set up for the project, which comprised of members from the marine sector in each of the Nordic countries

### **Method/Implementation:**

The work conducted and reported here is based on expert communication, both at the conference: *Innovation in the Nordic Marine sector - Nordic cooperation*, held in Reykjavik, Iceland on May 12<sup>th</sup> 2009, as well as through personal communication before and after the conference

The analysis indicated that there are opportunities for increasing the effectiveness of available innovation instruments and systems in the Nordic marine sector, by increasing cooperation amongst government, research and industry on a Nordic level. Important factor in optimising resources is to realise that each of the Nordic countries have different competences in each subsector of the industry. Each country should therefore focus on what they do best and increase the competitive strength in these core competence areas through involving their Nordic partners. Several companies and R&D-communities have top notch expertise, but are too small and resource poor to be able to realize their international potential. Nordic cooperation could bring these communities above critical mass and hence contribute to realization of the full commercial potential.

### **Recommendations:**

- Special emphasis should be put on multidisciplinary approach on the following subsectors of the Nordic Marine sector:
  - Fishing gear
  - Aquaculture
  - Processing and traceability
  - Marine biochemicals

- Government: Facilitate cooperation on a Nordic level and encouraging multidisciplinary research/projects where government, research and industry cooperate on solutions that benefit the Nordic marine sector as a whole.
- The marine industry: Seek cooperation on a Nordic level where expertise in each country is taken advantage of.
- Research and development partners: Seek cooperation on a Nordic level with government, industry, other R&D partners and those responsible for the operation of local and international innovation systems.
- Innovation systems: Formulate strategies that encourage cooperation on a Nordic level and take advantage of different expertise and available facilities in each of the Nordic countries. Pilot projects should be launched as soon as possible in one of the four subsectors identified in the report i.e. fishing gear, aquaculture, processing and traceability, and marine biochemicals. Multi-disciplinary approach is preferred.
- European/Canadian cooperation should be encouraged. The Nordic countries should emphasise their focus regarding the marine sector for the European community, and encourage establishment of EraNets via Nordic delegates in FP7 program committee, KBBE (Knowledge Based Bio Economy) network and SCAR (Standing Committee on Agricultural Research). The window of opportunity with regard to Nordic – Canadian development encouraged by Iceland and Norway should be exploited. Maybe through organising a well planned industry led fact finding mission from Canada to the Nordic countries focusing on one or several of the marine subsectors identified under bullet point 1 above.

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## Introduction

The Nordic marine sector is at present facing a number of challenges; for example related to climate change, changes in industrial structure and increased international competitiveness – globalization. In the longer term, innovation is important in order to sustain the competitiveness of the sector. The Nordic organizations Nordic Innovations Centre (NICE) and the Nordic Atlantic Cooperation (Nordisk Atlantsamarbejde – NORA) has in cooperation with the Nordic Fisheries Cooperation and the Icelandic chairmanship of the Nordic Council of Ministers in 2009 entered a project with the main objective to contribute to increased innovation in the Nordic marine sector. The results of the project shall create a foundation of an increased and closer cooperation on innovation within the Nordic marine area. The main emphasis of the project is twofold:

1. Facilitate a conference in Iceland on May 12<sup>th</sup> 2009
2. Publish a report on how Nordic cooperation can enhance innovation in the marine sector.

The main focus of the report shall be on the marine sector in the Nordic countries and the challenges the sector is facing with regards to modernization and innovation. The main issue to be addressed is how innovation systems, instruments and policies supports the capacity to innovate in the Nordic marine sector and how public support may be made more targeted, effective and efficient. In the report, innovation policies and instruments are viewed in an international perspective; with a focus on the Nordic countries and on the situation in EU outside the Nordic. The report is intended to conclude with assessments and general recommendations relative to:

- Which instruments can be implemented on a Nordic level?
- Which thematic areas within the marine sector are especially suited for Nordic cooperation?

The report can be broken up into three main parts. The first part looks at the Nordic Marine Sector in general, with focus on the available innovation instruments and systems. The second part examines opportunities for innovation in the sector, with special attention to four subsectors that are identified as being most promising (fishing gear, aquaculture, processing and traceability, and marine biochemicals). And the final part of the report concludes where the main opportunities for collaboration lie.

In order to prevent misunderstanding it is important to define and clarify leading concepts that will be used in this report. They are:

- **Marine sector:** all stakeholders that are directly linked to the catching-, aquaculture-, processing and biotechnology sector. Whether they are seafood companies or companies supplying them with machinery, technology and/or other kind of services.\*
- **Innovation:** Innovation is a new or significantly improved product, service, process, business model or organisational structure that creates commercial success or other societal value. This implies that research or inventions can only become innovations through interaction with commercial interests.
- **Innovation instruments:** Instruments that enable innovation, such as networking, funding, tax reduction, conferences, workshops etc.
- **Innovation programme:** Group of projects and/or other activities enhancing innovation within a defined theme or sector.
- **Innovation systems:** Network of institutions in the public and private sectors whose activities and interactions initiate import, modify and diffuse new technologies.

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\* These are for example: aquaculture companies, shipbuilding companies, fishing gear producers, fish-finding equipment providers, onboard handling experts (cooling, bleeding, tubs, etc.), basic processing equipment producers (machinery), fish processing companies, advanced processing equipment producers (depending on species and end products - aimed at specific solutions, improved quality, longer storage life, packaging solutions etc.), ingredient (for fish processing ) producers, utilisation of by-raw materials (biochemical processing), logistics solution providers, information system providers, traceability systems providers, hardware for information keeping (RFID, loggers etc.), management systems for the industry – Decision Support Systems, marketing solutions / know-how regarding marketing, labelling, feed producers for aquaculture, cage solution providers (aquaculture), information systems for aquaculture, feed management solution providers for aquaculture, R&D institutes, universities, public authorities bodies

## The Nordic marine sector

The objective of this chapter is to provide a “snapshot” of the marine sector in the Nordic countries and to examine each of the countries in regards to innovation in the sector. Main available innovation instruments and systems in each of the countries will be identified and reflected on, as well as mutual and outside funding opportunities.

### Snapshot of the sector

The marine sector is important for the Nordic countries in two important ways:

1. For national employment, value creation and utilisation of natural resources.
2. As a platform for international growth of Nordic companies, with relation to the marine sector

As a tool for national employment, value creation and utilisation of natural resources, the marine sector is of a great importance in the Nordic countries. The importance is however not the same in all the countries. The countries that rely most heavily on seafood production and services related to the sector are Faroe Islands and Greenland. In those two countries, more than 80% of the national export value comes from seafood production. The marine sector in Greenland is largely focused on the catching and processing of prawns, where Royal Greenland is dominating. The marine sector in Faroe Islands is much more diverse, as they are relatively large in catching, aquaculture, processing and production of fishing gear.

For Iceland, the marine sector is also of the utmost importance, even though other industries have replaced the marine sector to some extent in the past years. A quite interesting change in the characteristic of the marine sector in Iceland is that the importance of the export of seafood itself has decreased, while services and technology have increased greatly, due to companies like Marel, Maritech and Trackwell. Iceland is amongst the world’s largest suppliers of wild capture species and they have been exceptionally successful in the processing sector, where innovative companies have contributed to increasing quality and yield by implementing new technology.

Norway relies also greatly on the marine sector, but as a result of the countries’ large oil and gas revenues, the profitability of the marine sector has not been as important as for Iceland and Faroe Islands. The seafood industry has played a large role in the development of the Norwegian society and has been used to influence the regional development policy (geographical spread of people) in Norway. Norway has put a great emphasis on development in the marine sector and invested heavily there. Furthermore, the development of oil and gas exploration off the coast of Norway drew heavily on transfer of maritime technology and knowledge especially in the early days. Later some technology transfer where going the other way, from oil and gas to marine/maritime operations (e.g. mooring of aquaculture cages could draw on technology from oil and gas platform mooring technology). Norway is amongst the world’s largest suppliers of wild capture species and they are a world leader in aquaculture technology. Norwegian salmon accounts for half of the world’s supply of Atlantic salmon and they are currently investing significant amounts in development of cod cultivation. In 2008, Norwegian seafood exports amounted to NOK 39.1 billion and of this farmed seafood amounted to NOK 20.2 billion; for the first time export of farmed fish is larger than caught fish.

Denmark is one of the top seafood processing countries of EU. The marine sector does however not play as vital role in the Danish society as in the aforementioned countries. The strategically important location of Denmark, as a hub for export from Scandinavia to Europe has created an environment of import-processing-export in Denmark, where product development has a central role. An important thing, not to be forgotten, is the fact that Denmark is a leading country in fox cultivation, where marine material plays an important role as feed. The utilisation of the raw materials coming from marine environment has therefore traditionally been good in Denmark and there has been a basis for creation of strong services and technology suppliers in relation to improved utilisation of raw material.

Sweden and Finland are less dependent upon the marine sector than the other Nordic countries, although seafood supplies from the Baltic are important for both countries. Further, inland fisheries play an important role, where the species are different from the other Nordic countries. There is a growing interest in managing the Baltic Sea resources jointly between the involved countries and to improve the environmentally negative situation where contaminants from industry still pollutes the Baltic Sea. Conflicts between fisheries and oil interests are considerable in the Baltic area. The seafood industry in Sweden employs around 3.000 persons (2/3 in wild capture and 1/3 in aquaculture) with a total supply of around 250 thousand tons of fish. The Finish seafood sector employs around 3.500 people (3.000 in capture and 500 in aquaculture), but many of them are only working part time in the industry. Total Finish supply of fish is around 150 thousand tons in all. Economic and social importance of the sector in both Sweden and Finland is relatively small considering the nation as a whole, but of the utmost importance in some specific areas.

The volume and value of fish supplies, and their importance to the national economy differs hugely between the Nordic countries, as can be seen in the table below. Total fish supply from the Nordic countries amounted to over 6,4 million tons in 2007, compared to 7,1 million tons in the EU (and Denmark is the largest fishing nation inside the EU, with 16% of the total EU capture).<sup>1</sup> The importance of the marine sector to the Nordic countries becomes even more apparent when it is considered that only 25 million people inhabit the Nordic countries, compared to 220 million in the EU, and the fish supply is nevertheless almost the same.<sup>2</sup>

Key figures 2007	Faroe							Norden	Euro-area	USA
	Iceland	Islands	Greenland	Denmark	Norway	Sweden	Finnland			
Total area (1000 km2)*	103	1	2166	44	324	450	338	3428	2600	9631
Population (1000 persons)	315	49	56	5500	4740	9185	5300	25145	320000	302000
GDP (Billion euro)	15	2	1	228	284	332	180	1041	8921	10075
Total fish supply (1000 tonnes)	1400	622	110	695	3221	242	131	6421	7100	5400
Wild capture (1000 tonnes)	1395	582	110	653	2394	238	118	5490	5800	4900
Aquaculture (1000 tonnes)	5	30	0	42	828	4	13	931	1300	500
Total value of exported goods (million USD)	2402	771	432	141607	135700	168700	89800	539412		
Export value of seafood (million USD)	1005	631	364	4248	6300	1600	47	14195		
Ratio of seafood in exported goods	42 %	82 %	84 %	3 %	5 %	1 %	0 %	3 %		

\*Lakes and streams included

Source: Norden, FAO and statistics Ic, Fo, Dk, No, Sd, Fi

Species 2007	Faroe						
	Iceland	Islands	Greenland	Denmark	Norway	Sweden	Finnland
Flat fishes	22	4	26	26	14	1	-
Codfishes	599	452	10	87	1.096	16	1
Other sea water fishes	766	114	11	465	1.176	213	114
Crustaceans and mollusk	9	12	64	74	56	4	-
Freshwater fishes	-	-	0	1	1	2	4
Aquaculture	4,9	30,0	-	41,5	827,7	4,2	13,0
Total	1.400	612	110	695	3.171	241	131

Table 1: 2007 key figures regarding seafood supply in the Nordic countries compared to the EU and USA

<sup>1</sup> [http://www.islandsbanki.is/servlet/file/20080418\\_Seafood\\_EU.pdf?ITEM\\_ENT\\_ID=6595&COLLSPEC\\_ENT\\_ID=156](http://www.islandsbanki.is/servlet/file/20080418_Seafood_EU.pdf?ITEM_ENT_ID=6595&COLLSPEC_ENT_ID=156)

<sup>2</sup> <http://www.norden.org/pub/ovrigt/statistik/sk/N2008001.pdf>

Internationally, the marine sector serves as a platform for growth and expansion of multinational companies with roots in the Nordic countries. Many of those companies are suppliers of services and technology to the harvesting/fishing and/or the processing industry.

International seafood companies (fishing and processing) with roots in the Nordic countries have also expanded internationally. Examples of such, are Norwegian aquaculture companies in Chile, multinational processing and marketing companies originating in Iceland and Norway and multinational fisheries companies (mainly from Iceland and Norway).

Each of the Nordic countries has different strengths and weaknesses when it comes to innovation the marine sector. Collaboration between stakeholders differs, availability of funding varies, importance of the sector for the national economy has an affect, location in respect to markets can be an issue etc.

**Available innovation instruments and systems**

The available support towards innovation differs considerably between the Nordic countries. Governmental funding, in relation to the size of the marine industry, is for example quite scarce in Iceland and the Faroe Islands, whilst governmental support to the R&D sector is considerable in Norway. Innovation is therefore largely driven by the industry itself in countries such as Iceland and the Faroe Islands, while Norwegian R&D institutions are better able to operate without being funded by, or collaborating with the industrial partners. This difference is reflected in the close collaboration between the industry and R&D companies/institutions in Iceland, which is a link that is often not as obvious in Norway. It shall though be mentioned that this varies within the two countries. Governmental funding and application of various other innovation instruments and programmes in Norway have on the other hand allowed Norwegian R&D companies/institutions to work on solutions that Icelandic companies have not, due to lack of funding.

Following is a list of the main innovation programmes that are available in each of the Nordic countries:

**Iceland**

There are two main funds available for innovation in the Icelandic marine sector, the AVS R&D Fund of Ministry of Fisheries in Iceland and the Technology Development Fund of Rannís (The Icelandic Centre for Research). There are also a few smaller funds available that can benefit innovation in the sector. Other supports for innovation are also available in the form of supplying expertise, stock investment and lending capital, but the available funding is limited. The most important actors in the national innovation systems are presented below.

**AVS R&D Fund of Ministry of Fisheries in Iceland** is a fund exclusively created with the aim of increasing the value of Icelandic seafood, under the ministry of fisheries and aquaculture. It was established in 2003 and has grown considerably since then, as the budget has gone from 74 million ISK in 2003 to 325 million ISK (1,9 million Euros) in 2009. It is possible to get up to 50% of a project funded solely by AVS, and up to 70% as co-funding. In 2008 about 44% of

Year	AVS	
	Budget mill.	No. of projects
2003	74	34
2004	115	47
2005	217	64
2006	231	65
2007	254	65
2008	353	80
2009	325	76

Table 2: Budget of the AVS fund

the allocated grants went to projects related to catching and processing, 29% to aquaculture projects, 14% to marketing projects and 13% to biotechnology projects.<sup>3</sup>

**The Icelandic Centre for Research** (Rannís) acts as an umbrella for numerous funds and other innovation programmes. It reports to the Ministry of Education, Science and Culture with the purpose of providing professional assistance in the preparation and implementation of science and technology policy in Iceland. Rannís has functions such as operation of financial support system for research and technological development, provision of services and information to the Council for Science and Technology Policy, monitoring resources and performance in R&D, evaluating the results of scientific research, technological development and innovation, and more. Rannís therefore serves much more than only the marine sector. Rannís is in charge of seven separate funds that collectively have a budget of about two billion ISK (12 million Euros) in 2009. Traditionally, a relatively small part of the grants are allocated to projects related to the marine sector, since the Technology Development Fund (Tækniþróunarsjóður) has in reality been the only fund operated by Rannís to offer substantial support to the marine sector. The fund has a budget of 690 million ISK (4 million Euros) for 2009 and is able to allocate up to 10 million ISK to each project pr. year (for maximum of three years). Similar rules on funding apply as with the AVS fund. In 2008, the Technology Development Fund allocated grants to 43 projects, of which 13 were marine related. The Fund for Research Equipment (Tækjasjóður) has also funded equipment related to the marine sector, but the innovation drive in equipment funding is debatable.<sup>4</sup>

**The New Business Venture Fund** (Nýsköpunarsjóður) is a venture capital investor that takes an active part in business development and growth in Iceland by investing in innovative and pioneering firms. The fund invests in companies from which it can expect substantial added value, profitability and good return. New investment of the fund in 2008 amounted to one billion ISK in the form of venture/risk capital loans stocks. About a quarter of companies that the fund has invested in are related to the marine sector.<sup>5</sup>

**The Institute of Regional Development** (Byggðastofnun) has the objective to promote regional development and create job opportunities outside of the capital area. Funding can be in the form of grants, loans or investment in capital stock. However due to lack of funding, the institute has neither been able to award grants or invest in shares since 2007. The Institute of Regional Development works closely with development agencies that are located in various locations around the country. A large portion of the projects that these development agencies are involved in are related to the marine sector, but the budget is limited.<sup>6</sup>

It is apparent the available governmental funding for innovation in the Icelandic marine sector is scarce, at least in relation to the size of the sector. Direct funding through grants towards R&D and innovation in the sector is one billion ISK maximum (6 million Euros) in 2009. There are however opportunities for innovative companies to get support through expertise of various scientists, academy or other types of experts.<sup>7</sup>

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<sup>3</sup> [www.av.s.is](http://www.av.s.is)

<sup>4</sup> [www.rannis.is](http://www.rannis.is) and Magnús Lyngdal Magnússon

<sup>5</sup> [http://www.nsa.is/images/stories/skjol/Arsskyrsla\\_2008\\_03.pdf](http://www.nsa.is/images/stories/skjol/Arsskyrsla_2008_03.pdf)

<sup>6</sup> <http://www.byggdastofnun.is/>

<sup>7</sup> See for instance: [www.matis.is](http://www.matis.is), [www.nmi.is](http://www.nmi.is), [www.hi.is](http://www.hi.is), [www.ru.is](http://www.ru.is)

## Norway

The national innovation system in Norway includes several funding institutions supporting innovation through various innovation programmes and instruments. The innovation system supports not only research based innovation, but also innovation initiated from other sources more market oriented. The most important institutions are Innovation Norway, the Research Council, and the Fishery and Aquaculture Industry Research Fund. Following is a short brief on the main institutions and the innovation instruments available for the Norwegian marine sector.

**Innovation Norway**<sup>8</sup> has a long history and a large portfolio of instruments of which it has emphasised on its Marine Value Added Programme (Marint Verdiskapingsprogram). This programme aims at increasing the competitiveness of Norwegian seafood industries by providing facilities for networking among the companies as well as contributing with marketing and strategic knowledge and competence. Increasing the companies' ability to long term, marked anchored, strategic development will render the companies with better competitive positions and profitability. The objective of the programme is increased profitability for companies and for the industry at large.

**The Fishery and Aquaculture Industry Research Fund (FHF)**<sup>9</sup> is a funding scheme for industrial research and development work within fisheries and aquaculture. The Fund develops its research strategies based on an ongoing dialogue with the entire industry which is published as yearly strategic research plans, normally divided into four focal areas:

- Common initiatives for the fishery and aquaculture industries
- Fishing and hunting
- Industrial/processing
- Aquaculture

In addition funds are used for information and evaluation activities and some smaller special projects and strategic planning. Funds are allocated roughly equally to the three R&D-sectors fishing, processing and aquaculture.

**The Research Council of Norway (RCN)**<sup>10</sup> comprises three research divisions:

- Science: divided into the priority areas social sciences, humanity, physical sciences and technology, biology and biomedicine, clinical medicine and public health.

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<sup>8</sup> **Innovation Norway** promotes nationwide industrial development profitable to both the business economy and Norwegian national economy, and helps release the potential of different districts and regions by contributing towards innovation, internationalisation and promotion. The state owned company employs more than 700 people. Innovation Norway has offices in all the Norwegian counties and in more than 30 countries world wide. The head office is located in Oslo. ([www.innovasjon Norge.no](http://www.innovasjon Norge.no))

<sup>9</sup> **The Fishery and Aquaculture Industry Research Fund** is a funding scheme for industrial research and development work within fisheries and aquaculture, and is based on a levy of 0,3% on all exported fish and fish products. The funds shall be used for industrial R&D work for the benefit of all or part of the industry, and are distributed in the form of grants for research programmes and major projects. The levying of a research and development tax in the fisheries and aquaculture industry came into force on 1 January 2001. ([www.fiskerifond.no](http://www.fiskerifond.no))

<sup>10</sup> **The Research Council of Norway** is the country's official body for the development and implementation of the national research strategy, responsible for enhancing Norway's knowledge base and for promoting basic and applied research and innovation in order to help meet research needs within society. ([www.forskingsradet.no](http://www.forskingsradet.no))

- Strategic priorities: divided into the priority areas future technologies, society and public policy, marine resources and the environment, energy and petroleum research, climate and the environment and global issues.
- Innovation: divided into the priority areas innovation programmes, bio production, international cooperation and commercialisation, industry-oriented R&D and innovation incentives, competence-building, strategy and marketing)

The RCN operates some 90 research programmes of which the following are most relevant for the purpose of this report:

Programme	Acronym
User-driven Research based Innovation	BIA
Commercialisation of R&D Results	FORNY
Aquaculture - An Industry in Growth	HAVBRUK
The Oceans and Coastal Areas	HAVKYST
Maritim virksomhet og offshore operasjoner	MAROFF
The Food Programme	MATPROGRAMMET
Centres for Research-based Innovation	SFI
SkatteFUNN	SKATTEFUNN
Research, innovation and economic growth	VEKSTFORSK
Programme for Regional R&D and Innovation	VRI

**Table 3: Relevant RCN research programs**

The latter programme in the list above - Regional R&D and Innovation (Virkemidler for regional FoU og innovasjon -VRI) is a particular RCN initiative to contribute to industrial (and commercial) research and innovation in the regions for the purpose of increased innovation and value creation. All the counties have their VRI-programmes and offices and they operate in different industries – for example the west coast and one of the major fishing, aquaculture and maritime counties *Møre og Romsdal* operates exclusively within the marine and maritime industrial sectors. In general, VRI in all costal counties operates within their marine industries.

**SkatteFUNN**, a tax relief for R&D investments, is a scheme whereby business enterprises may apply for tax deductions. The scheme is qualification-based and open to all branches of industry and all types of companies - regardless of size. To be eligible for a tax deduction, business enterprises must be subject to taxation in Norway, although they do not have to be currently liable for taxation. The primary objective of the SkatteFUNN scheme is:

- To provide support to R&D projects carried out by companies.
- To enhance innovation in Norwegian trade and industry, and services.
- To foster the development of good business ideas.
- To motivate Norwegian companies to make their R&D efforts more strategic and targeted.
- To encourage greater use of development and research as strategic instruments to improve competitiveness.

The SkatteFUNN scheme is an indirect funding scheme. Support takes the form of a tax deduction up to 20% of the costs related to R&D activity. Expenses must be documented and

recorded in the project accounts. The tax deduction is awarded on top of the ordinary deductions.

By stimulating to increased cooperation between R&D institutions, companies and regional authorities on the one hand, and to form bonds to other national and international networks and instruments, e.g. ARENA, Norwegian Centres of Expertise (NCE) and Regions of Knowledge. The instruments are:

- interactions between companies and R&D institutions (arrangements for mobility between the sectors, competence brokers, action research in companies and networks, funding of pilot projects)
- user directed innovation projects (industry – R&D institute collaboration)
- Strategic R&D projects (university/institute directed research in collaboration with industry)

The Norwegian Fishermen's Association, Norwegian research institutions and other relevant stakeholders are currently claiming that the RCN are lacking a consistent profile<sup>11</sup> for fisheries technology, and have addressed this at a national level.

### Faroe Islands

There are some systems available for innovation in the Faroese marine sector, all with certain industry influence. The Faroese Research Council (Granskingarráðið, [www.gransking.fo](http://www.gransking.fo)), and the Fisheries Research Fund of the Faroe Islands (Fiskivinnugransking, [www.fvg.fo](http://www.fvg.fo)) are both the most important. There is also a Business Development Fund (Vinnuframagrunnurin, [www.fvg.fo](http://www.fvg.fo)) which can support certain projects related to the fishery and aquaculture. Also other innovation instruments and systems are available in the form of supplying expertise, stock investment and lending capital, but the available funding is limited. The most important instruments and programmes are presented below:

**The Faroese Research Council** is the leading body in funding research, development and innovation in the Faroe Islands. The council has two main working areas:

- to advise the Government and industry on matters of research policy
- to administer the research foundation, which funds research, development and innovation.

The council supports innovative projects and promotes innovation through cooperation between business, on-site researchers, research institutes and universities, both in the Faroese and abroad. Focus areas are for instance translation of knowledge and experience to technology, development of new concepts for transport, information technology, production processes, production systems and biotechnology

Each year the Faroese Parliament, grants money for the Faroese Research Foundation. The yearly grants for the Research Foundation have been the following in the past years:

Year	2002	2003	2004	2005	2006	2007	2008
In thousand DKK	4,030	5,180	4,680	4,680	6,180	6,680	6,980

<sup>11</sup> No strategic research agenda for fisheries technology is given by the RCN.

Altogether, 61 projects have been funded by the Faroese Research Council since 2002. In total, the financial support amounts approximately 37 million DKK (5 million Euros). Of these, there are 28 Ph.D. projects. Some of the projects are fully funded by the Research Council, while others are partially funded by other sources as well. Approximately 7 million DKK are available for new projects in 2009.

It is required that at least 1/3 of the total cost of funded projects is funded by others than the Faroese Research Council. Exceptions can be made in relation to Ph.D. projects.

**Fisheries Research Fund of the Faroe Islands'** intention is to support both scientific and industrial R&D projects in order to develop the Faroese fishing industry, stimulate and improve productivity – with regards to biologically, economically and socially sustainable use of the ocean's resources.

List of priorities are:

1. Responsible fisheries (Burðardyggur fiskiskapur)
2. Experimental fisheries and Value Added Seafood (Royndarveiða og virðisøking av fiski)
3. Economic and social development of the fishing industry (Búskaparlig og samfelagslig menning av fiskivinnuni)

Each year the Faroese Parliament, grants money for the Fisheries Research Fund. The yearly grants for the Research Foundation have been the following in the past years:

Year	2003	2004	2005	2006	2007	2008	2009
In thousand DKK	7,500	5,000	5,000	5,000	5,000	5,000	5,017

The fund can also support Academic-Industrial Research (Vinnugranskaraskipan)

Companies within the Fishing Industry, Research Institutions, and Individuals can apply for funding from The Fishery Research Fund. Priorities are given to projects which can document collaboration in the Faroe Islands and/or a relevant international collaboration, as well as Collaboration between Research and Industry. Projects with other financing resources are of great advance (Self financing).

**Business Development Fund** can be important for some specific innovation projects in the aquatic industry. The fund can support project that can help diversification and better usage of knowledge.

Seafood Research is at matter of Ministry of Fisheries, [www.fisk.fo](http://www.fisk.fo). The Faroese Research Council is a matter of Ministry of Culture and Education, [www.mmr.fo](http://www.mmr.fo). And Aquaculture is a matter of Minister of Trade and Industry, [www.vmr.fo](http://www.vmr.fo), as well as Food, veterinary- and environmental matters.

**Important basic info about the Faroe Islands** The Faroe Islands are a self-governing nation under the sovereignty of the Kingdom of Denmark. The Faroese Parliament legislates independently of Denmark on all areas of self-government, including the conservation and management of fish and whale stocks within the 200-mile fisheries zone. Unlike Denmark, the Faroe Islands are not a member of the EU, but maintain bilateral trade agreements and bilateral fisheries agreements with the EU and a number of other countries, including our nearest neighbours, Norway, Greenland, Iceland, and Russia.

## Greenland

There are two innovation programmes that provide the main framework for innovation in Greenland; they are The Greenland Innovation Centre and The Arctic Technology Centre.

**The Greenland Innovation Centre (GIC)**<sup>12</sup> began operation on the 28<sup>th</sup> of September 2008 and provide services such as:

- consultancy about innovation
- a sounding board and “midwife services” for new ideas
- general and specific technical advice
- practical testing and examination of products, processes, etc.
- national and international network creation
- information about new ideas for sustainable solutions
- collation and communication of knowledge about the use of technology both in Greenland and other arctic regions
- inspiration for young people interested in technology

It also provides facilities for:

- courses and training
- workshops and seminars
- international meetings
- trial set-ups
- workshops for the production, adaptation and testing of inventions
- demonstrations of prototype products and processes
- exhibitions for private companies

**The Arctic Technology Centre (ARTEK)**<sup>13</sup>, was founded in 2000 as a Greenlandic-Danish collaboration involving the College of Building and Construction in Sisimiut, Sanaartornermik Ilinniarfik and the Technical University of Denmark in Lyngby. The goal of Artek is to teach and provide in-service training for Greenlandic and Danish students and businessmen in Arctic technology. ARTEK also runs courses and seminars about Arctic conditions and contributes to research into Arctic technology.

The GIC and Artek cooperate on providing education and supplementary training for Greenlandic and Danish students, as well as commercial players, in the field of technology with special emphasis on application in Arctic areas. In financial terms, Artek is considered a DTU department with all the ensuing potential sources of revenue dependent on the number of students.

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<sup>12</sup> <http://www.greenland-innovation.com/>

<sup>13</sup> <http://www.arktiskcenter.gl/English/Hvad%20er%20Artek.aspx>

## EU instruments and systems available for the Nordic EU countries

As EU members Denmark, Sweden and Finland will have in place the different EU funds which have overlapping activities, they are:<sup>14</sup>

- The European Regional Development Fund
- The European Social Fund
- The Cohesion Fund
- The European Agricultural Fund for Rural Development and not the least;
- The European Fisheries Fund.

The most important fund relevant to this report is the Fishery Funds (EFF's) which are in place in all EU countries (not only coastal MS) and they differ from the other funds in that they are operated from each member state. Their action plans are established in each country and these plans are approved by DG MARE.

The EFF provides for five priorities or Axis as they are called in the programme:

- **Measures to adapt the EU fishing fleet:** financial assistance will be available to fishermen and fishing vessel owners affected by the measures taken to combat overfishing or to protect public health to help them temporarily or permanently lay up fishing vessels and to train, re-skill and provide early retirement to fishermen. Vessels that are permanently laid up, in addition to those already due for scrapping, may be reused for other non-fishing activities or for the creation of artificial reefs. The EFF may contribute to improving working conditions, the quality of products, energy yield and catch selectivity. It may also contribute towards replacing engines, providing non-renewable compensation to fishermen affected by permanent cessation of fishing activities and for premiums for young fishermen to buy their first fishing vessel. However, financial assistance may in no circumstances lead to an increase in the catch capacity or the power of the fishing vessel's engine;
- **Aquaculture, inland fishing, processing and marketing:** the EFF will promote the purchase and use of gear and methods that reduce the impact of fishing on the environment and improve human and animal health and safety and the quality of produce. Assistance will be limited to micro, small and medium enterprises rather than a few large enterprises. Priority will be given to micro and small enterprises;
- **Collective action:** the following projects will be eligible for aid: those which contribute to the sustainable development or conservation of resources, to improving the services offered by fishing ports, to strengthening markets in fishery products and to promoting partnerships between scientists and operators in the fisheries sector;
- **Sustainable development of coastal fishing areas:** the EFF will support measures and initiatives aimed at diversifying and strengthening economic development in areas affected by the decline in fishing activities.
- **Technical assistance:** the Fund may finance initiatives involving preparations, monitoring, administrative and technical support, evaluation, audit and checks needed to implement the proposed Regulation

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<sup>14</sup> [http://ec.europa.eu/fisheries/cfp/structural\\_measures/arrangements\\_2007\\_2013\\_en.htm](http://ec.europa.eu/fisheries/cfp/structural_measures/arrangements_2007_2013_en.htm)

## Strategic approach

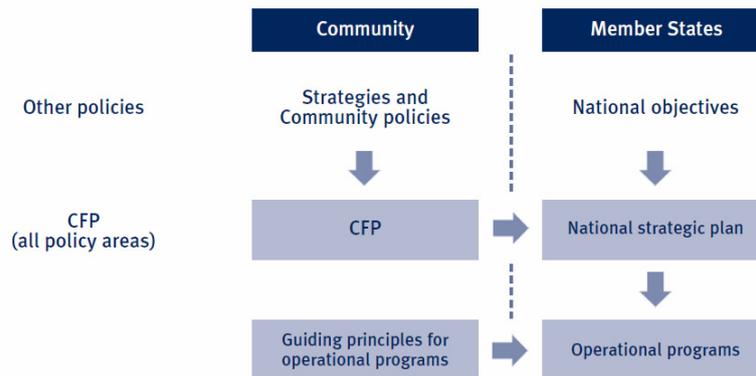


Figure 1: Strategic approach of the CFP

The EU's Framework Programme for Research and Technical Development (or FP7 for short) represents the Union's foremost instrument for the realisation of the ambitions expressed in the form of the European Research Area. The current programme, which is the seventh, FP7, runs between 2007 and 2013. The FP7 is probably the most known Framework Programme, but there are also others:

**The Competitiveness and Innovation Framework Programme (CIP)**<sup>15</sup> aims to encourage the competitiveness of European enterprises. With small and medium-sized enterprises (SMEs) as its main target, the programme supports innovation activities, provides better access to finance and delivers business support services in the regions. It encourages a better take-up and use of information and communications technologies (ICT) and helps to develop the information society. It also promotes the increased use of renewable energies and energy efficiency.

The CIP is divided into three programmes:

- Entrepreneurship and Innovation Programme (EIP)
  - Better access to finance for SMEs through venture capital investment and loan guarantee instruments
  - Business and innovation support services delivered through a network of regional centres
  - Promotion of entrepreneurship and innovation
  - Support for eco-innovation
  - Support for policy-making that encourages entrepreneurship and innovation
- Information Communication Technologies Policy support Programme (ICT PSP)
- Intelligent Energy Europe (IEE)

With a total budget of €3,621 billion, the programme runs from 2007 to 2013.

<sup>15</sup> [http://ec.europa.eu/cip/index\\_en.htm](http://ec.europa.eu/cip/index_en.htm)

A new addition under the EIP is the so-called KIC's, which is Knowledge and Innovation Communities, specifically targeting the industry in the member countries. In many of the new instruments the European Commission has succeeded in having the national funds of the member countries coordinated through EU action plans. Examples are ERA nets, Article 169 and article 171 actions, Joint Technology Initiatives and Joint Research Planning.

Two other programmes are worth mentioning here:

- COST programme directed towards networking within science, and
- EUREKA programme directed towards projects and networking within business, with its offspring EUROSTARS.

**COST** is an intergovernmental framework for European Cooperation in Science and Technology, allowing the coordination of nationally-funded research on a European level.<sup>16</sup> COST contributes to reducing the fragmentation in European research investments and opening the European Research Area to cooperation worldwide.

COST is a European programme for collaboration on technical, social and medical research. The programme aims to organise and co-ordinate R&D projects at universities, institutes and companies in Europe so that national resources are used more effectively. There is no central project funding in the COST programme. Instead, each country pays for the projects in which it participates. In addition to the EU Member States, Iceland, Norway, Switzerland, Turkey, Romania, Croatia and Bulgaria are involved in the COST programme.

The collaboration that takes place under the COST programme is channelled through so-called COST Actions that focus on particular themes.

COST is a complement to the EU's framework programme and planned co-operation with projects within this programme often takes place.

**EUREKA** is a pan-European network for market-oriented, industrial R&D network for 37 member countries that has been set up to promote collaboration between companies and researchers in Europe regarding market-related research and technological development.<sup>17</sup>

Created as an intergovernmental Initiative in 1985, **EUREKA** aims to enhance European competitiveness through its support to businesses, research centres and universities who carry out pan-European projects to develop innovative products, processes and services. The projects entail collaboration between companies, institutes and authorities from at least two member countries. It is the participants themselves that initiate and design their collaboration.

**Eurostars** has a budget of at least 400 million euro of which 100 million comes from the European Commission and the remaining balance consists of national R & D funds from the European countries which have joined the program.<sup>18</sup> Together with funding from participating companies and organizations, the programme's total project budget amounts to 800 million Euro.

The programme supports market-oriented R&D projects with partners from at least two member countries. The project should lead to market a product or service based on innovative technology. The Eurostars Programme will specifically enable R&D-performing SMEs to improve performance through its support of 'in-house' research; it will also enable companies to develop closer working relationships with the European research community. The objective

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<sup>16</sup> <http://www.cost.esf.org/>

<sup>17</sup> <http://www.eureka.be/home.do>

<sup>18</sup> <http://www.eurostars-eureka.eu/>

of the Eurostars Programme is to bring increased value to the economy, higher growth and more job opportunities by supporting the R&D-performing SME.

These are some of the main instruments and systems available for Denmark, Sweden and Finland as EU member states, but these countries have also national innovation systems in place.

## Denmark

The main national innovation instruments and programmes available for the marine sector in Denmark are provided by the Ministry of Science, Technology and Innovation; and the Ministry of Food, Agriculture and Fisheries.

**The Danish Agency for Science, Technology and Innovation.** The main innovation funding instruments in Denmark are located under the Ministry of Science, Technology and Innovation and the Danish Agency for Science, Technology and Innovation<sup>19</sup> is the main agency responsible for the Ministry's tasks within this area. The Agency's activities deal with, among other things:

- Public research funding
- Researcher mobility
- Dialogue on priorities in research and technology initiatives
- Regionalisation of research and innovation
- Commercialisation of research
- Interaction between knowledge institutions and the business community
- Innovation policy
- EU research policy
- International co-operation on research and innovation
- Research dissemination, etc.

The Agency also functions as secretariat to the Danish Research Coordination Committee, the Danish Council for Independent Research, the Danish Council for Strategic Research, the Danish Council for Technology and Innovation.

**Innovation Funds** (Innovationslovsmidler) are also available from the Ministry of Food, Agriculture and Fisheries, specifically targeting the industry in the sectors pertaining to this ministry.<sup>20</sup> There is further an Advisory Committee (RUFF) administering funds for R&D within the food area. The most recent development suggests a merger of the Innovation fund and the RUFF committee to a new, 'green development and demonstration' (GUDP) programme. This is supposed to be established in the fall of 2009.

The following elements are all instruments in the Danish innovation policies of relevance for the marine area:

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<sup>19</sup> <http://en.fi.dk/>

<sup>20</sup> <http://www.fvm.dk/Tilskud.aspx?ID=15379>

- Innovation consortia
- Regional technology centres
- High-technology networks
- ICT competency centres
- Regional ICT pool initiative
- Innovation vouchers
- Doubling-up initiative
- Matchmaking
- Open funding
- Proof-of-concept
- New concepts for technology transfer
- Inventor advisory service

## Sweden

The primary national innovation instruments and programmes available for the marine sector in Sweden are the Swedish research council, The Swedish Governmental Agency for Innovation Systems (VINNOVA) and the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (Formas).

**The Swedish Research Council** (Vetenskapsrådet)<sup>21</sup> which allocated some SEK 3 billion in research support in 2007 is the largest state funder of basic research at Swedish higher education institutions and research institutes. The Council is a government agency, under the authority of the Ministry of Education and Science, funding basic research of the highest scientific quality in all disciplines. The Swedish Research Council has a national responsibility to support and develop basic research and promote research innovation and research communication. Within the Research Council there are separate decision-making bodies for the different academic disciplines, led by Secretaries General of advanced academic competence:

- The Scientific Council for Humanities and Social Sciences
- The Scientific Council for Medicine
- The Scientific Council for Natural and Engineering Sciences
- The Committee for Educational Sciences
- The Committee for Research Infrastructures

Every year, numerous grant applications (5.600 for 2007) are submitted to the Research Council. These applications are assessed and prioritised, in terms of scientific quality and the applicants' expertise, by evaluation panels. The marine sector does not receive a large portion of the allocated funds, but is at least able to apply within some of the disciplines

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<sup>21</sup> [www.vr.se](http://www.vr.se)

**The Swedish Governmental Agency for Innovation Systems (VINNOVA)**<sup>22</sup> is a state authority that aims to promote growth and prosperity throughout Sweden. The particular area of responsibility for the Agency comprises innovations linked to research and development and its tasks are to fund the needs-driven research required by a competitive business and industrial sector and a flourishing society, and to strengthen the networks that are such a necessary part of this work.

Vinnova has 13 different generic programmes, such as commercialization, ICT, biotechnology, innovation in foods etc. There are no programmes specifically dedicated for the marine sector, but stakeholders in the sector are however able to apply for support inside relevant themes (Skärhamns for example has recently received support for developing a new method for processing of dried fish).

**The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (Formas)**<sup>23</sup> is a governmental research-funding agency related to the Ministry of the Environment. They are supporting basic research and need-driven research related to sustainable development within the areas of the environment, agricultural sciences and spatial planning. The research they support contributes to sustainable development of society (e.g. human and animal health and welfare, biological diversity, environment, productivity of ecosystems, economics, ethics as well as social and cultural values being taken into consideration). Formas' three primary areas are: a) Environment and Nature b) Agricultural Sciences, Animals and Food c) Spatial Planning.

## **Finland**

In 2007 research and development expenditure represented 3,5% of the GDP of Finland, which is amongst the highest in the world. The Finnish R&D expenditure was about 6,2 billion Euros, where the private sector contributed 67%, national public input was 26% and foreign funding 7%. About half of the business sector investments come from the electrotechnical industry. Over the past decade, the number of R&D personnel has grown from 40 thousand to nearly 80 thousand. This makes over 2% of the overall labour force, which is the highest figure among all the OECD countries. The number of doctoral degrees has similarly doubled in the past ten years.

Research and Innovation has the highest priority in Finnish society, as for example confirmed by the fact that it's Research and Innovation Council (previously the Science and Technology Policy Council) is chaired by the Prime Minister. This RIC advises the Council of State and its Ministries in important matters concerning research, technology, innovation and their utilisation and evaluation. The Council is responsible for the strategic development and coordination of Finnish science and technology policy as well as of the national innovation system as a whole. The science policy is designed to raise the level, coverage, impact on society and international visibility of Finnish research.

**The Academy of Finland** is the primary funding agency for basic research in Finland.<sup>24</sup> It is a public funding agency, under the authority of the Ministry of Education. The Academy of Finland's mission is to advance scientific research and its application, support international scientific cooperation, act as an expert organ in science policy issues and allocate funding to

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<sup>22</sup> <http://www.vinnova.se>

<sup>23</sup> <http://www.formas.se>

<sup>24</sup> <http://www.aka.fi/fi/A/>

research and other advancement of science. The Academy works to contribute to the renewal, diversification and increasing internationalisation of Finnish research. Its operation covers the full spectrum of scientific disciplines.

The Academy works to promote the progress of science by allocating funding to the highest-quality and the scientifically most innovative research. The Academy funds research annually with around 280 million Euros, which accounts for 16% of government R&D spending. There are four Research Councils at the Academy of Finland:

- Research Council for Biosciences and Environment
- Research Council for Culture and Society
- Research Council for Health and Research
- Council for Natural Sciences and Engineering

The Academy takes actively part in the public debate on science policy, the goals of science, its impacts and ethics. The Academy also promotes good scientific practices and strengthens the ethical sustainability of the research it finances.

**The Finnish Funding Agency for Technology and Innovation (Tekes)**<sup>25</sup> is the main public funding organisation for research, development and innovation in Finland. Each year, Tekes finances some 1.500 business research and development projects, and almost 600 public research projects at universities, research institutes and polytechnics. Research, development and innovation funding is targeted to projects that create in the long-term the greatest benefits for the economy and society. Tekes does not derive any financial profit from its activities, nor claim any intellectual proprietary rights.



Figure 2: Strategy focus areas of Tekes

Tekes key focal points are as shown in the figure above people, economy and environment.

### **Finnish Game and Fisheries Research Institute**

The Aquaculture Unit is supporting aquaculture and fisheries experiments and research by large network of aquaculture stations, fish stocks and cultivation experience. Continuous development of production methods and operating approaches is a crucial part of fish farming. The scale of projects ranges from devising solutions to single practical problems to broad international projects serving the development of the whole industry.

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<sup>25</sup> <http://www.takes.fi/eng/>

## Cooperative Nordic innovation instruments and systems

There are numerous innovation instruments and systems available that the Nordic countries have mutually created for the benefit of the region as a whole or a specific section of it. These are for example the Nordic Council of Ministers, the Nordic Fisheries Cooperation, NORA, NICE and NordForsk. Following is a short introduction on the main innovation instruments that are mutually available for the Nordic marine sector.

**The Nordic Council of Ministers**<sup>26</sup> is an intergovernmental forum for cooperation between the Nordic countries. The main office is in Copenhagen, but it has various installations in each country, as well as offices in neighbouring countries. The Council does not have any formal power on its own, but each government has to implement any decisions through its country's legislative assembly. This Nordic cooperation is one of the oldest and most wide ranging regional partnerships in the world, and involves Denmark, Finland, Iceland, Norway, Sweden, The Faroe Islands, Greenland and Åland. The objective of this cooperation is to strengthen Nordic interests and culture in a global world.

The Council can serve as a forum for discussion and decision making regarding aim and strategy of cooperation amongst the Nordic countries on innovation in the marine sector.

**The Nordic Fisheries Cooperation (AG-Fish)** has a long tradition, which commenced in 1949 with the first Nordic Conference in fisheries. Since then this cooperation has developed into formalized structures and processes and now encompassed most areas of the marine sector, such as fisheries, aquaculture, processing, and by-product industry. The activities of this cooperation has traditionally focused on research and Nordic policymaking, but attention is currently also being directed at industry cooperation and innovation. With a relatively modest budget (approx. 6mill NOK in 2009) the Fisheries cooperation over the years nevertheless has contributed to a large portfolio of important fisheries research and policy related project of interest and political relevance to all the Nordic countries.

The centre of gravity for this cooperation is the Committee of Senior Officials and its working group. This organization is comprised of representatives from the fisheries administrations (at ministry level) and fisheries research community of all the member countries. Hence it works as an advisory body, "think tank", communication node and gateway to the fishery sectors of these countries. The committee is therefore well equipped to identify issues of common interest, well connected and recognized in the sector, and able to identify and mobilize cooperation opportunities as they emerge through distribution of "seed money" and pilot projects. It is also able to mobilize considerable "political capital". What it cannot do, because of its limited budget and mandate, is fund and contribute to larger research and innovation projects by itself.

**Nordic Atlantic Cooperation (NORA)**<sup>27</sup> is an intergovernmental organization under the Nordic Council of Ministers regional cooperation program. NORA is funded by the Nordic Council, supplemented by contributions from the West Nordic Fund and the four participating countries in NORA: the Faroe Islands, Greenland, Iceland and the western coastal region of Norway.

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<sup>26</sup> [www.norden.org](http://www.norden.org)

<sup>27</sup> [www.nora.fo](http://www.nora.fo)

Since 1996, NORA has been a driving force in the strengthening of cooperation within the North Atlantic region with the goal of making the North Atlantic a powerful Nordic region, known for its strong, sustainable economic development.

This goal is advanced by:

- Promoting and supporting the various political and professional forums providing for the discussion of Atlantic issues and the development of joint strategies and initiatives.
- Strengthening cross-border cooperation among businesses, as well as research and development organizations and institutions, by providing, for example, financial support for collaboration projects.

In 2008 the total budget for NORA amounted DKK 10,8 million of which an amount of DKK 7,4 million were utilized as financial support for regional cooperation projects. The support for these projects is granted in accordance with the current strategic plan, which defines four focal sectors: marine resources, tourism, IKT and transport. Reflecting the economic structure of the North Atlantic countries, an important share of the support is being granted to projects within the marine resources sector. In 2008 ten out of a total number of 32 project grants were allocated for projects within marine resources.

During recent years, NORA has furthermore established itself as a key driving force with regards to the development of a closer collaboration between the Nordic region and the Western neighbours in e.g. Atlantic Canada. The priority given to this area of activity has resulted in a number of cooperation projects with Canadian participation, and during the seminar Innovation in the Nordic Marine Sector it was reflected by the attendance of several Canadian presenters.

**The Nordic Innovation Centre (NICE)**<sup>28</sup> is the Nordic Council of Ministers' operating instrument for promoting an innovative and knowledge intensive Nordic business sector. The organisation aims at developing the Nordic region as a single and well-functioning market, without national barriers.

NICE initiates and finances activities that enhance innovation capabilities, and cooperates primarily with small and medium sized companies and national innovation agencies and research institutes in the Nordic region. NICE coordinates innovation efforts in the Nordic countries and serves as a platform for further international cooperation. NICE is coordinating and/or actively participating in several ERA-NETs and numerous projects at EU level.

NICE keeps an important role providing policy advising on innovation. The organisation is an important player in creating new and different Nordic platforms for academic disciplines and industry sectors to meet, communicate and cooperate within strategically important areas or sectors. NICE grants both individual projects and larger focus areas, which is a group of several projects within a defined theme.

NICE has invested approximately 25 million NOK (only 50% of the projects' total budget) in marine related projects since the year of 2000. These projects are divided between seafood, by-products and aquaculture, and are mainly independent or part of different focus areas. The marine sector has until now not been defined as a focus area of its own.

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<sup>28</sup> [www.nordicinnovation.net](http://www.nordicinnovation.net)

**NordForsk** is a Nordic research board operating under the Nordic Council of Ministers for Education and Research; responsible for Nordic collaboration in research and research training.<sup>29</sup>

NordForsk co-ordinates important research priorities that have been identified as suitable for joint Nordic efforts, concentrating its efforts on research areas where the Nordic countries have an international position of strength. NordForsk has three roles: Co-ordination, financing and policy advice.

The objective for NordForsk's co-ordinating activities is to develop the Nordic Research and Innovation Area (NORIA) as a globally leading and attractive region for research and innovation.

NordForsk funding creates Nordic synergies that build on existing, significant national investments in research.

The policy advice role involves NordForsk acting as an advisory body to the Nordic Council of Ministers in the field of research. Through its policy instruments, as well as different analytic and communication activities, NordForsk aims to grasp and make the most of common Nordic opportunities.

Nordic Marine Academy is a research school with support from NordForsk and the Nordic Working Group on Fisheries Research (NAF) 2005-2009. The Nordic Marine Academy strengthens intra-Nordic research co-operation, expertise and innovation in marine sciences through research training and mobility of researchers and research students. The Research School covers all aspects of marine research with a particular emphasis on the exploitation, utilization and management of marine living resources and the impacts of human activities on marine ecosystems.

NordForsk administers the Programme "Impacts of Climate Change on Nordic Primary Industries – Adaptations and Precautions", a programme funded by the Nordic Council of Ministers within the fields of fishery, agriculture, forestry and food 2009-2013. The programme deals with the management of natural resources in the Nordic region, and its conclusions will be used in the preparation of a climate policy within the area.

### **International/EU-relevant instruments**

The Lisbon Agenda (2000) postulates that Europe is lagging behind USA and Japan in both RTDI (research, technology development and innovation) production and commercial utilization of new knowledge. In order to bridge the gap between Europe and US/Japan the European industry must take vital issue with this challenge and make an impact and influence on the direction on European knowledge development and RTDI. European Technology Platforms are envisioned as useful vehicles for this and the European Commission encourages its creation.

The idea is that industry should get together with all its stakeholders and develop:

- A vision for the future of the industry
- develop a Strategic Research Agenda (SRA) that matches the Vision
- develop an Implementation Plan of the SRA, and;
- Invest, together with public and private partners, in RTDI.

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<sup>29</sup> <http://www.nordforsk.org/>

Many (30-40) such platforms are established in the various industries and many of them have relevance for the aquaculture and fisheries industries. In particular it is established industry focused ETP's:

- the **European Aquaculture Technology and Innovation Platform**<sup>30</sup>
  - This platform has already established a common vision for the future and these days 7 Thematic Areas of the Platform is working on the first version of its strategic research agenda.
  - The Platform is incorporated under Belgian law as a not-for-profit trust
  - Has developed a membership fee-structure and are envisioning funding from the FP7 for further developing its research agenda and implementation plan.
- the **European Fisheries Technology Platform**
  - An initiative was taken late last year to launch such an ETP with Norway and later Spain as driving force.
  - The Platform will be launched autumn 2009
  - Presently a Task Force of the initiative is working on developing the necessary documents for the launch (draft Vision document; Terms of Reference etc.)

Out of European public funding of research, the European Commission contribute less than 5% - the vast funding comes from national sources. Nevertheless, with a budget of 53 billion Euros (of which 32.365 million are intended for collaborative research) for FP7 in 2007-2013 it is sizable source of research funding. And, importantly more and stronger initiatives are now taken to coordinate European research and funding (Joint Calls/initiatives, Joint Programming, ERA Nets and other collaborative instruments). Of particular interest is the role ETP's are envisioned for the future. In general the ETPs give input to the scientific Work Programs of DG RTD on a regular basis. Furthermore, regarding European aquaculture the DG MARE is in its new Aquaculture Strategy (COM 2009:162) calling for the establishment of a *“forum for dialogue between the European Aquaculture Technology and Innovation Platform, the Commission and Member States’ research programme managers to facilitate the programming of research activities at Community and national level”*.

All these measures we believe will greatly enhance European coordination and ability to invest in RTDI for the future. Furthermore, all this strategic work in the ETPs and EC will enhance and make more effective and efficient also the national research programmes as this strive will be setting the stage and paths for development.

### **Canada-Nordic cooperation**

In October 2008, the NORA Board carried out a fact-finding mission to Ottawa and two of the Atlantic provinces of Canada – Nova Scotia and Newfoundland-Labrador.<sup>31</sup> Meetings with politicians and representatives from industry, research and innovation environment in Atlantic Canada especially projected a genuine interest in further collaboration with the Nordic and North Atlantic countries. Innovation in the marine sector was identified as being one of the sectors with a huge potential for transatlantic collaboration, and the participation of Canadian presenters and resource persons – identified through contacts established during the mission – added important value to the Reykjavík conference on May 12<sup>th</sup> 2009. A representative from the National Research Council Canada (NRC-IRAP) stressed in his

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<sup>30</sup> [www.eatip.eu](http://www.eatip.eu)

<sup>31</sup> A report on the NORA fact-finding mission can be downloaded on [www.nora.fo](http://www.nora.fo) under the banner ‘Nordens vestlige naboer’: <http://www.nora.fo/index.php?pid=249>

presentation, that they would be interested to co-finance collaborative innovation projects together with Nordic project support schemes with a view to facilitate a closer cooperation between business and research in Canada and the Nordic/North Atlantic region. Within the Nordic cooperation it is of utmost importance to follow up on the momentum created by these initiatives by engaging more Nordic institutions in the cooperation with the west-ward neighbouring regions. For almost all knowledge and innovation areas and issues relevant for Nordic funding, there are similarities with Canada – a possible scope for co-funding is therefore in place.<sup>32</sup>

### **Summation**

There are numerous innovation support schemes available for stakeholders inside the Nordic marine sector, as has been portrayed in this chapter. The aim of the Nordic funds should be to integrate these resources by acting as a bridge between the national innovation systems, thus creating synergistic effects.

This report gives a broad overview of the Nordic and national innovation systems. A more detailed analysis identifying all available innovation programmes, national and international, could indicate where Nordic funds could benefit the most. Integration of national and international programmes in cooperative projects can benefit the marine sector as a whole, because it enables stakeholders to approach projects from a multidisciplinary point of view, transnational.

The experience from Norway shows that instruments working close to the final commercial products are on average working quite well (for example Innovasjon Norge, FHF and SkatteFUNN). The funding of relevant basic research for fisheries are however not satisfactory at present, partly because it is sometimes hard to see the connection between a strategic research agenda for basic research and commercial products. Collaboration of different funds or other instruments working towards a common goal could clarify the big picture and highlight the contribution of more basic research towards a finished product.

Cooperation between the Nordic countries regarding innovation in the marine sector is ideal because of how variably advanced the countries are in different subsectors. The sector in each of the Nordic countries is also confronted with different strengths and weaknesses when it comes to other issues, such as financial capability, governmental support, vertical integration etc.

The main strengths and weaknesses of each of the Nordic countries are presented in a table on the next page. It is important to note that the table can only be looked at as indicative, since the conditions within each country vary greatly. It is also important to remember that the weaknesses mentioned above can often be looked at as opportunities, as the case is often with SWOT-analysis.

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<sup>32</sup> <http://www.nora.fo/files/69/20090519123713926.pdf>

**Table 4: Strengths and weaknesses of the Nordic countries**

	<b>Iceland</b>	<b>Norway</b>	<b>Faroe Islands</b>	<b>Greenland</b>	<b>Denmark</b>	<b>Sweden</b>	<b>Finland</b>
<b>Strengths</b>	<p>Vertical integration. Therefore more will to collaborate within the value chain</p> <p>Research, education and industry collaboration</p> <p>Profitability necessary in seafood sector. Therefore drive for innovation</p> <p>Strong technical/services supply sector</p>	<p>Complete clusters: R&amp;D, suppliers, industry.</p> <p>Cooperative spirit among all stakeholders.</p> <p>Strong financial capability – particularly in aquaculture and parts of processing and fisheries sector.</p> <p>Aquaculture and fisheries has a strong political standing.</p> <p>Good balance small/large companies.</p>	<p>Profitability necessary in seafood sector. Therefore drive for innovation</p> <p>Short ways of communication due to small size of community</p> <p>Extremely important sector for the society. Therefore good political understanding.</p>	<p>Profitability necessary in seafood sector. Therefore drive for innovation</p>	<p>Good strategic location for markets</p> <p>Strong processing, technical and services sector</p> <p>Located within the main market area (EU). Therefore no dues on export to the EU.</p> <p>Strong research in marine bio prospecting.</p>	<p>Innovative companies.</p> <p>Many new companies in processing sector</p>	
<b>Weaknesses</b>	<p>Politics, lack of certainty for the harvesting and processing sector and unfavourable due system for product development</p> <p>High gearing of companies, often not connected to the running of the companies</p> <p>Little funding available for R&amp;D, partly due to economical crisis</p>	<p>Processing: Little value added after slaughtering from aquaculture.</p> <p>Similar final products among processors (few unique products or brands) = price-competition in end markets.</p> <p>Diversity in R&amp;D needs and funding ability in fisheries sector</p> <p>Diverging interests between coastal fisheries and new cod aquaculture industry</p>	<p>Lack of available graduate education</p> <p>Overinvestment in fishing fleet</p> <p>Few companies responsible for a major part of the value creation</p> <p>Short distance to main market areas. Therefore little drive for production of value added products with long shelf life.</p>		<p>Dependent on import of raw material for processing of seafood. Politically more oriented towards EU than the Nordic cooperation.</p>	<p>Limited production.</p> <p>Small companies.</p>	<p>Both fisheries and aquaculture are small sectors with small companies.</p>

## Opportunities for innovation in the Nordic Marine Sector

The objective of this chapter is to discuss the main opportunities for innovation in the Nordic marine sector. The discussion is broken up into four sub-sectors (fishing gear, marine biochemicals, processing/traceability and aquaculture) that are considered to represent the biggest opportunities in relation to innovation in the sector. Each of the four sub-sectors is discussed in regards to two main issues:

- What opportunities are in place?
- Who are the most important stakeholders?

Four key questions regarding drivers for cooperation will also be addressed for each sub-sector; they are:

- a) What is the international demand for technology and services under the specific theme?
- b) What is the scope and commercial interest for Nordic cooperation in addressing this demand?
- c) What should be the Nordic focus and where are the possibilities for Nordic synergies and cooperation?
- d) What kind of innovation instrument would be most effective in facilitating such cooperation?

### Fishing gear

The definition used in this report for fishing gear is: “technology that contributes to the capture of marine living resources”; this includes technology related to the fishing gear itself (trawls, lines, nets, ropes etc.), remote sensing, software design, information and communication technology, vessel design, machinery and energy systems etc. Fishing gear, as discussed in this report might also be referred to as “harvesting technology”.

The main issues being focused on today concerning fishing gear are connected to environmental concerns, cost efficiency, selectivity and safety for fishermen. Bycatch, fuel efficiency, benthic disturbance, ghost fishing and other related issues are increasingly being focused on from more and more innovative point of view. Integration of various software and hardware solutions are being applied as R&D companies attempt to make fishing gear lighter, more selective, more efficient and less destructive towards the ecosystem. Such systems are currently being used for machinery optimisation, operational decision support and surveillance of vessel systems as well.

Fishing gear can basically be divided into two main categories, where one focuses on “conventional” fishing gear, fishing vessel and related instruments; and the other on more novel harvesting technology such as the capture of zooplankton, macro algae or other untraditional species.

Fishing gear plays an important role in relation to innovation in the Nordic marine sector, as it can contribute to optimisation in the sector by reducing cost and increasing quality of the raw material. It can also severally limit the environmental impact of the catching sector, which is a particular opportunity for the Nordic marine sector because of the exemplar level of traceability in the sector i.e. environmental claims need to be verifiable.

On the basis of the points mentioned above the fundamental challenges in the framework of technological development in the marine sector are:

1. Institutional conditions for fleet renewal, innovation and technology development through the quota and fishing system policy. Will not be discussed in detail here.
2. Technology development, for instance:
  - Structural design
  - Refining processes on board, including cooling
  - Management systems
  - Design of fishing gear, and interactions (vessel / gear / environment)
  - Electronic solutions for navigation and fishing control

The various technologies mentioned above can be considered as universal for all fishing vessels above a certain size. The following can be considered as technology for more efficient and socially and environmentally sustainable fisheries.

- Reduction of greenhouse gases (CO<sub>2</sub>, NO<sub>x</sub>, Kyoto / Gothenburg Protocol)
- Good quality and efficient processing on board (food safety)
- Effective capture and safe capture procedures (as part of the coming eco-labelling)
- Electronic monitoring of catches and processes on board
- Increased automation on board

The goal of technological advancement on board requires focus on two different fields:

- Specialized focus on different components
- Interaction between the components in a holistic perspective (vessel / fishing gear)

The fisheries industry has undergone considerable development in recent years. The industry faces a number of challenges, which are expected to increase in coming years, particularly related to:

- Environment (emission of greenhouse gases, impact on seabed, selection and more)
- Economics and profitability (efficiency, fuel prices, introduction of “green taxes”)
- Some conflicts between the fishing industry and the petroleum industry

### **What opportunities are in place?**

There are numerous opportunities in place regarding innovation in fishing gear (harvesting) technology. Enabling technologies like new materials and integrated software and hardware solutions may for instance render possible new fishing gear solutions and information-based gear control. Known technology like use of liquid natural gas (LNG), diesel-electric and hybrid machinery solutions may be adopted from the offshore industry and optimized for fishing vessels. New cooling systems and handling systems for improved quality of the raw material and energy efficiency may be implemented. Optimised operational strategies on a fleet level, integrated with knowledge on fish conditions (i.e. size and fat distribution) may improve the value of fish harvested.

The main focus areas regarding opportunities for innovation in the fishing gear are *energy efficiency and environmental issues, decision support, materials and gear design and chilling and freezing*.

### **Energy efficiency – Environmental issues**

There is a considerable demand for “Greener fishing gear” in the world today. Despite the hard fall in oil prices from the "all time high" in autumn 2008, fuel prices are expected to rise again over the next few years. It is likely that operational costs will in the long run constitute a larger share of total costs of utilizing the fisheries. The regulatory framework can also be applied so that new and initially more expensive technological solutions can be economically profitable to adopt. This can also mean that new and more efficient technologies applied to the fishing industry will become more profitable.

Stakeholders in the supply chain are calling for gear that is more energy efficient, creates lower carbon footprint, is more selective, has less negative impact on the seabed etc. These are issues that create opportunities for cooperation amongst Nordic stakeholders. We are already seeing lighter and more selective fishing gear being introduced, for example by using ropes instead of wires, trawl doors that do not come in contact with the seabed, nets that are much lighter than before etc. Selectiveness in trawl systems is also being increased by using various implementations of both old (improved) technology and novel ideas. Increased selectiveness of long-lines using different kind of baits of variable sizes is also being tested.

Emission of greenhouse gases may be avoided by the use of clean technology in vessel machinery. In addition, significant energy reduction is seen as being possible by using hybrid or diesel-electric machinery systems in some fisheries.

### **Decision support**

In order to improve the basis for decision making, the decision makers must be supplied with updated, accurate and detailed information, presented in a straightforward manner. *Operational decision support tools* are the tools for monitoring of equipment and vessels for optimal resource utilization. *Strategic decision support tools* are design tools for the design of new vessels and equipment and other tools to help in the decision making process regarding the usage of different equipment.

There are three main areas where innovation regarding operational and strategic decision support likely to present opportunities for improvements and commercial value; they are:

- i. Remote sensing, communication and visualisation is progressing fast, enabling better visualisation below the surface of the ocean. This allows optimisation of gear effectiveness, cost reduction and minimising the impact of the gear on the ecosystem.
- ii. Improved design of the fishing gear by implementing ICT (Information and communication technology) can increase the selectivity of the gear with the aim to catch only the target species of the preferred size and the right quality (avoid bycatch). ICT can help with the design of the gear as well as its day-to-day operation.
- iii. Electronic logbooks and other digital data can help captains and other resource managers to decide where and when to catch the fish. Decision support software can be used to catch the best available raw material with the least amount of effort. This data can also be used to increase traceability and monitor against IUU fishing.

### **Materials and gear design:**

New materials have being developed and implemented into the design of fishing gear for a long time and will continue to be, as material choice broadens. Stronger and lighter materials have been introduced which have revolutionised the industry. The focus in the design and

implementation of new material in the sector will have to address issues such as reducing cost, minimising environmental impact, energy efficiency and ghost fishing.

### **Chilling and freezing**

Temperature is the most important parameter for conservation of fish on board fishing vessels. The cooling system is a central energy system and its design and quality will influence the flexibility of how fishing is carried out, the vessel's efficiency, total energy consumption etc. Ozone- and greenhouse effects have even caused a renaissance of natural cooling media such as CO<sub>2</sub> and NH<sub>3</sub>. Data logging in the field combined with numerical modelling of the cooling system and the dynamic interaction with fish and other technical equipment is a basis for technical and operational innovations.

### **Hydrodynamics**

The following sub-areas of hydrodynamics are considered the most important in relation to innovation:

- Computational Fluid Dynamics (CFD) complementing experiments. Currently, computational power is the limiting factor in CFD modelling, which is utilised more and more for studying details of different constructions. Even more complex structures and accompanying flows can be studied as the computational capacity is increasing. This implies that using CFD will become more widespread but experiments will further be needed for validation purposes. Developing accurate CFD models for porous and hydroelastic construction, such as fishing gear, is a challenge, especially in real time.
- Criteria for evaluating sailing properties. Without well documented criteria for evaluating a fishing vessel, more fishing vessels with poor sailing properties will be built. Relating the vessel motion to the security and working environment onboard is necessary, even how different equipment is affected.
- Flow in RSW (Refrigerated Sea-Water) tanks. Most pelagic fishing vessels are equipped with RSW systems. Pelagic catch has a tendency to form clumps of different size at the bottom of the RSW tanks. This can restrict circulation in the tanks, which has negative affect on chilling and thereby the quality of the catch. Thus, more emphasis should be placed on designing RSW tanks with regard to optimal circulation and chilling.

### **Other harvesting**

Opportunities for innovation in the Nordic marine sector concerning other harvesting technology, than fishing include the utilisation of species that have not traditionally been harvested in the region. Species like macro algae, zooplankton (i.e. *Calanus finmarchicus*), sea sponges, sea cucumber and sea urchins have potential commercial interest, as well as possible polyculture development in relation to aquaculture.

### **Build-up of expertise**

Advanced seafood production requires a broad knowledge base. Interdisciplinary knowledge is required to be able to handle tomorrow's challenges, and it is important to build and maintain expertise in various areas. It is important that the fishing industry, universities and R&D companies/institutions collaborate on this, since the most important source for data is the fishing industry itself. It is considered especially important to build up competences within modelling and simulation comprises both professional competence and knowledge on the systems to be modelled. Modelling competence within fishing gear, fishing vessels, surveillance and automation are is of particular interest in relation to innovation.

### **Who are the most important stakeholders?**

The Norwegian ship-building industry is a key player in this sub-sector. Developers of fishing gear, as well as developers of services for the fishing industry, such as log-books and fish-finding equipment are also important. The industrial companies are, as always of utmost importance, since without their demands for improved fishing gear, no real innovation will be achieved. Last, but not least, do official bodies, as well as NGOs play a large role. The discussion on bottom trawling versus long-lining is a highly political issue, as well as the size of vessels, type of processing (land/sea based), fisheries management systems and more.

### **Drivers for cooperation**

#### **What is the international demand for technology and services under the specific theme?**

There is an obvious international demand for the supply of “greener” fishing gear, where sustainability and limited environmental impact is emphasised. Optimisation in the catching sector is also being called for, where cost reduction and improved quality of the raw material is being focused at. The most pressing demands are:

- Sustainability and greener fishing gear / vessels
  - Carbon footprints, fuel efficiency, selectivity, seabed impact, ghost fishing
  - Documentation of environmental impact
- Software innovation within the marine sector
  - Mapping what knowledge is available and where it is
  - Decision support software, which allows resource managers to target the “best” raw material (i.e. right species, size and quality).
- Fish quality and traceability
  - Food safety
  - Quality documentation through entire value chain
- Governmental, industrial and research cooperation and communication
  - Domestic and international cooperation
  - Information sharing
  - Equipment sharing
  - Sharing time/projects on research vessels
  - Cooperative projects that include representatives from government, industry and research sector

#### **What is the scope and commercial interest for Nordic cooperation in addressing this demand?**

Research concerning harvesting technology is often quite expensive and some of the more basic research is replicated due to lack of communication. The most obvious benefits of a Nordic cooperation is sharing of expertise, information, facilities, equipment and costs. The number of specialist in this field inside the Nordic marine sector is relatively small, which

should facilitate cooperation and increase the likelihood of a favourable outcome that would create commercial interests that benefit everyone in the sector.

It is important to realise that fishing gear technology (as defined in this report) includes all relevant areas within fishing gear design, integrated ICT solutions, fishing vessel design and operational support

### **What should be the Nordic focus and where are the possibilities for Nordic synergies and cooperation?**

The focus should be on cooperation between countries where they share resources (including infrastructure) in R&D of innovative solutions, as well as the integration of ICT and hardware solutions, vessel design, not least to enable more focused decision support and traceability. The industry should be challenged to participate across the national borders in a systematic manner to solve common problems.

### **What kind of innovation instrument would be most effective in facilitating such cooperation?**

There are four innovation instruments that are considered likely to return favourable results in a relatively short time.

- Creating a forum for cooperation i.e. for example by bringing together experts in fields such as fishing gear and vessel design, remote sensing or operational optimisation. It would be beneficial to ensure that similar stakeholders in each country are getting connected, i.e. representatives from the coastal fishing fleet, fleet of long-liners or trawlers should meet across the national border lines. This would create a basis for further development in the sector. Here is an opportunity to cooperate with Canadian experts, which are for example advanced in remote sensing technology.
- Creating a Nordic database containing projects related to harvesting technology. This would prevent people from “reinventing the wheel” and give experts and other stakeholders ideas about improvements.
- Funding of pilot projects bring together experts from each of the Nordic countries. It could be beneficial if it would include representatives from government, industry and research. A successful pilot project would encourage stakeholders to work together on future projects.
- Funding strategic work to develop synchronized SRAs in each country at a national level for fisheries technology.

## **Marine Biochemicals**

Marine biochemicals are chemicals that are created through biochemical or biotechnological processes based on living marine organisms or parts thereof. Development in this sector has been extraordinary in the past few years and potentials for continuing success are considered overwhelming. Biochemicals are often very valuable and a successful innovation in the field could create great commercial interest for the sector. The growth in demand for bioactive compounds in the past few years has been tremendous and is predicted to continue growing at a fast pace. There is a huge diversity of species in Nordic waters, which may have significant and unique bioactivities or functions useful for food, pharmaceutical, cosmetic and energy industries.

### **What opportunities are in place?**

There are numerous opportunities in place for companies to introduce new technology processes and start production and marketing marine biochemical's for pharmaceutical, cosmetic, food or energy use.

#### ***Compounds extracted or processed directly from marine raw material***

- i. Utilization of by-products from the fish industry. There is a vast array of compounds that can be extracted from fish by-products including cold adapted enzymes, collagen and chitin, intact proteins and peptides, oils and fatty acids.
- ii. New components extracted from seaweed or microalgae. Seaweeds and microalgae contain a large number of utilizable compounds, such as polyphenolic antioxidants, mono-, oligo- and polysaccharides, peptides, pigments and oils.
- iii. Components extracted from animals, plants or invertebrates not traditionally harvested today (e.g. sea cucumbers, sponges, snails).

#### ***Introduce and develop new processes and products for biochemical products***

Development of new products for the health and sport market. This market is continuously growing. The new product and process development can be based on the Nordic clean environment, economically energy and manpower and knowledge in this field.

#### ***Principles discovered in the marine environment, but applied in different areas***

- i. Genetic material in surface of the ocean floor screened by applying metagenomics
- ii. Genetic material in non-culturable micro-organisms screened by metagenomics
- iii. Interactions and communication between organisms, particularly in cold environments (extremophiles)
- iv. Surface active components for preventing cell growth on submerged surfaces

### **Who are the most important stakeholders?**

The most important stakeholders in the marine biochemical sector are:

- Food companies
- Food supplement companies
- Pharmaceutical companies
- Cosmetic and consumer products companies
- Energy companies

### **Drivers for cooperation**

#### **What is the international demand for technology and services under the specific theme?**

New investigation methods for studying the aquatic biology, even under extreme conditions of temperature and pressure, have provoked a renewed interest for investigating the oceans on a global basis. The oceans cover 70 percent of the earth's surface and account for in excess of 90 percent of the biosphere. However, less than one percent of the micro-organisms can be

cultured by use of present technology. The oceans therefore remain host to an as yet untapped and under-utilised source of biodiversity, with great innovation potential.

There is a special interest in the Arctic and Antarctic regions, where the temperature is low and special life forms exist, as well as in marine geothermal habitats, such as coastal hot springs and hydrothermal vents. These habitats are surrounded by a profusion of algal vegetation containing various complex recalcitrant polysaccharides that may be utilized by a variety of microbes. These habitats are also expected to be valuable source of thermophilic polysaccharide degrading and modifying enzymes.

The nations having developed the marine biotechnology, or blue biotechnology, most extensively are USA and Japan. Other nations have also increased their interests and within the EU a new research programme called 'The Oceans of Tomorrow' is being launched.

There is a great and growing demand in the world for natural products for food and non-food uses. In recent years we have seen marine based biochemicals being more and more introduced into commercial products, the best example being omega-3 fatty acids. The marine environment can supply a variety of natural products, including traditional compounds such as proteins, oils, fatty acids, sugars and polysaccharides. In addition to these there are a vast number of novel compounds, e.g. secondary metabolites and compounds processed from the traditional compounds.

Various marine biochemicals can be extracted from by-product fractions from the fish processing industry. These materials are especially rich in proteins and lipids, which can be further processed into highly valuable and bioactive ingredients, e.g. peptides and long chain fatty acids. Health benefits of long chain omega 3 fatty acids are well documented and there is growing evidence for the multiple benefits of fish based peptides, e.g. against cancer, cardiovascular disease, obesity and inflammation. In terms of the fish raw materials, used to process food, in some cases less than 50 % is being utilized directly as food. The 50% not used for food now, contain a myriad of components which have great international demand for a variety of products (food, supplements, pharmaceuticals, cosmetics and energy sources).

Micro and macro algae are another source of important biochemicals, and are found in great abundance in Nordic waters. Polysaccharides comprise 40% of the total weight of macro algal biomass of marine sources which makes macro algae an economically feasible source of special polysaccharides for industrial applications. Marine algae are e.g. the only sources for industrially important polysaccharide phycocolloids like agar, carrageenan and alginate. However macro algae also contain a great variety of other complex and "unusual" polysaccharides of great potential for diverse non-food applications. Algal polysaccharides and derived bio-compounds have for example emerged as an important class of bioactive natural products having blood anticoagulant, anti-tumor, anti-mutagenic and anti-inflammatory activities.

There are clearly tremendous potentials for the Nordic countries in producing high value marine biochemicals. The Nordic countries are in an excellent position to lead the world in better utilization of marine raw materials and conversion of these materials to high value ingredients.

### **What is the scope and commercial interest for Nordic cooperation in addressing this demand?**

The Nordic nations which have developed investigations most extensively within the blue biotechnology area are Norway, Iceland and Denmark. In Tromsø a new marine biotechnology research centre, MabCent-SFI, has been established funded by the government, and in Iceland and Denmark, Matis and the Technical University of Denmark (DTU) also run advanced laboratories. The commercial interests are in the food industry, pharmaceutical industry, enzyme and fine chemicals supplier industry, and producers of ship paints. There is further an interest in the combination of the food and pharmaceutical industries, where integration is considered possible in the future.

In addition to the marine bioprospecting interests, there is an interest in combining screening for biological activities and processing for new applications with studies on by-products as raw material. Many of the activities screened for at e.g. the MabCent-SFI and Matis bioactivities lab could also be applied for by-product fractions and the industry interests are similar.

### **What should be the Nordic focus and where are the possibilities for Nordic synergies and cooperation?**

There is an urgent need to make closer contacts between industrial partners and the different research environments in the Nordic countries and synchronize activities. The blue biotechnology area is on a fast forward move in the industrialised countries in the hunt for exploitation of new biological principles found in the oceans, and further for harvesting new organisms not having been exploited so far. A concerted action could make the Nordic countries leaders in blue biotechnology, not only in Europe, but worldwide.

Collaboration on a Nordic level could for instance aim for combined effort to screen for activities in material obtained in the oceans, with similar screening of by-product fractions from the seafood processing industry. This is a new approach, which has not been addressed elsewhere so far.

### **What kind of innovation instrument would be most effective in facilitating such cooperation?**

1. Establishment of a well coordinated Nordic research network of institutes, universities and companies involved in utilisation of marine biochemical compounds
2. Establishment of specially designated funding sources for marine biochemical research in Nordic countries, requiring stakeholders from government, research and industry to collectively identify important issues and objectives.
3. Funding of workshops and conferences on marine biochemical research and industries in Nordic countries

Funds should be drawn from national sources, Nordic collaborative funds and EU funds that may become available through research collaboration or funds from the 'Oceans of Tomorrow' programme.

## Processing and traceability

The Nordic marine sector is faced with numerous challenges, as well as opportunities, when it comes to processing and traceability of seafood. The Nordic countries are in many respect leaders in these fields and have therefore been able to take advantage of development and implementation of new processing technology; and the use of traceability systems that are often covering the whole supply chain - from sea to plate.

### What opportunities are in place?

One of the main emphases on innovation in the marine sector is currently on data collection and data processing. Numerous companies have been working on solutions that make it easier to collect, share and use data in order to improve quality, reduce costs or optimize in their production in some other way. These companies are using available existing data whilst consistently adding to the data by collecting new information using technologies such as electronic logbooks, RFIDs, loggers and various other traceability systems. These technologies do for example support decision making in the companies on how to catch the best available raw material with the least amount of effort. Optimization in the value chain as a whole is increasingly being explored, where each link is being looked at as a part of the whole.

It is difficult to discuss innovation in the marine sector by breaking it into subsections, because everything is interconnected. Novelties in one field are immediately being used as a support in other subsections. Innovation in the catching sector can for example be very relevant for the processing, transport and retail sector. Examples of innovative novelties that are currently being implemented into the sector are:

- Electronic logbooks
- Decision support software for resource managers (captains, production managers etc.)
- RFIDs
- Loggers
- CBC (combined blast and contact) cooling of fillets in processing plants
- Application of on-line measurements physical properties, used for management
- Traceability
- Environmental issues
  - LCA
  - Labelling (ecolabelling/carbon footprint/ IUU fishing)

There is urging need to look at the value chain from the view of the buyer, both retailers and consumers. The shift of supply from cold-sea species, such as cod, Asian and African species, for example Pangasius, is a direct threat on the whitefish market, especially those producers who have been competing on the less expensive segments of the market. The lost battle of raw material supply for homogenous products like fish fingers, where the supply has shifted from cod to Alaskan Pollock to the presently increasing share of Pangasius, is a good example of this. The ongoing economic recession has also a large effect here, forcing large processors in Europe to look for cheap alternatives to cod. The lack of cod and other cold water species has also played a role in this development.

There is little doubt that aquaculture will play more and more important role in the supply of fish in the next decades, as it has been doing in the past decades. This shift in supply is due to increase in the supply of farmed fish, as well as decline in many important wild caught species. At the same time, much of the development in processing of fish and seafood has taken place in close collaboration with the traditional processors, i.e. processors of wild caught fish. There is a great need to increase the collaboration between the developers that have the most experience in processing and farmers of fish. Given the natural variability of wild caught fish and how the development has been in agriculture, it can not be expected that wild caught fish will be able to compete with farmed fish in price. To maintain as leaders of fish farming and of processing technology, the Nordic countries should take the lead in further collaboration between fish farming, processing and marketing. Technological developers must be integrated in such collaboration, for instance developers of Decision Support Systems, where information technology is utilized to optimize the value chain, not only from harvesting to the consumer, as is the case with wild caught fish, but taking into account the genetics of the farmed fish, feed, environment and other factors.

In the light of ever increasing data in the value chain of seafood, and the increased complexity of the situation for the managers, left with the decisions to be taken to optimize the profitability of the value chain. Such optimisation needs to take into account different constraints, both within processing itself and from other stakeholders. To enable more focused management collaboration is needed among the processing industry, R&D partners, mechanical solution providers and software solution providers. Such collaboration will strengthen the position of Nordic solution providers.

It can be reasoned for that the time of the great improvements in fish processing due to mechanical improvements is over. The development in the 1980's and 1990's was that companies like Marel, with integrated software and hardware solutions, hurt severely the market position of traditional mechanical companies like Baader. But it can also be reasoned that the upswing of companies like Marel is close to an end. The development in the past years has been that software solution providers grow faster than other solution providers. Nordic solution providers and innovation systems should take this into account.

### **Who are the most important stakeholders?**

It is of utmost importance here to obtain cross-cutting, multidisciplinary approach, where the whole value chain collaborates on creating value for the consumers. It is therefore difficult to point out only few stakeholders which are more important than all the others. Retailers have been, for quite some time now, a driving force concerning innovation in processing, and will continue to be so. Environmental issues will play larger role, as eco-labelling will make its way up the value chain. Processing companies may therefore expect more pressure from environmentally concerned NGOs in the future.

It may be expected that the growth of mechanical (Baader for instance) and half-mechanical (Marel for instance) solution providers will not be as high as the growth of more software related solution providers, such as Tracetracker. Companies within all those sectors, i.e. mechanical, mechanical-software and software solution providers are very important stakeholders.

## Drivers for cooperation

### **What is the international demand for technology and services under the specific theme?**

The most important driver within processing and traceability has always been, is and will always be the hope for increased profitability. Increased possibilities to share data between the links in the value chain have streamlined industrial processing and created new management styles, such as lean management, Just-in-Time and more. The seafood industry still has a lot of room for improvements here. There is a need to look at the value chain from the view of the buyer, both retailers and consumers. The shift of supply from cold-sea species, such as cod, Asian and African species, for example Pangasius, is a direct threat on the whitefish market, especially those producers who have been competing on the less expensive segments of the market. The lost battle of raw material supply for homogenous products like fish fingers, where the supply has shifted from cod to Alaskan Pollock to the presently increasing share of Pangasius, is a good example of this. The ongoing economic recession has also a large effect here, forcing large processors in Europe to look for cheap alternatives to cod. The lack of cod and other cold water species has also played a role in this development.

There is little doubt that aquaculture will play more and more important role in the supply of fish in the next decades, as it has been doing in the past decades. This shift in supply is due to increase in the supply of farmed fish, as well as decline in many important wild caught species. At the same time, much of the development in processing of fish and seafood has taken place in close collaboration with the traditional processors, i.e. processors of wild caught fish.

The competition at the food market will continue to harden, both within the seafood market and between different food types. Even though the economic recession has, to some extent, decreased the growth rate of fresh fish processing, it is rational to think that if Scandinavian processors are to keep the price difference between fish processed in Scandinavia and cheaper species, originating from Africa or Asia, being able to produce fresh, high quality products is of utmost importance. To obtain that goal, development in chilling technique, along fine-tuning of the value chain, in order to maintain quality and value for the consumer, is important.

Total utilization, where as much as possible of the raw material ends up on the plates of the consumers, without first being eaten by another animal, will also be a driving force for innovation. The collaboration between processing, value chain management and biotechnology will be a key for success in this field.

Wild caught fish will face numbers of challenges in the nearest future. The fisheries management of EU (Common Fisheries Policy; CFP) has failed almost completely, resulting in number of species threatened to become extinct. Pictures of discard and damaged coral reefs have been shown in all important market areas for wild caught fish. Along with those facts, and the increased awareness of consumers for environmental issues in general, has created an opportunity for extreme environmental groups to focus their activities on wild caught fish. At the same time, oil price has risen to formerly unknown heights with increased cost of acquiring raw material, even though the economic ongoing downturn has changed that picture somewhat.

To sum up, those are among the drivers of innovation in the next years:

- Market driven management of the value chain
- Added shelf life
- Environmental issues
- Shorter value chains
- Improved cooling of fresh products
- Total utilisation of raw material
- Differentiation is needed
- Lean production and cost-cutting
- Connection between industry and R&D
- Industry has to reach out to the academia in order to move and think faster

### **What is the scope and commercial interest for Nordic cooperation in addressing this demand?**

In general, there is a commercial interest tied to all transfer of know-how between the Nordic countries. More specifically, there is, for instance, a commercial interest in utilising the know-how of Icelandic white-fish fillet processing in the Norwegian salmon processing industry. Icelandic white-fish fillets have for a long time been known for high quality, and Norwegian salmon processors can benefit from such know-how. Similar examples might be mentioned in solution providers like Tracetracker, where the build-up of know-how and ability to solve day to day problems concerning traceability in the industry has been a key element.

### **What should be the Nordic focus and where are the possibilities for Nordic synergies and cooperation?**

There are many fields where there are possibilities for Nordic synergies. There is for example clearly a lot to gain from inter-Nordic collaboration on traceability and the applications of traceability. Norwegian and Danish have, through research projects like Tracefish, Trace and Seafood Plus, gained important knowledge on structural design and specification of traceability systems. At the same time, Icelandic studies have been focused at the applications of traceability, with management of vessels and processing as an aim. Apparently, there is a lot to be gained by further collaboration in those fields.

Other fields of particular interest are for example market research, aimed at how to differentiate Nordic products from other products, as well as the effect and best solutions concerning eco-labelling. Cooling of fresh products and utilisation of raw material are also quite important and allow for improvements on a Nordic level.

### **What kind of innovation instrument would be most effective in facilitating such cooperation?**

There are similar instruments proposed as for fishing gear, i.e.

- Creating a forum for cooperation i.e. for example by bringing together experts in fields such as optimisation, traceability, information systems, processing equipment and marketing.
- Creating a Nordic database containing projects related to processing and traceability.  
This would prevent people from “reinventing the wheel” and give experts ideas about improvements.

- Funding pilot projects that would bring together experts from each of the Nordic countries. It could be beneficial if it would include representatives from government, industry and research and include partners from more than only one link of the value chain. A successful pilot project would encourage stakeholders to work together on future projects

Innovation instrument should allow the industry to be committed to extensive research and development projects, 3-5 years, involving research institutions with lower self-finance from the industry than 50%.

## Aquaculture

The aquaculture sectors in the Nordic countries are quite different. Norway is by far the leading nation both regarding production volume and level/degree of innovation in production technology. Furthermore, the aquaculture sector in Norway differs significantly from fisheries in that the bulk of aquaculture companies are a) international conglomerates with production in several countries, b) big companies represent a large share of total industry production, c) has a higher degree of vertical integration and d) normally there is strong commercial department in the firms. The 2007 production volumes in the Nordic countries are shown in the table to the right (in thousand tons):

The figure below shows the aquaculture production volume of the Nordic countries since 1996, where the right side y-axis applies to Norway and the left side y-axis to the other countries. Apart from Norway with a production of approximately 830 thousand tonnes in 2007, there are two groups of countries regarding production volume, Denmark and Faroe Islands, producing some 30-40 thousand tonnes annually stand out from the other three Finland, Iceland and Sweden who are producing between 5-20 thousand tonnes annually.

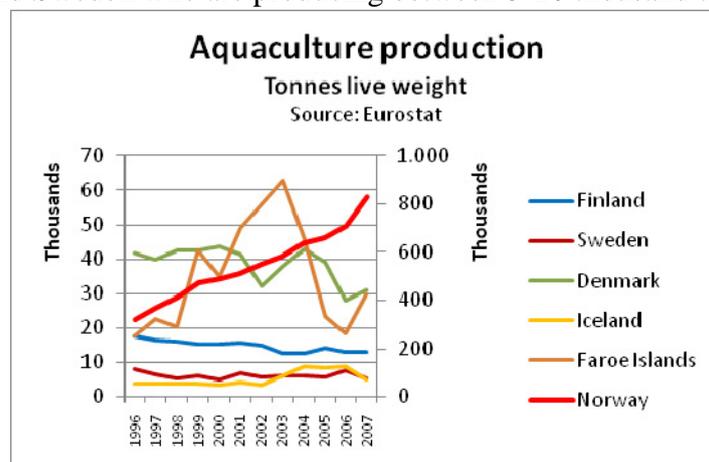


Figure 3: Aquaculture production of the Nordic countries since 1996

Production volume of the Norwegian aquaculture has been rapidly increasing over the past decade, while the other Nordic countries have seen a stable or downward sloping trend. The industry in the EU has seen a similar development, with stagnant or decreasing production volume, which has made the EU raise particular attention to this issue both in its former aquaculture strategy (2002) and its current strategy released earlier this year

The rapid growth of Norwegian aquaculture is largely due to an ability to invoke economics of scale in production, reduced cycle-times and not least scientific and technology

breakthroughs, such as large cages, vaccines and development in feed. The figure below illustrates this development (courtesy L. Horn, RCN) and, importantly, how close the innovations are linked to reduction in production costs; influencing strongly on prices and volumes traded. In short, innovations have made the success story of Norwegian salmon.

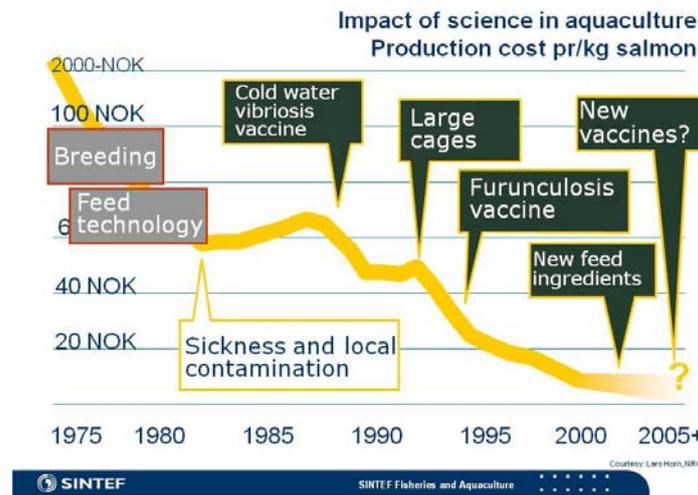


Figure 4: Impact of science on production cost in aquaculture

Aquaculture in the Nordic countries apart from Norway is on a very low scale. But, as the Norwegian case shows (also cases from other countries and regions such as pangassius and tilapia) growth in production is possible – there is therefore a market that could be developed for additional fish from the Nordic countries.

**Freshwater aquaculture** is a small industry in all the Nordic countries, with production volumes in the vicinity of 50 thousand tonnes in total, with Denmark as the exception producing more the 35 thousand tonnes, mainly rainbow trout. The Nordic countries seem to have different strategies and different goals related to for example volume, technology, species cultured, general R&D, R&D connected to new species, regulations and marketing. Sweden and Iceland for example, have their own breeding program for Arctic char, while Norway has not developed such programs. Production form and production volume are also very different - from earth ponds and seafarming to advanced recycling units. Although the Nordic countries have different strategies and goals they have also many similarities and common challenges.

Freshwater aquaculture could benefit from marine aquaculture - and there are synergies to be made in cooperation between marine and freshwater sector, for example through:

- increased knowledge about the survival and welfare of fish
- quality and product development
- development of food produced of sustainable raw material
- common/coordinated logistics
- coordination of marketing, common branding with a distinct Nordic profile

Especially for small farmers there is a need to improve farmers' ability to compete with low-cost aquaculture products originating from outside Europe

## What opportunities are in place?

The aquaculture sector is an important industrial sector in the Nordic countries which at present is challenged by global competition, technology changes and change in demand. Innovation is viewed essential cope with these challenges and to maintain a leading role and the competitiveness of the Nordic aquaculture industry. In the various countries there are national instruments to support innovation, knowledge and industrial development, but there is a need to align these instruments with the support and instruments from a Nordic level (and, indeed, likewise on EU level).

## Development lines

The steadily increasing pen size in aquaculture (160 metres circumference and up to 1000 tonnes pr pen presently in Norwegian salmon/sea trout) give rise to economics of scale but is only possible with a capacity to solve the associated challenges in technology, e.g. not all technology challenges with pens of this size have been solved (de-liceing is for example still a challenge). Therefore, in order to maintain the sustainability (economic, environmentally and socially) and competitiveness of Nordic aquaculture it is necessary to continue investments in RTDI. Below are listed a number of possible lines of development demanding new knowledge:

- Sustainability is becoming more and more important and is today a prerequisite for the industry.
- Effluents from the industry need to be controlled and a potential tool could be polyculture with production combining fish, muscles and seaweed. Polyculture is used extensively in Asian countries, but is only emerging in the Nordic countries. There is a need for further research in that area, regarding technology and specific species to be utilized.
- There is a need for innovation in development of cages for more exposed areas (offshore cages). Norwegians are doing some work in this area, are for example experimenting with submergible cages, e.g. due to waves, wind and algae blooming.
- There is a need for solutions for oxygen depletion, algae problems and turbidity.
- Tacit knowledge (dissemination). Knowledge in the sector needs to be extracted from those who are doing the best job. Some knowledge is tacit and there is a need to formalize it in order to transfer the knowledge to other units. Transfer of best practise is needed.
- There is a demand for more knowledge on feeding efficiency, both regarding technology and optimisation of feed volumes. This is an issue with multiple aspects, such as sustainability; cost efficiency, environmental impacts etc.
- There might be a scope for Nordic cooperation with regards to “genetic modification” i.e. developing fish with higher yields in the most expensive products, e.g. innovation in genetics towards preferred characteristics (for instance large loin, easy to process, little gaping, adapted to market demand, feed factor)
- Solutions for small scale farmers.
- New species
  - Use of hot water in Iceland to produce warm water fish e.g. sea bream and sea bass. Tilapia could also be an opportunity. Furthermore arctic char grows best in 15°C in Iceland.

- Other cold water species e.g. spotted catfish, halibut, sea urchin, and arctic char may benefit from ongrowing in warm/temperate water<sup>33</sup>.
- Processing technology / logistics: Processing development able to take into account difference between farmed and wild capture fish e.g. different morphology
- There is a societal wish for processing more domestically (non-EU Nordic countries) which may reduce some costs (for example reducing the transportation cost - about 50% yield for salmon) and possibly increase others e.g. increased tariffs.

Just with reference to the list above, it is clear that there are numerous opportunities in place regarding innovation in aquaculture. And further, there are constantly new materials being developed, software and hardware being created and we are getting more information on the animal life in the nets through remote sensing, information sharing and communication technology. The extant opportunities for innovation in aquaculture can be summarized under the following headlines that are addressing a number of challenges the sector is still facing:

- Environment
  - Competition for space; restrictions on use of space
  - Escapees
  - Animal health and welfare
  - Environmentally sound production
- Identification of and access to the best locations for production (also in weather exposed areas; offshore)
- Increased production efficiency (cost effectiveness) - Large production facilities/units
- Operational issues (e.g. heavy equipment handling under demanding weather conditions)
- Safety issues (people, fish, equipment) - Safe and efficient production platforms
- Energy (transport, lighting, operations)
- Ethical issues
- Development of technology for new species / new geographical areas
- New materials
- Integrated systems for documentation, control and decision support (ICT)
- Specialized vessels

### **Who are the most important stakeholders?**

There are many hundred firms operating within the aquaculture cluster in the Nordic countries, for instance in the following sectors:

- Farmers

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<sup>33</sup> 20-30% increase in production for the past few years in Iceland. Potentials are there, the markets have been the difficulties. The bulk of the production from Iceland is going towards the US. Need a lot of fresh water to produce i.e. opportunities for Iceland and Norway (Finland and Greenland?)

- Technology and material suppliers
- ICT
- Pharmaceuticals and Marine Biochemicals
- Feed producers
- Finance, insurance
- Research and education

Apart from the companies listed in the sectors above, processing companies of farmed fish, governmental bodies and NGOs are important stakeholders.

### **Drivers for cooperation**

#### **What is the international demand for technology and services under the specific theme?**

There is currently a substantial international demand for innovation concerning aquaculture. Issues particularly suited for Nordic cooperation are in summary form listed below:

- Climate change, because the issue is going to have a large impact on the sector. Therefore studies on climate change effects on Nordic aquaculture and Nordic adaptations are needed.
- There is a societal interest in knowledge, environment and sustainability. The consumer market is looking for objective knowledge about the product. We need to have formal and trustworthy information system to inform the consumer about those facts.
- Coexistence of large, small and niche production at the same market, innovation networks in need of support
- Mussels as “cleaners” and feed producers (Polyculture)
- Salmon culture as basis for further Nordic cooperation
- Cost effective feed production
- Health effects of seafood and marine mammals – bio prospecting
- Genetics and breeding (e.g. shellfish)
- Fresh water aquaculture – Recirculation. Re-circulation is also going to be an issue in farming technology of species such as Tilapia, Sea bream, Sea bass
- Fish health, welfare and disease control
- Reliable information to the consumers on health, welfare and environment (government responsibility)
- Cooperation in cod culture
- Cooperation in culturing “cheep Nordic Pegasus” – main component is inexpensive feed
- Differentiation in the market i.e. whitefish is not just whitefish (should be called by the species name)

#### **What is the scope and commercial interest for Nordic cooperation in addressing this demand?**

In general, there is a commercial interest tied to all transfer of know-how between the Nordic countries but given the Norwegian prominence within aquaculture farming technology there are an obvious interest in knowledge/technology transfer from Norwegian actors.

The focus for Nordic cooperation should be on topics where there are the greatest possibilities for Nordic synergies and complementarities. For example, Icelandic companies have very high competence and capabilities within processing whilst Norwegian farming companies process a very small fraction of their production into value added products domestically - therefore a scope for collaboration should exist and possibly there is a need for public seed money and initiatives to exploit this collaborative opportunity. Similarly, the high competence and capability of the Norwegian production (farming) sector is a clear case for knowledge (technology) transfer. For many years Norwegian aquaculture companies have exported their technology and established firms in Europe, South America and Asia. Not so much to other Nordic countries and this is an issue worthy of exploring.

### **What should be the Nordic focus and where are the possibilities for Nordic synergies and cooperation?**

The focus for Nordic cooperation should be on topics where there are the greatest possibilities for Nordic synergies and complementarities. Of those there are a number of subject fields where there are possibilities for Nordic synergies. For example, Icelandic companies have very high competence and capabilities within processing whilst Norwegian farming companies process a very small fraction of their production into value added products domestically - therefore a scope for collaboration should exist and possibly there is a need for public seed money and initiatives to exploit this collaborative opportunity. Similarly, the high competence and capability of the Norwegian production (farming) sector is a clear case for knowledge (technology) transfer.

### **What kind of innovation instrument would be most effective in facilitating such cooperation?**

- Strategic Networking
  - A network (ETP-like) focused on technology for biomass production in sea cages has been in existence since 2003: TEKMAR. A similar Nordic ETP-like network focused on seafood processing technologies should be established.
  - First years fully funded by Nordic funds and the idea is that after some time funding will also be coming from other sources. Industry pays for entering the network meeting, covering direct cost of each person.
- An aquaculture industry and research strategy panel should be established. The Panel should meet, discuss and recommend research avenues for funding (invitation only 20-30 experts)
- Network funding / Nordic funds could facilitate joint calls together with the Nordic Research Councils and/or FP7. Possibly utilizing the Joint Committee of the Nordic Research Councils for Natural Sciences and the equivalent Joint Committee for the Humanities and the Social Sciences.

## Conclusion

It is evident that innovation within the Nordic marine sector is considerable, but it is mostly restricted to national projects that are often specifically implemented on a single company basis, as majority of projects are industry driven. Multidisciplinary collaboration where government, research and industry cooperate on an international basis is rare in the sector, which is unfortunate because cooperation has synergistic effects. It is also a well known fact that the Nordic countries are variably advanced in different sectors of the industry, which creates opportunities for cooperation where each country could contribute by assisting the other countries in their expert field, for instance Norway in aquaculture and vessel design, Iceland in processing and traceability, Denmark in marketing, the Faroe Islands in development of fishing gear etc. Nordic innovation systems need to take this into account, by encouraging stakeholders in each field to work on projects regardless of their nationality and create a unified Nordic research and innovation area, parallel with the already established Nordic labour market. So, there is a potential; what is needed is powerful and well funded facilitating instruments on a Nordic level as complements to national instruments

A unified Nordic research and innovation area would enable more efficient sharing of resources, such as facilities and equipment, which are often not being capitalised as efficiently as possible. R&D companies in the marine sector are variable equipped to carry out necessary research and/or lack funding to use the available equipment. Examples of such equipment are research vessels, flume tanks, laboratories etc. Sharing of vessel time is an excellent example of how sharing of resources will benefit the industry and enabling more focused research projects, for instance on the effect of bottom trawling. Such cooperation on projects that require expensive equipment will lead to optimisation of resources.

Improved utilisation of human resources would also be achieved by creating a unified Nordic research and innovation area. This could for example be done by increasing information sharing amongst researchers, government and industry in the Nordic marine sector and enabling experts (and other stakeholders) to focus on their field. A cooperative database on ongoing research and finished projects would hinder scientists from “reinventing the wheel” and make it easier for those interested to identify experts in particular areas.

Industrial R&D projects, where the participants are working close to the final commercial product, often return better results, with respect to innovation, than projects that do not return concrete economic profits. It would increase innovative efficiency if government, research and industry worked more closely together on every level of R&D, considering each project a link in a chain that leads towards a common goal. It is therefore recommended that policy makers incorporate multidisciplinary stakeholders into projects and encourage a more comprehensive view on projects.

In order to increase opportunities for cooperation in the sector on a Nordic level, interested parties need to have an opportunity to meet and/or interact with potential partners. An example to enhance this is a Norwegian program, TEKMAR, which has been initiated for aquaculture. Such a program creates a venue where stakeholders in a specific field can meet, share information and initiate projects. Facilitating Nordic workshops and conferences where experts in each subsector (fishing gear, aquaculture, processing and traceability, and marine

biochemicals) could participate in would undoubtedly contribute to increased cooperation and attract stakeholders that are faced with similar challenges and objectives.

Contribution to innovation programs in the form of labour, expertise, facilities and equipment can be more effective than only direct financial support. Allocation of vouchers is an interesting option that can benefit the industry substantially and optimise the available funds. Allocation of vouchers is an approach that Canadian authorities have implemented with a good experience, particularly in order to link research companies with industry. The vouchers are only valid in approved companies or institutions. A Nordic implementation of a voucher approach would improve the availability of resources that are of unequal supply in each of the Nordic countries.

This report primarily addresses research, science and technology based innovation. It is pressing to note that this does not negate innovations stemming from other knowledge bases, i.e. business models, innovative business to business cooperation. On the other hand, collaboration between different fields, for instance marketing and processing gear, should be enhanced. This also applies to pan-Nordic business cooperation, which should be enhanced. Therefore, programmes aimed at increasing the competitiveness of Nordic seafood industries by providing facilities for networking among industries as well as contributing with research, marketing and strategic knowledge and competence should be initiated. All this will increase the industry's ability to obtain long term goals and leave the companies in the Nordic marine sector with better competitive positions and profitability.

Issues regarding the four subsectors are as follows:

### ***Fishing gear***

This report identifies the vessel, with all of its equipment, as a part of the fishing gear. Multidisciplinary approach is needed when concluding on opportunities for increased innovation. The most pressing challenges in the sector are related to cost reduction, environmental impact, sustainability and quality of the catch. These issues can only partly be solved by focusing on the fishing gear itself (trawls, lines, nets etc.). Optimal energy efficiency will for example not be achieved only by focusing on fishing gear technology; fleet management and vessel technology are just as important.

The numerous approaches to solving challenges in this sector make it even more important to cooperate; not least because the Nordic countries are variable advanced in the sectors that can contribute to success. Making stakeholders aware of ongoing R&D in each of the Nordic countries, by creating a database, would benefit the sector as a whole. Developing Nordic forums for parallel stakeholders in each country would enable more synchronized development of national (and Nordic) strategic research agendas.

### ***Aquaculture***

In general, there is a commercial interest tied to all transfer of know-how between the Nordic countries but given the Norwegian prominence within aquaculture farming technology, there is an obvious interest in knowledge/technology transfer from Norwegian actors. The focus for Nordic cooperation should be on topics with good possibilities for Nordic synergies and complementarities.

Increased collaboration on processing of farmed fish should be enhanced, for example by utilising Icelandic know-how in Norway, and thereby increasing the production of value

added products. Similarly, the high competence and capability of the Norwegian production (farming) sector is a clear case for knowledge (technology) transfer, for instance to Iceland, where fish farming has not gained strength, despite favourable natural conditions and considerable efforts. For many years Norwegian aquaculture companies have exported their technology and established firms in Europe, South America and Asia, so export of know-how to other Nordic countries should be straight forward.

### ***Marine biochemicals***

The Nordic countries have the possibility to become a leading party in processing and marketing of health products in the future. It is important to build a knowledge bridge between the food industry and the research groups from universities and research institutions. Program of network and pilot projects, based on the cooperation between the different groups is the only way towards success. Cooperation between the Nordic countries is a necessity in a such a program.

It is urgently needed to get a better overview of the research and innovation activities going on in the Nordic countries with main focus on leading centres in Norway, Iceland and Denmark. This could be achieved through a follow-up knowledge based network establishment with the purpose of formulating a Strategic Research Agenda for Nordic collaboration within the area. The network should have industrial partners participating for obtaining close connection between research and industrial application. This would enhance an optimal innovation for all stakeholders involved.

### ***Processing and traceability***

It is technology development that is considered the most important concerning innovation in processing and technology in the Nordic marine sector. A general strategy, in order to enhance innovation within the field would be the foundation of a Nordic marine Technology platform, focusing on processing and traceability (capacity building). This technology platform should not only include “hard” technology specialists, such as gear and software specialists, but also people with hands-on knowledge regarding marketing issues and the issues arising in that field. Experts on fisheries management should be included, since collaboration between different links in the value chain is a vital issue to obtain optimal value through the whole chain, and there is a need to increase the collaboration and understanding between people responsible for advice regarding fisheries management, fishers, managers of processing and R&D staff in processing.

Other, more focused remedies aimed at increasing innovation in the processing and technology field are the following:

### ***Downward value chain approach***

Emphasis needs to be put on Nordic collaboration to enhance the image of Nordic seafood being produced in environmentally concerned manner. Safety and health of the products is a key issue and so is the cost of production. Innovation needs to take into account different possibilities for solutions, the whole value chain, the views of the society, as well as economic and environmental issues. This can only be achieved with a multidisciplinary approach, including for example software solution providers for the value chain, such as developers of decision support systems and information systems.

### **Aquaculture and processing collaboration**

As proposed earlier, more collaboration between R&D partners in aquaculture on one hand and processing and traceability on the other hand is proposed.

### **Wild caught fish**

Wild caught fish will face numbers of challenges in the nearest future. The fisheries management of EU (Common Fisheries Policy; CFP) has failed almost completely, resulting in number of species threatened to become extinct. Emphasis should be put on serving the future need of the wild caught fisheries sector, for instance:

1. The need of cutting cost of acquiring raw material
2. The need for another market position than other whitefish, for instance fast growing, farmed species like Tilapia.
3. The need to improve and document better handling of the environment, in relation to harvesting/fishing, handling onboard and processing.
4. Social pressure, which will constraint the possibilities of the fisheries value chains to increase effectiveness.

### **Opportunities for collaboration in the Nordic marine sector**

There are numerous opportunities for collaboration in the Nordic marine sector. The Nordic countries need to realise that they have mutual interests and they do not benefit from competing amongst themselves. To most of the world the Nordic countries are seen as one unit, and that is what it needs to be in regards to the marine sector. Threatening competition is coming from other parts of the world, which the Nordic countries should unite against and turn it into opportunities; working on solutions together increases the possibility of a success. It has been far too common that the research society has been working on the same things in each of the Nordic countries, thus reinventing the wheel again and again. This could be avoided by increasing communication and data sharing. Initiating joint programs and joint calls would also undoubtedly increase efficiency, as it is known that the countries are variable advanced in each subsector of the industry.

Improved collaboration in the Nordic marine sector is not just about cooperation between countries, it also needs to be multidisciplinary across all sectors i.e. government, research and industry. This multidisciplinary approach has often been missing in the past, not only on a Nordic level but also on national level.

### **What areas of the marine sector are the most interesting for Nordic collaboration**

The most promising areas for cooperation in the Nordic marine sector are in fishing gear technology (harvesting technology), marine biochemicals, processing and traceability, and marine biochemicals. The Nordic countries are variable advanced in these different sectors of the industry, as Norwegians are for example experts in aquaculture and vessel design, Icelanders in processing, Danes in marketing, the Faroese in application of traceability solutions, Finland in communication technology etc. This should be taking advantage of by allowing each country to focus on what they do best. The processing industry in Norway could therefore benefit by initiating projects with R&D companies in Iceland, Icelandic

seafood producers might take advantage of Danish marketing expertise, the Danish catching sector could work with Norwegian vessel designers and Faroese traceability experts etc.

Examples of interesting collaboration opportunities:

- Iceland: Increased aquaculture, using available hot water and expertise from Norway
- Iceland: Use of inexpensive and environmentally friendly energy for drying or other high energy processing using engineering know-how from Denmark, Sweden and Finland.
- Norway: increased processing of farmed fish.
- Development and implementation of remote sensing and communication technology: Using expertise from Finland (e.g. Nokia), Sweden (e.g. Ericson) and passably Canada (e.g. MarPort).
- Management of the whole value chain: Utilize traceability systems and communication technology in cooperation with industrial partners. Using ICT to suggest where and when to get the best raw material, with the least amount of effort, whilst minimizing the impact on the environment. Traceability is then used to authenticate the chain of custody.

### **How can Nordic collaboration contribute to the development in marine innovation in the European Union?**

The Nordic countries are world leaders in implementing sustainable fisheries management. Collaboration with the EU on the Common Fisheries Policy is therefore of the utmost importance. Same applies for the discard problem, which is a major problem inside the EU. The Nordic countries are major suppliers of technology for management of the value chain, they are therefore important solution providers for the EU regarding fisheries, processing, governmental bodies and other resources i.e. input into fisheries management (result based fisheries management).

European cooperation should be encouraged. The Nordic countries should emphasise their focus regarding the marine sector for the European community, and encourage establishment of EraNets via Nordic delegates in FP7 program committee, KBBE (Knowledge Based Bio Economy) network and SCAR (Standing Committee on Agricultural Research).

### **Challenges facing innovation in the Nordic marine sector**

The world wide ongoing economic downswing creates challenges for the Nordic marine sector as a whole, since Nordic marine production is of high value and needs strong buying power of consumers. There will inevitably fierce competition on the high-end of the market for seafood products and therefore the Nordic countries need to differentiate from the rest, but at the same time focus on low cost production to be able to compete with less expensive Asian and African farmed fish. This will be challenging for innovation and the Nordic countries have to be innovative in order to be competitive.

Environmental challenges will continue to mark the marine sector, producers, R&D companies and governmental bodies.

The different attitude of the Nordic countries towards risk, workload and more factors can also create challenges. Given the economic disaster in Iceland, it may be rationalised that the “Icelandic way”, giving little attention to risk, is not the way forward. Innovation will however never thrive in no-risk environment, so too much caution will not enhance innovation.

The risk phobia of investors, due to the economical situation, is a challenge. Innovation requires “patient capital”, so uncertainty on financial market will point the interest of investors to more certain investments than innovation.



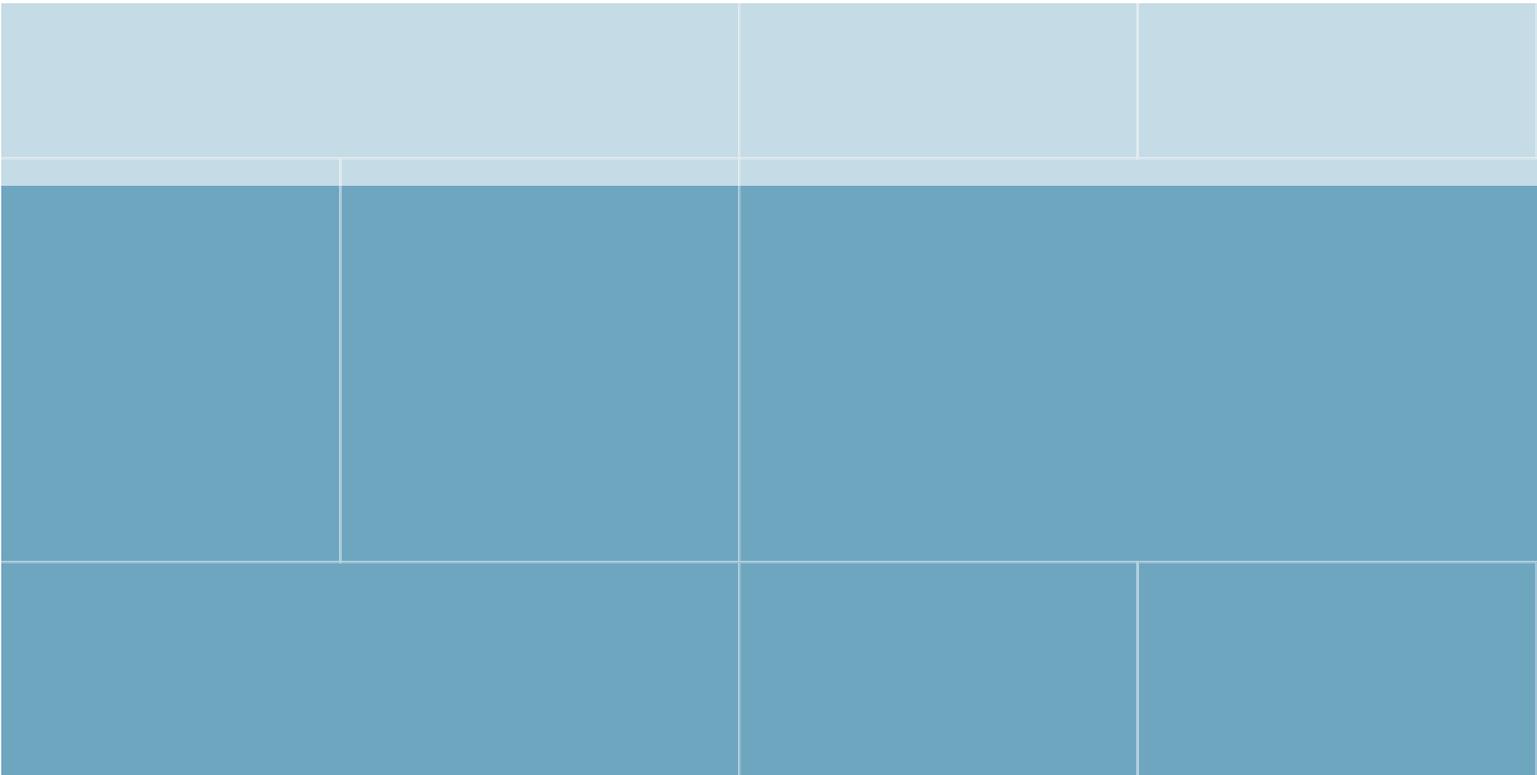
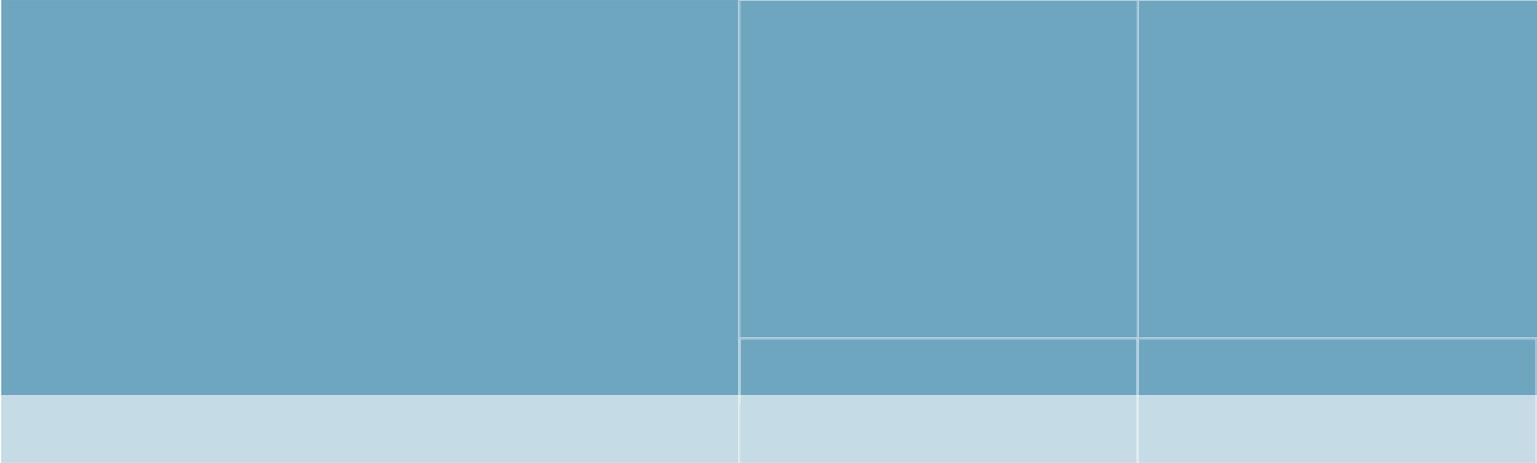
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