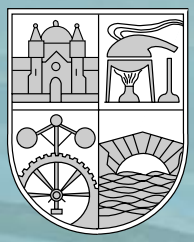

Exploitation of Marine Living Resources – Global Opportunities for Norwegian Expertise

Report from a working group appointed by

The Royal Norwegian Society of Sciences and Letters (DKNVS)
and Norwegian Academy of Technological Sciences (NTVA)

2006

Publisher

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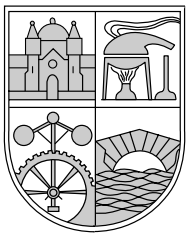

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Preface

In 1999 The Norwegian Academy of Technological Sciences (NTVA) and The Royal Norwegian Society of Sciences and Letters (DKNVS) published the report[1] "Norges muligheter for verdiskaping innen havbruk" ("Norways opportunities for added value in the biomarine industry") concentrating on, and describing, the national opportunities in developing and exploiting biomarine resources. During the six years that have passed since the report was published, the biomarine industry has received increased international attention. This report is a follow-up study of the previous report aiming at a closer look at the Norwegian opportunities for growth and development in an **international** perspective. Focus is put on the production and export of Norwegian biomarine expertise as a product like the production and export of fish.

Behind the report are a steering committee and a working group. The working group met 4 times and SINTEF Fisheries and Aquaculture have been responsible for the secretariat.

On behalf of NTVA and DKNVS I want to thank authors, working group, secretariat and sponsors:

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[1] http://www.ntva.no/rapport/havbruk.pdf

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On behalf of the publisher Trondheim August 2006

Asbjørn Rolstadås
Chairman of Steering Committee

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1 Summary

In 1999 The Norwegian Academy of Technological Sciences (NTVA) and The Royal Norwegian Society of Sciences and Letters (DKNVS) published the report "Norges muligheter for verdiskaping innen havbruk" ("Norwegian opportunities for added value in the biomarine industry"), concentrating on, and describing, the national opportunities in developing and exploiting biomarine resources. The report attracted attention from the industry and from politicians and other decision-makers.

The report identified a huge potential for the Norwegian biomarine industry, and one of the important pre-requisites for exploitation of this potential is competence or expertise. Expertise is crucial for further development of the marine sector.

This report will follow up the report from 1999 by examining more closely the global possibilities for Norwegian expertise within the marine living resource industry.

Mandate

Based on the current situation in the Norwegian fisheries- and aquaculture industry, the committee shall study and describe the global opportunities for the Norwegian biomarine cluster, including aquaculture, fisheries, fish processing, suppliers and marine bioprospecting, this will be referred to here as the marine industry. The committee shall concentrate on global possibilities for the Norwegian expertise within the marine industry.

Opportunities for Norwegian expertise in marine industries – areas and values

The report has pointed out areas of special interest with the view to increase the creation of value based on export of Norwegian expertise from the marine industry. The working group has based their selection of areas on two main principles;

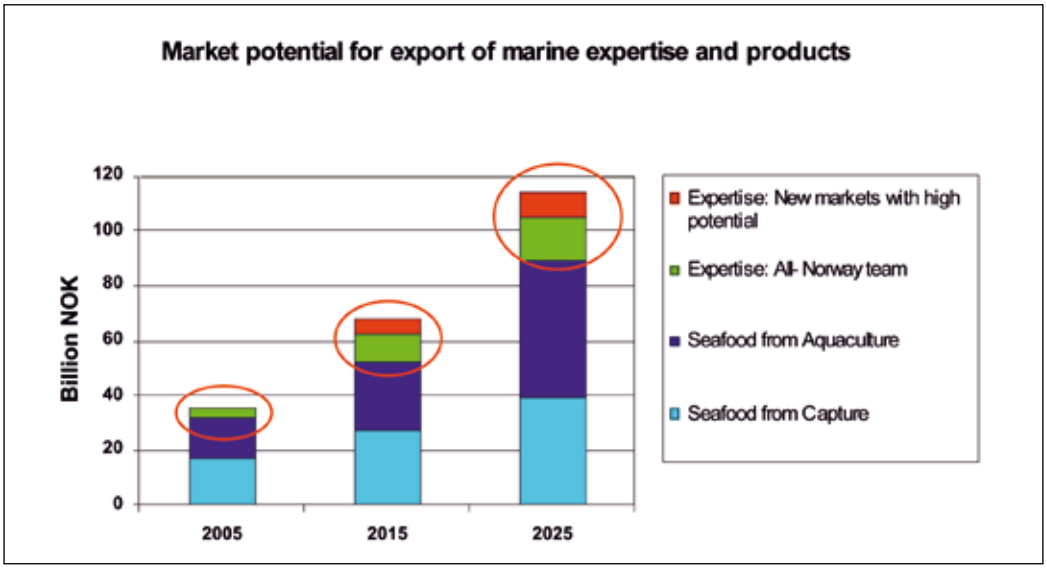
1) **The All-Norway team.** In selected areas, Norway is already established as a reputable supplier of technology and competence on the global market. These areas are focused below and should, in the interpretation of the working group, be strengthened.

2) **New markets with high potential.** In some areas the Norwegian marine industry is very well established and developed at a national level. Due to global tendencies and development, the working group thinks that in some selected areas, opportunities for the Norwegian marine industry are present.

The table below shows the possible potential for the export of marine expertise and products. We emphasise that this is the most interesting area from the working group's point of view.

	Area of expertise	Export potential in 2025 billion NOK
Expertise: New markets with high potential	Industrial farming of marine species By-products – higher exploitation ratio Bioprospecting New feed raw materials and fish feed formulae Sustainable fisheries Logistics, traceability and food safety	**10**
Expertise: The All - Norway team	Farming of salmonids Fishery technology Expertise-based resource management	**15**
Total expertise		**25**
Seafood from Aquaculture		**50**
Seafood from Capture		**40**

Today the export value of **"Expertise"** makes up 10% of the total marine export value. There is a potential to increase this to 25 % by 2025 and make "Expertise" an important contributor to the value-added chain together with the traditional export of seafood products.



As the table and figure shows the possible export potential for Norwegian marine expertise is estimated to 25 billion NOK[2] in year 2025; 10 billion NOK from expertise within new markets and 15 billion NOK from expertise within the All-Norway team. It is difficult to make a precise estimate, but this is considered as rather conservative.

Recommendations
In order to reach the export potential of 25 billion NOK of marine "Expertise" it is crucial that Norway continues to be at the leading edge technologically with our own production, since this is what makes our expertise interesting and demanded. FAO predicts an increase in the global aquaculture production of 2-3 times today's production by 2030. The main part of this increase is expected to come from industrial aquaculture, exactly where Norway has its main expertise. These future perspectives make up a large market potential for marine expertise from Norway.

The working group recommends that the government, the marine industry (research institutions included) and the public support system establish a national strategy with the main objective to increase the export of Norwegian marine expertise. The government has to take a leading role in working out the strategy.

An important part of the strategy work is to establish an acceptance that the export of expertise is equally important as the export of fish and fish products. The export of expertise needs to be considered as a legitimate export article.

In brief, the important elements in the strategy should be:

- Intellectual Property Rights (IPR) Strategies
- Investments in human capital
- Strategic alliances at both international and national levels
- Be attractive to industrial and long-term capital
- A public support system better organized /tailored for supporting export of marine expertise

There is a need to develop such a national strategy more in depth and to make sure it is orientated in line with the needs and desire of the industry.

[2] EUR = NOK • 0,12.

2 Introduction

2.1 Mandate

Based on the current situation in the Norwegian fisheries- and aquaculture industry, the committee shall study and describe the global opportunities for the Norwegian biomarine cluster, including aquaculture, fisheries, fish processing, suppliers and marine bioprospecting, this will be referred to here as the marine industry. The committee shall concentrate on global possibilities for the Norwegian expertise within the marine industry.

Interpretation of the mandate:
The analysis will focus on the existing expertise base within the Norwegian marine industry and its global possibilities. The primary goal is to increase the value added in the Norwegian marine industry by increasing the export. The marine industry is here defined to include all from producers of seafood to suppliers of goods and services including research and governmental institutions. The marine industry can be understood as exploition/use/utilization of living resources of the ocean.

Expertise is here understood as know-how essential for the development of the Norwegian fisheries and aquaculture industry, and which has been accumulated and/or developed in Norwegian marine research institutions, companies and governmental and non-governmental organizations.

2.2 Previous work

In 1999 The Norwegian Academy of Technological Sciences (NTVA) and The Royal Norwegian Society of Sciences and Letters (DKNVS) published the report "Norges muligheter for verdiskaping innen havbruk"("Norwegian opportunities for added value in the biomarine industry")(DKNVS and NTVA 1999), concentrating on, and describing, the national opportunities in developing and exploiting biomarine resources. The report attracted attention from the industry and from politicians and other decision-makers.

The main conclusions from this report were briefly:

- Norway has several natural advantages within the marine industry, such as large volumes of clean and protected inshore/near shore water, a healthy climate for production of high-grade seafood and large areas for growing marine plant biomass. The marine industry is sustainable.

- With the expected population increase, the need for high-grade protein produced in a sustainable manner will increase strongly. Access to water and farming areas can, however, be restricting factors for sufficient production onshore. The production of healthy food from the ocean will therefore be an important supplement, especially in the long term.
- The Norwegian marine industry has good premises to be internationally competitive when it comes to supplying food, energy and raw materials in a sustainable manner, also in a strongly globalised world.
- The potential for added value of an extensive Norwegian marine industry shows that it is on the order of size of the oil industry.
- If government support is comparable to that used for developing the oil industry, the added value from the marine industry will fully compensate for the future decrease in the oil revenues.
- Research and development is crucial for success, and it is suggested that Norway have a strategic framework for the development of the Norwegian marine industry like the EUs Framework programs.

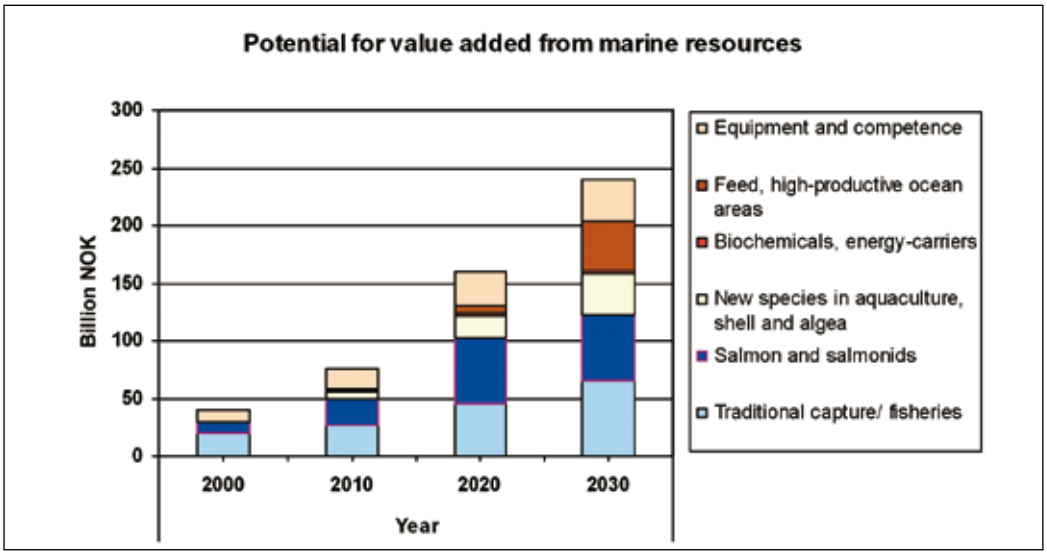


Figure 1. Potential for value added from marine resources. Source: NTVA/DKNVS.

The report identified a huge potential for the Norwegian marine industry and, as the last bullet point emphasizes, one of the important prerequisites for exploitation of this potential is competence or expertise. The expertise is crucial for further development of the marine sector.

This report follows up the report from 1999 by examining more closely the global possibilities for the Norwegian expertise within the marine industry.

2.3 Definitions

Definition of marine industry – The marine industry should be understood as all enterprises which utilise the production potential of the marine living resources in a sustainable manner. This includes enterprises in aquaculture, fisheries, fish processing, suppliers of goods and services, marine bioprospecting industry, research institutions and governmental institutions.

Definition of expertise – Expertise is here understood as special skills or knowledge essential for the development of the marine industry. This expertise has been accumulated and /or developed in Norwegian marine research and educational institutions, companies and governmental and non-governmental organizations.

Products and services – Products should be understood as solid objects (materials). Services should be understood as sale of expertise – the expertise can either be linked to a product (in e.g. support functions) or the expertise/knowledge needed to develop new solutions/ideas/constructions. Often this expertise is materialised through innovation of new products, solutions etc.

2.4 Expertise-based value

The figure below illustrates the marine industry, with the core activities in the middle, the direct suppliers and the research and educational institutions surrounding it.

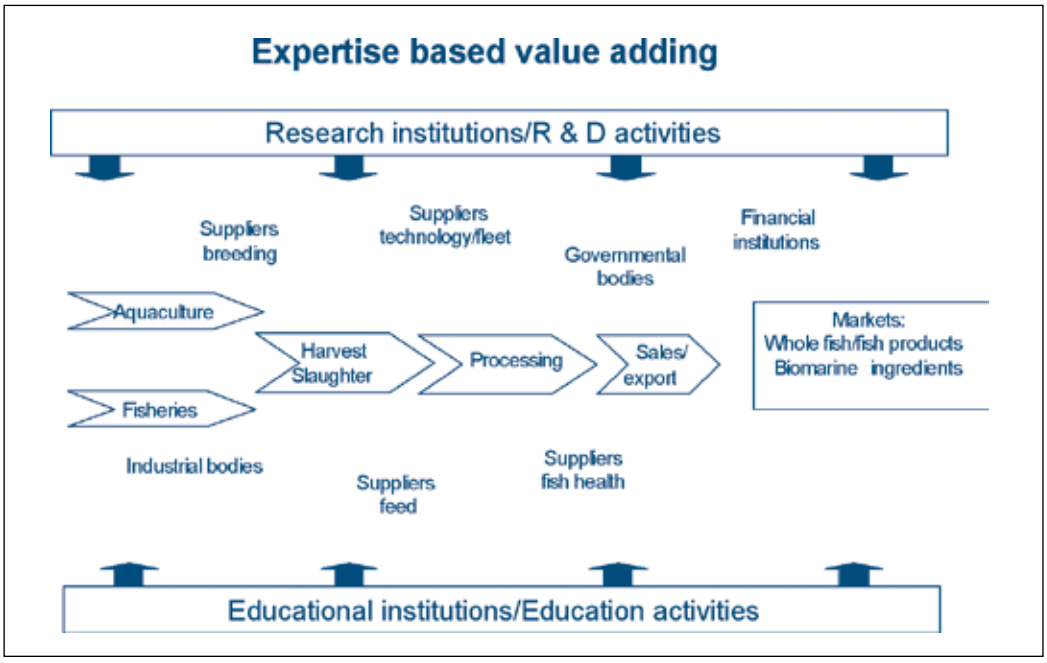


Figure 2. Expertise-based value adding. Source: SINTEF.

A study made of the innovation system in the Norwegian Aquaculture Industry shows that the direct suppliers to the industry act very often as a connecting link between the industry and the research or educational institutions, other knowledge intensive services, governmental and industrial bodies (see figure 3), (Aslesen 2004). The suppliers have traditionally been the buyers of research and development services (R&D), while the industry traditionally has initiated little R&D themselves and rather "bought" knowledge through the suppliers. This picture is changing today. With structuring of the industry leading to larger companies, more R&D services are bought and ordered directly by the industry.

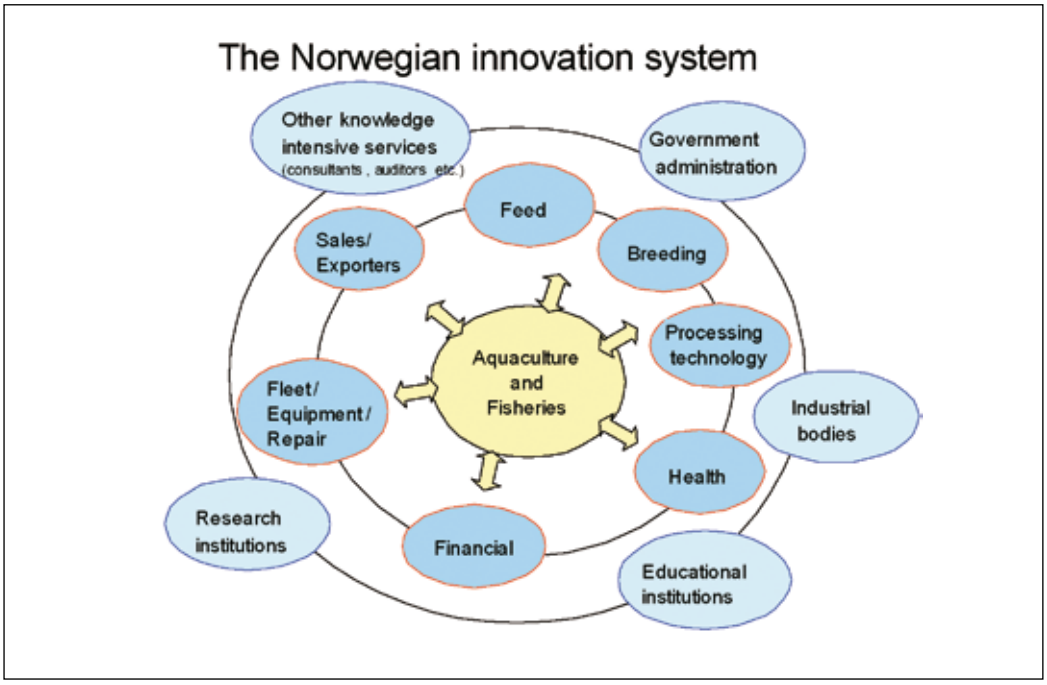


Figure 3. The innovation system in the Norwegian aquaculture and fisheries industry.
Source: (Aslesen, Mariussen et al. 2002).

Several Norwegian Aquaculture companies are on the stock market and this has drawn the capital market closer to the industry. We also see that the industry has been attractive for expertise and, together with governmental administration and industrial bodies, they have all been drawn closer to the core activities of the industry (Sundnes, Langfeldt et al. 2005). Within the Norwegian marine industry the aquaculture industry has been the major driving innovative force in recent years.

We have made an attempt to group the different parties of the value-added chain and to define their main deliveries.

Table 1. Parties of the marine value-added chain and their deliverables

Parties of the value-added chain	Products	Services
Core activities:		
Fishing fleet (fisheries)	X	
Aquaculture producing sector	X	
Processing (main product)	X	
Processing (by-product)	X	**(X)**
Sales/marketing	X	**(X)**
Suppliers (direct and indirect):		
Technology (vessels, equipment etc.)	X	**(X)**
Breeding products	(X)	**X**
Feed	X	**(X)**
Fish health	(X)	**X**
Financial		**X**
Research institutions		**X**
Educational institutions		**X**
Other knowledge intensive services (consultants, auditors etc)		**X**
Industrial bodies (organisations)		**X**
Governmental administrations		**X**

The core activities of the value-added chain are mainly delivering products. In this report we focus on the grey part of the table, the "suppliers" to the core activities in the marine industry. They are all delivering services (immaterial products) to the core activities, for some of them this is accompanied by, or part of, a product.

If we shall increase the export of Norwegian marine services to the global market the possibilities are best for the grey shaded part of the value-added chain– namely for the direct and indirect suppliers (see Table 1).

The importance of the Norwegian fisheries and aquaculture industry today

In Norway there are annually about 25 000 man-labour years in the core activities in the fisheries and aquaculture industry, including the fishing fleet, aquaculture sector, fish processing and sales. It added a value, defined as the contribution to gross national product (GNP), of about 16 billion NOK and a turnover of 50 billion NOK in 2004 (Sandberg, Olafsen et al. 2005).

The activity in the core activities, mentioned above, supported 23 000 man-labour years, a value of 14,5 billion NOK and a turnover of 36 billion NOK in other supplying Norwegian industries (multiplier effects). Many of these supplying industries are shown in the grey part of Table 1.

All in all, the entire importance of the Norwegian fisheries and aquaculture industry was 48 000 man-labour years, an added value of around 30 billion NOK and a turnover of 86 billion NOK in 2004.

Marine R&D personnel
In 2003 1 600 researchers, scientific personnel and specialist employees were engaged in marine R&D in Norway. They worked within the Institute sector, Universities and Colleges and in the industry (Sundnes, Langfeldt et al. 2005). As we already have mentioned, around 6% of their work was financed by foreign sources. This means that around 96 persons within the Norwegian marine R&D were directly financed by foreign sources in 2003.

2.5 The Norwegian marine expertise

The global challenges in regard to increased aquaculture production and development of sustainable fisheries in many ways make up the market for Norwegian marine expertise. The expertise Norway shall sell to other parts of the world has to be within areas we master and preferably where we are among the best in the world. The expertise needs to be competitive in a global market.

In the development of the Norwegian marine industry, the concept of competitive power is central and acts as a premise for further development of the domestic industry. It is therefore necessary to look closer at this concept. Competitive power is created through the advantages an industry or single party is able to create relative to its competitors. There are a large number of factors influencing the competitive power, from natural conditions, framework conditions, expertise/competence and innovative skill, infrastructure, capital and market conditions. **In this work we have chosen to concentrate on looking closer at how marine expertise can be sold as a product on its own in the global market, in addition to being part of the competitive power of the Norwegian marine industry.**

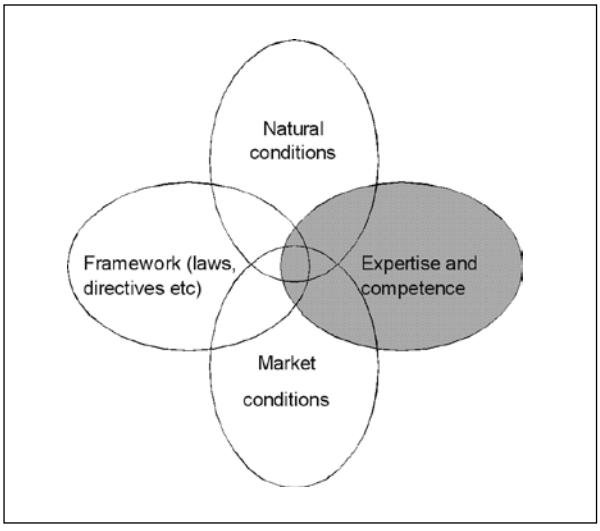


Figure 4. Competitiveness in Norwegian Aquaculture. Source: Based on Porter.

As mentioned earlier and as figure 4 shows, the product "Expertise" is a part of our native industries' competitiveness and may be one of the advantages Norway has compared to many of its competitors.

Unlike many other countries, the Norwegian marine industry has several regional clusters. These clusters often include aquaculture and fisheries companies (fish farmers, fishing vessels, processing and sales), feed and equipment suppliers, R&D institutions, regional government and others. These clusters are important because they can give competitive power if one is able to utilise the collaboration.

What does the Norwegian marine industry export today?
The estimated export value from the marine industry is 35,8 billion NOK in 2005.

Today, the main export product is fish. The value of the exported fish and fish products from Norway was about 32 billion NOK in 2005, approximately 17 billion NOK from wild catches and 15 billion NOK from aquaculture of salmonids. In year 2006 the export value of aquaculture products is expected to exceed the value from wild catches.

The rest of the export value, 3,8 billion NOK, comprises deliverables from "Suppliers", "Research, Development and Educational institutions" and "Other knowledge-intensive services" – the grey part of Table 2 - and what we in this report refer to as marine Expertise.

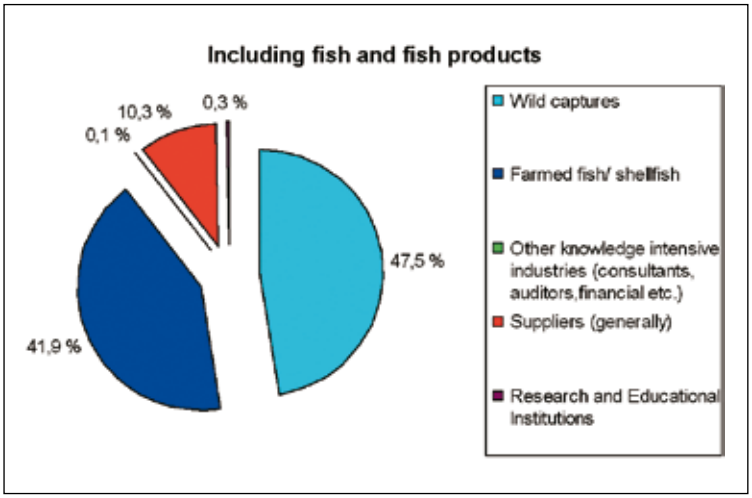
Table 2. Estimates of export value for the Norwegian marine industry in 2005

Parties of the value-added chain	Products	Services	Export value Million NOK
Seafood products:			
Fisheries	X		**17 000**
Aquaculture	X		**15 000**
Expertise:			
Suppliers (generally)	X	(X)	**3 700**
Research, Development and Educational institutions		X	**98**
Other knowledge intensive service activities (consultants, auditors, financial etc)		X	**25**
Industrial bodies (organisations)		X	**0**
Government administrations		X	**0**

Source: TBL, EFF, (Norconsult & Hartmark Consulting 2006), NLTH, personal information.

Based on information from the industry, we estimates the export figures of Norwegian **Suppliers** of equipment and vessels to the fisheries and aquaculture industry to be around 3,7 billion NOK. This includes the export of equipment, fishing vessels, breeding products, fish-health products etc. Value added in for instance the feed industry in other parts of the world, based on Norwegian competence and technology, is not included. The 3,7 billion NOK is likely underestimated due to poor statistics.

The marine **Research and Development institutions** (including Universities and University Colleges) in Norway had a total R&D contribution of 1,7 billion NOK in 2003, approximately 6%, or 98,4 million NOK, of these expenditures were financed by foreign parties or the EU (Sundnes, Langfeldt et al. 2005). We here define the R&D financed by foreign sources to be the export value of marine R&D. The **Educational institutions** accept and educate foreign personnel within the marine discipline. This is usually financed by Norwegian development aid and therefore not considered export value. Exchange of scientific personnel is rising and often financed through EU-projects, this is included in the figures.



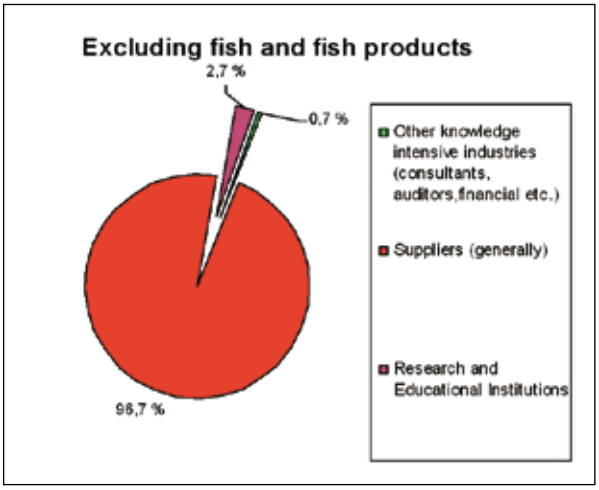


Figure 5. Share of Norwegian export value within the marine industry (in %). 5a. Including fish and fish products. 5b. Excluding fish and fish products.

The estimated export value of **Other knowledge-intensive services** (e.g. consultants, legal, accounting, auditing, tax consultancy, market research, business management) toward the marine industry is 10 million NOK of a total turnover of around 150 million NOK (Aslesen 2004). In

addition, the export value from the financial institutions is estimated to 10-20 million NOK. Based on these two information sources we estimate the total export value to 25 million NOK. The performers within the financial institutions say that the sale towards foreign marine customers is very marginal. They say their main expertise has been within aquaculture and that this is mostly a native market.

The industrial and governmental bodies and administration do not have any export value.

As Figure 5a shows the export of suppliers make up approximately 10% of the total export value of the Norwegian marine industry (including fish and fish products). When we leave out the fish and fish products (Figure 5b) we see that the suppliers by far have the largest export values, the other knowledge intensive services and research and educational institutions represent only 4% of the turnover.

All in all the estimated export value from the Norwegian marine industry in 2005 was 35,8 billion NOK including fish and fish products and 3,8 billion NOK excluding fish and fish products.

For comparison, the export value of the Norwegian petroleum sector was 346 billion NOK in 2005 (crude oil, natural gas, suppliers etc.) or 10 times more than the export value of fish and fish products. The turnover of the **petroleum supplier industry** is estimated to around 50 billion NOK in 2005 (Heum, Kristiansen et al. 2006). 60% of this international supplier turnover is export from Norway, while 40% is sales through established subsidiary companies abroad.

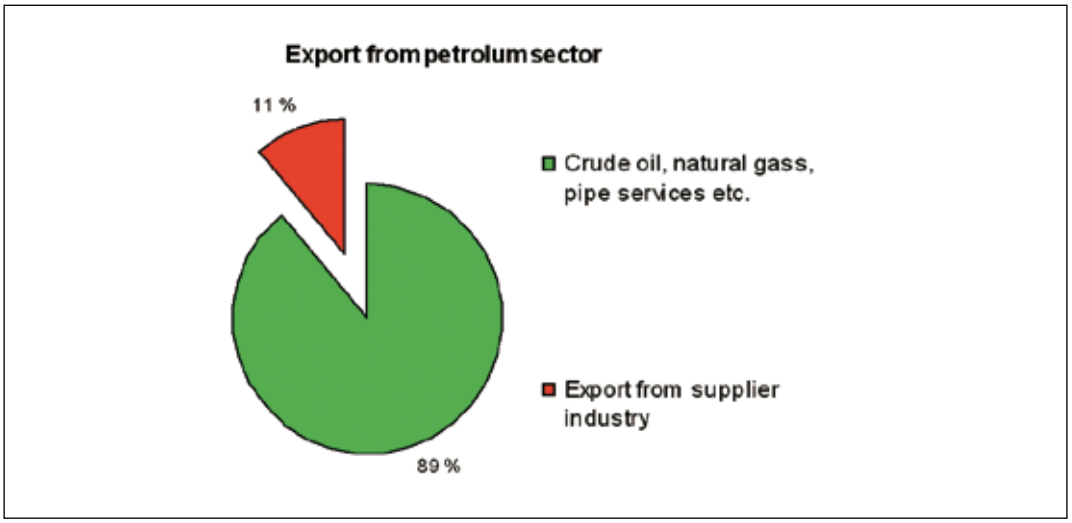


Figure 6. Norwegian petroleum export in 2005. Divided in suppliers and raw material share (in %).

Norwegian suppliers of oil- and gas technology have established a collaboration network – INTSOK - and the main objective is to support the member organisations in their effort to increase export of goods and services. INTSOK is working closely with the public support system. The budget was 30 million NOK in 2004 and where 15 million came from the government budget.

Existing Policy instruments

There are some policy instruments that aim to increase export from the Norwegian marine industry (see the list of the "organisations" and their instruments below). We have focused on the organisations/administrative bodies that have strategies followed by policy instruments (cash).

- **EFF - Norwegian Seafood Export Council** – Administers 50 million NOK per year for promotion of Norwegian fish and fish products.

- **Eksportfinans** – The Norwegian export credit agency – provides financing for exports of Norwegian capital goods and services. It can offer both governmental supported export credits and loans for a wide spectrum of Norwegian exports.

- **Innovation Norway** – provides some funding for stipends and loans for internationalisation (e.g. IFU and "Match making" programme in south Africa, India and Sri Lanka).

- **The Research Council of Norway (RCN)** – considers internationalisation a strategic tool to strengthen scientific quality, increase cooperation and financing from abroad and enabling Norwegians to generate and bring home new knowledge as a prerequisite for innovation and development of global competitive industries. RCN support international research through the EU Framework Programmes, where research institutions and companies can apply for funding. They also fund mobility of research personnel.

In addition, there exist other, more general financial instruments (Norad, UD and other ministries, Norfund, GIEK) which are not specifically directed towards the marine sector.

3 Global outlook

Global production from capture fisheries and aquaculture supplied about 101 million tonnes of food fish in 2002[3], providing an apparent per capita supply of 16.2 kg (live weight equivalent), with aquaculture accounting for the growth in per capita supply since 2000 (FAO 2002).

In 2002, total capture fisheries production amounted to 93.2 million tonnes. During the past decade, the reported landings of marine capture fisheries have fluctuated between 80 and 86 million tonnes (average 1993–2003, 84 million tonnes), a slight increase over the preceding decade (average, 77 million tonnes).

According to FAO statistics, the contribution of aquaculture to global supplies of fish, crustaceans and molluscs continues to grow, increasing from 3.9 percent of total production by weight in 1970 to 29.9 percent in 2002. Aquaculture continues to grow more rapidly than all other animal food-producing sectors. Worldwide, the sector has grown at an average rate of 8.9 percent per year since 1970, compared with only 1.2 percent for capture fisheries and 2.8 percent for terrestrial farmed meat-production systems over the same period.

Preliminary estimates for 2003 based on reporting by some major fishing countries indicate that total world fishery production decreased slightly (–1 percent) compared with 2002. However, the total amount of fish available for human consumption increased to 103 million tonnes especially through increased aquaculture output and, on average, the per capita supply has been maintained. The increase has mainly been from China.

3.1 Future scenarios for world fisheries and aquaculture

According to FAO's statistics (FAO 2002) and their future predictions, wild capture will decrease slightly in the years to come. The growing demand for seafood must be produced through aquaculture production. In 2030 SOFIA predicts that the aquaculture production will rise to a level of more than 80 million tonnes, while the wild catch still will be approximately 90 million tonnes.

[3] Supply of food fish are total sum of capture fisheries and aquaculture production minus fish utilized for non-food uses

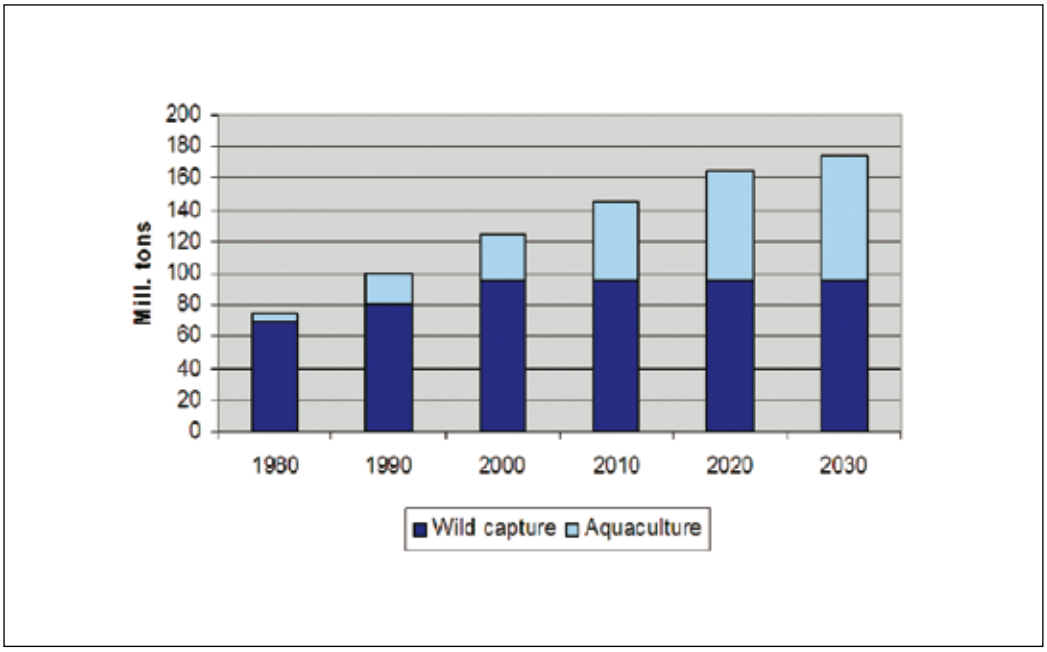


Figure 7. Wild capture and aquaculture production – world wide. Source: FAO.

The quantitative outlook developed in the IFPRI study (Delago, Wada et al.) reinforces five major structural shifts that are already underway, but will become more pervasive between now and 2020.

- Developing countries (particularly Asian countries) will dominate food fish production, from both capture fisheries and aquaculture. Stocks that are not fully exploited will be fished more heavily.

- South–South trade will increase with the emergence of urban middle classes. Domestic producers in developed countries will gradually leave the sector, and policy in these countries will probably come to favour import-friendly regimes for fish. Fish will become an increasingly high-value commodity and the shift, in traded products, from frozen low-grade whole fish to value-added products will continue.

- Environmental controversy will continue: sustainability concerns will increase and motivate environmental regulations and institutions, first in developed countries and then in developing countries. Overfishing will remain a major concern, and the use of pelagic stocks for fishmeal and fishoil will become an important policy issue. The link between pollution and food-safety in the fish sector, including pollution sources outside the sector, will receive more attention worldwide.

- Fisheries and aquaculture technology will address new challenges in both the North and South: reducing fishmeal and fishoil requirements in aquaculture; reducing and mitigating the environmental impacts of intensive aquaculture; finding alternatives to food-safety regulations requiring capital-intensive, scale-sensitive approaches to compliance; and utilizing information technology for improved fisheries management.

- Institutional development in the sector will be necessary for reducing poverty through fisheries and aquaculture development, as it will be for improving environmental sustainability and food safety.

3.2 Global outlook in the perspective of need for marine industry expertise

Based on the FAO outlook it is undisputable the increase in demand for seafood, but when analysing this global outlook in the perspective of need for marine industry expertise – and when trying to identify the macro-potential for development of the marine industry – it is easy to get lured into identifying the possibilities – instead of focusing more on the demand.

In the present context the demand is where you have the mix of capital – market demand – and likewise importantly the change in development status/level. To illustrate this – at least on a short term – Africa does not show this combination while e.g. SE Asia does.

Kieran Kelleher, ARD/WB presented at a Norwegian dialogue meeting in Washington DC May 2006 an overview of "Meeting the promise and challenge of sustainable aquaculture", and he described why poverty alleviation using aquaculture as a livelihood option worked in Asia and not in Africa. Although projects in Africa were physical potential, they were notably unsuccessful because the development objectives were wrong – production was focused towards subsistence, not the market. Central hatcheries and extension services did not work and the private sector and enabling conditions were weak.

In Asia development was supported by policies; national plans, land and water rights etc. The development was also supported by capacity building and investments in science and technology. The production systems were proven, integrated, market driven and the services like seeds, feeds and financ was in place. In most Asian countries the trade systems are well developed.

When having the S.E. Asian development environment – i.e. the mix of capital and market – and need by the more "developed status/level" there is a demand for expertise similar to that possessed by Norway.

To illustrate the need by the more "developed status/level" an example will be taken from S.E. Asia – where the growth in the aquaculture segment is the most notable. China is by far the most important producer and growth is astonishing. But it is mainly because of the multiplication effect that China becomes so important – simply by the number of farmers involved in aquaculture. The marine aquaculture likewise is growing very fast and here again one has to appreciate that farming land actually is very scarce in China – compared to the number of people – and therefore people have been encourage to go to the sea.

The production per farmer however is very small and the resource efficiency is very limited especially when looking at the more high-valued species, which have far higher production costs than experienced in Norwegian salmon farming.

Already it is seen in China that one of their main competitive edges – the low workers salaries – is diminishing, i.e. people from the country side used to migrate to the growth areas of coastal SE China to search for job opportunities, but now the factories have to send out scouts to the 'uplands' to source for workers, which also as expected means that salary levels are increasing. Chinese industry is now sourcing workers in Vietnam. This expected development trend will further and further put a pressure for increased efficiency in aqua-farming not only because the salaries are increasing but simply also because the resource utilisation is poor including utilisation of area and (trash fish) feed.

This will create good opportunities for Norwegian expertise including hardware expertise – if it is adapted to the local cultural and economic conditions. As for the latter it is of course a question of pricing and while Norwegian products now have a competitive advantage compared to a former low-cost country like Japan, Norway is not competitive in most other SE Asian countries which is the heart of present and developing aquaculture.

In the SE Asia region earlier focus has been on the small species-volume live fish market. However, the trend is now changing towards production of large volume (large scale) fish species productions for the fresh-on-ice and the processed products, and here Norway expertise has a competitive edge from the salmon industry.

4 Opportunities for Norwegian expertise

In this chapter, the working group points out areas of special interest with a view to increasing the export of expertise-based marine industry from Norway. The working group has based its selection of areas on two main principles;

1) **The All-Norway team**. In selected areas Norway is already established as a reputable supplier of technology and competence in the global market. These areas are presented below and should be strengthened.
2) **Areas with high market potential.** In some areas, the Norwegian marine industry is well established at a national level. Due to global developments, the working group suggests that there are opportunities for the Norwegian marine industry in some of these areas.

Areas of special interest/potential should be evaluated on the basis of the following criteria:

1. **Success at home.** As a rule, success in establishing an activity internationally is dependent on success in the national market. In some marine disciplines we are well established at a national level, but not at all, internationally. Still, the market potential and macro tendencies make the area interesting, and it is included.
2. **Expertise combined with a product.** If the export of expertise is combined with the export of a product (or included in a product), the value-added potential is considered by the working group to be at the highest level.
3. **Expertise transfer.** Norwegian aquaculture expertise is particularly closely connected to the industrial salmon industry. In a broader international perspective the "salmon expertise" can be transferred to other farmed species. Also the expertise related to Norwegian fisheries must be transferred and made useful to fisheries of other species, different fleets and with other environmental problems.

The areas, or disciplines, focused below fulfil one or more of the criteria listed. The areas are chosen by the working group as the most interesting and promising areas for increased export of Norwegian marine expertise (and products).

4.1 The All-Norway Team

Export of Norwegian expertise and technology is possible, but a small country like Norway will only be able to become a leading partner within a few selected areas.

In some areas we are already looked upon as a leading partner world wide. In the opinion of the working group, it is essential to back up companies and institutions that have demonstrated their ability and succeeded at the international arena. In many ways they represent "the All-Norway Team" within the industry today. Products and services are based on expertise built up in close co-operation between fishing industry, suppliers, research institutions and public administration.

In the opinion of the working group, "The All-Norway Team" today applies to specific areas in connection with:

- Farming of salmonids
- Fishery technology
- Marine bioprospecting
- Expertise-based resource management

Below, we will refer to the most important areas where Norwegian expertise and technology **already are established as a success abroad.** Fish processing will not be mentioned specifically since the working group is of the opinion that this is an area where Norway has not had any leading role.

4.1.1 Farming of salmonids

Farming of salmonids in other countries (Chile, Canada, Scotland, etc.) has been developed more or less based on Norwegian expertise and technology. To some extent Norwegian salmon expertise and technology is also present in farming of other species, like the production of sea bass and sea bream, but not on a very large scale. At present, cod-farming is in focus in Norway, and also in other salmon-producing countries the interest for cod farming is increasing.

Success stories related to export of salmon-based Norwegian products and services:

- **Technology:** In this context, technology is defined as technological solutions for land-based brood stock, fry and smolt production, and sea-based food fish production. The transport of living organisms in well-boats and tank lorries is also included. Examples of land-based technologies are the construction of buildings, energy installations, tank constructions, control-systems, IT systems, etc. Examples of sea-based technologies are marine constructions (cages, moorings, etc.), control systems, feeding systems etc.
  Examples of industry, companies and research institutions: AKVAsmart, Erling Haug, Aqua Optima, ARENA, SINTEF Fisheries and Aquaculture, Akvaplan NIVA, Institute of Marine Research.
- **Breeding and genetics:** Based on breeding systems from farmed animals, Norwegian institutions and companies have developed and established the most advanced breeding systems for fish and shellfish world wide. Salmonids and cod

are the most important species in Norway, but the Norwegian research institution AKVAFORSK, has also developed breeding systems for tilapia (the Philippines) and shrimps (Thailand). Norwegian breeding companies are established in the most important salmon farming countries.
Examples of companies: AKVAFORSK Genetic Centre, Aqua Gen, Salmon Breed.

- **Feed and nutrition:** The fish feed industry is global, and through a comprehensive structural change in recent years, only a few companies are left. Three of the biggest feed companies have their main research staff in Norway (EWOS, Skretting and Biomar). Salmon feed is the main product for the fish feed industry and their products and services are based on Norwegian expertise. The feed companies are present in all salmon producing countries and other aquaculture countries worldwide, and they are all working hard to develop dry feed for new species.
Examples of companies: EWOS, Skretting (Dutch owned by Nutreco), Biomar (Danish, earlier owned by Hydro), NIFES, AKVAFORSK.
- **Fish health:** Vaccination programmes and other fish health systems are well established in Norway and to some extent in other salmon producing countries as well. Fish farming of many other species worldwide have big problems with fish health, often due to bad environmental conditions and low resistance to diseases. The Norwegian salmon industry experienced early that fish health expertise is essential for the development and establishment of industrial farming.
Examples of companies: NorBio, Pharmaq, VESO, National Veterinary Institute, Fiskeriforskning / Norwegian College of Fishery Science.
- **"Hands-on" expertise:** Norwegian companies have been established in other salmon-producing countries and often key personnel are Norwegian. These personnel possess an expertise different from suppliers and research institutions, and this "hands-on" expertise in building up and developing a new business is very interesting and useful for other species as well.

The working group stresses the importance of strengthening areas (expertise and technology) and companies that have proven their ability and succeeded in establishing activity abroad. They are important for the further international development of the marine industry.

4.1.2 Fishery technology

The Norwegian fishing fleet has played a major role in the development of marine technology and ocean based industries along the coast. The ultimate cooperation between the fishermen/vessel owners and the technology suppliers, such as the yards, various kinds of equipment suppliers, consulting companies and research institutions, has been a driving force in this development. There is a strong technology transfer

between the fisheries, the offshore industry and the maritime sector in general. One example is the development of the offshore supply vessel that to a large degree was based on experience, knowledge and technology from the fisheries.

As a result of this, the Norwegian marine and maritime industry is a world leader in marine technology exporting equipment to a large part of the marine world. For instance, Norwegian fishing vessel technology is world-leading with respect to design and construction of larger trawlers. The American pollock fleet operating in the North Pacific, the New Zealand hoki- and orange roughy fleet, the Greenland and Canadian shrimp fleet and the pelagic fleet operating in both Northern Europe and outside South America are to a great extent based on Norwegian technology.

As an important part of the marine and maritime cluster, a strong ship design consultancy industry has developed. These companies develop and supply ship design concepts in an international market with main focus on sophisticated ship designs such as larger fishing vessels, research vessels and, at present, a number of offshore vessels of various kinds. Often, such ships are contracted to Norwegian yards which in turn order most of the equipment from national suppliers. Also, the export of Norwegian designs is normally accompanied by substantial deliveries of Norwegian equipment even if the ship is not build at a Norwegian yard.

Norway also holds a world leading position within the development of electronic equipment such as advanced sonars, echo sounders, catch monitoring systems and transducers for the world's fishing fleet. Norwegian-made equipment is in daily use all over the world on fishing vessels of all sizes. This includes scientific echo sounders and instruments for fishery research applications.

Ship design

The Norwegian ship design consultancy industry has developed rapidly from the establishment of the first enterprises in the 1970's to comprise more than 20 companies with about 200 employees to day. The industry is growing, has subsidiaries in Poland, Brazil and Shanghai and has expanded into both the offshore and aquaculture industry and ship building.

To illustrate their international activities, the company Vik-Sandvik has newly developed a new 71,5 meter midwater trawler for a Scottish ship owner. The ship shall be build by the Norwegian Yard Fitjar Mek. Verksted AS which again will purchase most of the equipment from national suppliers. Vik-Sandvik has also developed the largest and most advanced Norwegian owned combined purse seine/mid water trawler, the 94 meter long Libas as also is equipped for research tasks.

Another company, Skipsteknisk AS in Ålesund, is designing two 70 meter bottom trawlers for delivery to Iceland. The vessels shall be built by the Norwegian yard Solstrand AS, and also in this case a large part of the supplies will be ordered from Norway.

4.1.3 Marine bioprospecting

In Norway and also internationally, the production potential of the ocean have been utilized for production of biomass (fish, shellfish) used as feed and food. However, there is a considerable commercial opportunity in developing products within pharmacy, medicine, "functional food", cosmetics, etc. In Norway, some research institutions and companies have been working with marine bioprospecting for the last decades and in some areas the work has been successful. Still, the potential within this area is considered to be huge and marine bioprospecting will be fully described in the next section; Chapter 4.2. Areas with high market potential.

The alginate story

One success story is the work executed by NOBIPOL (a multidisciplinary research collaboration by NTNU) at NTNU and SINTEF. Through intensive research activity the last 25-30 years, they are established as leading research institutions in marine bioprospecting based on marine algae and by-products. Particularly important are exploration of the alginate from brown algae. Based on their research, a lot of alginate products are developed and industry established. NOBIPOL is working very close together with the industry, both at a national and international level.

4.1.4 Expertise-based resource management

In general, Norway has a well-functioning official administration; this is also the case within the fisheries and aquaculture sector where Norway is known to have a successful enforcement of laws and regulations. The Directorate of Fisheries is the enforcement tool of the Ministry of Fisheries and Coastal Affairs, being divided into one central unit in Bergen and local regional units along the coast (Krakstad, Klepsvik et al. 2005).

Designing laws and regulations, as well as the management itself, is to a large degree based on advice from the research community. This practice has a long history in Norway and expertise in building and making use of the system, including paying the system respect, is built over a long period.

The principles and specific concepts of the Norwegian system are transferable to other countries, although it is important to be aware of the fact that there might be different cultures with respect to public administration and resource management in other regions that need to be taken into consideration.

In the following, we will present two examples where Norway has built systems that might be of interest internationally. In addition, Norway has significant expertise in related fields that are important for oceanography and climate research.

Coastal Zone Management
Preparing coastal zone plans is mandatory in Norway for every municipality along the coast. Areas for e.g. aquaculture, certain fishery related activities, tourism, recreation and protected areas are to be designated. More than 80 % of the coastal municipalities have approved coastal zone plans. The plans are multi-year plans that shall be revised within a certain number of years.

Municipality decision-making involves a mapping process where mapping of the coastal zone involves expertise in different disciplines, and a political process on different levels where the public has access to the information.

Management of commercial fish stocks
The management of fish stocks is based on advice from researchers from Norwegian Institute of Marine Research (IMR). After allocation of quotas to the involved countries based on negotiations, the "Reguleringsrådet" suggests the allocation of each species to different groups of Norwegian fishers and how the fishing should be performed. Based on this process the Directorate of Fisheries advances its recommendation to the Ministry which then decides the final regulations.

The "Reguleringsrådet" consists of representatives from the Directorate of Fisheries (chair), industry organisations, trade unions, the county administration and the Sámi parliament. In this way the research, NGOs, the administration and the political echelons all take part in the decision process.

4.2 Areas with high market potential

For some areas, the Norwegian marine industry is well established and developed at a national level, but there is a limited export of products and services. Based on global tendencies and development, the working group finds that, for some selected areas, there are opportunities for the Norwegian marine industry. The areas below are chosen by the working group as the most interesting and promising areas for increased export of marine expertise (and products).

- Industrial farming of marine species
- Marine by-products – higher exploitation ratio
- Bioprospecting - the hunt for valuable, biological active components from marine organisms
- New fish feed raw materials and fish feed formulas
- Sustainable fisheries
- Logistics, traceability and food safety

4.2.1 Industrial farming of marine species

There is an increased global production of industrial farming. Figure 8 demonstrates the development from 1993 to 2003 for most industrialised species.

The industrial production of these species is located in China, Japan, Chile, Thailand, Indonesia, Vietnam, India, Brazil and Taiwan and represents opportunities for Norwegian marine expertise (and products). Asia is the dominating continent.

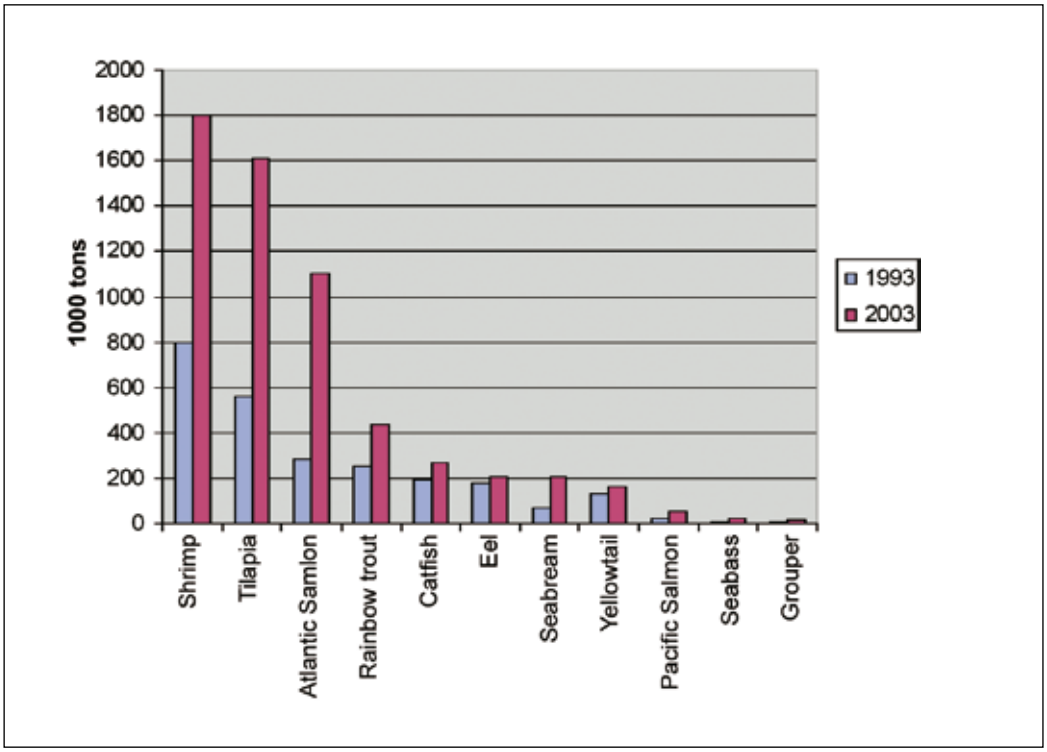


Figure 8. Farming of "industrial" species, 1993 and 2003. Source: FAO Statistics.

Technology transfer/conversion

Norwegian expertise is particularly closely connected to the salmon industry (see chapter 4.1.1.). Expertise from salmon farming is well established in the salmon producing countries, but to a small extent in farming of other, less industrialised fish species. If this expertise shall be interesting for farming of other marine species, it must be adapted or converted so that it is applicable for other conditions. At the moment, salmon expertise and technology are being applied to the farming of cod in Norway, and the Norwegian industry has learned that cod needs other solutions than salmon. This is a valuable experience that is useful when it comes to adaptations or conversion of expertise to other marine species in other parts of the world.

Value-added chain approach
Most of the countries in question that could use Norwegian marine expertise and products are less developed than Norway. Background experiences have demonstrated that even if the product and expertise we export is good (e.g. for sea cages), the whole project fails because other parts of the value-added chain are missing or are not functioning properly (e.g logistics to the market). Also in developed countries, important parts of the value-added chain could be absent. The result is often an unsuccessful project.

4.2.2 Marine by-products – higher exploitation ratios

Discards and by-products represent interesting raw-material for the production of marine ingredients. Increased utilization of by-products for consumption is also an interesting area. In both cases Norwegian companies and research institutions should have interesting opportunities.

Marine ingredients compete with well-accepted ingredients based on other raw materials (soya, milk, synthetic ingredients etc.), and the demands for quality, documentation and security of supply are high. Compared to the feed market, the prices are higher and the volumes are less. Still there is some trends world wide that open up markets for marine ingredients (RUBIN 2003):

- The international food-industry will, in the years to come, experience an increased pressure from consumers and non-governmental organisations related to demands for health promoting and natural products.
- Bovine Spongiform Encephalopathy (BSE) also known as "Mad Cow Disease" has resulted in that cattle-based ingredients are substituted.

There are opportunities for Norwegian expertise in:

1) **Increased consumption of by-products**
   In other parts of the world, like South East Asia, they have long traditions in utilizing by-products for consumption, for instance roe, milt, stomachs, intestines, swim bladders and heads. Norway is looked upon as an interesting producer and supplier. Know-how about the market, preferred quality, logistics and other aspects are necessary (RUBIN 2004).

2) **Production of value-added marine ingredients**
   In general, marine ingredients can be divided into two groups:

a) Ingredients for the feed markets (fish, pork, poultry, fur-bearing animal, cattle). The feed ingredients (protein and oil) must have high volumes and low prices.

b) Ingredients for human consumption and more specialized markets
A marine process industry based on fresh by-products has been established in Norway through the last decades. The products are directed to more advanced and demanding markets, like for instance markets for special feed ingredients, food industry (including e.g. "functional food" and flavour), health foods, cosmetics, pharmacy and industrial markets. The products in question are for instance flavours, omega 3 oils and products, gelatine, phospholipids, marine calcium, chitosan, glucosamine, DNA-salts, nucleotides and amino acids.

Omega-3 products is essential

High quality Omega-3 fatty acids from selected fish species safeguard important biological functions related to cardiovascular health, brain health and normal growth and development. Some companies have specialized in Omega-3 products based on marine resources and one of them is ProBio in Tromsø. ProBio was founded in 2000 and has in 6 years developed dietry supplements based on marine resources. One of their subsidiaries, ProBio Nutraceuticals, is producing Omega-3 products, antioxidants, vitamins and minerals.

Source: www.probio.no

A further development of the Norwegian marine ingredient industry is necessary in order to be attractive in the international market. The further development depends on a number of elements (capital, industrial approach), and one of the most important elements is scientifically-based expertise.

Of great importance is the Norwegian ingredient industry's (firms, research institutions, others) ability to protect their products, processes and expertise through Intellectual Property Rights (IPR) strategies. If they succeed in this, the export of expertise could be an increased value-added activity in the Norwegian industry.

From crab to medicine

In the future we will get our medicine through the nose. Chitosan from Norwegian shrimp- and crab Industry will increase the absorption in the mucous membrane of the nose. The nose gives a quick entrance to the blood stream for pain-relieving medicine, blood pressure medicine, insulin and vaccines. The polysaccharide chitosan helps the active medical substances in forcing through the cell layer in the mucous membrane and thereby entering the blood stream. Scientists at Norsk biopolymer laboratorium (Nobipol), a multidisciplinary biopolymergroup at NTNU, have developed a new method of producing specific chitosan. Before Christmas the biotechnical company Advanced Biopolymers AS was established in order to take hand of the commercialisation.

With this new processing technology we can make new chemical structures with specific functions accommodated to biochemical use. It can be water-soluble functions, the degree of influencing the open-closure mechanisms of the mucous membrane or the wound-healing

property of the substance, Einar Jahre Mustaparta tells. The civil engineer with experience from Norwegian biopolymer industry is brought in in order to lead the commercialisation of the new Haugesund company. Through 15 years the Nobipol researchers systematically have mapped the link between chemical structure, biological function and technical applications for chitosan. With the patented technology for tailor-making new chitosan molecules the biotechnology group of NTNU expect to see commercial results of the research.

Source: Translated Article from Teknisk Ukeblad (Lamvik 2002)

4.2.3 Bioprospecting - the hunt for valuable, biologically active components from marine organisms

Marine resources might be divided into (1) oil, gas and minerals, (2) marine biomass like fish, crustacean and plants, (3) the gene pool, and 4) energy (thermal, current, wave, etc.). In Norway, the industrial utilization of marine resources has focused upon the first and the second, while utilization of the genetic potential and energy potential has mainly been a target for research activities.

The ocean is well known as a rich source of biological and chemical diversity. It covers more than 70% of the earth's surface and hosts more than 300,000 described species of plants and animals to date. This diversity has been the source of unique chemical compounds with the potential for industrial development as pharmaceuticals, cosmetics, nutritional supplements, molecular probes, enzymes, and agrichemicals. A relatively small number of marine plants, animals, and microbes have already yielded more than 12,000 novel chemicals. Some of the marine bioactive substances with industrial applications as technological compounds, laboratory tools or ingredients in cosmetics are marketed and already generating high benefits to mankind (and investors). The development of drugs from marine organisms can be highly profitable. The extraction of arabinosides from the sponge, **Tethya crypta,** has led to more than $50 million annual sales in derived antiviral medicines.

During the last 25-30 years a research and industrial activity within marine bio-prospecting has developed in Norway. The starting point was utilization of by-products from the fish processing industry. Chitin and chitosan have been developed from shrimp waste, proteolytic enzymes from fish viscera, the diagnostic enzyme alkaline phosphates from shrimp and marine lipids from fish and sea mammals. Later on the investigation of marine bacteria and algae has been developed. Because of the extreme living conditions for the organisms (cold water), the products developed have unique properties.

The screening and development of chemicals of marine origin on a global basis have largely been based on organisms from tropical waters. The potential in cold water regions is far from fully explored. The production of marine chemicals in Norway has been based upon extraction from the raw material for example the by-product.

However, when a bioactive substance has proved to present interesting and promising properties, the commercial source of choice for the pharmaceutical industry must be based upon organic synthesis or fermentation, which allows the company to control all aspects of production.

Based upon the genetic pool in the northern marine environment, the methodology for effective screening of the organisms present and chemical industrial know-how, there is a great Norwegian production potential. Based upon the markets available, there are promising investment possibilities in bioprospecting of marine resources.

Antibiotics

The surface of the ocean swarm with bacteria and other micro organisms, several ten- fold of billions per litre water, and thousands of different specie. Small single celled organisms, a collection of bacteria. The fewest of us is able to look upon this as interesting, far less regard it as a gold mine. You need to be a researcher to do so.

At SINTEF and NTNU there's a group of researcher working with bioprospecting – "the hunt for valuable substances from nature which can be industrialised". They are in the search for antibiotics, pigments and polyunsaturated fatty acids from the thin ocean surface layer and from the sea bed. Antibiotic's is valuable substances, in 2002 almost 12 million people in this world died due to infectious diseases. A large part of this is due to the lack of effective antibiotics.

At the lab, water samples collected from the sea surface and sea bed throughout the Norwegian coast, are grown in small Petri-dishes. After some days the first colonies of bacteria emerge. Sergey Zotchev, a young researcher working here as an associate professor, took part in discovering the genes of a bacterium which can make the antibiotic Nystatin five years ago. The patent application then made the foundation for the company Biosergen AS where he today is one of four employees.

The researchers have a long list of organisms the hospitals wants to defeat. One after one the samples are tested towards particular bacteria's. Zotchev let the resistant bacteria from the hospital grow in a diffusion disk. If the new sample from the sea bed is capable to kill the resistant bacteria it will show. If so, the active compound needs to be isolated and followed up by a list of advanced analyses. The molecular weight will tell the researcher if the compound already exists. Bacteria after bacteria most go through thorough test procedures, most of them fall off and end up as not interesting. It is the search for the needle in the haystack. The procedure is therefore to investigate, analyse and get patent rights when you find something of value.

The researchers have analysed more than ten thousand extracts from bacteria which possibly can produce antibiotics. Now the researchers have got down with 33 actual extracts for fungus and 100 for bacteria. Many more analysis and a lot of work remain before we eventually are left with one or several new products. If you are lucky you could find something which is a billionaire business.

But the researchers strive with how to follow up the gold mine they hold, in half a year the financing of their research project is running out. The link between research and industry is difficult. The industry does not want to have "possibilities", they want the research to go further into commercialisation.

Source: Based on Gemini (Dragland 2006)

4.2.4 New fish feed raw materials and feed formulation

The total world catch of fish is close to 100 million tonnes per year and several species are overexploited. The industrial fisheries producing fishmeal and oil are close to 30 million tonnes and declining. Fishmeal and fishoil are the most important ingredients in the diets for marine fish and can not be fully replaced by plant proteins and oils due to the lack of essential amino acids and fatty acids. Nearly 90 % of the global production of fishoil and more than 50 % of the fishmeal produced is now consumed by the aqua-feed industry. It is expected that a reduced availability of fishoil will be the first limiting factor for the growth of the global aquaculture industry.

The Norwegian scientific community has seen this and has been able to work together across institutional boundaries. Results from this research have shown that it is possible to develop balanced feed diets based on marine raw materials with an increasing content of plant raw materials.

In recent years work with different protein and oil sources has been intensified, in the light of finding good replacement/alternatives to fishmeal and fishoil. Some of the main areas of Norwegian expertise are;

- New plant and oil raw materials, including GMO
- New marine raw materials, including krill
- Formulation based on nutrient content (not just raw material type)
- Macro og micro nutrients

The Norwegian research community and feed companies have considerable expertise within the development of fish feed. Here the work of developing high energy diets for salmons and increased feed utilization have been central. They are working with single nutrients, possible new raw materials, complete feeds, feed formulation, feed technology and optimal feeding of the fish. As part of this work, the animals' needs for the individual nutrients is mapped, both macro and micro nutrients (e.g. vitamins and minerals). Both nutritional, health and technological aspects of the raw materials are studied at the different life stages of the fish and specialised diets are developed.

Knowledge of the use of gene modified organisms (GMO), which hitherto has not been allowed in Norwegian fish feed, is opening new possibilities on the raw material side. Today, the Norwegian regulations limit the potential of GMO, but a possible change of regulations could open new opportunities.

The search for new marine raw materials is continuing. There are still enormous, unexploited resources in our oceans that might be good raw materials for fish feed, e.g. small, hard-to-catch, or simply unattractive, fish and zooplankton like lantern fish and krill. The biomass of lantern fish in the Indian Ocean is estimated to nearly 50

million tonnes and the biomass of Antarctic krill to 500 million tonnes. In the north-eastern northern hemisphere the biomass of zooplankton is estimated to 350 million tonnes. As an example, Norwegian research communities have, together with public authorities and Norwegian industry, established a cooperation to exploit the resources of krill in the Antarctic.

The total expertise within nutrition, raw material knowledge and formulation of fish feed is important to achieve an economically sustainable utilisation of the marine resources. The working group is of the opinion that this is an area where the Norwegian expertise is high and that this expertise has an international market potential. New aquaculture species and farmed species in many countries need specialised feed to maximize the production potential.

The Antarctic krill case

Antarctic krill E. superba, is one of the bigger and dominating krill species in the Antarctic, growing to a maximum size of 6.5 cm and weighing up to 2g. Life cycle from 3 -5 years becoming mature after 2 years. Krill has a circumpolar distribution, generally being found south of 50°S and away from truly coastal waters in the Antarctic where another, smaller, species dominates. Approximately area of distribution is 35 million square meters and biomass is estimated to 500 million tonnes.

Antarctic krill are found for most of their lives in pelagic swarms or schools. It is this swarming habit that has made them attractive to commercial fisheries. Krill in swarms can be of extremely high biomasses and have been measured covering an area of 450 km2 and have been estimated to contain over 2 million tonnes.

Up to this point however, harvesting the Antarctic krill has proved difficult. Basically due to logistics and that traditional trawling is unfit for harvesting krill, as the valuable resource is simply crush and destroyed before it can be processed. New technology has been developed and it is expected that boats specially designed for krill harvesting will be built in the near future. Krill-oil achieves a high price, and will probably be used in pharmaceuticals and in omega 3 capsules.

4.2.5 Sustainable fisheries

Overcapacity is a world wide challenge within fishery management calling for social difficult restructuring processes. In Norway the number of registered fishing vessels was reduced from around around 61,000 in 1960 to around 19,000 in 2002 (Ministry of Fisheries 2003).

The average age of the larger marine fishing vessel fleet segment world wide is however increasing. According to FAO (FAO 2004) in 1992 about 30 percent of the vessels were less than ten years old and 6 percent were more than 30 years old. In 2003 these percentages were 13 percent and 28 percent respectively. FAO further expects

that the construction of larger fishing vessels will increase over the next ten years, compared with the current low level. This is a global marked which should open up large opportunities for the Norwegian industry.

The fishing fleet for the future must be based on principles of sustainable utilization of raw materials from the sea. A growing consciousness is recognized among large consumer groups when it comes to the environmental impact of food production. The environmental impacts of catching, processing and transporting food to the marked are becoming important issues, and increased pressure from strong consumer groups and retailer organizations is expected in the direction of a more sustainable food production chain (Mandag Morgen, MicroNews, 1998). This also includes requirements with respect to documentation. Introduction of various environmental labels combined with requirements for traceability and safety of foods is expected to take place.

Another aspect is that future fishing vessel must offer fundamental improvements in working conditions on board. These do not conform to current minimum requirements for newly build vessels on board much of the world fishing fleet of today (FAO 2004).

Based on its current strong position within the design and construction of advanced ship concepts and delivery of advanced equipment, the Norwegian industry should be in a good position to play a leading role in this future development. A prerequisite for success is, however, that technology is further developed in line with the requirements that must be met in the future.

4.2.6 Logistics, traceability and food safety

The seafood market is global, and the value chain is often complicated with a large number of companies involved. Among consumers there is an increased focus on traceable fresh food with documented quality and documented sustainability. This requires sophisticated solutions for supply chain management (SCM). Within this field, Norwegian expertise can be found in several areas which are important for the industry:

- Multimodal transports, with emphasis on solutions involving sea transport
- Development and operations of special vessels and equipment for handling refrigerated and frozen goods
- Development and operations of special vessels and equipment for live fish transport
- Traceability, including standards for electronic data transfer and software solutions

The development of specialized vessels is an ongoing process, and has a sound basis in Norwegian marine industry. Technical solutions can be coordinated and exchanged with the offshore sector. Norwegian shipping companies have always been important links in worldwide supply chains, and the current broad operational expertise is a good platform for expansion. Transfer of transport loads from increasingly congested

road systems to sea transport is also seen as a means for improving the environment, especially in Europe.

As a relatively new business, Norwegian transporters of live fish (well boats) are now operating abroad, with subsidiaries in the UK and in Chile. Continuous research and development for improving quality and fish welfare will be necessary for increasing the market share.

The physical flows are only a part of the supply chain management. Equally important is the information flow between companies in the value chain. In addition to the commercial trade information (orders, invoices, payment transactions etc), electronic traceability systems are increasingly important. Norwegian research institutes have gained international recognition in this area, and have cooperated with software companies in developing world class solutions. A recent government initiative has presented the goal of establishing Norway as the leader in the implementation of traceability solutions by 2010; this reflects the importance of both food safety and market requirements.

The consumers are increasingly concerned with food safety issues. Documentation of properties of the goods through brand names/labels and demands for traceability systems are becoming more important in the international seafood trade.

The development of better defined quality standards for fish products will become more important and here the Norwegian expertise is important. The development of better defined quality standards, that include the whole value chain from production/ harvest through processing and further to the market and consumer, will be important to increase product quality. Norwegian expertise within fish handling, hygiene, wanted and unwanted substances (in e.g dioxins, PCBs), etc. is important when dealing with food safety and therefore increased focus on food safety can create international opportunities for Norwegian expertise.

4.3 Estimation of global market potential for Norwegian marine expertise

Norway's possibilities for increased export of new knowledge-based products and services (expertise) can be split into two parts;

- Increased export of expertise and products on new markets
- Increased export of expertise and products on existing markets

The working group has tried to estimate the global market potential. The table below shows the possible potential for the export of new knowledge-based products and services. We will underline that these are the most interesting areas from the working group's point of view.

Table 3. Estimates of the global market potential (export) of Norwegian marine expertise.

	Area of expertise	Export potential in 2025 billion NOK
Expertise:The All - Norway team	Farming of salmonids Fishery technology Expertise based resource management	**15**
Expertise: New markets with high potential	Industrial farming of marine species By-products –higher exploitation ratio Bioprospecting New feed raw materials and fish feed formulas Sustainable fisheries Logistics, traceability and food safety	**10**
Total expertise		**25**
Seafood from Aquaculture		50
Seafood from Capture		40

Today, the export value of **"Expertise"** makes up 10% of the total marine export value. By 2025 there is a potential to increase this to 25% and make **"Expertise"** a separate and important contribution to the value creation in the marine industry, together with the traditional export of seafood products.

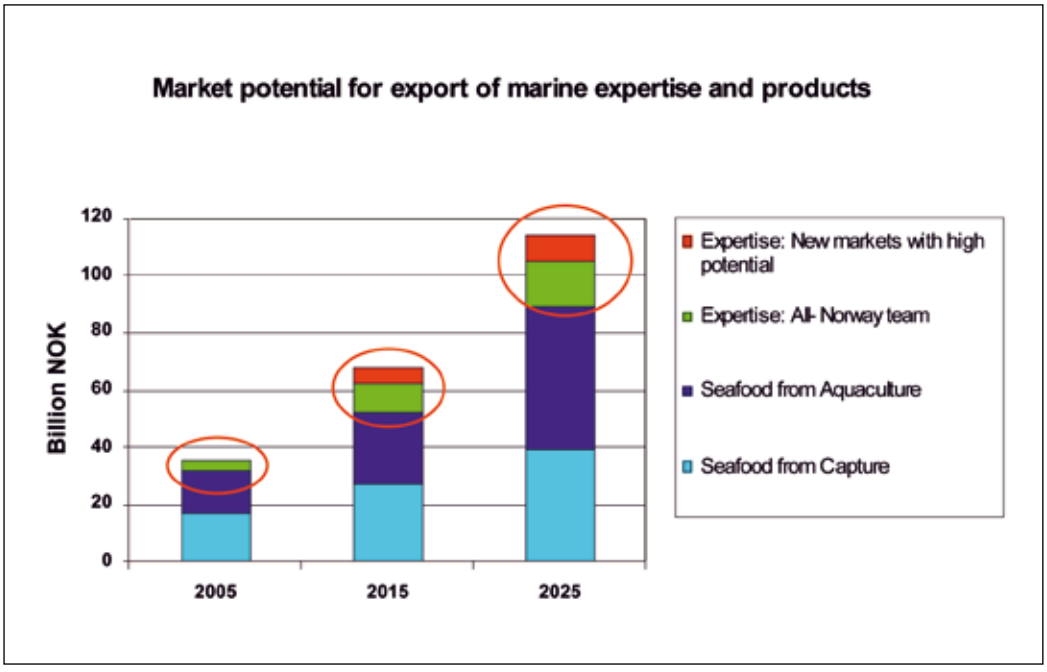


Figure 9. Market potential for export of marine expertise and products.

As Table 3 and Figure 9 show, the possible export potential for Norwegian marine expertise is estimated to 25 billion NOK in 2025; 15 billion NOK from expertise within the All-Norway Team and 10 billion NOK from expertise within New markets with high potential. It is difficult to make a precise estimate, but this is considered as rather conservative.

Chapter 2.5 showed that the export value of the marine industry was 36 billion NOK in 2005; 17 billion from products from Capture, 15 billion from Aquaculture products and 4 billion from suppliers of expertise (equipment, research, financial etc.). **The total export potential in 2025 is estimated to be 115 billion NOK, where marine expertise makes up an important part of 25 billion NOK, together with the traditional export of seafood products.**

5 Realising the opportunities

Realising the opportunities in chapter 4 is not an easy task, and the industry is facing big challenges trying to increase the export of expertise and products. This last chapter will focus on:

- the political background,
- the challenges and
- recommendations

5.1 Political background

The previous report from NTVA and DKNVS suggested the establishment of a marine research programme of 1 billion NOK a year to be able to realise the value-added potential within the marine sector.

Even if R&D activity within the marine sector has increased the last six years, it is far from the figures suggested by the previous report. Still, it is interesting to observe that the political framework has increased the focus on the suppliers and services through the period.

The governmental plan for increased value-adding in the marine sector (Regjerings-utvalget for Marin verdiskaping 2003), points out a considerable potential for growth of supplies and expertise to the aquaculture industry. The plan states:

- "An increased internationalisation of the supplier industry will require a closer collaboration combined with development of companies/players with the necessary size and strength".
- "In the future, an increased part of the value added growth in marine sector will be within the expertise-based service industries".

The committee wanted an increased focus on and internationalisation of the marine suppliers, including products and services. This is also pointed out in White Paper No. 19 2004-2005 "Marin næringsutvikling – Den blå åker" (Regjeringsutvalget for Marin Verdiskaping 2005), which says that it is expected to find the largest potential for the suppliers (to the marine sector) within deliveries of equipment and expertise/competence for aquaculture.

Regarding the policy for industries, the SORIA MORIA government declaration states that: "Our main objective is that Norway shall be one of the leading, innovative, dynamic and expertise-based driven economies in the world within some selected and superior areas. Norway shall be a favoured country for business activity".

The government wants to develop a national strategy in the areas where Norway has special skills or advantages, like in the marine sector, maritime sector, energy, environmental issues and tourism.

Regarding fisheries, and aquaculture policy, the SORIA MORIA declaration focuses on increased marine research and strengthening of the marine innovation system in order to arrange for research, development of new products and marine technology.

Still, the public support system does not seem to be able to give satisfactory support to the industry (suppliers, research institutions, others) who want to try to establish activity in other parts of the world.

5.2 Challenges

Today, the export of Norwegian expertise is modest (page 7). In chapter 4 the working-group has pinpointed some areas with a special potential, divided into two main groups:

- The All-Norway Team – areas where Norway is already established as a reputable supplier of technology and expertise in the global market
- The New Markets with high potential – due to global tendencies and development, the working group thinks that, in some selected areas, there are opportunities for the Norwegian marine industry.

The potential for the export of expertise is estimated to be 25 billion NOK, but the realization of such a potential is not an easy task. "The All-Norway Team" has gained some experience trying to export products and services world wide, and it is important to learn from their example.

The challenges for "the All-Norway Team" are not all the same as the challenges for the areas of "the New Markets with high potential", but below we describe the most important challenges that we believe are more or less common for both:

- Protection of intellectual property rights
- From raw-materials to value-added products
- Poor understanding of mechanisms in development work
- Problems with complete value chain deliveries
- To be present in the markets when marine species start growing

1) Protection of intellectual property rights
Compared to other countries, Norwegian technology is expensive. The danger of copying is present, and in many cases Norwegian marine technology has easily been copied. In general, the entrance barrier is low, due to a lack of protection of intellectual property rights (IPR), quality standards and certification schemes.

Compared to multinational companies and international research institutions, Norwegian companies and research institutes are not professional enough when it comes to implementation of IPR strategies.

As an example, small Norwegian consultancy works are making the customers capable of constructing their own business, and when the project is finished, all the expertise is transferred without any long-term income or new project in sight. Another example is the "export" of people with special competence or skills used for construction of industry systems in other countries.

Still, we have to realise that the development of technology is expensive in Norway and to some extent parts of the activity will take place in other countries with lower labour costs. For research and educational institutions, the situation is different because the costs of academic services are cheaper in Norway, compared to many other countries. In both cases it is still very important to secure the core expertise with well-developed IPR-strategies.

IPR strategies are important to both "the All-Norway Team" and "the New Markets". One example is breeding methods for farmed fish, and another is protection of genetic material.

2) From primary production to value-added products

Norwegian marine industry is traditionally good at primary production and has to move towards production of more value-added products in the future. Marine ingredients based on by-products and marine bioprospecting are areas of special interest. Norwegian companies must develop and position industrial products in attractive value chains. Figure 10 demonstrates a market pyramid where Norway has been traditionally present in the three fields at the bottom: food, feed and as a producer of primary products.

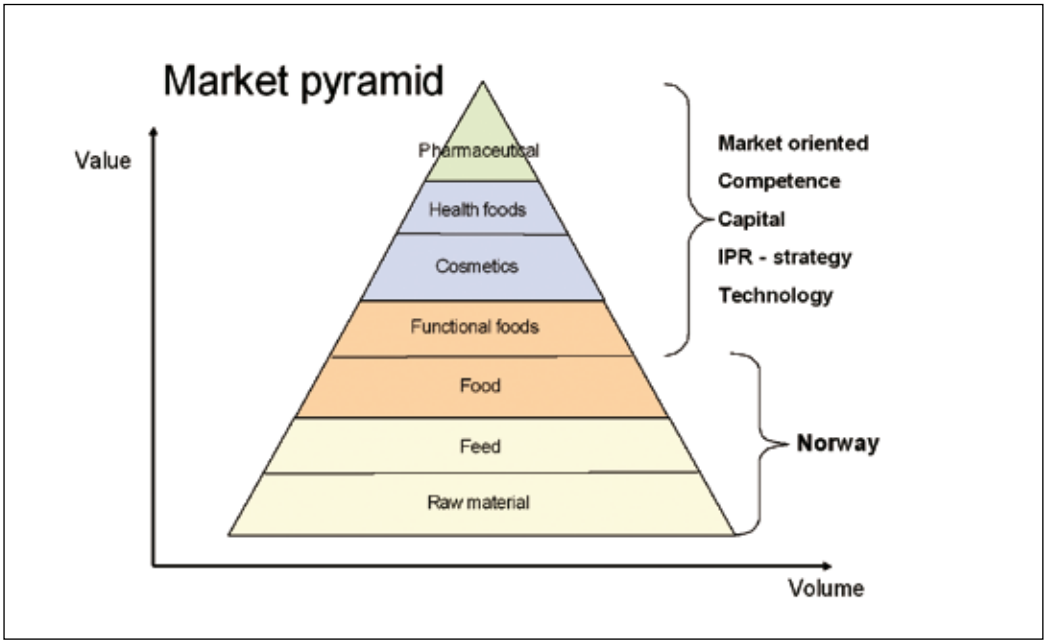


Figure 10. The market pyramid.

In the markets for functional foods, health-foods, cosmetics and pharmacy, marine ingredients are not very visible and the markets are quite different from the traditional fish market. The markets are demanding to their suppliers when it comes to expertise, technology and capital.

3) Poor understanding of mechanisms in development work

Industrializing new marine species or other development projects in Asia, for instance, is often accomplished in close co-operation between governmental institutions and private enterprises. They are very often financed by development funds. Even in well developed countries in Asia, like Taiwan and South-Korea, they expect projects to be financed (partly) by development funds. In development projects they also expect that the supplier of expertise (and products) helps with the financing part of the project.

The Norwegian governmental funding system does not seem to support Norwegian exporters of expertise and products directed to the development market. For instance, the Norwegian government has decided that Norwegian development funds should not be connected to deliveries of Norwegian products and services at all, while other western countries have allowed this for projects in the less developed countries.

The development organisations (The World Bank, The Asian Development Bank) are important parties in development projects. In a way, they represent a market of their own – with different demands and claims to their suppliers of expertise than other markets. The development organisations are interested in Norwegian expertise, but the way Norwegian companies and institutes are organised makes them less suitable or operative in this market.

Other countries have established solid positions in the development market. One example is Denmark. They have well established consultancy firms with long experience working with complicated, multidisciplinary, internationally oriented projects. In comparison, the Norwegian KIFT (knowledge intensive services) sector is characterized by small and fragmented companies (Aslesen 2004).

So as a summary, the Norwegian marine sector needs to better understand the mechanism in development work and then accommodate and organise the research and industry in the right way to meet the requirements from the development organisations. Only then will we be able to compete for large development contracts within the marine sector.

4) Complete value chain deliveries
In many cases, Norwegian suppliers produce and export excellent products and services directed towards one part of the value chain. If other parts of the value chain are not functioning very well, like for instance logistical systems into the market, the project will fail and the impression of Norwegian technology will also fail. Success in **all** parts of the value chain is important.

5) To be present in the markets when marine species start growing
A problem for Norwegian suppliers of expertise and technology is to be present with a value chain oriented, multidisciplinary team in the areas with a potential for farming of marine species. In many countries, commercialisation of marine species is still in an initial stage, but at one point in time the production will grow rapidly and the production gets industrialised. If Norwegian companies and research institutions want to take part in this industrial development, they have to be present at an early stage as well.

5.3 Recommendations

In order to reach the export potential of 25 billion NOK of marine "Expertise" it is crucial that Norway continues to be at the leading edge technologically with our own production, since this is what makes our expertise interesting and demanded. FAO predicts an increase in the global Aquaculture production of 2-3 times today's production by 2030. The main part of this increase is expected to come from industrial aquaculture, exactly where Norway has its main expertise. These future perspectives make up a large market potential for marine expertise from Norway.

The working group recommends that the government, the marine industry (research institutions included) and the public support system establish a national strategy with the main objective to increase the export of Norwegian marine expertise. The government has to take a leading role in working out the strategy.

An important part of the strategy work is to establish an acceptance that the export of expertise is equally important as the export of fish and fish products. The export of expertise needs to be considered as a legitimate export article.

In brief, the important elements in the strategy should be:

Intellectual Property Rights (IPR) Strategies

In the future, Norway must to a much larger extent capitalise on Norwegian knowledge and expertise through the sale of licences and rights. There must be an acute awareness of IPR both at a national level, in the companies and at the research institutions. Competence on patenting and patenting-processes should be strengthened. Norway has to be active within organisations like the European Patent Organisation (Norway has just joined the organisation). The public support system must demand an IPR strategy of actors granted governmental financing. The Norwegian working environment needs to be more professional when it comes to securing rights (patenting), and needs to develop strategies on how the patents in the long term can contribute to income through licensing and other similar arrangements.

Investment in human capital

Human capital is essential, and Norway needs to make investments in educational capacity and educational quality in order to attract talents from all parts of the world. It is also important to be attractive to Norwegians. Important scientific disciplines related to marine technology are not the most popular choice for young Norwegians at the moment. We have to see what other successful countries have done to attract the best people, e.g., Ireland.

Strategic alliances
Companies and institutions need to make strategic alliances at both national and international levels.

Strategic alliances at an international level can be made in many ways, but Norway should consider investing the oil fortune in large multinational companies which are the market for marine ingredients/ marine raw materials/ marine expertise. Norway should also consider making investments in and alliances with foreign research institutes.

At a national level the government and the marine industry should establish market alliances after the model of INTSOK in the oil industry. INTSOK is for the suppliers of technology, and a "marine INTSOK" should include the research institutions/ system. The alliance should support the members in their efforts for marketing and sales of marine expertise. The alliance must be financed as a Dutch treat between the government, companies and research institutions.

Industrial and long-term capital
Both public and private capital is needed in order to reach the export potential of 25 billion NOK. The main capital source will be private, and the capital is operating in a global market. By being best at expertise and framework conditions for the expertise-based industry, Norwegian working environments will be attractive to capital. The difficult part is to attract the industrial and long-term capital.

A tailored public support system
The public support system must accept that export of expertise is equally important as the export of fish and other products. There should be established favourable taxation rules for established companies that plan to export expertise and products. The public support system should also develop favourable establishment conditions for companies and institutions "producing" export-directed expertise.

There is a need to make such a national strategy more specific.

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