



Local raw materials for production of fish feed for aquaculture

- Realistic future possibilities for production of new local fish feed ingredients
- Nordic network covering the whole Nordic aquaculture value chain
- Listing of main players in each Nordic country



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Nordic Innovation Centre

Project no. 10102

June 2011

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Abstract

The Nordic countries are known for clean environment, efficient technology and high quality products, not least food products. The countries have a long history in fisheries and agriculture and aquaculture has been increasing in recent decades, especially the salmon production in Norway reaching a million tons annual production and the rainbow trout production in Denmark utilizing environmentally friendly recirculation technology. The Nordic aquaculture business has a huge potential to increase further, the global market demand for high quality environmentally beneficent products are increasing rapidly and the Nordic countries have the resources, know-how and image to respond to this with increased production. Access to safe, available and economical feed ingredients is becoming one of the most important challenges for strengthening the aquaculture industry and developing a more sustainable production. The major challenges for the industry are to reduce feed cost and environmental footprints without reducing product quality and value. In this project some realistic future possibilities for production of new local fish feed ingredients are put forward and a Nordic network has been established including the whole value chain from producers of fish feed raw material, through fish feed manufacturing and aquaculture to marketing of fish from Nordic aquaculture. Moreover, the main players in each country have been identified and are listed in the report.

Executive summary

The availability and price of fossil fuels for the transport sector could become a problem in the near future and that would affect the food security in the world. Moreover, it is expected that the global need for food will increase substantially in the coming decades. Surely aquaculture will play a crucial role in delivering high-quality proteins to the market. It is therefore of concern that aquaculture has mainly been growing in Asia and Central-America in recent years, but less in Europe although the Norwegian production of salmon has increased substantially. Europe only counts for approximately 2% of the total world aquaculture production and thus new solutions are needed. The Nordic countries have huge possibilities in becoming a leading region in sustainable aquaculture with the local resources, know-how and clean image.

The aquaculture industry is the fastest growing food production industry in the world and approximately 50% of all fish consumed by humans is from aquaculture. The main cost factor in aquaculture is the cost of feed. Furthermore, high amounts of feed ingredients from marine sources have been of concern both environmentally and economically. Thus, it is of importance for the aquaculture industry to aim for the development of new locally-produced, cost-effective, beneficent and eco-friendly ingredients for innovative practical feed production.

This report gives an overview about the status in the Nordic aquaculture industries, with focus on feed production and related businesses. Suggestions are put forward for an increased and more sustainable Nordic aquaculture in the future with focus on local environmentally friendly feed production and new species. Furthermore, information is listed about relevant players in the aquaculture value chain in each country. These are industry associations, R&D organizations, aquaculture companies, feed producers and raw material producers.

The aim is to find innovative solutions for a competitive and sustainable Nordic aquaculture focusing on local feed raw materials. Ideas are put forward on utilization of seaweed and algae, production of rapeseed and barley and high quality proteins from mussel meal, fungi, single cells or invertebrates. In some cases waste organic material from horticulture, green houses and other agriculture products could be utilized or even remnants from one fish species as feed raw material for another species. Moreover, the production could be beneficial for the environment as in the case of production of mussel meal, seaweed and algae, with utilization of excess nutrients / contaminants in the environment for the production of valuable raw materials.

In spite of good knowledge on feed for aquaculture there is still a need for research in the area, especially on sustainability, economical solutions regarding new technology, new species and new local feed raw materials. In this respect long-term effects on changes in the diet for different species need to be clarified. The carbon footprint of the production is also of increased concern as the aquaculture business is often accused for being unsustainable and impacting the environment negatively.

Food production, not least in the marine sector and aquaculture, is one of the main fundamental industries in the Nordic countries. Wild fisheries have stagnated or even declined and the aquaculture in other continents has been increasing substantially. It is therefore essential for these industries to implement innovative solutions to maintain the competitiveness of the region in this field. New opportunities for sustainable aquaculture production are emerging providing the tools.

A seminar on new opportunities for fish feed in aquaculture was held back to back with the project meeting in Iceland in April 2011. The attendance was very good from the whole value chain and the involvement and interest from the participants were beyond expectations. In continuation to the seminar rapeseed producers in Iceland, the feed company Fodurblandan hf., the aquaculture company Islensk Matorka and the R&D institute Matis have established a project on testing Icelandic rapeseed meal for tilapia feed. More project ideas are under development, including utilization of local seaweed and production of proteins with cultivation of invertebrates and/or fungi. In Denmark and Sweden there is increased interest in utilizing mussel meal as a new ingredient in fish feed. Norway will need substitutes for marine ingredients in fish feed for further expansion of salmon production in the future. Thus, the fish feed industry in the Nordic countries is in a need for innovative new solutions for a future sustainable aquaculture.

The project consortium has expanded the group and is preparing a project application to the Nordic Innovation Centre's marine programme. The Coastal Zones Research Institute in New Brunswick Canada has been included in the work. Also, new contacts have been established in Europe, mainly UK, Belgium and Spain. Moreover, contacts in the Nordic countries, Switzerland, UK and Canada on aquaponic systems have been established. The project has thus helped the group to build up a strong network of scientists and industrial partners.

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1 Introduction

Use of locally available raw materials as ingredients in aquaculture feed contributes to a sustainable utilization of resources as well as potential growth in fish production with less environmental impact. Thus, increased focus on local fish feed would strengthen Nordic aquaculture and provide new market opportunities making use of the clean image of the Nordic countries and the increased market demand for low carbon footprint food products.

Fish feed are placed in the middle of the aquaculture value chain. Raw materials of marine or land based origin are mixed with other important ingredients to feed pellets, which through their transformation in the fish are important for the final quality of the fresh fish or the processed fish products for the consumers.

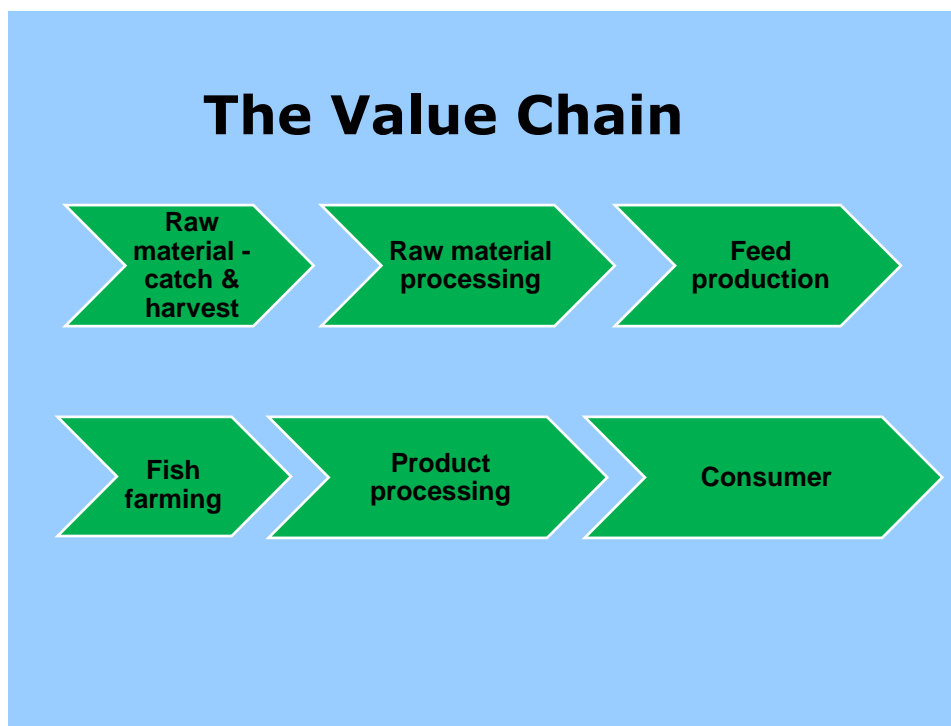


Figure 1: The value chain from raw material for fish feed, to fish for consumers.

The fish feed plays an important role in the value chain as it implies important control of the quality of raw materials, which is crucial for the food safety as well as efficient high quality feed types that ensures optimal growth for different fish species farmed under a variety of different conditions. Though the feed cost has to be controlled as this is most often appr. 50% of the total production cost in aquaculture.

Food safety and traceability is essential for any food production and it involves control at all stages of the value chain from raw material manufacture until the final fish product reach the consumer. Food safety is secured by applying risk analyses in accordance with Hazardous Analysis of Critical Control Point (HACCP) standard. The HACCP analysis identifies potential critical areas in the production and processing steps so preventive precautions can be taken to eliminate the hazards as well as making documentation of steps in the process.

The objective of this report is to summarize the status in the Nordic countries on aquaculture focusing on the feed raw materials. The main players in the whole value chain are listed for each participating country and suggestions are put forward for development of an increased and more sustainable Nordic aquaculture.

Agriculture associations have been contacted and asked for possible new raw materials for fish feed. The main corn products mentioned are rapeseed and barley. Research and development on rapeseed production has been ongoing in Iceland in recent years mainly focusing on oil production. The rest material (2/3 of the corn production) is rich in protein and is an excellent material for fish feed production. This is now being tested in a summer programme by a biology student from the University of Iceland in cooperation with Matorka, Fodurblandan, Siglingastofnun and rapeseed producers.

The Association of greenhouse producers in Iceland and stakeholders have been contacted involved in aquaponics in Norway and Denmark. Collaboration projects are being prepared as huge opportunities for green growth and natural circles of raw materials can be implemented through the aquaponics. Stakeholders with expertise in aquaponics in Switzerland, UK and Canada have also been contacted and future cooperation discussed. Moreover, the production of invertebrates from organic waste is being investigated further by another biology student at the University of Iceland in collaboration with specialists at the University and Matis.

The Rubin center in Norway (www.rubin.no) has done an excellent work pointing out possibilities for value adding use of marine by-products. By-products from fish processing plants on land (liver, roe, stomachs, heads, backbones, cuts and rejected fish from processing) are now mostly used as raw materials for feed production, but huge amount from processing on-board fishing vessels are still dumped into the sea. This provides new opportunities but have to be looked into in collaboration with the fishing industry and governmental institutes.

The utilization of by-products from slaughterhouses remains a problem due to European legislations. This is hopefully changing in the future as large amount of animal waste could serve as high value protein ingredients for fish feed without a serious danger to food safety.

From an integration of stakeholders point of view, the possibilities for practical implementation of the visions outlined in the report are every promising. In all countries a very good cooperation has been established between stakeholders from raw materials to the consumer product. The nutritional related projects executed at DTU Aqua are all related to stakeholders in the sector whether it is fish meal and fish feed producer, the fish farmers and their association as well as the processing industry. Any research project are evaluated in relation to its economic and sustainable impact in the production sector and are only funded if a positive impact on the productivity is made probable. The stakeholders are positive to the ideas of efficient utilizing of local raw materials for use in aquaculture feed and some are already involved in such activities. In Norway, there are three large producers manufacturing 1.2-1.5 million tons annually. The food safety is a big issue and thus the producers want clean products. A protein source should have minimum 50-60% protein and a fat source minimum 90% fat. Moreover, the producers wants to optimize the logistics, storage and processing with minimal level of complexity. However, the Norwegian feed industry is positive towards, new local feed ingredients, especially if they are available in large quantities.

2 Main actors in the value chain in Denmark

2.1 Fish meal and fish oil manufacturers in Denmark

The raw material for processing fish meal and fish oil is industrial fish not used for human consumption. The annual Danish production, of fish meal and fish oil, amounts to about 190,000 tons and 70,000 tons, respectively. The global production is currently about 5 mio. tons of fish meal and 1 mio. tons of fish oil. The figures are declining due to decreased catches in the sea. About 60% of the global production of fish meal is used for fish feed. However, offal from the pelagic fish (herring, mackerel) processing industry contributes significantly to the production of fish meal and fish oil, and accounts currently for about 20% of the fish meal for fish feed, cf. section 2.4. But offal from processing of farmed fish is not allowed for production of fish meal and fish oil for fish feed.

The Danish fish meal industry includes 3 factories:

TripleNine Fish Protein - 999

Fiskerihavnsgade 35
P.O. Box 359
DK-6701 Esbjerg
Phone: +45 79120999
Fax: +45 79120888
and
Sydhalevej 14
DK-7680 Thyborøn
999@999.dk
www.999.dk

Fiskernes Fiskeindustri – FF of Denmark

Havnevagtvej
P.O. Box 164
DK-9990 Skagen
Phone: +45 98441100
Fax: +45 98450211
ff@ffskagen.dk
www.ff-of-denmark.com

Hanstholm Fiskemelsfabrik

Nordre Strandvej 54
DK-7730 Hanstholm
Phone: +45 9796 1022
Fax: +45 9796 2627
info@hafimeal.dk
www.hafimeal.dk

2.2 Fish Feed producers in Denmark

The Danish fish feed industry includes 2 factories:

BioMar A/S

Mylius Erichsensvej 35
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Denmark
Phone: + 45 97180722
Fax + 45 98183012
infor@biomar.dk
www.biomar.dk

The BioMar group is one of the international leading suppliers of high performance fish feed with factories in several countries, mainly in Europe. Worldwide the BioMar Group supplies feed to around 50 countries and to more than 25 different fish species.

Aller Aqua

Allervej 130
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info@aller-aqua.com
www.aller-aqua.com

Aller Aqua produces feed at factories in Denmark, Poland and Germany for several different fish species.

The Danish fish feed manufacturers only uses raw materials from regulated fisheries. Sustainable fisheries are monitored by accredited organizations as f. ex. International Council for the Exploration of the Sea (ICES) and Food and Agriculture Organization of the United Nations (FAO).

The domestic feed production for the domestic market is about 45,000 tons, while about one hundred thousand tons are produced for the international market.

The Danish Fish Feed manufacturers have their own R&D departments keeping all information confidential. For the same reason information about raw materials are kept confidential. Especially due to the limitation of fish meal and fish oil searching for alternatives is currently a very hot issue. However, the following ingredients used for fish feed can be listed:

Fish meal - Soya meal - Soya protein concentrate - Pea protein - Hemoglobin meal -
Horse beans - Organic peas - Organic soya cake – Wheat - Maize gluten –
Fish oil - Rape oil

2.3 Aquaculture in Denmark

The Danish aquaculture sector includes:

<u>Type of production</u>	<u>Production (tons)</u>
≈ 200 fresh water trout farms	32,000
5 fresh water organic trout farms	300
15 sea water cage trout farms	9,000
10 salt water farms (land based)	500
8 Eel farms	1,800
≈ 50 Mussel farming plants	2,000
TOTAL	≈ 45,000

The organic production of rainbow trout in freshwater in Denmark has been established since 2005 but still the production is stagnating around 300 tons. From the beginning the challenge was to get the feed produced. Such low quantities were not interesting for the feed companies. So for some years the feed for the organic fish were produced at Danish Technological Institute. This caused elevated price for the feed. However, according to the common EU regulations for organic aquaculture being into force from 1st July 2010, it has been possible to have the feed produced at the commercial feed factories, as they can produce to the whole European organic aquaculture market.

However, significant increases in the organic production are hampered by still being a low critical mass, which makes a vicious circle including vulnerability to security of supplies, costs of production, diseases, relative high costs of environmental supervision by authorities etc. Further being a niche production one farm is very small (8 t/year) and one farm is placed in an edge area of the country so the fish slaughterers evaluate the costs of transportation the fish to be too high. Another challenge is the request of preferably using green energy; even it makes sense in relation to organic principles. However, expecting increased demand of organic fish, the Danish Aquaculture sector anticipates the organic production to be increased in the years to come.

A life cycle analysis (LCA) of trout farming including the time span from feed via farming of the fish to processing and finally to the cold counter in the supermarket has been carried out by the Danish company AgroTech and published in a report: "Global Warming Potential of Smoked Trout Filet", AgroTech 2009. The investigation showed that the discharge of CO₂ from trout farming was 1.2 kg CO₂/kg farmed fish compared to more than 19 kg CO₂/kg beef and about 3 kg CO₂/kg pork or chicken. The reasons for the low CO₂ impact of fish farming are that fish are poikilothermic and do not use energy for regulating their body temperature; living in water minimizes the energy against gravitation and therefore farmed fish utilizes a greater proportion of the feed for growth than land living homoeothermic animals. However, the feed accounted for more than half of the CO₂ discharge. So improved utilization of feed ingredients including using local raw materials for fish feed will contribute to farmed fish being an even more environmental friendly and sustainable food. The landings of wild catches from the sea are either sold directly as fresh or frozen fish in shops or delivered to the processing industry. The annual landings of fish for consumption and processing of fish meal and fish oil amount to about 250,000 tons consumption fish and 550,000 tons industrial fish.

2.4 Fish processing and marketing companies in Denmark

The Danish processing and marketing/export industry is organized through to organizations:

(1) Danish Seafood Association and (2) Konsumfiskeindustriens Arbejdsgiverforening (KAF) - [Employers' Association for the Consumer Fishery Industry].

The following companies are members of the Danish Seafood Association (extrapolated from the DSA homepage):

A. ESPERSEN A/S Fiskerivej 1 3700 Rønne	Phone:: + 45 5690 6000 Fax: + 45 5690 6001 roenne@espersen.dk www.espersen.dk
A/S Læsø Fiskeindustri Industrivej 4 9940 Læsø	Phone:: + 45 9849 8188 Fax: + 45 9849 8099 laeso@laeso-fish.dk www.laeso-fisk.dk
O.V.Jørgensen Hundested Fiskeeksport Færgevejen 2 3390 Hundested	Phone:: + 45 4793 7014 Fax: + 45 4794 0801 info@ovj.dk www.ovj.dk
Agustson a/s Søren Nordbysvej 24 9850 Hirtshals	Phone:: + 45 9894 5422 Fax: + 45 9894 5435 agustson@agustson.com www.agustson.com
Aker Seafoods Denmark A/S Nordre Kajgade 7 8500 Grenå	Phone:: + 45 8758 2000 Fax: + 45 8758 2001 akersea@akersea.dk www.akerseafoods.dk
Alimex Seafood A/S Skomagervej 13C 7100 Vejle	Phone:: + 45 7582 8299 Fax: + 45 75828298 info@alimex.dk www.alimex.dk
American Seafoods Europe ApS Vesterå 15, 3 9000 Aalborg	Phone:: + 45 9632 0440 Fax: + 45 9632 0441 allan.rasmussen@americanseafoods.com www.americanseafoods.com

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HJERTING LAKS A/S Bytoften 3 6710 Esbjerg V	Phone:: + 45 7511 5222 Fax: + 45 7613 2346 hjl@hjerting-laks.dk www.hjerting-laks.dk
Hyttels Røgeri A/S Rømqøvej 2 9800 Hjørring	Phone:: + 45 9892 2677 Fax: + 45 98901477 hyttel@hyttels.dk www.hyttels.dk
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Jens Møller Products ApS Havnen 95 7620 Lemvig	Phone: + 45 9781 1189 Fax: + 45 9781 1848 office@cavi-art.com www.cavi-art.com
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Fax: + 45 9848 8555
oh@nielsens-fiskeeksport.dk

Nordbornholms Røgeri ApS
Kæmpestranden 2
3770 Allinge

Phone: + 45 5648 0730
Fax: + 45 5648 0032
info@nbr.dk
www.nbr.dk

Nordic Seafood A/S
Søren Nordbysvej 15
9850 Hirtshals

Phone: + 45 9894 1533
Fax: + 45 9894 5233
mail@nordicseafood.com
www.nordicseafood.com

Nordstar Fiskeeksport A/S

Phone: + 45 9796 2144

Chr. Schrødersgade 40
7730 Hanstholm

Fax: + 45 9796 2262
info@nordstar.dk
www.nordstar.dk

NORLAX A/S
Gartnervænget 31
6855 Outtrup

Phone: + 45 7652 2300
Fax: + 45 7652 2390
norlax@norlax.com
www.norlax.com

Nortop A/S
Vandvejen 2
8000 Århus C

Phone: + 45 7027 0809
Fax: + 45 8627 6909
lh@nortop.dk

Nyfrogst Hirtshals A/S
Frysehuskajen 8 Østhavnen
9850 Hirtshals

Phone: + 45 9894 3011
Fax: + 45 9894 4665
benny@nyfrost.dk
www.nyfrost.dk

O.H. Fiskeeksport A/S
Niels Juelsvej 1
9850 Hirtshals

Phone: + 45 9894 3977
Fax: + 45 9894 2919
oh@oh-fiskeeksport.dk
www.oh-fiskeeksport.dk

Ocean Seafood A/S
Ved Stranden 7C
9000 Aalborg

Phone: + 45 9811 0700
Fax: + 45 9811 0888
jens@ocean-seafood.com
www.ocean-seafood.com

P. TAABELL & CO. A/S
Industribuen 3
7730 Hanstholm

Phone: + 45 9796 1677
Fax: + 45 9796 1244
taabel@taabel.dk
www.taabel.dk

Pandalus A/S
Industrivangen 3
7730 Hanstholm

Phone: + 45 9796 1255
Fax: + 45 9796 1088
mail@pandalus.dk
www.pandalus.dk

Pelagic Skagen A/S
Tobiskajen 2
9990 Skagen

Phone: + 45 9844 1833
Fax: + 45 9844 6160
ljh@pelagic.dk

Planets Pride Int.
Valbyvej 69E
4200 Slagelse

Phone: + 45 7027 0772
Fax: + 45 7027 0771
jh@planetspride.com
www.planetspride.com

Polar Salmon A/S

Phone: + 45 7512 4677

H. E. Bluhmesvej 18
6700 Esbjerg

Fax: + 45 7512 4462
polarsalmon@polarsalmon.com
www.polarsalmon.dk

Polar Seafood A/S
Baldrianvej 2
9310 Vodskov

Phone: + 45 9829 4422
Fax: + 45 9829 4181
polar@polarseafood.dk
www.polarseafood.dk

Polar Star Fish Co. ApS
Udsigten 4
9310 Vodskov

Phone: + 45 9638 3810
Fax: + 45 9638 3819
cr@polarstarfishco.com
www.polarstarfishco.com

Rahbek-Filet A/S
Jens Munksvej 4
9850 Hirtshals

Phone: + 45 7592 2000
Fax: + 45 9894 3698
mail@rahbek.dk
www.rahbek.dk

Rahbekfisk A/S
Værftsvej 13
7000 Fredericia

Phone: + 45 7592 2000
Fax: + 45 7620 2980
mail@rahbek.dk
www.rahbek.dk

Rasmus Clausen & Sønner ApS
Hyttedefadsvej 14
9970 Strandby

Tlf: 9848 2777
Fax: 9848 2877
info@rasmus-clausen.dk
www.rasmus-clausen.dk

Royal Danish Seafood A/S
Nordre Strandvej 62
7730 Hanstholm

Phone: + 45 9655 0700
Fax: + 45 9655 0705
rds@royaldanishseafood.com
www.royaldanishseafood.com

Royal Greenland A/S
Hellebarden 7
9230 Svenstrup J

Phone: + 45 9815 4400
Fax: + 45 9815 4435
info@royalgreenland.com
www.royalgreenland.com

Scan Products ApS
Aagærdet 44
6000 Kolding

Phone: + 45 7467 3800
Fax: + 45 7467 3303
scanproducts@scanproducts.dk
www.scanproducts.dk

ScanFish Danmark A/S
Industrihøjen 5
7730 Hanstholm

Phone: + 45 9796 2122
Fax: + 45 9796 1440
info@scanfish.net

www.scanfish.net

Seafood Action Center A/S

Jernbanegade 29
5500 Middelfart

Phone: + 45 6441 7014
Fax: + 45 6441 7019
henrik@seafoodaction.dk
www.seafoodaction.dk

SEAMAID A/S

Taastrup Hovedgade 98
2630 Taastrup

Phone: + 45 4457 5066
Fax: + 45 4457 5069
ba@seamaid.dk
www.seamaid.dk

Sirena A/S

Egebækvej 98
2850 Nærum

Phone: + 45 7027 6510
Fax: + 45 7027 6511
info@sirena.dk
www.sirena.dk

Skagerak Group

Sindalvej 5
9850 Hirtshals

Phone: + 45 9894 1100
Fax: + 45 9894 1322
ie@skagerakgroup.com
www.skagerakgroup.com

Tell Seafood A/S

Birkevænget 5
7730 Hanstholm

Phone: + 45 3696 7788
Fax: + 45 9796 2575
jt@tellsea.dk
www.tellsea.dk

Uhrenholt A/S

Teglgårdsparken 106
5500 Middelfart

Phone: + 45 6441 4141
Fax: + 45 6421 2126
sov@uhrenholt.com
www.uhrenholt.com

VARDE LAKS A/S

Snedkervej 2
6800 Varde

Phone: + 45 7522 5022
Fax: + 45 7521 0622
info@vardelaks.dk
www.vardelaks.dk

Vega Salmon A/S

Stenhuggervej 5
6710 Esbjerg V

Phone: + 45 7610 9500
Fax: + 45 7611 9505
info@vega-salmon.dk
www.vega-salmon.dk

Vendsyssel Seafood A/S

De Conincks Vej 19
2840 Holte

Phone: + 45 4542 4325
Fax: + 45 4542 4177
pb@vendsyssel-seafood.dk
www.vendsyssel-seafood.dk

Vilsund Muslinge Industri A/S
 Food Parken 1
 7900 Nykøbing M
 Phone: + 45 9772 3700
 Fax: + 45 9772 1142
 info@vilsund.com
 www.vilsund.com

Wecofisk A/S
 Jernbanegade 75
 5500 Middelfart
 Phone: + 45 6441 5002
 Fax: + 45 6441 5850
 henning@wecofish.dk
 www.wecofish.dk

Werner Larsson Fiskeeksport A/S
 Galeasevej 3
 9990 Skagen
 Phone: + 45 9844 1000
 Fax: + 45 9844 6207
 info@wernerlarsson.dk
 www.wernerlarsson.dk

The following companies are members of the Konsumfiskeindustriens Arbejdsgiverforening (KAF) - [Employers' Association for the Consumer Fishery Industry], representing a wide ranging number of Danish companies within the fishery sector extrapolated from the KAF homepage:

<u>Company name</u>	<u>E-mail</u>	<u>Phone(+45)</u>	<u>Fax(+ 45)</u>
Amanda Seafoods A/S	amanda@amanda-seafoods.dk	96221500	96221501
Bornholms A/S	Christian.sieverts@officer.dk	56643800	56643809
Cimbric A/S c/o Jeka Fish	cimbric@cimbric.com	97811700	97811701
Jacob Kongsbak Lassen	kongsbak-lassen@mail.dk	33799566	33796765
Heino A/S	kongsbak-lassen@mail.dk	33799566	33796765
Kattegat Seafood A/S	silva@silva-seafood.dk	87527300	86300015
Larsen Danish Seafood A/S	info@larsea.com	98423444	98433165
Vilsund Blue Delicacies A/S	ks@vmi.dk	97721700	97723058
Lykkeberg A/S	info@lykkeberg.com	39169200	39169201
Munkebo Seafood A/S	spinnaker@mail.tele.dk	65974850	65976398
Nortop A/S	lh@nortop.dk	70270809	86276909
A/S Sæby Fiske-Industri	administrator@saeby.com	98461066	98464241
Johs. Tvillings Filetfabrik	info@tvilling.dk	39163800	39163801
Vilsund Blue A/S	stm@vilsund.com	97723700	97721142

3 Main actors in the value chain in Iceland

3.1 Export products from Icelandic fisheries

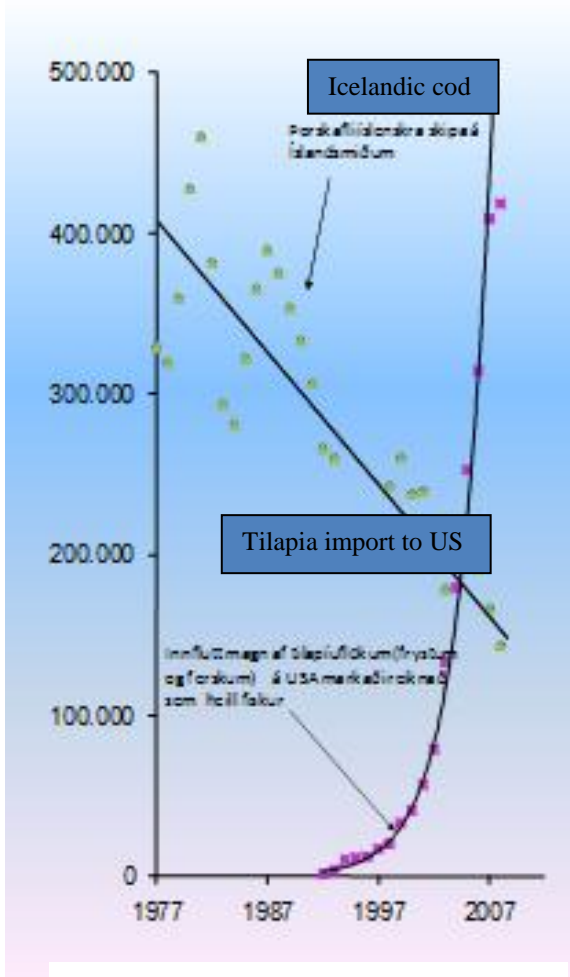


Figure 2: Development of cod catch and tilapia import to USA 1977-2007

Fisheries are one of the fundamental export industries in Iceland. It is therefore of concern that the quantity of exported marine products have been declining in general, although fisheries of some species have increased temporarily. This follows the global trend with stagnated wild fisheries while aquaculture has been expanding rapidly in Asia and Central-America.

Figure 2 shows the development of the Icelandic cod catch from 1977 compared to the development in import to USA of tilapia, one of the new whitefish aquaculture species on the market. Tilapia was almost unknown in USA 20 years ago but is now the fifth most sold fish species in USA.

The share of exported marine products of total value of exported goods from Iceland has decreased from over 60% in the year 2000 to appr. 40% in 2010, see figure 3, mostly due to increased aluminum production in Iceland. The aluminum industry has now a similar export share as the fisheries. Figure 4 shows the quantity of exported marine products from Iceland in the period 1996-2010. The total exported quantity in 2010 was 632,000 tons, a 5.5% reduction from 2009. Thereof 245,000 were demersal fish products, mostly cod (96,000 tons).

Pelagic fish was 47.9% of the total export with 303,000 tons, whereof herring was counting for 160,000 tons. The export of shellfish and crustacean was 18,000 tons in 2010, mostly shrimp (15,000 tons). The fish products are mainly exported to Europe appr. 80%, thereof 73% to EEA-countries, 9.1% was exported to Asia and 5.3% to USA and Canada.

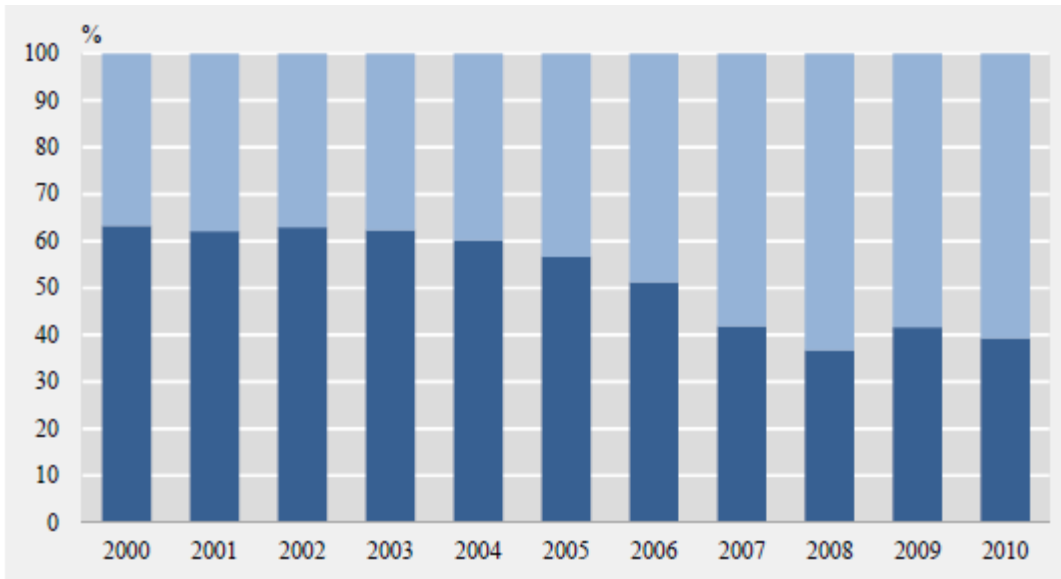


Figure 3: The share of exported marine products of total value of exported goods 2000-2010 (Hagstofan, 2011).

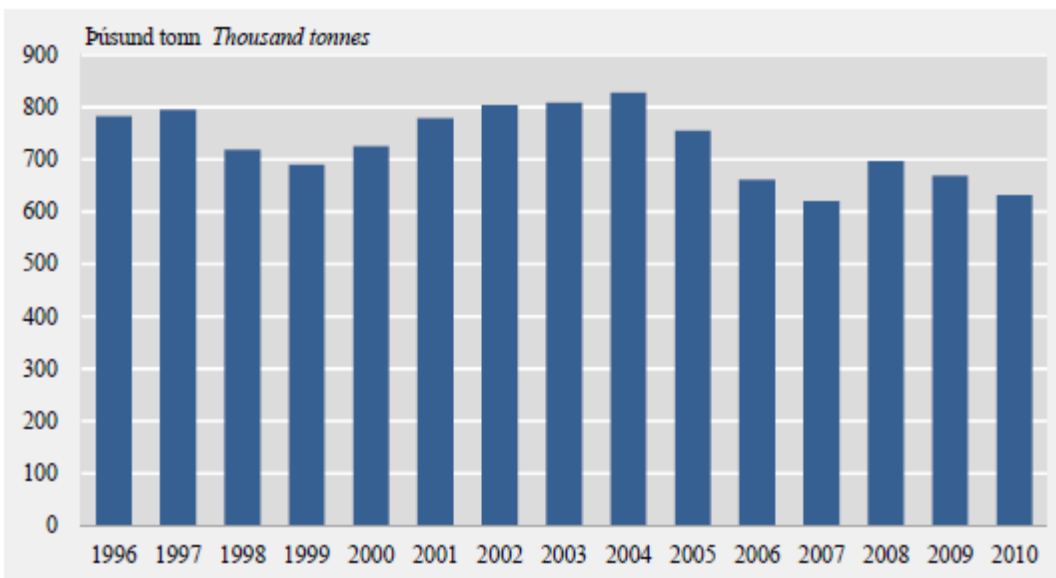


Figure 4: Quantity of exported marine products from Iceland 1996-2010 (Hagstofan, 2011).

3.2 Fish meal and fish oil manufacturers in Iceland

There are several fish meal and fish oil manufacturers in Iceland. The total production in 2010 was 127,673 tons, with a decline in production amount of 23.5% from 2009. The total export value of fish meal and fish oil though only decreased by 0.3%.

Table 1: Production (tons) in Iceland of fish meal and fish oil for export 2009 and 2010.

	2009	2010
Fish meal	101,668	77,627
Fish oil	65,149	50,046
Total	166,816	127,673

The fish meal and fish oil manufacturers in Iceland are:

Sildarvinnslan hf. in Helguvík, Neskaupstaður, Seyðisfjörður and Siglufjörður
Hafnarbraut 6
740 Fjardabyggd
Phone: +354 470 7000
Fax: +354 470 7001
www.svn.is
svn@svn.is

Stakksbraut 5
230 Keflavík

Strandarvegur 1-11
Pósthólf 133
710 Seydisfjörður

Vetrarbraut 12
580 Siglufjörður

HBGrandi hf. in Reykjavík, Akranes and Vopnafjörður
Nordurgardur 1
101 Reykjavík
Phone: +354 550 1000
Fax: +354 550 1005
www.hbgrandi.is
hbgrandi@hbgrandi.is

Bárugötu 8-10
300 Akranesi

Hafnarbyggd 7
690 Vopnafjörður

Isfelag Vestmannaeyja hf. in Vestmannaeyjar and Thorshöfn
Strandvegur 28
900 Vestmannaeyjar
Phone: + 354 488 1100
Fax: +354 488 1111

www.isfelag.is
upplysingar@isfelag.is

Langanesvegi 1
680 Þórshöfn

Vinnslustödin hf. in Vestmannaeyjar
Hafnargötu 2
900 Vestmannaeyjar
Phone: + 354 488 8000
Fax: +354 488 8001
www.vsv.is
vsv@vsv.is

Skinney Þinganes hf.
Krossey
780 Hornafjörður
Phone: +354 470 8100
Fax: +354 470 8101
www.sth.is
sth@sth.is

Lodnuvinnslan hf.
Skólavegi 59
750 Faskrúdsfjörður
Phone: +354 470 5000
Fax: +354 475 1513
www.lvf.is
lvf@lvf.is

Eskja hf.
Strandgötu 39
735 Eskifjörður
Phone: +354 470 6000
Fax: +354 470 6001
www.eskja.is
eskja@eskja.is

3.3 Fish feed producers in Iceland

The Icelandic fish feed industry includes 2 factories:

Fodurblandan hf
Korngörðum 12

104 Reykjavik
Island
Phone: +354 5709800
Fax +354 5709801
fodurblandan@fodurblandan.is
www.fodurblandan.is

and

Laxa hf.
Krossanes
603 Akureyri
Island
Phone: +354 4607200
Fax. +354 4627282
laxa@laxa.is
www.laxa.is

The feed producer Laxa hf. is the bigger producer of fish feed in Iceland with 85% market share. The company has produced fish feed for aquaculture for more than 20 years and produces today feed for five species, Arctic charr, cod, salmon, flatfish and rainbow trout. The feed produced by Laxa can be used for aquaculture fish from the size of 5-20 grams depending on species. The company produces grain sizes down to 1.8 mm, but not the finest grain sizes. These are imported from Biomar in Denmark and Skretting in Norway for reselling in Iceland.

The other feed producer in Iceland, Fodurblandan, produces fish feed down to 1.6 mm grain size and up to 16 mm for Arctic charr, salmon, halibut, cod and more species. They have been renewing their equipment and just got a new extruder with double screw. The company produces also feed for other animals but the production capacity today is not fully utilized. Fodurblandan has produced test feed blends based on Icelandic rapeseed for tilapia recently and is further collaborating with Matorka looking for opportunities to increase the share of local feed ingredients.

3.4 Sustainable production

The market demand for products produced in a sustainable way is increasing. To increase sustainability in aquaculture it is important to use sustainable feed ingredients. Moreover, use of renewable energy sources, sustainable use of water and keeping the impact on the environment to a minimum is important. Iceland has huge amount of renewable hydro power and geothermal energy and the cold water resources are plenty. Also land space is plentiful and there are a lot of opportunities for local production of feed ingredients. Thus, aquaculture could increase substantially with the production and marketing of products manufactured in an environmentally friendly way. Companies such as Wholefoods and Waitrose focus on good quality, healthy and environmentally correct products. Also many restaurants are increasingly focusing on food with low carbon footprint or carbon neutral, meaning produced in a sustainable way.

Iceland has huge possibilities in utilizing the lands abundant natural resources in a good manner producing high quality food products for export. The innovation company Matorka has started to look at new opportunities for the landbased aquaculture industry with the production of new rapid

growing, herbivorous / omnivorous species, utilization of effluent water from the aquaculture for green house production (aquaponics), increased production of local sustainable feed ingredients for aquaculture and processing of rest materials making valuable byproducts. Matorka names the ideology the Green Circle, see figure 5.

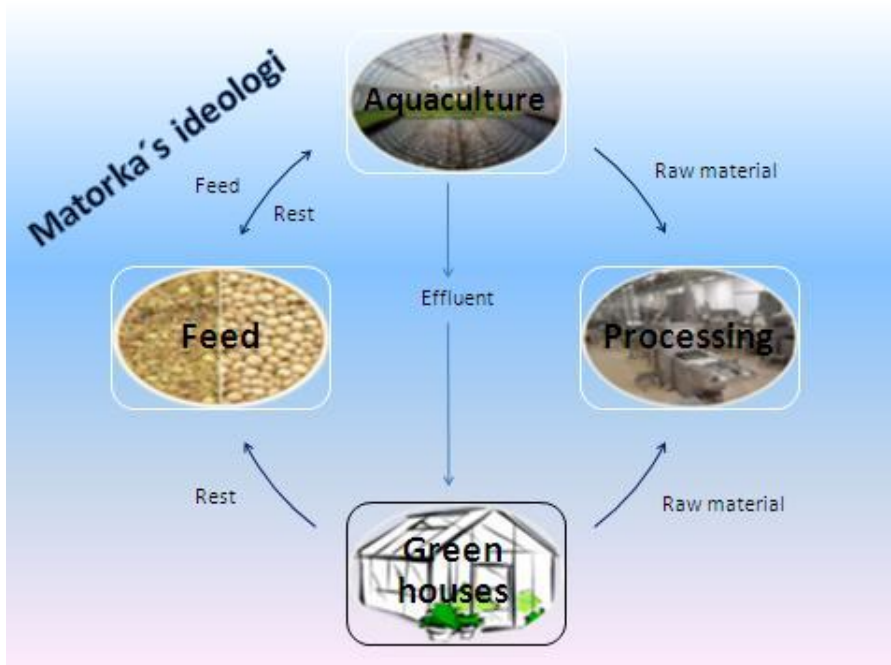


Figure 5: Matorka's Green Circle ideology.

3.5 Aquaculture in Iceland

Aquaculture in Iceland took off in 1984-1987 with import of salmon, but has never reached high production volumes. The production peaked in 2006 with almost 10,000 tons, whereof 7,000 tons were salmon, see figure 6. The salmon was produced in two stations in East-Iceland, and when they stopped, the production went down to 300 tons in 2008. Salmon is produced in Öxarfjörður in North-Iceland and salmon production has started in the West-fjords. The production in 2010 was appr. 1,000 tons and the annual production capacity is planned to increase up to a few thousand tons. The production of salmon in Iceland as food fish is not believed to reach very high volumes. Though, the export of salmon eye roes and fingerlings to Chile and Norway is increasing and could be expanded substantially.

The landbased aquaculture in Iceland is mainly Arctic charr production. The breeding started in 1991 at Stofnfiskur and in 1992 at Holaskoli. In recent years the production of Arctic charr has increased and is now appr. 3,000 tons, or 60% of the total aquaculture production in Iceland. It is expected to increase substantially in the next few years.

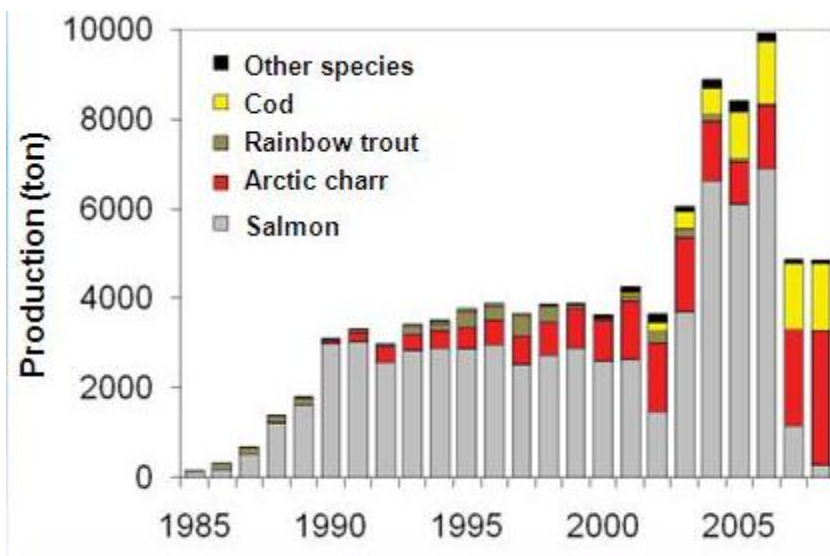


Figure 6: Aquaculture in Iceland 1985-2008.

The total netto export of aquaculture products from Iceland has been appr. 2,000 tons in recent years, mainly Arctic charr, see table 2.

Table 2. Total export from Icelandic fish farming

	2007	2008	2009	2010
Tons exported	2,185	2,118	1,962	1,559

The world production of Arctic charr was appr. 5,000 tons in 2008, 3,000 tons in Iceland and some hundred tons in Norway, Sweden and Canada. The Icelandic production has increased steadily from 200 tons in 1990. The company Islandsbleikja produces 70% of the Arctic charr in Iceland. Islandsbleikja has the largest aquaculture stations in Iceland, in Vatnsleysuströnd, Grindavík and Öxarfjörður. The annual production capacity of all three stations is more than 3,000 tons. Other producers are much smaller with 10-300 tons annual production capacities. The main companies are:

- Islandsbleikja
- Stofnfiskur
- Haukamyri
- Rifos
- Silfurstjarnan
- Kirkjubæjarklaustur
- Fellsmuli and Galtalækur
- Tungusilungur Talknafjörður
- Jöklableikja Hornafjörður
- Fagridalur Myrdal
- Hof Öräfum

- Fiskeldid Hlid Olafsfjörður
- Hallkelsholar
- Bleikjubær

The annual production of cod in aquaculture has been approximately 1,500 tons and is not expected to increase in the near future as there are still some technical problems to solve. Halibut and turbot farming are limited to small amounts, mainly R&D, but turbot farming is seen as a favorable opportunity. Also rainbow trout production could increase to a few thousand tons annually in the near future.

New companies have been established in recent years, focusing on utilizing geothermal heat for the production of rapid-growing warm-water species; tilapia and sea cucumber. Moreover, the Norwegian company Stolt Seafarm is planning a new production plant with sole production. All the new players are planning large production units with annual productions of thousands of tons. Thus, aquaculture in Iceland could be multiplied in a few years time.

3.6 Fish processing and markets in Iceland

The Federation of Icelandic Fish Processing Plants (Samtök fiskvinnslustöðva SF – www.sf.is) safeguards common interests of companies in Iceland engaged in fisheries, processing and selling marine products. Three other member associations are partly serviced and operated by SF:

- The Icelandic Aquaculture Association (LF) – www.lfh.is
- The Icelandic Association of Fish Meal Manufacturers (FÍF)
- Fisheries Technology Forum

The main fisheries and/or processing companies are:

- Brim hf
- Eskja hf
- FISK Seafood hf
- Vísir hf, Húsavík
- Fiskmarkaður Suðurnesja
- G Ingason hf
- HB Grandi hf
- Guðmundur Runólfsson hf
- Hraðfrystihúsið - Gunnvör hf
- Ísfélag Vestmannaeyja hf
- Samherji hf
- Agustson ehf
- Síldarvinnslan hf
- Icelandic Group
- Vinnslustöðin hf
- Þorbjörn hf
- Rammi hf

The federation of fish producers and exporters (**Samtök fiskframleiðenda og útflytjenda – SFÚ** – www.sfu.is) was founded in 1994 and was first named The federation of fish processing without fisheries (Samtök fiskvinnslu án útgerðar). The main companies in the federation are:

Toppfiskur
www.toppfiskur.is

Isfiskur
www.isfiskur.is

Skinnfiskur
www.skinnfiskur.is

Nyfiskur
www.nyfiskur.is

Frostfiskur
www.frostfiskur.is

Hamrafell
www.hamrafell.is

Other exporters of fish products includes:

Menja
www.menja.is

Nordic Seafood
www.nordicseafood.is

Danica
www.danica.is

Icelandic Sales Agency Ltd. (Íslenska umboðssalan)
www.isa.is

Fiskkaup hf. / Jón Ásbjörnsson
www.fiskkaup.is

Fiskval (Part of Icelandic Group)
www.fiskval.is

4 Main actors in the value chain in Norway

4.1 History of aquaculture in Norway

Farming of Atlantic salmon in sea cages was developed in Norway during the early 1970's. During its early days moist or wet feeds based on ground industrial fishes were fed to small cages located in sheltered areas and in shallow waters. Dry pelleted diets were introduced during the 1980ies and gradually out phased the wet diets. Cooking extruders were introduced around 1990 and allowed higher lipid levels in the diet. The Norwegian Government implemented feed quotas in 1996 in order to prevent anti dumping tariffs in the EU market. This encouraged further increase in the energy content of the diet and vacuum coating techniques of feeds with fish oil was developed. Today, grow out diets for Atlantic salmon contain 35-37 % fat and 37-38 % protein.

In order to limit the growth in Atlantic salmon production a temporary act was implemented in 1973. This issued a licensing system restricting the size of the individual farms as well as the ownership of the aquaculture operations. This act has been revised several times and today the act has a focus on sustainable development and ownership regulations have been deregulated. However, regional development is still an important criterion for issuing new licenses. Today the five largest Norwegian Aquaculture companies (groups) produce approximately 56% of the Norwegian Atlantic salmon and 46% of the total Atlantic salmon production in the world.

Originally, the feeds were mainly based on fish meal and fish oil with an addition of approximately 10% carbohydrates of vegetable origin. The increased process of fish meal and fish oil has increased the inclusion rates of vegetable protein and fat sources. Fish meal and fish oil is a limited resource with limited possibilities for increased production in the future. Further growth of the Atlantic salmon production will require a further increased inclusion rate of plant proteins and fats. However, the Ω -3 HUFA is presently only available from marine resources. Development of new sources for Ω -3 HUFA is the potential limiting factor in further growth of the Atlantic salmon aquaculture.

In 2009, the Norwegian marine fisheries amounted to 2.7 million tons of which 1.7 million tons were pelagic fishes and 670,000 tons cod fishes. Fish meal and oil were produced from 540,000 tons.

4.2 Fish meal and fish oil manufacturers in Norway

There are 36 companies processing fishmeal and oil or other similar products in Norway, of these there are 6 classical fish meal factories belonging to the company Welcon AS and two independent. The complete list of approved processors is shown in appendix 1.

Welcon AS

Production facilities:

Welcon Protein AS - Ryttervik

Varbergsvei 61

N-4370 Egersund

Karmsund Fiskemel AS

Husøyveien 283
4262 Avaldsnes

Måløy Sildoljefabrikk AS
6718 Deknepollen

Bodø Sildoljefabrikk A/S
Burøyveien 27
8012 Bodø

Independent producers:

Egersund Fiskemelfabrikk AS
Åsaneveien 103
4370, Egersund
Phone: +47 51 46 30 00
Fax: +47 51 46 48 51

Vedde AS
6030 Langevåg
Phone: +47 70 19 99 50
Fax: +47 70 19 99 60

4.3 Fish Feed producers in Norway

There are three major fish feed producers in Norway:

BioMar AS
Bolstadvei 24
8430 Myre
Norge
Phone: +47 76 11 92 00
Fax: +47 76 11 92 29
www.biomar.com

EWOS AS
Tollbodallmenningen 1B
Postboks 4 Sentrum, 5803 Bergen
Phone: +47 55 69 70 00
Fax: +47 55 69 70 01
www.ewos.com

Skretting AS
Sjøhagen 15
4016 Stavanger
Norway
Phone: +47 815 21 300
Fax: +47 51 58 57 68

www.skretting.com

These companies have several feed processing plants in Norway. Detailed information about the individual facilities can be found on the web page of the companies. There are also a couple of smaller companies (see below) and a long list of companies delivering feed ingredients (Appendix 2).

Polarfeed AS

Lufthavnveien 11
N-8370 Leknes
Phone: +47 76 06 40 69
Fax: +47 76 06 09 40
www.polarfeed.no

Troms Fiskeindustri AS

Stakkevollveien 57
Postboks 233
9253 Tromsø
Phone: +47 77 64 71 40
Fax: +47 77 69 48 43
trofi@oddberg.no

Troms Fiskeindustri AS delivers start and weaning feeds for marine fish larvae.

4.4 Aquaculture in Norway

The most recent statistical information about aquaculture in Norway can be found on the web page of the Directorate of Fisheries (<http://www.fiskeridir.no/statistikk/akvakultur>). In 2009 there were produced 862,000 tons of Atlantic salmon, 74,000 tons Rainbow trout, 20,000 tons cod, 1,600 tons halibut, 200 tons other fin fishes, 1,600 tons blue mussel, 8 tons scallop, 4 tons oysters and 67 tons of other species.

Permits for aquaculture in Norway (2010):

- Juveniles – Salmon / rainbow trout: 249
- Grow out – Salmon / rainbow trout: 991
- Brood stock – Salmon / rainbow trout: 33
- Research and development: 40
- Other marine fin fish: 513
- Shellfish: 377
- Sea ranching: 14

5 Main Actors in the Value Chain in Sweden

Aquaculture is currently a very small part of the Swedish food production sector. Not only is Swedish aquaculture limited, but curiously, most of the production is exported, while at the same time, a large percentage of fish consumed in Sweden is imported from other countries. Here, Norwegian salmon certainly the largest part, but imports from Asia are also increasing. For various reasons, including the conclusion by FAO that world aquaculture needs to expand to sustain fish as an important nutrient source for the human population (FAO, 2010), as well as the EU policy of decreasing the dependency of fish imports into Europe from other parts of the world, including Africa, the Swedish government has recently indicated that Aquaculture needs to be expanded in Sweden, as a part of the local food production sector (Det Väckande Vattenbrukslandet SOU 2009:26).

In 2009, the Swedish marine fisheries amounted to 197,000 tons of which 121,000 tons (61%) are feed-fish not used for human consumption (SCB 2010), see figure 7. The diagram below shows the percentage feed fish in the Swedish fisheries over 1981-2009 (Statistical Yearbook of Sweden 2011).

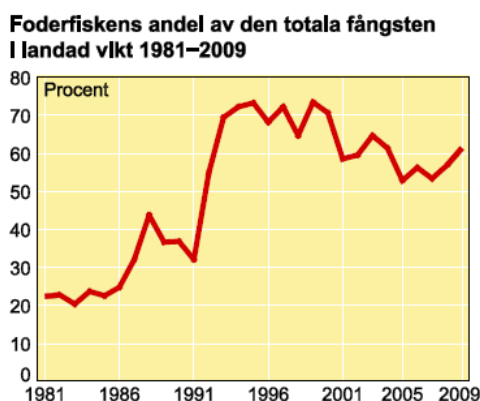


Figure 7: The amount of feed fish out of the total fisheries in Sweden.

5.1 Fish meal and fish oil manufacturers in Sweden

Although large percentage of the Swedish fisheries represent feed-fish, this is almost exclusively (89%) landed outside Sweden, in particular in Denmark. Consequently, there are currently not fish meal and oil producers in Sweden.

5.2 Fish Feed producers in Sweden

While Sweden was initially a leading nation in fish feed production with the establishment of Ewos AB, this multinational fish feed producer has currently no activities in Sweden, and there are no other fish feed producers in Sweden. It is likely that the very limited volume of the local finfish aquaculture is too small to sustain local feed production. Thus currently, all feed for Swedish finfish aquaculture is imported.

5.3 Aquaculture in Sweden

In 2009, Swedish aquaculture produced 7,225 ton fish for consumption and about 993 tons fish and freshwater crayfish for release. Rainbow trout production dominates both aquaculture food production (89%) and release, will smaller production volumes of Arctic char, brown trout and eel. In addition, about 2,125 tons of blue mussels were produced. In 2011, the total Swedish aquaculture production is estimated to reach 12,000 tons, of which 9,000 tons is rainbow trout and 1,500 tons Arctic charr.

The number and type of farms (2009):

- 83 fish farms for food production
- 71 fish farms for release
- 40 crayfish farms for food production
- 9 crayfish farms for release
- 17 blue-mussel farms
- 1 oyster farm

Production quantities (2009):

- 7,225 tons of fish for consumption
- 993 tons of fish for release
- 2 tons of crayfish for consumption
- 1 ton of crayfish for release
- 2.125 tons of blue mussels
- No significant production of oysters

Production of fish for consumption by species (2008/2009):

- 6,413 tons of rainbow trout
- 23 tons of Atlantic salmon
- 172 tons of eel
- 692 tons of Arctic charr

Swedish fish farming is mostly carried out in freshwater netpens (salmonids) or tanks (eel). However, of the rainbow trout production, 2,431 tons were produced in seawater netpens. It is estimated that aquaculture has given work to 367 men and 57 women in Sweden during 2009. Given the number of farms and production volumes, it is obvious that many of the production units are extremely small. Thus, in 2009, only 13 rainbow trout farms produced more than 100 tons, 16 farms produced between 10-100 tons, and 48 farms produce less than 10 tons.

6 Organizations in Denmark

6.1 Associations

The Danish Aquaculture Organization (DAO) is an association for the Danish aquaculture sector covering the value chain from “farming unit to table”. The association is active involved in aquaculture projects and disseminate scientific and commercial knowledge.

The Danish Aquaculture Organisation

Vejlsøvej 51
DK-8600 Silkeborg
Phone: +45 89212260
Fax + 45 89212261
Danskakvakultur@danskakvakultur.dk
www.danskakvakultur.dk

AquaCircle is a Danish Knowledge-Cluster for continuous development of Recirculation Technology in Aquaculture. Scientific based results may lead to innovation with the overall aim to strengthen the Aquaculture sector including the primary producers, the supporting industry, R&D, consultancies etc.

AquaCircle creates information on Recirculation Aquaculture Systems intended for Authorities, Financial Institutes, Science Communities, Fish Farmers, Industries, Educational Sectors, Consumers and to the general public.

Internally, among members, AquaCircle acts as a greenhouse - stimulating the creation and supporting the growth of groups - facilitating companies and people to cooperate with multiple and cross-sectorial approaches, to solve problems, test ideas and create innovative solutions to be implemented for the benefit of the sector and to enhance the use of Recirculation Aquaculture Systems. To secure the need for qualified scientists and employees to the Aquaculture sector, AquaCircle assists and support in building up relevant training and education on all levels.

The contact details of AquaCircle are:

AquaCircle
Pligtgaardsvej 22
DK-2660 Brøndby Strand
info@aquacircle.dk
www.aquacircle.org

The Association of Fish meal and Fish oil Manufacturers in Denmark is a secretariat for the 3 Danish manufacturers of fish meal and fish oil. The contact details are:

Association of Fish meal and Fish oil Manufacturers in Denmark
H. C. Andersens Boulevard 37, 1.
DK-1553 Copenhagen V.
Phone: +45 33145800
Fax +45 33931337
fm@fishmeal.dk

The Danish Seafood Association (DSA) is a unifying association for the Danish fishery industries. The contact details of the association are:

Danish Seafood Association

H. C. Andersens Boulevard 37, 1.

DK - 1553 København V

Phone: +45 3314 9999

mail@danishseafood.org

www.danishseafood.org

Konsumfiskeindustriens Arbejdsgiverforening (KAF) - [Employers' Association for the Consumer Fishery Industry] is another unifying association for the Danish fishery industries (mainly the sea fishery). Tasks include negotiations on quota and regulations of the fishery. The contact details of the association are:

Hanne Hampe-Mogensen

Phone: + 45 4166 7945

Poul Melgaard Jensen

Phone: + 45 3314 9999

Hanne Groth-Andersen

Phone: + 45 3314 6603 – E-mail: hga@danishseafood.org

6.2 Institutions - Research, development, education related to aquaculture

Technical University of Denmark, DTU, is a private foundation conducting research, education, research-based consulting services to the public authorities in Denmark. DTU comprises 18 institutes. One of these is National Institute of Aquatic Resources, DTU Aqua. In DTU Aqua, Section for Aquaculture in Hirtshals, conducts applied aquaculture research and counselling. Current research includes fish nutrition, environmental impacts of fish farming, fish physiology, fish welfare and aquaculture management. DTU Aqua has several full scale rearing facilities and advanced laboratory facilities. The partner will contribute with know-how and experience in fish nutrition as well as experimental work. Contact details are:

Technical University of Denmark**National Institute for aquatic Resources (DTU Aqua)**

The North Sea Research Centre

DK-9800 Hirtshals

Denmark

Phone: +45 3588 3300

Fax: + 45 3588 3260

aqua@aqua.dtu.dk

www.aqua.dtu.dk

Technical University of Denmark**National Food Institute (DTU Food)**

Building 221

DK-2800 Kgs. Lyngby

Denmark

Phone: +45 45252593

Fax: +45 4588 4774

hhani@food.dtu.dk

www.aqua.food.dk

The North Sea Research Centre [Nordsøen Forskerpark] includes a number of institutions, organisations and companies performing research, development, education and advisory within the fields of fishery and aquaculture. In connection to the research centre the biggest Aquarium in the Northern Europe, Nordsøen Oceanarium, is placed. Contact details are:

The North Sea Research Centre

Willemoesvej 2
DK-9850 Hirtshals
Phone: +45 98944188
Fax +45 98945480
info@nordsoemail.dk
www.nordsoenforskerpark.dk

The Freshwater Centre [Ferskvandscentret], is a national Centre for the Water Environment. Since opening in 1987, The Freshwater Centre has developed into a national centre for the aquatic environment and a meeting place for those who deal with environmental issues. The centre provides a framework for an interdisciplinary milieu, comprising AQUA Freshwater Aquarium, private businesses, research institutions and a number of information activities in the field of aquatic environment. Contact details are:

Ferskvandscentret (The Freshwater Centre)

A National Center for the Water Environment
Vejlshøjvej 51
DK-8600 Silkeborg
fvc@fvc.dk
www.ferskvandscentret.dk
Phone: + 45 89212121

7 Organizations in Iceland

7.1 Industry associations

Samtök fiskvinnslustöðva (Federation of Icelandic Fish Processing Plants)

Borgartuni 35
105 Reykjavik
Phone: +354 591 3050
Fax: +354 591 0358
www.sf.is

Landssamband fiskeldisstöðva (The Icelandic Aquaculture Association TIAA)

Borgartuni 35
105 Reykjavik
Phone: +354 591 3060
Fax: +354 591 0358
www.lf.is

Felag íslenskra fiskmjölsframleidenda (Federation of Icelandic Fish Processing Plants)

Borgartúni 35

Phone: +354 591 0355

Fax: +354 591 0358

www.sf.is

Samtök idnadarins (The Federation of Icelandic Industries)

Borgartúni 35

105 Reykjavík

Phone: +354 591 0100

Fax: +354 591 0101

www.si.is

Samtök atvinnulífsins (SA Confederation of Icelandic Employers)

Borgartúni 35

105 Reykjavík

Phone: +354 591 0000

Fax: +354 591 0050

www.sa.is

Landssamband íslenskra útvegsmanna (LIU - The Federation of Icelandic Fishing Vessel Owners)

Borgartúni 35

105 Reykjavík

Phone: +354 591 0300

Fax: +354 591 0301

www.liu.is

Landssamband smabataeigenda (National Association of Small Boat Owners)

Hverfisgötu 105

101 Reykjavík

Phone: +354 552 6595

Fax: +354 562 6590

www.smabatar.is

Felag skipstjórnarmanna

Grensasvegi 13

108 Reykjavík

Phone: +354 5201280

Fax: +354 520 1289

www.skipstjorn.is

Fiskifelag Islands
Pósthólf 8214
128 Reykjavík
Phone: +354 591 0308
Fax: +354 591 0301
www.fiskifelag.is

7.2 Research institutes, universities and funding

Matis ohf.
Vinlandsleid 12
113 Reykjavík
Phone: +354 4225000
Fax: +354 4225001
www.matis.is

Holaskoli
Fiskeldis- og fiskaliffræðideild
551 Saudarkrokur
Phone: +354 4556300
Fax: +354 4556301
www.holar.is

Vör – Sjavarrannsóknir við Breidafjörður
Nordurtanga
355 Olafsvík
Phone: +354 4366926
www.sjavarrannsoknir.is

Sjavarutvegsthjónustan ehf.
Helgubraut 17
200 Kopavogur
Phone: +354 5342496
www.sjavarutvegur.is

Haskoli Islands
Verkfræði- og natturuvisindasvið
VR-II
Hjardarhaga 2-6
107 Reykjavík
Phone: +354 5254700
Fax: +354 5254632
www.hi.is

Haskolinn á Akureyri
Sjavarutvegsfræði
Solborg
Nordurslóð 2

600 Akureyri
Phone: +354 4608000
Fax: +354 4608999
www.unak.is

Haskolinn i Reykjavik

Menntavegi 1
101 Reykjavik
Phone: +354 5996200
Fax: +354 5996201
www.ru.is

AVS-fund

Faxatorgi 1
550 Sauðarkrokur
Phone: +354 4536161
Fax: +354 4636162
www.avs.is

Verkefnasjodur sjavarutvegsins

Sjavarutvegs- og landbunadarraduneytið
Skulagata 4
150 Reykjavik
Phone: +354 5458300
Fax: +354 5521160
<http://www.sjavarutvegsraduneyti.is/raduneyti/nefndir//nr/1291>

Rannís

Laugavegi 13
101 Reykjavik
Phone: +354 515 5800
Fax: +354 552 9814
www.rannis.is

7.3 Government

Sjavarutvegs- og landbunadarraduneyti
Ministry of fisheries and agriculture
www.sjavarutvegsraduneyti.is

Mennta- og menningarmalaraduneyti
Ministry of education, science and culture
www.menntamalaraduneyti.is

Islandsstofa
Promote Iceland
www.islandsstofa.is

Matvælastofnun
Icelandic Food and Veterinary Authority
www.mast.is

Fiskistofa
Directorate of fisheries
www.fiskistofa.is

Hafrannsóknastofnun
Marine Research Institute
www.hafro.is

Hagstofa Islands
Statistics Iceland
www.hagstofa.is

Verdlagsstofa skiptaverds
www.verdlagsstofa.is

Vinnueftirlitid
Administration of Occupational Safety and Health in Iceland
www.vinnueftirlit.is

Vinnumalastofnun
Directorate of Labour
www.vinnumalastofnun.is

8 Organizations in Norway

The following organizations cover the whole value chain; fisheries sector, aquaculture, production industry, retail, and promotion of fisheries products, governmental and local regulatory agencies, and aquaculture research.

8.1 Marine fisheries

Norges Fiskarlag organizes fishermens as well as fishboat owners. The organization has thus a dual function, as a labour union as well as an employer organization.

Norges Fiskarlag
Postboks 1233 Sluppen
7462 Trondheim
Phone: +47 73 54 58 50
Fax: +47 73 54 58 90

Norges Kystfiskarlag is a labor union for the coastal fishermen.

Norges Kystfiskarlag
Postboks 97, N-8380 Ramberg
Phone: +47 76 05 21 00
Fax: +47 76 05 21 01
post@norgeskystfiskarlag.no

8.2 Recreational fisheries:

Norges Jeger- og Fiskerforbund (NJFF) is a special interest organization for recreational fishery and hunting in Norway. The organization participate actively in the public discussions on impacts of fish farming on wild fish stocks.

Norges Jeger- og Fiskerforbund
Hvalstadåsen 5
Pb. 94 1378 Nesbru
Phone: +47 66 79 22 00
Fax: +4766 90 15 87
njff@njff.org

8.3 Aquaculture

The Norwegian Seafood Federation (Fiskeri- og havbruksnæringens landsforening, FHL) represents the interests of approximately 500 member companies. FHL member companies cover the entire value chain from fjord to dinner table in the fisheries and aquaculture sectors in Norway. FHL is affiliated with the Confederation of Norwegian Enterprise (NHO).

FHL
Middelthunsgate 27
Postboks 5471 Majorstuen
0305 Oslo
Phone: +47 99 11 00 00
firmapost@fhl.no
www.fhl.no

Norske Sjømatbedrifters Landsforening is an association of small and medium size enterprises (SMEs) in fisheries, aquaculture and seafood processing business. It includes fish farmers, landing and harvesting companies, fish product producers, exporters, wholesalers and retailers. The NSL makes a total of approximately 180-190 memberships and 2200 man-years. It is a member of the national employer's association called HSH ("Handels- og servicenæringens hovedorganisasjon").

Norske Sjømatbedrifters Landsforening
Dronningens gt. 7
Postboks 639 Sentrum
7404 Trondheim
Phone: +47 73841400
post@nsl.no

8.4 Breeding companies

Aqua Gen AS is a selective breeding company which develops, produces and delivers genetic material to the global sea-farming industry. Through a market-oriented research and development Aqua Gen has achieved a leading position as a provider of fertilized eggs of Atlantic salmon and rainbow trout.

Aqua Gen AS
PO Box 1240
N-7462 Trondheim
Phone: +47 72 45 05 00
Fax: +47 73 54 62 91
firmapost@aquagen.no
www.aquagen.no

MarineBreed AS is a selective breeding company with a focus on improving the production properties of marine finfish.

MarineBreed AS
Sjølseng
6600 Sunndalsøra
Phone: +47 977 20 521
Fax: +47 71 69 53 01
www.marinebreed.no

SalmoBreed AS is a genetics company specializing in selective breeding of Atlantic salmon, to offer optimal adaptation to current and future production trends. SalmoBreed's family-based breeding program is one of the leading breeding programs for the species *Salmo salar*.

SalmoBreed AS
Bontelabo 2
N-5003 Bergen, Norway
Phone: +47 55 33 37 90
Fax: +47 55 33 37 99
post@salmobreed.no

8.5 Fish health

The Norwegian Veterinary Institute (NVI) is a national biomedical research institute in the fields of animal health, fish health and food safety, whose primary function is supply of independent research based advisory support to the governing authorities.

Norwegian Veterinary Institute
Ullevålsveien 68
Pb 750 Sentrum
N-0106 Oslo
Phone: +47 23 21 60 00

Fax: +47 23 21 60 01
e-mail: postmottak@vetinst.no
www.vetinst.no

The web page www.Fiskehelse.no give an overview on companies offering fish health services, diagnostic laboratories, pharmaceuticals for fish as well as associations connected to fish health. It give also general information about the fish health situation.

The webpage www.lusedata.no publishes regional data for the salmon lice situation in Norway. The data is based on the fishfarmers reports to the Norwegian Food Safety Authority (Mattilsynet).

www.Algeinfo.imr.no is a weekly information provided by the Institute of Marine Research, NIVA and SINTEF on the algae situation along the Norwegian coast. Information on safety of mussels is provided by the Norwegian Food Safety Authority (www.mattilsynet.no).

8.6 Seafood promotion

Norwegian Seafood Export Council believes that “The best seafood in the world comes from Norway” and that is what NSEC wants people all over the world to believe too. In order to win the world over to Norwegian Seafood, NSEC promote Norwegian Seafood in all our major seafood markets and support marketing activities in many of the more than 140 countries that import

Norwegian Seafood
Norwegian Seafood Export Council
P.O.box 6176
Strandveien 106
9291 Tromsø
Norway
Phone: +47 77603333
Fax: +47 77680012
mail@seafood.no
www.seafoodfromnorway.com/

8.7 Institutions - Research, development, education related to aquaculture

In 2009 nearly 3 billion NOK was used in research and development, og this was approximately 1.3 billion NOK used in aquaculture research. This research is conducted in the industry, at universities, institutes, colleges and independent organizations or companies. The NIFU has on request from the Norwegian Research Council prepared a report on marine research in Norway. This report, Ressursinnsatsen til marin FoU og havbruksforskning i 2009, is available at: <http://www.forskningsradet.no/servlet/Satellite?c=Nyhet&pagename=havbruk%2FHovedsidemal&cid=1253965989014&p=1226994216922>.

In this report we will list the 5 largest institutes and the 7 largest universities. For further information about their activity we refer to their web pages. The institutions are listed alphabetically:

- IMR (Institute of Marine Research) www.imr.no
- NIFES (National Institute of Nutrition and Seafood Research) www.nifes.no
- NOFIMA (The Norwegian Institute of Food, Fisheries and Aquaculture Research) www.nofima.no
- NTNU (Norwegian University of Science and Technology) www.ntnu.edu
- NVH (Norwegian School of Veterinary Science) www.veths.no
- SINTEF Fiskeri og havbruk (www.sintef.no/Fiskeri-og-havbruk-AS/)
- UiB (University of Bergen) www.uib.no
- UiN (University of Nordland) www.uin.no
- UiO (University of Oslo) www.uio.no
- UIT (University of Tromsø) www.uit.no
- UMB (Norwegian University of Life Sciences) www.umb.no
- VI (Norwegian Veterinary Institute) www.vetinst.no

8.8 Government

The Norwegian Ministry of Fisheries and Coastal Affairs: With responsibility for the fisheries and aquaculture industries, seafood safety and fish health and welfare, harbours, infrastructures for sea transport and emergency preparedness for pollution incidents.

Ministry of Fisheries and Coastal Affairs

P.O. Box 8118 Dep

0032 Oslo

Norway

Phone: +47 22 24 90 90

Fax: +47 22 24 95 85

postmottak@fkf.dep.no

The official webpage for information about Norwegian aquaculture and fisheries is: www.fisheries.no.

Directorate of Fisheries (Fiskeridirektoratet) shall promote profitable economic activity through sustainable and user-oriented management of marine resources and the marine environment. Their web pages provide up to date statistics for Norwegian fisheries and aquaculture: <http://www.fiskeridir.no/statistikk>

Directorate of Fisheries

PB 185 Sentrum, 5804 Bergen, Norway

Phone from Norway: 03495 - Phone from abroad: +47 800 30 179

postmottak@fiskeridir.no

www.fiskeridir.no

Norwegian Food Safety Authority (NFSA) (Mattilsynet) is a governmental body, operating on a national basis, whose aim is to ensure that food and drinking water are as safe and healthy as

possible for consumers. NFSA are responsible for all legislation within the production and distribution of food. This includes business activities within primary production, food industries, grocery stores, all kinds of food catering and some import, such as import of animals, food and plants.

They also inspect and license veterinarians and other animal health personnel, businesses who deal in by-products (for instance waste from slaughtered animals) and anyone who cares for animals. Furthermore the NFSA inspects industries producing cosmetics and body care products, as well as the distribution of medicinal products sold outside of pharmacies. On the web pages to NFSA (http://www.mattilsynet.no/fisk/godkjente_produkter_virksomheter) there are available lists for approved companies, equipment and methods within the following areas:

- Approved and registered feed companies (appendix 2)
- List of approved establishments for live bivalve molluscs
- List of approved establishments for fish meal, fish oils and others (appendix 1)
- List of approved establishments for fishery products and factory vessels (appendix 3)
- List of freezer vessels
- List of transport units for transport of live aquatic organisms
- List of vessels equipped for chilling in RSW (refrigerated seawater) or in CSW (chilled seawater)
- List of vessels where crustaceans are cooked on board
- List of lists of approved establishments handling animal by-products not intended for human consumption
- Production codes used in the lists of approved establishments
- Liste over godkjente desinfeksjonsmidler i akvakulturanlegg og transportenheter
- Liste over godkjente metoder for desinfeksjon av inntaksvann til og avløpsvann fra akvakulturrelatert virksomhet
- Liste over typegodkjent utstyr til desinfeksjon av inntaksvann til og avløpsvann fra akvakulturrelatert virksomhet

Mattilsynet
Po box 383
2381 Brumunddal, Norway
E-post: postmottak@mattilsynet.no
www.mattilsynet.no

9 Organizations in Sweden

The following organizations cover the whole value chain; fisheries sector, both freshwater and marine fisheries, aquaculture, production industry, retail, and promotion of fisheries products, governmental and local regulatory agencies, and aquaculture research.

9.1 Marine fisheries

Sveriges Fiskares Riksförbund (SFR) or Swedish Fishermen's Federation (SFR) is a politically independent organization for the Swedish fishermen, consisting of 23 local chapters from Haparanda to Strömstad. SFR's headquarters are in Gothenburg but through departments, members and representatives, activities are conducted throughout the country.

Sveriges Fiskares Riksförbund och tidningen Yrkesfiskaren

Fiskets Hus
Fiskhamnsgatan 33
414 58 Göteborg
Phone: +46 (0)31-12 45 90
Fax: +46 (0)31 - 24 86 35
www.yrkesfiskarna.se/

9.2 Freshwater fisheries

Svenska Insjöfiskarens Centralförbund (SIC) or the Swedish Freshwater Fishermen's Central Arenas Federation (SIC) was formed at the request of Fishing unions in the lakes Vänern, Mälaren and Hjälmarén. The aim is to take advantage of inland fisheries economic and trade interests.

Svenska Insjöfiskarens Centralförbund

Kontaktperson: Mats Ingemarsson
Postadress
SIC/SIC AB
Tjust-Lunnagård
341 93 Bolmsö
Besöksadress
Tjust-Lunnagård, Bolmsö
Phone: +46 (0) 70 5594028
matsilund@ljustby.nu
www.insjofiskare.se

9.3 Recreational fisheries

Sweden Angling and Fish Conservation Association is a democratically structured non-profit organization. Their ultimate goal is for there to be a good fishing in the fresh, clean water with healthy fish stocks.

Sportfiskarna

Svartviksslingan 28
167 39 Bromma
Phone: +46 (0) 8-410 80 600
info@sportfiskarna.se
www.sportfiskarna.se/

9.4 Aquaculture

Vattenbrukarnas Riksförbund (VRF) is a national membership association for the purpose of protecting members' interests and promote aquaculture development in Sweden. The members produce fish and shellfish for human consumption, fish conservation and recreational fishing.

Vattenbrukarnas Riksförbund (VRF)

Västra gatan 33

442 31 Kungälv

Phone: +46 (0) 303-104 26

<http://vattenbrukarna.se/>

9.5 Fish health

The main objectives of the Fish Health Control Programme is to prevent the occurrence of and to stop the spread of serious and contagious fish diseases to fish farms and to wild populations of fishes. Important parts of the voluntary fish health control programme are:

- breeding programmes for good fish health participation in control programme for virus infections and renibacteriosis (BKD)
- vaccination programme to prevent the diseases furunculosis and vibriosis
- extensive information, advice and training for our associated fish farming companies
- animal husbandry programme for improving animal welfare of fish during farming
- training for safe and restrictive use of medications, antibiotics and chemicals
- preventive efforts, advice and investigations for certain production diseases

Fiskhälsan FH AB

Besöksadress:

Uppsalavägen 3

Älvkarleby

Postadress:

Box 1

814 25 Älvkarleby

Phone: +46 (0)26-726 30

Fax: +46 (0)26-726 65

info@fiskhalsan.se

www.fiskhalsan.se

National Veterinary Institute SVA (Statens Veterinärmedicinska Anstalt) is a centre of expertise in veterinary medicine. We have first-rate knowledge of animal diseases – and of those diseases that can be transmitted between humans and animals, which are known as zoonoses.

Statens veterinärmedicinska anstalt

751 89 Uppsala

Telefon: +46 (0)18-67 40 00 vxl

Fax: +46 (0)18-30 91 62
sva@sva.se
<http://sva.se/sv/>

9.6 Fisheries production and retail

Fiskbranschens Riksförbund is the overall organization of trade and industry within the fishing area in Sweden.

Fiskbranschens Riksförbund

Box 24
451 15 UDDEVALLA
Yngve Björkman
yngve.bjorkman@fiskbranschen.se
Phone: + 46 (0) 522-393 69
Fax: +46 (0) 522-100 31
<http://www.fiskbranschen.se/>

Sveriges Fiskares Producentorganisation is the Swedish Fishermen Producers Organisation. In order to stabilize the market for fish and to provide the fishermen, the producers, a safety net for acute market failures, the EU has a system of withdrawal prices for the main species fished. This assumes that the fishermen themselves form producer organizations which, within the limits established by the Union, administer this system.

Sveriges Fiskares Producentorganisation

Fiskets Hus
Fiskhamnsgatan 33
414 58 GÖTEBORG
Phone: +46 (0) 31 12 45 99
Fax: +46 (0) 31 42 39 80
E-post: sfpo@sfpo.se
<http://www.sfpo.se/>

9.7 Seafood promotion

Svensk Fisk aka Swedish Fish works with inspiration, information and education to increase awareness and encourage consumption of fish and shellfish.

Svensk Fisk

Fiskhamnen
SE-414 58 Göteborg
Phone: +46 (0)31-85 00 54
Fax: +46 (0)31-85 00 64
(Besöksadress: Fiskauktionshuset, 4:de våningen)
Karin Fagerståhl, VD E-post: Karin Fagerstahl
Ilona Miglavs, Marinbiolog & Utbildningsansvarig E-post: Ilona Miglavs
Berit Andersson, Administration

info@svenskfisk.se
<http://www.svenskfisk.se/>

9.8 Regional and governmental agencies

Swedish Board of Fisheries is the government authority responsible for the conservation and exploitation of Sweden's fish resources.

Swedish Board of Fisheries

E-mail: fiskeriverket@fiskeriverket.se
www.fiskeriverket.se
Ekelundsgatan 1
Box 423
SE-401 26 Göteborg
Phone: +46 31 743 03 00
Fax: +46 31 743 04 44

Institute of Marine Research, Lysekil

Turistgatan 5
Box 4
SE-453 21 Lysekil
Phone: +46 523 187 00

Institute of Marine Research

Utövägen 5
SE-371 37 Karlskrona
Phone: +46 455 36 28 50

Institute of Coastal Research, Öregrund

Skolgatan 6
SE-742 42 Öregrund
Phone: +46 173 464 60

Institute of Coastal Research, Väröbacka

Skällåkra 71
SE-432 65 Väröbacka
Phone: +46 340 66 99 30

Institute of Coastal Research, Simpevarp

Simpevarp, Ävrö 16
SE-572 95 Figeholm
Phone: +46 491 76 28 40

Institute of Freshwater Research, Drottningholm

Stångholmsvägen 2
SE-178 93 Drottningholm
Phone: +46 8 699 06 00

Institute of Freshwater Research, Örebro

Pappersbruksallén 22
SE-702 15 Örebro
Phone: +46 19 603 38 60

Research Office, Luleå

Skeppsbrogatan 9
SE-972 38 Luleå
Phone: +46 920 23 79 50

Research Office, Härnösand

Stora Torget 3
SE-871 30 Härnösand
Phone: +46 611 182 50

Research Office, Gothenburg

Ekelundsgatan 1,
Box 423, SE-401 26 Göteborg
Phone: +46 31 743 03 00

Fishery Research Station, Älvkarleby

Brobacken
SE-814 94 Älvkarleby
Phone: +46 26 825 00

Fishery Research Station, Kälarne

Åvägen 17
SE-840 64 Kälarne
Phone: +46 696 538 20

Swedish Board of Agriculture (Jordbruksverket) is the Government's expert authority in matters of agri-food policy, and is responsible for the agricultural and horticultural sectors. In 2011, it will take over matters concerning aquaculture from the Swedish Board of Fisheries.

Swedish Board of Agriculture

Phone: 036-15 50 00
jordbruksverket@jordbruksverket.se
<http://www.jordbruksverket.se/>

The County Administrative Board is a government authority that exists in close proximity to the people in each county. The County Administrative Board has a unique position in the Swedish democratic system. Sweden comprises 21 counties, which are in turn divided into municipal areas. In order to get a long-term and safe water use, permits are required to conduct so-called water activities. The Environment Court hears applications for permits for water operations, but for smaller operations there may be a notification to the county.

<http://www.lst.se/lst/Kontakta/>

9.9 Institutions - Research, development, education related to aquaculture

The Swedish government has in a recent review on aquaculture in Sweden (Det Väckande Vattenbrukslandet) indicated that the two universities UGOT and SLU have the major responsibility for research, development and education within the field of aquaculture. UGOT and SLU have an active, ongoing dialogue to this effect.

University of Gothenburg (UGOT) Department of Zoology, Department of Marine Ecology

At UGOT, there is broad expertise in aquaculture-related fish physiology including larval development, growth, smoltification, metamorphosis, puberty and sexual maturation, especially linked to the endocrine control of these live processes. Further, there is expertise in gastrointestinal physiology, including mechanisms of nutritional uptake and effects of alternative feed sources. This includes stress effects alternative feeds on gastrointestinal immunology and disease resistance. There is also expertise on mussel and oyster farming. The below contacts represent the board of Aquaculture Center West, based at UGOT.

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Swedish University of Agricultural Sciences (SLU) Department of Wildlife, Fish and Environmental Studies

At SLU, you will find expertise in aquaculture, in the ecology of the aquatic fauna and flora, as well as in fish and water management. Environmental and hygiene aspects of water and the role of water

in agricultural land and in forests are other areas of research. The chemical and biological quality of water is regularly monitored in many lakes in Sweden.

<http://www.slu.se/en/collaboration/fields-interest/aquaculture/>

Professor Eva Brännäs

SLU, Dept. of Wildlife, Fish and Environmental Studies

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Skogsmarksgränd

901 83 UMEÅ

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10 Themes – Local raw materials for aquaculture feed

In the following a list of potential local resources for use in fish feed are listed:

10.1 Plant substitutes for fish meal and fish oil

Due to environmental aspects the high amount of fish meal and fish oil used for aquaculture feed has been of concern. Many projects have been run in recent years testing different substitutes for high quality fish products. The research institute Matis in Iceland has tested the possibilities of replacing fish meal and fish oil with different raw materials of plant origin for Arctic charr feed. The results showed that Arctic charr seems to have limited ability to utilize soybean meal and it is suggested to include maximum 15% in the diet, similar to the limits that are common for Atlantic salmon diets. The limits for use of corn gluten meal in starter diets seem to be $\leq 18\%$ but this raw material was not tested in bigger fish. The response of Arctic charr to the use of rapeseed meal as protein source was positive and even as high inclusion as 30% in the diet did not have negative

effect on growth. Rapeseed meal (15%, 30% and 45%) is now being tested for tilapia feed at Matorka's station in Fellsmuli in Iceland.

Regarding use of lipid sources it seems to be possible to use different sources with reasonable effect in feed for Arctic charr. Of particular interest is the effect of palm oil. Arctic charr larvae seem to be more demanding, regarding use of lipid sources, than bigger fish. The results clearly demonstrate the effect of fatty acid (FA) composition of the lipid sources on the FA composition of the fish and it is possible to change the FA profile with different lipid sources. Different lipid sources also have marked effects on different sensory traits in the farmed Arctic charr.

10.2 Micro algae

Micro algae, such as plant plankton, are the most important primary producers in marine ecosystems. Through the process of photosynthesis, micro algae utilize light, water, nutrients and CO₂ to grow. Plankton forms the basic element of all food webs in the oceans. Micro algae are growing exponentially in optimal conditions and some micro algae have higher protein content and may be rich in omega-3 fatty acids.

Micro algae are unique nutrients due to the content of:

- Iron, potassium, calcium, magnesium, manganese, selenium, zinc
- Ω -3 fatty acids
- Vit E and Vit C
- Beta carotene
- Vitamine B12
- Antioxidants
- Chlorophyll

The University of Iceland has been carrying out extensive research on micro algae. The aim is to produce value food supplements, but feed ingredients could also be of interest, not least offal-products from a food supplement production.

10.3 Sea weed

Sea weed is currently mainly produced in the Far East (China, Indonesia, the Philippines, Korea and Japan). Sea weed is macro algae and more than 10,000 species are known. It is used for human nutrition and is a unique nutrient due to content of:

- Bioactive substances with health enhancing effects (f. ex. immune stimulating)
- High amounts of minerals like iron, calcium, phosphorous, magnesia
- A, B, C and E-vitamins
- Trace elements: Zinc, copper, manganese, selenium, molybdenum, chromium
- Ω -3 fatty acids

Processing of seaweed, results in “offal”-substances that may be used for aquaculture feeds. Sea weed remove nutrients from the water and utilization of sea weed as a nutrient and/or for aquaculture feed purposes will contribute to sustainable utilization. Matorka has been preparing a feed trial with different sea weed strains that will be collected in Breidafjörður West-Iceland in collaboration with the feed company Fodurblandan and a sea weed harvester.

10.4 Squid meal

In some areas (incl. the North Atlantic) squid are available in such abundance that they can be harvested and used for production of squid meal and squid oil. Squid meal is an excellent supplemental source of protein that equals or exceeds that of fish meal in aquaculture feeds.

Analysis of squid meal has shown the following contents:

Protein	45 – 80%
Lipids	4 - 5%
Dry matter	90 – 92%
Ash	4 – 5%
Chlorides	3 – 4%

10.5 Mussel meal

Mussels are filtrating algae and organic particles (filter feeders) and using mussels as a protein source for fish feed may contribute to ecological balance of the marine environment. However, the content of dry matter of 6-8 % (of whole mussel) may be a challenge for sustainable production of mussel meal. But purchasing of N-kvota and/or compensating farming of mussels in connection to marine fish farming (net cages) may contribute to reduce the costs of production. By harvest of 1 ton of mussels about 15 kg nitrogen and 1 kg phosphorus is removed from the water.

Mussels have a protein content of about 15%, a low fat content (about 2-3%) and a high content of Ω -3 fatty acids, selenium and zinc.

Raw material for production of mussel meal may come from:

- Fishery
- Processing industry
- Mussel farming
- Compensation farming

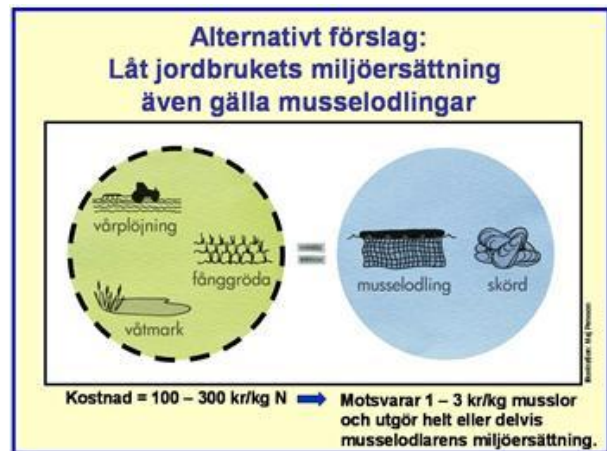
The content of protein in mussel meal may be approximately 65%, which is a little lower than in fish meal. However the contents of the essential S-containing amino acids methionine+Cystine, and Lysine in mussel meal are similar to those in fishmeal.

Odd Lindah has been an international pioneer in Sweden, in launching the concept of “environmental mussel production” where the mussel farmers would receive payment for removing N and P from the aquatic environment in a system resembling the current system for CO₂ emissions. The mussels, in particular those raised in the Baltic and do not reach the size for the

human consumption marked, would be used to produce mussel meal as sustainable, high quality protein ingredient in animal feed, in particular in fish feed.

There is an ongoing pilot project on the production of mussel meal with additional information given on <http://hs-vast.hush.se/?p=18250>.

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http://www.marecol.gu.se/Personal/Odd_Lindahl/



This concept is further explained in Swedish below, the text taken from the link <http://hs-vast.hush.se/?p=18266>.

10.6 Starfish meal

Starfish are predating mussels and may as well be a potential raw material for aquaculture feed.

10.7 Krill

Krill is important in marine ecosystems in nutrition of many fish and whales. Krill are key species in the pelagic marine food webs, as many species are either directly preying on krill or on species preying on krill. Even if krill might be an excellent local resource (in Norway and Iceland) for use in aquaculture feed, it shall be considered that harvesting big amounts of Krill may have serious effects on local ecosystems depleting a local animal food source. Unwanted by-catch from krill harvest can be significant, as net size is very small. Moreover, global warming may also affect krill abundance.

10.8 Microfungi

There is an active research going on in Sweden concerning the use of microfungi as a source of protein for fish feed. The project is carried out within a private company and thus information is mainly restricted to the information given on the company website, <http://www.cewatech.se/>.

In short: The biotech company Cewatech, Gothenburg has developed a technology based on cultivation of microfungi called zygomycetes on side products from the paper pulp industry. Now the technology has reached pilot scale in a joint project with Nordic Paper in Säffle, western Sweden.

The fungus is using the sugars in the paper pulp cooking liquid for growth. Initially the fungus was cultivated from the Indonesian food Tempe which is similar to tofu or camembert. The fungal biomass produced is rich in protein, fat, amino sugars, and vitamins which makes it suitable as a fish feed ingredient particularly as the amino acid composition is close to that of fish meal.

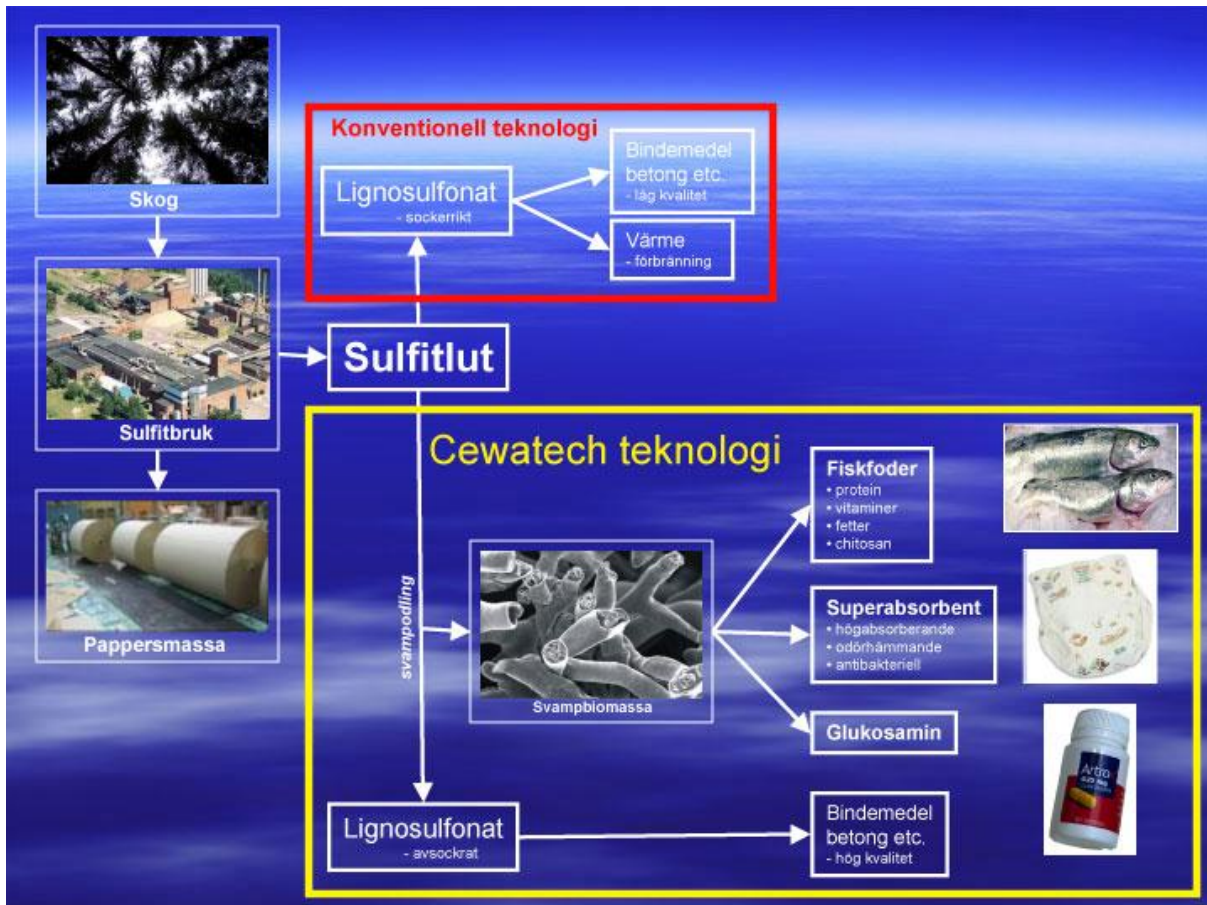


Figure 8: Use of microfungi as a source of protein for fish feed (<http://www.cewatech.se/>).

11 Conclusion – future opportunities

The project's main objective was to gather information about the status and development of the production of fish feed for different species in the Nordic countries. New alternative possibilities for local raw material production for aquaculture feed are identified and discussed. These must be environmentally beneficial, economically viable and of good quality. The World Wildlife Fund (WWF) and Aquaculture Stewardship Council (ASC) emphasize the importance of the development

of a more sustainable aquaculture. The origin and quality of feed raw materials, the feed manufacturing process and the logistics in transport are the main factors of concern. It can be concluded that the Nordic countries have a lot of possibilities to increase the production of novel and local feed ingredients developing a more sustainable aquaculture. Also new aquaculture species lower in the feed chain provide new opportunities.

The project has also developed a Nordic network in the field, including all the value chain from raw material producers to marketing of fish from Nordic aquaculture. Also contacts in Europe and Canada have been established. An application including four Nordic countries and Canada on implementing new local fish feed raw materials in aquaculture is under preparation and will be sent to Nordic Innovation Centre's Marine Programme in August. Moreover, formal collaboration with European companies and research institutes on the implementation of a future sustainable aquaculture for Europe, is under development.

In discussing sustainable fish feed ingredients, fish meal and fish oil, are often made out to be unsustainable feed sources which need to be replaced. This is only true if the meal/oil is obtained from unsustainable fisheries, i.e. from overexploited fish stocks. In reality, the Nordic countries carry out regulated fisheries which generate significant quantities of fish meal and oil as a sustainable feed source. However, in terms of the current and future expansion of aquaculture as an important source of food for the human population, it is clear that fish meal and oil are limited feed sources. There are two important paths that need to be taken concomitantly, in order to prevent that a lack of available fish feed will become a limiting factor, halting further aquaculture expansion. One path is to ensure that the available source of fish meal and oil is primarily used in aquaculture of carnivorous fish species, and not in other animal production (chickens, pigs), where alternative, vegetable feed sources are already available. The other path is to expand the available alternative feed sources available to fish feed producers. Furthermore, new aquaculture species (herbivorous/omnivorous) that more easily can be produced in a sustainable manner are of interest.

Already, plant proteins and oils are substituting significant percentage of fish-derived ingredients in fish feed, but more sources and research on these sources is needed. In Iceland local rapeseed and seaweed are now to be tested as feed ingredients in small projects. Moreover, micro-algae and novel protein production, with single cells or invertebrates, is of interest. Also small crustaceans and other organic waste that are now buried could be utilized for feed. It makes good sense to use organic waste and marine resources from a lower trophic level in the marine food web for fish feed rather than using fish for producing fish feed. From an ecological point of view this would improve the utilization of local marine resources. Using plankton in feed for farmed fish the resource is ecologically more efficient utilized than if farmed fish eats fish (transformed through fishmeal to feed pellets). However, the economical sustainability has to be considered in a commercial perspective.

The two Swedish initiatives, to produce protein meal from mussels and microfungi are interesting, but more research is needed, on their quality as fish feed source, how they affect the fish, and also how these sources may become economically sustainable. The mussel meal concept is interesting in its links to ecosystem services and ecosystem cycling of nitrogen and phosphorus, which is a limited global resource. It is also interesting in the fact that mussel meal is a marine resource, containing both omega-3 fatty acids and astaxanthin. The microfungi concept is remarkable as it essentially involves a non-food to food conversion.

From the above it can be seen that the Nordic countries have huge possibilities in developing and implementing a more sustainable aquaculture, especially by increasing the production and utilization of local feed ingredients and improving the infrastructure logistics. New feed shall of course be of good quality, provide optimal growth rates and ensure maximum fish health.

New species, lower in the feed chain can become of huge importance. The global fish market has been changing rapidly in recent years following stagnation in wild fisheries. New aquaculture species have been introduced and some of them have reached enormous market share in a very short time. The Nordic countries have tolerated declined fisheries, but need to take more part in the new developments, increasing their share in global aquaculture production.

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Sweden

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13 Appendices

13.1 Appendix A: Approved establishments for fish meal, fish oils and others in Norway

13.2 Appendix B: Approved and registered feed companies in Norway

13.3 Appendix C: Approved establishments for fishery products and factory vessels in Norway



norden

Nordic Innovation

Nordic Innovation Centre

Nordic Innovation Centre (NICE) is an institution under the Nordic Council of Ministers facilitating sustainable growth in the Nordic economies.

Our mission is to stimulate innovation, remove barriers and build relations through Nordic cooperation. We encourage innovation in all sectors, build transnational relationships, and contribute to a borderless Nordic business region.

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