netalgae

INTER-REGIONAL NETWORK TO PROMOTE SUSTAINABLE DEVELOPMENT IN THE MARINE ALGAL INDUSTRY

THE NORWEGIAN SEAWEED INDUSTRY

WORK PACKAGE 1&2

November 2012

Bioforsk –Norwegian Institute for Agricultural and Environmental Research
M. Meland, C. Rebours

ATLANTIC AREA Transnational Programme
ESPACIO ATLÁNTICO Programa Transnacional
ESPACE ATLANTIQUE Programme Transnational
ESPAÇO ATLÂNTICO Programa Transnacional

INNOVATION NETWORKS
REDES DE INNOVACIÓN
RÉSEAUX D'INNOVATION
REDES DE INOVAÇÃO

European Union
European Regional Development Fund

Nordland COUNTY COUNCIL

EXECUTIVE SUMMARY

The Netalgae project was established to support the European seaweed industry through the creation of an industry network to encourage co-operation amongst the seaweed industries and stakeholders across the project area. The project had a secondary aim, specifically to create best practise guidelines for the regulation administration and management of seaweed resources and related activities across the project area.

This document provides an overview of the Norwegian seaweed industry, its history, evolution and current status, the document outlines the scale, scope, value and the key raw materials used by the industry. The document also describes the regulatory and management systems in Norway.

The Norwegian seaweed industry is almost completely reliant on natural beds of *Ascophyllum nodosum* and *Laminaria hyperborea*. *L. hyperborea* accounts for about 90% of the national harvest. Mecanical harvesting provides almost all of Norways national seaweed output. Manual harvesting of other species such as *Ulva spp* is carried out at very low levels, mainly for the provision of high quality raw material to restaurant or grocery stores. Seaweed aquaculture is under development but generates very little biomass.

The Alginate Industry is by far the most important sector, consuming the vast majority of the seaweed processed in Norway (domestic and imports). The rest is used directly as food, fodder, biostimulants, cosmetics, aquaculture and in health sectors.

In Norway, regulations for harvesting seaweed apply to seabed algae such as *Laminaria hyperborea*. Harvest of foreshore algae such as *Ascophyllum nodosum* is not regulated, but is regulated by private owner rights because the species grow in the tidal zone. Environmental protection laws and other regulations can restrict areas for harvesting. Regulations of aquaculture of seaweed are under development.

THE NETALGAE PROJECT

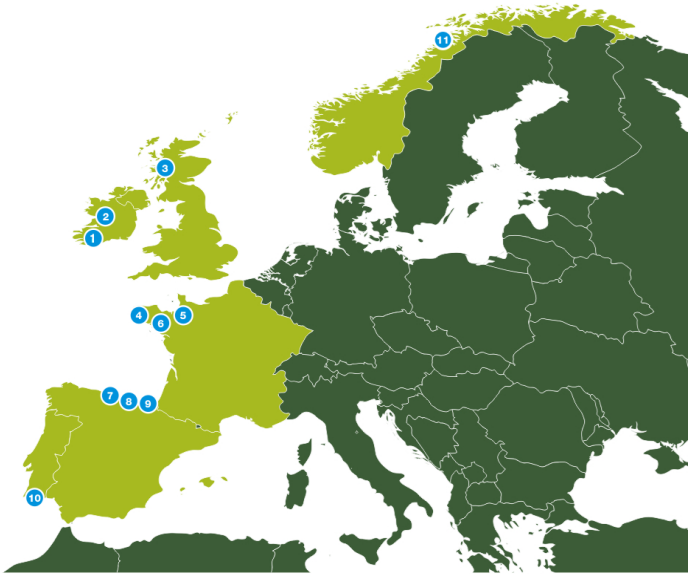
In 2009, more than 15 million tons of macroalgae (brown, red and green seaweed) were produced from global capture and aquaculture (based on the algal live weight equivalent: FAO, 2012). Worldwide, macroalgae production increased from 5.7% every year. In 2008, 93.8% of the global total production of aquatic plants came from aquaculture. Countries in East and Southeast Asia dominate seaweed culture production (99.8% by quantity and 99.5% by value in 2008: FAO 2010). In contrast, the European macroalgae industry is based on the harvesting of natural resources of macroalgae, and the production has decreased in the last 10 years. The further expansion of the industry depends on stable access to raw material, the development of valuable products and the transfer of expertise between developed and less developed regions.

The Netalgae project was designed to create a European network of relevant stakeholders within the marine macroalgae sector. The network was expected to make progress toward developing industrial, commercial and scientific links and to foster a culture of trade and cooperation among the members. The network includes primary producers, processors, technology suppliers, process consultants, research institutes, development agencies, local governments, relevant community groups and other stakeholders. A compilation of information from Norway, The United Kingdom, Ireland, France, Spain and Portugal lead to a wide ranging policy study of the existing practises within the macroalgae industry.

An analysis of these results enabled the Netalgae partners to establish best practise recommendations and suggest policies for the successful sustainable commercial use of marine macroalgal resources.

The project ran from 2010 to 2012 and was funded by the Atlantic Area Transnational Programme, the European Regional Development Fund and National co-funding. The partners were drawn from Ireland (1,2), The United Kingdom (3), France (4,5 & 6) Spain (7,8 & 9), Portugal (10) and Norway (11).

1. Indigo Rock Marine Station
2. Bord Iascaigh Mhara
3. Viking Fish Farms
4. Université de Bretagne Occidentale
5. SMEL- Syndicat Mixte pour l'Equipment du Littoral
6. Agrocampus Ouest
7. Mutrikuko Institutua
8. Ikaslan Gipuzkoa
9. TKNIKA - EAEko Lanbide Heziketarako Berrikuntza Zentroa
10. CRIA/University of Algarve
11. BIOFORSK



CONTENTS

1. Short description of the Norwegian seaweed industry.

The data obtained during the desk study conducted in the first year of the Netalgae project were published under: Meland M., Rebours C., 2012. Short description of the Norwegian seaweed industry. Bioforsk Fokus 7(2): 278-279. This report is based on this published article.

1.1. Context of seaweed harvesting.

The algae industry in Norway has long tradition of exploiting natural resources. Seaweed constitutes an important part of the ecosystem and are of important commercial value. Seaweed has been used as manure, feed and food since Norway was first populated. From around 1750, burning of kelp for potash for the European soap and glass industry was important for coastal farmers. Between 1800 and 1913 the export of potash increased from 1 500 to 6 000 tons, produced from 150 000 tons of kelp. From 1870, potash was used in iodide production, but in 1933 it was replaced by the “chile-salpeter”.

Norwegian alginate research was established around 1900, partly governmentally supported. Protan AS managed to produce pure alginate acid in 1943 thanks to collaboration with the Norwegian Institute for kelp research (NITT). The production was based on drift kelp and hand-cut *Laminaria digitata*. Since 1963 *Laminaria hyperborea* has been the most important raw material in alginate industry, due to mechanization of harvest and high volumes. The export of alginate increased from 100 tons in 1954 to 300 tons in 1960. Today Protan AS is named FMC Biopolymer AS and is owned by the FMC Corporation. Today the annual alginate production is around 5 000 tons dry weight.

From 1930, seaweed meal from *Ascophyllum nodosum* for animal food and fertilizer was an important product from the Norwegian industry. The seaweed was cut by hand, dried on shore and milled. Several companies in the 60s produced seaweed meal and extracts for agriculture and alimentation (Aasland 1997). Algea AS, established in 1937 is the only remaining company and is owned by the Italian Valagro Group. Nowadays 180 people are working in the seaweed industry. Around 45 persons harvest seaweed, either self employed or as employee of vessel operators or by the processing company.

1.1.1 Species exploited in Norway.

L. hyperborea is harvested between Rogaland and Sør-Trøndelag (figure 1). The annual landings are 150 000 tons, and the firsthand value is under 23 EURO/ton wet weight (w.w.) (FMC Biopolymer AS 2011, pers. comm.). *L. hyperborea* is processed to alginates (5 000 tons/year), used in pharma- and nutra-ceutical products. *A. nodosum* is harvested between Møre og Romsdal and Nordland. The annual landings are 10-20 000 tons, with a firsthand value delivered to factory of 50 EURO/ton w.w. (Algea AS 2011, pers. comm.). *A. nodosum* is processed to seaweed meal for agricultural, nutraceutical and cosmetic products. Around 140 kg of *Ulva lactuca* is harvested by hand in Rogaland yearly, the firsthand value is 50 EURO/kg w.w. sold to restaurants.

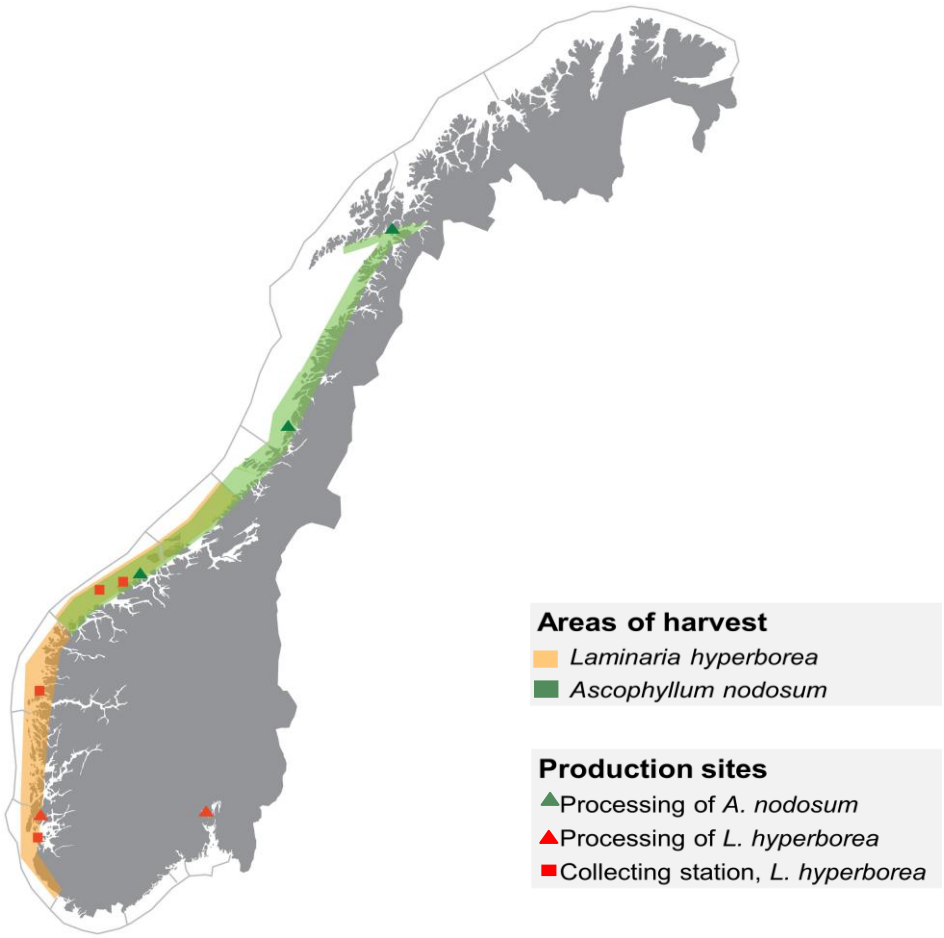


Figure 1: Area of harvest and processing of *Laminaria hyperborea* and *Ascophyllum nodosum* in Norway.

1.1.2. Harvesting techniques.

Since 1976, *L. hyperborea* has been harvested with a seaweed trawl, a 3 m long iron sledge with pinnacles pointing towards the drag direction (Figure 2a). The trawl tears plants larger than 20 cm from the substrate and leaves smaller plants for re-growth. The trawl can take up to 1 ton of kelp per drag and up to 150 tons daily. The seaweed is delivered to transport ships, collecting stations or directly to the factory. From the 70´s, *A. nodosum* is harvested either with paddlewheel (Figure 2b) or water jet driven seaweed cutters, which both leave at least 10 cm of the plant for re-growth (Algea AS pers. comm.). The harvested material is transported in bags or nets to the factory.

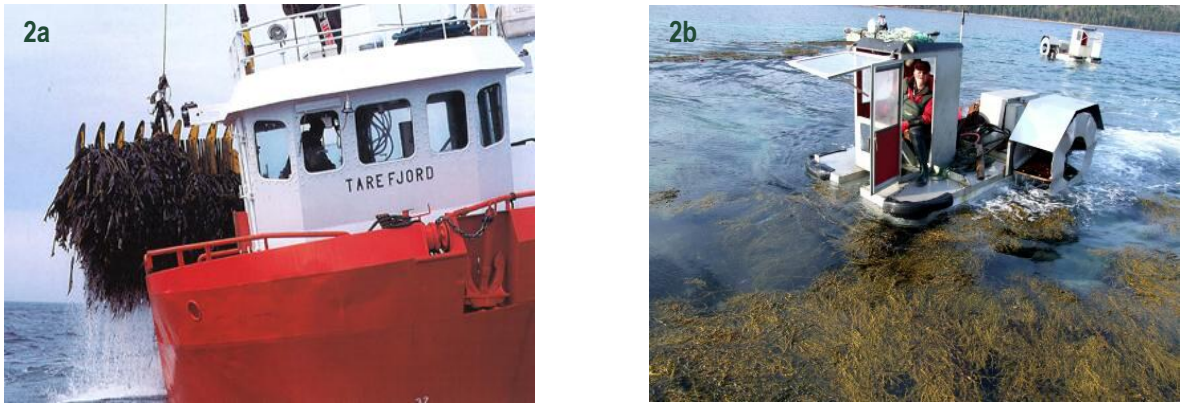


Figure 2: Harvesting methods for a) *Lamniaria hyperborea*, the seaweed trawl and for b) *Ascophyllum nodosum* the paddlewheel cutter. Photos: a) FMC Biopolymer AS, b) Sander Andersen

1.1.3. Biomass evaluation.

The biomass of *A. nodosum* is estimated around 1,8 mill tons along the Norwegian coast, in densities of 4-7 kg/m^2 (Steen 2009). The standing stocks *of L. hyperborea* are estimated to be between 50 and 100 mill tons based on a growth area of 5 000-10 000 km^2 and average densities of 10-15 kg/m^2 (Steen 2009).

1.1.4. Ecological issues.

Harvesting of *L. hyperborea* is estimated to remove 0,3 % of the total biomass yearly. On a local scale up to 50 % of biomass can be removed (Steen 2005). Re-growth after harvest differs between locations and varies with latitude (Rinde and Sjøtun 2005). The new generation approaches untrawled kelp forest size at 2-4 years (Christie et al. 1998). Ecological models indicate that loss of primary and secondary production in trawled areas is up to 98 % (Rinde et al. 2006). The re-growth of epiphytes is not fulfilled after 5 years, and diversity is not restored before plants reach average age of 7 years (Waage Nielsen et al. 2003). Distance to the closest intact, untrawled kelp forest is important for re-colonization of trawled areas (Christie et al. 2003). *A. nodosum* is harvested every 4-6th year, to ensure good regrowth and is assumed to have limited recruitment potential and relatively slow re-growth (Steen 2009). Re-growth by generating new branches depends on parts of the plants being left after harvest. The local harvesting efficiency is 60 % (Algea AS pers. comm.). Harvesting activity occasionally conflicts with environmental protection, which affects the raw material access. Regional harvesting regulations coordinate these interests for *L. hyperborea*.

Since 1970, 50 % of the kelp forest between Nord-Møre and Finnmark is assumed to be grazed by sea urchins (Sivertsen 1997). Grazing is estimated to cause a loss of 15M NOK.year^{-1} for fishermen in the area around Vega (Sakshaug et al. 2002). In grazed areas, mostly located in sheltered areas, the kelp forest production is estimated to be 1 % of the original production (Norderhaug et al. 2008). Sea urchin density is controlled by several factors such as predation and juvenile recruitment.

1.1.5. Aquaculture of algae.

Aquaculture trials have been done with *Saccharina latissima* and *Alaria esculenta* to produce ethanol. Several projects investigating algae culture as monoculture, polyculture or in fjord restoration are in progress.

1.1.6. Stakeholders.

1.1.6.1. Industry

— Algea AS harvests *A. nodosum* for production of seaweed meal and extracts. www.algea.com.

— Biomar AS produces fish feed for salmon and trout, exploring the use of algae in feed. www.biomar.com.

— FMC Biopolymer AS harvests *L. hyperborea* for alginate production. www.fmcbiopolymer.com.

— Frode Ljosdal AS harvests *U. lactuca* for sale as food to restaurants.

— Holmfjord AS cultivates kelp to restore the kelp forest in Porsangerfjorden. www.holmfjord.no.

— Salmon Group is an aquaculture company exploring integrated aquaculture. www.salmongroup.no.

— Seaweed Energy Solutions AS is exploring cultivation of kelp for biofuel. www.seaweedenergysolutions.com.

— Statoil is involved in cultivation projects to produce macroalgae for bioethanol. www.statoil.com.

1.1.6.2. Authorities.

— The Ministry of Fisheries and Coastal Affairs

— The Directorate of Fisheries

— The Ministry of the Environment

— The Directorate for Nature Management

— The County Governor

— The County Authorities

— The Norwegian Coastguard

— The Norwegian Food Safety Authority

— The Ministry of Health and Care Services

— The Ministry of Agriculture and Food

— The Norwegian Agricultural Authority

1.1.6.3. Research and Development units.

— Institute of Marine Research, IMR, is advisory expert to FKD, and survey *L. hyperborea* harvest. www.imr.no

— Lysefjorden Research Station uses upwelling as source for nutrients in production of macroalgae.www.lysefjordenforskningsstasjon.no

— Norwegian Institute for Agricultural and Environmental Research, BIOFORSK, achieves R&D on cultivation of aquatic plants and the development of innovative algae based products. www.bioforsk.no.

— Norwegian Institute for Nature research, NINA, achieves applied ecological research. www.nina.no.

— Norwegian Institute for Water Research, NIVA, is modeling distribution of kelp forests. www.niva.no.

— Norwegian University of Science and Technology, NTNU, achieves alginate research. www.ntnu.no.

— SINTEF is achieving R&D in fishery and aquaculture, and in seaweed cultivation projects. www.sintef.no.

— University of Bergen, UiB, is doing marine research on marine biodiversity. www.uib.no.

— University of Oslo, UiO, is doing marine research on kelp biology and kelp forest ecology. www.uio.no.

2. Introduction to the management and regulation of the Norwegian seaweed Industry.

The data obtained during the desk study conducted in the first years of the Netalgae project were published under: Meland M., Rebours C., 2012. Introduction to the management and regulation of Norwegian seaweed industry. Bioforsk Fokus 7(2): 275-277. This report is based on this published article.

2.1. National and regional regulating bodies.

The Ministry of Fisheries and Coastal Affairs, FKD, regulates harvest of *L. hyperborea* by laws, and instructs the Directory of Fisheries, FD, which sets the regulations together with industry, Institute of Marine Research (IMR), researchers, environmentalists, fishermen and kelp trawlers organizations, and local stakeholders. FD is responsible for supervision and control of the regional regulations. The County Authorities have regional management responsibility, which involves planning of the rotation cycle for the harvesting of *L. hyperborea*. The Ministry of the Environment, MD, is responsible for carrying out the environmental policies of the Government. The Directorate for Nature Management, DN, is the advisory and executive body of MD. DN is responsible for regulating environmental protection, and to make sure nature is not damaged by other activities. DN is the instructive authority to The County Governors who ensures that the government politics are conducted. The figure 3 summarises the organisation of the regulating bodies in Norway.

Additional regulatory bodies involved in aquaculture licensing are the Norwegian Food safety Authority, the Ministry of Health and Care Services, the Ministry of Agriculture and Food and the Norwegian Agricultural Authority.

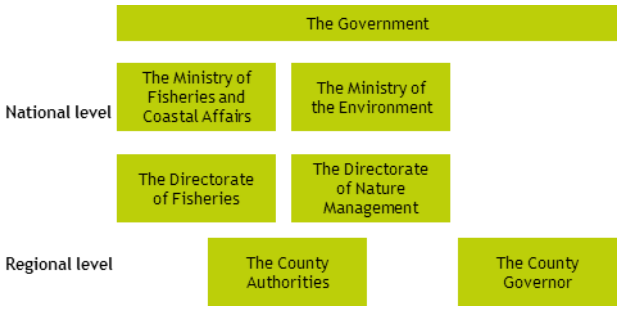


Figure 3: National and regional regulating bodies for seaweed harvesting in Norway.

2.2. Regulations on harvest of seabed algae (e.g. *Laminaria hyperborea*).

Regulations were preiously laid out in the “Scientific exploration and exploitation of other submarine resources than petroleum Act” and after 1972 in the “Saltwater Fisheries Act”. Today, the “Regulations of harvesting of kelp” is regulated in the “Management of wild marine resources Act” applying to harvesting of all marine organisms, methods of harvest, amounts, and how harvesting affects the marine environment. The regulation concerns harvesting of kelp in Norwegian waters, and is regulated by FD. The general regulation does not apply to areas with private owner rights. Harvesting of kelp at depths deeper that 20 m is forbidden, and at less than 20 m depth it is forbidden to harvest kelp unless permitted by regional regulations. Open fields are regulated for harvest by regional regulations for kelp harvesting. Areas are opened for harvest every 5th year. New fields can be opened if the harvester can document that harvest is sustainable. Boats must be registered in FDs register for kelp harvesting. The harvester has to pay tax for landings and the equipment used for harvest has to be adapted to the activity. Specific regional regulations for harvesting kelp exist in Sør-Trøndelag, Møre og Romsdal, Sogn og Fjordane, Hordaland and Rogaland.

Harvesting plans for *L. hyperborea* are made for five years in a row, and are continued if the regrowth of kelp is good and the harvest is sustainable. Practically it means they are continued if no stakeholder objections or negative results are reported in the annual survey.

2.2.1. Records required by harvesters.

The harvesters are required to keep journals that give the time, location and tonnage of harvested kelp, and yearly report these data to the FD. Tonnage is reported in wet weight. The FD, regional and central, records and publishes statistical data.

2.2.2. Control of activity.

The FD is in charge of control and supervision of the harvesting activity, and the Norwegian Coast Guard does unannounced checks of boats where harvesting journals can be examined. Since 2004 IMR has the responsibility to perform yearly survey of the harvesting fields and control areas to assess the impact of harvest on populations of *L. hyperborea* between Rogaland and Sør-Trøndelag (instructed by the FKD). Video transects are used to assess the removal grade and regrowth, as well as the coverage and density of kelp, plant height, recruitment, species composition, epiphytes, number of sea urchins and fish. Trawling can be terminated if results are negative.

2.2.3 Opening of new areas for harvest.

The FD evaluates requests to open new areas for harvest. The process takes several years because survey and test trawling in the specific area is required to decide if harvesting is sustainable. The decision to open a new area for harvest is based upon a long term survey done by the IMR. The status of sea urchins in the specific area, bird protection areas, conflicts with fishermen, the local community opinion and access to raw material for industry is also taken into consideration. The applicant has to document that trawling has no negative impact on the local ecosystem, as well as proposed quantities for harvest amount and areas for harvest. There is no exact cost of obtaining a license, but the cost of the survey before opening new areas for harvest is shared between the industry, regulators and IMR. The opening of a new area for trawling permits harvest of a maximum amount of *L. hyperborea* in a specific area, in a defined period of time of one year.

2.2.4. Regulations on harvest of foreshore algae (*e.g. Ascophyllum nodosum*).

There are no official regulations on harvesting of *A. nodosum*, because the foreshore, where the species grows, is in private ownership. To harvest *A. nodosum* the landowner has to give permission, and the harvester has to pay a fee to the landowner. The landowner agreement allows the harvester to harvest a maximum amount of *A. nodosum* in the area. The agreement has to be renewed each time the area is proposed to be harvested. No impact assessment or documentation is required by the authorities. Environmental protection regulations has to be respected. The harvesters of *A. nodosum* survey their own activity, and harvest seaweed beds every 4-6th year to ensure re-growth.

2.2.5. Regulations on seaweed aquaculture.

For cultivation of seaweed one has to apply to the FKD for a license and the process takes at least 5 months. In 2010 it was suggested that seaweed aquaculture should be managed under the “Regulation on license for aquaculture of other species than salmon and trout”, and applications will be evaluated by the County Authorities. The applicant must document that the application is supported by local area plans and does not conflict with environmental protection or cultural heritage protection. The applicant must also document that necessary permissions are obtained according to the Act on Food Production and Food Safety, the Act on Protection against Pollution and Waste, Harbors and Waters Act and the Act on Groundwater and Waterways. The environmental impact has to be considered, but specific assessments are not required so far for seaweed aquaculture. The cost of the application is 375 EURO, and it is suggested to demand a safety of 312 EURO/acre as “cleanup” insurance. The license can be withdrawn if within two years the activity is not more than 1/3 of the allowed

maximum production. The license for seaweed aquaculture will allow production of one species in a specified area.

In the regulation that is under development, restrictions would probably concern the use of area, which must be regulated in local area plans. The licensing unit will probably be defined per area. The seaweed cultivator will probably have to keep a record of stock and production, seedling and harvest times, and report the production annually.

2.2.6. National or local environmental restriction.

Harvest of seaweed is restricted in bird reserves, where seaweed harvesting can be totally banned, or partly allowed outside of the bird breeding season. Where areas are environmentally protected, it has to be specified in the regulations related to the specific area if aquaculture activity is allowed or not.

References

Aasland, T (ed). 1997. Utfordringen fra havet. Pronova Biopolymer AS. Didakta Norsk Forlag AS 182 pp.

Christie, H., Fredriksen, S. & Rinde, E. 1998. Regrowth of kelp and colonization of epiphyte and fauna community after kelp trawling at the coast of Norway. Hydrobiologia 375/376:49-58.

Christie, H., Jørgensen, N.M., Norderhaug, K.M. & Waage-Nielsen, E. 2003. Species distribution and habitat exploitation of fauna associated with kelp (*Laminaria hyperborea*) along the Norwegian coast. Journal of the Marine Biological Association UK 83:687-699.

Meland, M. & C. Rebours. 2012a. Short description of the Norwegian seaweed Industry. Bioforsk FOKUS 7(2):275-277.

Meland, M. & C. Rebours. 2012. Introduction to the management and regulation of the Norwegian seaweed Industry. Bioforsk FOKUS 7(2):278-279.

Norderhaug, K. M. & Christie, H. 2008. Reetablering av tareskog på Helgelandskysten- kvantitative malinger av tare og kråkeboller. NIVA rapport lnr 5661-2008. 19 p.

Rinde, E., Christie, H., Bekkby, T. & Bakkestuen, V. 2006. Økologiske effekter av taretråling. Analyser basert på GIS- modellering og empiriske data. NIVA rapport lnr 5150-2006. 31 p.

Rinde, E. & Sjøtun, K. 2005. Demographic variation in the kelp *Laminaria hyperborea* along a latitudinal gradient. Marine Biology 146:1051-1062.

Sakshaug, E., Dale, T., Fosså, J. H., Fredriksen, S., Hedlund N. & Sivertsen, K. 2002. Nedbeiting av tareskog i Norge. MareNor 2002. 49 p.

Sivertsen, K. 1997. Geographic and environmental factors affecting the distribution of kelp beds and barren grounds and changes in biota associated with kelp reduction at sites along the Norwegian coast. Canadian Journal of Fisheries and Aquatic Sciences 54:2872-2887.

Steen, H. 2005. Chapter 2.5. Høsting av tang og tare- økologisk uforsvarlig eller bærekraftig ressursbruk? Kyst og Havbruk 2005:52-54. Institute of Marine Research 51-54.

Steen, H. 2009. Chapter 2.11. Stortare. Kyst og havbruk 2009: 211-214. Institute of Marine Research.

Waage-Nielsen, E., Christie, C. & Rinde, E. 2003. Short term dispersal of kelp fauna to cleared (kelp- harvested) areas. Hydrobiologia 503:77-91.

www.fiskeridir.no

www.imr.no

www.ssb.no

www.lovdata.no

Bioforsk, Torggården, 8049 Bodø, Norway

Email: celine.rebours@bioforsk.no; marte.meland@bioforsk.no

Web: www.bioforsk.no

NetAlgae, Indigo Rock Marine Research Station, Gearhies, Bantry, County Cork, Ireland.

Tel: + 353 (0) 27 612 76 Fax:+ 353 (0) 27 61264 Email: info@netalgae.eu

ATLANTIC AREA Transnational Programme
ESPACIO ATLÁNTICO Programa Transnacional
ESPACE ATLANTIQUE Programme Transnational
ESPAÇO ATLÂNTICO Programa Transnacional

INNOVATION NETWORKS
REDES DE INNOVACIÓN
RÉSEAUX D'INNOVATION
REDES DE INOVAÇÃO

European Union
European Regional Development Fund

Nordland
COUNTY COUNCIL