Baltic Mussel Eco

MUSSEL FARMING THE NEW BALTIC SEA AQUACULTURE INDUSTRY

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND
INVESTING IN YOUR FUTURE

CENTRAL BALTIC
INTERREG IV A
PROGRAMME
2007–2013








Contents

Editorial
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Edited by: Anders Gummesson, SE Network AB, Norrköping, Sweden.

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Project Description

The Baltic EcoMussel project aims to accelerate the adoption of mussel farming in the Baltic Sea Region by providing information and tools to support investments.

Recent research shows that commercial farming of mussels in the Baltic Sea Region can be viable and offers socio-economic and environmental benefits.

Commercial farming of mussels would enable fishing communities to diversify their income sources, create jobs and provide an alternative feedstock for use as feed, in biogas production or in other sectors.

The innovative project aims to achieve a commercially-viable mussel economy in the Baltic Sea Region by supporting key stakeholders the tools needed for up scaling of mussel farms in the region.

This includes assessment of regulatory conditions and developing guidelines and business plans for farmers; assessment of market potential and socio-economic impacts of large-scale farming; establishing methodologies and routines for monitoring and evaluation of farms and gathering, informing and training key stakeholders from the research community, aquaculture and end-user groups.

Project partners

East Sweden Energy Agency (Sweden) - Lead Partner
Novia University of Applied Sciences (Finland)
Latvian Environmental Investment Fund (Latvia)
Kurzeme Planning Region (Latvia)

Project duration

January 2012- December 2013 (24 months)

The project is financed by

EU program “INTERREG IV A Programme 2007-2013”

Main activities in the project

- Assessment of regulatory conditions and developing guidelines and business plans for farmers;
- Assessment of market potential and socio-economic impacts of large-scale farming;
- Establishing methodologies and routines for monitoring and evaluation of farms;
- Gathering, informing and training key stakeholders from the research community, aquaculture and end-user groups.

A Word from the Project Leader

Carl Hamilton
Project Leader
Baltic EcoMussel

The Baltic EcoMussel project aims to support the development of commercial mussel farms in order to strengthen fishery as an industry, the countryside and the labour markets in the Baltic Sea Region. The project also indirectly aims to reduce nitrogen and phosphorous in the Baltic Sea, thus creating a cleaner sea.

Mussels are farmed in many countries within the EU. In Sweden, farms are mainly found on the west coast. Lately, a number of pilot projects have studied whether or not commercial mussel farming is possible in the Baltic Sea. Baltic EcoMussel has shown positive results indicating that there is a potential for establishing mussel farms and thus creating labour opportunities in coastal areas as well as favourable environmental and socio-economic effects. The project is targeted at being the opening of a commercial development of mussel farms in the Baltic Sea.

The Baltic EcoMussel project contributes to the achievement of the Swedish part of the European Union Baltic Sea strategy, EUSBSR, targets. The project has created tools for stakeholders to influence the development in the entire Baltic Sea area.

The project has also defined a number of strategic analyses to secure that commercialisation of mussel farms can be done in an effective and sustainable manner; assessing rules and regulations, the development of guide lines and business plans for mussel farmers, assessment of market potential and socio-economic effects of mussel farming on a large scale.

Furthermore, the project works with the implementation of methods and routines to monitor and evaluate farms as well as defining, informing and training selected key stakeholders in science, aqua agriculture and end user groups. The development of end use areas has been an important task within the project.

The project supports the development of the entire business chain from mussel farms to the final, commercial product. The target is to achieve this through local participation and international cooperation.

To reach these targets, a strong and professional partner organization has been formed within the project. Which has been coordinated by East Sweden Energy Agency in cooperation with Novia University of Applied Sciences In Finland, Latvian Environmental Investment Fund and Kurzeme Planning Region in Latvia.

Facts have been gathered from the Swedish west coast, Canada, Scotland and Denmark as well as from some other countries experienced in commercial mussel farming. The results of the project will be presented at a conference in Riga on November 26-27 and then spread throughout the entire Baltic Sea Region and elsewhere.

New programmes for cooperation supported by the EU structural funds are now being created leaning on the EU2020-targets for a smart, environmental and economical sustainable Baltic Sea area.

With the work already done on mussels in the Baltic Sea, a platform has now been created which makes it possible to further develop and coordinate new, innovative and environmentally positive projects.

Mussels contribute to saving the Baltic Sea environment. Also, when harvested, mussels support the development of innovative business solutions providing new labour opportunities in coastal and farmland areas.

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Summary and Conclusions

by E. Diaz & P. Kraufvelin

The project Baltic EcoMussel assessed and considered the environmental and socio-economic realities of three regions in the Baltic Sea to establish mussel farm activities, the east coast of Sweden, the open coast in Latvia, and at the entrance of the Gulf of Finland in Finland.

The project Baltic EcoMussel met contrasting public opinions; for example some people were against mussel farms considering it a non-reliable business, based on the fact that blue mussels exhibit a slow growth rate in the Baltic proper, and partially because they chose to ignore any possibilities of mussel cultivation in a non-optimal environment for mussels before having the concept tested.

Thus, our first goal has been to inform people about blue mussel aquaculture in the Baltic Sea region.

The second goal of the project was to prove that mussel aquaculture is feasible in the three target regions of the Baltic Sea (see above).

This goal was accomplished, and additionally we made new findings relevant for this industry:

- Mussels grow considerable faster on the cultivation ropes than on natural substrates on the sea floor
- 40 tons of mussel cultivation do not harm the marine ecosystem
- Proven recruitment of mussels at open coasts, e.g. the coast of Liepaja, Latvia.

Additionally, as a third goal, we wanted to identify investment costs for a mussel farm installation for each one of the study locations. We identified the necessary investments and costs taken as a reference a production of 80-100 tons of mussels every second year within a water area of 1 hectare.

These investments could be subsidized by municipalities, regional development programs and EU development programs or by the private sector.

The identification of end-uses for harvested mussels was our fourth goal. We suggest that mussels should be used in restaurants, which might be promoted as a local and organic culinary delicatessen from the Baltic region. Other end-uses for mussels include: fertilizers for agriculture and as fish and chicken food.

Additionally, we highlight the indirect positive environmental consequence of mussel farming at local scales. This is taking place through the recycling of nutrients.

Nitrogen and phosphorus from agriculture, municipalities and industries are taken up by the mussel tissues from the sea in situ (one of the few available *in site* methods for removal of nutrients already present in the sea) and when harvesting, N and P and carbon (C) are eliminated from the water and returned to land.

During the active filtration process of the mussels, the waters also become clearer which may benefit submerged macrophytes and natural fish stocks.

The next steps would be to test the equipment/methods/concepts in the regions at industrial scales and attract interest in developing this industry further. In synthesis, the investment of mussel industry in the Baltic region means investment in a green economic activity and in a greener future, implying cleaning and clearing the sea.

The Baltic EcoMussel Project – Background

The Baltic Sea of today faces many challenges in connection with the shortfall of traditional fishing activities in coastal communities while also restoring the fragile brackish waters, suffering from decades of serious environmental degradation. Just as in other European coastal communities, the decreasing availability of fish stock has left geographically remote small-scale fishing villages in a vulnerable position in terms of employment.

The situation is worsened by the fact that aquaculture, which has been an important alternative for livelihood throughout the Baltic Sea region, is haltering or even in decline.

This decline is not due to a decrease in demand for seafood, quite the contrary, but to the difficulty of reconciling environmental policy with a viable aquaculture economy.

Serious threat

In fact, the continuing eutrophication of coastal waters in the Baltic Sea, not only from aquaculture but also from many other human activities, is a serious environmental threat to the whole region, and calls for urgent action to 'avoid an irreversible disaster' (HELCOM, 2007).

On a global scale, concerns have also been raised that the aquaculture industry is currently threatening the world's wild fish stock as it is relying heavily on wild fish to feed the farmed fish (Naylor et al. 2000). Thus, there is not only a demand for alternative means of livelihood in the Baltic Sea coastal areas but also an increasing and urgent demand for alternative and more sustainable fish feed in the aquaculture industry, to meet sustainability goals and decrease the nuisance of eutrophication.

Benefits

Mussel farming could provide a series of benefits and realistic solutions to many of these challenges. Lindahl and Kollberg (2009) point out that mussel farms not only improve coastal water quality, but they also provide new jobs and produce healthy marine food, while recycling nutrients from sea to land.

It is under these premises that the Baltic EcoMussel project is being developed. The project explores how mussel farming could contribute both to increased ecological and economic benefits in different regions around the Baltic Sea.

Mussels as an Alternative to Subsistence in Rural Coastal Communities

Today, rural coastal and island communities face challenges, due to the global shortfall of fishing activity and the scarcity of alternative employment opportunities (Pita et al. 2010).

Finding alternative means for subsistence, often called 'employment diversification in fishing communities' (Pita et al, 2010), without harming the environment is important in order to keep remote coastal communities vibrant and alive not only in the short term, but also long term, providing future generations the environmental conditions of sustainable subsistence opportunities in these localities.

Ecological footprints

Such incentives would provide residents the possibility to generate an income in these areas without having to commute to distant economic centres. Nonetheless, previous employment initiatives such as the salmon industry have left an ecological footprint that is neither beneficial for the quality of the water nor positively received by neighbouring residents.

Mussel farming provides an interesting opportunity to combine local job creation with purifying the sea waters from the effects of on-going eutrophication processes. Hitherto, mussel farming is the only realistic, i.e. *in situ* operational, way of removing (through harvesting) nutrients already present in the sea.

Different conditions

At its best, mussel farming can create an additional income for traditional fishermen or fish farmers, providing them an incentive to stay active within the aquaculture sector. Due to natural condition limitations (6 psu salinity in the Gulf of Finland), the definition of large-scale mussel farming in the Baltic Sea may differ to the concept of large-scale farming in other locations with other conditions.

Here, we consider that the maximum size of one mussel farm can produce 100 tons of mussels in 2.5 years, with a minimal distance of at least 1 km to other farms. The farm in itself requires 1-2 fulltime workers at the initial start-up phase and the harvesting phase, and during the rest of the time the farm would require 1-2 part-time workers for maintenance tasks.

Synergy effects

It is still important to note that as a whole, the mussel industry can provide new employment opportunities. Although the labour effect from one mussel farm is limited, synergy effects can be achieved through linking multiple farms in one region. Such 'clustering' of activities allows for related industries and new innovation in the sector to take place.

Consequently, in this project, we take a broader approach to the socio economic effects of mussel-farming in the Baltic Sea. We consider the effects on employment creation in related industrial activities as well as the effects on the actual supply chain of the mussel farm.

Food supply

This approach allows us to explore the effects on farm equipment, transportation, specialized harvesting jobs, mussel meal industrial plants as well as the benefits from inserting mussel meal as food supply in related industries such as the local salmon, poultry, and pork farms.

The adapted approach towards the socioeconomic impacts has a dual connotation, as the analysis include a combination of the economic benefits for the community and the ecological benefits derived from the effects of nutrient removal in the local coastal waters.

Based on findings from a Baltic EcoMussel field trip, successful experience in Denmark shows that there are potential benefits for fish farmers with mussel farming as a supplementary activity. Furthermore, the initial stage of mussel farming requires the input of expert knowledge.

Mussel Farms as a Mitigation Tool

A pattern of hauling nutrients from rural to urban areas prevails in the Baltic Sea, which has received around 20 million tons and 2 million tons of N and P, respectively in the last 50 years (Conley 2012). This massive load of nutrients has decreased the resilience and productivity in about 60000 km². This has affected economies through reduction of oxygen in the sea bottom and consequently also on the availability of wild fish.

The cleaning characteristics of mussel farms could be used as a mitigation tool of this eutrophication process. The needed initial investments in mussel farms could be supported by subsidies in the EU-agro environmental aid program, which currently is directed towards methods in agriculture that decrease nutrient release from farmland to environment.

There are different types of subsidies to combat eutrophication, such as the "basic environmental subsidy", and "special agro-environmental subsidies" such as organic farming, wetland construction, traditional rural biotopes, and heritage breed.

Exploring possibilities

It has been calculated that 1 hectare of mussel farm removes 25 times more nutrients (N and P) than a single hectare of wetland (Lindahl and Kollberg 2009). One project objective of Baltic EcoMussel is to promote the incorporation of mussel farms in the "EU - Agro environmental program".

The operating scheme of mussel farms could be based in the association and application for funding of 5 land farmers which should receive from EU a subsidy for the implementation and maintenance of a mussel farm of 1 hectare for at least 10 years. This idea can be implemented regionally and around the Baltic countries.

Another important aspect of the benefits of mussel farms in combating eutrophication is how to serve as a bridge between responsible aquaculture and local community acceptance.

Responsible way

A recent study among stakeholders and their attitudes towards aquaculture around the Baltic Sea found that a properly managed growth of aquaculture is considered a necessary and responsible way to meet future global food needs (Aquabest 2012).

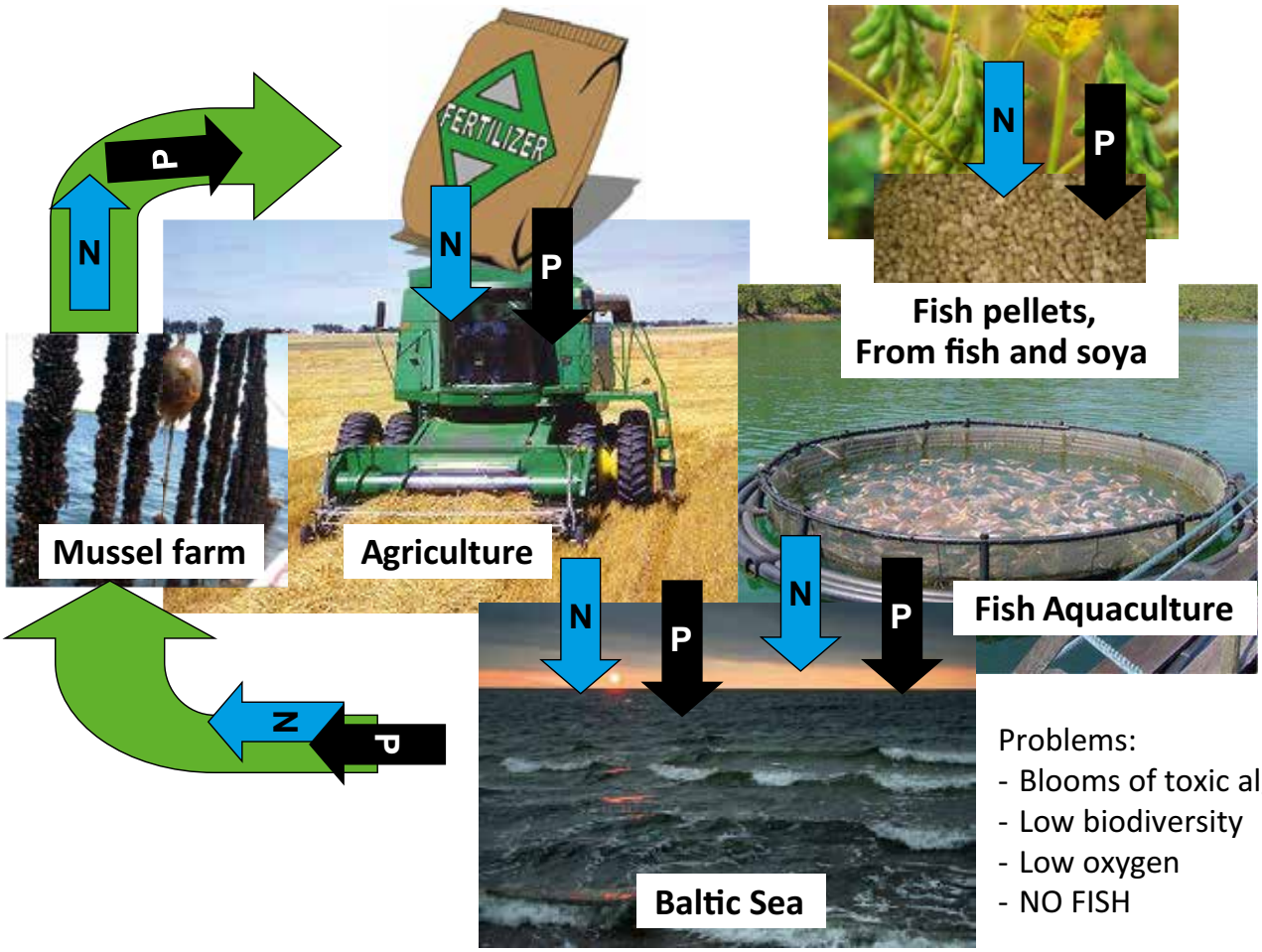
However, as Aquaculture in its current form is contributing to the nutrient load and the eutrophication process, its activities do face obstacles related to sustainability.

Mussel farms have been described as "the engine of an Agro-Agua recycling system of nutrients from sea to land" (Lindahl and Kollberg, 2009). Thus, mussel farming could provide a natural mitigation process of potential harms of increased aquaculture in the Baltic Sea.

A pivotal role

Hence, within the parameters of the Baltic EcoMussel project, we investigate whether the mussels can play a pivotal role in developing a "properly managed" and "responsible" aquaculture in the Baltic Sea that does not cause increased stress on an already heavily burdened ecosystem.

According to Lindahl and Kollberg (2009), the optimal effect of mussel farms in this respect, is achieved when all mussels are farmed and brought back to land as nutrients for human consumption or as feed or organic fertilizers.



Problems:
- Blooms of toxic algae
- Low biodiversity
- Low oxygen
- NO FISH

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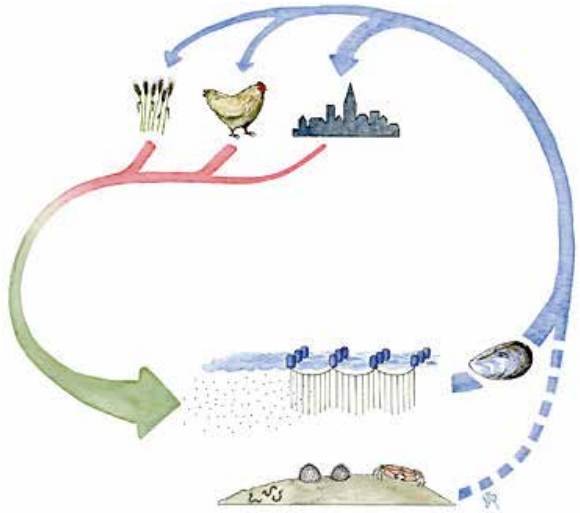
End Uses – and Closing the Nutrient Loop

While achieving increased mitigation against the on-going eutrophication in the Baltic Sea, finding an end-use for the farmed mussels is decisive for a long term profitable mussel industry in the region. The Baltic EcoMussel project will explore different end-use possibilities, and their labour market effects.

Highest profits could be achieved if the end use is directed towards human consumption and particularly gastronomic uses in restaurants. However, due to their small size, the mussels from the Baltic provide limited possibilities for gastronomic use and direct human consumption (albeit still possible).

Nevertheless, as fish and poultry feed, the mussels could still be used in the food industry, achieving higher profitability than in other industries such as fertilizers or bio-energy use.



Illustrator: Maj Persson.

Fish or mussel meal?

In fact, recent large-scale experiments, replacing fish meal with mussel meal as chicken feed, indicate that mussel meal could very well replace the need of fish meal in the poultry and egg production (Jönsson, 2007).

Mussel meal could also replace the use of soy or fish meal in fish farms, thus decreasing the nutrient load in the sea by closing the loop between nutrient loading fish farms and nutrient cleaning mussel farms.

An additional positive effect of mussel meal could be its nutritional benefits. The mussel flesh contains some essential amino-acids and essential oils in high quantities in comparison with other vegetable products (Naylor et al. 2009).

Provides jobs

This may improve the quality of the salmon/pork/poultry when mussel meal is used instead of for example soy. The converting process of mussels into meal is based on a lactic fermentation process (fragment proteins into amino-acid) and then a chemical process which converts the mussel meal into pellets with specific concentrations to respective animal diets.

Based on experience in Denmark, such a process provides jobs for two persons when the production process is stable.

Popular products

We should also incorporate the extraction of Omega-3; It has been said that *Perna canaliculus*, the New Zealand green-lipped mussel, has the highest concentration of the essential fatty acid Omega-3 fatty acids among animals producing it. Omega-3 products are very popular, since they can be used in clinical treatments.

Because Omega-3 fatty acids are essential in growth and development throughout the life cycle, they should be included in the diets of all humans (Simopoulos 1991).

Due to their high level of omega-3 fatty acids (see above), mussels could also have an important role to play in food supplement industry where the demand for omega-3 fatty acids is on the increase.

Decreasing toxic loads

The synergy effects from mussel farming in the Baltic Sea and innovative end-uses deserve further exploration.

Not only does the presence of mussels have a positive effect on other industries such as fish farming, providing cleaner water, improving photosynthetic activities of desired species as bladder-wrack and eelgrass deeper down in the water and consequently better conditions for fisheries and fish aquaculture (Petersen et al. 2012), but the mussel itself has also attributes that can decrease toxic loads in currently non-related industries.

For example, the adhesive material in the mussel may function as a biodegradable substitute to current chemical adhesive substances.

Aesthetic Concerns and Public Service Demands

The aesthetic impact of mussel farming is two-folded. First, the Baltic Sea presents serious negative effects on the aesthetics (and thus tourist attractions) due to the abundant presence of algae during the peak season for tourism. Mussel farms, due to the registered cleaning ability could improve water quality and thus also the overall aesthetics of the nearby waters.

However, overexploitation of mussel farming would impact the landscape with the presence of visible parts of the farms above the sea level. This could also impact the mobility of those who are accustomed to travel freely in these waters.

Still, by the use of suitable locations, which are not threatened by weather conditions nor affecting neighbouring residents, the mussel farms could give a considerable upswing for the community by improved water quality and mitigated effects of the fish farming industries.

Public services

Finally, what effects would mussel farming and the related industries have on the demand for public services?

Here, the demand depends on the scale of industry development, as well as the final destination of the processed mussels. Depending on the chosen techniques for the mussel farms, it might be necessary to develop infrastructure that supports the relocation of harvesting equipment (big machines with transport load on local roads).

Whether the farms are located on remote islands may impose demands on public ferries during harvesting time. However, such infrastructural demands arise periodically during harvesting time and when well-planned should not disturb other local community activities.

Other demands may include monitoring of water quality and prevention of plagues, administered by authority institutions. The exact need for public services will be determined based on interviews with representatives with mussel farms in other locations around the world.

Torbjörn Engman - a Baltic Mussel Farming Pioneer

Biologist, geographer, fish farmer, musician - and mussel farmer. Just some of the titles Ålander Torbjörn Engman can print on his business card. What started with a fish farm in 1984 has now led to Torbjörn Engman being one of the true pioneers of mussel farming in the Baltic Sea.

- I started my fish farming business in 1984 and continued until 2008. The reason I stopped was simply that the rules became more and more complicated. The Åland Provincial Government began to set increasingly stringent rules for the fish farming industry, says Torbjörn Engman.

When, in 2005, Torbjörn Engman brought in the culture frames used in fish farming, he noted, as usual, that the anchor ropes were full of mussels. He began to think if it would be possible to cultivate mussels in the Baltic, primarily as part of the efforts to clean the aquatic environment.

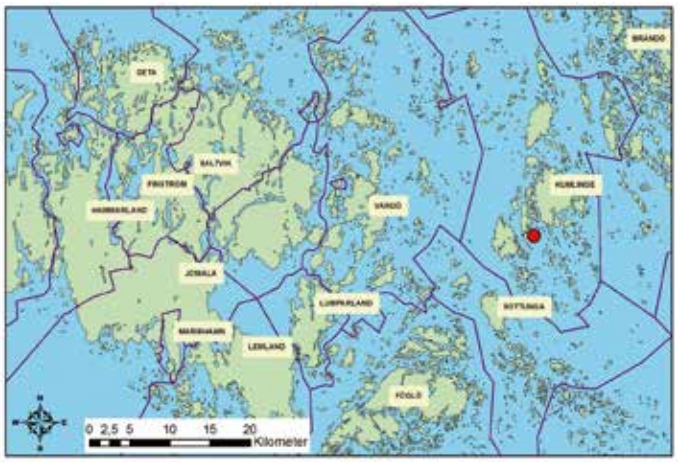
Good idea

- I got in touch with Odd Lindahl, who probably is the one person in Scandinavia who knows most about mussels. What he does not know of mussels is probably not worth knowing - although in his case it primarily involves mussel farms on the Swedish west coast.

- Odd said that it would probably be a good idea to test how mussel farming in brackish water would work - and I already knew that there were plenty of "wild" mussels in the waters around Åland.

Torbjörn Engman, himself a member of the Åland Islands Fishery Association, suggested that the association should launch a pilot mussel farming project. The purpose was to make mussel farming a part of the compensation for fish nutrient discharges.

The main idea was that the Åland fish farmers should take the lead in small-scale, environmentally friendly mussel farming.



Two-year trial

The Fishery Association endorsed the idea and in turn searched financial support from the Provincial Government. The application was granted - and in the summer of 2006 the first equipment came from Norway. The mussel farming project started with Torbjörn Engman as one of the persons responsible.

- The project was entered as a two-year trial, says Torbjörn Engman. We wanted to know if it was at all possible to grow mussels in our waters. Mussel farms had never occurred in the Baltic Sea before - and the question was whether or not it would be possible to do the same as they had managed to do on the West Coast.

The type of mussel farming used in the project was the traditional long line model. It means a surface line, 50 meters long, supported by surface buoys about seven meters apart. The actual cultivation bands are then attached to the long line.

The harvest was conducted in September/October 2008. The answer to the question “can mussels be cultivated in the Baltic Sea” became a resounding **yes**!

- We harvested approximately 3.5 tonnes of mussels which corresponds to about 2.5 kg per meter - and it is a very good result, says Torbjörn Engman.

Large scale

In the final report after the pilot project, Torbjörn Engman's conclusion is that mussels can be grown successfully in the Åland archipelago. Large-scale mussel farming around Åland could be very important for the uptake of phosphorus and nitrogen from the sea, thus having a purifying effect on the aquatic environment.

- The final report was very well received by the Provincial Government, says Torbjörn Engman. Planning for a large-scale pilot project began in 2009 - and in June 2010 the equipment was delivered from the Norwegian company Smart Farm A/S.

Small mussels

The new farm was carefully monitored - winters are known to be tough on this kind of constructions.

- Everything worked out fine technically - even though the winter of 2010-2011 was harsh, says Torbjörn Engman. Hard winds and ice caused great strain. But the farm survived the winter and the mussels remained affixed to the cultivation bands.

- When we harvested the farm on 27-28 November 2012, the result was 14.4 tonnes of mussels - considerably less than expected, says Torbjörn Engman. That was mostly due to poorly adapted harvesting equipment for the Baltic mussels - they are much smaller than those harvested outside the Swedish and Norwegian west coast.

Early in the planning of the large-scale project, the environmental benefit was the main challenge. But, as the planning progressed, the economic aspects seemed more and more important. The idea was that mussel farming also has to be economically viable to rationally reach the environmentally improving effects.

- We noted, that the mussels we harvested were very good and tasty. They simply must be commercially viable, says Torbjörn Engman.

Locally produced

One result of the successful experiments with mussel farming in Åland waters is that Torbjörn Engman's 27-year-old son and his business partner decided to go for mussel farming for human consumption.

They have performed an extensive market research - both on the Åland Islands and on the Finnish mainland. It has shown considerable interest for locally produced mussels among restaurants and shops. The farming is on - and if all goes as planned, they expect to be able to harvest five to six tonnes of mussels from their farm in early summer of 2015.

Soon, the Åland restaurants will be able to serve their guests locally produced delicacies: blue mussels from the Åland archipelago!

Mussel Farming – How to Do It

There are hundreds of species of mussels but only about a dozen or so are fished commercially. Blue mussel shells have been found in kitchen middens dated as long ago as 6000 B.C. Until the 19th century, blue mussels were harvested from natural sea beds in several European countries and used as food, fish bait and a fertilizer. The initial step for mussel farming was based upon storage and relaying fishery products.

Mussel growing methods have been established based on historical, geographical, physical realities. There are several techniques for growing mussels - various methods are being used in different parts of the world. Based on place, tidal conditions, species, climate and weather, cultural aspects and historical experience, farmers have chosen different methods for growing mussels. The most suitable method for the Baltic Sea is farming on long lines (ropes/socks or nets).

Cultivation on long-lines

The mussels are attached to ropes that are suspended vertically in the water from anchors and floating structures.

Vertically, mussel farm height should not be more than 10 m, the optimal depth is at 4 m.

Mussel reproduction takes place in spring and in the beginning of summer. If substrates for settlement of mussel larvae are placed out later than this, the mussels might only settle in very small amounts.

Recommendation: temporarily submerging of mussel long-lines is part of a farming practice designed to lower the crop below surface ice during winter months (e.g. in Canada) and this is highly recommended for Baltic Sea region.

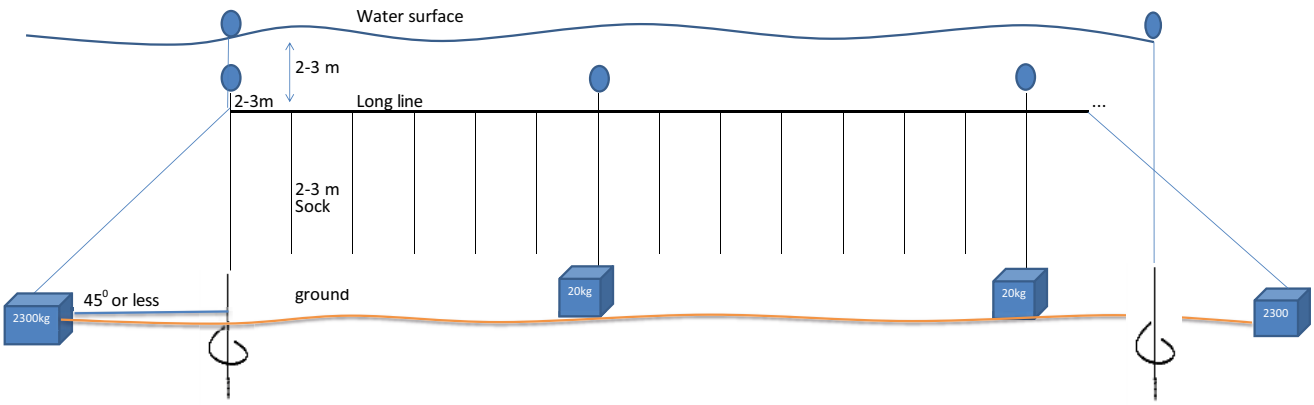
Mussels are generally harvested every second year. To provide stable income a farmer should have at least two farms.

To harvest mussels, special equipment is used, either obtained by the farmer or by use of rented services.

How can blue mussels be used?

Blue mussels contain a variety of substances that can be used in a number of different products and materials. Blue mussels are not only good at harvesting nutrients through their food intake of plankton.

Taking into consideration that the innovation and market is moving in the future, mussels might be used in other industries, like to produce anti-corrosive products and superglue as well.



What Can Blue Mussels be Used for?

Blue mussels contain a variety of substances that can be used in production of different product and material. Blue mussels are not only good at harvesting nutrients through their food intake of phytoplankton.

They also provide valuable seafood and raw material for feed-stuff, fertilizers etc. Mussel farming can be used as a mitigation tool to compensate for nutrient discharges in nutrient trading schemes.

Compared with the environmental sector, the industrial sector of blue mussels use or blue mussel aquaculture is based on profitability. Basically, the industrial sector is managed by private entities, whereas the environmental sector is managed by public institutions.

Mussels in Our Kitchen

Humans have used mussels as food for thousands of years. Mussel's production for human consumption takes 70 per cent of the total quantities caught. The species *Mytilus edulis* is commonly harvested for food throughout the world, from both wild and farmed sources.

Mussels are an important ingredient of many seafood dishes in various cuisines including Spanish (especially Galician), Portuguese, French, Dutch, Belgian and Italian.

Traditionally, mussels have been sold fresh in the shell, although in the last few years, some attention has been directed towards value-added products such as mussels in a prepared sauce, smoked mussels, and blast frozen cooked mussels.

Mussels can be smoked, boiled, steamed, roasted, barbecued or fried in butter or vegetable oil.

As with all shellfish, except shrimp, mussels should be checked to ensure they are still alive just before they are cooked; enzymes quickly break down the meat and make them unpalatable or poisonous aftear dying or cooked. Some mussels might contain toxins.

Mussels as a Fertilizer

The proportion between nitrogen, phosphorus and potassium in the mussel remainder makes it suitable to use as a fertilizer when cultivating grain. The easily decomposed shells have a liming effect and micro-nutrients like e.g. selenium are added to the soil.

Since the mussels live in saline water and ions of both sodium and chloride have a negative effect on e.g. growing potatoes, it is, however, important that the water inside the mussels is drained before the reminder is spread on the farmland.

Anti-Corrosive Products

Protein from Swedish blue mussels and cerium from China are constituents of an environmentally friendly alternative to current anti-corrosion methods.

The fact is the adhesive blue mussel protein can prevent corrosion in stainless steel. Researchers at the Royal Institute of Technology (KTH) in Stockholm have used this knowledge to develop an anticorrosive agent for carbon steel.

The assignment to develop a new anti-corrosive product came from Biopolymer Products, which saw the possibilities for commercializing the research results.

Superglue

Using reverse-genetics molecular biology techniques, researchers at the Idaho National Laboratory (INL) have replicated the genetic machinery used by the blue mussel, *Mytilus edulis*, to produce adhesive anchors and threads.

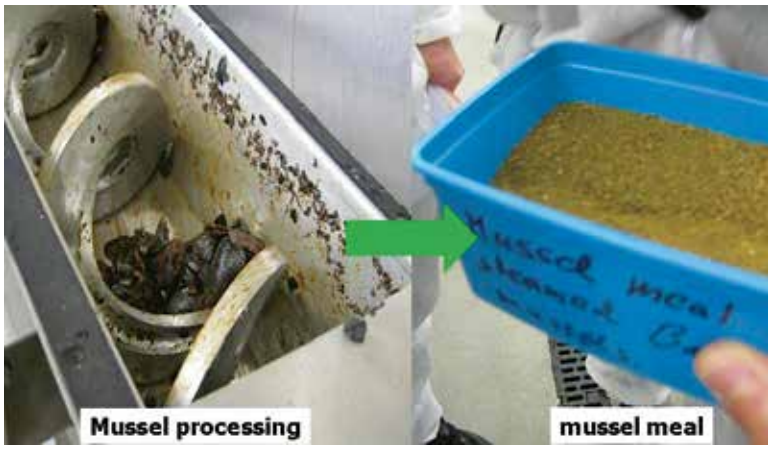
The INL technology makes it possible to produce adhesives that mimic those of the mussel – they are very strong, unaffected by water and bind to a variety of surfaces such as glass, ceramic, wood, rock, concrete, plastic (even Teflon) and biological substrates including skin, muscle, bone and other tissues.

This is the only adhesive that can be applied underwater, is impervious to turbulent forces and is environmentally safe. There are no current conventional glues that come close.

Fish Feed Production

Fish is a vital source of proteins, minerals, and healthy fatty acids. Small pelagic fish which are unattractive for human consumption and trimmings from the fish processing industry are primarily used for fish oil and fish meal production.

Blue mussels which could not be used for human consumption can be used for fish feed production. The second step in the chain is the manufacture of fish meal and fish oil from the industrial fish and the processing of vegetable raw materials to extract fatty acids, proteins, and starch.



One kilo industrial fish yields an average of around 3-5 per cent fish oil and 20-25 per cent fish meal, the rest is water.

Since mussels are at the second step of the marine food-chain, the use of mussels instead of fish for feed production is of a large ecological importance at a time when many fish-stocks are over-exploited on local/regional and global scales.

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How to Start a Mussel Farm Business

In the Baltic Sea, the area of marine aquaculture is partly underdeveloped (with the exception of the farming of rainbow trout) and there is no commercial mussel farming. Due to this reason, the possibilities for end-use are not fully developed.

To establish a mussel farm, several things are needed:

A territory or place in the sea

Currently, in the open Baltic Sea, the main economic activities are fisheries, navigation and operation of ports as well as tourism and recreation in coastal areas. Also private enterprises are increasing their economic activities by facilities for wind energy production facilities. This increases the competition and in the future there might be problems to get free space in the water for mussel farms.

Appropriate equipment (farming equipment, boat, harvesting equipment)

Technical issues depend on Baltic regional and local conditions, wave exposure, winds, water circulation/currents, and benthic/sediment conditions.

The price for equipment should be evaluated with the return on investment and profitability.

Qualified labour force

Qualified labour force might reduce several risks. To reduce such risks, a farmer can go on study visits to obtain knowledge, can hire an expert from other mussel farms or cooperate with scientists who are keen on mussel farming.

A farmer might need a help from scientists in farming stage, for example regarding the best solutions for locating mussel farming equipment for optimal recruitment and growth and minimum environmental harm, for assessing biological and health risks, extreme weather conditions or other predictable threats.

Within Canada, farmers cooperate with aquaculture associations which hire several scientists who monitor sampling weekly/monthly. Also in Denmark, the scientists are working together with farmers.

General guidelines

The entrance of the Gulf of Finland and the east coast of Sweden present similar features, representing an archipelago structure, while the coast of Latvia represents an open coast.

The oceanographic requirements for both types of coastline converge in the following points:

1. Salinity should be higher than 5 per mille
2. Oxygen levels should be saturated with concentration exceeding 90% in the water, and
3. There should be sufficient amounts of micro-algae estimated to a concentration of 2-4 µg/l of chlorophyll-a. It is also important that the mussel farm should be far from sewage and run-off of pollutants.

For archipelago coasts, the site should present moderate protection to waves given by the dominant wind direction, while the sea floor should be a flat platform with minimal depth variation between 10-15 m.

For the coast of Latvia, it is recommendable that the mussel farm remains submerged below 5 m to avoid high wave action.

Partners of the Baltic EcoMussel Project

The Baltic EcoMussel Project started in January 2012 and ends December 31st 2013. The programme is financed by the European Union within the framework of INTERREG IV A Programme 2007-2013.

The project has four partners: East Sweden Energy Agency (Sweden) - Lead Partner; Novia University of Applied Sciences (Finland); The Latvian Environmental Investment Fund (Latvia); Kurzeme Planning Region (Latvia).

Partners and people involved have met frequently during the two years. The picture on this page was taken in the Sankt Anna Archipelago on May 29th, 2012.

From left to right:
Ligita Laipeniece, Kurzeme Planning Region;
Kristians Godins, Kurzeme Planning Region;
Bo Storrank, Joint Technical Secretariat;
Zaiga Ozolina, Latvian Environmental Investment Fund;
Eliecer Díaz, Novia University of Applied Science;
Patrik Kraufvelin, Novia University of Applied Science;
Mats Emilsson, East Sweden Energy Agency;
Kerstin Konitzer, East Sweden Energy Agency;
Gints Kārkliņš, Latvian Environmental Investment Fund;
Johan Niskanen, East Sweden Energy Agency;
Carl Hamilton, East Sweden Energy Agency.

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