BUSINESS SITUATION ANALYSIS
for a mussel farm
located in east-coast Sweden

Project ”Baltic Blue Growth”

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Introduction

Today, mussel farming does not exist on a commercial basis in East coast Sweden. The main obstacle is not biological, but the lack of a profitable market for mussels sized 1-3 cm. Mussel size determines the possible use of mussels – small size mussels cannot compete with human consumption mussels grown in Europe or other parts of the world, but there are other possibilities to develop valuable products. In addition - mussel farming in Baltic Sea is seen as one of the possible solutions to reduce eutrophication.
The goal of this paper is to provide Baltic mussel farmers with useful information about marketing aspects to develop their business. Another target group is coastal municipalities and regions, interested in the costs and potential to catch nutrients from the Baltic Sea coastal waters. We present a business situation analyses based on the investment costs, management costs and production capacity from the Baltic Blue Growth project's St. Anna mussel farm in East Sweden region. In our case study, the market is determined as:

- Nutrient uptake by use of an environmental fund
- Mussel for animal feed

This document is focused on today's situation. For future use, the suggested marketing strategy should be revised and adapted to the future market situation.

Summary of main conclusions

Mussel aquaculture in the Baltic Sea is based primarily on a two-year production cycle. Based on our case study, we expect a yearly harvest of 40 ton wet weight mussels. According to results from our test-farm, yearly operational costs including harvest and transport of mussels from our test-farm is around 0,3 EUR/kg. Depending on the level of investment support, the total production cost for 1-3 cm blue mussels (*Mytilus edulis*) from the Swedish east cost is 0,7-1,1 EUR/kg. The mussel farmer will start to receive income in the second year due to the 2-year growth cycle. We present here 3 scenarios on how to reach a viable business:

1. Payment for the nutrient uptake: 500 EUR/kg P, 50 EUR/kg N
2. 50% start-up support from EMFF.
   Payment for the nutrient uptake: 360 EUR/kg P, 30 EUR/kg N.
3. 50% start-up support from EMFF.
   Payment 0.069 EUR/kg for feed mussels.
   Payment for the nutrient uptake: 350 EUR/kg P and 25 EUR/kg N.

Yearly revenue in year 2-9 must be 41000-26 400 EUR per year, depending on the level of start-up investment support from EMFF (0-50%). Depending on scenario, there will be a need for payment of nutrient uptake corresponding to 500-350 EUR/kg P and 50-25 EUR/kg N, annually to the operator.

The case study

Farm-site, location	**Structure of farm**	**Harvest 2017-2018**	**Estimated growth rate**
Sankt Anna archipelago, Sweden (N16.836, E58.384)	Long line, 16*150 m lines. Substrate: New Zeeland fuzzy rope Growth depth 2-12 m Total substrate length 24,000 m	79 tons from 16 units 24 000m substrate 3.3 kg/m	1-3 cm within 14 months

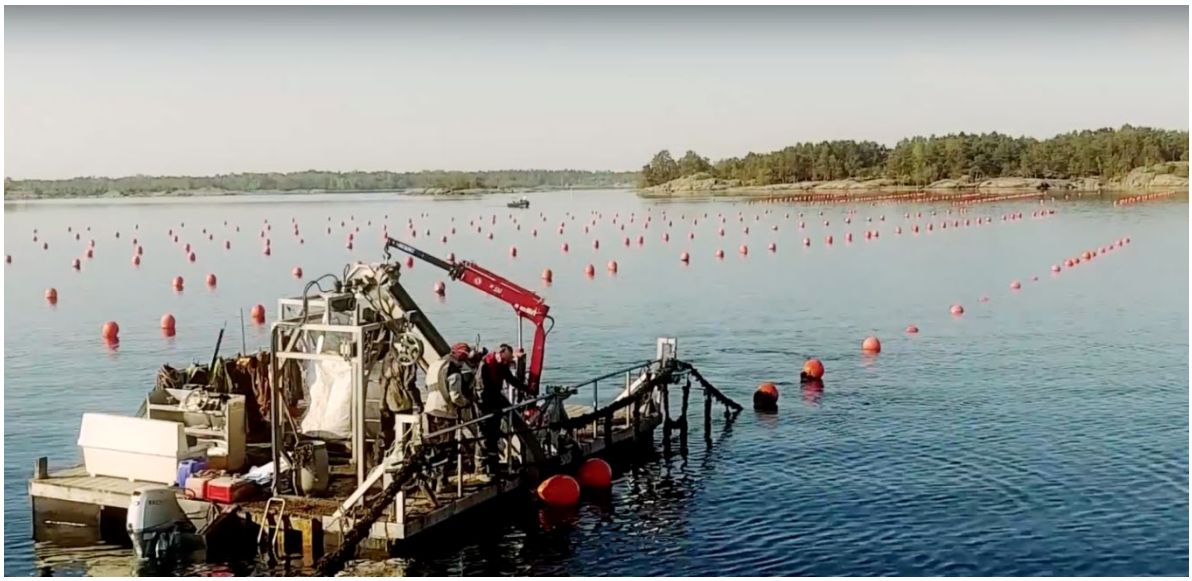

Figure 1 Photo of the St. Anna mussel farm and work vessel at harvest

The example farm is placed in a middle archipelago of the Baltic proper. Depth at the site is ~20 m, salinity around 6 PSU, current and wind conditions acceptable, and in addition, the area is not normally affected by ice movements during freezing or spring break-up. After 2 years of growth the size of the mussels will be up to 3 cm, mixed with a lot of smaller mussels that are either food-limited (suppressed by their peers) or from a later settling. The growth substrate of the farm consist of 24 000 m fuzzy rope, so called Christmas three rope from New Zeeland and it is operated with a ~6 m wooden barge. Other equipment such as buoys, anchors and machinery is specified in detail in Appendix 1.

Figure 2 Close-up of the longline farm construction with New Zeeland ropes

Marketing strategy

The Baltic Blue Growth project has identified and examined a number of potential markets for 1-3 cm mussels grown in East coast Sweden. Some of these markets are legal in Sweden already today: Mussels for animal feed, mussel shell and mussel fertilizer. However, the most common and profitable market for mussel farmers on the Swedish west coast, mussels for human consumption, is not legal for the Swedish east-cost. To open up this market, new guidelines from the Swedish food safety agency on how to implement existing Swedish laws in the brackish environment of the Baltic Proper is needed. There has been no such initiative yet from Swedish administrations.

If the market for human consumption of mussels from the Baltic Proper was unlocked, a number of interesting food products from small mussels should be possible: Canned mussels, mussel fondue and “super-local” mini mussels served in spring and the late autumn season at sea-side restaurants. Process plants for such products exist in Denmark and at the Swedish west coast.

Dried mussel meal, a product that is manufactured for animal feed today, is a product that could be aimed towards human consumers as well. But due to the present legal status, mussel sales for human consumption have not been considered in our scenarios.

Baltic mussels have the potential to be sold as fertilizer to organic farms, or as a compost product in gardening-shops. But so far there exist no guidelines, manufacturers or wholesalers for mussel-fertilizer products in Sweden. Non-food mussels are considered as animal by-products, and due to EU-regulations such products are only legal to use as fertilizer after heat-treatment, composting or equivalent treatment to kill off bacteria. At the Swedish west-coast, where spill mussels are used as fertilizer today, the mussel farmers are happy if users pay for the transport. Therefore mussel fertilizer as a product for sale has not been considered in our scenarios.
For clean mussel shells, there is an existing market in Denmark to use them for various constructions such as drainage, isolation, road-paving and garden decorations. The shells can be sold for about 140 EUR/m^3, but first they need to be separated from the mussel meat, which is a costly process. Due to the animal by-product regulations and bad smell, it is not legal to just pile them up and wait for the meat to disappear by natural processes. Thus, mussel shell is not a primary product to be sold directly from the mussel farm, but rather a by-product from the food- or feed-mussel industry.

To sum up, for reasons given above, only the markets of animal feed and nutrient uptake are considered in our scenarios for the Swedish east coast mussel farmer presented here. This document is focused on today's situation. For future use, the suggested marketing strategy should be revised and adapted to the future market situation.

Mussel meal for animal feed; price, current status and potential

Dried mussel meal has a nutrient profile similar to fish meal, but different taste. Mussel meal doesn't have the distinct fish taste that some people claim that they can taste from ecological eggs and other products where fish-meal has been added to the animal feed. Mussel meal could be a direct replacer for fish meal in various products, and has compared to fish meal quite a few environmental as well as culinary advantages. However, the cost for producing mussel meal today is today far higher than the prize to produce fish meal.
The production of animal feed from mussels is currently in a start-up, pilot-scale phase in Sweden and Denmark. The market is basically the same as the market for fish meal, which is international with high demand and raising market prices. In the present scale, the costs for production of animal feed from mussels in Sweden is very high and leave no margin left for the mussel farmer to get any pay for the raw material. In Denmark, Hedeselskabet with an investment loan from Denmark's Green Investment Fund is building up a mussel feed facility in cooperation with existing feed industry. The aim for this project is to lower operation costs to < 0.11 EUR/kg mussel and increase the capacity of 25 ton mussels per hour. If this succeeds, the estimate is that Danish spill mussels could be sold for 0.067 EUR/kg (numbers from *InProFeed* project, 2018). The Swedish estimate of future price for feed mussel, given an up-scaled production, lands on a similar value: 0.071 EUR/kg (numbers from *Pilotprojekt för produktion av musselmjöl*, 2013).

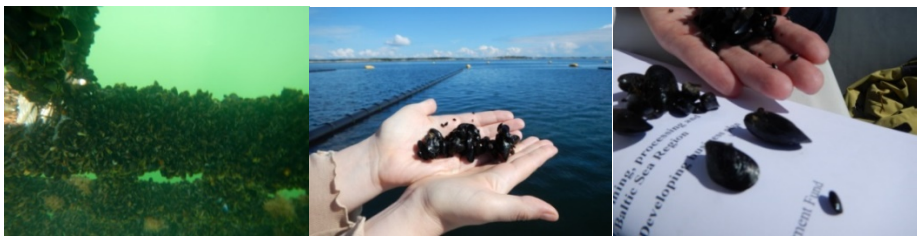

Figure 3 Mussels of the Baltic Sea. Latin name of blue mussel is Mytilus edulis. Size of mussels in the Baltic proper is 1-4 cm

It is expected by market economists that the prize of fish meal will rice with 90% until 2030 (BP by Mariager fjord municipality) due to the expansive world-wide growth of aquaculture. Raising prices on fish meal will open up the market for alternative marine proteins such as mussel meal.

In Sweden today, mussel meal is most interesting as a replacer for fish meal in ecological feed for laying hen, where fish meal as an additive is unpopular and has been under national debate for a long time. Presently 2500 ton/year of fish meal is used for Swedish ecological hen-feed, and 800 ton/year for ecological pigs (numbers from 2012). This equalize 66 000 ton of harvested mussels per year, should all fish-meal be replaced by mussel meal.
Swedish poultry producers have banned the use of fish meal in poultry, and there are no fish feed producers in Sweden today. There is, however, an outspoken interest by ecological poultry producers to start to use mussel meal in poultry food. So this is another potential future market.

To sum up, the Swedish market for fish meal today would equalize at least 66 000 ton of harvested mussels per year. This could be compared to the whole Swedish west coast mussel production of today, around 2000 tons per year (number from 2016). In conclusion, there is enough demand for feed mussels as a product on the national market.

Mussel harvest for nutrient uptake; price, current status and potential

For coastal municipalities and regions, the most interesting potential market is that of nutrient trade. Mussels can be compared to catch crops. They feed on the plankton blooms in coastal waters, clear the water and thus extract excess nutrients caused by human activities on land. According to a recent report by the Baltic Sea Centre at Stockholm University (report 2/2018), N and P content of harvested mussel in percentage of the wet weight is around 0.7-0.8 % N and 0.06 % P on a yearly average. Based on results from the Baltic Blue Growth project, mussels harvested in April-May, which is recommended for the manufacture of mussel meal, contained on average 1,0 % N and 0,10 % P. Good (or moderate) ecological status of coastal water is a very important economic asset for the Swedish east coast. It is critical for the tourist industry, but also for the coastal municipalities to attract inhabitants. There is a public understanding about our economic dependence of the sea. In many juridical cases, the expansion of agriculture, animal farms and manufacture industry is hindered by strict environmental laws. At the same time, increased population in coastal areas put pressure on local production, as well as on existing waste-water treatment. Local and regional permitting authorities struggle with the balance of political interests: On the one hand, food production, economic development and local jobs are necessary to build up the infrastructure, on the other hand we need to protect the environment and implement measures to live up to international agreements, such as of EUs water framework directive and the Baltic Sea Action Plan. For at least 10 years, mussel farms have been suggested by researchers and policy makers as a mitigation tool for eutrophication. Mussel farming has the rare potential to combine economical, ecological and social development. There are several publications available to suggest a prize for nutrient uptake from the Baltic Sea, based on comparisons to the cost for various other nutrient reduction measures. Regardless of the payment model used, the willingness to pay - and hence the prize - for nutrient uptake with mussel farms is likely to be site specific. It will depend on the prize, opportunity and disposal of alternative measures in an area.

The figure below from Dahlgren et al 2015[1] illustrate how the cost to reduce P in EUR/kg for a municipality will rapidly increase as opportunities for cheap measures are used up. The figure also show how and why the cost for a municipality (or it's inhabitants) to fulfil the local nutrient reduction target will be much higher *per kg P* in a populated archipelago, as compared to a mid-sized city. It is due to the rapidly increasing costs for cleaning of wastewater in scattered settlements. *In east coast Sweden, Mussel farms become an interesting option when costs for alternative measures start to exceed 350-500 EUR/kg P.*

According to the latest update of the Baltic Sea Action Plan (from ministerial declaration in Copenhagen, 2013) the needed yearly reduction of nutrient emission to the Baltic Proper is 99 000 tons of nitrogen and 11 000 tons of phosphorous. According to Dahlgren et al 2015[1] every Swedish municipality in the catchment area should reduce the yearly nutrient emission to water with on average 60 kg P and 780 kg N per 1000 inhabitants. For all municipality types in the below

[1] Dahlgren S, Källström N, Lind F, Morin M, Mrozowski T, Seppä T, Wallin M. 2015. Restoring Waters in the Baltic Sea Region. Boston consulting group.

example, the cost to reach the last 60-20% percent of nutrient reduction target will be very high if only land-based measures are used.

In the Swedish east coast, mussel farms for nutrient uptake will likely have the biggest development potential in the archipelago. - given that some kind of public municipality environmental fund system would exist. This conclusion is based on a) experience from the BBG-project that mussel farms have the best production and are most cost efficient in archipelago areas, and b) conclusion that alternative measures will be significantly more expensive per kg reduced P in the archipelago-type municipality as compared to the other municipality archetypes (Fig. 3)

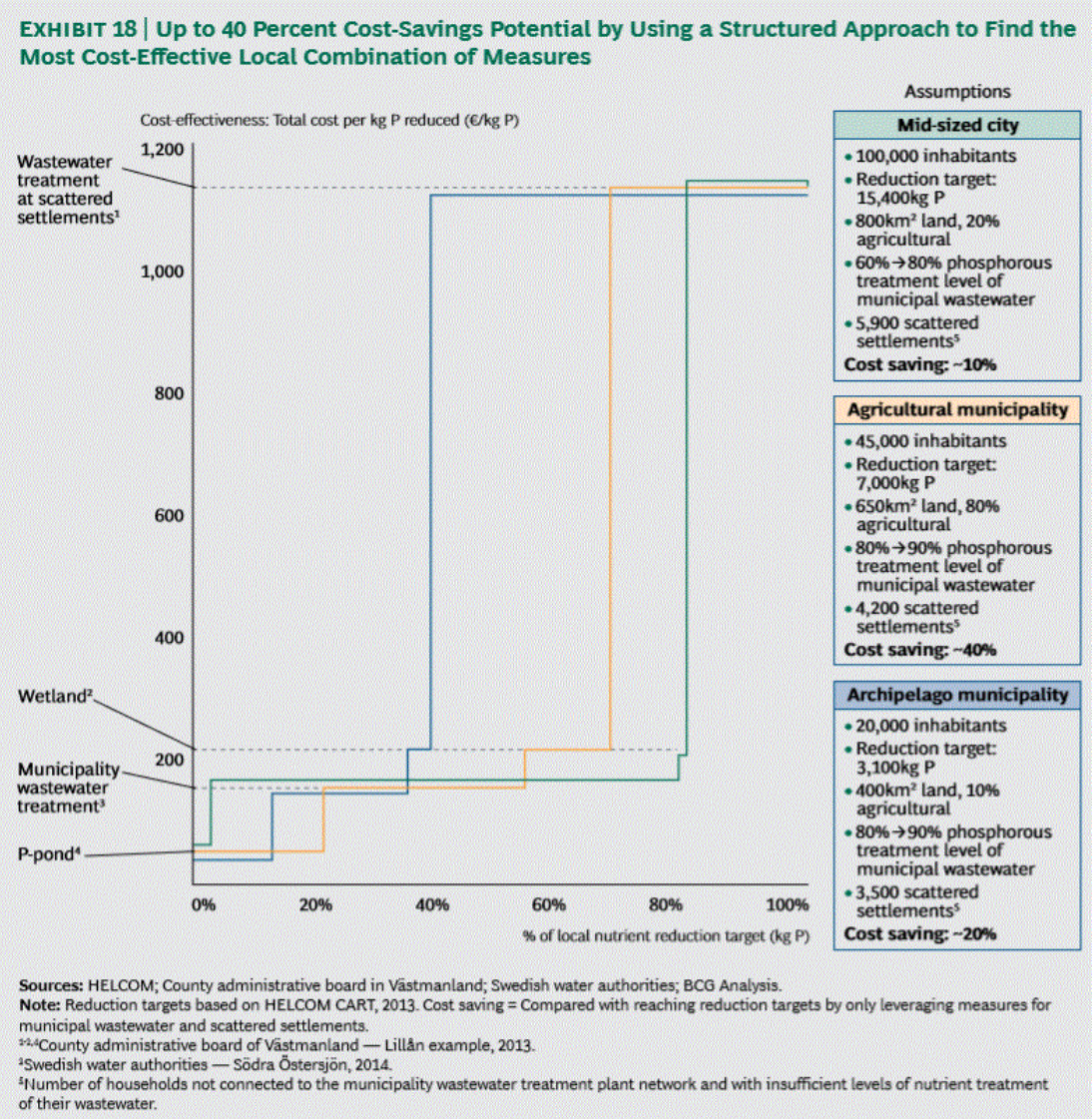

Figure 4 Example costs for some Swedish type-municipalities (or its inhabitants) to fulfil 100 % of the local nutrient reduction target

In the area of the Baltic Proper, there are roughly 12 Swedish municipalities that could qualify as the “archipelago archetype”. No. of inhabitants in these coastal communities vary between 5000-44 000, but is on average close to the archetype of 20 000. From the rough estimate summarized in the report, 60 % of phosphorous outlet in this municipality-type comes from private wastewater units that would need a higher treatment level. The estimated cost to fix such units is more than 1000 EUR/kg P. Today these municipalities together discharge 36 tons more P per year than the system can take, directly into our most economically valuable coastal areas. Even if all thinkable measures that cost less than 200 EUR/kg P were implemented in these archipelago regions, there would still remain a yearly outlet of 22 tons excess P per year.

Based on this theoretical level where mussel farming is cheaper than any other possible phosphorous reduction measure in the Swedish east coast archipelago, the market development potential is **22 000 ton harvested mussels per year**. This corresponds to 550 mussel farms similar to our St. Anna example farm. As an extra bonus, this yearly mussel harvest would also take up 220 ton nitrogen.

There are already today some examples of private and public environmental funds that are willing to pay for nutrient uptake by mussel farms. One example is the crowdfunded Finnish initiative *Nutribute* http://www.nutribute.org/. A Swedish example is an internal environmental fund by Kalmar municipality, that has paid the same amount of money for uptake of nutrients by local mussel farms, 19 EUR/kg N and 290 EUR/kg P as a national study estimated as necessary for future investments in sewage-treatment plants (Olshammar M et al. 2012). The problem with this kind of funds for the financing of mussel farms is their reliability in a longer time-perspective. In order to secure the willingness to pay, one must acknowledge nutrient catch mussel farms in juridical and economic terms. In Sweden today, mussel farms are neither allowed as compensation measures for nutrient polluters, nor as an approved method for public bodies to live up to internationally agreed nutrient reduction targets. Funds are built on voluntary payments, and there are no motivation tools available to expand or secure these initiatives for the future.
Several political proposals on how to introduce nutrient discharge trading systems in Sweden has been discussed, but they have so far deemed as incompatible with Swedish environmental regulation. In recent years however the Swedish government has agreed that trading with nutrient certificates is in line with the international Water Framework Directive.

Internationally in the Baltic Sea Region, only a handful of real-life examples exist where “nutrient credits” from mussel farms have been used. But there is a discussion going on between the Danish municipality Mariagerfjord and the Danish environmental ministry about establishment of large scale, municipality owned mussel farms for a yearly harvest of 2000-2500 ton mussels during a 10 year period. This would correspond to a yearly uptake of 112-170 ton N, or 60-90% of the nutrient reduction target set for their water-area. The investment would be made by local tax money, with the premises that a) mussel farms get the status of a national nutrient reduction method, and b) the nation provides a model for how to acknowledge the nutrient catch from mussel farms.

Legal framework

Regulations for mussel farming

There are 4 types of water areas available for mussel farming in Sweden: Privatly owned, municipality owned, state owned and “common water”. To get access to private, state or municipality owned water, one must arrange a water leasing agreement with the owners. If the site is situated close to the coast, it could be subject to shoreline protection. If this is the case, apply for an exemption from shoreline protection at the local municipality.
If the site is situated in common water, one must write to the Legal, Financial and Administrative Services Agency (Sv. Kammarkollegiet) to apply for access.

A special licence for mussel-farming is needed. This is applied for at the local county board according to Swedish fisheries regulations SFS 1994:1716, SJVFS 2011:34 and FIFS 2011:12.

The mussel farm must be marked with special markers in the water, so called navigation aids (SSA). It also has to be marked in the sea-charts. The use of SSA requires permission from the Swedish transport board, and when the SSAs are in place the coordinates must be sent in to the Swedish maritime service for marking in the sea-charts.

Regulations for feed mussel production

Mussels that are harvested for mussel feed production count as animal by-products (category 3) and must be treated according to EG regulation 1069/2009. Most regulations concern the animal feed production plant, but as a primary producer of feed mussels (i.e. mussel farmer) one must register the business to the Swedish Agricultural Agency and follow the Swedish business guidelines for feed mussels. It is important that the harvest, packing and transport of harvested mussels are documented in ways that secure traceability. When using external logistics, the transport company must be registered for transport of animal by-products.
One week before the start of mussel-harvest, a quality control of 1 kg mussels should be sent for analyses of harmful substances, according to the sampling strategy described in the guidelines. The full list of required substances test is regulated by the EU-limits for harmful substances in feed from aquatic evertebrates (EU-regulations 744/2012, 277/2012 and 574/2012), EU-limits for marine biotoxins in mussels (EU regulation 744/2012, 277/2012 and 574/2012), and with a special addition of check for the cyanobacterial toxins nodularin and microcystin, which is a special concern for the Baltic Proper.

Regulations for nutrient uptake by mussels

As described under marketing strategy, there is currently no legal framework or guidelines in Sweden for how to regulate nutrient uptake by mussel-farms. The Baltic Blue growth project has produced a report “Mussel ESP payment study” with recommendations for policy makers about different models how to develop legal nutrient trading scheme within shared European environmental law.

In the few existing real-life examples from Sweden, were nutrient uptake from mussel farms has been sold, there has been external controllers involved for the checking of harvest weight. The role of the controller has been to secure that the mussels wet-weight is registered properly, with subtracting of the weight from excess water and packing material.

Placement of the mussel farm

In order to achieve a viable business, it is extremely important to choose the best possible site for mussel farming. Apart from the legal issues, there are basically six things to consider: 1. Logistics, 2. Exposure conditions, 3. Harmful substances 4. Biological conditions, 5. Conflicting interests and 6. Conditions special to the Baltic proper.

Special conditions of the Baltic proper: The most determining factor on mussel production in the Baltic proper is salinity. Low salinity has chiefly three effects: The mussels will grow slower, get smaller and also have less strong byssus threads so they will more easier dislodge from the mussels substratum. Different from in the North Sea, mussels in the Baltic proper grow badly in the uppermost 1,5-3 m. Ideally, all growth substrate should be submerged to at least 3m sub-surface and at the same time not touch the sea-floor. Given that the depth of ropes and nets of mussel farms is normally 3-6 m, the water-depth at a chosen farm-site should be at least 9-12m. In most coastal areas of the Baltic proper, you will also need ice-safe buoys.

Logistic issues will largely influence the costs for maintenance and harvest of the farm. In order to save work-time and fuel, the farm site or sites must be situated very close the harbour for the work-vessel/vessels that is used for inspection, putting out buoys, sampling and smaller repairs of the farm. Ideally, the farm site should also be fairly close to a fishing port or some other quay where to larger work vessels have access. The on and off need of larger vessels for launching, anchoring, harvest and/or to do larger repairs of mussel farms, together with access to cranes, trucks etc. for unloading and further transport of harvested mussels can easily raise the costs for mussel farming significantly, if this is not well planned from start.

Exposure conditions. Wave high, under-water currents, wind and winter ice at a site influence both the cost for farm construction, vessels and maintenance, as well as affect the mussel production. In the BBG-project, farming of mussels at off-shore and other exposed sites have proven more expensive and less successful compared to the more protected sites. At exposed sites, you will

need stronger (and thus more expensive) farm constructions. No loose substrates that could tangle, substantial anchoring and larger, more expensive work-vessels. Rough weather conditions limit the number of days it is possible to work to maintain a farm, which clearly increases the risk of damage to farm-units. In addition, strong wave action and currents can dislodge mussels from substratum so that the mussel harvests get lower than what it would have been at a more protected site.

Harmful substances and e-coli. To manage the regulations for feed mussel production, it is important that the environment (water and bottom sediment) at the chosen site is reasonable free from heavy metals and environmental toxins such as PCB and DDT. The Swedish coastal environmental monitoring program uses blue mussels as indicator species for environmental toxins. So with help from the regional county board it is possible to get information about known contaminated sites. These are usually the larger harbors, and present or previous industrial sites. Another problem can be e-coli bacteria outlets from private sewage systems, emergency drains from municipal pump stations, or agricultural ditches. Contact the local municipality and land-owners for more information.

Biological conditions. Food availability, mussel larvae, predators and biofouling are the biological factors of most interest. Mussels feed on microalgae, which depend on the nutrients and temperature. Water exchange and turbidity of the water is also important. Too little water exchange may lead to food shortage, but too high current or storms that stir up clay and other particles will both reduce phytoplankton availability, and make mussels shut down their filtration systems. Areas that lack a wild mussel population should be avoided, a) because this is an indicator of less good conditions for mussel growth, and b) because they might suffer from a lack of planktonic mussel larvae. This could be the case for example for areas that are far from the coast. Marine predators are a less of a problem in the Baltic proper compared to more saline areas. But large flocks of eider ducks paus and feed along their migration route in springtime and autumn, and/or resident eider ducks that are stay and nest can be a big threat to mussel farms in some coastal areas. Biofouling is normally not a problem in an area otherwise suitable for mussel growth, as mussels in general out-compete other organisms settling on the substrate.

Conflicting interests. To increase the possibility to get permit for mussel farming, but also to minimize possible future conflicts with neighbors it is wise to aim for a site not too close to the following activities:Shipping routes, Harbours (buffer 500 m), Anchorage points (buffer 250 m), Bathing places (buffer 250 m), popular play areas for water scooters, waterskis and high speed boats, fishing, underwater cabling and underwater pipes and shoreline protection areas. Natural conservation and other areas of national interest may or may not be in conflict with mussel farming activities. A paper from the Aquabest project “GIS analysis of suitable localities for mussel farms along the county of Kalmar’s coast” (Andersson J, Eriksson A and Olofsson E, 2013) further discuss which Swedish nature- and national interests that are compatible, or in conflict with mussel farming. From the regional planner´s point of view, it is important to have a forward-looking strategy on how to intergrate mussel cultivation with other present and future sea-users. A review paper with international examples for how to do this has been published on the BBG web-page, Overview of existing practice on integrating existing and planned mussels cultivation in Marine Spacial Planning.

The BBG-project has launched a useful tool for the prospective Baltic mussel farmer to find suitable sites for mussel farming. This “Plan your farm”-tool is available at http://www.sea.ee/bbg-odss. This tool gives useful information about mussel growth potential (based on salinity and phytoplankton availability), a hint about oceanographic challenges present in different areas, as well as the degree of fishing and maritime traffic.

Competitors

In our case study example, the market is determined as:

1. Nutrient uptake by use of an environmental fund
2. Mussel for animal feed

On the market for local nutrient uptake, the main competitors of today are the other types of (mainly land-based) potential nutrient reduction measures. Given the ambition of the WFD to compensate nutrient outlets within the same catchment area or water body, it seems unlikely that there will strong international or even regional competition between mussel farms for nutrient uptake. Instead, it will be super-local environmental conditions, alternative possible income sources for the mussel farmer and "willingness to pay" that set limits for this kind of mussel production.

The market for feed mussels is however exposed to competition. This will be discussed further.

Concurrence from the Swedish west coast mussel farmers

In Sweden there are only a small number of active commercial mussel farms. They are all located around the Kattegat in the Swedish west coast, and none of them are in a leading position internationally. There is no Swedish fishery for wild mussels. Size limit for the mussels that can be sold for human consumption is 4 cm, and the sales prize is between 0.7-2.5 EUR/kg.

Harvest of Swedish blue mussels from an international perspective

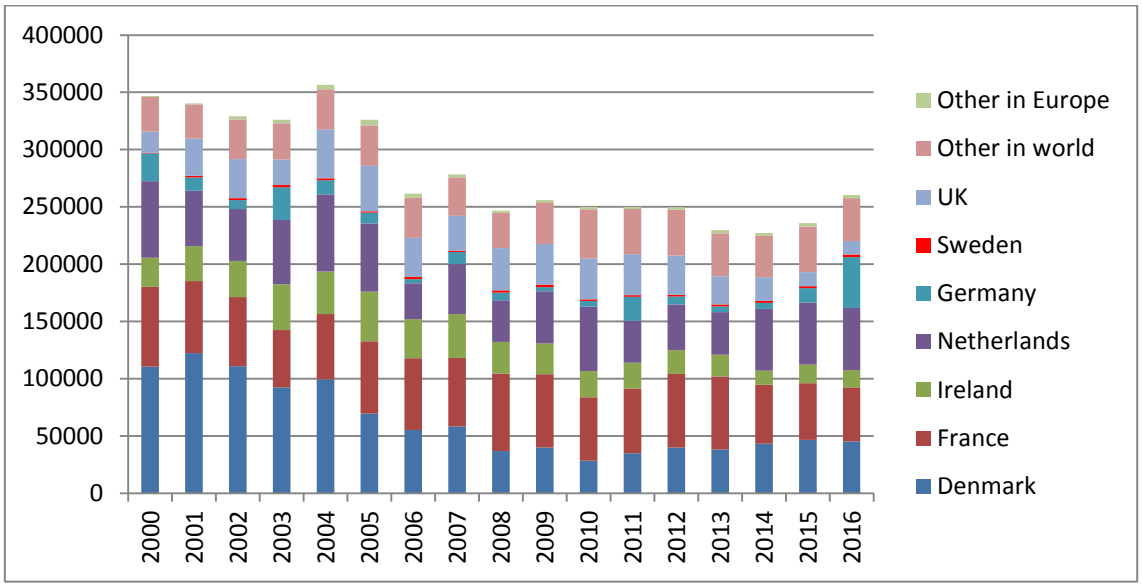

Figure 5; Fishing/harvest of blue mussel in the world 2000-2016 (tons) (FAO, 2019)

Because the aim of west coast mussel production is to produce large mussels, there are no big volumes of small mussels harvested in Sweden today. Mussels smaller than 4 cm are either given away for free as fertilizer to organic farmers, or sold for 0.3 EUR/kg to a fondue factory with the maximum capacity of 10 ton/year. The Swedish mussel meal producer Musselfeed AB take care of some spill mussels, but yet only in the pilot scale. Different from Denmark, it is not allowed for Swedish fish farmers to harvest mussels as a nutrient mitigation tool. If this would change in the future however, <4 cm feed mussels from the Swedish west cost would have lower production costs compared to mussels grown in the Baltic proper and hence be tough competitors in a future Swedish feed-mussel industry.

International competition

During last 60 years the structure of main players has changed several times. The main competitors of blue mussels production (from aquaculture and fishing) are:

- France
- The Netherlands;
- The UK;
- Denmark;
- Canada

Main producers live around the northern part of the Atlantic Ocean. In other areas of the world the market is dominated by other mussel species.

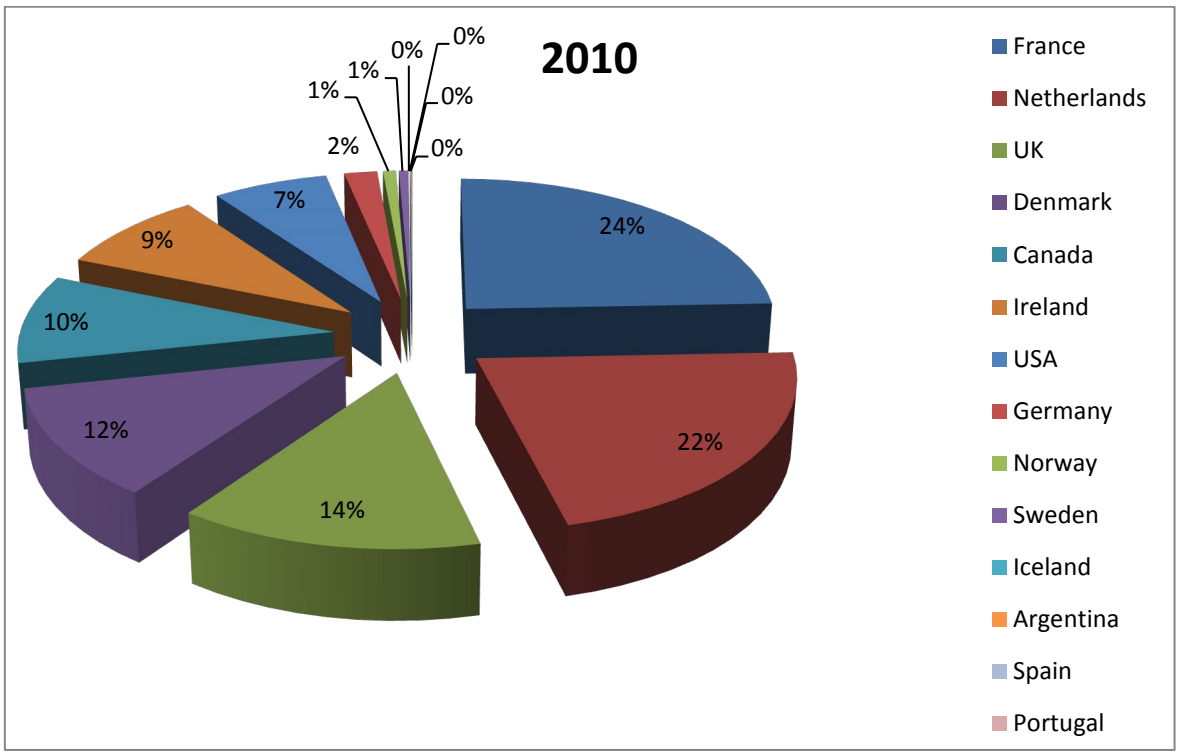

Figure 6; The main market players

Source: *www.fao.org, 2012*

The numbers given above all derive from the industry for human consumption mussels. It is difficult to predict which of these countries that could be interested players also for the production of feed-mussels. Since the market for human consumption is more profitable, feed mussels will likely always be a side-business for nutrient uptake, fish farming or some other main source of income.
From the Swedish East coast farmers' perspective the worst competition will likely come from Danish mussel farmers that could harvest small mussels as a nutrient mitigation tool. But due to the close geography, there might also be opportunity for business cooperation.

To sum up: On a future market for feed mussels there will likely be tough concurrence both nationally and internationally. Sales prize will be determined by a) prize on fish-meal and b) supply of small mussels from more high saline areas than the Baltic proper. It will not be possible for a Baltic mussel farmer to survive with feed mussels as the main source of income.
However, the willingness to pay for nutrient uptake will likely be higher in the Baltic proper as compared to more saline areas. This in because phosphorous is the main limiting nutrient and phosphorous outlets have the worst ecological effect in brackish waters. In more saline areas it is nitrogen that is the main problem, causing the worst eutrophication effects. Phosphorous waste is expensive to clean up and mussel farms may do it more cheaply than industrial methods. In this context, mussel farms for nutrient uptake can have a competitive advantage in the Baltic proper compared to the western Baltic.

Risk evaluation and analysis of technical aspects

A number of significant risks are distributed, which may adversely affect business development and implementation process.

Technological and environmental risk –moderate

- **Weather – very high.**

Ice, strong wind and waves are main enemies for mussel farmers. They might destroy a mussel farm faster than anything else.
The farmer might avoid the occurrence of risk by choosing a somewhat protected farm-site, most appropriate equipment, using other farmer's experience.
The farmers need to improve its experience participating in events, seminars, conferences etc.

- **Predators – high**

In April/May and Sep, large flocks of eider ducks paus and feed along their migration route along east coast Sweden. Resident eider ducks that stay and nest in an area can also be a big threat to mussel farms. There are some methods to keep eider ducks away from mussel farms, of which nets has proven the most effective – but also increase the cost of labour.
The farmer might avoid the occurrence of risk by choosing a farm site where eider ducks are rarely seen by the inhabitants – and not along the main migration routes, which are fairly well known to ornithologists.

- **Technology risk – moderate.**

Even choosing the most expensive equipment might not help the farmer to receive the predicted harvest – because the best practice will be site-specific
Each farmer must pay attention to two aspects:

1. Farming process – the chosen technology should have been proven useful in earlier tests *in similar environmental conditions*
2. Harvesting process –the farmer must have thought through in advance which special equipment and vessel to use, where to land the mussels and overall strategy. Using ad-hoc solutions could be a) very expensive and b) the farmer can lose a lot of the mussels at harvest.

- **Environment risk – low.**

The mussels reduce the net amount of nitrates and phosphorus, makes the water more clear and have generally good effects on the surrounding water quality. A large/high productive mussel farm may have problems with increased sedimentation of nutrient-rich deposits at bottom under the farm, causing anoxic conditions.
The farmer can avoid the risk by choosing a farm site with good water exchange and have adequate space between the production units.

Management risk - moderately low

The company structure is simple and adequate for mussel farming.
Employed personnel will not require special knowledge, however it would be a benefit, if the management team has a salesperson, administrative skills and some knowledge about marine biology, engineering and maritime affairs.
The staff should have an adequate training so that their technical and professional skills are appropriate.

Economic Risk – moderate

Economic risks include the following factors:

- **Industry risk - low**

Mussel farming at the Swedish East coast has very different preconditions compared to today's mussel industry, but will be helped by the new emerging industries like mussels for nutrient catch, mussel feed, mussel fertilizer, production of adhesive materials, new uses of mussel shells etc. that are driven mainly by Danish but also other European interests. On the whole, the mussel industry has potential to develop and grow significantly according to the European Commission regulation and several international documents.

- **Revenue stability risk – very high**

At the Swedish east coast, the market for nutrient uptake by mussel farms is small and unregulated.

The price is set on averagely low level.
Market for mussels to mussel feed is limited due to the small capacity of existing mussel feed plants. Processing price is high and unpredictable.
The revenue stability may have an impact on substitute products entry into the market, customers' financial deterioration, cost increase in raw materials and other factors.
Today around the Baltic Sea the competition is not severe. The companies increase their competence discussing or exchanging information.

- **Customer risk - high**

The company may sell products to several companies, thus the company does not depend on one customer. However, “willingness to pay” for the products may vary depending on legislation, media and customers choice.

- **Supplier risk - low.**

The company will purchase raw materials from a number of suppliers, so they won’t make dependence solely on one supplier.

- **Company size risk - moderately low.**

The company will be big enough in the Baltic Sea region area. The company might influence the market tendency. Sales will be smaller while comparing the companies are farming in more saline water.

Financial risk - high

Financial risk for a new entity is higher than for an existing and viable business one would have.
Many banks or other financiers don't support the fishery industry. The financing depends on the willingness to invest from the private financiers or owner credit history in financial sector.

Political risk – moderate

Risks are associated with the alterations in legislation – future markets for Swedish East coast mussel farmers depend on political decisions.
Several countries suggest tosupport mussel farming as a compensation measure for nutrient mitigation. In this suggestion develops also in Sweden, the mussel farming might attract wider interest of the politicians.

Mussel farming will operate on the moderate risk conditions.

SWOT

Strengths	**Weaknesses**
• Environmentally friendly industry • Low tech farming techniques • Product with high nutritional value ➢ Catch nutrients in water ➢ Increases water transparency	• Mussels are small and grow slowly • Market is small, changeable and low-pay • Mussels cannot be sold for human consumption ➢ Low production efficiency ➢ Mussels are not profitable as a product
Opportunities	**Threats**
• Increasing demand for high value, locally produced eco-products • Feed solutions are developing ➢ New industry in east coast Sweden ➢ Nutrient management tool for municipalities	• Competition with mussels from more saline areas • No pay for the environmental service • Predation by eider ducks ➢ High risk business ➢ The future depend on subsidies and political decisions

St. Anna mussel farm; the business case

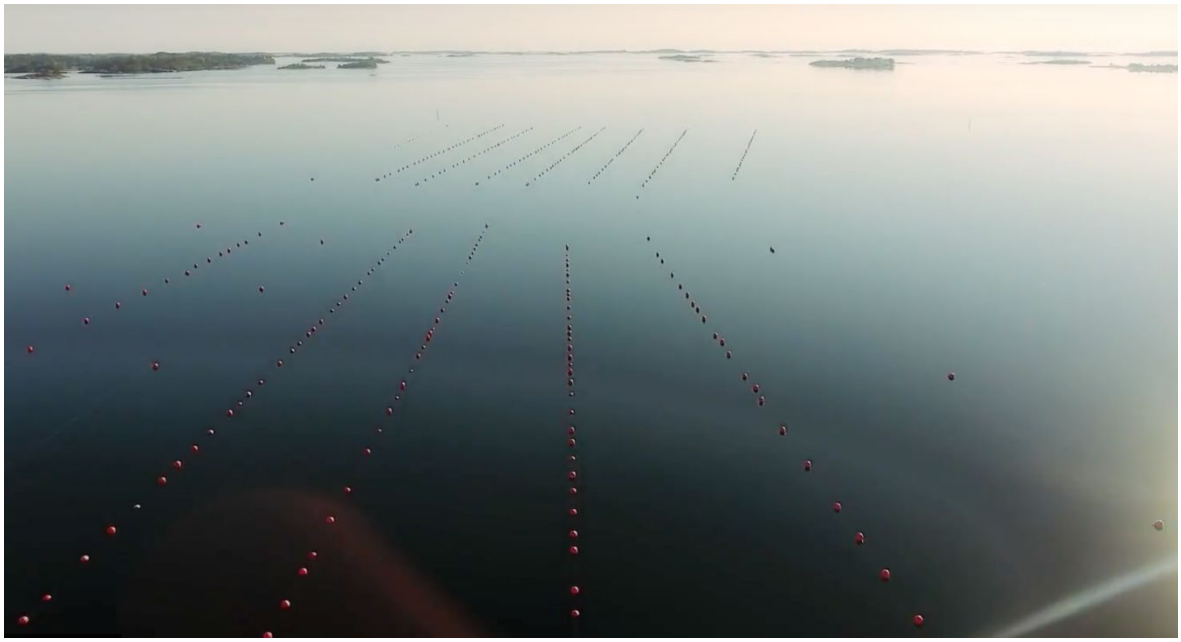

Figure 7. Drone-photo of the example farm in St. Anna archipelago. The farm consists of 16 longlines, each of 150 m length. From each of the longlines 1500 m New Zeeland substrate rope hangs down in continuous loops to 12 m depth.

The mussel farm is located in St.Anna in East Sweden region. Based on the investment costs given in Appendix 1, management costs derived from the BBG-project, and some estimated input values (administration costs, transportation costs etc) given below, our calculation shows that the minimal pay per kg mussel needed to turn our example mussel farm into a viable business is **0.7-1.1 EUR/kg mussel** depending on investment support (50-0 %)

In our count example, the market is determined as:

- Nutrient uptake by use of an environmental fund
- Mussel for animal feed

Based on our project results, each April-May, the mussel farmer harvests 40 000 kg of mussel, which consists of:

	kg
Nitrogen	400
Phosphorus	40

We assume that the production has followed all guidelines necessary for animal feed and that the farm is a registered as a primary producer. We further assume that an up-scaled production plant for mussel meal would exist, on either the Swedish west coast or mid-northern Denmark.

When calculating revenue, we use asales price of raw feed mussels (wet weight) of 0.069 EUR/kg, This is an average of the numbers presented from InProFeed project, 2018 and Pilotprojekt för produktion av musselmjöl, 2013. *It should be stressed that this is ongoing work, and we don't yet know when or if an up-scaled mussel meal production will be reality.*

Feed mussels	Kg/year	EUR/kg	EUR/year
Estimate from Swedish and Danish projects	40 000	0.069	2760

Based on the estimated prize of feed-mussels processed to mussel meal, total yearly revenue from or St. Anna example farm sum up to: **2760 EUR per year**.

In the case study we calculate *the minimal pay for nutrient uptake needed* to turn our example mussel farm into a viable business. Given the 3 different scenarios:

1. Payment only for the nutrient uptake
2. 50% start-up support from EMFF
3. 50% start-up support from EMFF and a payment 0.069 EUR/kg for feed mussels

This means that minimum pay for the nutrient uptake is (EUR/kg):

Scenario:	1. No external funding, no sale	2. 50% investment support, no sale	3. 50% investment support, mussels sold as feed
Nitrogen	50	30	25
Phosphorus	500	360	350
Feed mussels	0	0	0,069

In east coast Sweden P-uptake is prioritized so the willingness to pay for P-uptake is higher than for N. However, the mussels will always take up both N and P.

	kg	EUR/kg	EUR/year
Nitrogen	400	25	10000
Phosphorus	40	350	14000
Feed mussels	40 000	0.069	2760
SUM:			**26760**

Total revenue sum up to: **26760 EUR per year.**

The numbers presented in tables below (Tab. 1-5) is based on scenario 3. The company starts to receive incomes in the second year.

Costs Plan

PRODUCTION COSTS

Production costs include:

- Salaries
- Social tax
- Fuel costs

- Transportation costs
- Material costs
- Fuel costs
- Quality check; EU-limits for harmful substances in feed
- Unexpected; For example temporal rent of a hovercraft

Table 1; Production costs

EUR	Y0	Y1	Y2	Y3	…	Y9
Production costs	**6216**	**12662**	**12662**	**12662**		**12662**
Salaries	3 474	5 760	5 760	5 760		5 760
Social tax	1 092	1 810	1 810	1 810		1 810
Transport costs	669	1338	1338	1338		1338
Material costs	0	1 000	1 000	1 000		1 000
Fuel	981	1 419	1 419	1 419		1 419
Quality check	0	800	800	800		800
Unexpected	0	535	535	535		535

Laboratory analysis should be done testing harvested mussel quality and according the local requirements.

Salaries will be established based on employment.

Social tax was set based on public information on January 2019. In Sweden it is 31.42%.

Transport costs are calculated in 5% in turnover, estimated 0,3-3 EUR/km, distance 500 km.

Unexpected costs are calculated in 2% in turnover.

Profit and Loss Statement

Table 2; Profit and loss statement

	Y0	Y1	Y2	Y3	Y4	Y5	Y6	…	Y9
Turnover	0	26760	26760	26760	26760	26760	26760		26 760
Operational costs	6216	12662	12662	12662	12662	12662	12662		12 662
Administrative costs	0	4 025	4 025	4 025	4 025	4 025	4 025		1 419
EBITDA	-6 216	10 073	10 073	10 073	10 073	10 073	10 073		10 073
Depreciation	3297	13 188	13 188	13 188	13 188	13 188	13 188		13 188
Interest cost	5 593	4 194	2 584	2 158	1 733	1 308	882		61
Other incomes, support from government		6 594	6 594	6 594	6 594	6 594	6 594		6 594
Income tax	0	0	0	0	6	99	193		0
Net profit	-15 105	-715	896	1321	1747	2172	2597		3 418

The first year the company had loss of 15 TEUR, the main cost position are production, administration and interest costs.

ADMINISTRATIVE COSTS

Administrative costs are calculated 4 TEUR starting from Y1.

INTEREST COSTS

Interest costs are calculated based on credit amount and credit payment period. Interest rate is 3,5%. Such rate is higher comparing with banks loan interest rate, and smaller using risk capital.[2]

OTHER INCOMES

Other incomes are calculated for using the EU support and depreciated. It is included in a balance.

INCOME TAX

It is calculated based on tax rate in Sweden (22% in 2019).

Risk analysis

In drawing up financial flows, many factors are taken into account, but for information to be more reliable a number of methods to verify their accuracy are used.

The discount rate value was calculated on CAPM as follows:

R=Rf+B (E-Rf)

Table 3; Calculation of risk rate

Risk	Rate	Information grounds
Risk-free interest rate (Rf)	0.4%	10-year government bond rate[3]
Equity risk Premium	5.96	Damodaran data base[4]
Beta industry	0.72	Damodaran data base[5]
TOTAL	**4,4%**	

Calculating the net present value (NPV) of the project cost-effectiveness of the discount rate 4,4% is used.

Cash flow

Corporate cash flow is divided into three parts - the operating cash flow, cash flow from investing activities and financing cash flow.

ECONOMIC ACTIVITY

Operating cash flow develops from the projected net profit, which is adjusted from depreciation write-offs and from investments in working capital, if necessary.

Depreciation write-offs develop from the planned asset depreciation schedule, as well as the planned new asset depreciation schedule.

In the first operating year, it is necessary to invest in working capital financing; working capital in Y1 is growing, but continues to increase in proportion to turnover changes.

Working capital cycle is 30 days.

INVESTMENT PLAN

[2] http://www.tradingeconomics.com
[3] http://www.investing.com/rates-bonds/sweden-government-bonds?maturity_from=130&maturity_to=290
[4] http://pages.stern.nyu.edu/~adamodar/
[5] http://pages.stern.nyu.edu/~adamodar/

The amount of equipment has been set based on invoices for equipment supplier. In YO mussel farmer should invest 160 T EUR

Based on the investment costs given in Appendix 1, management costs derived from the BBG-project and some estimated input values (administration costs, transportation costs etc), our calculation shows that the minimal pay per kg mussel needed to turn our example mussel farm into a viable business is **1,1 EUR/kg mussel (scenario 1).**

Based on investment calculation a financial plan was set as follows.

FINANCIAL CASH FLOW

Mussel farmer will use financial institutions to cover investment cost.

50% of investment cost will be covered attracting EU fund, and it will be used to cover part of loan in Y1.

Own input capital is set to 40 TEUR in Y0.

CASH FLOW

The projected cash flow shows that in the first 2 years the company will need to closely monitor financial resources and structures, as well as keep track of costs so that they don't exceed the budget. However, by economic activity evolving, the company generates cash flow will be sufficient to allow both to grow and to create earnings potential.

Table 4; Cash flow forecast

	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9
Operating cash flow	-11 808	3 649	7 490	7 915	8 340	8 766	9 191	9 617	9 890	10 012
Net profit	-15 105	-715	896	1 321	1 747	2 172	2 597	3 023	3 296	3 418
Depreciation	3 297	13 188	13 188	13 188	13 188	13 188	13 188	13 188	13 188	13 188
Changes of working capital	0	2 230	0	0	0	0	0	0	0	0
EU support		6 594	6 594	6 594	6 594	6 594	6 594	6 594	6 594	6 594
Investment cash flow	-159 787	-2 400	0	-2 400	-2 400	0	-2 400	-2 400	0	0
Financial cash flow	199 734	0	-12 153	-12 153	-12 153	-12 153	-12 153	-12 153	-3 488	-3 488
Net cash flow	28 138	1 249	-4 663	-6 638	-6 213	-3 387	-5 362	-4 937	6 403	6 525

A company can cover part of loan using the EU support. It will reduce loan amount and reduce interest payment.

BALANCE

Table 5; Balance forecast, TEUR

Prognosis of balance	Y0	Y1	Y2	Y3	Y4	Y5	···	Y8	Y9
Inventory	518	1 055	1 055	1 055	1 055	1 055		1 055	1 055
Receivables	0	2 230	2 230	2 230	2 230	2 230		2 230	2 230
Cash and cash equivalents	28 138	31 787	24 724	20 486	14 273	10 886		6 991	13 515
Current assets	**28 656**	**35 073**	**28 009**	**23 771**	**17 559**	**14 171**		**10 276**	**16 800**

Property, vessel, land	27 359	25 194	25 429	23 264	23 499	21 334		19 639	17 474
Equipment	48 555	43 575	38 595	33 615	28 635	23 655		8 715	3 735
Other equipment	80 577	74 534	68 491	62 449	56 406	50 363		32 235	26 193
Tangible assets	**156 490**	**143 303**	**132 515**	**119 327**	**108 540**	**95 352**		**60 589**	**47 401**
Balance	**185 147**	**178 375**	**160 524**	**143 099**	**126 098**	**109 523**		**70 865**	**64 202**
Current loans		3 488	3 488	3 488	3 488	3 488		3 488	0
Accounts payable	518	1 055	1 055	1 055	1 055	1 055		1 055	1 055
Deferred incomes	0	6 594	6 594	6 594	6 594	6 594		6 594	6 594
Current liabilities	**518**	**11 136**	**11 136**	**11 136**	**11 136**	**11 136**		**11 136**	**7 649**
Loans from credit institutions	27 900	24 413	20 925	17 438	13 950	10 463		0	0
Other loans	131 887	51 994	43 328	34 662	25 997	17 331		0	0
Deferred incomes	0	66 706	60 112	53 518	46 924	40 331		20 549	13 955
Long term liabilities	**159 787**	**143 112**	**124 365**	**105 618**	**86 871**	**68 124**		**20 549**	**13 955**
Fixed capital	39 947	39 947	39 947	39 947	39 947	39 947		39 947	39 947
Previously profit / loss		-15 105	-15 820	-14 924	-13 603	-11 856		-4 064	-768
Current year profit / loss	-15 105	-715	896	1 321	1 747	2 172		3 296	3 418
Total equity	**24 842**	**24 127**	**25 023**	**26 344**	**28 091**	**30 263**		**39 179**	**42 598**
Balance	**185 147**	**178 375**	**160 524**	**143 099**	**126 098**	**109 523**		**70 865**	**64 202**

	Y2	Y3	Y4	Y5	...	Y8	Y9
Asset return	0,17	0,19	0,21	0,24		0,38	0,42
Share of equity	0,16	0,18	0,22	0,28		0,55	0,66
Total liquidity	2,52	2,13	1,58	1,27		0,92	2,20
EBITDA margin	38%	38%	38%	38%		38%	38%
Loans/EBITDA	6,38	5,17	3,97	2,76		0,00	0,00
Share of liabilities	0,84	0,82	0,78	0,72		0,45	0,34
Working capital in days	30	30	30	30		30	30

Project profitability calculation

	Y0	Y1	Y2	Y3	Y4	Y5	...	Y9
Cash flow	28 138	3 649	-7 063	-4 238	-6 213	-3 387		6 525
Discount rate	4,4%							
Business NPV	14 095							

The present value calculation:

- The discounted cash flow resulting from cash flow projections (net cash flow);
- The discount rate is formed from prior estimates of the risk factors;
- The business NPV is the cash flow net present value.

The project value is 14 TEUR, IRR is 3%.

Appendix 1: St. Anna example farm

Investment in equipment

EUR

Work vessel, barge		amount	qty	price	sum
Motor	new		1	6 000	6 000
Crane	new		1	12 500	12 500
Platform	new		3	800	2 400
Deck planks	new		1	5 000	5 000
Rail	new		1	2 000	2 000
Boat					**27 900**

Harvest equipment		amount	qty	price	sum
Harvester	new		1	47 800	47 800
Corner flags	new		4	500	2 000
Harvest equipment					**49 800**

Mussel farm		Qty	Meter	Price	sum
New Zealand rope, 14 mm	32	1	1500	1,2505	60024
Dane line, 28 mm	32	1	5280	1	5280
Anhcor rope, 32mm	32	1	1600	3,12	4992
Silk rope, 8 mm	32	1	3200	0,26	832
Block anchor	32	2		450	28800
Big buoys	32	2		82,1	5254,4
Buoys	32	37		25,2	29836,8
Mussel farm					**135 019**

Establishment; Workhours and fuel - input values

	Work (h)	**Salary (EUR)**	SUM
Work on the farm site before launching of the system 50h	50	18	900
Anchor rope, main line, rope to the buoys	360	18	6 480
Launching of cement blocks	128	18	2 304
Launching of collecting rope	90	18	1 620

	Fuel (l)	**Fuel prize excl. VAT (EUR)**	
Fuel costs, boat and crane	1800	1,25	2 250

Yearly management; Workhours and fuel - input values

	Work (h)	**Salary (EUR)**	**SUM**
Inpection and maintenance	193	18	4455
Harvest	127	18	2724
	Fuel (l)	**Fuel prize excl. VAT (EUR)**	
Inspection and maintenance	785	1.25	981
Harvest	350	1.25	438