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Interreg Baltic Sea Region

Baltic Blue Growth

Examples of two Danish business plans for production of environmental mussels

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1. Introduction

The Baltic Sea experiences a high nutrient load, specifically of nitrogen (N) and phosphorus (P), mainly from the surrounding land. A continuous high nutrient load cause eutrophication, ultimately meaning the perish of many important marine ecosystems, let alone businesses dependent on products from the sea.

Healthy marine environments are a great resource of food and other biomasses. However, for the past few decades, a continuous decline in marine fish species has been detected, especially of the popular edible species, due to overnutrification and overfishing. This phenomenon has induced an explosive increase in aquaculture, mainly consisting of fish farms, to meet the increasingly high demand on seafood products without endangering the conservation of specific species any further. The current, high number of fish farms has alleviated the fishing problem in some areas, where the most fished species are now able to maintain healthy population numbers. EU advocated in a communication in April 2013 for an increased European Fish Farming, and where protein can be found in other animal productions, fish production is the most climate and environmentally effective method. However, the increase in offshore fish farming leads to an increased nutrient load to the marine environment, further enhancing the effects on the marine environment. With a growing demand on marine products, it is important to uphold this increasing production, but with a current and future focus on solutions for accumulating and removing nutrients from the water bodies.

With the EU Water Frame Directive, all EU members have an obligation to work towards *Good Ecological Condition* in all water bodies, including the Baltic Sea. Mussels are efficient nutrient accumulators, and thus, several projects have been put in to motion to test whether cultivation of blue mussels may alleviate the general issue with overnutrification and oxygen depletion in water bodies. Furthermore, Denmark has implemented the Baltic Action Plan in the official ocean strategy, which sets goals for reduction and emission of N and P.

Upholding law associated with the WFD will vary between countries, as it is up to the individual country to form plans that will bring the directive to life within the countries' existing laws. In Denmark, the responsibility lies within the municipality, and it is up to this governmental body to ensure that quotas are kept. If the commune registers a problem with overnutrification of a public water body, they may choose to send forth a tender, which enables different companies to fulfill the task of removing the required amount of nutrients. This is one constellation for achieving the goals from the WFD and Danish water plans. However, all nutrient loading industries are required to minimize nutrient load to water bodies, but are in some cases given an option of compensating for such affairs – in the examples described in this report, mussels are used for nutrient accumulation and removal from fish farming.

In the following, an example of business construction from both scenarios is included, where the municipality example explains the lawful body's search for business creation to meet the WFD goals, and the company forms mussel business simply to allow further production of main product and development.

2. Mariager Fjord – governmental level

2.1 Introduction to project

Mariagerfjord Kommune in Denmark has entered an agreement about a pre-project with the Danish Ministry of Environmental affairs, which dictates that the commune will need to document nitrogen removal by mussel farming. The project aims to reach the environmental goals in the Water Area plan for Mariager Fjord. According to this, the fjord is in need of a total nitrogen removal of 182.4 tons per year.
The Danish Hydraulic Institute (DHI) has made a modelling of the mussel farms effect on the ecosystem in Mariager Fjord. In the model, different scenarios were calculated for mussel farming on five standard longline farms of 250X750 m. The goal was to reach a total nitrogen removal of 100 tons per year. However, the analysis concludes that production of mussels on five standard farms, covering an area of 86.7 ha., will remove a total of 72 tons N and 4.7 tons P per year.

Orbicon has developed a business plan, which analyses the possibilities of establishing and operating five mussel farms in Mariager Fjord. Orbicons' analysis focused on mussel production using SmartFarm technologies, as this method is viewed as more efficient for nutrient removal, which is the main purpose of this project. This method of production, where mussels are farmed on nets under floating pipes, will increase the production per unit. However, SmarFarm, and other pipe systems, are more expensive than traditional longlines, but will include substantial advantages for upscaling the production. Conversely, pipe systems are substantially more visible in the water, creating a possible visual disruption for an areas recreational users. Furthermore, the pipe systems are far more sensitive to ice formation.

The business plan concludes that processing the mussels to mussel feed will create the most profitable value chain, if the produced mussels do not reach full consumption sizes. Thus, the business case describes a value chain in which the mussels are primarily used for animal feed, and therefore represent a source of protein with lower revenue. The production of mussels will need to be conducted by a private operator. It is therefore necessary to establish one or more collaborations between possible operators to ensure mussel production in Mariager Fjord, and the following processing to either food or feed.
This business plan analyses the possibilities for business formation, and problematize the fact that Mariager Fjord currently has no mussel businesses that hold knowledge of the fjord and would be able to establish an operating business.
It is estimated that once a description of an operating business has been made, including products, logistics and finances, possible partners will be more willing to make a risky investment. Thus, the purpose of this business plan is to form a knowledge foundation for creating a private mussel production and processing, so that the private company may function as an operator for the municipality.

2.2 Summary of main points in business plan

The business plan includes the following assessments:

- A business plan for establishing and operating five mussel farms in Mariager fjord. Each farm will be 18.8 ha of size. It is recommended that the mussels be farmed on SmartFarm systems, where all production processes are automatized. A yearly harvest of 20-25 tons of mussels per pipe is expected, with a combined harvest of 2000-2500 tons per year per farm. A total removal of 112-170 tons nitrogen is expected each year.

- The mussels will primarily be used for animal feed production, although a smaller amount is expected to be sold for consumption.
- The five mussel farms will not disturb any ship traffic on the fjord. The Danish
- The five mussel farms will not be in conflict with any known ancient monuments of historic value.
- The five mussel farms will not cause any significant negative impacts on Natura2000 areas (H223, H14, and H222) but may, in some cases, contribute to achieving good ecological status in these. Mussel farming will not adversely affect areas with other nature protection.
- The five mussel farms will not cause significant visual impacts.
- A large global market for mussels is expected as both food and feed. The deposition of mussels from the five mussel farms is thus not expected to be a major challenge in the long term. Extensive development efforts have been initiated with national and international projects in relation to optimizing the use of mussels as a feed product.
- There may be production restrictions in relation to sedimentation of organic material and the presence of heavy metals in the seabed. However, these conditions are not considered to be of a nature that influence the possibilities of producing mussels and use them for feed or food.
- An estimated investment requirement of approximately 61 million DKK, or approx.. € 4,2 million, is needed over a ten-year production period on pipe systems. If using longlines, the investment requirement is slightly lower, at approximately 28 million DKK.
- The project will create eight new jobs in the area, and further jobs in relation to transport, processing and sales of mussels will gradually form.
- For a private operator who establishes and operates the five mussel farms, there will be a total deficit of DKK 12 million over a ten-year period. Thus, an annual loss of DKK -1.2 million. Investments that have not yet been depreciated will continue to exist after 10 years. Of an investment of 61 million DKK, 54 million will be depreciated after a ten-year period. A total annual deficit of DKK 1.9 million. DKK over a 10-year period is thus expected when establishing and operating five compensation farms.
- It is expected that needed funding could be obtained through various state funding, including from the EU, so that the business is made profitable for the operator. There will thus be a need for a payment for the removal of N in the production of 93,000 t of mussels during the ten-year period, corresponding to a minimum of 1.116 t N. The price for the N-removal hereby ends on 17 DKK / kg N for a payment of 1.9 million annually to the operator. Investment loans from Denmark's Green Investment Fund or from Norwegian Export Credit are a possibility.
- The goal of the project is that mussel farming achieves status as a national mitigation tool for nitrogen, and the possible loss associated with production is thus of less importance for the overall goal.
- There are short-term risks related to the marketing of mussels for feed, as no market has yet been established for this product. There are also challenges in relation to port access, as the nearest port, is used for transport of odor-sensitive product. Furthermore, the risk of ice cover, and thus, the impact on mussel production, is an important factor.

2.3 Financial aspects of commune contra business constellation

The contractual basis must partly ensure that the targeted amount of nutrients is removed from the marine area, and partly that economic risks are distributed between the authority and the operator in relation to the uncertainty profile there will be for compensating production in Mariager Fjord.

If the operator who wins the tender either does not want to, or is unable to make their own investment in the establishment of mussel farming in Mariager fjord, a loan agreement between the authority and the operator will have to be concluded, which can be repaid through the duration of the contract.

It is the aim of this project to ensure that some sort of grant scheme is created, meaning a lower risk for businesses starting up in the unknown area for mussel production that is Mariager Fjord. The grant scheme, which will constitute the contract between the operator and the authority, will not be affected neither by the investment of the operator nor by loan scheme.

Orbicon is currently working on creating the best solution for a grant-based contract between the governmental body, Mariagerfjord Kommune, and whichever operator, or operators, end up handling the production in the fjord.

After about a ten-year period, it is believed that the mussel production business in Mariager Fjord will be well established, and the grant-based contract may therefore dissolve. However, if the fjord continues to see nutrient-caused issues, a new contract can be formed.

It is the hope that the project in Mariager Fjord will set the path for future marine mitigation tools and allow grant-based constructions for any future business development involving the production of nutrient accumulating species, such as mussels or seaweed.

3. Musholm Fish Farm – business level

Musholms primary production consists of marine Rainbow trout, and the company produce around 5000 tons on a yearly basis, including a production of 200 t organic trout in a land based facility. Musholms official two environmental permit, given in Denmark to all polluting businesses, dictates a combined, maximum discharge of 115 tons nitrogen and 13.2 tons phosphorus for each calendar year.
Some licenses for marine fish farming include a condition or a possibility for cultivation of mussels with the main purpose of limiting the N and P load from the fish pens. In Denmark, a law on "compensating measures for establishment or enlargement of marine fish farms" was in June 2017, adopted by the Danish Parliament. The law has not yet (Feb. 2019) been completely implemented (statutory order). However, Musholm has utilized this new constellation for two years so far to achieve a permit, which enables a larger production of the primary product – here rainbow trout.

The following is a description from the proposal for the law:

A compensatory marine mitigation tool is not a direct purification of a specific source of pollution, such as a marine water body and is not connected physically to the marine sector itself. The instrument can be located far from the sea farming - only it is located and has an effect in coastal waters or sea areas that marine aquaculture affects by discharge.

3.1 Compensating mussel production

Musholm has a current production capacity, located at *55° 29.110N 11° 06.503E,* of 400 tons blue mussels, on pipe systems. Production of mussels take place over one production season, seven months, whereafter they are harvested before the winter, as the Great Belt is at risk of ice and heavy storms, which may damage the production systems, costing the company a large hit to their yearly revenue. However, at this point the mussels harvested are no larger than 1 cm, making them unsuitable to sell on the standard mussel marked. Furthermore, Musholm has suffered large losses of biomass to eider ducks predating on the mussels. Therefore, the production systems with mussel growth are sent, at Musholms expense, to the Limfjord in Northern Jutland, where cultivation of mussels already takes place in large amounts and conditions are perfect for such businesses.
Table 1 consists of data, collected in another project, where farmed mussels where tested for maximum nutrient accumulation capacity. As shown, smaller mussels have a more efficient nutrient accumulation, where Musholms plan for not selling the mussels and simply using them to expand the given permit, complies with the nutrient removal numbers for smaller mussels.

Table 1 Analysis of nutrient content in mussels of different sizes. Data is taken from project KOMBI in Horsens Fjord 2010-2013

Size group	Shell length	Content (% Wet weight) whole mussels	
		Nitrogen	Phosphorus
Small mussels	1-3,5 cm	1,37%	0,10%
Large mussels	≥4,5 cm	1,06%	0,08%

The results found in project KOMBI are high, and represent the optimum for mussel accumulation. The business plan utilizes an estimate of accumulation ability of 0.9% N wet weight, to visualize a

more reachable target. According to the ruling Danish guideline on aquaculture the maximum discharge N pr. ton fish is 47.5 kg.

In 2017, Musholm produced 360 t mussels, which were used to lower the nutrient load with 3.6 t N, making it possible for the company to comply with the environmental permit of max. 90 t. N. for the western facility. Musholm has not yet reached the full potential of 400 t mussels in their farms.

3.2 Financial aspects of business constellation

Musholm has a yearly turnover of approximately 250 million DKK, mainly from the marine rainbow trout farming.
According to the present environmental license for Musholm V (West) the maximum discharge of N is 90 tons pr. year. It can however be increased by 10 ton N on the condition of utilizing mussel production for compensation.

Currently, the business plan does not include any measures for creating a market for the mussels, and expanding the mussel production to reach full capacity. The sole purpose of the mussel production is to increase the allowed trout production. However, looking at the yearly development in the Danish mussel value (Table 2), a gradual increase is observed.

Table 2 Development in value and prices for mussels sold for food in Denmark

Year	Total weight (tons)	Value (1000 kr.)	DKK per kg.
2017	2.414	11.065	4,58
2016	2.221	10.521	4,74
2015	1.229	-	-
2014	1.810	9.947	5,50
2013	810	6.439	7,95

The 3.6 t N of removal from the mussels equal 76 tons of fish besides the normal production. The average price for trout is 33 kr./kg = € 4.42/kg., adding an additional € 336,112 to the total turnover. The price for trout per kilo varies largely.
With a yearly turnover of approx. € 31.000.000, and a net profit/revenue of € 4,900,000[1], the net profit ends at about 16%.
Additional turnover from 76 t. fish of € 336,112 lands a profit of, with 16%, approx. € 54,000

However, producing mussels may also be a costly affair, and for the targeted production of 400 tons of mussels, the production cost per year is about € 168,000, producing a yearly revenue of approximately € -114,000.
With a rather large deficit from the mussel production, Musholm will need to find a market for the mussel products to be able to profit from it. However, the production of mussels have only taken place for two years and is currently focused on research and development. The production costs are expected to be lowered after the start-up phase is over.

[1] Period: Apr 1 – 2017 to March 31 - 2018

3.3 SWOT Analysis

The following SWOT analysis is based on Musholms current business plan, and does not include any further possibilities. Even though Musholm can see opportunities within the mussel producing industry and with the expanding market, a plan has not been made to include such a production in future business development. The opportunities mentioned in the table below is therefore just a mentioning of scenarios that has become apparent to the company, and does not represent any concrete plans.

Fish production is not included in the S.W.O.T. analysis, which only deals with mussel production as a business.

Table 3 S.W.O.T analysis of Musholms current business in regards to mussel farming.

Strengths	Weaknesses
- N + P removal - Increased trout production	- Not profitable as a product - No apparent use for the mussels, when they are harvested
Opportunities	**Threats**
- The market for marine food products is expanding - Development in feed solutions - Prolonged growth time (2-3 years)	- Predation by eider ducks - Conditions in The Great Belt - Experienced mussel producers, located elsewhere, saturating the market. - Current reputation of aquaculture by politicians and the public

4. Conclusion

There are several ways to construct a valuable business within production of marine proteins, and these business plans offer examples of just a few scenarios. For any new business development, knowing the area selected for production is key. As seen with Musholm, the waters in The Great Belt are simply not very suitable for production of mussels, but is ideal for fish production. For this reason, many companies now strive to legalize general compensation, rather than specific, meaning compensating for nutrient load in any water within the same country, rather than forcing compensation measures in waters, where it is less likely to be neither a profitable business, nor a very efficient mitigation tool. Musholms strategy of moving the mussels to the Limfjord for further growth after one production season makes sense when they are currently located in an area with little potential for mussel farming. Conditions in the Limfjord are ideal for mussel production, and therefore, the company is currently working towards compensation for fish production with mussels exclusively in the Limfjord, to be included in further business models.