

Marine Spatial Planning: The case of aquaculture

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This paper introduces “Marine Spatial Planning, “Blue Growth policy” and the “EU strategy for the Baltic Sea” (EUSBSR) as the measures of the European Union aimed at the sustainable management of the economic potential of the oceans. It discusses how those concepts work and relate to each other. The focus is on one economic sector within the concept of Blue Growth, namely aquaculture. After an overview of what it entails, the paper explains the economic and environmental aspects of the fish and bivalve farms in aquaculture the ecological problems that it involves. The final part of the paper presents an analysis of selected EUSBSR Aquabest guidelines aquaculture projects in the Baltic Sea region.

1 Introduction

Oceans and seas have always had an important ecological relevance. They are home to an immense number of organisms and species in all kinds of varieties. Half of the earth’s oxygen is produced in oceans and it has great capacity for CO2 storage. Besides that, the sheer mass of it leads to its importance in heat transportation all around the world. This makes it an important element for our climate and weather patterns (Vosburgh, 2015; NOAA, 2020).

The economic importance of the oceans has also been growing over the past centuries. Besides fish and other seafood, ingredients from the sea are used in other food products and in medicine. International trade routes are established with marine transportation and marine recreation has been growing in importance in the tourism sector. According to a WWF report made in 2015, our oceans are worth almost 24 trillion euros. And these values do not take everything into account. The energy created by offshore wind farms for example. This value, however, is very dependent on the condition of the ocean. Exploitation of resources, lack of regulations, destruction of ecosystems and climate change all threaten its well-being (Vosburgh 2015; NOAA 2020).

Marine spatial planning, which is commonly defined as an operational tool and Blue Growth, an economical and/or political strategy, tries to optimize the economic use of the ocean while sustaining its environment and biodiver

sity the organisms that live there. It is important to keep in mind that, despite their positive rhetoric, may not necessarily be what is best for the development of the natural sea area. Still it is relevant to explore their goals for both the economy and the environment, the issues and possible solutions for conflicts.

This paper explores the practical implementation of marine spatial planning and its economic and environmental effects by analysing one of the target sectors of marine spatial planning- aquaculture. We end the paper with an analysis of the selected projects within the framework of the EU Strategy for the Baltic Sea (EUSBSR).

2 Methodology

This paper is divided in three sections. The first part gives a brief introduction of the European Union strategy of Marine Spatial Planning, the concepts of Blue Growth and ecosystem-based management. This is based on information compiled from the policy documents of EU countries and scientific publications.

The second section gives an overview of the aquaculture sector and its ecological and economical aspects. In this section about aquaculture we followed the same princi-

ple as in the first section. Texts that promoted the use of aquaculture were compared with scientific papers about its ecological impacts.

Finally, the last section presents a case study of the EU Strategy for the Baltic Sea with a focus on its aquaculture-related projects. It is based on the papers and reports published by the projects' working groups. These publications provide extensive information on the various aspects and outcomes of the implemented experimental measures, which allows to draw the conclusions regarding the effect of such approach on the regional aquaculture and evaluate future opportunities.

3 Marine spatial planning

The sea is not a free, untouched area. Many different economic activities take place there. The sea space is also a valuable natural space. In recent years, new uses have emerged, such as the generation of renewable energies, through offshore wind power plants, the laying of infrastructures (submarine cables, pipelines, etc.), maritime tourism etc. Due to the increasing use of marine space, there are conflicts of use and incompatible overlaps with (inter)national environmental and nature conservation objectives. The task of maritime spatial planning is to regulate and order these uses (cf. ARL 2013).

“Marine spatial planning is a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas as to achieve ecological, economic, and social objectives that are usually specified through a political process” (Ehler & Douvère 2009)

The Marine spatial planning (MSP) is not just a tool to organise the use of marine space and the interactions between the uses, but it also aims to balance the demand for development and with the need to protect

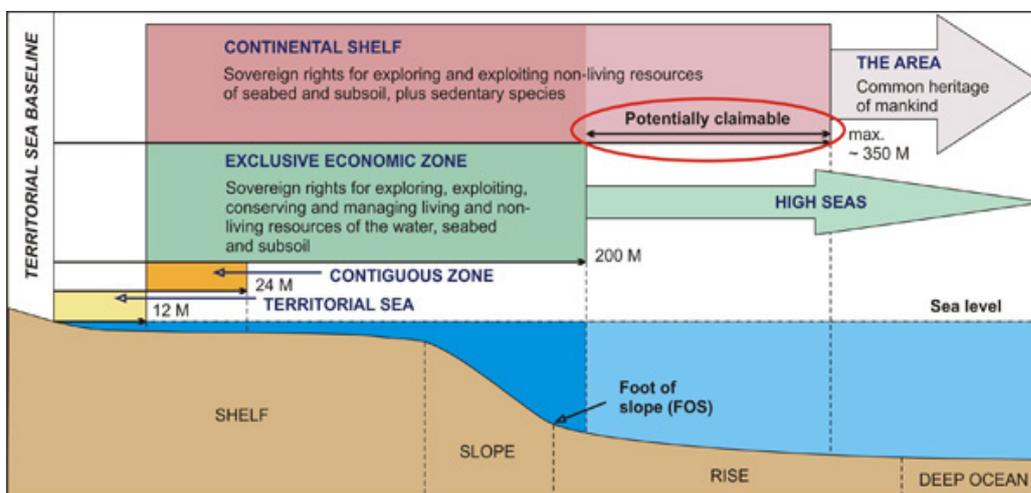
marine ecosystems. MSP can only plan and manage human activities in marine areas, not marine ecosystems or its components. The allocation of human activities in marine areas can be done, designating marine areas for development or preservation, or by specific uses, e.g offshore aquaculture, wind farms, etc. (Ehler & Douvère 2009).

MSP integrates the ecosystem-based management (EBM) approach. EBM is an established paradigm for marine management which may provide the best means to ensure the long-term sustainability of marine ecosystems and the services they provide. The goal of EBM is to consider the entire ecosystem and the cumulative impacts of different sectors, by maintaining productive and resilient conditions. MSP has been long acknowledged to support and implement EBM. The planning process must always take into account the biophysical, human and institutional dimensions of a given ecosystem – its “total ecology” – making the necessary trade-offs to ensure a balance between development and conservation objectives, and therefore allowing for socioeconomic development without compromising the use of resources by future generations. Due to such potential and relevance for marine management and for the development of corresponding policies, MSP has been developed around the world (K. Orbach 2016).

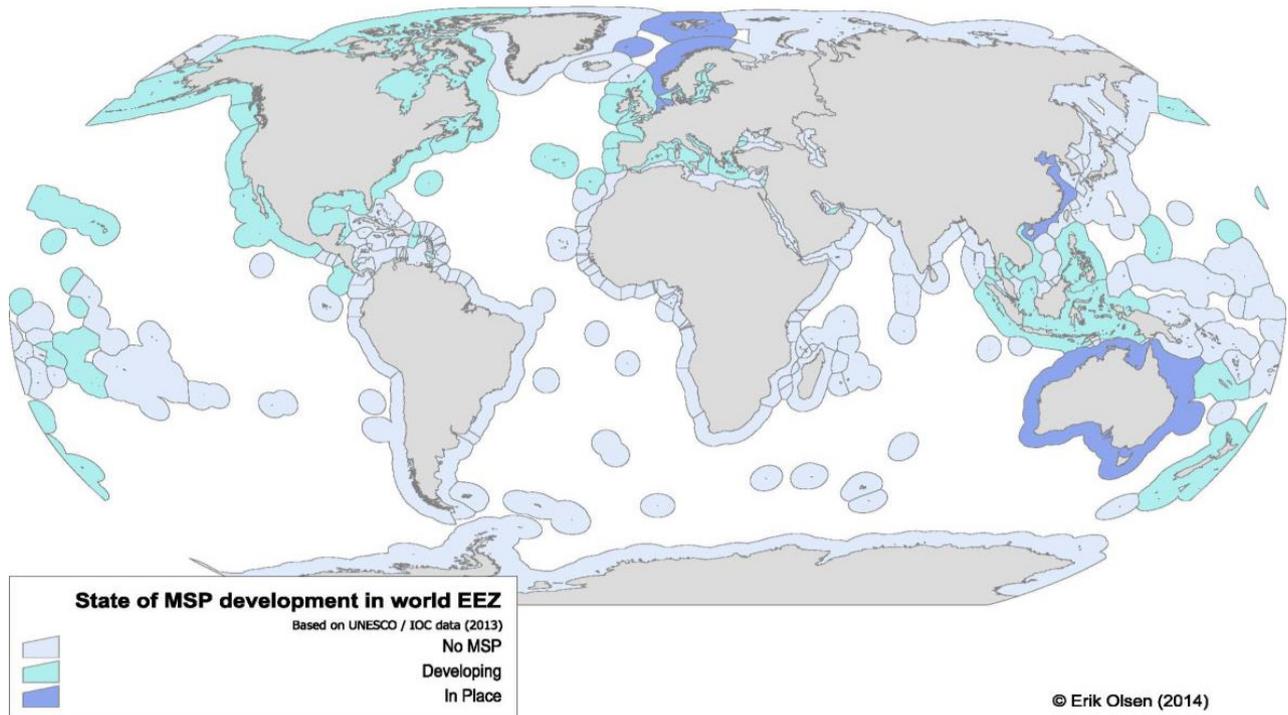
The United Nations Convention on the Law of the Sea (UNCLOS) parcels the sea into different maritime zones. These can be claimed by coastal states. Each zone grants certain rights to the coastal state and carries certain obligations to the foreign states and vessels. These maritime zones have been divided into the following categories: Territorial Waters, Contiguous Zone, Exclusive Economic Zone (EEZ) and High Seas (UNCLOS 1982).

Every State has the right to explore the territorial waters to 12 nautical miles (22.2 km), measured from its so-called baseline. Accordingly, the coastal state has the following sovereign rights over this maritime area. The Contiguous

Illustration 1: UNCLOS maritime zones



Source: Federal Institute for Geosciences and Natural Resources

Illustration 2: Map of marine spatial planning (MSP) development

Source: Eric Olsen, 2014 based on data from the UNESCO

4 Blue Growth and the relation to aquaculture

Zone must not exceed the 24 nautical mile mark (44.4 km). The coastal state can therefore carry out controls to prevent infringements against customs and health regulations. The Exclusive Economic Zone (EEZ) has an extension of 200 nautical miles (370 km). The coastal state has only limited sovereignty, only for exploring, exploiting, conserving and managing the natural resources. The High Seas, which lie beyond 200 nautical miles from shore, are to be open and freely available to everyone, governed by the principle of equal rights for all (UNCLOS 1982; Kastrisios & Tsoulos 2017).

In the last decade the number of countries with MSP initiatives has increased significantly and marine spatial plans have started to be implemented, monitored and revised in fifty countries in the world. Countries, such as Australia, Germany, Belgium, etc. have already implemented MSP, and in a larger number of other countries MSP is under development. Almost 10% of the area of the world's (EEZs) have been approved by governments and it is expected to become more prevalent in the upcoming decade, up to 50% of all EEZs by 2025 (K. Orbach 2016).

The term Blue Growth is used by diverse stakeholders and is defined differently. It embodies different meanings, depending on the contexts that it is used for. It has been referred as, "Blue Green Economy" or "Blue Growth, the new maritime Green Economy (EU, 2011)", "Green Economy in a Blue World (UNEP, 2012)", "Blue Growth (FAO, 2013)" or "Green Growth in Fisheries and Aquaculture (OECD, 2014)" (Ababouch 2015).

In this paper we draw on the definition by the European Commission, which defines Blue Growth as a long term strategy to support sustainable growth in the marine and maritime sectors as a whole. According to the European Commission paper on Maritime Affairs it can contribute to the EU's international competitiveness, resource efficiency, job creation and new sources of growth, at the same time trying to protect the marine environment and its biodiversity, by advocating ways, in order to balance economic growth, social development, food security, and sustainable use of maritime resources (European Commission 2012).

The EU's overall Integrated Maritime Policy (IMP) sets three main objectives, in order to provide a coherent approach to maritime issues: [1] sustainable development of the European maritime economy, [2] protection of the environment and [3] cooperation of all maritime stakeholders across sectors and borders. The IMP pro-

poses among other tools and cross-cutting strategies like the Blue Growth, in order to help and reach the main objectives (Schultz-Zehden 2019).

This strategy has three main components: Firstly, develop sectors that have a high potential for sustainable jobs and growth, that consists of the following economic sectors:

- » aquaculture
- » coastal tourism
- » marine biotechnology
- » ocean energy
- » seabed mining

Secondly, essential components to provide knowledge, legal certainty and security in the blue economy and third, sea basin strategies to ensure tailor-made measures and to foster cooperation between countries, such as: Adriatic and Ionian Seas, Baltic Sea etc.

Based on the (FAO) Food and Agriculture Organisation, blue growth strategy supports the three pillars of sustainable development- economic, environmental and social. These are relevant to the aquaculture sector, because aquaculture affects economic, ecological and social issues (van der Blom 2013: 20f).

However, Blue Growth envisioned as win-win-win, covering economic, ecological, social aspects is considered as a political term by critics. It aims to draw the attention of investors, by presenting maritime space as an attractive, profit-making opportunity, while simultaneously maintaining some form of social legitimacy by promising that these new uses do not undermine sustainability, because they are combined with maritime conservation. In practice, the contradictions in this approach are conspicuous. In his article, Barbesgaard points out that multinational corporations, speculative investors and many others are pushing through a ‘power grab’ to gain control of maritime – ‘blue’ – resources. In his perspective the Blue Growth strategy represents a process of ‘capturing of control by powerful economic actors of crucial decision-making ... including the power to decide how and for what purposes marine resources are used, conserved and managed (Barbesgaard 2018; Brent et al. 2018).

5 Aquaculture

5.1 Overview

Aquaculture can be defined as the culturing of different kinds of fish and plants in a controlled environment. Together with fisheries it is the main source of seafood production. However, it should not be confused with fishing. Whereas fishing is dependent on the natural resources

and circumstances of the sea, aquaculture works in a more regulated setting. This includes that aquaculture farms are owned by certain actors that try to manipulate the zone (Lucas 2015; Bone et al. 2018).

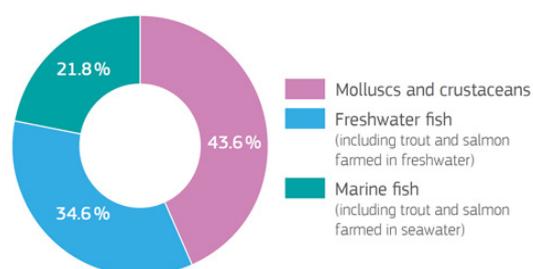
Approximately half of the production of aquaculture is focused on fish. Here we make a difference between freshwater fish and marine fish. Another quarter of the production consists of seaweed. This is used in many beauty products, as well as for cooking in certain Asian countries. The last quarter is then mussels, clams and oysters (bivalves). The exact distribution as it was in 2013 in the EU is shown in figure 5.1. (Lucas 2015).

Modern aquaculture farms follow the whole life process of the fish. The fish are hatched in tanks to create an optimal condition. Sometimes they remain in tanks up until they can be sold, but most of the time they are transferred to an outdoor water source. This is because the fish often need large volumes of water to live in and the natural circumstances (natural light, currents, etc) that the sea brings. Farmers have less control over their fish populations when they are in the sea, but it is cost efficient and can be done on a much larger scale than by cultivating in tanks (Føre et al. 2017).

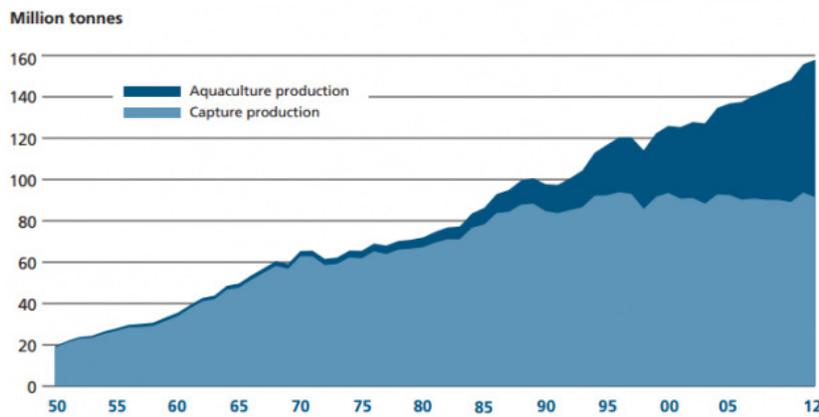
Since the capacity of production by fishing has reached its peak, aquaculture has been growing in importance. This is especially stimulated by Asian and African countries. Western countries, being more concerned with sustainability and environmental issues, are slower in embracing this new development. Figure 5.2 shows the exponential growth of aquaculture and the stabilising of the fishing production up until 2012. By 2018, aquaculture provided half of the seafood meant for human consumption (Lucas 2015; Bon et al. 2018).

With a constantly growing human population, the production demands of aquaculture rise as well. Like every other form of production, aquaculture can have negative effects on the environment and human life. It is important to keep these effects within acceptable limits despite the growing pressure to produce. However, it is not easy to measure these effects, because the aquaculture populations are so big and are both part of the natural ecosystem as outside it (Tsagaraki et al. 2010; Føre et al. 2017).

Illustration 3: EU aquaculture production per product type



Source: EUMOFA & EUROSTAT

Illustration 4: Fish production quantity 1950-2012

Source: FAOSTAT

5.2 Economic importance

Since the beginning of the 21st century, the natural fish stocks worldwide have reached their maximum level of exploitation or are already over-exploited (FAO 2011). This is in conflict with the ever-growing human population. Aquaculture has a lot of potential in providing the necessary seafood production. In 2012 aquaculture alone provided 90 million tonnes of seafood. This production has only grown since then (Lucas 2015).

Aquaculture has a lot of economic advantages compared to other food production sectors. An important one is that it does not rely on freshwater, thus opening up large new territories for production. It is also not dependent on a certain climate, aquaculture can be used all over the world, as long as there is water. Furthermore, fish production is more efficient than livestock. Not only does it not take away living space for humans that they then have to go look for somewhere else, they also have a higher edible body percentage and contain higher protein and lipid levels. They use the energy out of the food that they consume more efficiently. The main reason for this is that they are cold-blooded and thus lose less energy to keep their body temperature up. The higher edible body percentage has to do with the fact that their skeleton consists of mostly small bones, therefore their carbon footprint (kg CO₂ equivalents/kg edible part) is lower than that of livestock. There is however also a backside to this since it can be more work to clean away all the bones (Tsagaraki et al. 2010; Lucas 2015).

Bivalves as well as seaweed are highly energy- and resource-efficient. They do not need to be fed to be cultivated. Bivalves are filter-feeders, which means that they only need clean and unpolluted water that has a certain current. Their best asset however is that they can produce a lot of protein on a small surface: a surface with dimensions of 12x12m can produce two tonnes of mussels per year. Besides that, mussels produce little waste, since only the shells cannot be eaten (Lucas 2015).

Still, it is important to know it must be emphasized, that growth in production in aquaculture will not go on exponentially. When we let the negative consequences of irresponsible aquaculture management cultivate, it is possible that these effects will also impact the fishing livestock we are trying to produce. Even though aquaculture has many advantages, it is still limited in what it can produce in a sustainable way. Different farms are competing for farming areas and want to produce as much as possible; this is often conflicting with other aquaculture farms and other users of the coastal area. In a situation where everyone is driven by individual profit, the seas are not sustained as they should be (Tsagaraki et al. 2010; Bone et al. 2018).

5.3 Ecological issues

The ever-growing aquaculture farms leave their mark on the seas and waters that they use. It is however not always clear how exactly. To start, because water is a moving thing so it can be quite hard to get proper measurements. Secondly, the tests done are often quite different in their methods and goals, so it is not always easy to find one conclusion. Nevertheless, it is agreed upon that the effects are there, even if they are not immediately visible (Sara 2006; Bone et al. 2018; Tsagaraki et al. 2010; Gichana et al. 2017).

The first important aspect is that aquaculture farms take places away from other species. Especially in ecosystems that are already vulnerable they can lead to a loss of habitat for the original population. When fish that are part of an aquaculture farm live in the sea they become part of the existing ecosystem and that cannot happen without consequences because often these fish are invasive and destroy some already existing relations within the system (Bone et al. 2018).

A second problem with aquaculture farms is that the nutrients used to feed the fish are not part of the natural water and lead to poor water quality. Both the food that is not consumed as the body wastes from the fish end up in the water. These wastes then discharge into the natural water system. For every ton of fish (in this case Tilapia) that is cultivated, more than 1000 kg of organic matter flows away into the surrounding waters. These wastes can change the ecological processes in the area in the long run. The problem here is that the prices of decent fish food rise every year. This forces the aquaculture farmers to start using cheaper alternatives that often use more plant ingredients. The fish cannot digest these plant parts as well and thus more waste is created. The wastes, together with the presence of large populations of fish, leads to degradation

of sediments and has effects on underwater plants in the area. Aquaculture often also involves an amplification in diseases and disease transmission because of the big fish populations. The diseases can then possibly spread to other species. This all damages the ecosystem, which gets even more out of balance (Tsagaraki et al. 2010; Bone et al. 2018; Gichana et al. 2017).

Another problem with aquaculture is that it sometimes concerns carnivorous fish. As food for these fish, small other fish are often needed. Aquaculture concerns itself mostly with larger fish that are more in demand for food consumption. This means that the search for food leads once again to the depletion of natural fish reservoirs, undoing some of the advantages that aquaculture has. This is partly because aquaculture is first concerned with the economy and second with the ecology (Tsagaraki et al. 2010).

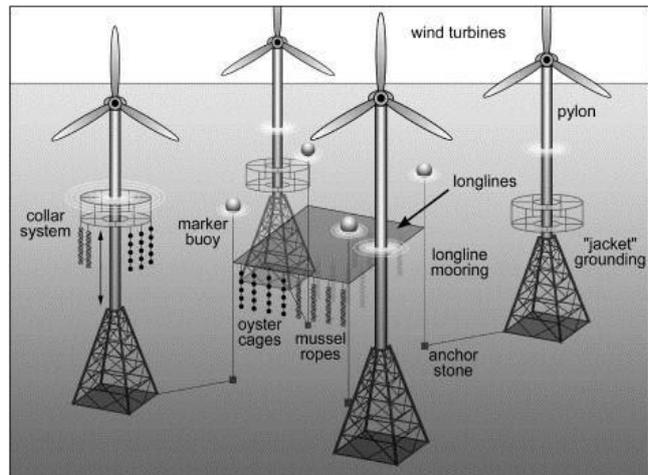
One last thing to note is that aquaculture cannot be seen as a separate business. It is part of a whole network that concerns and affects the whole marine area. The aquaculture farms have to share their waters with fisheries, oil and gas production, and tourism- and shipping infrastructure. They influence each other and the area they operate in (Tsagaraki et al. 2010).

5.4 Possible solutions

Seeing that the effects of aquaculture are not always easy to define, it is quite hard to find solutions for the problems it creates. Still it is generally agreed that it is necessary to see aquaculture as part of a bigger system of coastal zone activities and ecosystems. It influences and is influenced by a lot of other actors that need to be considered. When we look at aquaculture only on farm level, many aspects and effects of it are lost. This of course links to Marine Spatial Planning as described earlier. Regulations on a bigger scale are necessary to keep the negative effects in check (Tsagaraki et al. 2010; Bone et al. 2018).

Besides the idea that aquaculture cannot be seen as a separate sector, there are also a lot of specific solutions. Often the long-term advantages of these solutions have not yet been tested. One such idea is doing aquaculture in offshore wind farms (see Figure 5.3). Here mussel, seaweed and salmon production are placed within the wind farm. The bivalves and seaweed can use the foundations of the farm. With this system, the aquaculture farms can be created off-shore and thus take up less space in an already crowded area. The checking of the wind farms can be done at the same time as the fish farms for efficiency (Yttervik 2015; Buck 2004).

Illustration 5: Multifunctional Offshore-platform



Source: Science Direct

6 Case Study: aquaculture in the Baltic Sea region

6.1 Overview of the region

The choice of the Baltic Sea Region as a case study for this paper is based upon the diversity of its characteristics in terms of environment, economy and geography. The challenges the Baltic Sea has been facing in recent years have made the countries representing the area to start the wide-spread cooperation in terms of solving the arising problems. A range of projects on various levels have been implemented in this lasting process, which represents an informative base for this case study.

Baltic Sea is a small sea on a global scope. However, it is one of the world's largest bodies of brackish water, consisting of the saline water from the Atlantic and North Sea and fresh water flowing from the rivers in the North-eastern part. The low salinity defines the sensitivity of the ecosystem of the Baltic Sea and its inhabitants, uniquely tolerable to such salinity level. The human-induced threats and pressures such as overfishing, eutrophication, habitat destruction, pollution and overall climate change are putting at risk both the ecosystem of the sea and the future provision of the goods and services which it currently offers the nations residing in its area (HELCOM 2018).

The region is represented by nine neighbouring states, Denmark, Germany, Poland, Lithuania, Latvia, Estonia, Russia, Finland and Sweden, making 85 million people in total living in the area. The Baltic Sea provides a tight connection between these countries, being one of the main sources of livelihood throughout the ages. Such high activity in the area exerts a considerable pressure on the

environment which puts the unique natural attributes of the Baltic Sea at risk (HELCOM 2018).

The use of marine waters of the Baltic Sea includes several activities, which profitability is followed by the degradation of the environment. That, in turn, would mean the reduction of the value placed on it. The region is represented by the following types of use of the marine waters:

- » Fish and shellfish harvesting
- » Marine aquaculture
- » Tourism and leisure
- » Offshore wind energy
- » Marine transport

Aquaculture, among others, is an important source of livelihood in the Baltic Sea Region. Aquaculture is a globally growing activity, which is due to the reduced fish catches, being not able to meet increasing demand for seafood. However, in the Baltic Sea region, the aquaculture has been facing a decline throughout the years, despite the high demand for the seafood in the area (AQUABEST 2012).

In response to this problem, the EU Member States of the Baltic Sea region – Sweden, Denmark, Estonia, Finland, Germany, Latvia, Lithuania and Poland, have established a framework for further development of the regional maritime sector called The European Union Strategy for the Baltic Sea Region (EUSBSR). In 2009 the Strategy was approved by the European Council. The Strategy comprises a wide range of policies and consists of a set of intertwining objectives, which represent its main challenges as follows (EUSBSR 2020):

- » Saving the sea
- » Connecting the region
- » Increasing prosperity

The Strategy is carried out in a close cooperation between the European Commission and the involved stakeholders: other EU members, regional and local authorities as well as cross-governmental and non-governmental bodies. The course of action also welcomes the engagement of the non-EU countries neighboring the Baltic Sea Region, which are Norway, Iceland, Russia and Belarus (EUSBSR 2020).

The core of the EUSBSR is the realization of the extensive joint projects, called the Flagships, 150 ongoing and finished as of 2020, which should demonstrate the advance of the Strategy. The Flagship projects are the pilot examples of the desired change in the certain field of action. The aim is to develop the possible solutions, methodologies and networks of cooperation as well as to define the key investments on the regional level (EUSBSR 2020).

The implementation of the Strategy is supported by the

already existing institutions and funding sources, instead of any newly founded, which aims to facilitate the consentience and complementarity between the involved parties on the macro-regional level (EUSBSR 2020).

6.2 The spatial planning approach to the aquaculture in the region

The following part gives an overview of 3 consecutive Flagship projects of the Strategy with their varying methods and procedures and highlights the practice examples of the improvement in the aquaculture sector of the region.

BESTAQ, 2011-2012

The aim of the BESTAQ project was to find the weak spots in the development of the aquaculture and to define the framework, which could promote the methods of sustainable aquaculture and ensure the further growth of the sector. An extensive survey regarding the attitude towards aquaculture in the region as well as opportunities and weaknesses of the industry, has highlighted the fact the problems in the various countries are similar. The project working group has proposed the code of conduct as the possible solution, which would define the development outlines and measures to initiate the required changes. The further step of this work was a preparation of a new project called AQUABEST, which should have been a follow-up to the proposals of the BESTAQ (AQUABEST 2012).

AQUABEST, 2012-2014

Following the trail of BESTAQ, the AQUABEST project had to identify and address the actual flaws of the regional aquaculture industry and propose the respective practical solutions to overcome them. The outlined problems appeared to be the following:

- » Eutrophication due to the reliance of the regional aquaculture on the imported nutrients
- » Lack of spatial planning expertise, which could ensure the offshore development of the aquaculture and reduce the negative environmental impact, conflicts and competition
- » Recirculation farming has not been assessed as feasible in the region
- » Difficulties to adopt the eco-efficient technologies due to current licensing systems in the region

Two counties in Sweden, Jämtland and Kalmar, have been chosen as the experimental sites for the AQUABEST project. The project had to localize 10 suitable spots for the aquaculture farms in each county according to 3 different aspects: geographical, environmental and social. Besides that, the farms productions had to be at least 1000 tons per year. These farms should have become the research base for the case studies on the sustainable development

of the aquaculture in the region and be further incorporated in the planning process led by the municipalities (AQUABEST 2014).

The course of action has been divided into 4 consecutive steps:

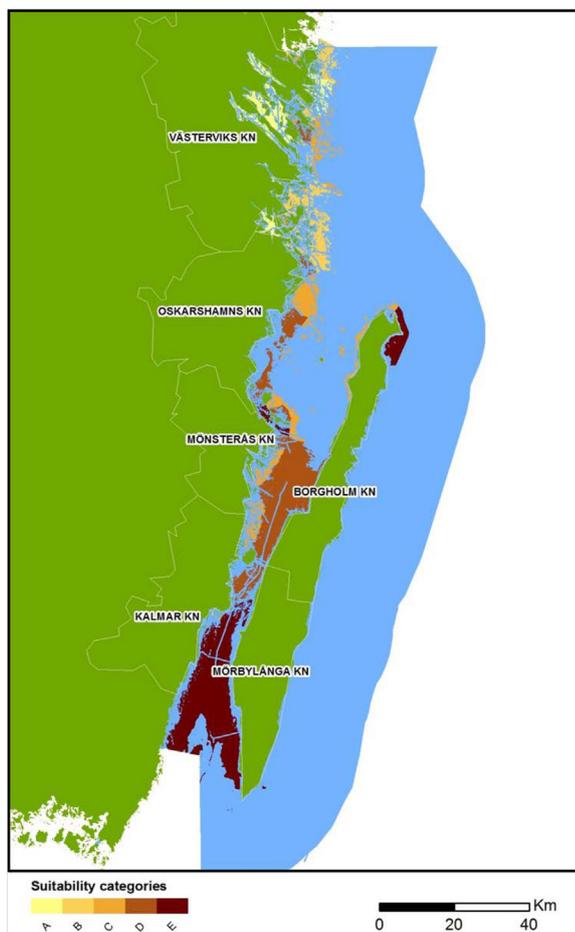
» Establishing a working group

The group has consisted of the representatives of the various organizations involved in the aquaculture sector in Sweden. Its purpose was to gather expertise from the disciplines affecting aquaculture, such as legislation, water management or industrial development.

» GIS Analysis

GIS-tools, namely ArcGIS 10, have been used to perform analysis on the factors important for the placement of aquaculture farms. The models of the possible farming sites have been designed based on the environmental conditions data: salinity, oxygen concentration, chlorophyll concentration, water depth and exchange time. These models had to identify and rank the sites in terms of suitability of each water body for mussel farming.

Illustration 6: Suitability categories for the establishment of mussel farms.

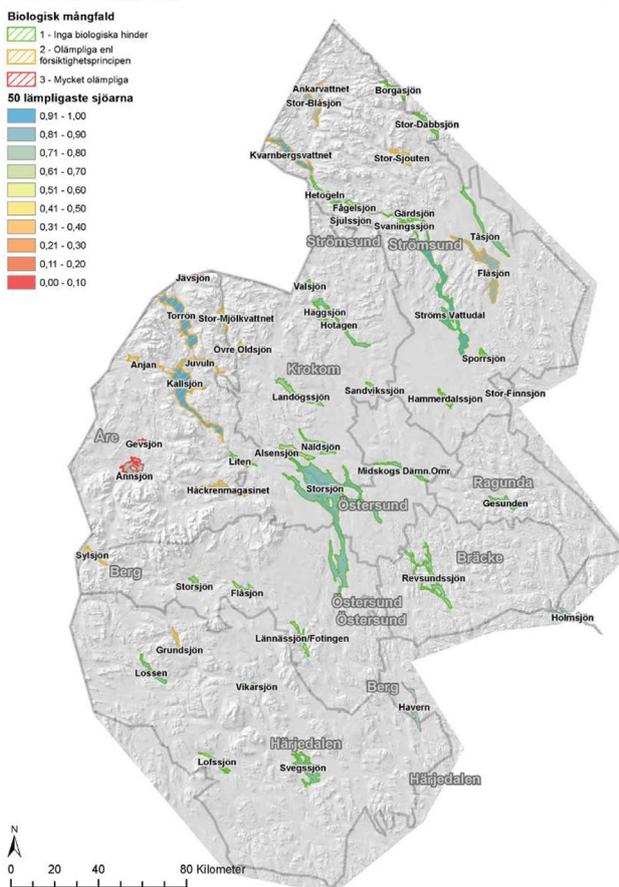


The darker the areas, the greater the suitability, paler areas are less suitable. KN = municipality (Kalmar). Source: AQUABEST

The second step of the analysis has evaluated the locations regarding the possible administrative and physical obstacles to the establishment of aquaculture farms on these sites. A graphic result of the GIS analysis is shown on Figures 6 and 7.

Illustration 7: A map of suitable lakes in the whole region of Jämtland

Underlag för fiskodling i Jämtlands län



Source: AQUABEST

» Stakeholder consultation

This step has been aimed to assess the social acceptance, possible conflicts and business interest towards the aquaculture farms as well as to gather the proposals from the relevant stakeholders. It has been performed in the form of meetings with different organizations, companies, land- and water rights owners.

As a result, 6 localities have been pointed out as advantageous compared to others due to less conflicts in the area. The participants have exchanged their opinions and shared the views on the project proposals, which have further been taken into consideration.

» Environmental space evaluation

During this stage, the results of GIS analysis, namely the chosen areas, have been compared to the on-the-spot evaluation of the actual mussel amount. Remarkably, the

sites with the biggest mussel amount were not the ones pointed by the GIS analysis. That led to the conclusion that the GIS analysis, despite being an effective tool, was still too large-scale and substandard, whereas the consideration of the actual local conditions of a smaller scale is more important for the production capacity of the aquaculture farms (AQUABEST 2014).

The outcome of the project has shown that spatial planning tools and processes, including the social aspect can ensure the environmentally, economically and socially sustainable aquaculture in the region. However, the local conditions of the exact sites should be taken into account. The project has attracted attention to the sector as well as marked the growth opportunities for the sector in the ecologically sustainable framework (AQUABEST 2014).

In 2013, for the purpose of further initiation and implementation of the innovative approach to the marine sector of the Baltic Sea region, EUSBSR has launched a macro-regional Flagship project called SUBMARINER NETWORK. In 2019 the project has issued a research pointing on the mussel farming as the possible solution to the existing environmental problems in the Baltic Sea region.

One of the main environmental pressures in the Baltic Sea is eutrophication – an excess of nutrients in a water body, causing the dense algal bloom which reduces the dissolved oxygen in water and blocks the sunlight. This affects the photosynthesis of the bottom plants and cuts the oxygen supply for the water organisms. Over the course of years Baltic Sea has gathered up a surplus of such substances as phosphorus (P) and nitrogen (N) due to the run-off from land of the large amount of nutrients, which have been applied to the soil in form of artificial fertilizers, detergents or animal food. This led to the nutrient oversupply of the aquatic ecosystem of the Baltic Sea and induced the lasting eutrophication process (Submariner Network 2019).

Despite the land-based nutrient removal measures the nutrient overload in the waters of the Baltic Sea would still

be present for decades. Therefore, it is important to focus on the phosphorus and nitrogen removal directly from the water (Submariner Network 2019).

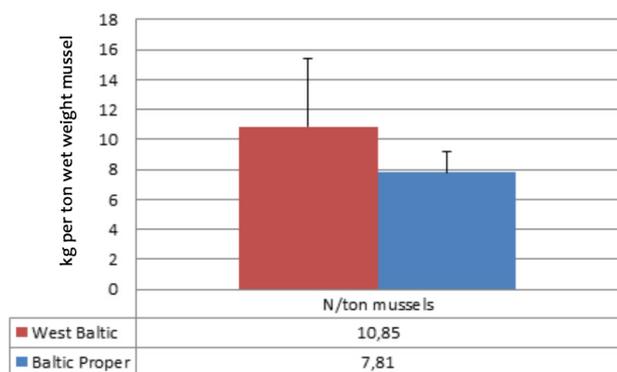
In 2018 the researchers of the Stockholm University have issued a paper, which suggested avoiding mussel farming as the water-based measure against eutrophication. The concern was based upon the uncertainty regarding the production rates, production/harvest cost and nutrient content of the harvest. Besides that, low salinity of water in the Baltic proper has been considered as less suitable for farming than the high-saline water of the Western Baltic and North Sea. Therefore, the research has reported the low efficiency of the mussel farms (Submariner Network 2019).

However, the new data from 2019, which has been gathered in the process of using advanced farming and harvest technology has proven the irrelevance of low or high salinity of the water when it comes to mussel farming. The research reports the mussel farms being a sustainable way to remove the nutrient excess, provided they are placed in the environmentally suitable locations. The figures 8 and 9 show the comparison between the amount of nitrogen and phosphorus uptake in salty waters of the Western Baltic and the low-saline waters in the Eastern part (Submariner Network 2019).

Besides that, the report of the Submariner Network, based on the new data, has shown that production costs and therefore the cost of phosphorus and nitrogen recycling by mussel farming, is on a medium level compared to the land-based measures, yet being as effective and more directed. The cost-efficiency can be optimized even more by collaboration between farmers, for example sharing the harvesting equipment, transport, or processing technologies. Table 1 shows the comparison of the costs of the various counter-eutrophication measures.

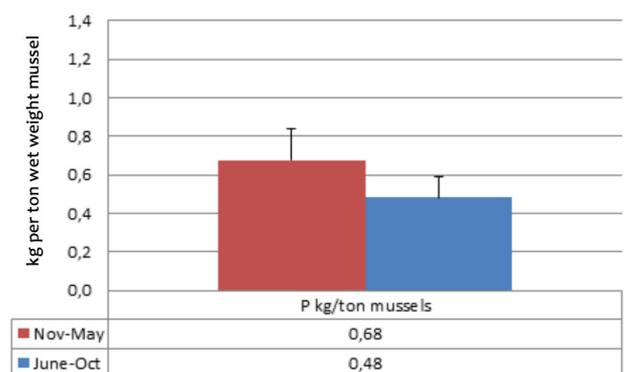
Another positive quality of the farmed mussels is a possibility to use them as a cost-effective raw material for

Illustration 8: Nitrogen uptake per harvested ton (average of all seasons).



Source: SUBMARINER NETWORK (8 & 9)

Illustration 9: Phosphorus uptake per season in the Baltic Proper.



the animal feed production and organic fertilizers. The mussels farmed in the Baltic Sea contain as high nutrient value as soy protein, which is primarily used in the animal breeding industry. Another option of the mussel use is the fish feed. These use possibilities can contribute to the closing of nutrient loop in the Baltic Sea region, which would mean that mussels farmed locally could be used for the other nutrient needs in the regional industries (Submariner Network 2019).

The case study shows that the approach to the aquaculture with modern tools of spatial planning can make it more effective, profitable and socially accepted and have a positive impact on the regional economy. With careful site selection and choice of mussels as a farming product it can also be an effective and cost-efficient addition to the land-based measures to reduce marine eutrophication. With proper volumes of production, mussel farming contributes to the sustainability of the aquaculture in the region, helping to close the regional nutrient loop – another positive aspect of such a case of ecological economics.

7 Conclusion

The main aim of this paper was to analyse the aquaculture sector by taking into account its economic and environmental aspects. An implementation of the Marine Spatial Planning and Blue Growth seems to be a pragmatic solution and it tends to be implemented by many countries. Still its long-term advantages compared to an economic use of the sea without such strategy have not been proven yet.

The evidence of this study indicates that by using multifunctional offshore platforms for both aquaculture and offshore wind farms rather than using separate sites, the economic efficiency for both sectors can be maximized, by reducing maintenance costs. Furthermore, this setup can have a positive effect on reducing the ecological footprint on the maritime areas, due to co-location of these maritime uses.

As mentioned above, the case study has shown that a number of factors, such as selection of the location, selection of mussels as product and its volume, play an important role in the efficiency of aquaculture farms and can have a positive impact on the regional economy. On the ecological aspect, by moving the aquaculture farms in multifunctional offshore-platforms, away from the already crowded coastal areas, avoids potential conflicts over the use of maritime space (such as coastal tourism, maritime transport) as well as potential conflicts over the use of the same resources (for example between recreational and professional fisheries sector).

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References

- Ababouch Lahsen, FAO FIPI (2015), Fisheries and Aquaculture in the Context of Blue Economy.
- AQUABEST (2012), Developing responsible aquaculture in the Baltic Sea Region (CODE OF CONDUCT) on 15.01.2020
- AQUABEST (2014), Spatial planning guidelines for Baltic Sea Region aquaculture
- Bone, J., Clavelle, T., Ferreira, J.G., et al (2018), Best Practices for Aquaculture Management
- Buck, B.H., Krause, G., Rosenthal, H. (2004), Extensive open ocean aquaculture development within wind farms in Germany: the prospect of offshore co-management and legal constraints, *Ocean & Coastal Management*, Vol. 47, pp. 95-122
- Daan W. van der Blom (2013), Aquaculture in Sweden, "Sustainability of land-based recirculation aquaculture as a future alternative for Swedish fish farmers".
- European Commission (2012), Blue Growth: Opportunities for marine and maritime sustainable growth from: <https://ec.europa.eu/maritimeaffairs/sites/maritimeaffairs/files/docs/publications/blue->

- growth_en.pdf on 16.01.2020
- European Commission (2012), Blue Growth: https://ec.europa.eu/maritimeaffairs/policy/blue_growth_en on 16.01.2020
- EUSBSR (2020), from: <https://www.balticsea-region-strategy.eu/about/about> on 15.01.2020
- FAO (2011), Review of the state of world marine fishery resources, Food and Agriculture Organization of the United Nations
- Føre, M., Frank, K., Norton, T., et al (2017), Precision fish farming: A new framework to improve production in aquaculture, *Biosystems Engineering*, Vol. 173, pp.176-193
- Gichana, Z.M., Liti, D., Waidbacher, H., et al (2018), Waste management in recirculating aquaculture system through bacteria dissimilation and plant assimilation, *Aquaculture International*, Vol. 26, pp. 1541-1572
- HELCOM (2018), State of the Baltic Sea – Second HELCOM holistic assessment 2011-2016. Baltic Sea Environment Proceedings.
- Kastrisios, Christos & Tsoulos, Lysandros (2017), Maritime Zones Delimitation- Problems and Solutions.
- Lucas, J. (2015), Quick guide: Aquaculture, *Current Biology* Vol.25, No. 22, pp. 1064- 1065.
- Mads Barbesgaard (2018), Blue growth: savior or ocean grabbing?, *The Journal of Peasant Studies*, 45:1, 130-149, DOI: 10.1080/03066150.2017.1377186
- Michael K. Orbach, Francisco A. L. Andrade (2016), Marine spatial planning in Portugal: an ocean policy analysis.
- NOAA (2020), Why should we care about the ocean?, from <https://oceanservice.noaa.gov/facts/why-care-about-ocean.html> on 07/01/2020
- Olofsson E., Andersson J. (2014), Spatial planning guidelines for Baltic Sea Region aquaculture.
- Sarà, G. (2007), Ecological effects of aquaculture on living and non-living suspended fractions of the water column: A meta-analysis, *Water Research*, Vol. 41, pp. 3187-3200
- Schultz-Zehden A., Weig B., Lukic I. (2019), Maritime Spatial Planning and the EU's Blue Growth Policy: Past, Present and Future Perspectives. In: Zaucha J., Gee K. (eds) *Maritime Spatial Planning*. Palgrave Macmillan, Cham
- Submariner Network (2019), Submariner Network Mussels Working Group, 2019. Mussel farming in the Baltic Sea as an environmental measure. Berlin, Germany
- Tsagaraki, T. M., Petihakis, G., Tsiaras K., et al (2010), Beyond the cage: Ecosystem modelling for impact evaluation in aquaculture, *Ecological Modelling*, Vol. 222, pp. 2512-2523
- Vosburgh, K. (2015), Ocean Assets Valued at \$24 Trillion, but Dwindling Fast, from <https://www.worldwildlife.org/stories/ocean-assets-valued-at-24-trillion-but-dwindling-fast> on 07/01/2020
- Yttervik, R., Olsen, G.P., Ostvik, I., et al (2015), A case study study of multi-use platform: Aquaculture in offshore wind farms, *EWEA Offshore 2015*, Copenhagen
- Zoe Brent, Mads Barbesgaard, Carsten Pedersen (2018), The Illusion of 'Blue Growth' in: <https://www.tni.org/en/article/the-illusion-of-blue-growth> on 08.01.2020