

MUSSEL FARMING AND ITS POTENTIAL IN THE BALTIC SEA

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Abstract. The paper covers research findings on mussel farming and the analysis of current situation in mussel farming in the Baltic Sea. The mussel farming has a development potential in the Baltic Sea region. Some developers have chosen progressive activities to achieve the aim. For example, in Sweden the development of mussel farming is suggested as one of the instruments for reducing eutrophication. Several countries in the Baltic Sea region are in the beginning phase of the mariculture development. The following research methods were used in the research: studies of scientific publications, case studies and document studies on some important factors impeding the development of mussel farming in the Baltic Sea.

Keywords: *Aquaculture potential, marketing, mussel farming.*

INTRODUCTION

Blue mussel shells have been found in kitchen middens dated as far back as 6000 years ago. Until the 19th century, in most European countries blue mussels were harvested from wild beds for food, fish bait and fertilizer (Gouletquer, 2014).

Latin name of blue mussel is *Mytilus edulis*. This species occupies the North Atlantic and the North Pacific coasts, and lives also in the Baltic Sea. The size of mussels varies up to 10 cm, the largest specimens may reach up to 20 cm (Tyler-Walters & Seed, 2006).

Mussel cultivation in the Baltic Sea is not widespread. The locals focus on using mussels for human consumption, whereas in the last few years the first small-scale pilot plants have been established for the abatement of eutrophication in other areas of the Baltic Sea. The knowledge about the impacts of mussel farming on the ecosystem of the Baltic Sea and the influences on socio-economy is limited; experience from other mussel farming areas in northern Europe might be partly used. A lot of academic research has been performed and scientific publications developed world-wide on best approaches in mussel farming and on marketing tools; different aspects are analysed and discussed. Deep analysis of perceived opportunities and pursued strategies in an emerging industry has been done in the case of Norwegian Blue Mussel farming (Ottesen & Grønhaug, 2004). Analysis of mussel farmers' perceived risks and development and application of risk management strategies in the emerging mussel aquaculture industry in Denmark was performed and published by researchers Ahsan and Roth (2010). The results of extensive socio-economic analysis and aspects of stakeholder involvement in mussel-farming in the Gulf of Trieste are published in scientific paper and discussed

in academic environment (Canu & Solidoro, 2014). Aspects of production and consumption of oysters and mussels in France are analysed within the European market paying special attention to the realisation of produced oysters and mussels (Girard & Mariojouis, 2003). Results of academic investigations on history, experience and findings of production and marketing trends of the cultured Mediterranean mussel in Greece are discussed in scientific publications by Theodorou *et al.* (2011).

In the Eastern Baltic Sea countries there are many small fishermen but almost none is related to the business of blue mussels. In the Western Baltic Sea mussel farmers have had business for a longer period of time but some of them are newcomers. Blue mussel processing as a business is in a pilot-project phase and it is a challenge for local fishermen.

1. PLACE OF FISH FARMING AND MUSSEL FARMING IN ECONOMY

Agriculture has significant influence on people's life and is responsible for food provision in the world. Today a number of people are still suffering from hunger (Food and Agriculture organization of the United Nations, 2011). Due to this reason the importance of agriculture increases.

According to the information from the Food and Agriculture organization of the United Nations (FAO), in developing countries the livelihood of over 500 million people directly or indirectly depends on fisheries and aquaculture. Due to several reasons, such as the willingness to increase one's own welfare, the overfishing increases and fish stocks are decreasing (FAO, 2012).

Notwithstanding the agriculture sector does not include such areas as fishery and forestry, these sectors are highly important in overall food providing industries.

Gross domestic product (GDP) is the market value of all officially recognized final goods and services produced within a country in a given period (Wierzbicki *et al.*, 2016).

To examine the increase of volume the gross domestic product (GDP) and fishery sectors were analysed.

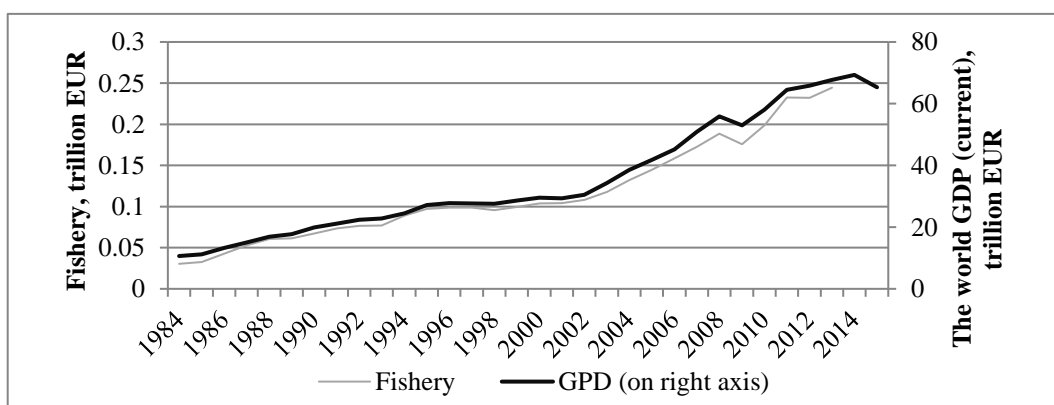


Fig. 1. World GDP from 1984–2015 and fishery trade and production from 1984–2013), (Developed by author; World Bank (GDP) data, 2016; FAO data, 2017).

Analyses of the world GDP and fishery shows that the tendency of growth is relatively very similar. From 2003 to 2009, the amount of both positions increased by 10 % per year which was a sharp increase. In 2009, GDP decreased by 5 % and in 2015 by 6 %.

Fisheries production and trade increased by 8 % every year. In 2009, fishery decreased by 7 %. The increase of fisheries trade and production has been faster than 1 % of GDP within last 5 years.

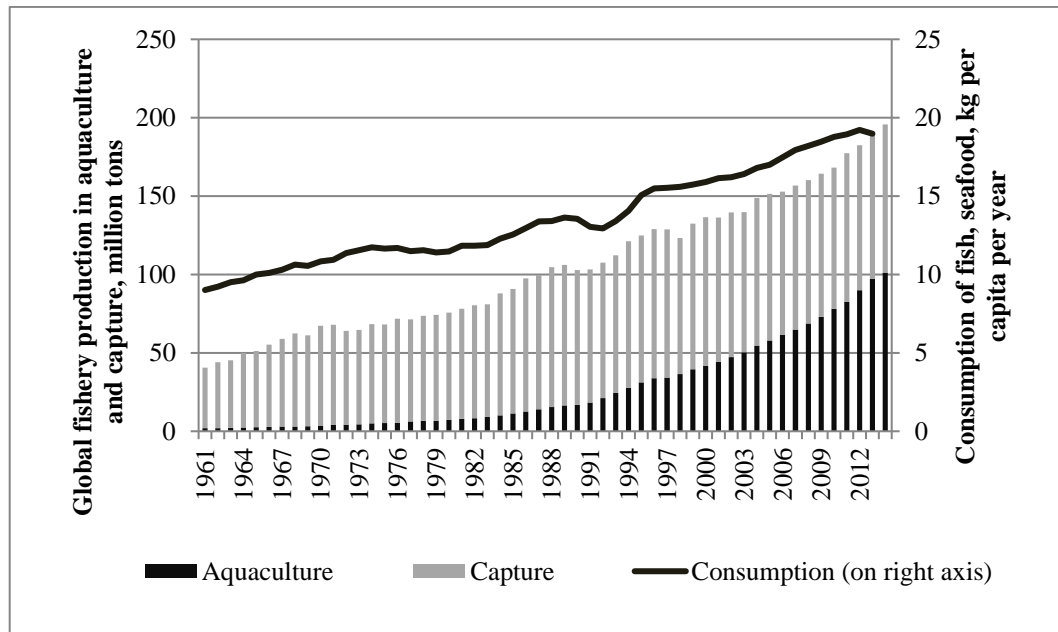


Fig. 2. Global fishery production, 1961–2014. (Developed by author; FAO data, 2017).

Figure 2 includes the volume indices of use of fishery for commercial, industrial, recreational and subsistence needs. The harvest from mariculture, aquaculture and other kinds of fish farming is also included.

During the last 60 years fishery production has increased multiple times. The tendency of fishery increase has a linear input.

In these 60 years, the average annual increase of fisheries capture production reached 3.8 %, but in last 10 years the average annual increase was comparatively lower – 2.2 % per year.

During the last 20 years the amount of capture remained at the same level, but overall it increased by 5 times. The highest increase within these 20 years was in 1994 – by 6 %, in 1999 – by 7 %, and in 2004 and 2011 by 5 %. The decrease was in 1998 – by 8%, in 2001, 2003, 2006 and 2012 – by 3 %, and in 2010 – by 1 %.

During the last 20 years the amount of aquaculture had increased by 7 % yearly.

In 1992, 1993 and 1994, the amount of aquaculture had increased by 15 % per year, while in next periods the growth rate of aquaculture was lower.

In 2000, average consumption of fish food was 15.8 kg per capita per year, and in 2011 it reached 18.9 kg per capita per year.

During the last 10 years the consumption of fish and seafood yearly increased by 2 % and this increase has a linear tendency.

The increase of the volume (in tons) of global fishery production was smaller than the increase in euros. In order to analyse the volume of production of blue mussel, the overall volume of mussel production will be analysed.

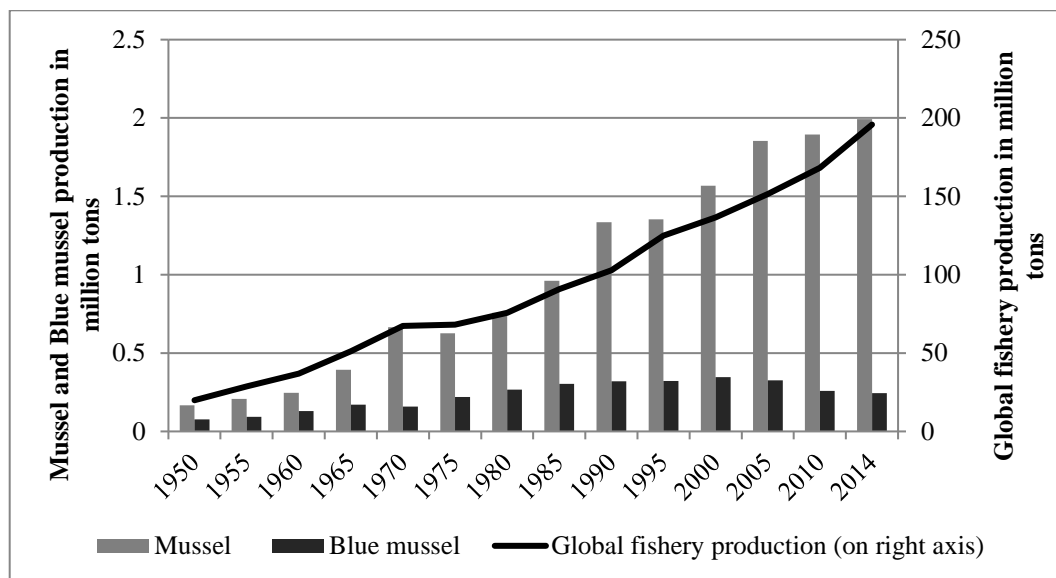


Fig. 3. Fishery and mussel production in the world in 1950–2014 (Developed by author; FAO data, 2017).

The production volume of fishery and mussels has increased progressively since the beginning of 90s. But the production volume of blue mussels has not significantly increased and the decrease tendency of the production volume has been observed every 2–3 years up to 2006.

In the last 10 years the total volume of blue mussel production decreased by 3.5 % per year, while the volume of mussel production increases by 1 % per year.

If the tendency repeats, it is possible to forecast the decline of mussel production. More notable decline of the blue mussel production repeats every 15 years, the last one was observed in 2006 and also in 2008.

In the last 3 years the amount of blue mussels decreased. One of the factors influencing the volumes was storms.

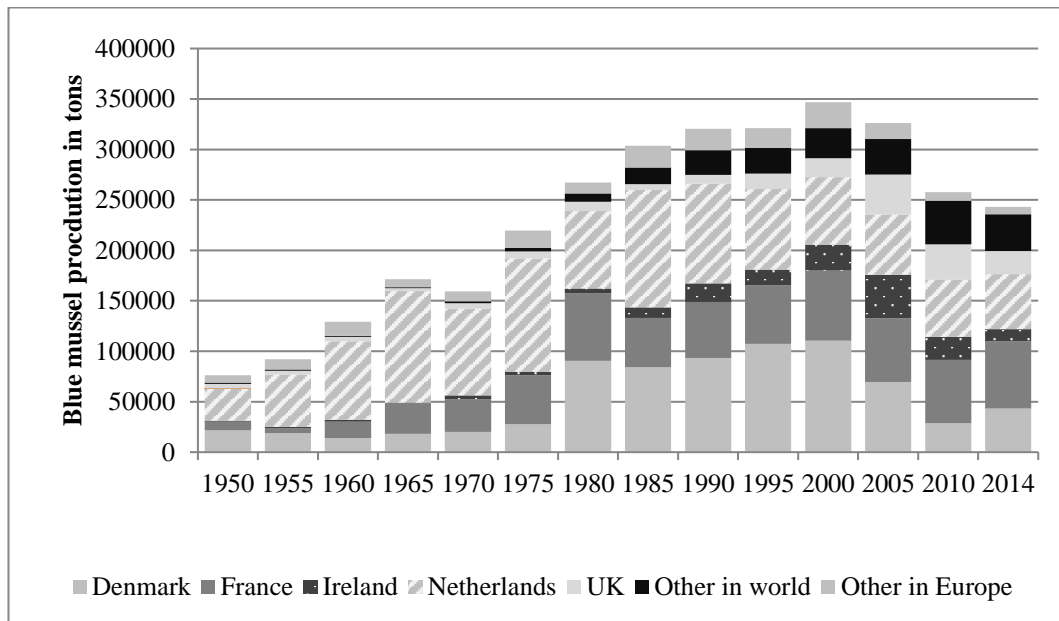


Fig. 4. Fishing of blue mussel in the world in 1950–2014 in tons (Developed by author; FAO data, 2017).

During the last 60 years the structure of main players has changed several times. In the 1950s the main players in the sector were in the Netherlands, but in the 2000s they were in France and Denmark. In 2014, blue mussel fishing took place mainly in Denmark, France, the Netherlands, Canada, the UK and Ireland.

Within the last 3 years, Denmark lost its leading position and has remained only in the 3rd place. In 2010, the Danes farmed blue mussel more than 3.5 times less than in 2000 (in numbers –110 618 tons).

2. RESTRICTING FACTORS IN LATVIA

2.1. Research Output

The research on mussels has been carried out in several projects (see Table 1).

The research has not been carried out in BONUS and within the 7th Framework Programme (CORDIS, 2016).

The estimated costs of the research on mussel farming constitute 200 thousand euros.

Though there has been historical experience in pearl fishing in the 18th century in Latvia (Rudzīte & Rudzītis, 2007) it cannot be compared with mussel farming.

To create a pilot mussel farm in the Baltic Sea or in the Gulf of Riga and to carry out research, Latvian Institute of Aquatic Ecology has made provisional calculations; the amount of potential investment estimates approximately 100–500 thousand euros.

Table 1. Research Projects on Mussel Farming in Latvia until 2015

Project	Program	Amount of funding, thousand euro	Project partner in Latvia	Amount of funding per partner thousand euro
SUBMARINER (Baltic Sea Program, 2013)	The Baltic Sea Region	3581	Environmental Development Association	120
			Ministry of Environmental Protection and Regional Development	156
AQUABEST (Baltic Sea Program, 2013)	The Baltic Sea Region	3745	Institute of Food Safety, Animal Health and Environment – "BIOR"	36
Baltic EcoMussel (Central Baltic INTERREG IV A Programme, 2013)	The Central Baltic Program	723	Latvian Environmental Investment Fund	104
			Kurzeme planning region	83

Mussel farm potential can be determined by establishing a proper pilot project in the Baltic Sea or in the Gulf of Riga and it should be carried out in 24 months.

During the study, it is important to involve competent industry specialists from foreign countries, such as Denmark, Canada, France, and the Netherlands etc.

After successful implementation of the project, it will be possible to define the possibilities of industry development.

During the research it is important to assess not only biological, environmental and technical aspects but also to analyse the available information based on economic and financial aspects.

For a long time Sweden has participated as a partner in mussel farming projects. The studies carried out on mussel farming in total amount to more than 20 million euros, part of the amount covers other industries, like algae, etc.

2.2. Legislation

In Latvia it is necessary to amend the existing legislation to start business in the Baltic Sea (Lancmane, 2013). There is legal basis for economic activities in aquaculture in inland water but mariculture is generally regulated.

It is suggested to introduce a licensing process for potential farming developers. There are different opinions of different institutions about the permissions to be obtained by the potential farming developers.

While evaluating the terminology, it was stated that mussel farming and harvesting can be interpreted differently, e.g. mussel is a wild or aquaculture animal (Lancmane, 2013). There are different viewpoints regarding the use of the end product of farming – mussel.

Mussel farming reduces eutrophication in water (Lindhahl *et al.*, 2005; Gren, Lindhahl & Lindqvist, 2009; Stadmark & Conley, 2011). This factor might be a cause for future pollution quotas of allocation to the countries considered. Thus, it is important to understand Latvia's starting position and the instruments, which might help to reduce the pollution in the Baltic Sea, as well as the factors, which could prevent pollution.

2.3. Outlets and End-user Market

Before starting a business it is important to identify the end-user market, technologies used in farming and harvesting, and prices. Generally these factors affect the amount and production costs of the farming.

Seafood market recognizes the relative short term production shortage or excess by increasing the price when there is shortage and decreasing it during overproduction (Rodriguez, Villasante & Garcia-Negro, 2011).

The opportunities in expansion of new market and sales, e.g. selling mussels for biotech companies, may increase mussel production volumes, as well as change the market price. New market can occur if the authorities promote research projects to discover new possibilities.

Sometimes, based on current legislation, the industry might not develop because there are restrictions to the distribution of product in the country of interest. Thus, it is important to determine markets and to evaluate current legislation to avoid restrictions.

2.4. Tourism and Leisure Activities

Mutual cooperation and understanding is an essential component among the various sectors.

Notwithstanding the appearance of a farm might be unpleasant to tourist's eye, the mussel farm makes the environment cleaner. To promote the public awareness of the new sector, public information activities should be organised, thus decreasing the public scepticism and doubt. At the same time, as stated by some fishermen and mussel farmers, sometimes tourists can be pro-active and they make their own check to look what there is in the nets, ropes. However, their actions are not always good and sometimes it may cause damage to farms, for example, they become entangled in ropes and nets, regardless the fact that the place is marked by buoys, or they may use sharp objects and cut nets.

2.5. Methods of Growing

National authorities are allowed and may control the method used for mussel farming, e.g. dredging method is not allowed in some countries. This method is cost-effective if compared to other methods, however, in harvesting process it is possible to exhaust the whole mussel bed, thereby potentially reducing the amount of mussels in the Baltic Sea. At the same time, in Denmark (International Council for the Exploration of the Sea, 2009; Madina, 2014), this method is not prohibited, and a number of companies obtained mussel by dredging from the seabed. These companies have also been certified by the Marine Stewardship Council.

2.6. Local Employment

In order to develop and enhance regional competitiveness and income levels, mussel farming can act as additional source of income for coastal living.

By exploiting mariculture it is possible to develop the production and processing at a regional level, thus mussel farming can increase the number of jobs and tax revenue contribution in the region, as well as the income from tourism in seaside areas.

In order to reduce costs, it can be combined with other scopes of mariculture, although this aspect has not been sufficiently researched and requires further evaluation.

2.7. Environmental Aspect

Mussel is one of the basic species, which provides ecosystem services. Increasing of their number in the Baltic Sea will decrease nitrogen and phosphorus concentrations (Lindahl, 2012) with a condition that new pollution will not get into the sea.

2.8. Innovation

Since mussels are mainly sold for human consumption purposes and food production has a small-scale realisation, the sector's potential has not been fully realised. Promoting scientific research may result in new end-user markets.

3. PROGNOSIS OF VOLUME OF MUSSELS

Based on the historical data, the prognosis of mussel fishery was set using probabilistic projection methods.

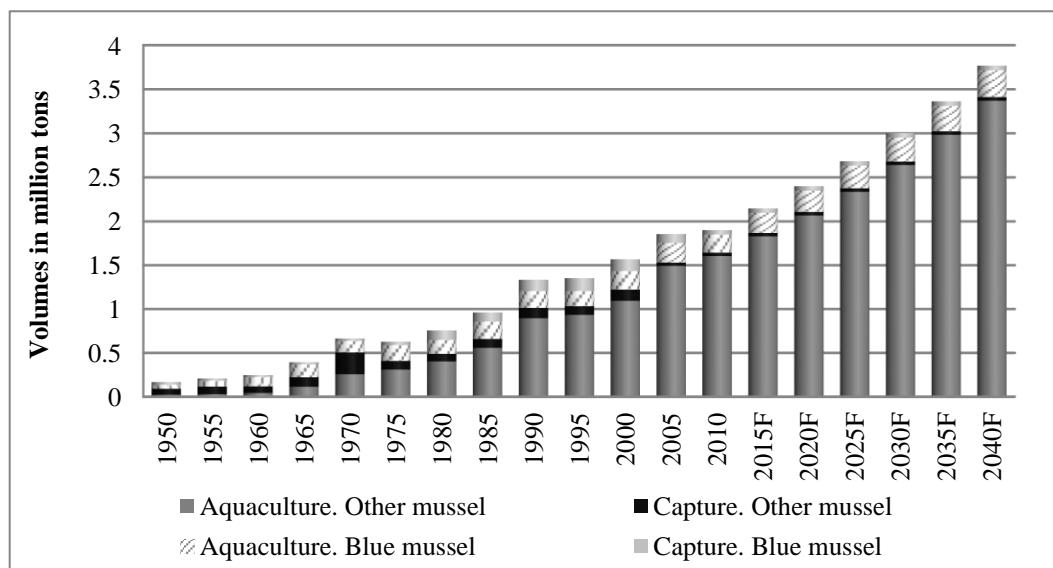


Fig. 5. Prognosis of volume of mussels, 1950–2040 (FAO data, 2017; prognosis by the author).

The volumes of captured mussels were set according to the level of volumes in 2010 and corrected taking into consideration the data in 2011–2014, the increase of 0.01 % per year is foreseen, but the fishery volume of aquaculture mussels should increase as follows:

- Fishery of other mussels will increase by 1–3 % per year;
- Fishery volume of blue mussels will increase by 0.5–1.5 % per year.

CONCLUSION

Global fishery production (in tons) had increased by 7 % yearly during the last 20 years.

The consumption of fish food is continuously increasing. Within the last 10 years the consumption of fish and seafood increased by 2 % per year and the increase has a linear tendency. One of the reasons is the growth of population (World Bank, 2016).

Fishery volume of aquaculture mussels is going to increase by 1–3 % per year in the world.

Participation in research projects might encourage industry development. The demand for mussels depends on price, habits of people, costs to fulfil the requirements of governmental institutions, logistics and marketing activities.

Mussel farming industry is new in the Baltic Sea countries, and due to this reason new terminology needs to be developed.

In Latvia there is a lack of precise specific legal regulations for mariculture activities. This factor is a serious obstacle for potential stakeholders to start mussel farming business.

Mussel farming industry has a potential to develop in case the end-user market develops. Mussel farming might be combined with other scopes of mariculture to reduce costs and it might increase regional development.

Advanced marketing activities could be useful to promote mussels from the Baltic Sea.

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REFERENCES

- Ahsan, D. A., & Roth, E. V. A. (2010). Farmers' perceived risks and risk management strategies in an emerging mussel aquaculture industry in Denmark, *Marine Resource Economics*, 25(3), 309–323. <https://doi.org/10.5950/0738-1360-25.3.309>
- Canu, D. M., & Solidoro, C. (2014). Socio-economic analysis and stakeholder involvement: Mussel-farming in the Gulf of Trieste, *Marine Policy*, 43, 55–62. <https://doi.org/10.1016/j.marpol.2013.03.022>
- Central Baltic INTERREG IV A Programme 2007–2013. Search for Projects. Retrieved August 28, 2016, from <http://projects.centralbaltic.eu/>

- European Commission. Community Research and Development Information Service – CORDIS, European Commission: CORDIS: Search: Simple: Searching term: mussel farm, Country: Latvia, Sweden. Retrieved August 28, 2016, from [http://cordis.europa.eu/projects/result_en?q=%27mussel%27%20AND%20%27farm%27%20AND%20\(contenttype%3D%27project%27%20OR%20\(result/relation/categories/resultCategory/code%3D%27brief%27,%27report%27\)%20AND%20\(address/country%3D%27LV%27%20OR%20relatedRegion/region/euCode%3D%27LV%27\)](http://cordis.europa.eu/projects/result_en?q=%27mussel%27%20AND%20%27farm%27%20AND%20(contenttype%3D%27project%27%20OR%20(result/relation/categories/resultCategory/code%3D%27brief%27,%27report%27)%20AND%20(address/country%3D%27LV%27%20OR%20relatedRegion/region/euCode%3D%27LV%27))
- Food and Agriculture organization of the United Nations. (2011). World Hunger Falls, but 805 Million Still Chronically Undernourished. *FAO – News Article*. Retrieved August 1, 2016, from <http://www.fao.org/news/story/en/item/243839/icode/>
- Food and Agriculture organization of the United Nations. (2012). Strategy for Fisheries, Aquaculture and Climate Change. *FAO*. Retrieved c from <http://www.fao.org/3/a-at500e.pdf>
- Food and Agriculture organization of the United Nations. (2017). Consumption of Fish and Fishery Products 1961–2013. *FAO*. Retrieved January 20, 2017, from <http://www.fao.org/faostat/en/#data/CL>
- Food and Agriculture organization of the United Nations. (2017). Statistics of Global Fishery Trade and Production 1984–2013. *FAO*. Retrieved January 20, 2017, from http://www.fao.org/figis/servlet/SQServlet?file=/work/FIGIS/prod/webapps/figis/temp/hqp_5255688575442364397.xml&outtype=html
- Food and Agriculture organization of the United Nations. (2017). Statistics of Global Fishery Production in the Capture and Aquaculture 1961–2014. *FAO*. Retrieved January 20, 2017, from http://www.fao.org/figis/servlet/SQServlet?file=/work/FIGIS/prod/webapps/figis/temp/hqp_7634066470684589918.xml&outtype=html, http://www.fao.org/figis/servlet/SQServlet?file=/work/FIGIS/prod/webapps/figis/temp/hqp_1277083878917406293.xml&outtype=html
- Food and Agriculture organization of the United Nations. (2017). Statistics of Fishery and Mussels Production and Trade 1950–2014. *FAO*. Retrieved January 20, 2017, from http://www.fao.org/figis/servlet/SQServlet?file=/work/FIGIS/prod/webapps/figis/temp/hqp_4929554883674150148.xml&outtype=html, http://www.fao.org/figis/servlet/SQServlet?file=/work/FIGIS/prod/webapps/figis/temp/hqp_3141120526197857863.xml&outtype=html, http://www.fao.org/figis/servlet/SQServlet?file=/work/FIGIS/prod/webapps/figis/temp/hqp_2050222146843308738.xml&outtype=html
- Food and Agriculture organization of the United Nations. (2017). Statistics of Fishing of Blue Mussels in the world 1950–2014. *FAO*. Retrieved January 20, 2017, from http://www.fao.org/figis/servlet/SQServlet?file=/work/FIGIS/prod/webapps/figis/temp/hqp_7014769052054884030.xml&outtype=html
- Girard, S., & Mariojouis, C. (2003). French consumption of oysters and mussels analysed within the European market. *Aquaculture Economics and Management*, 7(5–6), 319–334. <https://doi.org/10.1080/13657300309380348>
- Gouilletquer, P. (2014). Cultured Aquatic Species Information Programme. *Mytilus edulis*. Cultured Aquatic Species Information Programme. *FAO Fisheries and Aquaculture Department*. Retrieved August 1, 2016, from http://www.fao.org/fishery/culturedspecies/Mytilus_edulis/en
- Gren, I. M., Lindahl, O., & Lindqvist, M. (2009). Values of Mussel Farming for Combating Eutrophication: An Application to the Baltic Sea. *Ecological Engineering*, 35(5), 935–945. <https://doi.org/10.1016/j.ecoleng.2008.12.033>
- International Council for the Exploration of the Sea. (2009). *Request from Denmark to Review Environmental Impact Assessment of Mussel Fishery in the Limfjord*. Retrieved June 1, 2013, from <http://www.ices.dk/sites/pub/Publication%20Reports/Advice/2009/Special%20Requests/Denmark%20environmental%20impact%20assessment%20of%20mussel%20fishery.pdf>
- Lancmane, A. L. (2013). Atzinums par Tiesību un Normatīvajiem Aktiem, kuri Tieši vai Pastarpināti Ietekmē Gliemju (*Mytilus edulis*, *Mytilus trossulus*) Audzēšanu un Ieguvi Latvijas Teritorijā (Baltijas Jūrā un vai Rīgas Līcī) un to Realizāciju Komerčiālos Nolūkos Latvijas Teritorijā. Project Baltic EcoMussel. Retrieved October 1, 2013, from http://lvif.gov.lv/uploaded_files/sadarbiba/balticecomussel/Jurista_atzinums_final_redits.pdf

- Lindahl, O. (2012). *Farming Blue Mussel as an Environmental Measure - final comments Balticsea 2020*. Retrieved August 15, 2016, from <http://balticsea2020.org/english/alla-projekt/overgodning/eutrophication-completed-projects/52-farming-blue-mussel-as-an-environmental-measure>
- Lindahl, O., Hart, R., Hernorth, B., Kollberg, S., Loo, L., Olrog, L., Rehnstam-Holm, A., Svensson, J., Svensson, S., & Syversen, U. (2005). Improving Marine Water Quality by Mussel Farming: a Profitable Solution for Swedish Society. *AMBIO: A Journal of the Human Environment*, 34(2), 131–138. <https://doi.org/10.1579/0044-7447-34.2.131>
- Madina, M. (2014). EU Allows Denmark to Continue Harmful Mussel Dredging – Considered as Sustainable. Protecting the world ocean. Retrieved June 28, 2016, from <http://baltic.oceana.org/en/bl/media-reports/press-releases/eu-allows-denmark-to-continue-harmful-mussel-dredging-considered-as->
- Ottesen, G. G., & Grønhaug, K. (2004). Perceived opportunities and pursued strategies in an emerging industry: The case of Norwegian Blue Mussel farming. *Aquaculture Economics and Management*, 8(1–2), 19–39. <https://doi.org/10.1080/13657300409380351>
- Rodríguez, G. R., Villasante, S., & Garcia-Negro, M. D. (2011). Are red tides affecting economically the commercialization of the Galician (NW Spain) mussel farming? *Marine Policy*, 35(2), 252–257. <https://doi.org/10.1016/j.marpol.2010.08.008>
- Rudzītis, M., & Rudzīte, M. (2007). Latvijas pērļu liktenis. *Vides Vēstis*, 6(7/8), 42–45.
- Stadmark, J., & Conley, D. J. (2011). Mussel farming as a nutrient reduction measure in the Baltic Sea: consideration of nutrient biogeochemical cycles. *Marine Pollution Bulletin*, 62, 1385–1388. <https://doi.org/10.1016/j.marpolbul.2011.05.001>
- Theodorou, J. A., Viaene, J., Sorgeloos, P., & Tzovenis, I. (2011). Production and marketing trends of the cultured Mediterranean mussel *Mytilus galloprovincialis* Lamarck 1819, in Greece. *Journal of Shellfish Research*, 30(3), 859–874. <https://doi.org/10.2983/035.030.0327>
- The Baltic Sea Region Programme 2007–2013. (2013). Funded projects. Retrieved August 28, 2016, from <http://eu.baltic.net/index.php?id=5308&contentid=>
- The World Bank. (2016). GDP and Population, total 1984–2015. Retrieved August 28, 2016, from <http://data.worldbank.org>
- Tyler-Walters, H., & Seed, R. (2006). Common Mussel (*Mytilus edulis*). *MarLIN - The Marine Life Information Network*. Retrieved August 15, 2016, from <http://www.marlin.ac.uk/species/detail/1421>
- Wierzbicki, A., Brandes, U., Schweitzer, F., & Pedreschi, D. (Eds.). (2016). *Advances in network science: 12th International Conference and School, NetSci-X 2016, Wroclaw, Poland, January 11–13, 2016*. Springer, 29–30. <https://doi.org/10.1007/978-3-319-28361-6>



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