Biomass Types

Policy Brief

Mussels as a potential biomass for symbiosis

This brief is a part of the Blue Green Bio Lab Tool Kit, that represents the findings in the Blue Green Bio Lab project. The project targets the urgent challenges of reducing nutrients to waters of the Baltic Sea Region, limiting greenhouse gas emissions, and enhancing European self-supply with food, feed, and energy. Together, aquaculture, agriculture and industry can provide solutions to these challenges through industrial symbiosis based on the sustainable exploitation of local blue and green biomasses initially grown and/or harvested with the objective to produce positive ecosystem services. The Blue Green Bio Lab project is co-financed by Inter-Reg Baltic Sea Region with partners in Denmark, Latvia, and Sweden.

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Description of mussel species

Mussels are a group of marine and freshwater bivalve mollusks characterized by sedentary behavior and feeding by filtering the ambient water. In the Baltic Sea several species of mussels and clams are found inhabiting hard surfaces (rocks, reefs), soft sand and mud. The most frequent species of bivalves in the Baltic Sea are Mytilus trossulus or blue mussel, Limecola balthica or Baltic clam, Cerastoderma glaucum or lagoon cockle and Dreissena polymorpha or zebra mussel. In this brief the blue mussel and zebra mussel will be described in more detail, as they have the widest distribution in the Baltic Sea.

In the Baltic Sea blue mussels inhabit marine rocky areas from Kattegatt and Skagerrak to the Bothnian Sea. The optimal salinity for their growth is 25 per mille, therefore the size of the bivalves decreases from 10 to 4 cm in the southern-northern direction (Picture 1). There are also indications of mussel size slightly decreasing in general since 1990s. Blue mussels efficiently filter very small particles (down to the size of 4 micrometers, i.e., 1/250 of 1 millimetre) and can potentially filter up to 7 litres of water per hour. Reproduction of blue mussels involves spawning at springtime and the forming of larvae. The larvae drifts for 1-3 months and then settles on a solid substrate- be it another mussel, a rock, or a cultivation substrate for mussel farming. The first spawning of blue mussels takes place during the mussels second year of life. The total life span of a blue mussel is around 12 years and generation time is 1-2 years. The mussel density can be up to 2000 animals per m2, and the biomass can extend to 1 kg per m2.

Zebra mussel is an invasive species originating from the Caspian/Black Sea region. It invaded the rest of Europe and the Baltic Sea basin in 18-19th century. Shell size of adult zebra mussels varies between 1,35 cm to 2 cm (Picture 2). Optimal water temperature for the development and filtration of mussels is between 12-22 degrees Celsius, while salinity preference is up to 6,2 PSU (grams of salt per kilogram of seawater) and sometimes even up to 10 PSU. Zebra mussels can filter 10 times smaller particles than blue mussels, and their filtration volume is 1 liter/day. Their consumption rate peaks at 15 degrees, as originally zebra mussels are from warmer regions. Being 1,5- 5 times smaller as the blue mussel, zebra mussels can form very dense colonies. Density of zebra mussels in the Baltic Sea can reach 10,000 individuals/m2 with biomass up to 3 kg per m2.
For successful survival zebra mussels need hard

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substrates and a water depth of at least 30 cm. In the Baltic Sea zebra mussels prefer lagoons and coastal areas, exposed to freshwater inflows. Zebra mussels are a dominant species in the Curonian Lagoon, where mussel beds cover 23% of the bottom of the lagoon.

Climate and environmental goals in the Baltic Sea region

European Water Framework Directive (WFD) focuses on ensuring good qualitative and quantitative health of rivers and lakes, ground water and bathing waters. The emphasis is on reducing and removing pollution and on ensuring that there is enough water to support wildlife at the same time as human needs.
. The key objectives of the WFD are to protect and, where necessary, restore water bodies to attain good water status and prevent deterioration. Good status means both good chemical and good ecological status. WFD requires Member States to use their River Basin Management Plans (RBMPs) and Programmes of Measures. The river basin district approach is applied to make sure that neighboring countries cooperate.

Like the European Union's aims for climate neutrality, the Baltic Sea region also has the goal to be a climate neutral region in 2050, according to the European Union Strategy for the Baltic Sea Region. The region has aims for clear water in the sea, rich and healthy wildlife, climate change adaptation, risk prevention and management. The Action Plan of the Strategy includes 9 actions in 3 policy areas, relevant for these aims. The emphasis of actions is on the reduction of nutrient emissions, recycling of nutrients, prevention of pollution and strengthening of a sustainable and circular bioeconomy.
The Baltic Sea Action Plan (BSAP) by Helsinki Convention is the central framework for implementation of the Strategy, with the overall objective of reaching good environmental status for the Baltic Sea by 2030. The plan has four sections with specific goals:
— Biodiversity, with its goal of a "Baltic Sea ecosystem (that) is healthy and resilient",
— Eutrophication, with its goal of a "Baltic Sea unaffected by eutrophication",
— Hazardous substances and litter, with its goal of a "Baltic Sea unaffected by hazardous substances and litter", and

Picture 1: Blue Mussels. Source: Per Dolmer, Blue Research.

— Sea-based activities, with its goal of "Environmentally sustainable sea-based activities".
The 4 sections of the BSAP are related. For example, attaining the goal under the "biodiversity" section also relies on the successful implementation of actions included under the other three sections. Actions and measures within all sections are designed to strengthen the overall resilience of the Baltic Sea, thus improving its ability to respond to the effects of climate change. The "eutrophication" section includes 36 actions in various sectors – such as agriculture, wastewater, data reporting, atmospheric depositing, and nutrient recycling. Such actions should help reach the desired state of the marine environment with concentrations of nutrients close to natural levels, clear water, algal blooms at natural levels, plants and animals with natural occurrence and distribution, and natural oxygen levels.

HELCOM Baltic Sea Regional strategy for Nutrient Recycling is another tool for improving nutrient use and reducing leakages to the Baltic Sea environment from agriculture. The Nutrient Recycling Strategy aims for closing nutrient cycles, reducing greenhouse gas emissions, improving soil quality and enhancing carbon sequestration. The circular use of nutrients should be safe and secure, based on the best available knowledge and should encourage new business models together with improved policy coherence. The Strategy has a list of possible measures in the form of tool box with ideas for nutrient recycling development in the region.

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Local climate and environmental goals

This section looks at the translation of goals at the Baltic Sea level to the local scale, through the objectives and actions of two project partner regions of the Blue Green Lab project.

Skive Municipality in Denmark adopted a new climate action plan in 2022 with the goal of a 70% reduction in CO_2 emissions by 2030 and climate neutrality by 2050. These climate targets are in accordance with international agreements and with national targets established for greenhouse gas reduction formulated in the Danish Climate Act. To reach the 70% reduction

Picture 2: Zebra Mussel. Source: Wikimedia Commons.

target by 2030, Skive Municipality must half their CO_2 emissions per year by 2030, i.e. by 314,000 tonnes CO_2/year. If the implementation of the climate action plan is successful, Skive Municipality will achieve:
- 82% reduction in CO_2 emissions in 2030 compared to 1990
- 97% reduction in CO_2 emissions in 2050 compared to 1990.

The large reduction in CO_2 emissions by 2030 in Skive Municipality is expected largely due to the development of the Power-to-X industry (PtX) and the transition of the agricultural sector, especially in terms of land use. PtX production of green fuels such as hydrogen, methanol and green ammonia will reduce emissions in the transport sector. In addition, the expected green transition of the agricultural sector, based on the Danish Agricultural Agreement, aims for a more than 50% reduction in CO_2 emissions from land use in Skive Municipality.

River basin management plans of 2021-2027 are also relevant for Skive Municipality to gradually improve the water quality in Skive Fjord, Lovns Bredning, Hjarbæk Fjord and Risgårde Bredning. For Skive Fjord, Risgårde, Lovns Bredning and Bjørnsholm Bugt it is required to reduce 739.5 tonnes of nitrogen/year, while for Hjarbæk Fjord, the reduction requirement is 894.6 tonnes N/year.

Kurzeme Planning Region in Latvia has adopted a development programme for its region until 2027. The programme "Kurzeme 2027" aims to secure balanced and sustainable growth of the region in accordance with national climate and environmental goals. Climate neutrality, conservation of biodiversity and natural environment are named as priority action areas, although no specific numeric values are provided. The region aims to improve the energy efficiency of public buildings and adopt additional local municipal plans as measures for climate neutrality. Implementation of integrated blue and green infrastructure solutions is also foreseen. Use of renewable energy sources is planned but without specific values mentioned.

Options for biomass use in achieving climate and environmental goals

Skive Municipality already anticipates the use of aquatic (=blue) biomasses, potentially including blue mussels, for achieving climate goals and improving water quality in Skive Fjord. It has already been calculated that blue biomasses could decrease CO_2 emissions by 26,000 tons per year by 2050, i.e., about 8% of the total necessary reduction in Skive's climate action plan. Blue mussels capture CO_2 during their shell formation, which is not released when the shells are broken. The same principle of carbon removal is true for zebra mussels. The shells of mussels can form a part of construction materials, be an ingredient of chicken feed or nutraceuticals.

Furthermore, both species of mussels can reduce the water turbidity by filtration substantially and thus improve the ecological status of the respective area.

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Use of zebra mussel for water treatment has been explored in Swedish lake Ekoln and evidence shows zebra mussels being capable of removing 1,2-1,8 t of phosphorous per year (or approx. 60 % of annual load). Zebra mussels can also remove pathogens by filtration. As zebra mussels do not require large depth, the substrate for growth in a water reservoir can also be a reedbed with ropes below it.

Calculations on the filtration capability of blue mussels indicate that if the allowed amount of mussels is cultivated at 13 farms in Skive Fjord then 731 tons of nitrogen can be removed. This constitutes 98% of the necessary nitrogen removal of coastal waters not only of Skive Fjord, but also of Bjørnsholm Bugt, Risgårde Bredning and Lovns Bredning. The cost of nitrogen removal through the cultivation of blue mussels is between 48-64 Danish kroner kg/N. Mussels are regarded as one the most cost-effective measures for nutrient reduction in the Baltic Sea. Kurzeme Planning Region as well as other coastal municipalities could also use mussel cultivation as an option for achieving environmental goals.

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Project facts

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Homepage: https://interreg-baltic.eu/project/blue-green-bio-lab/

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