Interreg Baltic Sea Region | Co-funded by the European Union

Circular Economy Blue-Green Bio Lab

Biomass Types

Policy Brief

Terrestrial cultivation of aquatic species 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 cultivated species

The circular use of energy resources or sidelines of energy streams provide options for the terrestrial cultivation of various aquatic species. In this brief three examples are presented- Vannamei Shrimp, Asparagopsis and Clarias. The choice of species for terrestrial cultivation can be more extensive, however, if the necessary conditions can be established. Tilapia, crayfish, baramundi and several green algae are also well-suited for indoor aquaculture.

Vannamei Shrimp or white leg shrimp (Litopenaeus vannamei, Picture 1) is a species native to the Pacific coast of Mexico and Central and South America, living in tropical marine habitats like mangroves. The adult shrimp mostly occur in the open areas of the ocean where they also spawn, while juveniles tend to inhabit estuaries and coastal areas. Adult shrimp can be up to 22 cm long and about 35 g in weight. The optimal temperature for development and growth of these shrimp is between 28 and 32°C and the favourable salinity range is 25-35 per mill. Too low or too high salinity levels can be stressful to the species and can lead to poor growth rates, reduced survival, and increased susceptibility to disease. The white leg shrimp is now widely cultivated in many parts of the world, including Asia, South America, and the United States. In the Baltic Sea region, the white leg shrimp is cultivated at farm in Grevesmühlen, northern Germany and at experimental pilot facilities in Gdansk, Poland and Klaipeda, Lithuania. The shrimp is an excellent source of protein and is low in fat and calories, making it a popular choice for those looking for a healthy and nutritious food option.

Picture 1. White leg shrimp. Photo credits: Seafood.lv

Asparagopsis or **Asparagopsis taxiformis** (Picture 2) is a red alga native to the warm waters of the Atlantic, Pacific, and Indian Oceans. In its natural environment, A. taxiformis typically grows in shallow, rocky areas,

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Blue-Green Bio Lab Partners: Latvijas Hidroekoloģijas Institūts, Lysekils Kommun, LEVA i Lysekil, Klimafonden Skive, Zemgales Plānošanas Reģions, Skive Kommune

and tolerates a wide range of temperatures and salinities, though the algae's optimal temperature range for growth is between 15°C and 25°C. Temperatures below 10°C or above 30°C can be detrimental to its growth and reproductive success. The algae's salinity the range is between 20 to 40 per mill with the best growth between 30 to 35 per mill. Exposure to salinities below 20 ppt or above 40 ppt can be stressful to the algae and may limit its growth and reproductive success. Asparagopsis has a complex life cycle with sexual and asexual reproduction and can reproduce both by spores and vegetative fragmentation. Its size and shape are highly variable from a few centimetres to several meters in length and may be bushy or more wire-like in appearance. The algae has an important ecological role in its native ecosystems as a primary producer, providing food and habitat for other marine organisms, as it can form dense mats on rocky substrates. It captures CO2 during photosynthesis when building its biomass and has the potential to reduce methane (also a greenhouse gas) production from beef cattle by up to ~99% when added to cattle feed. The methane reduction is caused by a chemical compound called bromoform in Asparagopsis which has anti-microbial properties and inhibits certain microorganisms in the cattle's gut that produce methane during digestion. The aquaculture of Asparagopsis is not widely occurring yet in Europe, one of the first pilots **Volta Greentech** is established in Lysekil, Sweden.

Picture 2. Asparagopsis taxiformis harvested for further treatment. Photo: A.N. Hristov, Penn State University.

Clarias or **African catfish** (Clarias sp.) is a group of species native to freshwater habitats throughout Africa (Picture 3). Catfish there are typically found in slowly flowing rivers, swamps, and other freshwater habitats with abundant vegetation and muddy bottoms. They are bottom-dwelling fish that feed on insects, crustaceans, and small fish. They may also scavenge for food, feeding on dead or decaying organic matter on the bottom of water bodies. Catfish can breathe air using a modified swim bladder that serves as a primitive lung, which allows them to survive in poorly oxygenated water and to cover short distances over land in search of new water sources. They have a high capability of adaptation, and can tolerate low pH, low oxygen levels, and high temperatures. In their native habitats, catfish typically live in freshwater with temperatures ranging from 22°C to 30°C, though some species are able to tolerate temperatures up to 35°C. In aquaculture settings, catfish are most often raised in temperatures from 25°C to 30°C, which is considered the optimal temperature range for growth and reproduction. They are relatively large fish that can reach lengths of up to 1-2 meters in some species. However, most species of catfish typically grow to a maximum length of around 50-100 centimetres in the wild. Catfish are also able to reproduce quickly and in large numbers, which can make them successful invaders in new habitats. Therefore, they have established populations in many parts of the world, where they are considered invasive species, competing with native fish for food and habitats. In some cases, catfish have been associated with environmental degradation, such as increased sedimentation or nutrient pollution, due to their feeding and burrowing behaviours.

Picture 3. African sharptooth catfish Clarias gariepinus. Photo credits: Eurofish.dk.

The aquaculture of Clarias catfish is relatively well-established in southern Europe (Spain, Portugal, Italy) where meteorological conditions are favourable for catfish production. In United Kingdom, Netherlands and northern Europe catfish is cultivated in indoor recirculating systems or in heated ponds, although not on a large scale.

Climate and environmental goals in the Baltic Sea Region

The circular economy action plan adopted by European Commission in March 2020 is one of the main building blocks of the European Green Deal, Europe's new agenda for sustainable growth. It is also a prerequisite to achieve the EU's 2050 climate neutrality target and to halt biodiversity loss. The action plan targets how products are designed, promotes circular economy processes, encourages sustainable consumption, and aims to ensure that waste is prevented and that resources used are kept in the EU economy for as long as possible. Measures that will be introduced under the new action plan aim to make sustainable products the norm in the EU, focus on the sectors that use most resources and where the potential for circularity is high such as: electronics and ICT, batteries and vehicles, packaging, plastics, textiles, construction and buildings, food, water and nutrients.

Like the overall European Union (EU) climate aims, the Baltic Sea region also aims for climate neutrality by 2050, as per the EU Strategy for the Baltic Sea Region (BSR). The region aims for clear sea waters, rich and healthy wildlife, climate change adaptation and risk prevention and management. The emphasis of planned actions is on reduction of nutrient emissions, recycling of nutrients, prevention of pollution and strengthening of sustainable and circular bioeconomy.

The Baltic Sea Action Plan (BSAP) adopted by the Helsinki Convention (HELCOM) is the central framework for implementation of the EU Strategy for the BSR, holding the overall objective of reaching good environmental status for the Baltic Sea by 2030. Actions and measures are designed to strengthen the overall resilience of the Baltic Sea, thus improving its ability to respond to the effects of climate change. These actions should help to reach the desired state for the marine environment with concentrations of nutrients at close to natural levels, clear waters, algal blooms at natural levels, plants and animals with a natural occurrence and distribution, and natural oxygen levels.

HELCOM Baltic Sea Regional strategy for Nutrient Recycling is another tool for improvement of nutrient use and reduction of nutrient leakage to the Baltic Sea environment from agriculture. 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.

Climate and environmental goals for Lysekil Municipality

To understand how Baltic Sea Region level goals are being translated at the local scale, objectives and actions of Blue Green Bio Lab partner Lysekil Municipality are considered.

Lysekil Municipality has adopted their "Green Strategy", which runs until 2030. The strategy addresses expectations for the intensive development of green infrastructure and adaptation to climate change effects like extreme rainfall and flooding. The climate targets addressing reduction of emissions are approved on a regional scale (Västra Götaland). These regional climate targets are some of the most ambitious in Sweden with aims for a fossil-free region by 2030 and an 80% reduction in greenhouse gas emissions by 2030 compared to 1990 levels. Compared to 2010, emissions will be reduced by 30% (Fig.1).

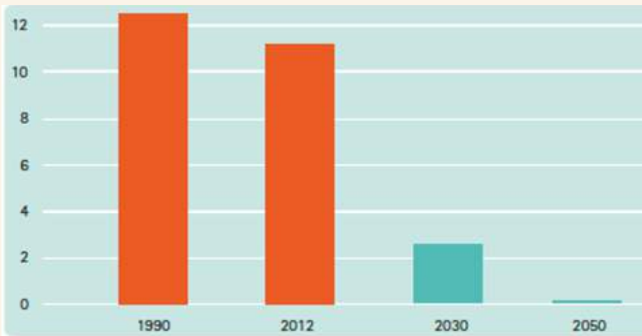

Fig.1. Total greenhouse gas emissions in Västra Götaland (million tons of CO2 equivalents/year) compared to the 2030 and 2050 target.

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All municipalities in Västra Götaland have adopted climate pledges to achieve the regional targets. In 2022 of the 426 climate pledges adopted, about 90 per cent have been implemented or started. A total of 219 pledges have been already completed, resulting in estimated emission reductions of just over 44,700 tons of CO2. In 2021 reductions from implemented pledges were estimated at about 31,100 tons of CO2.

Options of biomass use for achieving the climate and environmental goals

The considerations of Lysekil Municipality to concentrate on the potential for indoor cultivation is due in part to the presence of the largest private business in the area, Preem refinery plant. Preem conducts extensive refinement of crude oil and the sale of petroleum products to oil companies active in Sweden and on the international market, mainly in north-western Europe. Preem is Sweden's largest fuel company and accounts for 80 percent of Sweden's refinery capacity and 30 percent of the Nordic refinery capacity. As the refining process generates excess heat, the plant is supplying the municipality with hot water for heating. Currently Preem provides 50 GWh, but the supply capacity is 800 GWh. Preem has the goal to become a climate neutral company by 2035, through investing in renewable fuels production, feedstock switching and carbon sequestration measures like carbon capture projects.

Establishing heated indoor facilities for the terrestrial cultivation of exotic aquatic species are in line with both the municipality's target for the sustainable use of resources and regional goals regarding fossil fuel use. Its not yet possible to accurately calculate the actual conributions of these indoor facilities to local and regional climate goals as cultivation efforts are still in the pilot stages. Conceptually however, production of additional biomass locally will reduce fossil fuel use, thereby reducing the region's carbon footprint associated with transportation, energy use and waste management.

Seawater salinity near Lysekil is optimal for all species discussed in this brief and filtered seawater is already used in Asparagopsis cultivation. Furthermore, the environmental status of the surrounding fjord will likely improve if mussels are cultivated there as a feed substance for African catfish, thereby ensuring even greater local circularity for these economic activities.

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Project facts

The Blue-Green Biolab project is co-financed by Interreg Baltic Sea Region.

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

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