Production potential of macroalgal growth in the Baltic Sea

Socio-economic benefits of sustainable macroalgae production in the Baltic Sea region

Marine macroalgae cultivation is an upcoming industry for food production without competing for arable or freshwater resources while removing excess nutrients from the water. Recent research reveals that macroalgal products might also provide useful source ingredients for pharmaceuticals and cosmetics industry. Nevertheless, commercial macroalgae production is still widely in its infancy and there is a lack of in-depth and wide-spread knowledge on the production potential of macroalgae in coastal waters. We are also largely unaware which ecological factors lead to high algal growth and how much algae could be potentially cultivated in aquaculture farms. To deal with this challenge, GRASS aims to build capacity on macroalgae cultivation, harvesting and the use among public authorities and other relevant stakeholders across the Baltic Sea region. Efficient management of marine resources is of key importance for achieving good environmental status in the European seas and blue growth of coastal communities.

High production potential and cultivation hotspots

Existing environmental data and expert opinions were catalogued and harmonized into a GIS database which allowed us to model macroalgae production potential in the Baltic Sea region. The model carries out spatially explicit analyses on the environmental suitability and production potential of the key harvestable macroalgal species such as *Fucus vesiculosus* and *Ulva intestinalis* (Fig. 1). Due to its ephemeral nature, *U. intestinalis* had a higher production potential (daily growth rate in %) compared to *F. vesiculosus* and had a wider spatial distribution of production hotspots encompassing Danish Straits, coasts of southern Sweden, Germany, Poland, Lithuania, Latvia and Estonia (Fig. 1).

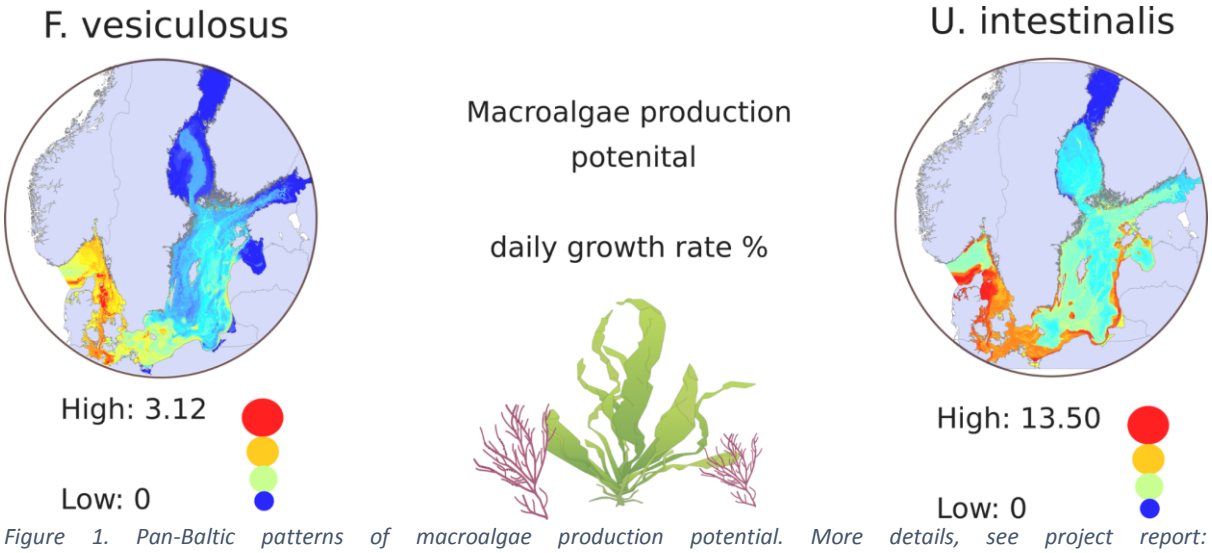


Figure 1. Pan-Baltic patterns of macroalgae production potential. More details, see project report: http://www.sea.ee/bbgodss/Materials/GRASS_GoA2.1_final_report_30062020.pdf

Techniques and technologies

There are no current production sites for cultivation of the species *Fucus vesiculosus* and *Ulva intestinalis* within the Baltic Sea, although there are ongoing research projects of the latter. Established techniques and technologies for open-sea macroalgae cultivation only exist in the western Baltic Sea Region, focusing on *Saccharina latissima*, using buoys and experimenting with off-shore rigs. Knowledge exchange regarding applied techniques and developing technologies for various species

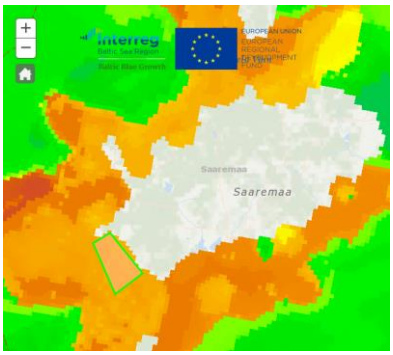
within the BSR could contribute to the development of sustainable macroalgae cultivation within the Baltic Sea.

Environmental benefits and risk

Seaweed remove nutrients and the process of cultivation does not require use of fertilisers. Therefore, seaweed harvesting and aquaculture can be seen as a way to decrease the nutrient levels to eutrophic coastal areas and to mitigate the negative symptoms of eutrophication. Different seaweed cultivation techniques interact with the environment in different ways. The magnitude of impacts depends on the method of cultivation, the surface area of the farm and the site where the farm is located. Significant improvements in the water quality can be expected in highly eutrophicated areas as in such environments positive impacts of seaweed farming are the highest. However, seaweed cultivation also presents some risks which are largely associated with large scale seaweed farming and harvesting including aesthetic impacts and changes to primary and secondary productivity levels.

Decision-support tool for identifying promising areas for macroalgae farming

The resulting modelling products were made public through an online Operational Decision Support System (ODSS) that provides stakeholders with the basis to identify suitable areas for macroalgae cultivation and harvest (http://www.sea.ee/bbg-odss/Map/MapMain). On the main page of the portal under “switch layers tab” the user can, for example, select the map of modelled *Fucus* growth potential and display the results across the Baltic Sea. The user can then click on “plan your farm” tab and draw a theoretical farm area polygon and acquire various important statistics (e.g. algal growth rate, water temperature and salinity) relatable to the polygon area (see Fig. 2 for illustration). Through its analytical capabilities to synthesize and disseminate up-to-date information and knowledge to different end-users, the ODSS is designed to facilitate and improve the quality of decision-making of maritime spatial planners, scientists, policy actors and investors.



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Name	Average	Area (km2)	Percent (%)	Count	Classes
AIS Shipping Density (2016)	0	73.73	83.62	1	
N Removal by mussels (Mytilus, g/m rope @ 2 years)	7.3	50.09	56.81	3	
P Removal by mussels (Mytilus, g/m rope @ 2 years)	0.67	50.09	56.81	3	
Mussel growth (kg/m rope @ 2 years)	1.13	83.39	94.59	7	
Sediments				2	Sand,Hard bottom complex
Summer chlorophyll (mg m-3)	3.29			39	
Salinity (psu)				1	5 - 7.5 psu
Simplified wave model (m2 s-2)	218046.21			71	
Temperature (°C)	18.02			4	
Baltic Sea Ice		60.87	69.04	1	
Fucus growth (daily growth rate in %)	0.97	88.1	99.92	105	
Ulva growth (daily growth rate in %)	10.61	88.13	99.96	83	

Figure 2. The map shows the growth potential of the green algae Ulva intestinalis around Saaremaa (Northeastern Baltic). Brown color indicates high and green medium algal growth potential. When a user selects a potential farm area (a green rectangle on orange), the model displays specific summary statistics of growth rates and associated environmental variables.

Implications and awareness

The decision-support tool is accessible to everyone - from public authorities interested in setting up / investing in / funding a farm in their region to private actors who want to get involved in the macroalgae business. Knowledge from the ODSS (1) raises awareness and confidence in public sector towards balanced and environmentally friendly marine macroalgae farming and harvesting in the Baltic Sea region as well as (2) support decision-makers with the best tools for strategy development, resource allocation and spatial planning.