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Description of the Innovation (ca. 250 words):

Innovation Off-Shore-Ulva: The growing world population demands an increase in sustainable resources. A crucial basis to reach this goal is the opening of new farm grounds and the cultivation of extractive species, such as sea lettuce, on industrial level, aiming to provide renewable biomass for food and non-food applications. The potential for European large-scale oceanic farming of the commercial green seaweed crop *Ulva* was until lately not yet fully realized due to the lack of suitable methodology and problematics in controlling the life-cycle of *Ulva*. We were able to develop the technology of full-life cycle aquaculture of the Northern Hemisphere crop *Ulva fenestrata* and established a solid basis for its industrial off-shore cultivation. The project “Off-Shore-Ulva” established a sound technology to transfer the cultivation of native European *Ulva* strains, which was until date mainly performed on- or near-shore, into the ocean. Using this newly established methodology and expanding the cultivation of *Ulva* into the ocean and thus opening new farm grounds brings several advantages to the emerging European seaweed industry and offers a sustainable way for large-scale biomass production. E.g. the needed on-shore facilities are reduced to a minimum, which results in a more sustainable way of farming high-value biomass. By biochemical profiling we determined the applicability and safety of the produced biomass and established a circular crop species for the European seaweed market. All techniques are publicly available since it is our belief that the European aquaculture sector, but more importantly also our ecosystems, largely benefit from sound cultivation protocols.

What makes your innovation unique compared with other products? (ca. 400 words)

To date, cultivation of sea lettuce in Europe has mainly been limited to coastal near-shore areas and on-shore tanks, basins or pond-based cultivation systems. However, land-based cultivation systems are especially challenged by their dependence on the massive intake of seawater and the distinctive fixed and variable costs for construction, operation and maintenance. Consequently, tank cultivation requires high power inputs and the use of expensive materials and equipment and is, if not operated effectively, in most cases too costly and inappropriate for commercial-scale production of seaweeds.

Thus, to enable that the emerging seaweed market can compete with terrestrial crops, cost-efficient methods for a sustainable large-scale production of *Ulva* biomass were required. This is especially true for Northern Hemisphere cultivations where irradiance and temperature regimes strongly fluctuate.

With our innovation of transferring the cultivation of sea lettuce into the ocean we offer a unique and novel technology in *Ulva* aquaculture, with which seaweed farmers are able of producing large quantities of high-value and sustainable *Ulva* biomass.

By strain selection, development of seeding technologies, and optimizing hatchery conditions, best performing crop strains of *U. fenestrata* were investigated and sound cultivation protocols for off-shore rope cultivation of *Ulva* were developed. Further, the combination of efforts made on seedling hatcheries, biochemical assessments of the off-shore produced biomass, and the optimization of harvesting schedules enabled us to establish a closed life-cycle aquaculture of *U. fenestrata*.

The developed protocols are publicly available in order to transmit the obtained knowledge to the rapidly emerging European seaweed aquaculture sector, and they are already successfully being used by commercial companies.

Find the developed methodology e.g. here: <https://www.mdpi.com/2077-1312/9/6/615/htm> ; <https://www.frontiersin.org/articles/10.3389/fmars.2022.816890/full>

What special new advantages does your innovation bring in terms of for example commercial, environmental and social factors? (ca. 400 words)

Commercial value: With our developed innovation “Off-Shore-Ulva” we opened the possibility of farming *Ulva* on an industrial large-scale in the ocean. Especially start-ups in the seaweed aquaculture market will profit from this innovation, as it keeps maintenance costs in comparison to on-shore farming at a relatively low rate. Furthermore, the possibility of large-scale biomass production increases the possibility for commercial companies to compete with already existing crop systems. To fill this with numbers, in our 2 ha test farm at the University of Gothenburg we were able to achieve an average amount of 1.8-2 kg m⁻¹ rope of high-value *Ulva* biomass which corresponds to 5-7 tons per ha (test site) – biomass which is suitable in the food, feed, and biomaterial sectors as we can show by detailed biochemical profiling.

Environmental value: The sustainable production and cultivation of *Ulva* biomass in the ocean contributes to a good environmental health status of our strongly pressured oceans. The cultivation of *Ulva* in the ocean is not depending on scarce fresh water sources, no fertilization is needed and the photosynthetic active seaweeds produce important oxygen while simultaneously accumulating CO₂, nitrogen and phosphorous, and by the provision of semi-natural seaweed habitats it has been shown that the cultivation of seaweeds in the ocean furthermore supports a stable biodiversity.

Social value: A central, recurring, and utmost important issue of the 21st century is the urgent need for new, sustainable future resources to supply a constantly growing world population. The necessity of the provision of renewable and novel materials and nutritious food sources – especially vegetarian and vegan protein – was emphasized by the United Nations Sustainable Development Goals (SDGs). The by us developed techniques offer a crop species that can compete with existing crop systems and can contribute urgently needed fine chemicals and simultaneously functions as valuable protein source. Currently, the vast portion of food production comes from terrestrial agriculture, however, trends of crop yields predict an insufficient production growth by 2050 to cover food demands. Therefore, the developed technique clearly addresses the sustainability goals 1. Zero Hunger and 14. Life below water. Predictions for future agricultural expansion emphasize that aquaculture, especially mariculture, remain the only viable alternative for extensive growth of global food production and we are convinced that our innovation can vastly contribute to reach the goal of establishing more sustainable seaweed crop systems.

For which market and target group was your innovation mainly developed? Who is likely to be the key customer group? (ca. 200 words)

The most obvious target group which profits from our innovation is the European seaweed aquaculture sector and here especially seaweed farmers. However, the off-shore produced sea lettuce biomass contains a large number of high-value compounds which makes it suitable for a wide range of applications. Besides being commercially exploited by traditional markets of food, the biomass can be used as animal feed to improve health and productivity and the cell components of *Ulva* can be additionally used in the biomaterials sector. That the off-shore produced biomass is suitable in different sectors and has great down-stream potential for the valorisation of different compounds has therefore been intensely studied by us and underlines the circularity of the here displayed innovation.

Please give very briefly 3 reasons why you believe your innovation should win the Seagriculture 2022 Innovation Award:

Our innovation “Off-Shore-Ulva” should win the Seagriculture 2022 Innovation Award because:

- The of-shore cultivation of *U. fenestrata* in Europe could be a game changer for the emerging seaweed aquaculture sector as it provides publicly available techniques for the sustainable exploitation of urgently needed circular future resources at a relatively low cost.
- Our innovation “Off-Shore-Ulva” is built on a sound research base which takes into account the development of a full-life cycle aquaculture that saves natural seaweed stocks and contributes a sustainable and ecosystem friendly crop system from the seedling hatcheries to optimal harvest schedules.
- The availability of knowledge that was established by the “Off-Shore-Ulva” innovation needs to be spread among the European seaweed farmers, and the Seagriculture Innovation Award will help to reach this goal.





