Integrated Multi-Trophic Aquaculture of Mussels (Mytilus edulis) and Seaweed (Saccharina latissima) in the Western Baltic Sea

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Increasing demand for seafood in a situation of stagnating traditional fishery makes aquaculture a sector of immense growing potential for seafood and biomass production. Associated ecological problems, like eutrophication of coastal ecosystems, have fostered the development of sustainable aquacultural techniques. Presently, Integrated Multi-Trophic Aquaculture (IMTA) is the most promising approach of environmentally friendly aquaculture. In IMTA systems, traditional finfish culture is combined with extractive organisms like algae and shellfish. Hence waste of one species is turned into a value for another, creating a positive mutual and environmental effect among the associated farm components.

Aquaculture in the Baltic Sea faces challenges like reduced salinity, low current velocity and eutrophication. Hence, potential species for Baltic aquaculture need to be adapted to local environmental conditions. As blue mussels (Mytilus edulis) and sugarweed (Saccharina latissima) are endemic and exhibit good growth rates in the western Baltic Sea, they represent potential candidates for Baltic extractive aquaculture. However, as both species are not occurring naturally in close vicinity, there are reasons to suspect their solely positive mutual relationship.

This study observed the species interaction in different development stages of shellfish (Mytilus edulis) and seaweed (Saccharina latissima) in an integrated system, and the respective species potential for extractive aquaculture in the western Baltic Sea.

Chapter I, this preliminary, introducing part of the thesis presents the results of a case study about a commercial IMTA in the Kiel Fjord, where mussel cultivation (Mytilus edulis) was implemented in an already existing seaweed (Saccharina latissima) farm. Mussels from the Kiel Fjord were not polluted and algaetoxins were not observed during the project. The microbial quality of the shellfish water was classified as “A” during major harvesting season. Therefore mussels are sold fresh for human consumption and seaweeds as raw material for cosmetic. Both organisms are certified organic.

In Chapter II general criteria for the integrated aquacultural potential of M. edulis and S. latissima in the western Baltic Sea were evaluated. Biological key criteria like growth and condition of organisms are important parameters determining the success of the aquacultural production. In a brackish system like the Baltic Sea, lower growth rates and poor condition due to reduced salinity and hence permanent osmotic stress were expected. Therefore growth and biomass production of seaweed (S. latissima) and mussels (M. edulis) were determined monthly in a monitoring study at four locations in the Kiel Bight (Baltic Sea) from October 2010 until May 2011. Seaweed growth performance and biochemical composition strongly depended on location. Mussel shell growth was comparable within sites, but shellfish condition indices reflected regional differences. Besides local characteristics, species exhibited a different sensitivity to the specific brackish Baltic Sea

conditions. Whereas mussel growth and condition was comparable to more saline regions, seaweed production was reduced. Nevertheless, the potential of both species for extractive aquaculture is high, concerning the retention of nutrients in eutrophic coastal waters of the Baltic Sea.

Chapter III exhibited ecological insights into seaweed / mussel interaction in integrated aquaculture, thereby focussing on the period of mussel larvae settlement. Settlement and survival of mussel spat are the most crucial factors determining the success of mussel production. As Mytilus larvae are known to avoid the vicinity of Saccharina latissima, the seaweed was suspected to deter mussel larvae from settling in integrated aquaculture. Therefore the settlement of mussel spat (M. edulis) was observed if associated with young and adult seaweed specimens (S. latissima), and seaweed crude extract at two locations in the Kiel Fjord (Baltic Sea) in different water depths.

During this investigation, mussel larvae abundances were high and juvenile mussels settled all over the observed water column. The intensity of settlement was influenced by algae abundance and changed within water depths. Seaweed and seaweed crude extract exhibited a negative effect on mussel settlement in the beginning of the study. However, this repellent effect was reversed for young seaweed specimens after four weeks, resulting in an enhanced mussel settlement. According to the results of this investigation, the aquacultural farm design needs to consider a possible negative impact of seaweed on mussel settlement. Hence, seaweed cultivation components need to be placed downstream in the farm to avoid reduced bivalve larvae settlement.

In Chapter IV, the impact of mussels on early nursery stages of seaweeds were observed. The excretion of dissolved nutrients as well as the depletion of competing phytoplankton by mussels was suspected to enhance seaweed growth and development. The cultivation of S. latissima generally requires two production phases: hatchery phase in tank culture and grow out phase in the sea. Both production periods were evaluated with and without mussels.

The presence of mussels resulted in significantly more large multicellular sporophytes after lab phase. This supporting effect of mussels on seaweed growth was still visible after six months of field exposure, resulting in a higher biomass, higher carbon content and larger size of sporophytes that were combined with mussels during the hatchery period. Nevertheless, in the field mussels culture ropes caused a shading effect and a significant mechanical stress, resulting in a substantial loss of sporophytes in the direct vicinity of mussel culture ropes. The results of this investigation suggested a positive effect of shellfish on early life stages of S. latissima during hatchery, thereby enhancing algal production in the following grow out phase in the field. Consequently, the use of mussels as a biological fertiliser is a sustainable approach to produce seaweed in a shorter time period, at low cost, and with the possibility to be certified organic.