Green Aquaculture INtensification in Europe (GAIN)

Cornelia Kreiss[1,2], Imke Edebohls[1,3], Simone Brüning[1], Ralf Döring[1]

- **The overall project objective was the support of ecological intensification of aquaculture in the European Union (EU) to improve competitiveness and sustainability of EU aquaculture creating added value through quality**
- **The Thünen Institute of Sea Fisheries was responsible for economic analyses of specific innovative eco-intensification strategies in aquaculture and down-stream production systems.**
- **Several of the intensification strategies, like valorisation of mortalities, fish sludge or fish by-products, algae aquaponic production from smolt waste water or the shortening of carp production within a recirculating aquaculture system, showed positive benefit-cost ratios.**

Background and aims

The GAIN project was designed to support the ecological intensification of aquaculture in the European Union (EU) and the European Economic Area (EEA), with the dual objectives of increasing production and competitiveness of the industry, while ensuring sustainability and compliance with EU regulations on food safety and environment.

The Thünen Institute of Sea Fisheries was responsible for the economic analysis of specific innovative eco-intensification strategies in aquaculture production systems. Such innovative strategies were, for example, the valorisation of side-streams, fish by-products, the introduction of novel feeds or shortening of carp production cycle.

Approach

The assessment of the economic viability of eco-intensifying innovations in production systems were analysed by applying the typical farm approach from the *agri benchmark* network. Further, good example farms were used as baseline for cost-benefit (CB) analyses for specific cases such as aquaponic systems. Input-output economic analyses were applied for innovations concerning downstream industry such as the processing industry.

Farm datasets defined within the project:

- Typical Norwegian salmon grow-out farm for the region Nordland updated for 2019 and utilised for the calculation of novel feeds and valorisation of mortalities.
- Adaptation of typical farm data collection categories to smolt. Typical smolt farm or a reduced set of data to estimate costs and benefits of the valorisation of mortalities, fish sludge and an uncoupled open water aquaponic system producing sea lettuce (*Ulva lactuca*).
- Modelled turbot example farm based on expert knowledge and literature utilized for novel feed CB analysis.
- Example Polish carp farm for Western Pommerania utilised for the aquaponic calculation of a RAS system for carp production shortening the production cycle.

Cost-benefit (CB) analysis:

For all calculations, the characteristics of the respective production systems (or farms in some cases) were finalised and utilised for the analysis of changes in production processes (e.g. usage of novel feeds), respectively utilisation of by-products, sludge, mortalities, or nutrients for production of algae (aquaponic), mostly for a set of different species.

Key findings

Side streams:

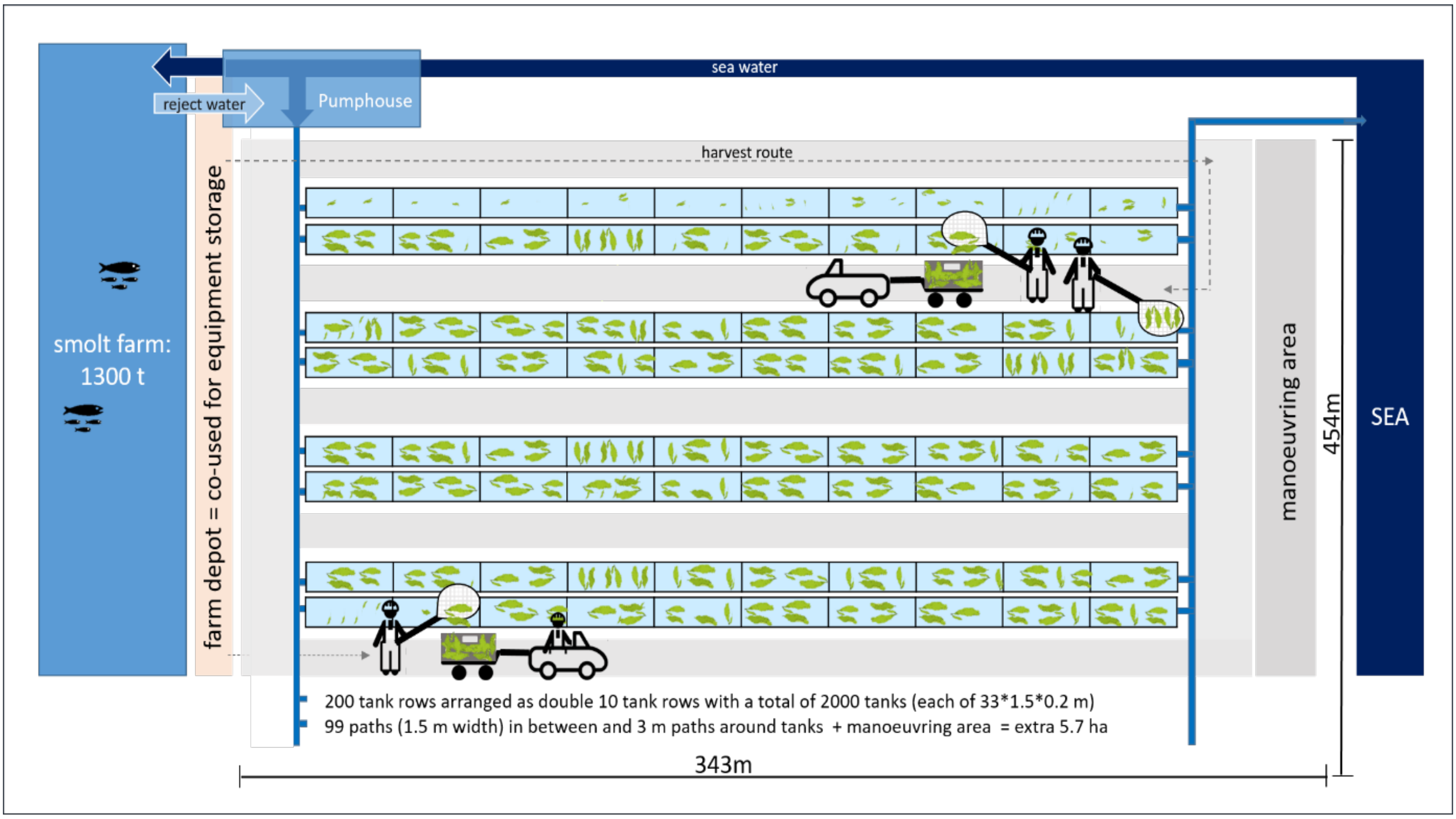
- Completion of the calculations for two aquaponic systems: Production of sea lettuce (*Ulva lactuca*) utilizing smolt wastewater within an open decoupled system (profitable in the long-term) and for a Polish example carp pond farm a shortened Recirculating Aquaculture System (RAS) with production of *Nasturtium officinale* (profitable in the long-term).
- Shells as bio-filter material: Two CB analyses for use of mussel shells as bio-filter material (both examples reveal mussel shells to be more cost-effective than plastic material when run for a period of three years);
- Valorisation of mortalities: CB analyses conducted for several valorisation scenarios for drying of dead fish ("*Waister*" dryer) in a salmon grow-out farm (only pet food with higher returns than today's practice of ensilage) and smolt production (all three alternative valorisation scenarios are delivering higher returns than today's practice of ensilage).
- Sludge valorisation: Calculation finalised on changes in short-term and mid/long-term profits under six scenarios for sludge drying with two different drying systems and

three marketing options (Biofertiliser plant, Cement factory and Biogas plant).

Novel feeds:
CB analyses were conducted for salmon, turbot, seabream, seabass and trout production. Results showed that novel feeds that were promising from a growth performance perspective (NOPAP feeds) were in most cases economically unfavourable. Only for turbot, the NOPAP30 feed resulted in increased profits.

By-products:
Comparative economic analysis on industry scale for various by-products from all GAIN species for two scenarios for the purchase price of fish by-product raw material were calculated for a theoretical processing facility located in Northern Germany. This was assessed for fish gelatin, fish protein hydrolysate, peptones and lactic acid bacteria. In general, comparing the processes examined for economic viability, especially the utilization of fish-by products for processing of dry peptones and liquid peptones with subsequent utilization as growth media for lactic acid bacteria are promising. The profitability of processing Fish protein hydrolysate is depending predominantly on the by-product type and the valorization of fish by-products into gelatin did not prove to be profitable in the current input-output analysis.

Sketch of sea lettuce (*Ulva lactuca*) grown in a mix of smolt waste water (30%) and seawater (70%) as downstream production system of a smolt RAS system (1300 t annual production) in Nordland, Norway.



Further Informationen

[1] Thünen Institute of Sea Fisheries
www.thuenen.de/en/sf

[2] Thünen Institute of Fisheries Ecology
www.thuenen.de/en/fi

[3] Thünen Institute of Farm Economics
www.thuenen.de/en/bw

✉ cornelia.kreiss@thuenen.de

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