Approaches to Tackle Emerging Challenges in European Aquaculture

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Abstract
The word demand for fish is increasing. Whilst on one hand, fishing is carried out in a not sustainable ways in the main fishing areas (e.g., overexploitation of natural stocks, remarkable fuel and energy consumption), on the other hand, aquaculture, above all when not performed inland, involves environmental concerns related to the emissions of pollutants in the sea, low resource efficiency and the high consumption of chemicals. Thus, aquaculture should aim to reduce its environmental impact and to produced fish and seafood in a circular economy perspective. This contribution focuses on different approaches to tackle two environmental issues related to aquaculture in Europe: 1) the reduction of impact due to aquaculture farming of edible species and 2) the improvement of the farming of a cleaner fish species to reduce the overexploitation of natural stocks and to solve the dramatic problem of sea lice in Atlantic salmon farming. The first approach aims at developing self-sufficient multi-trophic systems for inland aquaculture in Mediterranean areas. The second approach aims at optimizing the farming of the lumpfish that is used in sea net pen as a killer of salmon sealice. The description of the planned approaches and preliminary results of the SIMTAP (Self-sufficient Integrated Multi-Trophic AquaPonic) project and lumpfish aquaculture, including future challenges and research directions, are reported.
Keywords: Aquaculture, salmon, environmental impact, multi-throphic system

1. Introduction

Among the sustainability concerns that humanity has to face, the most serious sustainability deficit is the ecological debt, which is running up due to the overuse and depletion of natural resources. Today humanity is using the equivalent of 1.7 Earths. Regarding fish supply, from 1960 to 2016, the world demand for edible fish products increased from 9.9 kg to 20.0 kg per capita per year and reached 171 Mtons. This value outpaced population growth and even exceeded the value of food consumption deriving from meat from all terrestrial animals' production (FAO, 2018). The supply is no longer sustained by fisheries, which remained stable for more than 10 years at around 90 million tons, but by aquaculture production, which increased by an average of 8.8% per year (1980-2010). Considering that the 60% of fish stocks are overexploited while 90% is fully exploited, aquaculture can be an effective solution to reduce overfishing while meeting the increasing demand of seafood. In this regard, the role of food production is remarkable; animal-based food has high land-use and carbon footprint and the growing demand for meat and seafood puts significant pressure on terrestrial and marine ecosystems (FAO, 2018).
In this context aquaculture, both on sea than in-land, can play a relevant role to meet the increasing demand of seafood but, on the other side, has to face serious environmental concerns related to the use of pesticides, the emissions of organic pollutant in the water bodies and the increasing demand of unsustainable feed ingredients (i.e., fishmeal), disease transmission, dispersal of non-native species and destruction of habitats.
This contribution focuses on different approaches to tackle two environmental issues related to aquaculture in Europe. The first approach focuses on the development of in the project SIMTAP aims at developing self-sufficient multi-trophic systems for inland aquaculture in Mediterranean areas. The second approach regards salmon aquaculture in Norway and to reduce the overexploitation of natural stocks and to solve the dramatic problem of sealice in Atlantic salmon farming.

2. The SIMTAP project

The Project SIMTAP (Self-sufficient Integrated Multi-Trophic AquaPonic) has been funded by the PRIMA (Partnership for Research and Innovation in the Mediterranean Area), is led by the University of Pisa and started on June 2019. The SIMTAP's concept relies on a self-sufficient integrated multi-trophic

aquaponic system combining saltwater hydroponic production in greenhouses and in-land aquaculture. SIMTAP can re-use brackish water from open-loop hydroponics, in a cascade effect recycling the nutrients. The project moves from the IMTA approach towards an innovative self-sufficient integrated multi-trophic aquaponic system for small scale, labour-intensive and environmentally-friendly marine fish and halophytic plants production adapted to the typical socio-economic and climatic condition of Mediterranean areas.

The main goal of SIMTAP is to define, design, set up and test an innovative food production system that drastically reduce, on one side, the required fish feed inputs (e.g., fishmeal, fish oil, soybean, etc.) and the consumption of resources (water, energy), and, on the other side, the production of waste and pollution, decreasing the Life Cycle impact on the environment of this segment of the food industry. Moreover, SIMTAP can be coupled with the re-use of the effluents from greenhouse soilless cropping systems, in a cascade effect acting both as a bioremediation of wastewater (run-off) from greenhouse cultivations, and as a recycling of the nutrients still contained in the same wastewater, thus helping the SIMTAP cycle. Besides, the water source can be either brackish or marine.

The project aims to evaluate the effectiveness and performance of SIMTAP systems in terms of food production and use of energy, water and other resources. Life Cycle Assessment (LCA), analysis of energy consumption and emergy assessment of SIMTAP will be performed to quantify and compare the potential environmental impacts with the conventional hydroponic and aquaculture systems.

3. Control Of Sea Lice In Atlantic Salmon Farming

Infestations by the salmon louse (*Lepeophtheirus salmonis* Krøyer) represents the major fish health problem that the Atlantic salmon (*Salmo salar*) industry has to face. This ectoparasite grazes on the skin and mucosal tissue of fish, causing infections, osmotic stress and death of the fish (Johansen et al., 2011). Sea lice infestation has a large impact on the economy of fish farmers so due to costly treatment procedures, reduced growth, increased feed wastage and reduced market quality of the final product. The salmon aquaculture industry has been struggling with the issue of sea lice for many years and is looking for a cost-effective and environmentally sustainable alternative to chemical or mechanical treatments. The biological control of sea lice using 'cleaner fish' has been individuated as a feasible, alternative and sustainable method of parasite control in Atlantic salmon aquaculture. The use of cleaner fish is particularly attractive because it can reduce the use of chemotherapeutants, may be more cost-effective than medicating and potentially less stressful to farmed fish. In recent years, the lumpfish (*Cyclopterus lumpus*) has been individuated as a suitable species for biological delousing of Atlantic salmon (Imsland et al., 2014). Commercial production of lumpfish is topical in aquaculture and has raised exponentially in the last few years because of recent findings on the effectiveness of this species in delousing also in harsh environmental conditions (e.g. low water temperature). At present, nearly all the lumpfish used as cleaner fish in salmon farming industry come from wild parents, which after being used as breeders are sacrificed, affecting natural populations. Hence, to limit the use of wild breeders and to keep pace with the growing demand of lumpfish required for sea lice control, the aquaculture industry is looking for new methods to breed lumpfish. The main challenges that lumpfish industry has to face concern the better control of maturation for year-round production, formulation of appropriate diets, artificial selection of elite lines with desirable traits and development of vaccines for disease-free juvenile production, as well as the welfare of farmed lumpfish including the definition of optimal densities and tank design. Lastly, the risk of farmed lumpfish escaping from net pens needs to be critically assessed.

4. Conclusions

Considering that aquaculture is the fastest growing food production industry and that the quantity of aquaculture products directly consumed is now greater than that resulting from conventional fisheries, the development of innovative, less environmental impactful and sustainable rearing activities represent the priority for aquaculture industry.

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