BOOK OF ABSTRACTS

14th International Conference

LCA FOOD 2024

HEALTHY FOOD SYSTEMS FOR A HEALTHY PLANET

8 – 12 September, Barcelona, Spain

ORGANIZED BY:

98

Navigating the environmental impacts of Manila clam production chains starting from wild and hatchery-produced seed

Arianna Martini[1], Riccardo Napolitano[1], Fabrizio Capoccioni[1], Marco Martinoli[1], Nicolò Tonachella[1], Domitilla Pulcini[1]

[1]Consiglio per la Ricerca in Agricoltura e l'Analisi dell'Economia Agraria (CREA) - Centro di ricerca "Zootecnia e Acquacoltura", Via Salaria 31, 00015 - Monterotondo (Rome) - ITALY
E-mail contact address: arianna.martini@crea.gov.it

1. INTRODUCTION

Italy is the world's second-largest producer of Manila clam (*Ruditapes philippinarum*) from aquaculture (23 thousand tons worth 212 million euros in 2021). Manila clam production volumes have begun to decline over the past 10 years in part due to a decreased availability of wild seed that clam farmers rely on. This has led Italian farmers to purchase seed from hatcheries. The Manila clam supply chain based on hatchery seed brings benefits to farmers, ensuring continuity of production, but with higher production and environmental costs. As the supply of wild seed is expected to decline further due to the effects of climate change and habitat degradation, it is important to evaluate the environmental impacts of current production chains (wild seed and hatchery-based seed), to identify the hotspots and possible strategies to contain the impacts. The study also sought to consider the unique ecosystem services of bivalve, that is the potential carbon storage via shell formation resulting from the balance of the carbon deposited as $CaCO_3$ into the shell and the CO_2 released during the same process.

2. METHODS

Two case studies of Manila clam production were investigated by applying the Life Cycle Assessment (LCA) methodology (CS-A, CS-B). CS-A refers to a conventional production chain that relies on wild spat collection. CS-B refers to the production chain dependent on hatchery seed. The following processes have been considered: 1) seed procuring (from the wild or hatchery), 2) growth-out phase, and 3) depuration. The Functional Unit was 1 kg of clam, shell included. A mass allocation principle was applied. Foreground data were collected through questionnaires and interviews with the technical personnel. The Ecoinvent 3.9.1 database was used to gather background data. The Life Cycle Impact Assessment (LCIA) was carried out using SimaPro 9.1.0.7 (PRé Consultants), adopting the ReCiPe 2016 (H) method. A scenario analysis covering three possible situations was carried out for CS-B to evaluate possible mitigation strategies. To estimate carbon flows associated with shell formation (i.e., oceanic carbon storage and CO_2 released through biocalcification), the following equations were used [1, 2]:

- Oceanic carbon storage= $CaCO_3$ mass shell × (CO_2 molecular mass/ $CaCO_3$ molecular mass)
- Released CO_2= shell mass × Ψ × % $CaCO_3$ shell × (CO_2 molecular mass/ $CaCO_3$ molecular mass), where Ψ is the ration of CO_2 released/$CaCO_3$ precipitate, assumed to be 0.6.

Navigating the environmental impacts of Manila clam seed production
in hatcheries: combining innovation with resources' recovery

Sustainability in fisheries and aquaculture systems

848

3.   RESULTS AND DISCUSSION

The LCIA results for the two case studies are shown in Table 1. In CS-A, the phase that contributed the most to all the impact categories is the combined wild seed supply and growth-out phase (63-87% contribution). For CS-B, the hatchery seed production represented the main driver of FE and ME (about 56-57%), while the growth-out phase predominately affected GW (66%), HT (43%), and FS (64%). Depuration was the phase that contributed the least in both CS-A and CS-B. Fuels, electricity, and antifouling paint were the inputs that contributed most to the environmental impacts in the different chain segments of the two case studies. The scenario analysis carried out for CS-B demonstrated that switching to electricity from renewable sources and reducing fuel use during the rearing phases (e.g., through boat electrification) would substantially reduce GHG emissions (up to -6% and -47%, respectively). Finally, the computation of carbon flows associated with biocalcification is shown in Table 2.

4.   CONCLUSIONS

For the first time, a Manila clam production chain entirely based on seed produced in a hatchery was analysed through LCA, together with a conventional production chain. Given the expected decline in wild spat seed availability, this is the first attempt to design the sustainable clam production chain of the future. In addition, the case of the Manila clam is one example of how the peculiar ecosystem services offered by bivalve aquaculture are not adequately defined and integrated into LCA methods. Further efforts of the research community are required to develop standard methods to fill this gap.

5.   ACKNOWLEDGMENTS

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Navigating the environmental impacts of Manila clam seed production
in hatcheries: combining innovation with resources' recovery

Sustainability in fisheries and
aquaculture systems

849

3/3

Table 1. Life Cycle Impact Assessment for the three case studies.

Impact category	Unit	CS-A	CS-B
Global warming (GW)	kg CO_2 eq.	0.854	1.052
Freshwater ecotoxicity (FE)	kg 1.4-DCB eq.	0.026	0.051
Marine ecotoxicity (ME)	kg 1.4-DCB eq.	0.034	0.065
Human carcinogenic toxicity (HT)	kg 1.4-DCB eq.	0.025	0.032
Fossil resource scarcity (FS)	kg oil eq.	0.256	0.310

Table 2. Computation of the carbon flows occurring during shell formation.

Case study	CS-A	CS-B
CO_2 released by biocalcification (kg CO_2 kg^{-1} clams)	0.154	0.144
Stored oceanic carbon in shells (kg CO_2 eq. kg^{-1} clams)	0.240	0.229

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850

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99

Can the transition from mono- to polyculture reduce aquaculture environmental footprint? An LCA approach proposed within the BLUEBOOST project

Arianna Martini[1], Fabrizio Capoccioni[1], Domitilla Pulcini[1], Markus Langeland[2], Yannic Wocken[2], Neil Duncan[3], Friederike Ziegler[2]

[1]CREA - Centro di ricerca "Zootecnia e Acquacoltura", Via Salaria 31, 00015 - Monterotondo (Rome), Italy; [2]RISE Research Institutes of Sweden, PO Box 5401, 402 29 Göteborg, Sweden
[3]IRTA La Rápita, Ctra. Poble Nou km 5.5, La Rápita, Tarragona, Spain
E-mail contact address: arianna.martini@crea.gov.it

1. INTRODUCTION

The increased intensive aquaculture production of recent decades raised concerns about its environmental effects, i.e., decreased water quality, depletion of natural resources, and greenhouse gas emissions. Aquaculture impacts are, however, frequently lower than those of other foods derived from animals [1]. Integrated Multi-Trophic Aquaculture (IMTA) combines fed aquaculture (e.g., fish) with non-fed aquaculture (e.g., shellfish). Its application aims at reducing nutrient and carbon emissions by using a circular approach: the combined production of higher-trophic and lower-trophic species might reduce waste released into the environment and increase the overall productivity of the system. The BLUEBOOST project will develop six monocultures to commercially scaled IMTAs that consider a wide range of low trophic species and environmental conditions. LCA will be used to evaluate and optimize the environmental sustainability of the systems. To date, only a few LCA studies have dealt with IMTAs [2-5], facing some methodological dilemmas related to modelling such multifunctional systems. We discuss possible methodological approaches for the environmental evaluation of IMTA systems.

2. METHODS

The six IMTAs will be developed from existing monocultures by integrating species from different trophic levels (e.g., algae, invertebrates, detritivores and filter feeders, and fish), in both marine and freshwater (Figure 1). Challenges that arise when applying LCA methodology to IMTA systems include complex multi-species functional units, differing production cycles between species, and species having different needs in terms of material and energy inputs, which can be difficult to separate. An additional challenge will be providing a comprehensive picture of all aspects that contribute to increased circularity in aquaculture systems (e.g., product and waste circularity, nutrient and carbon charges), which are often not investigated by LCA applied to animal production. LCA will be used to first assess the impacts of the monocultures, and then quantify the effects and improvements of integrating low-trophic species in the implemented IMTAs. Finally, principles for upgrading an experimental case study into an optimized commercial production will be developed.

Can the transition from mono- to polyculture reduce aquaculture environmental footprint? An LCA approach proposed within the BLUEBOOST project

Sustainability in fisheries and aquaculture systems

851

3. RESULTS AND DISCUSSION

The BLUEBOOST project poses some methodological issues and offers the opportunity for the development of various LCA approaches. The first choice is the functional unit, which has to consider the diverse co-products and their intended use (e.g., food, feed). Different approaches include multiple functional units for different co-products or a single unit for all (e.g., wet weight, protein content, or monetary value of the products). Second, the different production cycles of co-farmed species and their material and energy needs must be screened. Third, the allocation principle adopted. The pros and cons of such methodological choices will be weighed. The expected outcomes of the project will include the environmental footprint assessment of the monoculture and implemented IMTAs, as well as their Life Cycle Inventory. The impacts delivered by BLUEBOOST will hopefully aid the transition towards climate-neutral and sustainable aquaculture.

4. CONCLUSIONS

BLUEBOOST would fill knowledge gaps that exist in the conceptual development, practical implementation, and regulation of IMTAs.

5. ACKNOWLEDGEMENTS

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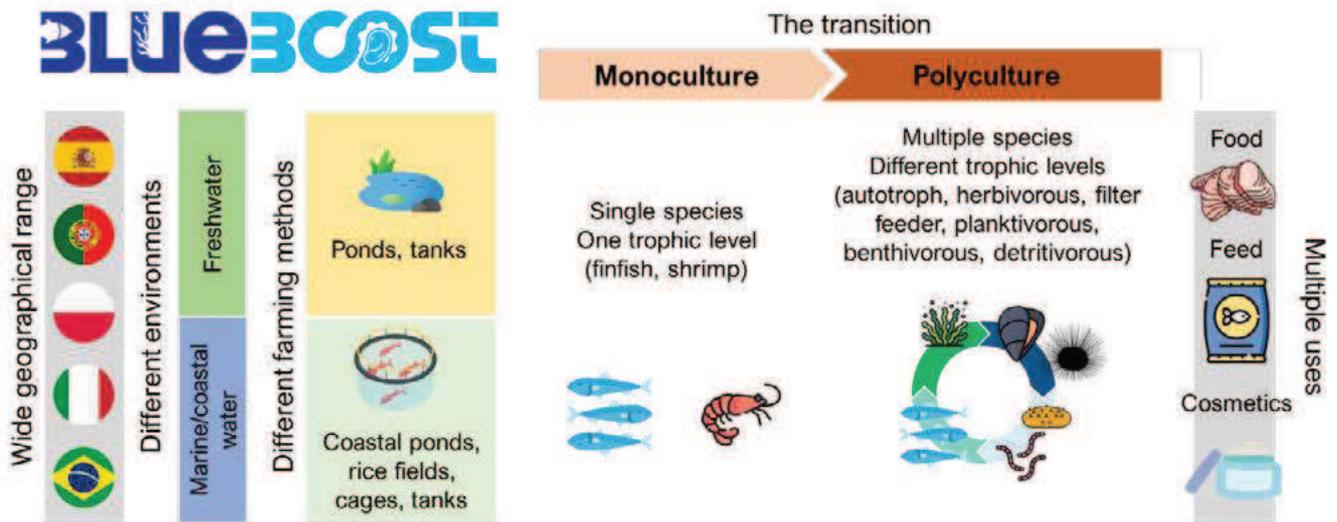
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852

Figure 1. Transition from mono- to polyculture systems

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and aquaculture systems

885

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112

Sustainability of luxury food: LCA of sturgeon caviar and meat

Riccardo Napolitano[1], Arianna Martini[1], Marco Martinoli[1], Domitilla Pulcini[1], Nicolò Tonachella[1], Fabrizio Capoccioni[1]

[1]Consiglio per la Ricerca in Agricoltura e l'Analisi dell'Economia Agraria (CREA) Centro di ricerca "Zootecnia e Acquacoltura" Via Salaria, 31, 00015 - Monterotondo (Roma) - ITALY

E-mail contact address: riccardo.napolitano@stir.ac.uk

1. INTRODUCTION

Italy is the leading producer of caviar from aquaculture in Europe (62 t in 2022, 35% of the European production; Eurostat, accessed on 20/05/2024). The caviar production chain is complex and characterized by great temporal variability depending on species. Males and females are initially grown without producing any profitable commodities because of late sex determination (3-8 years). Then, males are slaughtered for meat production, while females are farmed up to 8 to 18 years old when eggs are suitable for caviar production. Despite the large body of studies on the environmental impact of agri-food supply chains, the caviar production chain has never been assessed. To fill this gap, the first comprehensive Life Cycle Assessment (LCA) of aquaculture caviar production was carried out to evaluate its environmental impacts associated and suggest possible mitigation strategies.

2. METHODS

The LCA methodology was used to assess the impacts associated with the production cycle of caviar from four different species of sturgeon: Siberian sturgeon (*Acipenser baerii*), Russian sturgeon (*A. gueldenstaedtii*), white sturgeon (*A. transmontanus*) and beluga (*Huso huso*), farmed in a facility in northern Italy. The following phases of the production chain were identified: (1) hatchery, (2) pre-fattening, (3) mixed fattening of males and females, (4) fattening of females, (5) transport, and (6) processing and packaging of caviar and meat. The functional unit (FU) was 1 kg of caviar. The reference flow was the production of 1 kg caviar and associated meat mass (average 5.9 kg meat kg-1 caviar). The economic allocation principle was applied. For the Life Cycle Inventory (LCI), foreground data referred to one year of production (season 2022/23) were provided by farmers through questionnaires and interviews. The Ecoinvent 3 database was used to gather background data. The Life Cycle Impact Assessment (LCIA) was carried out using the software SimaPro 9.5.0.1 (PRé Consultants), adopting the ReCiPe 2016 Midpoint (H) v.1.08 method and considering the Global Warming impact category. Scenario analyses were also performed to unveil the effects of possible mitigation strategies. The first scenario simulated a 30% and 50% increase in solar energy supply. The second scenario foresaw a reduction of feed use through the removal of male sturgeons at an earlier stage of the production chain by genetic sex determination (Kuhl et al., 2021).

3. RESULTS AND DISCUSSION

Results showed high variability depending on the species, due to differences in terms of caviar price and time necessary to obtain it. Caviar-associated emissions ranged between 52 and 76 kg CO_2 eq. kg^{-1} of caviar, while sturgeon meat varied between 4.8 and 10 kg CO_2 eq. kg^{-1} of caviar (Table 1). The fattening phase (both mixed-sex and only female fattening) is that contributing the most, representing about 78% of the total emissions, while hatchery and pre-fattening contribute always less than 6%, transport and processing 7% and 9%, respectively (Figure 1). The main hotspots of the supply chain were feed and electricity and the scenario analysis showed that Climate Change-related impacts could be reduced by up to 18% through feed reduction and up to 19% by the energy shift (depending on species).

4. CONCLUSIONS

This study represents the first LCA of caviar and sturgeon meat production. Impacts associated with sturgeon fillet production are in line with fillets from other farmed species, while the impacts of caviar production cannot be compared with any other product of the aquaculture industry. Furthermore, due to the long-timescale needed for caviar production, it is crucial to develop strategies to contain the impacts associated with feed use, such as the recent advances in genetic sex determination that could allow an early selection of females, thus reducing feed use for males.

5. ACKNOWLEDGEMENTS

6. REFERENCES

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Table 1. Results of LCIA in the category Climate Change, divided by species and products. Results referred to the FU of 1 kg caviar.

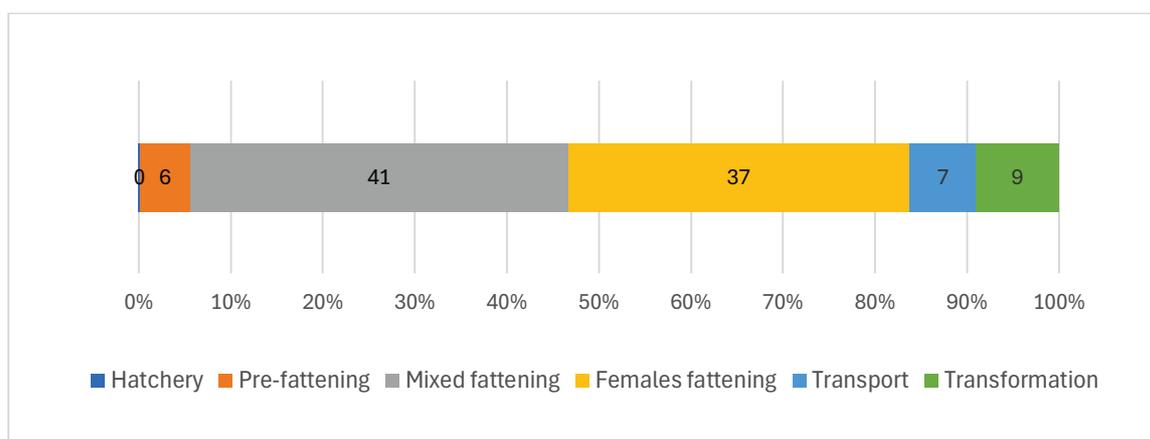| Impact Category	Unit	Species	Sturgeon Meat		Caviar		
					Caviar (I°)	Caviar (II°)	Total caviar
Climate change	(kg CO_2 eq.)	Beluga	**4.85**		74.5	0.3	**74.8**
		White	**4.86**		50.1	0.3	**50.5**
		Russian	**8.15**		45.8	0.3	**46.0**
		Siberian	**9.99**		59.9	0.7	**60.6**

Figure 1. Contributions of the caviar production chain processes to the Climate Change impact category. The bar represents average values among the four species.
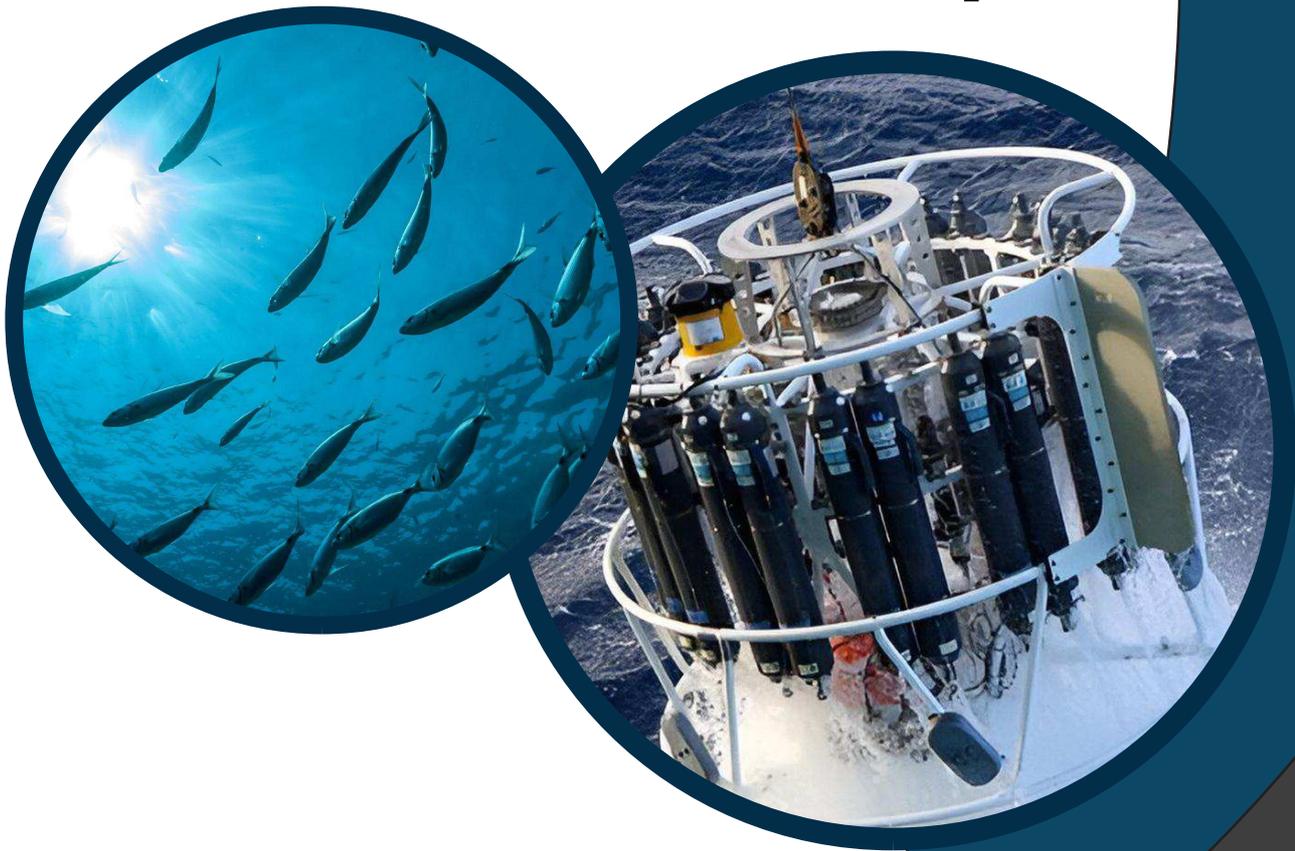
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THE INFLUENCE OF ANTICOAGULANTS ON PERIPHERAL BLOOD STORAGE AND CELL MORPHOLOGY OF RAINBOW TROUT (*ONCORHYNCHUS MYKISS*)

Teresina De Iorio, Martini A, Martinoli M, Pulcini D, Tonachella N and Capoccioni F
Council Of Agricultural Research and Economics, Italy

Abstract:

Background: Hematology is pivotal in monitoring fish welfare. To date, no specific guidelines for fish blood sampling and storage conditions, such as the type of anticoagulant or the fixation method to be used, are available. Therefore, there is an urgent need to standardize these procedures in order to avoid or reduce misinterpretation of the morpho-functional results.

Objective: To investigate the impact of three different anticoagulants and two fixation methods on rainbow trout blood cell morphology.

Methods: Peripheral blood from 15 farmed rainbow trout's (400-600 g) was collected from the caudal vein using a 22G needle, sampled into vacutainer tubes containing Li-heparin, K3EDTA, and ACD-A- coated tubes (Beckton Dickinson) and analyzed immediately (fresh) or after 24 hours. Blood smears were fixed in methanol or 4% formaldehyde, stained with hemofast (Mascia Brunelli), and observed under an Axioplan (Zeiss) equipped with a Hayer digital camera.

Results: The data obtained demonstrated that formaldehyde fixation provides the best cell morphology, regardless of the anticoagulant used and storage time. In fresh blood samples, either K3EDTA or ACD- A induced low-rate hemolysis, while Li-heparin caused only Red Blood Cells (RBCs) spherocytosis. After 24 hours from sampling, Li-heparin caused high-grade hemolysis, accompanied by echinocytosis, spherocytosis, teardrop- and sickle-RBCs shape, while K3EDTA induced spherocytosis and schistocytosis. Interestingly, ACD-A-treated samples preserved the initial cell morphological changes with no substantial abnormalities.

Conclusion: Li-heparin showed a minor effect on cell morphology in fresh samples. However, neither Li-heparin nor K3EDTA can be recommended for rainbow trout blood cell preservation, while ACD-A preserves cell membrane integrity without deformations. Although this is only preliminary data, it highlights the effect of different anticoagulants, fixation methods, and storage time on fish blood cell morphology. Further in vitro studies will be carried out also using flow cytometry to understand the influence of anticoagulants on fish blood cell morphology and function.

Biography

Teresina De Iorio is currently working as a research fellow at the Council for Agricultural Research and Economics (CREA), focusing on the impact of prebiotic and probiotic feed in fish immunology. In particular, she works on the development of a microscopy and flow-cytometry multiparametric approach to analyze rainbow trout's innate immune responses subjected to different typologies of endogenous or exogenous stressors. She has recently completed her PhD course, focusing on the impact of aging on mammalian intra- and extra-cellular environments. She developed an age-specific 3D in vitro model, based on the decellularization of tissues, which she exploited to understand the influence of age-associated extracellular matrix changes on several cell functions.