

Editorial

New Perspectives in Sustainable Aquaculture

Caterina Longo ^{1,2,3,*}  and Cataldo Pierri ^{1,2,4} 

¹ Department of Biosciences, Biotechnologies and Environment, University of Bari Aldo Moro, 70125 Bari, Italy; cataldo.pierri@uniba.it

² CoNISMa—National Inter-University Consortium for Marine Sciences, 00196 Rome, Italy

³ IRCCD—Interdepartmental Research Center for Coastal Dynamics, University of Bari Aldo Moro, 70125 Bari, Italy

⁴ CIRSA—Interdepartmental Research Center for Risk Analysis and Management in Health and Environmental Emergencies, University of Bari Aldo Moro, 70125 Bari, Italy

* Correspondence: caterina.longo@uniba.it

The strong growth of the aquaculture industry can represent a serious threat to aquatic ecosystems and requires the development of new strategies to control and minimize the impact of such activities on the structure and function of biological communities.

Historically, aquaculture plants have always been built in coastal areas with reduced hydrodynamics, where the impacts on the macrobenthic communities, both with rocky and soft bottoms, can have dramatic consequences. Solutions to this problem can come from a technical–engineering and ecological–biological perspective.

Hence, this Special Issue aims to collect recent research, both at the laboratory and in-field scale, on innovative aspects aimed at contributing to the environmental sustainability, economic stability, and social acceptability of the aquaculture sector.

In this Special Issue, important contributions have been published on various innovative aspects of aquaculture, from animal welfare obtained through new technological approaches to new productions in the field of fish feed, and to the minimization of the environmental impact through integrated multi-trophic aquaculture (IMTA) of invertebrates and algae as a bioremediation of fish farm waste.

Giangrande et al. [1] describe one of the first attempts at integrated multi-trophic aquaculture (IMTA) in the Mediterranean area, where a set of autochthonous invertebrates and macroalgae are co-cultured in a coastal fish farm of European seabass *Dicentrarchus labrax* (Linnaeus, 1758) and sea bream *Sparus aurata*, Linnaeus, 1758. The innovative IMTA system was developed in the Gulf of Taranto (Mediterranean Sea, southern Italy), a semi-enclosed basin where around the floating fish cages a set of filter-feeder bioremediator organisms (sabellid polychaetas and sponges) coupled with macroalgae were reared in the water column. The promising biomass increase of the reared bioremediator organisms, the ease of cultivation methods and the diversification of valuable by-products for the aquaculture companies represent an interesting tool to exploit this innovative IMTA system. The results obtained open up new sustainable horizons for the growth of the mariculture sector.

Carbonara et al. [2] adopted a multi-parametric approach for the evaluation of the welfare of European sea bass *Dicentrarchus labrax* when fed with different diets: two enriched-organic diets and one conventional diet. To do this, they measured primary, secondary and tertiary stress response indicators. Moreover, they also considered a hepatic microsomal mixed function oxygenase (MFO) system as a functional index in order to assess the possible effects of pollutants through diet. The measured parameters were statistically analyzed (PCA), and those showing significant differences between the diets were subjected to a multicriteria decision analysis (MCDA) by means of a non-structural fuzzy decision support system (NSFDSS), a decision-setting model used for ranking a set alternative on the basis of agreed-upon criteria. The growth performances and physiological welfare obtained in this study support the transition towards organic aquaculture for European sea



Citation: Longo, C.; Pierri, C. New Perspectives in Sustainable Aquaculture. *J. Mar. Sci. Eng.* **2023**, *11*, 1531. <https://doi.org/10.3390/jmse11081531>

Received: 27 July 2023

Accepted: 28 July 2023

Published: 31 July 2023



Copyright: © 2023 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

bass. Moreover, the multiparametric approach outlined a comprehensive overview of the sea bass physiological state, and the PCA followed by the MCDA were found to be useful tools for integrated fish welfare assessment.

Trani et al. [3] in their study explored the potential of polyculture and focused on the use of sponges, which play a fundamental role in organic matter recycling and sustainable biomass production. The research specifically looks at the filtering activity and nutrient release of keratose sponge *Sarcotragus spinosulus* and its potential application in microbial bioremediation. The results show that the sponge efficiently removes *Vibrio parahaemolyticus*, a pathogenic bacterium with implications for human health and aquaculture, demonstrating high retention efficiency. Additionally, the study reveals that the species acts as a source of inorganic nitrogen, facilitating the growth of primary producers and potentially benefiting integrated multi-trophic aquaculture (IMTA) systems. The findings suggest that integrating *S. spinosulus* with traditional mariculture could lead to more environmentally sustainable practices. The sponge's ability to remove harmful particles and potentially reduce the need for antibiotics in aquaculture highlights its potential as a valuable component in IMTA systems. Overall, the study indicates that *S. spinosulus* shows promise as a candidate for bioremediation and sustainable aquaculture practices due to its effective filtering and nutrient recycling abilities.

Garcia et al. [4] describe the stages of gonadal development of the white shrimp *Peneaus schmitti* caught off the coast of Espírito Santo, Brazil, through the macroscopic and histological analysis of their ovaries. They found that specimens of *P. schmitti* captured between March and October 2019 presented five stages of gonadal development. The study allowed the researchers to obtain useful knowledge on reproductive physiology of the white shrimp essential for appropriate stock management and conservation purpose. Furthermore, these are basic aspects that contribute to the development of in-captivity rearing technologies of the species, since this is one of the most promising aquaculture species in Brazil.

In the research conducted by Ashour et al. [5], the effects of the partial or total replacement of fishmeal (FM) with amphipod meal (APM) (*Gammarus pulex*) on different biological and economic indicators of the grey mullet fry (*Mugil cephalus*) have been detected. Among the five formulated diets, that with a 50% ratio of FM/APM (D50) represents the best performing replacement level for grey mullet fry, both on the biological parameters considered (growth performance, feed and nutrient utilization, whole-body composition, histological changes of both liver and intestine) and economic yield. Their results support the utilization of amphipoda meal as a natural renewable alternative protein source for substituting 50% of FM, thus minimizing the pressure on wild fish capture and the environmental impact of aquaculture.

In the study of Zhou et al. [6], Landsat-8 satellite images were employed to investigate the presence of and changes in aquaculture rafts in Haizhou Bay in Lianyungang, Jiangsu Province, China. The methodology involved a combination of edge detection and Hough transform techniques to automatically identify and extract aquaculture rafts, leading to accurate statistical results. The developed method successfully extracted and counted the number of aquaculture rafts accurately, mitigating errors associated with manual calculations or subjective estimations using local aquaculture data. By applying this method to images from 2013 to 2020, the study revealed a four-fold increase in the number of laver breeding rafts over the seven-year period. This growth in laver rafts likely contributed to the rapid expansion of raft frames and the occurrence of *enteromorpha* disasters in Haizhou Bay. Interestingly, the study also highlighted the potential benefits of increasing laver cultivation during its growth cycle, which could effectively reduce seawater eutrophication and positively impact the ecological environment of the sea area.

Longo et al. [7] describe aquaculture as important for food production, but it has negative environmental impacts and faces challenges from aquaculture diseases. Bioremediation, using filter-feeder invertebrates like sponges, has emerged as a promising solution to address pathogen-related aquaculture diseases and water contamination. The study

showed that the demosponge *Hymeniacidon perlevis* filtered and removed bacteria from water, reducing bacterial abundances in the out-flowing water and acting as an efficient bioremediator in a land-based experimental fish farm. Using *H. perlevis* in aquaculture waste treatment is more attractive than other technologies with negative environmental impacts, such as antibiotic-supplemented feeds. The sponge's resilience and the potential marketable value of its biomass make it a promising option for aquaculture facilities. Future studies should explore the bioaccumulation of microbial pollutants in *H. perlevis*, assess its tolerance limits, and investigate its capacity to utilize microorganisms for further bioremediation opportunities in coastal communities. Overall, the research highlights the potential of *H. perlevis* as a valuable bioremediation tool in aquaculture, including in land-based aquaculture plants.

Hjelle et al. [8] in their field study evaluated the effect of a recently developed acoustic lice treatment (AcuLice) on the stress of treated Atlantic salmon *Salmo salar* and the salmon louse *Lepeophtheirus salmonis* dynamics during the large-scale use of a delimiting method. They found that the Atlantic salmon group reared with AcuLice low-frequency sound treatment for one hour in commercial open sea cages showed minor or no acute stress responses compared to the control group without AcuLice treatment. Moreover, the field study showed that the AcuLice treatment had a significant effect on the reduction in the salmon lice load, thus confirming the AcuLice system as an effective method able to reduce the need for traditional salmon lice treatments with no added stress to the fish.

Arduini et al. [9] propose the potential exploitation of the polychaete worm *Sabella spallanzanii* (Gmelin, 1791), obtained as a by-product of an innovative integrated multi-trophic aquaculture (IMTA), as the main component in the formulation of a novel aquarium fish feed. They found that the novel experimental feed tested on ocellaris clownfish, *Amphiprion ocellaris* (Cuvier, 1830), was beneficial, supporting the suitability of *S. spallanzanii* as a viable alternative source of animal proteins and lipids for the fish feed industry, thus suggesting the potentiality to resolve the paradoxical overfishing pelagic fish to produce fish feed.

Aguilo-Arce et al. [10] in their review reveal the potential of sponges as an emerging by-product of integrated multitrophic aquaculture (IMTA) systems. The authors point out, together with their well-known use as bath sponges or as marine bioactive compound bio-factories, the uncommon but sustainable use of such inedible filter feeders as ornamental features or biofilters in aquariums, sponge-based foods for certain aquarium fish species and for restoration purposes.

As Guest Editors of this Special Issue, we would like to extend our deepest gratitude to all the authors who have generously contributed their work to this collection. It has been an absolute honor and privilege to collaborate with such a talented group of researchers, and we are sincerely appreciative of the effort, time, and dedication they have devoted to their submissions. Each article offers a wealth of unique insights and perspectives on sustainable aquaculture, encompassing environmentally friendly, resilient, and competitive approaches.

We have been truly impressed by the exceptional quality of the submissions, as well as the meticulousness and rigor demonstrated by each author. Their valuable contributions have made this Special Issue an outstanding collection, which we firmly believe will be of immense interest and value to readers in the field. Once again, we extend our deepest thanks to all the authors for their invaluable contributions to this Special Issue and for their unwavering commitment to advancing scientific knowledge and understanding in the realm of sustainable aquaculture.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Giangrande, A.; Pierri, C.; Arduini, D.; Borghese, J.; Licciano, M.; Trani, R.; Corriero, G.; Basile, G.; Cecere, E.; Petrocelli, A.; et al. An Innovative IMTA System: Polychaetes, Sponges and Macroalgae Co-Cultured in a Southern Italian In-Shore Mariculture Plant (Ionian Sea). *J. Mar. Sci. Eng.* **2020**, *8*, 733. [[CrossRef](#)]
2. Carbonara, P.; Zupa, W.; Bitetto, I.; Alfonso, S.; Dara, M.; Cammarata, M. Evaluation of the Effects of the Enriched-Organic Diets Composition on European Sea Bass Welfare through a Multi-Parametric Approach. *J. Mar. Sci. Eng.* **2020**, *8*, 934. [[CrossRef](#)]
3. Trani, R.; Corriero, G.; de Pinto, M.C.; Mercurio, M.; Pazzani, C.; Pierri, C.; Scrascia, M.; Longo, C. Filtering Activity and Nutrient Release by the Keratose Sponge *Sarcotragus spinosulus* Schmidt, 1862 (Porifera, Demospongiae) at the Laboratory Scale. *J. Mar. Sci. Eng.* **2021**, *9*, 178. [[CrossRef](#)]
4. Garcia, R.C.P.; Craveiro, C.F.F.; Bernabé, C.V.; Silva, M.A.; Aride, P.H.R.; Oliveira, A.T.; Gonçalves, F.R.S.C.; Neto, J.S.; Lavander, H.D.; Faggio, C. Gonadal Development of Females of the White Shrimp *Penaeus schmitti* (Burkenroad, 1936) Caught in Southeastern Brazil. *J. Mar. Sci. Eng.* **2021**, *9*, 653. [[CrossRef](#)]
5. Ashour, M.; Abo-Taleb, H.A.; Hassan, A.-K.M.; Abdelzaher, O.F.; Mabrouk, M.M.; Elokaby, M.A.; Alzahrani, O.M.; Mahmoud, S.F.; El-feky, M.M.M.; Shaban, W.M.; et al. Valorization Use of Amphipod Meal, *Gammarus pulex*, as a Fishmeal Substitute on Growth Performance, Feed Utilization, Histological and Histometric Indices of the Gut, and Economic Revenue of Grey Mullet. *J. Mar. Sci. Eng.* **2021**, *9*, 1336. [[CrossRef](#)]
6. Zhou, C.; Wong, K.; Tsou, J.Y.; Zhang, Y. Detection and Statistics of Offshore Aquaculture Rafts in Coastal Waters. *J. Mar. Sci. Eng.* **2022**, *10*, 781. [[CrossRef](#)]
7. Longo, C.; Pierri, C.; Mercurio, M.; Trani, R.; Cardone, F.; Carbonara, P.; Alfonso, S.; Stabili, L. Bioremediation Capabilities of *Hymeniacion perlevis* (Porifera, Demospongiae) in a Land-Based Experimental Fish Farm. *J. Mar. Sci. Eng.* **2022**, *10*, 874. [[CrossRef](#)]
8. Hjelle, B.M.K.; Imsland, A.K.D.; Balseiro, P.V.; Handeland, S.O. Acoustic Delicing of Atlantic Salmon (*Salmo salar*): Fish Welfare and Salmon Lice (*Lepeophtheirus salmonis*) Dynamics. *J. Mar. Sci. Eng.* **2022**, *10*, 1004. [[CrossRef](#)]
9. Arduini, D.; Calabrese, C.; Borghese, J.; De Domenico, S.; Putignano, M.; Toso, A.; Gravili, C.; Giangrande, A. Perspectives for Exploitation of *Sabella spallanzanii*'s Biomass as a New Integrated Multi-Trophic Aquaculture (IMTA) By-Product: Feeding Trial on *Amphiprion ocellaris* Using *Sabella* Meal. *J. Mar. Sci. Eng.* **2023**, *11*, 123. [[CrossRef](#)]
10. Aguilo-Arce, J.; Ferriol, P.; Trani, R.; Puthod, P.; Pierri, C.; Longo, C. Sponges as Emerging By-Product of Integrated Multitrophic Aquaculture (IMTA). *J. Mar. Sci. Eng.* **2023**, *11*, 80. [[CrossRef](#)]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.