



HEALTH PROMOTION

Ethics in aquaculture: animal welfare and environmental sustainability

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Summary

In recent decades, also driven by the European Union, aquaculture has undergone significant development to meet the increasing demand for seafood products. However, the concentration of efforts and resources in the fishing industry raises complex ethical issues that have yet to be fully explored, concerning animal welfare, environmental impact, and social justice. Balancing economic interests with environmental and ethical concerns is a challenging yet crucial task to ensuring a sustainable future for aquaculture. The adoption of ethical values in the fishing industry not only promotes economic, environmental, and social responsibility but also fosters consumer trust in responsible food sourcing. Interventions such as developing animal welfare standards, implementing sustainable farming techniques, adopting environ-

mental management policies, and promoting ethically responsible business practices are pivotal. A multidimensional approach is essential to ensure an ethical and sustainable future for aquaculture, critical for global food security and marine environmental well-being. This holistic approach requires collaborative efforts from various stakeholders, including policymakers, researchers, industry players, and consumers, to address the multifaceted challenges faced by the aquaculture sector. Additionally, raising awareness among consumers about the impact of their choices on the environment and animal welfare can further drive the demand for ethically produced seafood and encourage responsible practices within the industry.

Introduction

Aquaculture represents a crucial resource bridging the growing global food demand and environmental sustainability promoted by the European ‘Green Deal’ program aimed at reducing greenhouse gas emissions by 50% by 2030 [1, 2]. As part of efforts to achieve this ambitious goal, farmed fish products, as a source of protein for food and feed with a low carbon footprint, emerge as a highly valuable resource in building a sustainable food system. Additionally, certain aquaculture activities, such as bivalve farming, can play a significant role in ecosystem decarbonization [3, 4]. Among the EU member States, in 2017, Italy ranked as the third-largest aquaculture producer alongside the United Kingdom (14%), following Spain (21%) and France (15%). However, in terms of production value, the United Kingdom took the lead (21%), followed by France (16%) and Spain [5]. Over the past decade, the European Commission has increased efforts to enhance the EU’s aquaculture potential, including the publication of its “New strategic guidelines for more sustainable and competitive EU aquaculture for the period 2021-2030” (COM(2021)0236) [6].

The new guidelines complement the overall “Farm to Fork” strategy aimed at accelerating the EU’s transition toward a sustainable food system, acknowledging the potential of sustainable aquaculture to provide low-carbon footprint food and feed. These guidelines place

particular emphasis on fish health and welfare (2.1.3; 2.2.2) [7]. These aspects, which have significant moral implications, are also considered strategic concerning the economic benefits for the sector. Specifically, they highlight the need to address the following challenges:

- lack of good practices and species-specific farming technologies within aquaculture;
- the need to better prevent diseases and parasite infestations, thus reducing the need for veterinary medicines;
- the necessity to decrease the reliance on pharmaceutical products, including antimicrobials and antiparasitic substances, which can harm the environment or contribute to antimicrobial resistance;
- gaps in research (including the fish microbiome, potential impacts of climate change on fish health, and stress effects on fish immune systems);
- limited availability of specific veterinary medicines (including vaccines) for use in aquatic animals;
- lack of good practice for early detection, prevention, and control of aquatic diseases not listed in relevant EU legislation.

Fish welfare: what regulatory attention?

Despite fish welfare receiving less attention in recent times compared to that of other farmed animals, various

measures have been implemented on an international scale within the legal framework [8, 9].

On December 5, 2005, the Permanent Committee of the European Convention for the Protection of Animals Kept for Farming Purposes adopted the “Recommendation concerning farmed fish” (which entered into force on June 5, 2006). This recommendation provides specific guidelines for best practices in fish farming to ensure welfare, considering significant interspecies differences in water conditions, social behavior, and environmental structures. Although somewhat generic, these elements are fundamental in promoting the health and welfare of farmed fish. Specific training for all individuals involved in fish farming, tailored to their diverse managerial responsibilities, is considered an essential component in this regard [10].

In 2008, the World Organisation for Animal Health adopted guidelines concerning the welfare of farmed fish during transport (Welfare of farmed fish during transport - OIE Aquatic Animal Health Code, Chapter 7.2-10/06/2016) [11].

The Marine Strategy Framework Directive 2008/56/EC represents the initial binding regulatory tool for EU Member States to consider the marine environment systemically [12]. Also noteworthy is Directive 2010/63/EU (2010) on the protection of animals used for scientific purposes. In Recital 8, it specifies that its scope includes “not only vertebrate animals, which include cyclostomes” but also cephalopods “since their ability to experience pain, suffering, distress, and lasting harm has been scientifically proven”.

Directive N. 2014/89/EU establishes a framework for maritime spatial planning, aiming to promote sustainable growth of economies associated with the sea and sustainable development of marine areas while ensuring the responsible use of resources. Additionally, the previously mentioned “New strategic guidelines for a more sustainable and competitive EU aquaculture for the period 2021-2030” (COM(2021)0236) from the European Commission deserve special consideration.

This document explicitly refers to both Council Directive 98/58/EC concerning the protection of animals kept for farming purposes (establishing general standards for the protection of animals of all species kept for the production of food, wool, skin, fur, or other agricultural purposes, including fish, reptiles, and amphibians) and Council Regulation (EC) N. 1099/2009 on the protection of animals at the time of killing, which identifies general requirements for the preservation, transport, and slaughter of farmed fish. In addition, these guidelines explicitly reference Council Regulation (EC) No. 889/2008 on organic production, which defines more specific requirements such as maximum stock density levels, restrictions on the use of artificial light and oxygen, *etc.*

Despite the importance of these international regulatory references, the European Commission considers them insufficient for safeguarding fish welfare, explicitly urging the adoption of further measures to:

- develop best practices concerning fish welfare during rearing, transportation, and slaughter;
- establish common, validated, species-specific, and measurable indicators concerning fish welfare throughout the entire production chain (including transportation and slaughter);
- pursue research and innovation, particularly on species-specific welfare parameters, including nutritional requirements in different farming systems; and
- provide fish welfare knowledge and expertise to fish farmers and other operators involved in managing farmed live fish.

The topic of sentience and the welfare of fish

The issue of sentience and fish welfare is undoubtedly central to ethical reflections that emphasize the need to overcome the traditional view of animals merely as instruments serving humans, acknowledging them as entities with specific value, dignity, and in some cases, even subjectivity [13, 14].

However, attention to the welfare of fish destined for human consumption has received limited recognition (even legally) in the broader debate on animal welfare, which has been almost exclusively focused on terrestrial animals.

The topic of fish welfare-in-the context of experimentation and dietary practices- is relevant in connection to recognizing the intrinsic value of the animal itself and its sentience- its capacity to consciously receive and react to stimuli, perceiving them within its own consciousness, and relating to environmental contexts consciously, following a continuity line with humans. This is also in relation to the public interest in benefiting from high standards of animal health and welfare, ensuring the quality of the consumed product [15].

The significance of the neocortex in the neural mechanism in humans, correlated with its absence in fish (as well as in non-mammalian animals), has long generated the belief that such animals were exempt from the subjective experience of suffering.

According to Rose et al. (2014), the extensive literature on surgical interventions in fish reports normal feeding and activity immediately after these procedures, emphasizing their post-operative normalcy. This study highlights that C-fiber nociceptors are the most widespread type in mammals and responsible for lancinating pain in humans while they are rare in teleosts, and absent in elasmobranchs. Additionally, A-delta nociceptors, not yet found in elasmobranchs but relatively common in teleosts, likely serve to signal rapid and less harmful injuries, triggering flight and avoidance responses [16]. However, empirical studies, while emphasizing that the capacity to suffer may differ in “degree” and “type” from human experience, have shown that painful stimuli are strongly aversive to fish [17]. Specifically, these studies have identified, in addition to behavioral

responses, a peripheral nociceptive system and recorded specific changes in fish brain activity during nociceptive stimulation. Based on these observations, teleost fish should be considered capable of nociception and, according to some opinions, perception of pain.

As a result, injuries or experience of other harmful conditions are a concern in terms of the well-being of individual fish. Growing evidence also highlights that fish can experience states akin to fear and avoid situations where they have encountered adverse conditions [18]. Sneddon indicates that the nociceptive system biology in fish is surprisingly similar to that of mammals. In addition, potentially painful events trigger behavioral and physiological changes such as reduced activity, vigilant behavior, suspension of normal behavior, increased ventilation rates, and anomalous behaviors, all of which are prevented using pain-relief medications [19].

The welfare of farmed fish, as sentient beings with specific ethological needs, thus becomes an essential point that requires particular and appropriate conditions not only to ensure the absence of pain but also to uphold the right to live in a suitable environment. This environment should enable the expression of a wide range of natural behaviors, access to proper nutrition, and minimize diseases and stress. Ensuring living conditions similar to their wild counterparts not only aligns with an important ethical principle of respecting otherness and vulnerability but can also ensure the success of restocking plans [20].

In general, providing favorable conditions for the welfare of non-human animals kept in captivity is more easily achievable when dealing with a few individuals. However, this becomes much more challenging, if not impossible, in intensive farming conditions that may involve a high number of animals living in large groups. While this is an intrinsic problem in intensive animal farming, it is particularly evident in aquaculture practices, often relying on extremely high numbers.

In general, the assessment of the welfare of fish in aquaculture can be done using the freedoms proposed in 1992 by the Farm Animal Welfare Council of the United Kingdom, which outlined the five notable freedoms for animals: (1) freedom from hunger or thirst; (2) freedom from discomfort; (3) freedom from pain, injury, or disease; (4) freedom to express normal behavior; and (5) freedom from fear or distress.

These recommendations imply a commitment to provide animals with accommodation, environment, food resources, water, and care suitable for their health and well-being. This involves continuous and careful monitoring of transport conditions, housing environments, and the ability to take appropriate and timely measures to eliminate deficiencies, pain, suffering, distress, or lasting harm. Additionally, animals must be transported under adequate conditions. The European Commission provides clear guidelines on its dedicated Animal Welfare website [21].

Ensuring the welfare of farmed fish in aquaculture farms is a complex issue involving a plurality of species-specific variables that require adequate knowledge,

consideration, and monitoring. These necessitate adequate knowledge, consideration, and monitoring. Parameters such as the physicochemical aspects of water, welfare indicators, environmental complexity, stocking density, and the social and foraging behaviors of the animals become particularly relevant in this context [22].

According to Ashley (2007), the concept of welfare should encompass not only physical health but also a broader aspect related to the absence of mental suffering. However, it's important to note that, according to this author, the stress response is an adaptive function and doesn't necessarily equate to suffering or poor well-being [23].

Ensuring the welfare of fish thus requires a thorough understanding of the biology of the various species housed, each having specific anatomical, physiological, and behavioral characteristics. These characteristics necessitate physical and chemical requirements.

These factors make it challenging to provide generalized recommendations or requirements for all fish species, highlighting the need for a comprehensive understanding of the physiology and ecology of each farmed species. It is also crucial to consider the equipment and appropriate resources necessary to provide a suitable environment that considers both the biodiversity of fish species and the unique aspects of each environmental context [22].

Supporting the commitment outlined by the EU towards greater attention to animal welfare, certain unique aspects of aquaculture in comparison to other forms of interaction with animals cannot be ignored. These aspects complicate the determination of individual animal welfare [24]. As highlighted in the document by the Bioethical Committee for Veterinary and Agri-food in aquaculture, evaluating individual welfare conditions must be based on objective parameters inherent to the sensitivity, suffering, and species-specific perceptual capacity [25]. This necessity inevitably entails acquiring data from studies conducted on a sufficiently extensive population of specimens to ensure statistical significance, given the high physiological and behavioral diversity among the various aquatically farmed species. Each species is uniquely characterized by specific dietary, health, and behavioral needs.

A particularly critical aspect involves the inferential methodology based on observing a subset of the population to draw conclusions that can be species-specific or generalized to the entire population. In addition, it is important to note that scientific knowledge regarding species physiology applies to an individual within the species group only through deduction from the entire species. The very practices in aquaculture, concentrating a very high number of specimens in a confined space, lead to perceiving fish as a homogeneous entity where individuality holds no significance.

In its report (Command Paper 2836, 1965), the Brambell Committee stated that "welfare is a broad term encompassing both the physical and mental well-being of the animal. Therefore, an attempt to assess welfare must take into account the scientific evidence available

on the feelings of animals, which can be inferred from their structure, functions, and behavior” [26].

Ethical dilemmas and decision-making complexities: conclusions

Aquaculture has become a significant source of global food supply. While it offers solutions to the growing demand for seafood, it also presents a multitude of ethical challenges that require careful consideration.

One crucial ethical issue of aquaculture concerns its environmental impact. Industry expansion often leads to habitat alteration, pollution and genetic interactions with wild populations. Ensuring responsible practices that minimize environmental degradation and safeguard biodiversity is critical to ethical and sustainable aquaculture.

Another major ethical concern in aquaculture is the balance between production needs and fish welfare.

Assessing the welfare of fish is a complex ethical challenge requiring a multidimensional approach [27]. Parameters such as water quality, population density, environmental enrichment, and feeding regimes must be carefully monitored to ensure the well-being of different aquatic species. This requires an ongoing research effort to identify new welfare indicators that are specific and more effective for different fish species [28, 29].

Establishing clear ethical standards and effective regulations is crucial. Ethical guidelines must ensure adequate space for aquatic organisms, responsible use of resources, mitigation of environmental impacts, and proper training of staff in assessing and managing fish welfare. Regulatory frameworks must evolve to address these complex ethical challenges, ensuring compliance and accountability throughout the aquaculture sector. Clear and comprehensive guidelines are imperative not only to ensure the welfare of aquatic species, but also to avoid compromising the future development of the industry. Moreover, the distinct nature of fish farming, regulated by aquatic ecosystems, underscores the need for tailor-made ethical parameters.

Implementing strict animal welfare standards, promoting sustainable farming practices, adopting environmental management policies, using innovative technologies, and training staff in assessing and managing fish welfare are all essential. In addition, consumer education on sustainable practices and their environmental impact plays a critical role in shaping ethical choices in purchasing preferences [30, 31].

Alongside the increasing focus on fish welfare, it is important to highlight the significance the EU Commission places on social acceptance and recognizing the benefits and value of aquaculture activities and products for the growth of this sector. Among the particularly important factors in achieving this goal, effective communication about the practices of sustainable aquaculture plays a fundamental role [28, 32].

Stakeholders’ negative perceptions of aquaculture activities, particularly in terms of their impact on

the environment and other economic activities is a dangerous barrier to the establishment of new aquaculture facilities. Therefore, a public awareness campaign should emphasize the numerous, often largely unknown, benefits of aquaculture: job creation in remote areas, providing access to a low-carbon food source, and offering ecosystem services.

Continued research and technological innovation also play an important role in this area. Advances in aquaculture technology, genetic selection and sustainable food alternatives may indeed offer new avenues towards more ethical and environmentally conscious practices. Balancing production needs with animal welfare, minimizing environmental impacts, establishing robust ethical standards, promoting transparency, and encouraging innovation are key pillars in ensuring an ethical and sustainable future for the aquaculture industry. By integrating ethical considerations into practices and policies, we can work towards greater protection of aquatic life and the planet as a whole.

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Conflict of interest statement

The authors declare no conflict of interest.

Authors’ contribution

All authors conceived the study and contributed to the preparation of the manuscript related to their sections and approved the final version to be submitted.

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