# Animal Health & Welfare in Aquaculture – Gap Analysis Shrimp, salmon, and tilapia

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# Introduction

#### ABOUT THIS REPORT

The aquaculture industry has experienced significant growth in recent years, becoming a crucial source of protein for the global population.<sup>1</sup> As this sector expands, there is an increasing need to address the health and welfare of aquatic animals in farming systems. This report focuses on a comprehensive analysis of animal health and welfare standards and guidelines in aquaculture, with a particular emphasis on highly traded and high-value species such as salmon, shrimp, and tilapia.

Aquatic animal health and welfare are interconnected yet distinct concepts. **Health** pertains to the physical state of an animal, typically defined by the absence of disease. In contrast, **welfare** encompasses the overall quality of an animal's life at a specific moment, including physical health and overall well-being. While certain practices in aquaculture may simultaneously impact both health and welfare, there are instances where they must be considered separately to ensure comprehensive care. It is important to note that health and welfare is not static but rather a dynamic state, influenced by the animal's experiences and adaptive abilities. While there has been progress in recognizing the importance of welfare for some species, there remains a significant gap in addressing the welfare of others.<sup>2</sup>

This report aims to determine the extent to which animal health and welfare is currently incorporated into aquaculture standards, guidelines, and regulations. Through a comprehensive gap analysis, the current state of animal health and welfare tools across the sector will be assessed, providing an overview of existing practices and identifying potential areas for improvement. Our review encompasses a wide range of sources, GSSI-recognized and non-recognized certification standards – referred to as: Voluntary Sustainability Standards (VSS) - UN FAO guidelines, EU regulations, and retailers' purchasing policies. By examining these diverse sources, this report seeks to provide a holistic understanding of the current landscape of animal health and welfare in aquaculture.

METHODOLOGY AND LIMITATIONS

#### Methodology

To evaluate the extent to which VSS, FAO Guidelines, EU regulations, and retailers' purchasing policies address health and welfare, a gap analysis was conducted. This analysis was conducted against a comprehensive list of themes developed through a systematic literature review (as detailed in Section 1.4). The list represents the themes found to be relevant for the species included in this study, i.e. salmon, shrimp, and tilapia. These themes reflect the current state of health and welfare considerations for these species and provide a benchmark for assessing the alignment and coverage of the selected standards and guidelines.

#### Limitations

While this methodology offers valuable insights into the coverage of health and welfare within the reviewed documentation, several limitations should be acknowledged:

**1. Focus on standard-content only:** The review was limited to the certification standards of third-party VSS. It did not assess the ability of these VSS to ensure consistent implementation of their standards at the farm level. Factors such as scheme governance and the independence of accreditation bodies (ABs), certification bodies (CBs), and the standard owner were not evaluated.

**2. Exclusion of Local Standards**: The analysis concentrated on global VSS. Local or regional standards that may provide higher or lower levels of coverage were excluded from the scope of this review. As a result, the findings may not fully represent all standards available at the local level.

**3. Thematic Scope:** The list of themes was developed based on existing literature and current understanding of welfare considerations. As scientific knowledge evolves, some may no longer be considered relevant or additional themes may emerge, which could influence the comprehensiveness of the benchmark used in this analysis.

<sup>&</sup>lt;sup>1</sup> FAO, 'The State of World Fisheries and Aquaculture 2024' (2024).

<sup>&</sup>lt;sup>2</sup> Ana Silvia Pedrazzani and others, 'Non-Invasive Methods for Assessing the Welfare of Farmed White-Leg Shrimp (Penaeus Vannamei)' (2023) 13 Animals 807.

#### HEALTH AND WELFARE IN THE AQUACULTURE SECTOR

Health and welfare are closely connected themes that play a central role in responsible aquaculture practices. Health has long been a recognized component of responsible aquaculture practices, with established standards and guidelines in place across the aquaculture value chain (AVC). More recently, there has been increasing interest in welfare, particularly concerning fish and crustaceans, broadening the scope of what constitutes responsible practice. This shift appears to be largely driven by growing consumer awareness and demand for ethically-sourced seafood. Beyond ethical justifications, aquatic animals that are not chronically stressed exhibit better growth rates, have a lower susceptibility to disease, and produce a higher-quality final product.<sup>3</sup> Retailers are at the forefront of this movement, for instance by committing to electrical stunning before slaughter. Such initiatives reflect a broader recognition among retailers of the importance of animal welfare in procurement practices.

The concept of animal welfare in aquaculture is frequently framed within the context of the "Five Freedoms," which provide a comprehensive framework for ensuring the well-being of farmed aquatic species. These freedoms include: freedom from hunger, freedom from discomfort, freedom from pain, injury or disease, freedom to express normal behavior, and freedom from fear and distress. By addressing these fundamental needs, aquaculture operations can significantly improve the welfare of animals while potentially enhancing productivity and product quality.<sup>4</sup>

NGOs, including members of the Aquatic Animal Alliance, play an important role in advocating for improved welfare standards in aquaculture. These organizations work collaboratively to develop guidance emphasizing humane treatment and responsible farming practices. They also engage in public outreach to raise awareness about the welfare issues facing aquatic animals, by engaging in public consultations and industry events. Some NGOs are also pushing for legislative changes that recognize the ability of aquatic animals to feel pain and experience suffering throughout their life cycle, based on increasing scientific evidence of their sentience. In some jurisdictions, there have been successes with implementing legislation. For example, New Zealand has been a pioneer in this area, enacting legislation that acknowledges the welfare of crustaceans. This progressive stance has since been seen in other countries, including Austria, Australia, the United Kingdom, Norway, and Switzerland, where decapod crustaceans are now recognized as sentient beings under various welfare laws.<sup>5</sup> In other cases, we can see that aquatic animals are excluded from the scope, or considered only for partial application of animal welfare legislation. Such is the case with European Union legislation.<sup>6</sup>

#### LITERATURE REVIEW

This section reviews the literature on health and welfare in aquaculture, focusing on themes selected for this study. These themes help structure the findings and facilitate comparison with VSS, FAO Guidelines, and EU Regulations, to assess their potential as tools for ensuring welfare-relevant outcomes (*See Chapter 3*). The list of themes was developed specifically for this report and includes:

- 1. Management
- 2. Monitoring and Disease Prevention
- 3. Reproduction
- 4. Cultivation parameters
- 5. Husbandry practices
- 6. Equipment

#### <sup>4</sup> ASPCA, The Five Freedoms (ASPCA, 1965)

<<u>https://www.aspca.org/sites/default/files/upload/images/aspca\_asv\_five\_freedoms\_final1.ashx\_.pdf</u>> accessed 5 January 2025

<sup>5</sup> Pedraafzzani and others (n 2).

<sup>&</sup>lt;sup>3</sup> Mariano Dara and others, 'Fish Welfare in Aquaculture: Physiological and Immunological Activities for Diets, Social and Spatial Stress on Mediterranean Aqua Cultured Species' (2023) 8 Fishes 414.

<sup>&</sup>lt;sup>6</sup> While not excluding fish from the general scope of the "Directive 98/58/EC concerning the protection of animals kept for farming purposes", it regularly excludes the application of articles to aquatic animals, such as the more specific, prescriptive provisions of Annex I. Similarly, such specific provisions were only added to the EU Organic Farming Regulation for aquatic animals at a later stage, during the most recent revision in 2018. For more specific on the UE Organic Farming Regulation, see section 2.3 of this report.

- 7. Feeding
- 8. Slaughter
- 9. Cohabitant species
- 10. Life stages

A summary of selected literature is presented below, outlining key animal welfare insights to help inform what the tools discussed in the gap analysis could encompass to support an AVC that safeguards aquatic animal welfare. It highlights findings as they relate to the selected species (see Bibliography).

#### Management

Management practices in aquaculture are critical to ensuring the welfare of aquatic animals. Management practices include proper training of those handling the aquatic animals, management planning, reporting, record-keeping. It may also include novel monitoring technologies, such as those based on artificial intelligence, to monitor the welfare. Finally, welfare assessments have shown to be a significant tool in promoting welfare.<sup>7</sup>

#### Monitoring and Disease Prevention

Health monitoring in aquaculture prioritizes prevention over intervention, particularly in organic systems where chemical treatments are limited or prohibited.<sup>8</sup> Natural remedies and preventative measures are employed to maintain health, though in some cases, conventional medicines may be used when necessary. In salmon, health assessments include monitoring body condition, fin health, and stress indicators like plasma glucose and cortisol levels. Studies have emphasized the importance of maintaining healthy environments, as poor water quality and overcrowding can lead to increased stress and disease outbreaks, thereby negatively affecting both health and welfare.<sup>9</sup> For shrimp, specific pathogen free and genetically resilient stocks are key to disease prevention. Shrimp health indicators like luminescence or muscle necrosis are monitored during the larval and grow-out stages.<sup>10</sup> Health indicators can also include diagnostic testing using microscopic, histological, molecular, or microbiological methods. These health indicators help guide management strategies and inform the welfare protocols necessary for aquatic animals.

Stocking density is another important element for welfare and disease prevention. Studies have shown that intermediate stocking densities (around 25 kg/m<sup>3</sup>) resulted in the best welfare outcomes for Atlantic salmon, while both low and high densities led to poorer welfare. For most shrimp species, each stage requires specific conditions, including stocking density, to ensuring optimal welfare.<sup>11</sup> Moreover, it will depend on the cultivation method employed. Nile tilapia have shown mixed results regarding optimal stocking density, with some studies indicating that lower densities improve growth rate and food conversion, while others suggest that higher densities may reduce aggressive interactions. However, the effects of stocking density on social behavior and welfare are not fully understood, as aggressive interactions are difficult to quantify in large groups.<sup>12</sup>

#### Reproduction

Reproductive health in aquaculture is an important component of health and welfare, as it is influenced by the overall health of a species throughout its life cycle. Reproductive success is influenced by the stress levels

<sup>7</sup> Dara and others (n 3).

<sup>10</sup> Ana Silvia Pedrazzani and others, 'Insights into Decapod Sentience: Applying the General Welfare Index (GWI) for Whiteleg Shrimp (Penaeus Vannamei—Boone, 1931) Reared in Aquaculture Grow-Out Ponds' (2024) 9 Fishes 440.

<sup>12</sup> João Favero Neto and Percilia Cardoso Giaquinto, 'Environmental Enrichment Techniques and Tryptophan Supplementation Used to Improve the Quality of Life and Animal Welfare of Nile Tilapia' (2020) 17 Aquaculture Reports 100354.

<sup>&</sup>lt;sup>8</sup> For example, in the EU Organic Farming Regulation

<sup>&</sup>lt;sup>9</sup> CE Adams and others, 'Multiple Determinants of Welfare in Farmed Fish: Stocking Density, Disturbance, and Aggression in Atlantic Salmon (*Salmo Salar*)' (2007) 64 Canadian Journal of Fisheries and Aquatic Sciences 336; Ruben Avendaño-Herrera, Marcos Mancilla and Claudio D Miranda, 'Use of Antimicrobials in Chilean Salmon Farming: Facts, Myths and Perspectives' (2023) 15 Reviews in Aquaculture 89.

<sup>&</sup>lt;sup>11</sup> Pedrazzani and others (n 2); Pedrazzani and others (n 10).

experienced by breeding animals, so maintaining appropriate environmental conditions is key. For Atlantic salmon, while much of the focus in aquaculture has been on the grow-out phase, attention to reproduction is critical for ensuring sustainable populations. Efficient breeding practices and avoidance of overcrowding during breeding are necessary to reduce stress and promote healthy offspring.<sup>13</sup> For shrimp specifically, reliance on eyestalk ablation to stimulate egg production of females was unavoidable in the early stages of hatchery technology, but it is now becoming dispensable for well-domesticated species such as *Litopenaeus vannamei*.<sup>14</sup>

#### **Cultivation Parameters**

Cultivation parameters include water quality, temperature, salinity, and lighting. In salmon farming, studies have shown that water quality parameters, such as oxygen levels and turbidity, appear most significant in impact health and welfare. Additionally, higher disturbance levels during feeding times appeared to improve welfare in salmon, suggesting that social dynamics and environmental factors need to be carefully balanced.<sup>15</sup> In penaeid shrimp farming, management practices vary according to life stages, reflecting the natural life-history migration cycle from high salinity oceanic waters to shallow coastal areas and estuaries. Each stage requires specific environmental conditions, such as temperature and salinity, all crucial to ensuring optimal health and welfare.<sup>16</sup> In comparison, tilapia is a species that is more adaptable. It tolerates moderate oxygen levels and adapts to a relatively wide range of environmental conditions.<sup>17</sup>

#### Husbandry Practices

Husbandry practices include the handling, crowding, grading, transportation, and environmental enrichment. Addressing these is key to maintaining low stress levels of the aquatic animal, which is essential for their health and welfare. The literature review on this topic was too limited to present a comprehensive overview of welfare considerations, but a few comments can be made. For instance, in tilapia farming research found that the incorporation of environmental enrichment techniques like artificial water hyacinths and shelters can reduce stress and promote natural behaviors. However, these methods can also increase territorial aggression, requiring careful management to balance welfare benefits with potential social conflicts in aquaculture systems.<sup>18</sup> Similarly, grading management, which groups fish of similar sizes, can intensify aggressive interactions and leads to higher injury rates, suggesting that both enrichment strategies and size selection must be carefully managed to minimize social conflicts in aquaculture systems.<sup>19</sup> In contrast, salmon farming uses grading to minimize aggression. Since salmon exhibit less territorial behavior, recommended husbandry practices can vary significantly, highlighting the importance of tailoring farming techniques to the specific needs of each species.

#### Equipment

Maintenance and hygiene of equipment as it directly influences the animals can influence the animals' health and can be seen as a minimum requirement in the context of aquatic animal health and welfare. Beyond this, equipment has a true potential to drive an increase in welfare forward. Already, precision aquaculture technologies are enhancing monitoring capabilities in shrimp and salmon farming. These technologies include biosensors, computer vision systems, wireless sensor networks, and high-quality cameras for analyzing animal behavior. It should be noted that for many sensors, clear water systems will be required for its functioning. In salmon farming, these technologies help optimize feeding regimes, water quality, and fish health management. For shrimp, emerging technologies allow farmers to closely monitor conditions such as water temperature and salinity, which can be critical during sensitive life stages like larval rearing. Some advanced systems can detect signs of shrimp stress

<sup>13</sup> Adams and others (n 9).

<sup>18</sup> Favero Neto and Giaquinto (n 12).

<sup>&</sup>lt;sup>14</sup> Pedrazzani and others (n 10).

<sup>&</sup>lt;sup>15</sup> Adams and others (n 9).

<sup>&</sup>lt;sup>16</sup> Pedrazzani and others (n 2); Pedrazzani and others (n 10).

<sup>&</sup>lt;sup>17</sup> Mohammad Hossein Khanjani, Moslem Sharifinia and Saeed Hajirezaee, 'Recent Progress towards the Application of Biofloc Technology for Tilapia Farming' (2022) 552 Aquaculture 738021.

<sup>&</sup>lt;sup>19</sup> Eliane Gonçalves-de-Freitas and others, 'Social Behavior and Welfare in Nile Tilapia' (2019) 4 Fishes 23.

based on coloration of uropods.<sup>20</sup> The use of advanced equipment and data-driven approaches is expected to revolutionize how welfare is monitored and managed, providing real-time insights that enhance both production efficiency and animal welfare.

#### Feeding

Feeding practices in aquaculture are integral to both the health of the animals and the efficiency of the farming system. For shrimp, nutritional management during the larval-rearing phase focuses on feed size, composition, and nutritional content to ensure proper development. During the grow-out phase, the quality and quantity of feed, particularly its protein content and conversion ratio, are key welfare indicators. Similarly, for salmon, feeding practices must account for the social dynamics in the farming environment, as excessive feeding or poorly timed feeding can increase aggression among fish.<sup>21</sup> Studies on salmon welfare have shown that the timing and frequency of feeding, as well as the nutritional composition of the feed, can significantly influence welfare outcomes.<sup>22</sup> In both shrimp and salmon farming, effective feeding strategies must align with the specific needs of each species and life stage to reduce stress and promote optimal growth.

#### Slaughter

The welfare of aquatic animals during slaughter is considered one of the most important topics in the context of welfare. Some slaughter methods, such as CO2 narcosis or electricity, induce significant, avoidable stress.<sup>23</sup> Understanding pain perception and sentience in aquatic animals at the time of slaughter often involves research focused on specific species, with evidence showing that methods effective for some species may not be suitable for others. Understanding of pain perception and sentience in decapods, like shrimp, largely relies on behavioral and physiological studies.<sup>24</sup> These have confirmed that shrimp species do respond to stressors, such as exposure to extreme temperatures or harmful chemicals triggering hormonal responses. Further, shrimp have demonstrated reactions indicative of nociception (the sensory perception of harmful stimuli), for example, escape behaviors when exposed to noxious stimuli such as tail-flipping away from threats or harmful substances. For Atlantic salmon, humane slaughter methods typically involve stunning the fish to ensure they are unconscious before being killed, minimizing pain and distress.<sup>25</sup> For Nile Tilapia, recent research found humane slaughter of Nile tilapia would involve rendering the fish unconscious swiftly and permanently before death. Effective methods include percussive stunning using a pneumatic bolt gun, which induces immediate and irreversible unconsciousness. Alternatively, a sequential approach combining electrical stunning followed by immediate throat cutting and immersion, can achieve permanent loss of consciousness.<sup>26</sup> Finally, it should be noted that continuously evolving technologies have the potential to make a significant impact on humane practices. An example is Ace Aquatec's technology to introduce in-water controlled stunning.27

#### **Cohabitant Species**

In aquaculture, the presence of cohabitant species can influence the welfare of each species in the system. For example, in polyculture systems, where multiple species are raised together, the welfare needs of all species must be considered to ensure a balanced ecosystem. This includes managing environmental conditions, feeding

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<sup>21</sup> Dara and others (n 3).

<sup>22</sup> Adams and others (n 9).

<sup>23</sup> Dara and others (n 3).

<sup>24</sup> Pedrazzani and others (n 10).

<sup>25</sup> Adams and others (n 9).

<sup>26</sup> Erika Sundell, Jeroen Brijs and Albin Gräns, 'The Quest for a Humane Protocol for Stunning and Killing Nile Tilapia (Oreochromis Niloticus)' (2024) 593 Aquaculture 741317.

<sup>27</sup> Responsible Seafood Advocate, 'Regal Springs Partners with Ace Aquatec' (21 July 2022) <https://www.globalseafood.org/advocate/tilapia-producer-stunning-technology-a-major-fish-welfare-advancement/>.

Oceanloop, 'Oceanloop, AWI Use AI to Improve Animal Welfare in Indoor Shrimp Farming' (2025) <a href="https://www.rastechmagazine.com/oceanloop-and-awi-use-ai-to-improve-animal-welfare-in-indoor-shrimp-farming/">https://www.rastechmagazine.com/oceanloop-and-awi-use-ai-to-improve-animal-welfare-in-indoor-shrimp-farming/</a> accessed 5 February 2025.

strategies, and minimizing interspecies conflict. While studies on cohabitant species in selected literature is limited, the general principle of maintaining biodiversity and ecological balance remains a priority for maintaining overall welfare.<sup>28</sup>

#### Life Stages

Welfare considerations in aquaculture vary across life stages. During shrimp's larval rearing phase, specific attention must be given to water quality, feed composition, and health indicators such as shell necrosis, ectocommensal bacteria, parasites, and fungi, as well as hepatopancreas condition. In the grow-out stage, factors like stocking density and water quality become more important. For salmon, welfare considerations differ between the freshwater juvenile stage and the seawater grow-out phase. Understanding these differences contributes to improved environments and welfare.<sup>29</sup>

#### **GLOSSARY OF TERMS**

Animal welfare (from: World Organisation for Animal Health): Animal welfare refers to "the physical and mental state of an animal in relation to the conditions in which it lives and dies". An animal is in a good state of welfare if (as indicated by scientific evidence) it is healthy, comfortable, well-nourished, safe, able to express innate behavior, and not suffering from unpleasant states such as pain, fear, and distress. To achieve a good state of welfare requires disease prevention, or, in case of disease, veterinary treatment. It also requires careful management of the culture environment, nutrition, and procedures for humane handling and slaughter.

Feed(s) (from: FAO Guidelines to Sustainable Aquaculture): Edible material(s) that are consumed by animals and contribute energy and/or nutrients to their diet.

Feed additives (from: FAO Guidelines to Sustainable Aquaculture): Chemical substances, other than nutrients, that are used in feeds to fulfill specific needs such as preserving nutritive quality, improving appearance, preventing caking, and delaying spoilage. Usually used in micro quantities and requiring careful handling and mixing.

Humane slaughter (from: World Organisation for Animal Health; Aquatic Animal Health Code): Process in which a farmed fish is stunned before killing. The stunning method should ensure immediate and irreversible loss of consciousness. If the stunning is not irreversible, fish should be killed before consciousness is recovered.

Veterinary medicines (from: FAO Guidelines to Sustainable Aquaculture): Any substance or combination of substances presented for treating or preventing disease in animals or which may be administered to animals to restore health and correct or modify physiological functions in animals.

LIST OF ACRONYMS

AVC – Aquaculture Value Chain

CB – Certification Body

COFI-AQ - Committee on Fisheries Sub-Committee on Aquaculture

- DO Dissolved Oxygen
- EC European Commission

EU – European Union

FAO – UN Food and Agricultural Organization

FAO GSA – FAO Guidelines for Sustainable Aquaculture

GSSI - Global Sustainable Seafood Initiative

RAS – Recirculating Aquaculture System

VSS – Voluntary Sustainability Standard

WOAH - World Organisation for Animal Health (formerly known as: OIE, Office International des Epizooties)

<sup>&</sup>lt;sup>28</sup> Dara and others (n 3).

<sup>29</sup> ibid.

# GAP ANALYSIS

#### VOLUNTARY SUSTAINABILITY STANDARDS

This section presents a detailed review focused on health and welfare in relation to aquaculture Voluntary Sustainability Standards (VSS). A comprehensive gap analysis was conducted across several key themes presented in the Literature Review. These themes include farm management, monitoring and disease prevention, reproduction, cultivation parameters, husbandry practices, equipment used at the farm, feeding, slaughter methods, and the management of cohabitant species. Additionally, the analysis identifies specific conditions for certain life stages that require specialized care.

Please note that the three selected species will be discussed separately, as some reviewed standards focus exclusively on certain species. Further, different species have distinct care needs, which the literature also confirmed (*see Literature Review*). This separation therefore allows for a more nuanced understanding on the specific welfare requirements pertinent to each species and to what extent standards currently offer coverage of those themes.

#### SALMON

This subsection aims to highlight how and to what extent the health and welfare needs of salmon are addressed within the frameworks of VSS. A total of seven VSS were reviewed in this context, comprising two standards specifically dedicated to salmon welfare and five that address responsible farming practices more generally. Many of the standards reviewed for this section were salmon-specific, reflecting the unique consideration associated with this species. Additionally, some standards rely on the OIW Aquatic Animal Health Code.

#### Management

Farm management serves as an overarching theme supporting the effective implementation of all requirements set forth in the following themes (cultivation parameters, reproduction, etc.). Effective farm management encompasses essential topics such as staff training, traceability, health and welfare plans, and the use of novel technologies. While most standards address inspection and record-keeping, the level of detail provided varies. At times, the coverage of training in not just health but specifically in welfare management may benefit from more specificity for consistent application across farms. Welfare assessments or measures that may have a similar welfare impact are mentioned in the majority of standards. The potential role of emerging technologies, such as artificial intelligence for monitoring of salmon health and welfare, is absent from all standards. These technologies may enhance welfare monitoring and its assessment by providing real-time data and insights into salmon health and welfare. Acknowledging the novelty of many of these technologies and the fact that they may not be economical for smaller farms, the lack of coverage is expected and not of direct concern.

#### Monitoring and Disease Prevention

Health monitoring is closely linked to other health and welfare factors. In this context, we considered stocking densities, culling, and medical treatments, among others. Stocking densities are important to prevent overcrowding and stress and are frequently covered by standards, with varying levels of specificity. Some standards set maximum density limits with varying values, while others provide no limits. Similarly, the level of coverage on management of casualties, particularly through humane slaughter or culling, differs from one standard to another. Most standards did include criteria on the topic of sea lice, a critical concern for salmon farming, as salmon is vulnerable to infestations due to open-system cultures. Sea lice-specific criteria are addressed by most standards, with the salmon-specific standards providing more detailed coverage.

Vaccination is recognized as essential for disease prevention. Standards typically address issues such as handling stress or the use of anesthesia to reduce stress during vaccination, as well as the broader welfare implications of these practices. All standards cover vaccination and often designate the farm's veterinarian as the decision-maker for vaccinations. Finally, the use of antibiotics is addressed in most standards, with guidelines on treatment rotation to prevent resistance and limits on usage per cycle, including prophylactic use.

#### Reproduction

Reproductive management helps ensure the long-term health and welfare of farmed salmon. Most current standards provide some coverage in this area, but only a few covered the unique needs of broodstock and hatchery

fish. Use of transgenic fish is addressed in nearly all standards. Additionally, use of hormones and other reproductive interventions, such as sex reversal or triploids, can have significant welfare implications if not carefully managed. When hormones are mentioned in standards, it is usually in the context of prohibiting their presence in feed or their use as growth promoters.

#### Cultivation parameters

Cultivation parameters such as water quality, temperature, dissolved oxygen (DO), salinity, and photoperiod are important for ensuring optimal growth conditions and overall well-being. Generally, standards address most of these parameters, with varying level of specificity. With respect to grow-out, factors such as temperature and salinity are less critical, as salmon are typically cultivated in open culture systems such as offshore cages or nets, where farms have limited control over these variables. DO levels are essential for salmon's respiratory needs, and maintaining appropriate oxygenation is crucial for preventing stress and supporting healthy growth. Most standards provide clear recommendations for required oxygen levels, typically around 70-80% dissolved oxygen saturation. Some standards highlight the need for water quality, including dissolved oxygen, to meet species-specific requirements.

#### Husbandry practices

Addressing husbandry practices like handling, crowding, and transportation is important to minimize stress. Most standards recognize the importance of handling and include criteria on good practices. Some standards would benefit for more detailed coverage in this context. Crowding for instance, may occur when fish are concentrated in small spaces, often prior to or during grading, handling, or transport. This can lead to increased competition for space, food, and oxygen, which in turn results in physical injuries, heightened aggression, and stress. Some standards address crowding by emphasizing the importance of minimizing its frequency and duration, and by ensuring careful monitoring of water quality and health. Transportation involves moving the animals between stages of production or to processing facilities and is considered a high-stress event. Most standards address transportation in terms of maintaining water quality and appropriate densities. The welfare-specific standards offer more detailed guidance in this context, providing specific recommendations based on the type of transport used, whether by truck, well boat, or helicopter.

#### Equipment

Poorly maintained equipment, such as damaged nets or poorly constructed tanks, can expose fish to risks like entanglement, abrasions, or inadequate water flow, all of which can compromise fish welfare. Standards varied widely in the level of detail regarding equipment, with a majority providing detailed criteria concerning the correct mooring of pens and use of knotless meshes. Further, standards frequently mention the importance of smooth surfaces and the absence of sharp edges to prevent injury. The welfare-specific standard offers a more extensive scope of coverage in this context.

#### Feeding

Several aspects of feeding are important to welfare, particularly feed composition, feeding practices and the conditions for fasting. Without clear guidelines in this context, practices may be suboptimal for fish health, leading to nutritional deficiencies or imbalances that can affect growth rates, immune function, and overall welfare. Generally, standards require that records are kept on the sourcing of feeds, as well as the feeding schedule. Some but not all standards include detailed coverage of feed composition, with some standards putting the onus on the feed supplier. Feed suppliers are often required to be established producers that can trace where their feed ingredients came from. Feeding practice guidelines include the frequency and method of feeding. Standards often require the spreading of feed evenly throughout the rearing space and following the feed manufacturer's guidelines. Finally, specific guidelines on fasting are found less frequently and are covered by a minority of the standards reviewed.

#### Slaughter

Most standards include criteria on slaughter, frequently stating that electrical or mechanical stunning is the only acceptable method. Other methods, such as chilling, asphyxiation, or  $CO_2$ , are generally considered inhumane and are prohibited by some standards, but not all. Some standards that do not prohibit these methods emphasize that they should be avoided wherever possible. Finally, it was found that some standards do not include many criteria directly but rely on the WOAH Aquatic Animal Health Code instead.

#### Cohabitant species

The welfare of cohabitant species, such as cleaner fish, appears to be an often-overlooked aspect of animal welfare in aquaculture. Welfare-specific standards provide detailed and specific guidelines for the welfare of species like wrasse or lumpfish, which are commonly used as cleaner fish. Detailed coverage among these standards typically includes comprehensive criteria for the care and management of cleaner fish, including guidelines on their capture, breeding practices, and health management, ensuring their well-being alongside the farmed fish. Other standards may include general statements such as the allowance of the cleaner fish use on farms or the general expectation that their health and welfare should not be compromised.

#### Life stages

Most standards include some life stages with specific criteria, especially for eggs, seedlings, and juveniles. Stages alevin, fry, or parr are covered by some standards.

## CONCLUSIONS ON SALMON

This section evaluated how various VSS address salmon health and welfare, focusing on seven standards, including both salmon-specific welfare and general responsible farming criteria. Most standards provide a comprehensive set of criteria on management, particularly through the involvement of a veterinarian, staff training and record-keeping. Monitoring and disease prevention through vaccination and antibiotic use are often included, with varying levels of detail among the standards. Slaughter practices are generally covered, with some standards opting for clear prohibitions and others allowing for certain slaughter methods only if they cannot be avoided. Less detailed coverage is provided for reproductive management and husbandry. In the context of feeding, it was noted that feed composition and schedule is often included in standards, and the level of responsibility put on the farm versus the feed supplier, will depend on the standard.

#### Figure 1. Coverage of Salmon Welfare by VSS

1	Management	
2	Monitoring and Disease Prevention	
3	Reproduction	
4	Cultivation Parameters	
5	Husbandry Practices	
6	Equipment	
7	Feeding	
8	Slaughter	
9	Cohabitant Species	
10	Life Stages	

\* Green = High Coverage, Light Green = High-Medium Coverage, Orange = Medium Coverage, Grey = Low-No Coverage

#### SHRIMP

This subsection examines how and to what extent the health and welfare of shrimp is addressed within the framework of Voluntary Sustainability Standards (VSS). A total of five VSS were reviewed. The standards address shrimp within broad contexts of aquaculture or responsible farming practices. Despite the global importance of shrimp as a farmed species, the standards reflect limited species-specific focus, often relying on general aquaculture principles.

#### Management

Management practices form the foundation for ensuring effective health and welfare protocols in shrimp farming, influencing various aspects of farming operations such as training, traceability, and emergency response. All standards reviewed include criteria requiring farm workers to be trained in animal welfare and handling techniques. Similarly, traceability, inspection, and record-keeping practices are covered by all five standards. Some include criteria such as tracking the origin of seedlings, identifying batches, and maintaining online traceability systems available for audits. The drying of cultivation ponds between production cycles is generally covered by standards, with a few exceptions. Similar to salmon standards, most shrimp standards mention an assessment that has comparable impacts to a welfare assessment.

#### Monitoring and Disease Prevention

Stocking density criteria are important to prevent overcrowding, increasing stress, aggression, and disease risks. Stocking densities are addressed in the majority of standards, with some prescribing maximum densities. Casualty slaughter is addressed in immediate removal and killing of moribund shrimp. Some standards emphasize respecting animal welfare during culling practices, without providing detailed protocols. Use of medical treatments and antibiotics is relatively well-covered, with four standards prohibiting prophylactic antibiotic use and requiring treatments to be directed by veterinarians or aquatic health professionals. Finally, all standards require mortality recording and reporting. A minority of those include detailed criteria such as documenting body condition, including lesions or gill damage, which may help identify underlying health and welfare concerns.

#### Reproduction

Most standards address broodstock management, including criteria for sourcing wild crustaceans and ensuring sustainable acquisition practices. Eyestalk ablation, a controversial yet common practice used to induce reproductive maturation in female shrimp, is prohibited by two out of five standards. This practice, which involves cutting or crushing one eyestalk of female shrimp, is widely recognized as causing significant pain and stress. Eyestalk ablation is considered to be dispensable with appropriate management in well domesticated species such as *L. vannamei*, but more challenging in less domesticated species such as *P. monodon.*<sup>30</sup> Some hormone supplements have shown benefits, but no hormone treatment has been shown to be effective in replacing eyestalk ablation. As most reviewed standards are not shrimp-specific, a high coverage of hormone usage was still found. Often standards prohibit prophylactic use. Similarly, genetic modification techniques are addressed by all standards, with three prohibiting such practices entirely and two allowing them under strict regulations, such as requiring environmental impact assessments and compliance with local laws.

#### Cultivation Parameters

Environmental parameters include water quality, temperature, salinity, dissolved oxygen (DO), ammonia, and photoperiod. All standards mention water quality monitoring. Most standards address temperature, salinity, and ammonia, with general criteria for recording these parameters and aligning them with the species' needs. Maximum or minimum thresholds are usually not provided, potentially due to the fact that the majority of standards are not species-specific and different species require different thresholds. DO is covered by all standards.

#### Husbandry Practices

Husbandry practices, including handling, crowding, grading, and transportation, are addressed by most standards. Handling criteria generally include statements about minimizing stress during procedures. Crowding and grading are covered by some standards, with varying levels of detail. Transportation is often addressed, but the level of detail is different among the standards. For instance, one includes details on preventing escapees during transport,

<sup>&</sup>lt;sup>30</sup> Kanchana Sittikankaew and others, 'Transcriptome Analyses Reveal the Synergistic Effects of Feeding and Eyestalk Ablation on Ovarian Maturation in Black Tiger Shrimp' (2020) 10 Scientific Reports 3239; Umaporn Uawisetwathana and others, 'Insights into Eyestalk Ablation Mechanism to Induce Ovarian Maturation in the Black Tiger Shrimp' (2011) 6 PLoS ONE e24427; Amaya Albalat and others, 'Welfare in Farmed Decapod Crustaceans, With Particular Reference to Penaeus Vannamei' (2022) 9 Frontiers in Marine Science 886024.

but does not address welfare. Other standards offer a higher level of detail, considering maintenance of water quality and/or adhering to maximum density limits.

#### Equipment

All reviewed standards include some criteria on equipment with varying approaches. One standard mentions water filtration using appropriate mesh sizes, while another provides requirements for equipment designed to minimize harm, maintaining records of used tools, and using backup systems for oxygenation. Furthermore, ponds, a central component of shrimp farming, are covered by almost all standards. Standards include criteria such as water exchange rates and fertilizer use. One standard specifies criteria for pond designs that support shrimp's (natural) foraging behavior.

#### Feeding

In the context of feeding, it was observed that standards primarily focus on traceability and sourcing, less on feed composition. Most standards require feed to be sourced from recognized manufacturers and most standards add some criteria on addressing natural feeding methods and dietary requirements. Feed ratios such as the Forage Fish Dependency Ratios (FFDR) are mentioned in two standards, where both standards provide ratios based on specific species of shrimp. Fasting is covered by some standards.

#### Slaughter

Slaughter practices are addressed by most standards. They generally emphasize the use of humane slaughter methods, such as electrical or mechanical stunning. Majority of standards prohibit less humane methods, like ice bath chilling or asphyxiation. If a standard allows for their use, it is only under the condition that more humane techniques are unavailable. Slaughter by use of CO<sub>2</sub>, another controversial method, is prohibited by only one standard.

#### Cohabitant Species

The welfare of cohabitant species in polyculture systems is covered by a minority of standards. These standards require management plans for the welfare of all species involved.

#### Life Stages

In the context of life stages of shrimp, it was found that standards refer to general terms such as seedlings or juveniles.

#### CONCLUSIONS ON SHRIMP

This subsection evaluates how various VSS address shrimp health and welfare within five standards applicable to shrimp farming. Most standards provide responsible aquaculture principles, with limited species-specific guidance on welfare concerns such as shrimp sentience in reproduction and slaughter. Disease management and certain aspects of reproduction are largely covered. Eyestalk ablation is prohibited by 2 out of 5 standards. Cultivation parameters such as dissolved oxygen and temperature are most frequently covered. Husbandry practices, including handling, grading, and transportation, have some coverage within standards. No shrimp-specific welfare standards were reviewed.

#### Figure 2. Coverage of Shrimp Welfare by VSS

1	Management	
2	Monitoring and Disease Prevention	
3	Reproduction	
4	Cultivation Parameters	
5	Husbandry Practices	
6	Equipment	

<b>7</b> F	eeding	
<b>8</b> S	ilaughter	
9 C	Cohabitant Species	
<b>10</b> Li	ife Stages	

\* Green = High Coverage, Light Green = High-Medium Coverage, Orange = Medium Coverage, Grey = Low-No Coverage

#### TILAPIA

This subsection explores the extent to which the welfare needs of Nile tilapia are covered within the frameworks of Voluntary Sustainability Standards (VSS). Five VSS were analyzed, some of which are the same as reviewed under salmon and/or shrimp, as they are not species-specific standards.

#### Management

Standards applicable to tilapia farming address management practices throughout, as observed in previous sections on salmon and shrimp standards. Most standards require farm workers to be trained in animal welfare and handling techniques. Traceability, inspection, and record-keeping are well-covered in some standards, with detailed criteria such as batch identification, monitoring the origin of seedlings, and ensuring online traceability for audits. Other standards provide less detail, focusing on aspects like drug usage records or compliance with audit requirements. Given that tilapia farming primarily takes place in pond systems, effective pond management is important for disease control and overall welfare. Practices such as drying ponds between production cycles to disrupt pathogen life cycles are covered in some standards, typically through requirements for coordinated production cycles and pond-drying practices.

#### Monitoring and Disease Prevention

Health monitoring is generally covered by standards, with varying levels of detail. Stocking densities are mentioned in all but one standard, with most standards providing mostly general guidelines, such as avoiding stress-inducing densities, and one standard prescribing a specific maximum stocking density. In the context of humane culling, some standards specify the need to consider welfare. Detailed protocols are generally not included. Vaccination is often covered, permitted, and recommended. Standards designate the farm's veterinarian as decision-maker for vaccinations. Some standards add details to safeguard the welfare in the context of treatments. Finally, the use of antibiotics is comprehensively covered, with standards prohibiting prophylactic use and requiring veterinarian oversight.

#### Reproduction

With regards to reproductive management in tilapia aquaculture, most standards cover broodstock welfare, for instance by including criteria like holding broodstock in quarantine to verify disease status before transfer. Use of hormones is covered by all but one standard. Most standards prohibit prophylactic hormone use. Usage of monosex populations and triploids is covered by two standards, with one prohibiting its use. Finally, usage of genetic modification techniques has a high coverage. Specifically, it is prohibited by three standards and allowed by two standards under strict regulations, including environmental impact assessments.

#### **Cultivation Parameters**

Environmental conditions relevant for health and welfare include water quality, temperature, salinity, dissolved oxygen (DO), and ammonia. Many standards emphasize water quality monitoring and its importance. DO is covered by all standards. In this context, detailed guidance on minimum levels needed to avoid hypoxia is not provided. Considering desirable DO levels are often species-specific, this may be unsurprising. Parameters like temperature, salinity, ammonia, and photoperiod are addressed by most but not all standards. These include requirements for recording these parameters and aligning them with the needs of the species.

#### Husbandry Practices

Husbandry practices include handling, crowding, grading, and transportation. Handling is mentioned by most standards, through criteria stating that handling moments should limit stress experienced by the farmed animal,

and that personnel should be trained to effectively mind animal welfare during handling operations. Some standards add criteria on specific handling techniques like crowding and grading. Transportation, considered a high-stress event, is covered by a majority but not all standards in the context of welfare. Focus for transportation is on water quality and density requirements.

#### Equipment

Standards addressing equipment in tilapia farming vary in coverage. While all standards include some criteria, the depth of guidance differs. One standard mentions only the need for water filtration with appropriate mesh sizes, whereas another includes comprehensive requirements such as maintenance records and backup systems. Nets and ponds are addressed by most standards, with general criteria like proper maintenance and the use of nets to prevent escapees. One standard specifies that tilapia grow-out in artificial tanks with closed water systems is prohibited, while also emphasizing that pond designs should closely mimic natural environments.

#### Feeding

In the context of feeding, all standards cover feed content, with most including criteria for aligning feed composition with the natural dietary needs of the farmed animal. Storage and record-keeping are well-covered, with most standards requiring traceable feed records and proper maintenance to avoid expired or contaminated feed. Guidance on feeding methods and quantities are often included, but with a lower level of detail. Fasting, the withdrawing of providing feed for a period, usually before transport or slaughter, is mentioned by some but not all standards.

#### Slaughter

Slaughter practices are covered by most standards, with one standard adding extensive criteria, including worker training and feedback mechanisms from slaughter facilities to farms. When included, standards hold that humane methods are to be used, such as electrical and mechanical stunning followed by bleeding when the fish are still unconscious. Some but not all include a prohibition of less humane methods, such as ice bath chilling or asphyxiation, but they only allow these practices if more humane techniques are unavailable for the farmed species.

#### **Cohabitant Species**

For the welfare of cohabitant species in tilapia polyculture systems, a minority of standards require management plans to ensure the welfare of all species involved. For example, tilapia can be farmed alongside species like catfish or carp, which may have different water quality and stocking density requirements. While detailed criteria for their care are not included, it is important to note that most standards are not species-specific.

#### Life Stages

The welfare of tilapia across all life stages is not covered, but almost all standards do include criteria on juveniles or seedlings. No coverage is observed for the distinct needs of larvae or fry.

#### CONCLUSIONS ON TILAPIA

This subsection evaluates the coverage of tilapia health and welfare within five VSS. Management practices are covered, with some standards requiring training, traceability, and pond management techniques like drying between cycles. Disease prevention includes guidance on vaccination and antibiotic use, though details on stocking densities and humane culling vary. Broodstock welfare and hormone use for sex reversal are addressed by most standards, while environmental parameters like dissolved oxygen are included but often lack specific thresholds. Lack of specific thresholds may be due to the fact that most standards are not tilapia-specific. Further, husbandry practices such as handling and transportation are addressed by most standards, emphasizing stress reduction and water quality. Slaughter practices typically encourage humane methods, though not all standards prohibit less humane techniques. Further, as seen with shrimp, the ability of VSS to ensure the consideration of welfare in tilapia farming is less comprehensive than observed in the salmon review. This discrepancy is likely due to the inclusion of two welfare-specific standards in the salmon review, which were tailored specifically for salmon, offering a more focused approach to welfare considerations. Finally, it should be mentioned that the coverage of tilapia welfare as scored in figure 3 is slightly higher than under shrimp, which is primarily because tilapia is more resilient to certain stressors than shrimp.

#### Figure 3. Coverage of Tilapia Welfare by VSS

1	Management	
2	Monitoring and Disease Prevention	
3	Reproduction	
4	Cultivation Parameters	
5	Husbandry Practices	
6	Equipment	
7	Feeding	
8	Slaughter	
9	Cohabitant Species	
10	Life Stages	

\* Green = High Coverage, Light Green = High-Medium Coverage, Orange = Medium Coverage, Grey = Low-No Coverage

#### FAO

#### FAO ECOLABELLING GUIDELINES

The FAO Ecolabelling Guidelines for aquaculture were launched in 2011 to promote sustainable practices within the aquaculture sector. These guidelines provide a framework for developing ecolabelling schemes that drive transparency and improve responsible farming practices, helping consumers identify more responsibly sourced seafood products. Since their introduction, they have been adopted by various countries and organizations, influencing market dynamics, and encouraging producers to adopt sustainable practices in response to consumer demand for responsibly produced products.<sup>31</sup>

The FAO Ecolabelling Guidelines clearly state that "animal health and welfare" are issues that "should be considered relevant for certification in aquaculture."<sup>32</sup> A closer examination reveals that the Guidelines generally prioritize animal welfare as it relates to the broader scope of animal health.<sup>33</sup> This implies the other themes will not be addressed directly or with much detail. The Guidelines include clauses that touch upon various health-related issues, and by extension, some aspects of animal welfare. For instance, while the Guidelines provide some coverage on water quality, management practices, and staff training, areas that can influence animal welfare. Comparing the Ecolabelling Guidelines to the list of themes reveals that while some subthemes related to aquatic animal health are addressed, others are not. In conclusion, the Ecolabelling Guidelines are expected to influence certain welfare indicators, but primarily within the scope of specific subthemes of health, leaving other welfare themes unaddressed.<sup>34</sup>

<sup>&</sup>lt;sup>31</sup> Technical Guidelines on Aquaculture Certification 2011.p.1-2

<sup>32</sup> ibid. p.19

<sup>&</sup>lt;sup>33</sup> ibid. p.19

<sup>34</sup> ibid.p.19-20

#### COFI GUIDELINES ON SUSTAINABLE AQUACULTURE

Guidelines for Sustainable Aquaculture (GSA), building on the 2011 Ecolabelling Guidelines, were adopted by the Food and Agriculture Organization's (FAO) Thirty-sixth Session of the Committee on Fisheries (COFI) in July 2024.<sup>35</sup> The GSA were developed over an eight-year global consultative process to provide guidance on sustainable aquaculture development consistent with the FAO 1995 Code of Conduct for Responsible Fisheries and the FAO Blue Transformation Roadmap.<sup>36</sup> These guidelines aim to enhance food security and nutrition, improve socioeconomic conditions for aquaculture-dependent communities, and promote sustainable use of aquatic resources. The GSA comprises three sections covering objectives and principles, guidance for promoting sustainable aquaculture, and support for implementation and monitoring. They are designed to be a tool for policy processes, decision-making, and action at local, national, regional, and global levels.<sup>37</sup>

In Section B of the \*Guidelines for Promoting Sustainable Aquaculture\* under the GSA, the general definition of sustainable aquaculture references health, but does not explicitly reference welfare. The term "sustainable aquaculture" is primarily defined in broader environmental and health-related terms, focusing on aspects like resource use, ecological impact, and production efficiency. Sustainable aquaculture practices are described as potentially involving the "conservation and effective management of aquatic biodiversity, minimizing the use of antibiotics and other chemicals, and ensuring high animal welfare standards".<sup>38</sup> This inclusion of animal welfare in the supplementary section signals recognition of its importance, yet it still remains secondary to the broader objectives of sustainability, without a framework outlining how these welfare standards should be implemented or monitored within certification processes.<sup>39</sup>

GSA provides more detail on what is expected in the context of biosecurity and animal welfare. It states "healthy and resilient aquatic organisms, produced through good farming practices, disease prevention and long-term biosecurity management, are fundamental to sustainable aquaculture. Protecting the health and welfare of aquatic organisms require the adoption of regulations and standards on health of aquatic organisms and on antimicrobial use, at all steps in the production cycle".<sup>40</sup> This highlights the critical connection between biosecurity and the welfare of aquatic organisms, emphasizing that protecting their health requires the adoption of regulations and standards focused on both their well-being and the responsible use of antimicrobials throughout the entire production cycle. In practical terms, this implies that States and relevant stakeholders should actively develop and formalize national and regional strategies for aquatic organism health, ensuring a comprehensive approach to disease prevention and welfare management. The GSA specifically references the \*Progressive Management Pathway to Aquaculture Biosecurity\* (PMP/AB) as a key framework for addressing these issues. This strategy, outlined in Annex 2 of the GSA, provides guidance for improving biosecurity and safeguarding the welfare of farmed aquatic species. By integrating the PMP/AB into national and regional strategies, stakeholders are encouraged to adopt a phased approach that ensures ongoing improvements in biosecurity practices and animal welfare standards, aiming for sustainable, resilient aquaculture operations. However, while health and welfare are addressed in these guidelines, the level of detail remains relatively broad, with emphasis mostly placed on biosecurity and disease management.

Put in the context of this gap analysis, the GSA guidelines offer detailed coverage on management (theme 1) and monitoring and disease prevention (theme 2), including the limitation of antimicrobial use, vaccinations, staff training, and regular inspections. This makes the GSA's focus more comprehensive on health-related aspects compared to the Ecolabelling Guidelines, which touch on a wider range of welfare topics but with less specificity. The GSA guidelines do not address some crucial welfare issues, e.g. reproduction, stocking density, and slaughter, leaving notable gaps in the coverage of broader welfare concerns in aquaculture.

40 ibid. p.17

<sup>&</sup>lt;sup>35</sup> FAO, 'FAO Committee on Fisheries Adopts Guidelines for Sustainable Aquaculture' <a href="https://www.fao.org/americas/news/news-detail/cofi-36-adopto-directrices/en">https://www.fao.org/americas/news/news-detail/cofi-36-adopto-directrices/en</a>.

<sup>&</sup>lt;sup>36</sup> FAO (n 1).

<sup>&</sup>lt;sup>37</sup> Guidelines for Sustainable Aquaculture 2024. P.1

<sup>&</sup>lt;sup>38</sup> ibid. p.8

<sup>&</sup>lt;sup>39</sup> ibid. p.8

# CONCLUSIONS ON FAO

The FAO Ecolabelling Guidelines and the GSA guidelines both emphasize the importance of health in aquaculture, but they differ in their approach to animal welfare. The Ecolabelling Guidelines acknowledge animal health and welfare as relevant but focus primarily on health, with welfare considered as it impacts health outcomes, resulting in limited coverage of welfare-specific issues. In contrast, the GSA guidelines provide more detailed coverage on health-related topics like antimicrobial use, disease prevention, staff training, and inspections, offering a more comprehensive focus on health. If taken together, both frameworks offer some guidance on aquatic animal health and welfare but leave significant gaps in addressing broader welfare issues, such as reproduction, stocking density, and slaughter, meaning they do not fully cover the range of welfare concerns necessary for sustainable aquaculture.

#### Figure 4. Coverage of Aquatic Animal Welfare by FAO Guidelines

1	Management	
2	Monitoring and Disease Prevention	
3	Reproduction	
4	Cultivation Parameters	
5	Husbandry Practices	
6	Equipment	
7	Feeding	
8	Slaughter	
9	Polycultures	
10	Life Stages	

\* Green = High Coverage, Light Green = High-Medium Coverage, Orange = Medium Coverage, Grey = Low-No Coverage

#### EUROPEAN UNION

#### EU ORGANIC REGULATION

European Union's (EU) Organics Regulation outlines the requirements for products that are produced or exported to the EU and wish to be labeled as organic, directly applying to all EU member states. This Regulation covers both agriculture and aquaculture, with specific requirements for aquaculture detailed in Annex II, which was added in the 2018 revision. The regulation makes it clear that animal welfare is a key objective, emphasizing that the observance of high standards for health, the environment, and animal welfare in the production of organic products is intrinsic to the high quality of those products. While the regulation provides general guidance for organic farming, it also offers some specific provisions for certain species, such as mollusks, to clarify how particular articles should be interpreted.

The Organic Regulation includes a comprehensive outline of how farm management should approach health and welfare, addressing key themes like the maintenance of disease prevention, environmental conditions, and farm management practices that support the well-being of the animals. The EU Organic label is not a third-party VSS, but the process that needs to be followed to utilize the ecolabel is similar in many ways. Producers apply for the ecolabel through an accredited Certification Body (CB). This process ensures compliance with the EU Organic Regulation's requirements, including those for animal welfare.

#### Management

In the context of farm management, the EU Organic Regulation emphasizes the training of staff, with a particular focus on those involved in transportation and killing of animals. This reflects the EU's recognition of these key moments in the life cycle of farmed animals as crucial for ensuring their welfare. Similar to VSS, the Regulation also covers biosecurity and fallowing with a relatively high level of specificity. For instance, it mandates that the

competent authority, or a control body must determine if and when fallowing is necessary and the appropriate duration. This approach highlights the importance of farm management in maintaining environmental standards while also addressing broader welfare concerns indirectly. The regulation is less detailed regarding day-to-day management activities such as inspection, record-keeping, health and welfare planning, and welfare assessments. It offers little detail on these topics outside of the context of exceptional circumstances.<sup>41</sup>

#### Monitoring and Disease Prevention

In the context of health monitoring, subthemes like stocking density, casualty slaughter, veterinary treatments, and mutilation, are generally covered with some level of detail under the Organics Regulation. For instance, with regards to stocking density, the Regulation does not prescribe specific density thresholds, which aligns with the understanding that optimal density is species-specific. However, it clearly outlines welfare indicators associated with stocking density, such as fin damage, growth rate, and behavior. Additionally, specific prohibitions are in place concerning mutilation. Additionally, veterinary treatments are also discussed in detail.

#### Reproduction

Reproduction encompasses topics such as broodstock management, hatcheries, breeding practices, and the use of hormones. The Regulation provides detailed coverage of these issues, particularly focusing on minimizing or prohibiting interference with natural reproductive processes. Specifically, broodstock must be handled in a way that minimizes physical harm and stress, with the use of anesthesia where appropriate. The use of hormones or hormone derivatives is strictly prohibited. Furthermore, species-specific techniques are addressed, such as eye stalk ablation for shrimp, which is also prohibited under the Regulation. Hence, there are examples where the EU Regulation addresses the specific species' needs, despite the Regulation being applicable to any organic farm.

#### Cultivation parameters

The Regulation places significant emphasis on cultivation parameters, with several articles addressing key factors such as water quality, temperature, lighting, and oxygen levels. Similar to its approach to reproduction, the Regulation seeks to minimize or prohibit artificial interference, particularly when it comes to natural environmental conditions. However, it provides clear exceptions where necessary, such as permitting the artificial heating or cooling of water solely in hatcheries and nurseries. The Regulation does not establish specific criteria for ammonia levels or salinity.

#### Husbandry practices

The Regulation includes several references to specific considerations for the husbandry phase. It features a dedicated article on the husbandry environment, which specifically requires that grading operations be kept to a minimum and only permitted when necessary to ensure animal welfare, further emphasizing the Regulation's clear focus on animal welfare. A minority of husbandry subthemes, particularly stripping, crowding, and towing enclosures, are not addressed.

#### Equipment

The Regulation includes two articles specifically addressing equipment, stating that "holding systems, equipment, and utensils shall be properly cleaned" and that "proper equipment and protocols shall be used to avoid stress and physical damage associated with handling procedures".<sup>42</sup> What is commendable about these articles is their clear focus on animal welfare. However, both articles are relatively general, lacking specifics regarding equipment tailored to particular farming methods. This absence of detail means the Regulation falls short of providing the specificity needed. In comparison, the VSS appears to offer more detailed references to equipment for specific farming methods.

#### Feed

With the exception of a few articles addressing feed content and ensuring it meets the nutritional requirements of animals at various stages of development, the Regulation provides no specific details on feed requirements. While the EU has several feed-specific regulations, which are also referenced in this Regulation, these also focus

<sup>&</sup>lt;sup>41</sup> Regulation (EU) 2018/848, Recital 60, Art 22

<sup>&</sup>lt;sup>42</sup> Regulation (EU) 2018/848 of the European Parliament and of the Council of 30 May 2018 on organic production and labelling of organic products [2018] OJ L150/1, Art. 3.1.6.1

primarily on feed contents, rather than feeding methods, fasting, and record-keeping, issues that are directly relevant to animal health and welfare.

#### Slaughter

Humane slaughter appears to be a clear focus of the European Commission in drafting the Regulation. It mandates specific training for all individuals involved in the process and emphasizes that suffering, pain, and distress should be avoided or minimized at all times, including during slaughter. The Regulation prohibits any slaughter technique that does not render the fish immediately unconscious and insensible to pain. As highlighted in the literature, the insensibility to pain varies by species, and a general prohibition of techniques that fail to achieve this is therefore more appropriate in a non-species-specific regulation. The EU reinforces this by stating that "differences in harvesting sizes, species, and production sites shall be taken into account when considering optimal slaughtering methods".<sup>43</sup> Additionally, it is important to note that there is a separate EU Regulation on the protection of animals at the time of killing, specifically Regulation (EC) No 1099/2009.

#### Polycultures & Life stages

No reference to any (sub)theme in this context.

## EU STRATEGIC GUIDELINES

The European Commission (EC) published the EU Strategic Guidelines for Sustainable Aquaculture<sup>44</sup> in 2021 as part of its efforts to promote the sustainable growth of the aquaculture sector. These guidelines, while not legally binding, serve as a framework to guide EU member states in developing their national aquaculture strategies and action plans. As the plan is not intended for auditing farms, a detailed description of each performance area is not included; instead, a general summary is provided, similar to FAO guidelines under 2.2. The EC published these guidelines in response to the growing need for sustainable food production and to address challenges faced by the aquaculture industry. The guidelines aim to increase the competitiveness and sustainability of EU aquaculture, ensure food security, create jobs in coastal and rural areas, and reduce the EU's dependence on imported seafood. They focus on key areas such as simplifying administrative procedures, coordinating spatial planning, enhancing competitiveness through research and innovation, promoting environmentally friendly production methods, improving animal welfare standards, and diversifying aquaculture products. By providing this strategic direction, the EC seeks to foster a more coordinated approach to aquaculture development across the EU, balancing economic growth with environmental and social considerations.

The guidelines specifically address animal health and welfare concerns, acknowledging that despite existing EU legislation on aquatic health, several challenges remain.<sup>45</sup> These challenges include:

- The lack of species-specific husbandry practices and technologies;
- The need for better disease and parasite prevention to reduce veterinary medicine use;
- The necessity to decrease pharmaceutical use, including antimicrobials and anti-parasitic substances;
- Research gaps in areas such as fish microbiome, climate change impacts on fish health, and stress effects on immune systems;
- Limited availability of specific veterinary medicines for aquatic animals;
- Absence of good practice codes for certain aquatic diseases;
- Inconsistent disease investigation across EU Member States and sectors.

The guidelines also emphasize the importance of sustainable feed ingredients, species-specific health and welfare indicators, continued research on welfare parameters, and improving knowledge and skills on welfare among aquaculture operators. These strategic guidelines complement existing EU regulations such as the Animal Health

<sup>&</sup>lt;sup>43</sup> Regulation (EU) 2018/848, Art. 3.1.6.9

<sup>&</sup>lt;sup>44</sup> Formally known as: European Commission, 'Strategic guidelines for a more sustainable and competitive EU aquaculture for the period 2021 to 2030' (Communication) COM (2021) 236 final

<sup>&</sup>lt;sup>45</sup> Under 2.1.3. of Strategic Guidelines

Regulation<sup>46</sup>, regulations on veterinary medicinal products and medicated feed<sup>47</sup>, and Directive 98/58/EC on the protection of farmed animals. Practical impact of these additional regulations and directives should not be overestimated, as aquatic animals are often excluded from application of the more prescription articles that contain requirements and prohibitions for farm operations.

# CONCLUSIONS ON EUROPEAN UNION

In conclusion, while the EU Organics Regulation provides a comprehensive framework for the health and welfare of aquatic animals, it demonstrates a clear focus on specific aspects of disease prevention, reproduction, husbandry, and slaughter. The Regulation addresses key welfare concerns, such as minimizing interference in natural processes, ensuring proper handling to reduce stress and physical harm, and safeguarding humane slaughter practices. However, there are areas where the Regulation does not offer significant coverage of the themes, particularly in relation to monitoring, record-keeping, feed requirements, and the equipment used for specific farming methods. In comparison to other standards of the VSS, the Regulation tends to offer a similar level of coverage of environmentally focused standards. Specifically, it provides more explicit guidance on health, husbandry practices, and slaughter. While it includes clear management activities such as planning, monitoring, and record-keeping, it also contains prohibitions. Ultimately, while the Regulation effectively prioritizes animal welfare in many respects, some key welfare themes are absent.

Figure 5. Coverage of Aquatic Animal Welfare by EU Regulation on Organic Farming

1	Management	
2	Monitoring and Disease Prevention	
3	Reproduction	
4	Cultivation Parameters	
5	Husbandry Practices	
6	Equipment	
7	Feeding	
8	Slaughter	
9	Polycultures	
10	Life Stages	

\* Green = High Coverage, Light Green = High-Medium Coverage, Orange = Medium Coverage, Grey = Low-No Coverage

The European Commission's 2021 Strategic Guidelines for Sustainable Aquaculture provide a framework for EU member states to enhance the sustainability and competitiveness of their aquaculture sectors. While not legally binding, these guidelines address key challenges such as the lack of species-specific husbandry practices, the need to reduce veterinary medicine use, and the promotion of sustainable feed ingredients. They also emphasize improving animal welfare standards, reducing environmental impacts, and fostering research on fish health. However, their practical impact is limited by the absence of binding requirements for specific farming practices, as many of the more prescriptive regulations do not apply to aquatic species. These guidelines complement existing EU legislation but are not intended for farm-level auditing or enforcement.

<sup>&</sup>lt;sup>46</sup> Formally known as Regulation (EU) 2016/429 on transmissible animal diseases, applicable from 21 April 2021

<sup>&</sup>lt;sup>47</sup> Formally known as EU Regulation 2019/6 on veterinary medicinal products and Regulation (EU) 2019/4 on medicated feed, applicable from 28 January 2022.

#### **PURCHASING POLICIES**

This section presents a review of 40 sourcing policies from global retailers, focusing on the Asia-Pacific (10%), Europe (58%), and North America (30%) regions, including the largest retailers in each area. Only those policies that provided specific commitments to health and welfare, rather than general statements found on websites or in annual reports, were considered in the conclusions presented here. It should be noted that this review is based on publicly available information and that this section may not be representative for all purchasing commitments for the reviewed retailers. Names of retailers are omitted, as the purpose of this section is to provide an initial understanding of health and welfare references in purchasing policies, not an in-depth review of retailers against the list of themes utilized for previous sections.

Interest in articulating purchasing decisions regarding aquatic animal health and welfare varies significantly by market. The UK market is considered leading, with retailers increasingly prioritizing animal welfare across all farming sectors. One major UK retailer has committed to improving the welfare of farmed decapod crustaceans, including ceasing the sale of live decapods and ensuring that all farmed shrimp in its supply chain is electrically stunned by 2026. Another retailer has also taken clear steps to prioritize aquatic animal welfare by implementing a detailed set of welfare criteria, including the prohibition of live fish, decapod crustaceans, and cephalopods in stores, non-sourcing of farmed octopus, and mandatory stunning of decapod crustaceans prior to slaughter. This retailer also ensures staff training in species-specific welfare standards, implements farm animal health management plans focusing on stress reduction and water quality, and sets limits on practices such as stocking densities, handling, grading, and treatment. Furthermore, they extend welfare considerations to cleaner fish, setting a high standard in the industry. Looking at other UK retailers that have placed less emphasis on welfare in their communications, many still reference general animal welfare principles, such as the Farm Animal Welfare Council's '5 Freedoms.' These principles outline basic welfare standards for farmed animals, including freedom from fear and distress, hunger, discomfort, pain, injury, and disease, as well as the ability to exhibit normal behavior. Further examination reveals that many retailers heavily rely on environmental VSS to address aquatic animal welfare without implementing additional purchasing requirements. As a result, it remains unclear whether most UK retailers' concern for animal welfare has genuinely influenced their purchasing strategies, as many have relied on VSS for their sourcing even before referencing welfare.

In continental Europe, health & welfare commitments vary among major retailers. Some include welfare-specific standards alongside environmental requirements. For example, certain retailers implement their own commitments, such as prohibiting the use of GMOs in fish farming and regulating hormones. Others have developed specific farming practices that address stocking density, stunning before slaughter, and humane handling of fish, alongside monitoring water quality and managing wastewater. Many retailers in Southern Europe still offer limited to no guidance on purchasing requirements related to health and welfare. In North and South America, major retailers generally reference animal health and welfare less frequently than their European counterparts. However, notable exceptions include Canadian retailers, which incorporate specific health and welfare requirements into their policies. These include considerations for water quality, stocking density, and adherence to the five freedoms, reflecting a more comprehensive approach to aquatic animal welfare. Expanding our search to major retailers in Asia-Pacific and Southern Africa, many retailers emphasize animal welfare as part of responsible sourcing but rarely provide specific guidelines to influence purchasing decisions directly.

Finally, it was generally observed across all retailers that policies for terrestrial animals are consistently more comprehensive than those for aquatic animals. This appears partly because terrestrial animals have often served as the starting point for most health and welfare policies, and many conditions applicable to terrestrial animals do not apply to aquatic animals, resulting in lower standards for aquatic animal welfare. For example, stunning before slaughter is one of the few commonly committed-to welfare measures for aquatic animals. Additionally, consumer pressure on welfare tends to focus more on terrestrial animals, with the sentience of aquatic animals being underestimated. However, exceptions exist, particularly among UK retailers that have introduced purchasing commitments explicitly designed with aquatic animal welfare considerations in mind.

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