

A GUIDE ON FISH WELFARE

IN SPANISH AQUACULTURE

(Vol. 1): Concepts and Generalities



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1. INTRODUCTION

Billions of people obtain nutrient-rich nourishment from fish that come from fisheries and aquaculture. Nowadays, the contribution of aquaculture has surpassed that of fisheries as a major source of aquatic animal protein. This contribution continues to grow mainly thanks, in part, to both a growing demand from part of the population and a stagnation of the fishing industry (FAO 2022). In Spain, fish farming is one of the animal production sectors with most rapid growth in the last decades and likely to continue to grow (APROMAR 2021). However, this swift development poses a great challenge for the industry since its production methods, as in the rest of the animal husbandry-related sectors, animal welfare and the environment must be respected.

Given the sector's rapid development and growth prospects, it is relatively recent that fish, and related welfare issues, have attracted scientific cause of concern and public and governmental interest (Saraiva & Arechavala-Lopez, 2019). In this respect, fish welfare has been an important priority within European policies and professional producers' organizations, as well as for producers themselves and all other professionals in the fish farming value chain, including consumers, NGOs, the scientific community, and regulatory bodies in the European Union Member States. This harmony has led to a constructive debate among stakeholders in Spain, which has resulted in the development of this general guide on animal welfare of aquaculture fish.

Respecting the welfare and promoting the health of farmed fish are technical and social responsibilities fully assumed by the Spanish aquaculture sector, intent on working every day to monitor and improve these tasks. The welfare of farmed fish encompasses various ethical, economic, environmental, and legal implications, as well as the image of this sector

in society, hence the importance of addressing this issue with the utmost rigorousness and objectivity.

From the perspective of production, the lack of official Spanish or European guidelines or regulations makes it difficult to implement standardized good animal welfare practices for fish farms in Spain or Europe on an equal footing. However, most Spanish aquaculture companies currently incorporate (to a greater or lesser degree), in their internal production records and quality certifications, implementation and monitoring statistical values related to fish animal health. Although this information is private and comes from the goodwill of each company, it is also routinely supervised by the local public veterinary regulatory bodies (such as the Regional Offices of Agriculture, the Departments of Livestock and Fisheries, among others) of each Autonomous Community.

At the sectoral level, it is considered necessary to have and agree on operational animal welfare indicators, based on the available scientific knowledge, that are clear, measurable, and achievable, in a standardized way. The indicators will be proposed and elaborated by the fish farming sector, together with the participation of scientists, and social and institutional actors to allow improvement in animal welfare, with full guarantees of a future agile, safe, and sustainable implementation in the Spanish aquaculture sector and its value chain. This document aims at reaching a consensus based on further progress in increasing animal welfare and aspects related to fish production in Spanish aquaculture.

The preparation of this instrument on fish welfare in Spanish aquaculture is the result of a collaborative and participatory pursuit between the companies of the Spanish Aquaculture Business Association (APROMAR), together with

several animal welfare and protection associations and organizations (Equalia, Compassion in World Farming International, FishEthoGroup association), Spanish universities (Universidad Autónoma de Barcelona, Universidad Politécnica de Madrid, Universidad de Cádiz) and public research organizations (Instituto Mediterráneo de Estudios Avanzados-CSIC). This Guide has been funded through the Production and Marketing Plans of the Fisheries Producers Organization No. 30-APROMAR, with co-financing from the Ministry of Agriculture, Fisheries and Food of the Spanish government and the European Maritime and the European Union Fisheries Fund.



Objective and scope of the guide:

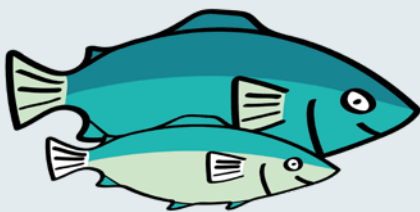
The elaboration of this guide on welfare of fishes in Spanish aquaculture is important to fix concepts, establish common bases and develop the first consensual guidelines on animal welfare. This document provides information on the state of aquaculture activity in Spain and contributes to promoting more coordinated and responsible development of animal welfare. The guide is aimed at companies and professionals in the aquaculture sector, as well as public administrations, legislators, scientific-technological and educational sectors, and society in general. This publication is intended to be the first of a series of guides offering codes of conduct and recommendations for the correct evaluation and promotion of the welfare of the different fish species and production systems in Spanish aquaculture.



2. FISH WELFARE IN AQUACULTURE

Animal welfare is a complex concept that can be defined in different ways. Most definitions fall into one of three broad categories (see below) that express different views on what we should be concerned about in the treatment of animals (Huntingford *et al.*, 2006):

- a) **Functional welfare.** The functional definitions are given on the capacity of the animal to adapt to its current environment, its welfare, in this case, calling for it to have good health and for its biological systems to function properly without the need to respond beyond its capacity.
- b) **Natural welfare.** Nature-based definitions refer to each species being able to express its natural behavior and lead as natural a life as possible.
- c) **Emotional welfare.** Definitions based on feelings or emotional preference are established in terms of subjective states of mind, i.e., that the animal feel good, without potentially negative experiences such as pain or fear; and that it may have access to positive experiences such as companionship and other stimuli as in the case of gregarious species.



Combining these three approaches, this guide will use the term welfare as defined by Broom (1996) and adopted in its unabridged version by the World Animal Health Organization (OIE 2008): “**Welfare is the state of an animal in terms of its capacity to interact with its environment. An animal is in a state of welfare if (as indicated by scientific evidence) is healthy, comfortable, well-fed, safe, capable of expressing its inborn behavior, and does not suffer unpleasant states such as pain, fear, or anguish**”.

Fish are the most numerous and varied group of vertebrate animals on the planet, with some 35,000 known species. They are found in all types of aquatic ecosystems and are evolutionarily adapted to the environments they inhabit. In addition, there is scientific evidence demonstrating their ability to feel fear, pain, anguish, and stress (Schreck *et al.* 2016, Sneddon and Brown, 2020), confirming that they are sentient beings and deserving of the best welfare conditions. Therefore, achieving welfare in aquaculture means providing appropriate husbandry conditions. It has to do with employing appropriate practices that improve the living conditions of fish, provide a death without suffering, and reduce any risks that, being detrimental to their welfare, could be avoided (Fife-Cook and Franks; 2019, Kristensen *et al.* 2020).

In view of the very large variety of species and production areas, meeting the needs for fishery goods in aquaculture is a huge challenge for the industry, especially because of the difficulty to generalize, considering that the biological needs to be satisfied vary between species, throughout the life cycle, and depend on the different stages of production, technology, environmental setting, and farming system used.

“Welfare is the state of an animal in terms of its capacity to interact with its environment. An animal is in a state of welfare if (as indicated by scientific evidence) is healthy, comfortable, well-fed, safe, capable of expressing its inborn behavior, and does not suffer unpleasant states such as pain, fear, or anguish”

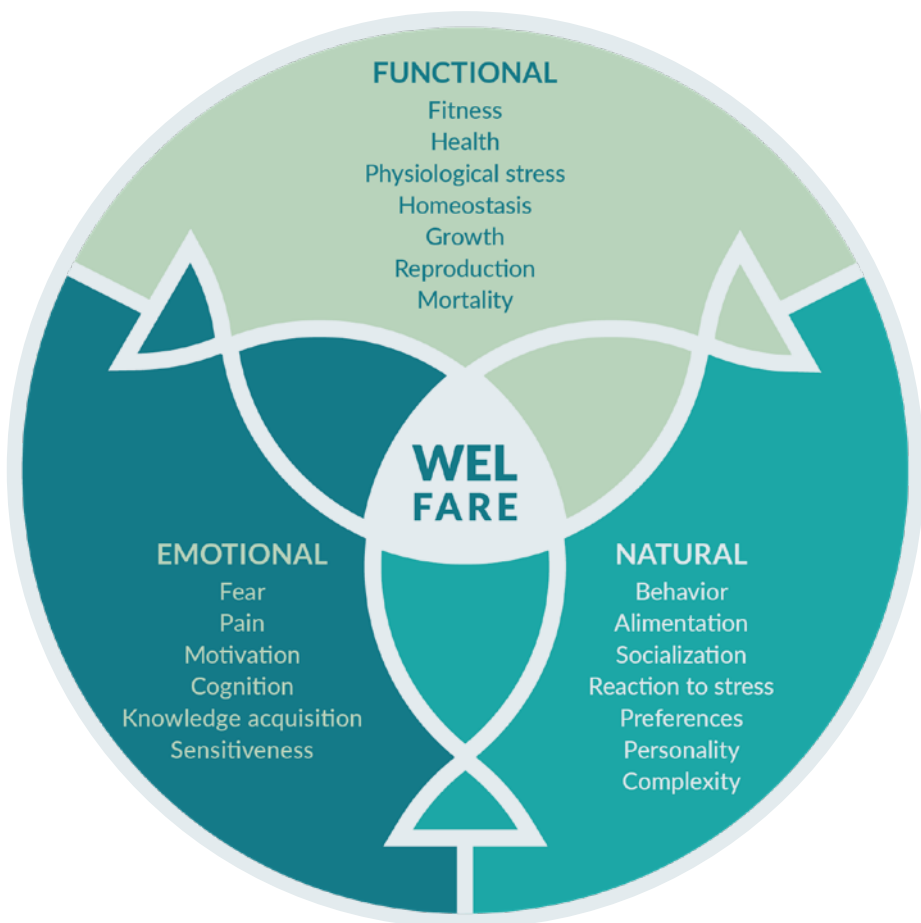


Diagram depicting the complexity of the term welfare and the three major categories comprising it.

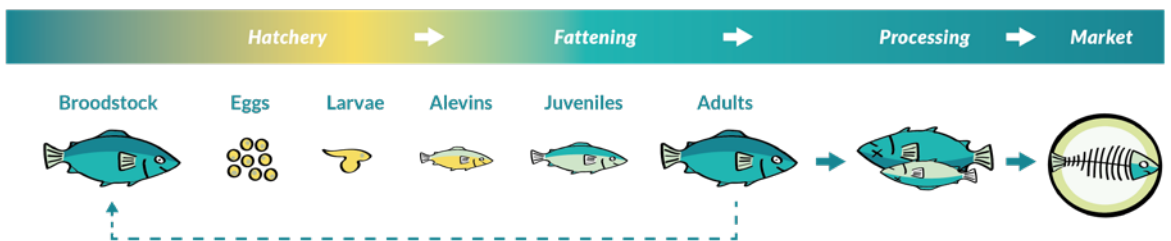
3. FISH AQUACULTURE IN SPAIN

Spanish aquaculture is one of the most diverse at the European level in terms of the number of species raised and their production systems. Nearly 94% of Spanish aquaculture is carried out in marine or brackish waters, whereas the rest of the production (6%) is carried out in inland waters. Overall, the production cycle has several phases according to the stage of life of the fish being farmed and/or the final product.

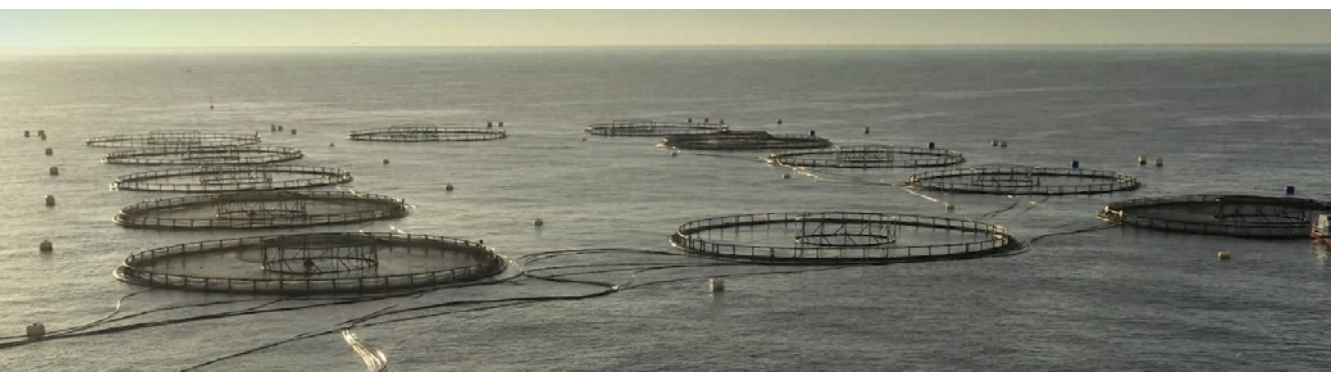
Each species can be hatched in different production systems that may vary throughout the life of the fish or depending on the quantity to be produced. For instance, the first life stages of marine species such as **seabass**, **seabream** or **meagre** are carried out in land-based hatcheries (tanks with open or closed intensive production systems) whereas fattening or later-life stages are carried out in floating net-pens in the open sea or near the coast, under intensive farming. However, it is also carried out in intertidal zones with semi-intensive or extensive culture fisheries (estuaries).








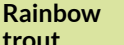



In much the same way, the **amberjack** is now being intensively reared (in tanks and floating net-pens) whereas **tuna** is still raised in floating net-pens since its production still depends on juveniles caught alive in the wild. Rearing of flatfish such as **turbot** and **sole** is carried out in open- or closed-systems in tanks at land-based facilities throughout their life cycle.

In freshwater aquaculture, the entire production cycles of species such as **rainbow trout** or **sturgeons** are also carried out in land-based facilities (tanks with either open or closed intensive production systems). For its part, **eel** is produced in land-based farms, with different levels of intensification, although this activity still depends on the capture of wild elvers for its production. Another inland waters species is the **tench**, whose production is achieved in tanks and/or in natural nursing ponds on land.



Fish production chain in aquaculture underscoring the different stages of the fish life cycle.



Species	Scientific name	Type	Hatchery/ nursing	Fattening	Cycle time*	Production 2021
 Seabass	<i>Dicentrarchus labrax</i>	Marine, intertidal	Tanks, open systems or RAS	Floating nurseries or estuaries	18-24 months	23.924 t
 Seabream	<i>Sparus aurata</i>	Marine, intertidal	Tanks, open systems or RAS	Floating nurseries or estuaries	16-24 months	9.632 t
 Meagre	<i>Arygorosomus regius</i>	Marine, intertidal	Tanks, open systems or RAS	Floating nurseries or estuaries	20-24 months	5.981 t
 Turbot	<i>Psetta maxima</i>	Marine	Tanks, open systems or RAS	Tanks, open systems or RAS	18-20 months	7.629 t
 Sole	<i>Solea senegalensis</i>	Marine	Tanks, closed systems or RAS	Tanks, closed systems or RAS	18-20 months	1.020 t
 Tuna	<i>Thunnus thynnus</i>	Marine	-	Floating nurseries	< 12 months	10.062 t
 Amberjack	<i>Seriola dumerili</i>	Marine	Tanks, open systems or RAS	Floating nurseries	-	123 t
 Rainbow trout	<i>Oncorhynchus mykiss</i>	Inland	Tanks, open systems or RAS	Tanks, open systems or semi-RAS	12-24 months	15.537 t
 Sturgeon	<i>Acipenser naccarii</i> , <i>A. baerii</i>	Inland	Tanks, open systems or RAS	Tanks, open systems or semi-RAS	3-9 years	131 t
 Eel	<i>Anguilla anguilla</i>	Inland	Tanks, open systems or RAS	Tanks, open systems or RAS	~24 months	320 t
 Tench	<i>Tinca tinca</i>	Inland	Tanks or Ponds	Ponds on land	12-24 months	17,5 t

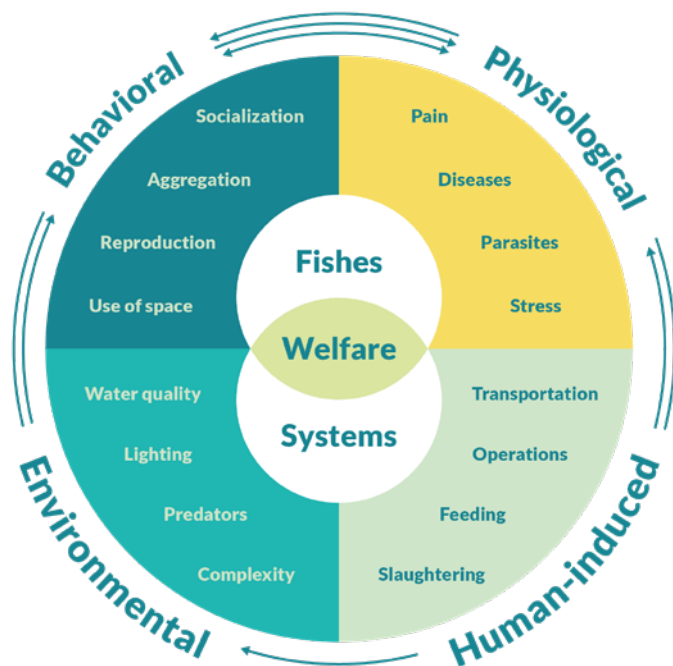
Summary table of the different species of Spanish aquaculture, indicating the type and systems of production, and the duration of the cycle.

* Note: the cycle length shown is approximate and might vary according to the company and farming conditions.

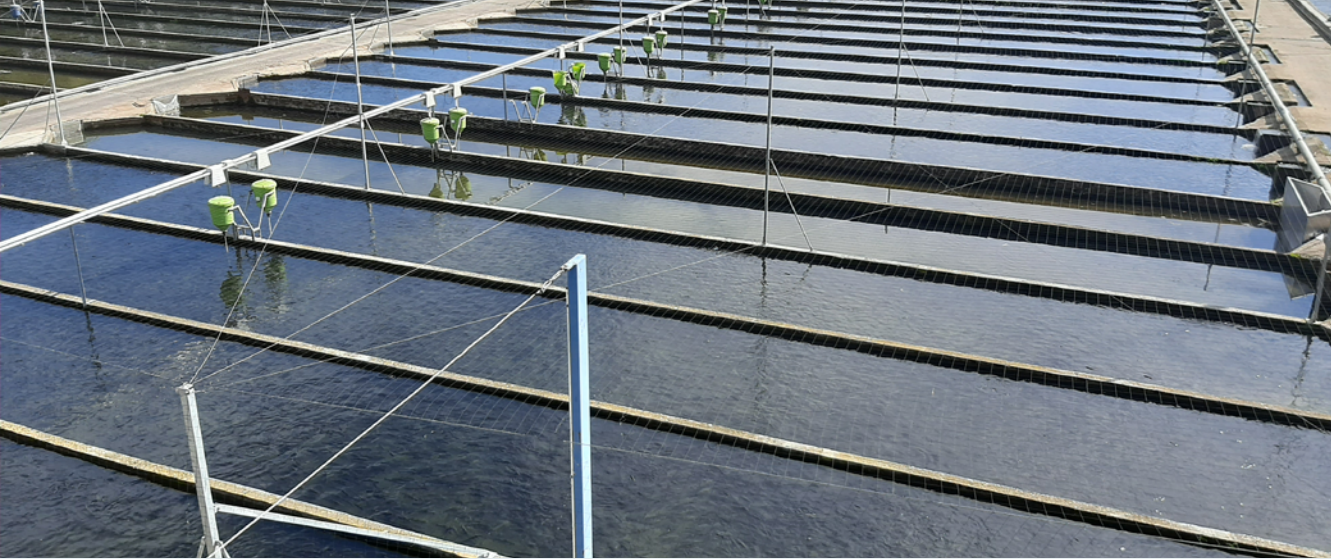
4. KEY POINTS ON WELFARE AND GOOD PRACTICES IN AQUACULTURE

Animal welfare plays a critical role throughout the production cycle of any aquaculture species. Fish are in captivity and, therefore, there may be welfare constraints when subjected to human actions. Thus, fish are affected behaviorally, physiologically, and environmentally, facing challenges directly induced by such human activity (Saraiva *et al.*, 2022a). These four main categories are interrelated and applicable to all fish farming systems, although their effects may differ in intensity and severity depending mainly on the species, life stage, and production method.

From the aquaculturist's point of view, the challenges faced by captive fish can be classified in an operational manner, pointing out the procedures that are carried out at the different stages of the production cycle in which the welfare of the fish may be compromised and in which the aquaculturist must act in a consistent and responsible manner. The classification covers seven major blocks or operational contexts, which are detailed below:



*Schematic representation of the linkages between the different behavioral, physiological, environmental, and human-caused challenges to which fish are exposed during aquaculture rearing conditions and operations. Arrows represent the interrelationship between the four categories, and some specific challenges are cited as examples within each major category. Modified from Saraiva *et al.* (2022a).*

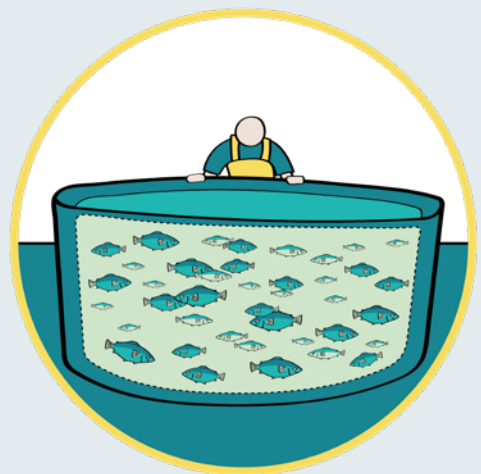


4.1. Environment and confinement

Fish are bred in captivity and, therefore, the **design** and **dimensions** of the facilities where they are reared should be contingent on the biology and life stage of each species. They should be provided with the best culture conditions and allowed sufficient space to move around freely. In the case of open-sea net-pens, their location must be carefully considered to avert possible undesirable **weather conditions** (currents, waves) to which the fish may be exposed, so as to avoid damage to their welfare and to the facilities.

Of course, **water flow** and **water quality** in any fish production system must be ideal, and care should be taken to provide the fish with appropriate levels of the different parameters (oxygen, temperature, pH, current velocity, etc.) relative to the physiological and behavioral needs of each species and life stage. These parameters should be systematically monitored. Optimal **lighting conditions** (natural or artificial) should be provided, both in terms of intensity and frequency, considering the natural rhythms and needs of each species. Also, fish **densities** in each production unit should be well adjusted to allow for the natural behavior of the animals and to avoid counterproductive effects on their welfare (Saraiva *et al.* 2022b).

In production systems there is perceptible **environmental noise**, created mainly by the systems and machinery used in the different operations (engines, boats, pumps, etc.). This noise should be minimized as much as possible to avoid undesirable effects on fish welfare. **Environmental enrichment** is an advisable tool to provide positive stimuli and improve fish welfare (Arechavala-López *et al.*, 2022). However, any environmental enrichment should be designed and tested according to the species, life stage, and production system used. Finally, special attention should be paid to the presence of **predators** (birds, wild fish or cetaceans), acting accordingly and always keeping in mind the welfare of both farmed and wild fish.





4.2. Management and maintenance

During fish farming, **routine operations** related to the maintenance of facilities and fish, such as cleaning of tanks or nets, repairs, component changes in floating hatcheries, sorting and sizing, or removing dead fish, among others, must be carried out by trained personnel, using specially designed tools and equipment to minimize potential damage to fish welfare.

There are also several routine operations related to fish handling that might compromise fish welfare through direct physical contact. For example, the **use of nets** to handle, sort, move, or control individuals is quite common. To facilitate movement, fish are concentrated in their production units, either by netting or screening, and/or by managing the water level. This results in **agglomerations** that can be detrimental to fish, where the timing of the maneuver and density of concentration are crucial.

As fish grow, **transfers** occur between production units and systems either manually or by automatic pumping and counting. Similarly, fish are **sorted** into different stages of the production cycle, depending on size or when deformities are present. In any of the above cases, it is necessary to ensure that the tools and machinery are in good condition and operated by **qual-**

ified personnel. Efforts should also be taken to reduce as much as possible the time the fish are out of the water and to minimize any physical damage, stress, or other undesirable effects on their welfare.

A particular case is the handling and maintenance of **brood-stock** in hatcheries. These spend more time in captivity than those destined for production, and their needs and sizes also differ from those of their conspecifics. Therefore, routine handling maneuvers (individual health and fertility inspections) and maintenance must be carried out by qualified personnel, paying even more attention to their welfare and to the biological needs of each species and hatchery system.





4.3. Feeding

Feeding is a crucial operation in fish aquaculture, as it has a direct relationship with fish welfare (health, growth, behavior, etc.), the sustainability of the activity and the economics of the business. In this regard, **feeding strategies** play a very important role, as feeding regimes, schedules, and procedures greatly affect the welfare status of the animals. Fish hunger and food availability are very important factors affecting welfare and effective production. A feeding strategy tailored to the biological needs of each species and life stage will help control appetite and foraging behavior, thus reducing other undesirable social interactions. In other words, the feeding behavioral needs of the species must be met.

Adequate **food availability** is based on the appropriate **distribution** of food in time and space, the size of the **food ration**, and the **characteristics** of the food. Fish have a well-developed taste system, so the type of feed provided must not only meet the **nutritional** needs of the fish, which will have an impact on its health and growth but must also consider the physical appearance and **organoleptic** characteristics of the feed (size, shape, taste, palatability, texture, color, buoyancy).

Another aspect related to fish feeding and welfare is **fasting** periods, which often occur at times prior to transport or slaughter. Sometimes, fasting periods may be due to weather conditions that prevent operations in floating facilities in the open sea, fish farmers thus being unable to feed their fish. In any case, care must be taken to ensure that fish are not exposed to prolonged fasting that could lead to worrying states of starvation, putting their health and welfare at risk.





4.4. Animal health

Health is one of the most traditional and important components of aquaculture fish welfare. Aquaculture companies have surveillance and biosecurity plans that establish the preventive and mitigating measures necessary for responsible production. **Surveillance plans** are a key tool in the control of fish diseases and are essential in the surveillance carried out by the competent authority. There are three types of surveillance to be carried out in parallel in aquaculture: passive (monitoring the state of fish stocks by observing clinical symptoms and production indicators), active (health visit by a veterinarian), and specific (tailored to the relevant diseases or alterations).

Furthermore, fish production companies are required to submit a **biosecurity plan**. This consists of a document that identifies the most likely pathways for the introduction and spread of diseases and describes the measures (of both infrastructure and management practices) that will be implemented to reduce these risks, as well as the verification controls for each measure described in the plan. Preventive measures include **vaccination**. This process is usually carried out in hatcheries and consists of different phases. The fish are concentrated and transferred to the vaccination area, where they are submitted to injection (individual) or immersion (group bathing). Prior **sedation** is sometimes used to facilitate handling, reduce stress, and improve the quality process. Besides, it is convenient to conduct a follow-up of

the possible reaction to side effects of the vaccine during recovery and ensuing months.

When biosecurity and preventive measures are not sufficient, and the disease has clinical manifestations, **palliative or therapeutic measures** must be taken to safeguard the health and welfare of the fish. These measures, authorized and available under the supervision and prescription of a veterinarian, depend on the type of disease or pathogen detected. They include, for example, formalin or hydrogen peroxide baths, chloramine, antibiotic or antiparasitic baths, osmotic baths, medicated feeds, etc. However, some treatments may have adverse effects on the treated fish, either because of the handling, the active ingredient, or the drug itself. Therefore, it is advisable to monitor these effects and evaluate the welfare of the fish after treatment.





4.5. Transportation

Transportation is the process by which fish are moved from one unit or facility to another, the distance varying considerably. It is a critical operation for fish welfare, divided into five phases (Saraiva *et al.* 2021):

The **pre-transport**, or first phase, includes a good planning of the route to be taken, the means of transport to be used (boat, truck) and possible adversities to be considered (traffic, weather, etc.). This phase also includes the preparation and review of the systems and equipment to be used (tanks, pumps, measuring systems, etc.), and the preparation of the fish to be transported (selection, fasting, etc.).

During **loading** phase, the fish are then transferred from the production unit into the transport vehicle. In this second phase, the fish are concentrated and moved by pumping (recommended), nets or cranes and containers. During this process it is advisable to monitor their condition and the quality of the water.

Once the fish are loaded, they are **transported** by road or sea. In this phase it is of vital importance to continuously control and monitor the water quality, the behavior of the fish (if possible), as well as to have support systems and replacements of the control equipment. It is essential that the transporter follow the most suitable route, foreseeing possible adversities, and contemplating possible alternatives in or-

der to ensure the survival and welfare of the fish so transported.

Upon arriving at destination, the fish are **unloaded** into the corresponding production unit by gravity, pumping, or netting. It is essential to check for possible casualties (and analyze the causes), control the water quality at the new farm, and monitor the welfare of the fish transported during the acclimatization period.

Finally (**post-transport**), a review of the systems and equipment used for transport, cleaning, washing, and disinfection must be carried out. It should be noted that the procedure described above is general, and each specific operation must be weighed to contemplate the requirements of the species and life stages of the fish being transported, as well as the means, vehicles, and equipment available.





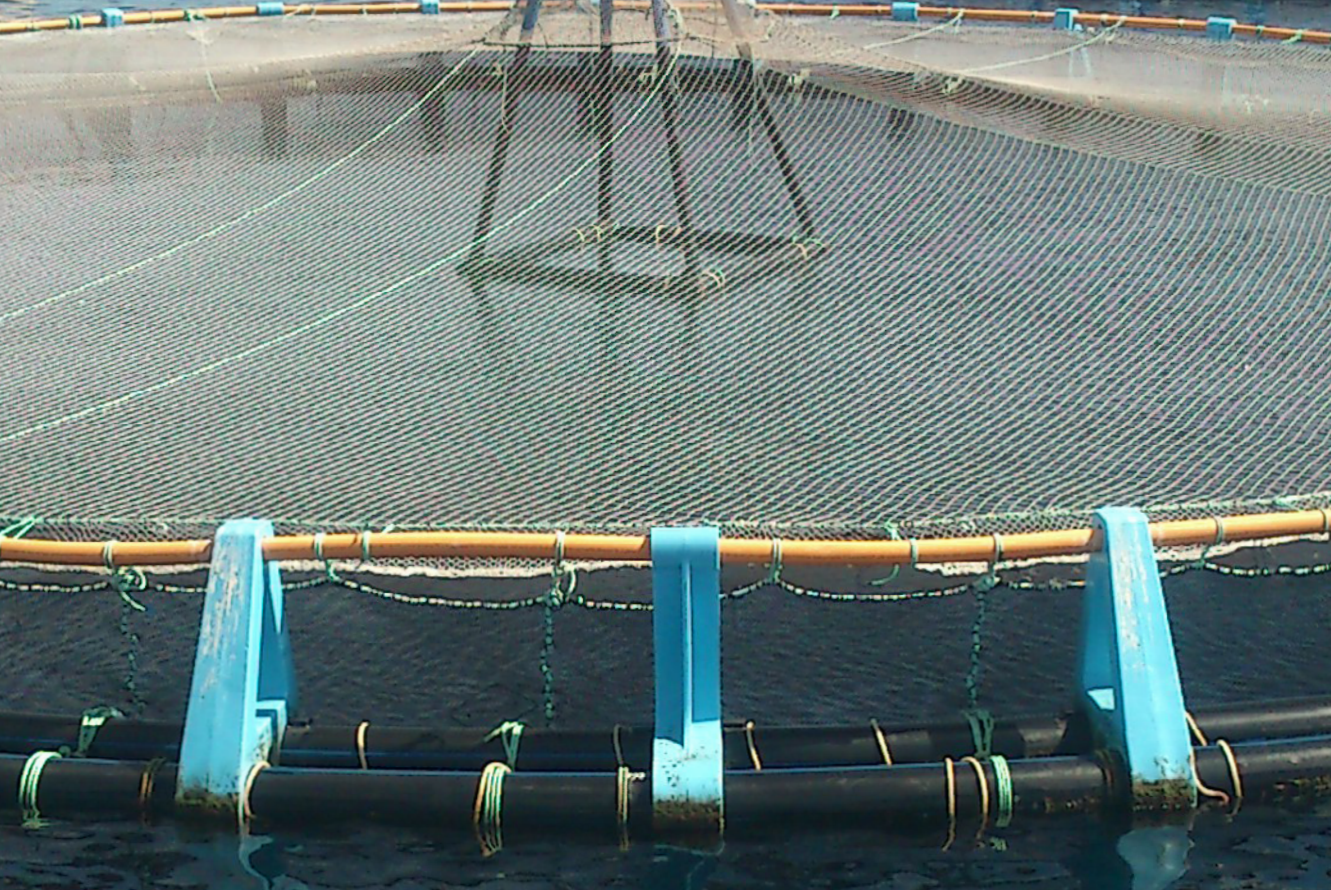
4.6. Stunning and slaughtering

Slaughter is the final phase of the life cycle of aquaculture fish. This process, of relatively short duration, is very relevant to their welfare. They should be provided with the most humane end possible, free of pain and suffering. The process starts with the fasting of the fish to be slaughtered a few days before. Subsequently, the day of slaughter begins with the **concentration** and **transfer** of the fish to the area where they are to be slaughtered, using pumps or nets with cranes. Sometimes, the fish must be transported to the slaughter plant, but in most cases, it is usually carried out in the same facility or in a boat transferred to the on-growing area. One of the most commonly used slaughtering techniques is death in ice water (ice-slurry), theoretically causing thermal shock. However, the World Organization for Animal Health advises against its use because it has been scientifically proven to generate a lot of stress, anxiety and suffering in fish (OIE 2010).

It is however suggested that effective **stunning** be resorted to prior to the slaughter, ensuring

a more humane procedure and causing a rapid and lasting loss of consciousness in the fish. Various stunning methods have been recommended, such as the use of electric shocks or percussion (accurate and precise blows to the head) as the most current methods. Once stunned, fish are **slaughtered** by cutting the gills (exsanguination), percussion or thermal shock (in ice water), among others. The choice of each technique, both for stunning and slaughtering, will depend on the species and size of the fish to be slaughtered, the production system, the knowledge and the equipment used in each facility, without prejudice of future scientific and technical advances.





4.7. Formation and training

Fish are sentient animals, so all necessary measures must be taken to eliminate any possible pain, distress or harm that may be inflicted on them by the aquaculture activity. To this end, it is essential that companies have both **qualified personnel** for each of the tasks to be carried out and an updated and continuous **training plan** in animal welfare, promoting responsibility and good practices in the company.

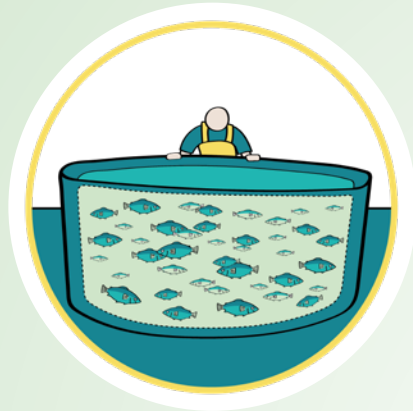
In addition, to ensure good conduct with respect to the welfare of the fish, each company would have to have a specific **animal welfare plan**, indicating the measures and procedures to be carried out at each stage of production. It should be noted that fish farmers already have an obvious interest and respect for the welfare of their animals; and have been developing

practices and technologies that make it possible to assess the condition of the fish, monitor performance, improve their welfare, and ensure the profitability of the farms.



Good practices in aquaculture

Environment and confinement



Management and maintenance



Animal health



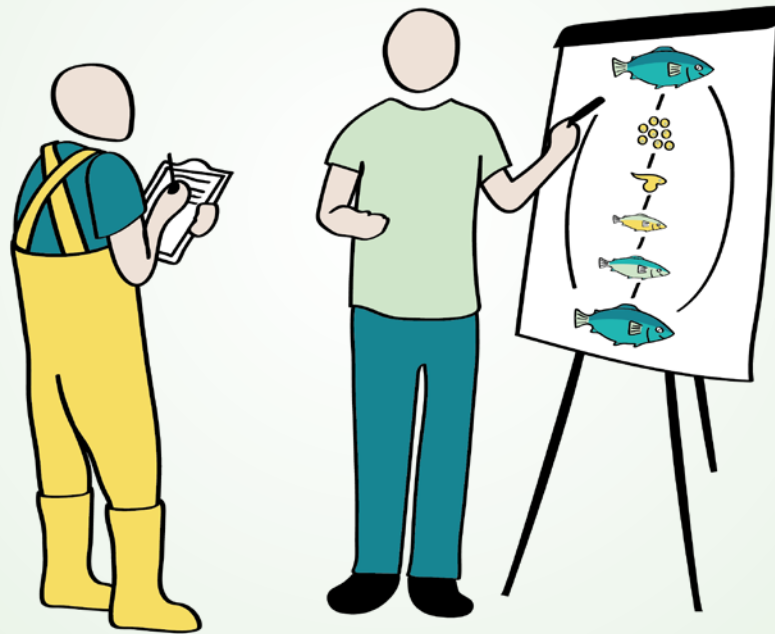
Feeding



Transportation



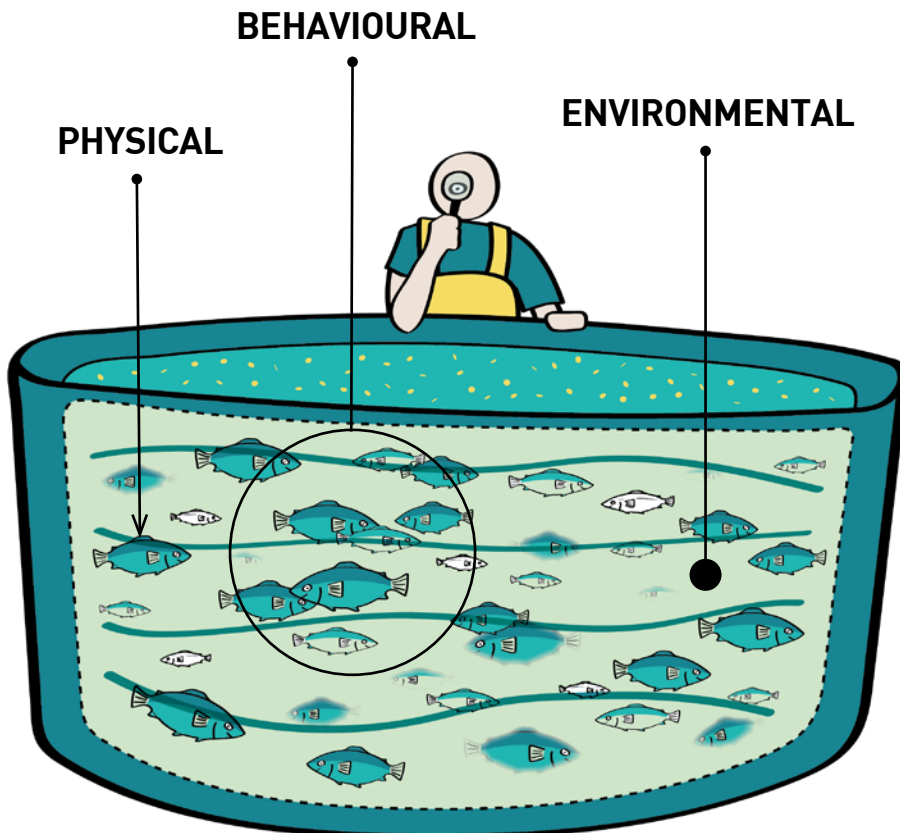
Stunning and slaughtering



5. OPERATIONAL WELFARE INDICATORS

Fish have different biological needs and abilities to cope with stressors, which can vary among individuals and species throughout the life cycle. In addition, aquaculture farming systems also present specific welfare challenges. It is therefore essential to have indicators that allow reliable and objective assessment of the welfare status of fish in relation to their production systems. Such tools will in turn allow for the evaluation of the different procedures carried out in the company and for the adoption of the necessary measures to promote fish welfare.

Welfare indicators should therefore allow monitoring and assessment of the welfare of fish in aquaculture. *Operational Welfare Indicators* (OWIs) are those that can be measured directly on the farm, and should be robust, provide a valid reflection of welfare, repeatable, comparable, and easy to measure (Stien *et al.*, 2020). Shown next are different operational indicators of welfare in aquaculture fish, listed in general terms and classified according to their operability:



5.1. Physical indicators

Straight indicators, based on the animal, provide information on the body condition or external appearance of the fish. Among the most used is the **condition factor** or **growth rate**, since one of the first signs of stress is loss of appetite. These indicators are used to measure the nutritional status and somatic growth of the fish.

Under stressful conditions, **skin coloration** can be affected, exhibiting significant and easily observable changes. The **skin condition**, with the presence of active lesions such as ulcers, hemorrhages, or superficial wounds, is a clear indicator of negative effects on fish welfare due to different causes such as, for example, improper handling. These **wounds** can be quickly affected by bacteria present in the marine environment, and in turn, **external parasites** attached to the skin of the fish can cause irritation, or more serious lesions. Similarly, the **fins condition** or state can indicate the state of welfare of the fish, since in captive conditions they may appear eroded, thickened, malformed, split and/or hemorrhagic (even infected).

The **condition of the gills** may also be an indicator of welfare related to water quality. Likewise, the presence of opercular, mandibular, and/or vertebral **deformities** have been generally related to bad practices, nutritional deficiencies, or poor water quality, but the etiology is usually unknown. The **condition of the eyes** is easily observable, and the most frequent related pathology in aquaculture corresponds to mechanical trauma derived from handling, followed by exophthalmia, cataract, rupture and/or hemorrhage.

Mortality (number of dead fish as a function of the total of a population in a given period of time) is a retrospective indicator and can help to observe trends that negatively impact fish welfare and that, if not corrected in time, may continue to recur.



5.2. Behavioral indicators

They are also animal-based and direct, but in this case, they provide information on behavioral patterns. In general, **alterations in the swimming pattern** of fish may show possible variations related to their welfare; but should be analyzed according to each species and context. For example, in some species lack of oxygen may trigger frantic swimming and, in others, behaviors associated with lethargy and/or lack of appetite. Increased **surface activity** may also be related to oxygen deprivation in some species or, conversely, to increased interest in food in others. In addition, stress events, related to their distribution and propagation in tanks and nurseries, trigger avoidance behaviors in fish. In fact, observation at the group level can help diagnose animal welfare; and the use of space, or the way fish distribute themselves, provides useful information about how they relate to their environment.

On the opposite side are **stereotypies**, or abnormal, repetitive, and unchanging behavioral patterns that have no obvious function. They usually appear due to a lack of stimuli or interest in captivity. Stereotyped behaviors such as frantic swimming in a triangular or circular direction have been observed in fish. Swimming patterns have also been described close to the tank wall or the cage net with little or no reaction to other external stimuli (**thigmotaxis**), or even blocking or **freezing** behaviors (standing still without moving), as a response to acute or continuous stress. Aggressive behaviors (biting, attacking, chasing) are often common in hierarchical species. Sometimes these **agonistic behaviors** are exacerbated by other factors such as inadequate densities or feeding strategies, or size differences within the same group. If no aggressive behavior is observed, the presence of scars or signs of bites on the skin are direct indicators.

Fish **appetite, anticipatory behavior, and/or foraging** are clear indicators of fish welfare, as

they are directly influenced by feeding type and strategies, social interactions, water quality or other environmental conditions. Finally, **lethargy** in fish is also considered a general sign of disease; and an increased **ventilatory rate** (opercular movement) may be related to low oxygen saturation, increased metabolism, or decreased water quality.

5.3. Environmental indicators

They provide information about the environment in which the fish are living, based primarily on the environmental characteristics, water quality, and physiological needs of the fish (and their tolerance ranges). Among these indicators is, for example, **water temperature**. As poikilothermic animals, abrupt and extreme changes in temperature will have a negative impact on their metabolic function. In addition, it is necessary to consider the optimal range in which animals will not exhibit physiological alterations that affect their growth and welfare. Similarly, each species is adapted to and tolerates different ranges of **salinity**, a parameter relevant to the osmotic balance of individuals and respiration, and which, together with temperature, influences most parameters related to water quality.

For example, **dissolved oxygen** is a good indicator of water quality, which can decrease with increasing temperature and/or salinity, leading to hypoxia. In addition, the high density of individuals managed in intensive farming or the execution of certain procedures such as point concentration of fish can also lead to a decrease in the amount of oxygen present at a given site. **Carbon dioxide** (CO₂), a by-product of fish respiration, is correlated with dissolved oxygen and greatly influences fish metabolism and water pH (measure of water acidity or alkalinity). Alterations in **pH** can lead to failures in osmoregulation and respiration or trigger metabolic problems in fish.

Total ammonia nitrogen (TAN) is an environmental indicator related to pH and water quality. It indicates the amount of ammonia (NH_3) and ammonium (NH_4^+) present in the water. Ammonia is neurotoxic, mainly affecting fish osmoregulation and respiration. In the presence of water and organic matter, it can form ammonium ions that cannot penetrate fish tissues. The next step in the nitrification chain is the presence of **nitrites** (NO_2^-) and **nitrates** (NO_3^-) by oxidation, which are also toxic and can greatly alter the respiration and health of fish.

The characteristics of suspended organic and inorganic material are very important because they can increase the biological oxygen demand. In the case of small and abrasive type particles, they can injure the gill tissue, leading to the appearance of local lesions and compromising the oxygen transfer process, which can lead to fish being more susceptible to develop secondary infections by microorganisms. Therefore, it is important to test for **water turbidity** (or transparency) and **total suspended solids** (TSS). In addition, as turbidity or TSS increases, observation of the animals may become more difficult and thus the assessment of their welfare may become more challenging.

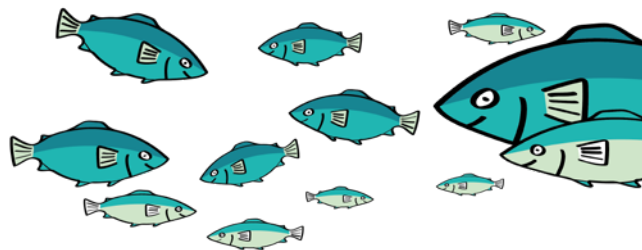
In this respect, **current intensity** or velocity is essential for fish welfare in both tanks and floating nurseries. For example, low current intensity means poor water exchange and, in closed systems, can lead to hypoxic conditions, especially in situations with high temperatures and densities. Conversely, if the current is so high that it exceeds the physical capacity of the fish, it will lead to swimming problems, fatigue, and restrictions in the use of space. In offshore installations, this indicator will be influenced by location, biomass, cage size, and net maintenance. In the case of land-based facilities, the current velocity is more related to the geometries and operating conditions of the hydraulic engineering used (tanks, collectors, and gates).

The **lighting conditions** of the production system or unit is also a good environmental indicator of welfare. The **light intensity** should be appropriate for the species and life stage. Too high a light intensity can cause direct damage to the retina of the fish, whereas too low an intensity can inhibit the activity of the animals. Similarly, the **photoperiod** (or length of light/dark hours) to which the fish are exposed plays an important role in their biological processes, behavior and development, and the chronobiology of the species must always be respected.

The objective measurement of welfare is a challenge, and a proper assessment requires the use of a set of indicators that provide a global view of the system, rather than relying on the values of a single indicator. In addition, the available assessment indicators may not be suitable or applicable for all species or in all production systems.

It is worth mentioning that there are other indicators based on physiological parameters analyzed from fish samples (tissues, blood, mucus) that require specialized laboratories, instruments, and laboratory personnel for their determination. These **laboratory indicators**, although based on the animal, are not as operational as those mentioned above. Their performance and interpretation are more complicated, and they are usually more expensive. Nevertheless, they are useful for validating the use of operational indicators, certifying welfare assessment, and assisting in the implementation of management measures.

Therefore, for a reliable and objective measurement of welfare, the values and quantifiable ranges of each indicator must be adjusted to the needs and characteristics of each species, life stage, site, and production system.





6. LEGISLATION, REGULATIONS, AND CERTIFICATIONS

6.1. Historical framework

Animal welfare practices in aquaculture are mostly based on voluntary guidelines and standards. Aquaculture fish are not specifically and adequately protected by current legislation. Traditionally, animal health aspects have been legislated without considering other key welfare factors. At the international level, the Aquatic Animal Health Code of the World Organization for Animal Health (OIE) includes recommendations on fish welfare during farming, transport, and slaughter; and the Food and Agriculture Organization of the United Nations (FAO) is developing its new Guidelines for Sustainable Aquaculture (expected publication in 2024).

The European Union regulates the protection of animals intended for human consumption through a directive (98/58/EC) and several regulations dedicated to transport (1/2005/EC), animal health (2016/429/EU), slaughter (1099/2009/EC), and organic production (2018/848/EU, 2020/464/EU). In 2005, the Council of Europe published a Recommendation on fish in aquaculture farms, mandatory for Spain, which sets out guidelines for the protection and care of fish during their rearing. Apart from these

mandatory standards, the Farm to Table Strategy points out the direct relationship between health and animal welfare. The EC Animal Welfare Platform has developed a Guide on water quality and management for the welfare of farmed fish, and the Strategic Aquaculture Guidelines 2021-2030 have also been updated.

The Government of Spain has published a series of royal decrees and laws to incorporate European legislation on animal protection (348/2000/RD, 32/2007/Law), health (8/2003/Law, 1614/2008/RD), transport (1614/2008/RD, 542/2016/RD) and slaughter (37/2014/RD) at the national level. Within the framework of the Multiannual Strategic Plan for Spanish Aquaculture (PEAE) 2014-2020, each of the Autonomous Communities has drawn up strategies to develop the sector at regional level, e.g., Galicia (2012), Canary Islands and Valencian Community (2014), Asturias (2015), Catalonia (2019), Andalusia and Extremadura (2020), Murcia and Basque Country (2021). The PEAE 2014-2020 will be updated with Spain's Contribution to the Strategic Guidelines for a more sustainable and competitive EU aquaculture 2021-2030 to be published shortly. Finally, there are several UNE (Spanish Association for Standardization) standards for trout production (173001, 173002, 173003), hygiene practices and operations in marine aquaculture (173201, 173202), and stunning and slaughter (173300).



6.2. Certifications

On the other hand, several independent international organizations have developed animal welfare standards and certificates for certain fish species in aquaculture (see Annex). Certifications dedicated to aquaculture are as recent as the industry itself and are still under development and improvement. Traditionally, they have focused on evaluating the social and environmental impact of the farms and/or companies being certified, focusing on labor rights, social responsibility, minimizing the impact on the environment, good facilities, and good business practices, both organizational and farm management.

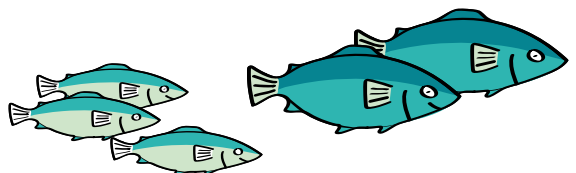
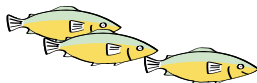
However, certifications rarely contemplated the concept of animal welfare and its evaluation in their certification process. Thus, it is difficult for consumers to differentiate aquaculture products from fish welfare-friendly practices. The demand for products with greater respect for animal welfare and increased awareness on the part of society has increased the pressure on the entire fish value chain. Since 2020, the main international certifications have started to self-assess and revise their standards to include recommendations and obligations to protect fish welfare.

For example, the *Royal Society for the Prevention of Cruelty to Animals* (RSPCA), a reference certification in animal welfare, in particular the welfare of salmonids in aquaculture, updated its standard in 2021 and conducts activities regularly. On that same year, *Friends of the Sea* (FOS) published its first standard dedicated to fish welfare, paying special attention to the needs of each species. The following year, *Global G.A.P.* published a new version of its certification, including the key point of humane slaughter; and *Global Animal Partnership* (G.A.P.) published its first version dedicated to salmon farming, highlighting the mandatory use of environmental enrichment and the approval and prohibition of slaughter techniques, depending on whether they are considered humane or not.

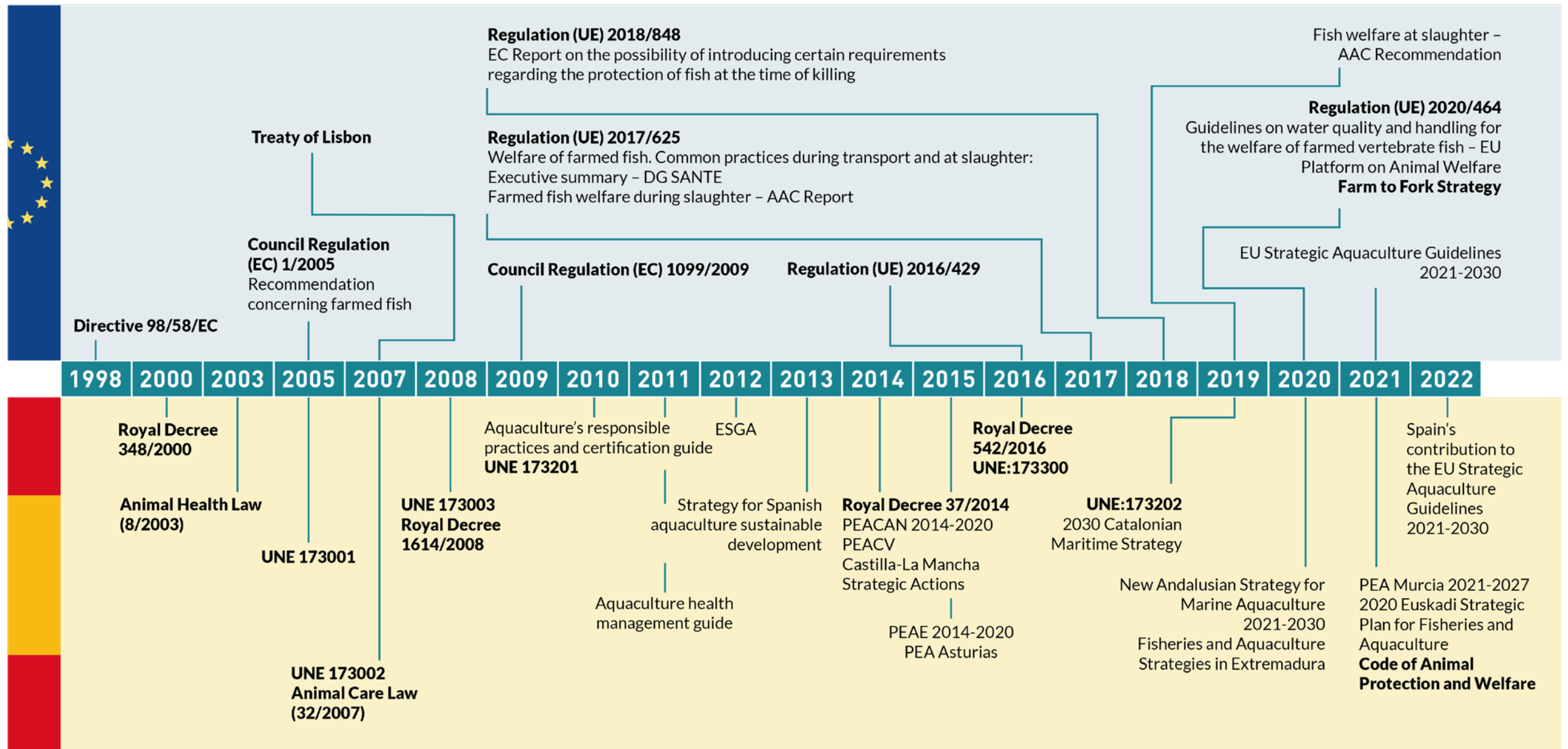
Finally, the process of updating the *Aquaculture Stewardship Council* (ASC) standards promises to include welfare considerations.

Humane slaughter is an aspect of welfare that has recently been incorporated into the certifications, although with disparity of criteria and whose debate still persists. In the context of Spanish aquaculture, none of the renewed certifications approves the use of ice water for stunning or slaughter, and one of them (Global G.A.P.) includes this technique among those allowed if there is no effective alternative technology available (see Annex). On the other hand, the Spanish Association for Standardization (UNE) has described the slaughter procedure for seabass, seabream, rainbow trout, turbot, sturgeon, meagre, and sole in ice water by means of certification UNE 173300, although it is not considered an effective stunning system or ideal for slaughter. However, deciding on the existence of more humane and effective stunning and slaughter techniques that can replace those currently used is an ongoing debate within aquaculture.

Another point that is being incorporated in the certifications is the use of welfare indicators. The use of physical or behavioral signs that indicate the mental and physical state of the fish and that will serve to evaluate how the farming practices affect them. In this aspect, the UNE 173201 and 173202 standards only indicate the observation of general appearance and an apparent state of health, ignoring other welfare considerations beyond health. It should be borne in mind that any change will place greater demands on producers, with likely effects on costs, professionalization, and regulatory measures. However, it will ultimately result in more sustainable and fish-friendly production. Therefore, it will be important to cautiously apply and regulate the most useful and reasonable measures to ensure the welfare of each species and the increasingly conscious access of consumers to aquaculture products.



Overview of regulatory and legal framework in terms of animal welfare and aquaculture



Legally binding **highlighted in bold**



7. CHALLENGES FOR SPANISH AQUACULTURE IN FISH WELFARE

7.1. Diverse and responsible fish aquaculture

Society is increasingly demanding high welfare standards for fish raised in aquaculture. Aquaculture is the fastest growing husbandry sector in the last 40 years. Today, it has overtaken fisheries globally as the main source of aquatic animal protein. If the sector really wants to position itself as a **sustainable and responsible** alternative to fishing, it must continue to work to ensure the welfare of farmed fish. This is therefore a clear **priority for fish farmers**. If the welfare of the fish is good, they will grow better and healthier and produce a higher quality product. Some companies are already raising awareness and applying certain measures to ensure good husbandry practices and conditions. However, there are still many challenges to be met.

Aquaculture producers must change the focus from health to welfare; and include animal welfare in all the actions they carry out. To do this, **current practices need to be analyzed and reviewed** from a welfare-inclusive perspective, and to evaluate how actions can be improved, from the commonplace to the most extraordinary. Indeed, one challenge is to incorporate welfare appropriately in the review of practices and to develop and **implement new practices, indicators, and technologies** that improve animal welfare during fish farming. In that respect, the implementation of **effective humane slaughter techniques and**

practices seems to be one of the main challenges, and with major repercussions, for both the industry (reputation, improvement, market) and society. It is also a recurring theme in terms of legislation, regulations, and certification development, and a major challenge for fish farmers to implement and get involved in its development and adaptation.

In addition, the variety of species farmed in Spain (tuna, meagre, seabream, sturgeon, sole, seabass, turbot, amberjack, tench, rainbow trout, eel) makes it necessary **to apply specific actions** for each of them, bearing in mind the **life cycle stages and production systems**. This first guide lays the general foundations for fish welfare in Spanish aquaculture as a preliminary work for the following specific guides.

7.2. Fish welfare research and training

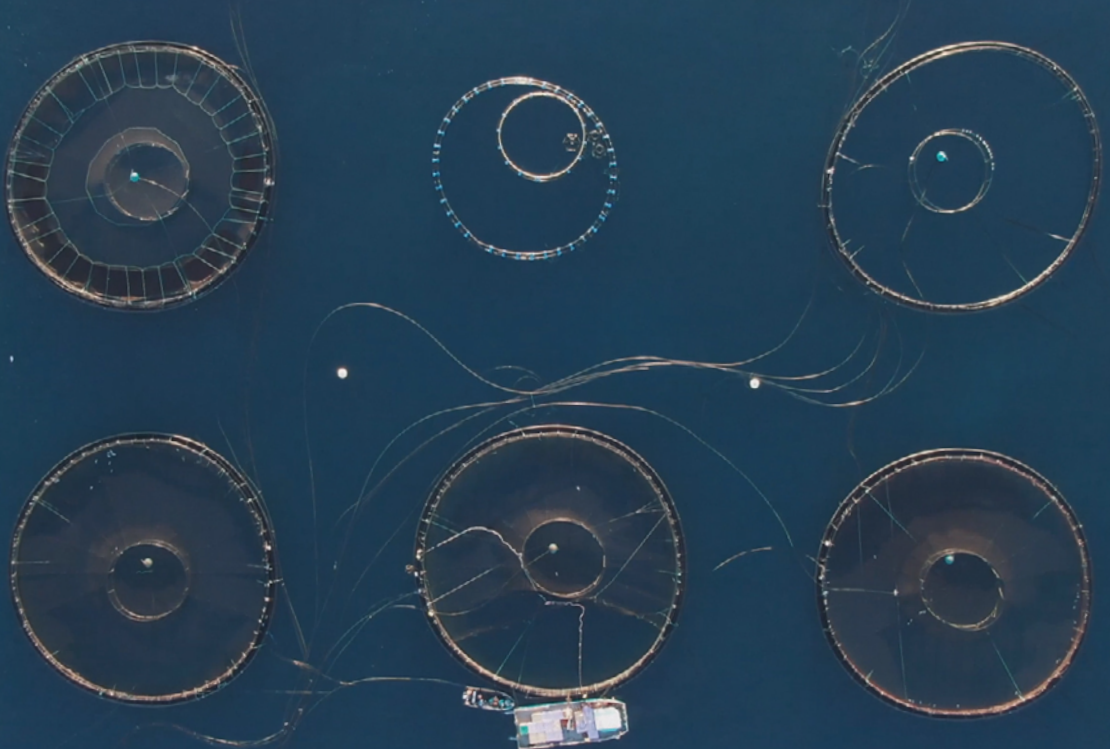
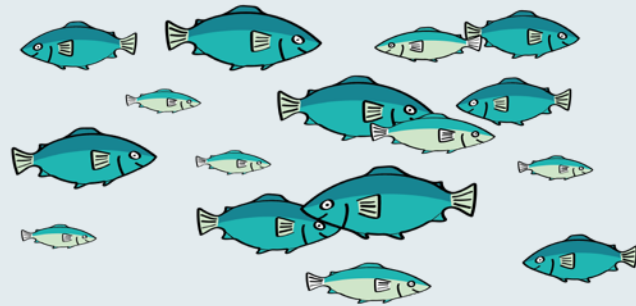
It is necessary **to promote scientific and technological research** to provide knowledge on animal welfare by species, size, and production systems; and to further the development and implementation of plans and measures that ensure or improve the welfare of farmed fish. Being one of the leading countries in aquaculture in the EU, by both volume and diversity, Spain has a great **opportunity** to excel in the implementation of welfare improvements and **to lead** the technological and scientific expansion of fish welfare.

Fish farmers must continue **to train and to professionalize** animal welfare efforts. They must be more responsible, competitive, and safe. On the one hand, animal welfare must be effectively added to corporate **continuous and updated training** programs to raise awareness and instruct all personnel working with fish whether directly or indirectly. On the other hand, animal welfare must be incorporated into the **curriculum** of institutes and universities without delay so that the next generations of technicians and professionals are conversant with it when they join the production companies.

They must disclose their plans for improvement, set completion dates, and highlight the value of what they do. This way, an image of trust and productive responsibility will be conveyed to society, to influencers, and to the food market, which will **reward a job well done** and cast out run-of-the-mill performance. Social awareness of the positive actions undertaken by the fish farming sector regarding animal welfare reinforces values of sustainability, responsibility, and food safety. By emphasizing acknowledgment of **value-added products** through animal welfare standards and certifications, for instance, fish farmers will gain greater public trust and emphasize the virtues of good management.

7.3. Transparency, valuation, and social acceptance

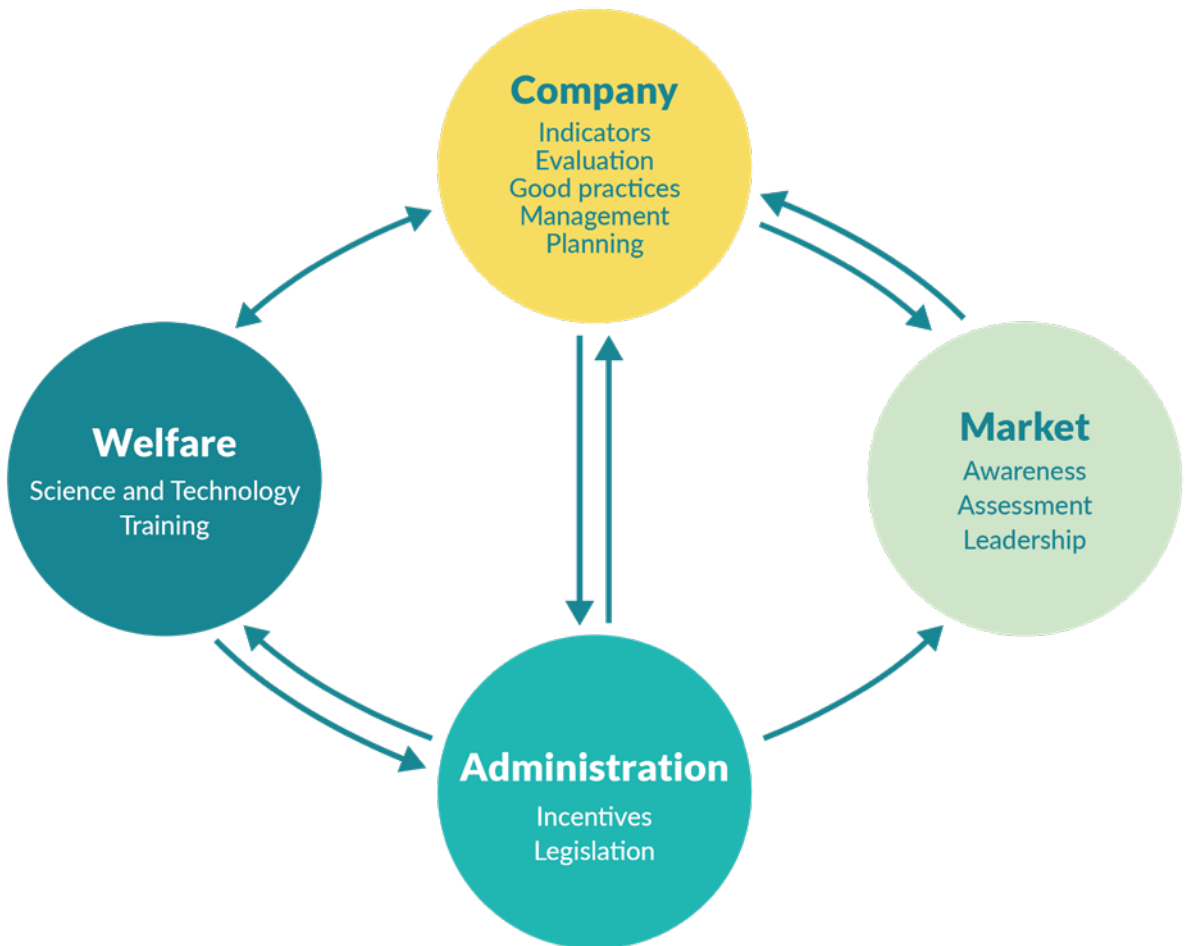
Increasing the **transparency of business practices and policies** to bring the industry closer to society and the market will be one of the most important challenges in the coming years. Aquaculture producers must divulge the fish welfare practices they perform as well as the actions being taken to improve those efforts.



7.4. Administrative and legislative instruments

Another challenge is the provision of **economic instruments** or specific **compensatory measures** relative to investments, certifications and/or actions to communicate animal welfare issues. In this respect, **official commitment** is required to encourage an achievable transition and developments to be carried out by companies and academia. Such support could take

the form of financial aid (e.g., FEMPA funds) or market incentives to ensure such a transition. Similarly, and once the knowledge and good practices in the field are achieved, **new legislation, regulations, and/or certifications must be developed** (or existing ones updated), in tandem with state-of-the-art scientific and business knowledge, to promote the interests and future of aquaculture fish welfare, plans that may be brought up to date as more insight is gained.





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Appendix

	RSPCA		GAP	Global GAP	FOS	ASC	UNE 173201 UNE 173300
Version	02/2021	03/2020	06/2022	04/2022	11/2021	03-07/2019	06/2010 (173201) 11/2016 (173300)
Species	Salmon	Rainbow trout	Atlantic salmon	Fish, crustaceans, mollusks	Seabass, seabream, rainbow trout, flatfish, others	Atlantic salmon, rainbow trout, seabream, seabass, meagre and flatfish	Seabass, seabream, rainbow trout, turbot, sturgeon, meagre and sole
SACRIFICE							
Requires stunning	Yes	Yes	Yes	Yes	Yes	No	Yes, if death is not immediate
Method definition	Fast, without pain or stress. Desensitizing to death	Fast, without pain or stress. Desensitizing to death	Not defined	Effective method, causing immediate unconsciousness	Not defined	Not defined	Stun should cause unconsciousness until death.
Accepted techniques	Percussion, Electricity	Percussion, Electricity	(stunning) Automated percussion Electricity	Not defined		Not defined	Electricity, Percussion, Ice (stun)
Techniques accepted after stunning	Exsanguination, Branchial Cut	Exsanguination, Branchial Cut	Exsanguination	Exsanguination	Exsanguination, asphyxia, other	Not defined	Bleeding, Hypothermia
Prohibited techniques	Not defined	Not defined	CO ₂ , ice, cooling, asphyxia, anesthetic overdose	Ice, asphyxiation (if alternative techniques or technologies are available)	Not defined	Not defined	Not defined
WELLBEING INDICATORS							
Consider the welfare	Yes	Yes	Yes	Yes	Yes	No	No
Wellbeing indicators/WOMs	Physical, Behavior Developing	Physical, Behavior	Physical, Behavioral	Physical	Physical, Behavior	No	General appearance and apparent health status
Mortality alert level	Specific	Specific	Specific	Higher than expected	Specific	Specific, except for trout	Not defined
ENRICHMENT							
Do you recommend enrichment?	To the cleaning fish.	No	Mandatory, indicates types	For cohabitant species	Structural enrichment	No	No
FISH HANDLING							
Time out of water	15 sec max	15 sec max	10 sec max, longer time requires anesthesia	Guide included in the health plan	Max 15 sec. Take them out of the water only when necessary	Unlimited	Unlimited
Over-crowding	Max 2 h. Max 2 times in 1 week or 3 times in a month	Max 2 h. Max 2 times in 1 week or 3 times in a month	Max 2h. Max 3 times in 30 days	Guide included in the health plan	Max 1.5 h. for sorting, 2 h. for weeding. Minimum frequency	Unlimited	Minimum possible duration. Try to prevent repetition, if there is repetition, allow recovery
Overcrowding adjustment	Oxygen levels. Visual indicators, guidance	Oxygen levels	Oxygen levels. Visual intensity indicator	Guide included in the health plan	Oxygen levels. Visual intensity indicator	No	Signs of asphyxia or unacceptable suffering

General description of the main international aquaculture certifications regarding the welfare of fish and other aquatic animals.

