LAW GROUP 2025

Beneath the Surface: Assessing the Legal Protection of Fish Welfare in EU Aquaculture

Giulia Pusceddu
1402315

WAGENINGEN UNIVERSITY
LAW GROUP

Beneath the Surface: Assessing the Legal Protection of Fish Welfare in EU Aquaculture

Author: Giulia Pusceddu
Supervisor: Chiara Macchi

LAW80436 36 ECTS

Wageningen MSc Thesis 2025/02

Published in the Netherlands
Wageningen University
Law Group
P.O. Box 8130 | 6700 EW Wageningen
Visiting address: Hollandseweg 1 Wageningen
The Netherlands

www.wageningenur.nl/law

Abstract: With an ever-growing global population, fish farming has been promoted as a sustainable method for producing fish. Recognising its potential, the EU has endorsed it as a way to bridge the production-consumption gap, ensuring both environmental protection and economic growth in the seafood sector. Nevertheless, aquaculture presents significant challenges, including the serious threat to fish welfare: from rearing to slaughter, fish are negatively affected by several factors, and often feel stress and pain.
From a legal perspective, animals, including fish, are recognised as "sentient beings" under Article 13 of the TFEU, which obligates the EU to consider their welfare in its legislation. Despite this recognition, there remains a noticeable gap in how the EU legal framework deals with the welfare of farmed fish. Up to 1.2 billion fish are farmed in the EU each year, and yet there is currently no specific legislation that takes into account their unique needs, allowing for unethical practices to persist. Therefore, this thesis advocates for the development of a comprehensive EU law for the protection of the welfare of farmed fish, while giving importance to recent initiatives in this area, which already signal a promising shift toward greater legal safeguard for these often-overlooked animals.
Keywords: aquaculture, fish welfare, fish, EU law

Table of contents

List of Figures

https://www.europarl.europa.eu/RegData/etudes/STUD/2023/747257/IPOL_STU(2023)747257_EN.pdf

Figure 11: *How RAS works*
Source: *Main advantages of recirculating aquaculture systems.* (April 16, 2019). Dibaq Group. https://dibaq.com/en/advantages-recirculating-aquaculture-systems/

Figure 12: *Sea bass cage underwater*
Source: Eurogroup for Animals. (2018). *Looking Beneath the Surface: Fish Welfare in European Aquaculture.* p.28.
https://www.eurogroupforanimals.org/library/looking-beneath-surface-fish-welfare-european-aquaculture

Figure 13: *An area of carp ponds*
Source: EUROFISH. (December 11, 2020). *Pond fish farming in Poland, a century-old activity, is adapting to changes at many levels.*
https://eurofish.dk/pond-fish-farming-in-poland-a-century-old-activity-is-adapting-to-changes-at-many-levels/

Figure 14: *Live sea lice on the skin of a salmon*
Source: Keane, K. (August 9, 2018). *Sea lice 'breakthrough' for salmon farmers.* BBC.
https://www.bbc.com/news/uk-scotland-45110143

Figure 15: *The transportation steps*
Source: Saraiva, J. L., Arechavala-Lopez, P., Cabrera-Álvarez, M. J. & Waley, D. (2021). *Research for ANIT Committee – Particular welfare needs in animal transport: aquatic animals*. European Parliament. Policy Department for Structural and Cohesion Policies. Brussels. p.14.
https://www.europarl.europa.eu/RegData/etudes/STUD/2021/690875/IPOL_STU(2021)690875_EN.pdf

Figure 16: *Fish left to suffocate*
Source: Eurogroup for Animals. (July 19, 2022). *New investigation exposes harsh reality of Spanish aquaculture sector*.
https://www.eurogroupforanimals.org/news/new-investigation-exposes-harsh-reality-spanish-aquaculture-sector

Figure 17: *The current EU regulatory framework on animal welfare*
Source: Di Concetto, A. *Animals in the Farm-to-Fork Strategy.* European Institute for Animal Law & Policy. Lecture on 5 December 2023 at Wageningen University.

Figure 18: *Number of animals slaughtered every day in the world in 2021*
Source: Roser, M. (September 26, 2023). *How many animals get slaughtered every day?* Our World in Data.
https://ourworldindata.org/how-many-animals-get-slaughtered-every-day

List of Abbreviations

AHAW	Animal Health and Welfare
API	Associazione Piscicoltori Italiani
APROMAR	Asociación Empresarial de Acuicultura de España
CEE-CAA	Central and Eastern Europe Coastal Aquaculture Authority
CFP	Common Fisheries Policy
CoE	Council of Europe
EC	European Commission
EE	Environmental Enrichments
EFSA	European Food Safety Authority
EU	European Union
F2F	Farm to Fork
FAO	Food and Agriculture Organization
FAWC	Farm Animal Welfare Council
FEAP	Federation of European Aquaculture Producers
FGM	Federation of Greek Mariculture
FPP	Fisheries Policy Package
FSBI	Fisheries Society of the British Isles
GFL	General Food Law
HAPO	Hellenic Aquaculture Producers' Organisation
LABWI(s)	Laboratory-based Welfare Indicator(s)
LWE	Live Weight Equivalent
MMFF	Mediterranean Marine Fish Farming
OIE	Office International des Epizooties
OWI(s)	Operational Welfare Indicator(s)
QoL	Quality of Life

RAS	Recirculating Aquaculture System
RSPCA	Royal Society for the Prevention of Cruelty to Animals
SFAMN	Syndicat Français de l'Aquaculture Marine et Nouvelle
TFEU	Treaty on the Functioning of the European Union
WI(s)	Welfare Indicator(s)
WOAH	World Organisation for Animal Health

Introduction

This thesis was born out of a recent and deeply personal passion for animal welfare, which led to the realisation that fish receive little attention in this field. It was this awareness, combined with the discovery that aquaculture is the fastest-growing food production system globally, that inspired the questions and reflections behind this work.
The final objective of this thesis is to assess the extent to which the law of the European Union (EU) addresses the protection of fish welfare in aquaculture by combining legal analysis with scientific and empirical data, and to propose potential improvements to the current regulatory framework.
The first chapter is an attempt to paint a picture of the scale and significance of aquaculture, providing essential background information, including its definition and historical evolution, key data on production and consumption within the EU, and the main commercial species farmed in the region.
In Chapter 2, the focus shifts to animal welfare, specifically addressing the concept of fish welfare, how it can be assessed, and the welfare challenges that farmed fish typically face throughout their life cycle, highlighting the specific needs of these animals in the sector. The perspectives of various stakeholders in aquaculture, such as producers, NGOs and consumers, are also examined to show the diverse priorities and concerns that influence approaches to fish welfare. To enrich the analysis concerning the public perception, semi-structured interviews were conducted with key figures in the aquaculture and animal welfare sectors, namely Javier Ojeda, manager of the Asociación Empresarial de Acuicultura de España (APROMAR)[1], Elisa Bianco, Essere Animali[2]'s Head of the Corporate Engagement Department, and Dimitris Papapanagiotou, Greek Biologist and General Manager of KITO Marine Farm SA.

[1] In English, "Spanish Aquaculture Producers Association".
[2] Essere Animali (in English, "Being Animals") is an Italian organisation, whose general mission is to create a more compassionate food future, in which plant-based nutrition is the main choice made by all people.

Chapter 3 describes the international legal instruments that most contribute to the protection of fish welfare, such as the Aquatic Animal Health Code by the World Organisation for Animal Health (WOAH), the European Convention for the Protection of Animals Kept for Farming Purposes, the European Convention for the Protection of Animals During International Transport and the Recommendation concerning farmed fish by the Council of Europe (CoE).
This part is particularly interesting to explore how these complement or diverge from the EU legal framework regarding fish welfare, which is discussed in Chapter 4. The latter is divided into three sections. The first one starts with the mentioning of Article 13 of the Treaty on the Functioning of the European Union (TFEU), and examines the EU binding legislation related to fish welfare, such as Council Directive 98/58/EC concerning the protection of animals kept for farming purposes, Council Regulation (EC) 1/2005 on the protection of animals during transport and related operations, Council Regulation (EC) 1099/2009 on the protection of animals at the time of killing, Regulation (EU) No 1380/2013 of 11 December 2013 on the Common Fisheries Policy (CFP) and Regulation (EU) 2016/429 (Animal Health Law). The second section explores some soft law initiatives, including recommendations, codes of conduct and guidelines, which represent the increasing interest of the public and private sectors in protecting the welfare of farmed fish. These publications aim to bridge the gap between recent research outcomes and the operational measures used in aquaculture. Instead, the third section considers the role of selected EU Member States in supplementing and enforcing these protections, offering a comprehensive analysis of the current EU legal landscape.
Drawing on the information presented throughout the thesis, the final chapter highlights the significant gaps in EU legislation regarding the protection of the welfare of farmed fish, and proposes potential improvements. In the end, the thesis provides for an optimistic outlook, exploring the recent advancements in fish welfare, which already signal a promising shift toward greater legal safeguard for these often-overlooked animals.

CHAPTER 1: AQUACULTURE IN THE EU

1.1 The definition of aquaculture

Aquaculture, also called fish farming, "is to water what agriculture is to land"[3]. Two important definitions can be useful to understand the meaning of the term. One is provided by the Food and Agriculture Organisation (FAO), which claims that it is:

> "The farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants. Farming implies some sort of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated, the planning, development and operation of aquaculture systems, sites, facilities and practices, and the production and transport"[4].

The other one is given by the EU. After its original and more detailed definition contained in Council Regulation (EC) No 788/96 of 22 April 1996[5], the EU specifically established a new one in Article 4.1 (25) of Regulation (EU) No 1380/2013 on the CFP, affirming that aquaculture is:

> "the rearing or cultivation of aquatic organisms using techniques designed to increase the production of the organisms in question beyond the natural capacity of the environment, where the organisms remain the property of a natural or legal person throughout the rearing and culture stage, up to and including harvesting"[6].

Today, there are different types of aquaculture, namely extensive, semi-intensive and intensive[7]. Extensive aquaculture is a form of farming entirely based on the use of natural resources, with little or no human intervention: for instance, the fish feed themselves from the present natural resources. For semi-intensive systems, different countries have established different definitions of them, not

---

[3] Directorate-General for Parliamentary Research Services & Weissenberger, J. (2017). *Aquaculture: Overview for the EU.* European Parliament. p.1. https://data.europa.eu/doi/10.2861/650792

[4] FAO. (n.d.). *Aquaculture*. Fisheries and Aquaculture. https://www.fao.org/fishery/en/topic/16064

[5] Council Regulation (EC) No 788/96 of 22 April 1996 on the submission by Member States of statistics on aquaculture production. (Date of end of validity: 31/12/2008).

[6] A similar definition of "aquaculture" can be found in Article 4.6 of Regulation (EU) 2016/429 (Animal Health Law).

[7] Each type influences how fish are raised and the associated impacts on their welfare.

always referring to the same criteria[8]. In general terms, this type of farming is the intermediate between extensive and intensive aquaculture: compared to the extensive one, there is a greater input of production factors by man, who can, for example, feed from the outside to speed up the growth of the fish, fertilise the bottom to implement natural food production and intervene in the oxygenation of the water. Lastly, intensive aquaculture is the most significant in terms of its impact on fish welfare due to its high level of human intervention and reliance on controlled environments.

1.2 The evolution of aquaculture

Regarding the origin of this practice, it can be said that, while for other animal-based food products there has been a rapid transition from hunting to farming on a large scale, in the case of fish, this process has been much slower and more complex[9]. The earliest trials in fish farming date back approximately 8000 years, when common carp started to be farmed in the Henan Province, in China[10]. Around 475 B.C., this country also produced the first known monograph on fish farming, the "Yang Yu Jing" (Treatise on Pisciculture), thought to have been authored by Fan Li, a government bureaucrat in the Yue State[11].
Historical interest in aquaculture is also reflected in archaeological evidence from other cultures. For instance, ancient Egyptian and Roman artifacts, including historical texts, tomb paintings and bas-reliefs, depict people fishing in managed water systems, indicating early efforts at farming aquatic animals[12].
In Europe, aquaculture practices gradually developed, with the farming of common carp in ponds already well established during the Middle Ages[13]. In

---

[8] Oddsson, G. (2020). *A Definition of Aquaculture Intensity Based on Production Functions—The Aquaculture Production Intensity Scale (APIS)*. Water, 12(3), 765, p.5. https://doi.org/10.3390/w12030765

[9] Sánchez-Suárez, W., Franks, B., & Torgerson-White, L. (2020). F*rom Land to Water: Taking Fish Welfare Seriously.* Animals, 10(9), 1585, p.4. https://doi.org/10.3390/ani10091585

[10] With its extensive experience in aquaculture, it's no surprise that China remains by far the world's leading producer of aquaculture products.

[11] Hu, F., Zhong, H., Wu, C., Wang, S., Guo, Z., Tao, M., Zhang, C., Gong, D., Gao, X., Tang, C., Wei, Z., Wen, M., & Liu, S. (2021). *Development of fisheries in China.* Reproduction and Breeding, *1*(1), p. 64. https://doi.org/10.1016/j.repbre.2021.03.003

[12] Rogers, A.J. (2024). *Aquaculture in the Ancient World: Ecosystem Engineering, Domesticated Landscapes, and the First Blue Revolution*. Journal of Archaeological Research, 32, p. 433 https://doi.org/10.1007/s10814-023-09191-1

[13] Müller, T., Ferincz, Á., Weiperth, A. , Ivánovics, B., Tóth B, Bógó, B., Horváth, J., Urbányi, B., Specziár, A. (2024). *Uncommon life history and winter spawning of common carp (Cyprinus carpio) in a natural thermal spring, under temperate climate*. Fish Physiology and Biochemistry, 50, p.2043. https://doi.org/10.1007/s10695-024-01305-w

Italy, the practice of vallicultura[14] dates back to the 15th century[15], while in other regions, aquaculture arrived more recently: in North America, it began about 100 years ago, in Africa, it started in the 1940s, and in Australia, New Zealand, and several Pacific Island states, it developed even later[16].
According to FAO:

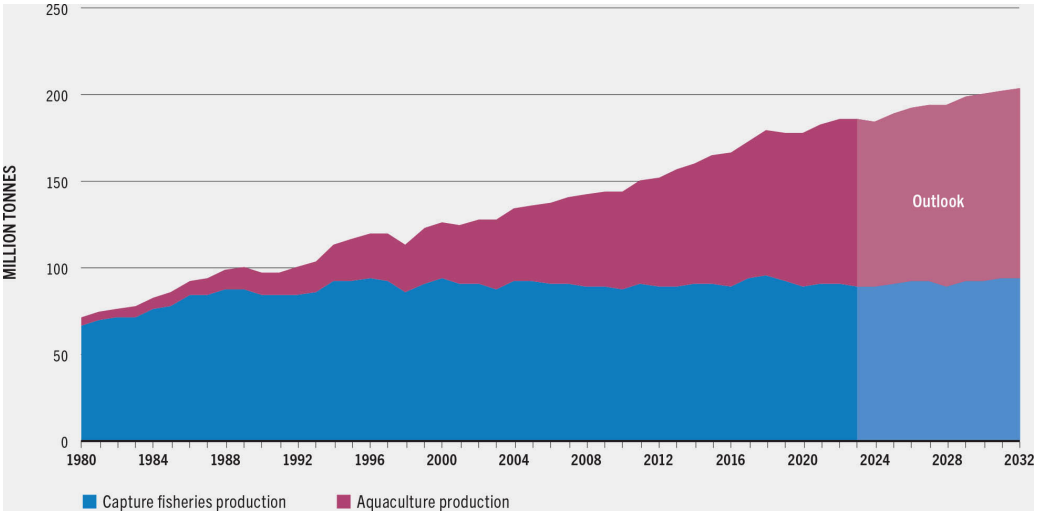
> "Starting from an insignificant total production, inland and marine aquaculture production grew by about 5 percent per year between 1950 and 1969 and by about 8 percent per year during the 1970s and 1980s, and it has increased further to 10 percent per year since 1990"[17].

Today, its growth did not stop, becoming the fastest-growing food production system[18]. Global demand for fish represents a key driver of aquaculture growth, with per capita consumption of aquatic animal foods rising from 9.0 kg live weight equivalent (LWE) in 1961 to 20.5 kg in 2019[19], and reaching 24.55 kg[20] in the EU in 2022[21]. During the same year, the aquaculture sector surpassed capture fisheries in total production for the first time, achieving a record of 130.9 million tonnes, of which 94.4 represented aquatic animals[22]. This trend is expected to continue, with FAO projections predicting a 10% increase in aquatic animal production to 205 million tonnes by 2032[23] (see Figure 1 below).

---

[14] The term "vallicoltura" originates from the Italian word *valle* (in English: "enclosure"). This farming method takes advantage of the natural seasonal migration of certain fish species from the sea to coastal lagoons. Fish are contained within enclosures, preventing their return to the sea, and are harvested years later, as they attempt to migrate back to the sea.
[15] Boudouresque, C.F., Blanfuné, A., Pergent, G., Pergent-Martini, C., Perret-Boudouresque, M. and Thibaut, T. (2020). *Impacts of Marine and Lagoon Aquaculture on Macrophytes in Mediterranean Benthic Ecosystems*. Frontiers in Marine Science. 7:218, p.2. https://www.frontiersin.org/journals/marine-science/articles/10.3389/fmars.2020.00218/full
[16] Fabrice, T. (2021). *Fish domestication in aquaculture: 10 unanswered questions*. Animal Frontiers, 11(3), p. 87. https://doi.org/10.1093/af/vfab012
[17] FAO. (2000). *The State of World Fisheries and Aquaculture.* Part 1. https://www.fao.org/4/x8002e/x8002e04.htm#:~:text=Starting%20from%20an%20insignificant%20total,percent%20per%20year%20since%201990
[18] Rogers, A.J., 2024, p.427
[19] FAO. (2022). *The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation.* Rome. p.vi. https://doi.org/10.4060/cc0461en
[20] This data indicates per capita consumption of fish, not of aquatic animal foods.
[21] EUFOMA. (2023). *THE EU FISH MARKET*. Publications Office of the European Union. Luxembourg. p.29. https://eumofa.eu/documents/20124/35668/EFM2023_EN.pdf
[22] FAO. (2024). *The State of World Fisheries and Aquaculture 2024*. *Blue Transformation in action*. Rome. p. xviii. https://doi.org/10.4060/cd0683en
[23] Ibid, p. xxvii

Figure 1: *FAO projections regarding aquatic animal production*



Source: FAO. (2024). *The State of World Fisheries and Aquaculture 2024*. Blue Transformation in action. Rome. p. xviii. https://doi.org/10.4060/cd0683en

For what concerns the EU, the latter has recognised aquaculture's potential and has endorsed it as a way to bridge the production-consumption gap, ensuring both environmental protection and economic growth in the seafood sector[24]. However, EU-based aquaculture currently supplies only around 37% of the aquaculture products consumed within the region. In the Union, fish farming is also geographically concentrated, with only four countries being responsible for about two thirds of the EU's total production of farmed aquatic organisms in 2021: Spain produced around 24 % of the total, followed by France (17 %) and Greece and Italy (both 13 %)[25].

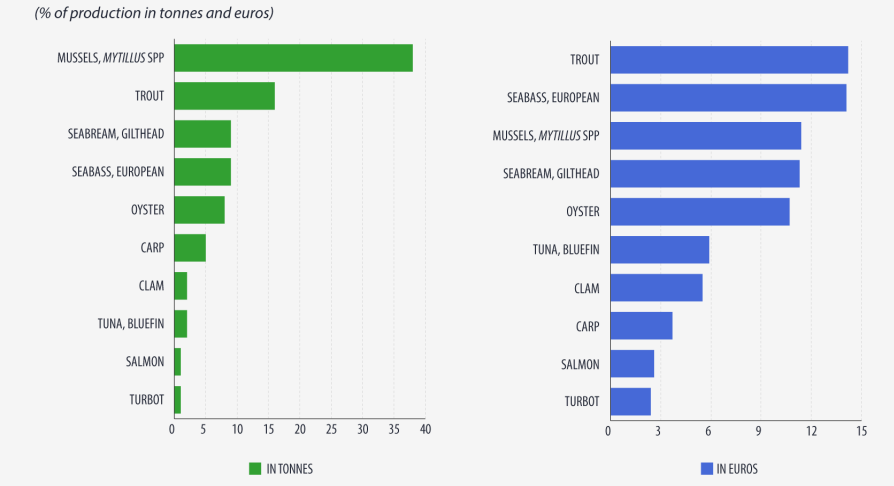
1.3 A focus on the main farmed fish species in the EU

Considering the immense diversity of fish species (over 33,000 described[26]), of which 513 are farmed globally[27], this thesis only covers the main farmed fish species in the EU: these are Atlantic salmon, Rainbow trout, Common carp,

[24] EU Environment. (May 17, 2016). *Aquaculture & Sustainability – Science for Environment Policy*. [Video]. Youtube. https://www.youtube.com/watch?v=40ABPqP6Rc8
[25] Altmayer, A. (June 2024). *EU aquaculture: State of play.* European Parliamentary Research Service (EPRS). p.3. https://www.europarl.europa.eu/RegData/etudes/BRIE/2024/762336/EPRS_BRI(2024)762336_EN.pdf
[26] Martinez, A. S., Willoughby, J. R., & Christie, M. R. (2018). *Genetic diversity in fishes is influenced by habitat type and life-history variation*. Ecology and evolution, 8(23), p.12022. https://doi.org/10.1002/ece3.4661
[27] The data refers to the year 2021. Therefore, it can be inferred that the number is probably higher than 513 in 2024.
See: Cai, J., Galli, G. and Zhou, X. (2023). *Top 10 species groups in global aquaculture 2021*. FAO Fisheries and Aquaculture Division. p.2. https://openknowledge.fao.org/server/api/core/bitstreams/8f5e7023-4522-4162-a65a-e91fa834d193/content#:~:text=Thanks%20to%20a%20major%20disaggregation,to%20513%20in%20world%20aquaculture

European sea bass and Gilthead sea bream[28]. It is worth mentioning that marine aquaculture dominates EU production, with freshwater farming accounting for roughly 20% of the total volume[29].

Figure 2: *Main fish species in EU aquaculture production in 2021*



Source: *EU aquaculture in 2021: 1.1 million tonnes farmed.* (October 2, 2023). EUROSTAT. https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20231002-2

The following sections provide a brief overview of the main farmed fish species in the EU. On one hand, focusing on their most relevant natural features and understanding their habitats and behaviors is crucial, as it highlights the contrast between their lives in the wild and the conditions they experience in aquaculture. On the other hand, data on their production and consumption within the EU are presented to highlight their significance in the industry.

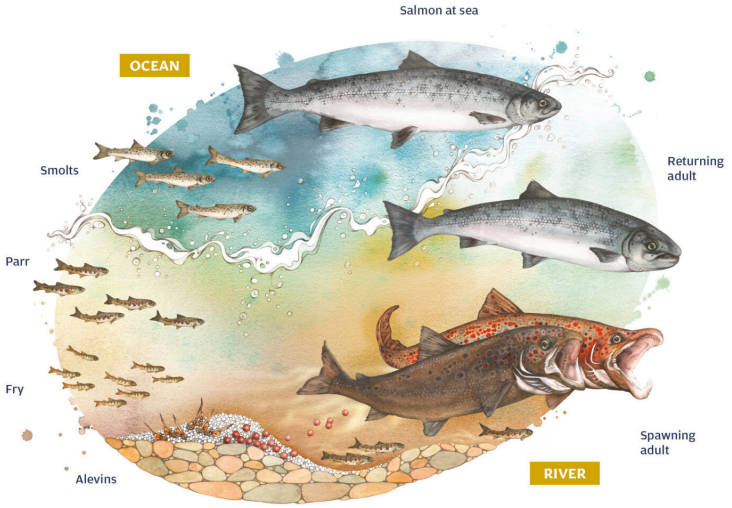
1.3.1 Atlantic salmon

In its natural habitat, Atlantic salmon (*Salmo salar* L.) is an anadromous fish[30], beginning its life in fresh, cold river waters, before migrating to saltwater to feed and grow. This remarkable fish can travel long distances (up to 50 km per day)[31] during its migration, overcoming various obstacles to return to its river of origin, guided by its keen sense of smell and physical agility. Its color varies with life stages, displaying silvery flanks and a dark greenish-blue back during its ocean phase, while adopting reddish-brown hues during the spawning season[32].

---

[28] European Commission. (n.d.). *Aquaculture types*. EU Aquaculture Assistance Mechanism. https://aquaculture.ec.europa.eu/about/aquaculture-types
[29] Altmayer, A., 2024, p.3.
[30] Schiewe, M. H., & Kareiva, P. (2001). *Salmon*. In S. A. Levin (Ed.), Encyclopedia of Biodiversity, 5, p. 236. Elsevier. https://doi.org/10.1016/B0-12-226865-2/00239-X
[31] *Who is the salmon?* (n.d.). CIWF. https://www.compassionfoodbusiness.es/media/7440680/who-is-the-salmon.pdf
[32] *Atlantic Salmon*. (n.d.). American Oceans. https://www.americanoceans.org/species/atlantic-salmon/

Figure 3: *The anadromous nature of the salmon*



Source: *The State of North Atlantic Salmon.* (n.d.). NASCO. https://nasco.int/atlantic-salmon/state-of-salmon/

As a carnivorous predator, Atlantic salmon consumes a diverse diet, primarily consisting of fish and fish larvae, krills and planktonic crustaceans during the post-smolt stage[33]. Additionally, it represents an indicator species, reflecting the health of its ecosystem, as it thrives in clean, fresh waters[34].
Atlantic salmon is a highly valued fish known for its exceptional nutritional benefits, including high-quality protein and omega-3 essential fatty acids, along with various vitamins and minerals[35]. The EU is the global largest consumer of Atlantic salmon, significantly benefiting from associated economic activities in "fish processing, smokeries, wholesale, groceries and restaurants"[36].
Since the inception of the farmed salmon industry in the 1960s[37], its production has now expanded dramatically, with approximately 70% of salmon produced

[33] Hellenbrecht, L. M., Utne, K. R., Karlsen, Ø., Glover, K. A., & Wennevik, V. (2023). *Diet analysis of Atlantic salmon (Salmo salar) post-smolts after the ecological regime shift in the Northeast Atlantic*. Fisheries Research, 262, 106672, p.1. https://doi.org/10.1016/j.fishres.2023.106672
[34] *Salmon*. (n.d.). National Geographic. https://www.nationalgeographic.com/animals/fish/facts/salmon
[35] MOWI. (2024). *Salmon Farming Industry Handbook.* p.21. https://mowi.com/wp-content/uploads/2024/05/2024-Salmon-Industry-Handbook.pdf
[36] Pavlidis, M., Papaharisis, L., Adamek, M., Steinhagen, D., Jung-Schroers, V., Kristiansen, T., Theodoridi, A., Otero Lourido, F. (2023). *Animal welfare of farmed fish*. Research for PECH Committee, European Parliament, Policy Department for Structural and Cohesion Policies. Brussels. p.39. https://www.europarl.europa.eu/RegData/etudes/STUD/2023/747257/IPOL_STU(2023)747257_EN.pdf
[37] FAO. (2009). *Salmo salar*. In: Cultured aquatic species fact sheets. Text by Jones, M. Edited and compiled by Crespi, V. and New, M. https://www.fao.org/fishery/docs/CDrom/aquaculture/I1129m/file/en/en_atlanticsalmon.htm#:~:text=Sea%20cage%20culture%20was%20first,Chile%20and%20Australia%20(Tasmania)

worldwide coming from aquaculture[38]. In Europe, Atlantic salmon is the most significant farmed fish species, with production exceeding 1.8 million tonnes in 2021. However, more than 99% of this production occurs outside the EU, primarily in Norway, Scotland and the Faroe Islands[39]. Within the EU, Ireland stands out: the country was responsible for about 98% of 12,100 tonnes of farmed salmon in the EU in 2022[40]. Moreover, all of its salmon is certified organic and adheres to Regulation (EC) 2018/848 on organic production and labeling[41].

1.3.2 Rainbow trout

Rainbow trout (*Oncorhynchus mykiss*) is a freshwater salmonid species native to rivers and lakes along North America's west coast, from California to Alaska, and Russia's Kamchatka Peninsula[42]. This species is distinguished by its slender, black-speckled body and small scales. Its coloration includes a striking range of green, purple and blue tones, with an iridescent orange or pinkish band along its sides that becomes especially vivid during the breeding season[43].

Figure 4: *Distinctive Coloration and Physical Features of Rainbow Trout*

Source: *Rainbow Trout*. (n.d.). Illinois Department of Natural Resources. https://dnr.illinois.gov/education/wildaboutpages/wildaboutfish /wafsalmon/wafrainbowtrout.html

The rainbow trout is predatory and aggressive, with a large mouth lined with sharp teeth. It thrives in mountain lakes and streams with highly oxygenated water, growing best at around 9-20°C[44], and its diet consists of insects, molluscs,

---

[38] Shahbandeh, M. (March 12, 2024). *Salmon industry - statistics & facts.* Statista. https://www.statista.com/topics/7411/salmon-industry/#topicOverview

[39] Pavlidis et al., 2023, p. 39

[40] EUROSTAT. (2024). *Aquaculture statistics.* https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Aquaculture_statistics#EU_Aquaculture

[41] Regulation (EU) 2018/848 of the European Parliament and of the Council of 30 May 2018 on organic production and labeling of organic products and repealing Council Regulation (EC) No 834/2007. https://eur-lex.europa.eu/eli/reg/2018/848/oj

[42] Pavlidis et al., 2023, p. 46

[43] *Rainbow Trout*. (n.d.). National Geographic. https://www.nationalgeographic.com/animals/fish/facts/rainbow-trout#:~:text=They%20are%20torpedo%2Dshaped%20and,on%20their%20back%20and%20fins

[44] CERES. (n.d.). *Case study 1: Rainbow Trout in north-west Europe.* p.1. https://ceresproject.eu/wp-content/uploads/2019/11/20191113Storyline-1-Rainbow-trout-FB-MP_2.pdf

fish eggs, small fish and crustaceans such as crayfish, which provide a carotenoid pigment that gives the fish's flesh its orange-pink hue[45].
In Europe, rainbow trout farming began in the 19th century with the species' introduction from North America[46], and it has since become the most commonly raised fish in European inland aquaculture. In 2018, it accounted for 60% of freshwater aquaculture production in the EU[47], while in 2019, the EU produced 194,450 tonnes of rainbow trout, valued at 677 million euros[48].
Modern trout farming primarily relies on intensive flow-through pond systems and recirculating aquaculture systems (RAS), though small-scale, semi-intensive farming still persists in some rural parts of Central and Eastern Europe[49].
In 2021, total rainbow trout production in the EU reached 195,834 tonnes[50].
Italy, Denmark, France and Poland were the largest producers of portion-sized trout[51], while large trout were mainly farmed in France, Finland and Denmark[52].
In 2020, approximately 86% of the trout consumed within the EU was produced domestically, with farmed trout comprising nearly all of the trout consumed (98.37%)[53]. Apparent consumption[54] represented 95% of the total supply, with the primary markets being Germany, France, Italy and Poland, each consuming over 20,000 tonnes LWE. Italy, France and Poland mainly relied on domestic production for their national supply, whereas Germany's supply was largely fulfilled by imports, covering 88% of its national consumption[55].

---

[45] FAO. (2009a). *Oncorhynchus mykiss*. In: Cultured aquatic species fact sheets. Text by Cowx, I. G. Edited and compiled by Valerio Crespi and Michael New. https://www.fao.org/fishery/docs/CDrom/aquaculture/I1129m/file/en/en_rainbowtrout.htm
[46] *Species - Rainbow Trout*. (n.d.). NewTechAqua. https://www.newtechaqua.eu/specie/rainbow-trout/
[47] EUMOFA. (April 2021). *Freshwater aquaculture in the EU.* Publications Office of the European Union. Luxembourg. p.1. https://www.aquafeed.com/documents/229/0012954001617121663.pdf
[48] EUMOFA. (2021). *The EU fish market 2021 edition.* Publications Office of the European Union. Luxembourg. p.101. https://doi.org/10.2771/563899
[49] Pavlidis et al., 2023, p. 46
[50] FEAP. (2023). *European Aquaculture Production Report 2015-2021*. p.35. https://feap.info/wp-content/uploads/2023/04/2023-04-05-production-report-2023.pdf
[51] Ibid.
[52] Ibid, p. 33
[53] Compassion in World Farming. (2023). *2023 EU AQUACULTURE INVESTIGATION SUMMARY*. p.4. https://www.ciwf.org/media/7455622/trout-investigation-summary_web.pdf
[54] Apparent consumption is the result of (catches + aquaculture production + imports) – exports. This definition was provided by EUFOMA. (2023). *THE EU FISH MARKET*. Publications Office of the European Union. Luxembourg. p.6. https://eumofa.eu/documents/20124/35668/EFM2023_EN.pdf
[55] EUFOMA. (May 2023). *Case study - Large trout in the EU*. Publications Office of the European Union. Luxembourg. p.19. https://eumofa.eu/documents/20124/35623/PTAT_Large+trout.pdf/4923045b-73a7-e7ce-16ec-bd33301286a8?t=1686569699668

1.3.3 Common carp

Common carp (*Cyprinus carpio* L.), also known as European or Eurasian carp, is a freshwater fish native to the lakes and slow-flowing rivers of Eurasia. It can be distinguished by its golden-brown body, speckled with small scales, a long dorsal fin and an elongated and protractile mouth[56], which makes it easier to catch food on the bottom.

Figure 5: *Distinctive features of common carp*

Source: Woon, B. (n.d.). *Carp Characteristics – Habitats, Diets & More.* BadAngling. https://badangling.com/carp/carp-characteristics-habitats-diets-more/

It is omnivorous[57] and it is known to be an extremely tolerant fish, which adapts to various environmental conditions and a wide range of temperatures, surviving winter lows below 2°C and tolerating short periods above 30°C. Additionally, both juveniles and adults exhibit resilience to low oxygen levels[58] and can regulate their internal pH, even in waters with significant pH fluctuations.
Its introduction to European aquaculture dates back to the late Roman Empire, when it was considered a luxury food and was kept in storage ponds, or "piscinae", as a valuable source of protein for the elite. Additionally, during the Middle Ages, the carp was particularly valued during periods of fasting, and became widely cultivated in small ponds across Europe. Christian monasteries played a key role in its farming, making dedicated fish ponds and raising carp especially in monoculture[59].

---

[56] The fish has two barbels, that contain taste buds, on each side of the mouth.
[57] FAO. (n.d.). *Common carp - Natural food and feeding habits.* https://www.fao.org/fishery/affris/species-profiles/common-carp/natural-food-and-feeding-habits/en/
[58] EFSA. (2008c). *Scientific Opinion of the Panel on Animal Health and Welfare on a request from the European Commission on animal welfare aspects of husbandry systems for farmed fish: carp*. The EFSA Journal, 843, p.3. https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2008.843
[59] FAO. (2025). *Cyprinus carpio.* Cultured Aquatic Species Information Programme. Text by Peteri, A. In: *Fisheries and Aquaculture*. Updated 2005-07-12. https://www.fao.org/fishery/en/culturedspecies/cyprinus_carpio/en

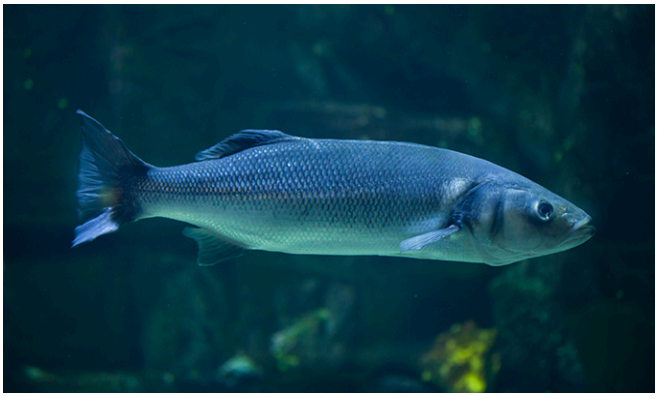
Nowadays, pond farming represents the dominant aquaculture method for carps in Europe, with production methods ranging from extensive natural ponds to net pens (in Poland) and flow through systems (mainly in Bulgaria)[60].
European production of common carp has been stable over the last few years. In 2021, it reached 52,244 tonnes in Europe[61] and carp became the EU's second most farmed freshwater fish. Poland, Czechia and Hungary lead in production, followed by smaller contributions from Germany, Croatia, Italy, Austria and Belgium.
Carp consumption is especially significant in a few EU Member States, with Poland being the largest market in 2021, consuming an estimated 20,300 tonnes in LWE. In Hungary, carp is the most consumed fish species, while it ranks second in Romania and Czechia. Its consumption is traditionally seasonal, with peaks around Christmas in Hungary, Czechia and Poland, and in early spring, following the winter pond harvest[62].

1.3.4 European sea bass

The European sea bass (*Dicentrarchus labrax* L.) belongs to the Moronidae family, and is a marine fish species, primarily found in shallow waters less than 100 meters deep[63]. It inhabits litoral zones, lagoons and estuaries, and is occasionally found in Eastern Atlantic rivers from Norway to Senegal, as well as in the Mediterranean and Black Sea[64].
The sea bass has a streamlined, fusiform body, slightly compressed on the sides, and is typically silver-gray, with darker tones along its back and tail and lighter ones in the ventral side. Its body is covered in scales, with a lateral-line canal that extends partially from the upper gill area to the caudal fin.

[60] EUMOFA, April 2021, p.17.
[61] FEAP, 2023, p. 40
[62] EUFOMA. (May 2024). *Monthly Highlights*. No.5/2024. Publications Office of the European Union. Luxembourg. p.41. https://eumofa.eu/documents/20124/118634/MH+5+2024+EN_Final.pdf/79d6b70a-4854-5fcc-1393-e70009c59a48?t=1719841957604
[63] Vandeputte, M., Gagnaire, P. A., & Allal, F. (2019). *The European sea bass: a key marine fish model in the wild and in aquaculture.* Animal genetics, 50(3), p. 195. https://doi.org/10.1111/age.12779
[64] Pavlidis et al., 2023, p. 65

Figure 6: *The European sea bass*



Source: *Underwater noise pollution stresses and confuses fish.* (August 10, 2017). Newcastle University. https://www.ncl.ac.uk/press/articles/archive/2017/08/confusedseabass/

The species tolerates wide environmental conditions, surviving temperatures from 2°C to 32°C and withstanding fluctuations in oxygen levels and pH in surrounding waters[65]. Besides, it's a demersal[66] and carnivorous fish, with a diet based on the habitat: in coastal areas, it hunts smaller fish and crustaceans, while in deeper waters it feeds on larger fish and cephalopods[67]. It is also a swift swimmer, using currents and foam for camouflage when surprising prey. Being dioecious, it lacks sexual dimorphism, and typically spawns in winter, when coastal water temperatures range from 12°C to 14°C[68].

This fish holds the distinction of being the first Mediterranean marine fish successfully reared under intensive conditions in Europe[69]. Traditionally, it was cultivated in extensive or semi-intensive seawater and brackish ponds and lagoons, a practice that persists in certain regions, such as Egypt[70]. In the 1970s, laboratory breeding trials for European sea bass began in France, with intensive larval rearing techniques emerging in the early 1980s, marking a significant development in the species' aquaculture[71]. The current dominant production system involves two main approaches: highly specialized, high-tech on-land facilities[72], where reproduction, egg hatching, larval rearing and weaning occur, and open sea cages for the on-growing and harvesting stages. As of 2021, the total production of European sea bass within EU Member States reached

---

[65] APROMAR. (2024a). *A guide on fish welfare in Spanish aquaculture - Volume 2: Welfare of European sea bass.* Spanish Aquaculture Business Association. p.6. https://drive.google.com/file/d/1jTrcY6PZP2UFYXMYiDKeyaMRWYcW2hua/view

[66] It lives and feeds on or near the bottom of the sea.

[67] Vandeputte et al., 2019, p.195

[68] APROMAR, 2024a, p.6

[69] Bagni, M. (2005). *Dicentrarchus labrax.* Cultured Aquatic Species Information Programme. FAO Fisheries and Aquaculture Department. Rome. https://www.fao.org/fishery/en/culturedspecies/dicentrarchus_labrax/en

[70] Pavlidis et al., 2023, p. 66

[71] Chatain, B. & Chavanne, H. (2009). *Genetics of European seabass (Dicentrarchus labrax L.).* Cahiers Agricultures, 18(2-3), p.250. https://doi.org/10.1684/agr.2009.0296 Translated by DeepL Translate.

[72] These are often referred to as "Mediterranean hatcheries".

approximately 99,000 tonnes, with Greece and Spain leading production levels at 53,500 tonnes and 23,924 tonnes, respectively[73]. In 2022, the total farmed sea bass production across Europe and the Mediterranean reached approximately 301,420 metric tons, reflecting a modest increase of 1.2% from the previous year[74]. The production of European sea bass juveniles also remains significant (around 353 million), with Greece producing the most at 151 million, followed by Italy, Spain and France[75]. In 2021, apparent consumption of sea bass within the EU reached 110,723 tonnes, largely comprising fresh products. Imports from outside the EU amounted to 21,594 tonnes in LWE, with Türkiye as the main supplier, while extra-EU exports totaled 12,560 tonnes LWE, primarily destined for the United States and the UK. Significant trade flows also occurred within the EU itself, with 65,588 tonnes exchanged among Member States in 2022. Greece, Spain and Croatia were the primary exporters within the EU, while Italy, Spain and France were the main importers. Italy and Spain were also the largest individual markets, accounting together for 62% of EU sea bass consumption, with 35,130 tonnes and 33,742 tonnes, respectively[76].

1.3.5 Gilthead sea bream

Gilthead sea bream (*Sparus aurata*)[77] belongs to the Sparidae family and is present in coastal areas with a variety of habitat preferences, from the British Isles to Cape Verde and throughout the Mediterranean Sea, where it inhabits seagrass beds, rocky and sandy bottoms, including depths of 30 m[78]. The fish has a smooth, dark spot at the level of the operculum, a high, oval body, compressed on both sides and a dorsal line presenting a marked convexity. It measures up to 70 centimeters long and has a silvery coloration, with a green, gray, or bluish back. The head is large and rounded and the lips are thick.

[73] FEAP, 2023, p. 50
[74] APROMAR, 2024a, p.6
[75] FEAP, 2023, p.50
[76] EUFOMA. (March 2024). *Case Study: Fresh European Seabass in the EU*. Publications Office of the European Union. Luxembourg. p.1. https://eumofa.eu/documents/20124/99991/PTAT+fresh+seabass+in+EL+ES+IT_EN.pdf/9ded129d-bfac-fdd0-6bfc-0c120e9303a7?t=1711556054886
[77] Its common name comes from the characteristic golden stripe between its two eyes.
[78] The seabream is a benthopelagic species meaning that it lives near the bottom, midwaters or near the surface of the water column.

Figure 7: *Small group of Gilthead sea breams*

Source: *GILTHEAD SEA BREAM FARM*. (n.d.). Niedditas. https://www.nieddittas.it/en/the-corru-mannu-nature-trail/1-gilthead-sea-bream-farm/

This fish tends to be solitary, although it occasionally swims in small groups. Furthermore, it is mainly carnivorous: its strong teeth crush molluscs, crustaceans and fish before eating them. However, it is also herbivorous[79], feeding on algae and the Mediterranean tapeweed. Sea bream can withstand large variations in salinity[80], tolerating and preferring brackish water, with minimum and maximum survival water temperatures[81] ranging from 5 to 34°C, respectively[82]. The fish is a protandrous hermaphrodite species meaning that it is a male at birth until it approximately reaches two years of age, becoming a mature female from three years old. Nevertheless, some individuals act as males their entire lives[83].

Nowadays, the gilthead sea bream is farmed in all countries of the Mediterranean basin since its features makes it well-suited to captivity and intensive farming conditions. Since 1990, most production has come from open sea cage farming.

In 2021, European production of gilthead sea bream was 102,632 tonnes[84], with Greece and Spain being the countries with the largest production of 67,000 tonnes and 9,632 tonnes, respectively. The European production of sea bream juveniles was approximately of 458 million[85]. Greece produced 218 million juveniles followed by Italy, France, Croatia, Cyprus and Spain. The total aquaculture production of sea bream in Europe and the rest of the Mediterranean for 2022 was 1.8% higher than the previous year[86].

---

[79] Mylonas, C. C. & Pavlidis M. A. (2011). (Eds.): *'Sparidae: biology and aquaculture of gilthead sea bream and other species'.* Aquaculture International, 19(4), 809–810. https://doi.org/10.1007/s10499-011-9455-7

[80] Sea bream is an euryhaline species.

[81] Sea bream is an eurythermal species.

[82] EFSA. (2008b). *Scientific Opinion of the Panel on Animal Health and Welfare on a request from the European Commission on animal welfare aspects of husbandry systems for farmed European seabass and Gilthead seabream*. The EFSA Journal, 844, p.7. https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2008.844

[83] APROMAR. (2024b). *A guide on fish welfare in Spanish aquaculture - Volume 3: Welfare of gilthead sea bream.* Spanish Aquaculture Business Association. p.6. https://drive.google.com/file/d/1Xp7Z-H53U_ZRmLf-cTFjCvs3dnHA-vOg/view

[84] FEAP, 2023, p. 52

[85] FEAP, 2023, p. 53

[86] APROMAR, 2024b, p.6

In the EU, the market for gilthead sea bream is significant, with an estimated apparent consumption of 140,303 tonnes in LWE. This species ranks as the 19th most consumed fish within the EU, with consumption mainly concentrated in six Member States: Italy, Spain, Portugal, France, Greece and Germany. Italy leads as the largest consumer, with apparent consumption nearing 41,000 tonnes LWE. In particular, the Italian market heavily relies on imports, which accounted for 83% of its total supply in 2021. Spain is the second largest market, consuming almost 16,000 tonnes LWE, with a similarly high dependence on imports, making up 89% of its total supply. Portugal also stands out as a significant consumer, with consumption levels around 16,000 tonnes LWE. Despite Greece being the foremost producer of gilthead sea bream, it ranks as the fifth largest consumer, with over 12,500 tonnes LWE consumed in 2021. In the country, gilthead sea bream is particularly important, as it is the third most consumed fish species, representing 6% of the total fishery and aquaculture product consumption in the country[87].

[87] EUFOMA. (June 2024). *STUDY ON THE CHALLENGES OF AQUACULTURE PRODUCTS IN FOOD OUTLETS*. Publications Office of the European Union. Luxembourg. p.23. https://eumofa.eu/documents/20124/115068/Aquaculture+outlets+study+_final.pdf

CHAPTER 2: FISH WELFARE

In this chapter, the focus shifts towards animal welfare, with a particular emphasis on fish welfare (see section 2.2 below), to set the foundation for understanding both international and EU legal frameworks related to its protection in aquaculture (see chapter 3 and 4).

2.1 Animal welfare and its evolution

After World War II, intensive livestock farming became more prevalent in both the United States and Europe, with large numbers of animals kept in tightly packed conditions to maximise production efficiency. During this time, Ruth Harrison[88]'s influential book, *Animal Machines* (1964), brought public attention to animal welfare issues. For the first time, she provided a detailed critique of the harsh conditions in which animals were raised for food, questioning the morality of treating living beings as mere "machines" for food production[89]. The public outcry following Harrison's work led the British government to appoint a commission, chaired by Professor F.W. Rogers Brambell, "to examine the conditions in which livestock [were] kept under intensive husbandry and advise whether standards ought to be set in the interest of their welfare, and if so what they should be"[90]. The resulting Brambell Report marked a turning point by systematically assessing animal welfare in such environments and recommending standards to improve conditions. For instance, it affirmed that "an animal should at least have sufficient freedom of movement to be able without difficulty, to turn round, groom itself, get up, lie down and stretch its limbs", and "must be provided with adequate food and drink to prevent it suffering from hunger and thirst"[91]. Although the final document did not explicitly define welfare, it claimed that "any attempt to evaluate welfare [...] must take into account the scientific evidence available concerning the feelings of animals that can be derived from their structure and functions and also from their behaviour"[92]. Following the release of the report, the United Kingdom government established the Farm Animal Welfare Advisory Committee, later renamed as the Farm Animal Welfare Council (FAWC) in 1979. FAWC introduced the concept of the "Five Freedoms", basic welfare standards to ensure animals were recognised:

---

[88] Ruth Harrison (1920-2000) was an important British activist and writer.
[89] Harrison, R. (1964). *Animal machines– the new factory farming industry*. Vincent Stuart Publishers Ltd. London. p.37. https://archive.org/details/animalmachines0000harr/page/n9/mode/2up
[90] Brambell, F.W.R. (1965). *Report of the technical committee to enquire into the welfare of animals kept under intensive livestock husbandry systems*. Her Majesty's Stationery Office, London. p.1. https://archive.org/details/b3217276x/page/n1/mode/2up
[91] Ibid, p.13
[92] Ibid, p.9

1. Freedom from hunger and thirst, by ready access to water and a diet to maintain health and vigour.
2. Freedom from discomfort, by providing an appropriate environment.
3. Freedom from pain, injury and disease, by prevention or rapid diagnosis and treatment.
4. Freedom to express normal behaviour, by providing sufficient space, proper facilities and appropriate company of the animal's own kind.
5. Freedom from fear and distress, by ensuring conditions and treatment, which avoid mental suffering[93].

The 1970s also saw the development of animal welfare as both an ethical and a scientific field. On the ethical front, philosophers like Peter Singer[94] and Tom Regan[95] questioned whether animals possessed intrinsic moral rights beyond their subjective experiences relevant for their welfare. In contrast, animal welfare science focused on empirical, descriptive questions, using methods from ethology and biology to objectively assess animals' welfare status.
In general, animal welfare has been defined in various ways, with three main approaches dominating the discourse: physiological functioning, natural living and feelings[96]. The first view emphasises the animal's biological health and takes into account measurable parameters. In fact, many biologists argue that feelings and subjective experiences are not accessible to scientific inquiry, so they propose limiting welfare to physiological functioning, such as health, growth and other quantifiable factors[97]. The second perspective encompasses the "telos" concept proposed by Bernard Rollin, referring to an animal's nature and its right to live according to it[98]. In this regard, animal rights activists have often highlighted that a natural environment and natural species-specific behaviour should be important aspects or components of animal welfare, and have questioned the ethics of killing and restricting animals' freedom of expression of normal behaviour. The last approach focuses on the emotional experiences of animals, including both aversive feelings like pain and fear, as well as positive feelings like pleasure and comfort.

---

[93] FAWC. (October 2009). *Farm Animal Welfare in Great Britain: Past, Present and Future.* p.2. https://assets.publishing.service.gov.uk/media/5a7d89fe40f0b64fe6c24508/Farm_Animal_Welfare_in_Great_Britain_-_Past__Present_and_Future.pdf
[94] Singer, P. (1975). *Animal liberation. A new ethics for our treatments of animals.* Harper Collins. New York.
[95] Regan, T. (1983). *The case for animal rights.* Routledge & Kegan Paul. London.
[96] Fraser, D. (2009). *Assessing animal welfare: different philosophies, different scientific approaches.* Zoo biology, 28(6), p.510. https://doi.org/10.1002/zoo.20253
[97] Diggles, B. K., Cooke, S., Rose, J. D. & Sawynok, W. (2011). *Ecology and welfare of aquatic animals in wild capture fisheries.* Reviews in Fish Biology and Fisheries, 21, p. 745. https://www.researchgate.net/publication/226363396_Ecology_and_welfare_of_aquatic_animals_in_wild_capture_fisheries
[98] Rollin, B. (1989). *Studies in bioethics. The unheeded cry: animal consciousness, animal pain and science.* Oxford University Press. New York.

One of the earliest and widely accepted definitions of animal welfare was presented by Professor Donald Broom[99], who linked it to the animal's ability to cope with its environment, both physically and emotionally.
Years later, the WOAH slightly rephrased this concept, stating that "[A]nimal welfare means the physical and mental state of an animal in relation to the conditions in which it lives and dies". The WOAH also offered a definition of good welfare, which is experienced by the animal that "is healthy, comfortable, well nourished, safe, is not suffering from unpleasant states such as pain, fear, and distress, and is able to express behaviors that are important for its physical and mental state"[100]. Moreover, in 2009, the FAWC introduced the notion of "Quality of Life" (QoL), which can be assessed using animal-based measures that take into account not only the suffering of animals but also positive aspects, such as the degree of pleasure experienced. In light of this, FAWC developed various levels of welfare, including "a life not worth living", "a life worth living" and "a good life"[101].

2.2 The concept of fish welfare

The discussion now narrows to address fish welfare specifically, clarifying the concept itself, how it can be assessed and identifying the main fish welfare-related issues, looking at each step of the life-cycle of the fish in aquaculture. Lastly, the perspectives of various stakeholders in aquaculture—such as producers, NGOs and consumers—are examined to highlight the diverse priorities and concerns that influence approaches to fish welfare.

2.2.1 Fish welfare in aquaculture

With an ever-growing global population, fish farming has been promoted as a sustainable method for producing fish, helping to preserve wild fish populations while supporting food security. However, aquaculture presents its own complex set of challenges. One major concern is that many farmed fish are carnivorous, requiring other fish for feed, which raises concerns over resource management and food waste, as fish feed is prioritised over direct human consumption.
In addition, fish farming is inevitably linked to environmental problems, with pollutants such as feed, antibiotics and chemicals frequently entering aquatic ecosystems, and social problems, including poor labour conditions and child labour. Besides, local fishing communities, which heavily rely on traditional fisheries, may experience reduced access to resources and altered ecosystems

[99] Broom, D.M. (1986). *Indicators of poor welfare*. The British Veterinary Journal, 142(6), p.524. https://www.sciencedirect.com/science/article/pii/0007193586901090
[100] Article 7.1.1 of the Terrestrial Animal Health Code
[101] Webster J. (2016). *Animal Welfare: Freedoms, Dominions and "A Life Worth Living".* Animals, 6(6), 35, p.4. https://doi.org/10.3390/ani6060035

due to the expansion of aquaculture. Last but not least, fish welfare stands out as a central issue in the industry[102].

2.2.2 The growing importance of fish welfare

Historically, references to the concept of fish welfare date back as early as the seventh century, when Chinese poet Du Fu (712–770 AD) expressed his "sympathy and compassion" for fish[103], urging others to do the same. Another example is found in the biography of Saint Francis of Assisi by Thomas of Celano, where it is noted that he was moved by a "feeling of pity towards fish"[104].
Fast-forwarding to more recent years, in 1980, the Royal Society for the Prevention of Cruelty to Animals (RSPCA) commissioned the writing of what was probably the first report that specifically concerned fish welfare. In particular, the "Report of the panel of enquiry into shooting and angling", commonly known as Medway report, urged that all vertebrates, including fish, be regarded as capable of suffering, challenging the idea that only warm-blooded animals could be considered from a moral point of view[105].
Around this period, in Scotland and Norway, intensive salmon farming began developing with significant welfare issues emerging, including disease outbreaks and lice infestations. In response, in 1992, Peter Lymbery[106] published the report "The Welfare of Farmed Fish", highlighting for the first time the welfare challenges faced by farmed salmon, especially during slaughter, and calling for urgent action to stop their suffering[107].
By the mid-1990s**,** although several studies had already been performed on the responses to stress, performance and health of fish produced for aquaculture and stock enhancement, and some showed that the stress physiology of fish was

---

[102] Compassion in World Farming. (2023). *Rethinking EU Aquaculture for people, planet, and animals.* p.3. https://www.ciwf.org/resources/reports-position-papers-briefings/rethinking-eu-aquaculture-for-people-animals-and-the-planet/
[103] Streeter, E. C. (2023). *A Short Anthology of Short Poems*. Selected Readings Editions. p.14. https://static1.squarespace.com/static/631b84989ceff12e89eb0633/t/648b79575021fe1b1034e7ce/1686862167737/b+Poetry+-+sample+-+GP.pdf
[104] Celano, T. (ca.1229). *The first life of St. Francis* (par. 60, ch. 21). In M. L. Cameron (Ed.), *The inquiring pilgrim's guide to Assisi* (A. G. Ferrers Howell, Trans.). Retrieved 14 September 2024 from Indiana University at https://dmdhist.sitehost.iu.edu/francis.htm
[105] Medway, L. (1980). *Report of the panel of inquiry into shooting and angling (1976–1979)*. Panel of Enquiry into Shooting and Angling. Horsham. p.52.
[106] His work was on behalf of the NGO Compassion in World Farming.
[107] Lymbery, P. (1992). *The welfare of farmed fish*. Compassion in World Farming. Petersfield, Hampshire.

very similar to that of mammals[108], the amount of comprehensive studies regarding pain in fish remained limited. In this regard, in his "Fish welfare literature review", Dr T.G Pottinger observed that the available literature was not complete enough to prove that fish and mammals feel pain in the same way or in a completely different manner[109].
At the same time, in 1996, the "Report on the welfare of farmed fish" by the British FAWC affirmed that while fish feelings couldn't be understood with certainty, "the evidence available made it very likely that at least some aspects of pain are felt by fish"[110].
The early 2000s saw the publication of the "Briefing Paper" on fish welfare published by the Fisheries Society of the British Isles (FSBI)[111]: although there is no clear definition of their welfare, the authors considered relevant aspects like suffering and pain, human–fish interactions, responses to stressors and the assessment of welfare, while highlighting gaps in the common understanding of the concept of fish welfare[112].
For what concerns the European context, an important turning point was represented by the EU COST Action network, with the Cost action 867 ''Welfare of Fish in European Aquaculture'' (2006–2011)[113], which advanced fish welfare science in Europe, involving over 100 stakeholders from multiple countries[114]. Among its goals, the network wanted to expand the knowledge related to fish welfare, to elaborate clear guidelines on farmed fish welfare and to provide the industry with some specific operational welfare indicator protocols.
More recently, the question of whether fish experience pain has gained substantial attention, sparking ongoing debate within fish welfare science.

---

[108] On this subject, see: Schreck, C.B. (1981). *Stress and Compensation in Teleostean fish : Response to Social and Physical Factors*. In: Pickering, A.D., Ed., *Stress and Fish*, Academic Press, London; Schreck, C.B. (1990). *Physiological, behavioral, and performance indicators of stress.* American Fisheries Society Symposium, 8:29-37; Barton, B.A., & Iwama, G.K. (1991). Physiological changes in fish from stress in aquaculture with emphasis on the response and effects of corticosteroids. Annual Review of Fish Diseases, 1:3-26.
https://www.sciencedirect.com/science/article/pii/095980309190019G
[109] Pottinger, T.G. (1995). *Fish welfare literature review*. Institute of Fresh Water Ecology, IFE Report No. WI/T11063f7/1. p.5.
https://nora.nerc.ac.uk/id/eprint/7223/1/Fish_Welfare_Literature_Review_-_TG_Pottinger_-_1995.pdf
[110] FAWC. (1996). *Report on the welfare of farmed fish*. p.2.
https://assets.publishing.service.gov.uk/media/5a7dfff2ed915d74e6223727/FAWC_report_on_the_welfare_of_farmed_fish.pdf
[111] FSBI. (2002). *Fish Welfare.* Briefing Paper 2, Granta Information Systems, 82A High Street, Sawston, Cambridge.
https://www.fsbi.org.uk/wp-content/uploads/2018/02/brief-welfare-norefs.pdf
[112] Among these gaps, the authors particularly focused on the absence of knowledge related to the mind of the fish, and the complex relationship between measurable states (e.g. physical injury) and subjective states of welfare (e.g. pain).
[113] The COST Action focused on the five main farmed species in Europe: Atlantic salmon, rainbow trout, sea bass, sea bream, and carp.
[114] Kiessling, A., van de Vis, H., Flik, G., & Mackenzie, S. (2012). *Welfare of farmed fish in present and future production systems*. Fish physiology and biochemistry, 38(1), p.1.
https://doi.org/10.1007/s10695-011-9594-9

In general, fish have long been excluded from the moral circle granted to other animals that are considered as sentient beings[115]. Several authors, like James D. Rose, argued that fish brain is structured in a way that it is impossible that they can feel pain[116]. Nevertheless, this view has been increasingly challenged by new evidence. For instance, in 2002, Lynne Sneddon's studies demonstrated that fish, particularly rainbow trout, possess specific receptors that respond to potentially painful stimuli. Her findings indicated that fish react to harmful stimuli in ways that suggest more than a simple reflex, aligning more closely with behaviors indicative of pain perception[117]. Following Sneddon's work, a growing number of studies by several researchers have added empirical support to the idea that fish can experience pain[118], sparking a growing ethical and legislative interest in fish welfare. This important amount of evidence resulted in a shift in attitudes toward fish in intensive aquaculture, where farmers are now responsible for every stage of a fish's life cycle. This change of mindset has naturally extended to ethical questions about the way fish should be handled and their quality of life. Today, in Europe, the notion of fish welfare is commonly adopted by a range of stakeholders, from fish farmers, animal advocacy groups and scientists, to policymakers and consumers (see section 2.2.5 below). As aquaculture continues to grow, interest in protecting fish welfare is likely to escalate in the upcoming years.

---

[115] Lund, V., M. Mejdell, C., Röcklinsberg, H., Anthony, R., Håstein, T. (2007). *Expanding the moral circle: farmed fish as objects of moral concern.* Diseases of Aquatic Organisms, 75, p. 109. https://www.int-res.com/articles/dao_oa/d075p109.pdf

[116] Rose, J. D. (2002). *The neurobehavioral nature of fish and the question of awareness and pain.* Reviews in Fisheries Science 10, p.1. https://www.researchgate.net/publication/247933362_The_Neurobehavioral_Nature_of_fish_and_the_Question_of_Awareness_and_Pain

[117] Sneddon, L. U. (2002). *Anatomical and electrophysiological analysis of the trigeminal nerve in a teleost fish, Oncorhynchus mykiss*. Neuroscience letters, 319(3):167–171. https://doi.org/10.1016/s0304-3940(01)02584-8

[118] For a detailed discussion, see: Sneddon, L. U., Braithwaite, V. A., & Gentle, M. J. (2003). *Do fish have nociceptors? Evidence for the evolution of a vertebrate sensory system.* Proceedings. Biological sciences, 270(1520), pp. 1115–1121. https://doi.org/10.1098/rspb.2003.2349; Chandroo, K.P., Yue, S. and Moccia, R.D. (2004). *An evaluation of current perspectives on consciousness and pain in fish.* Fish and Fisheries, 5, pp.281-295. https://doi-org.ezproxy.library.wur.nl/10.1111/j.1467-2679.2004.00163.x; Dunlop, R., & Laming, P. (2005). *Mechanoreceptive and nociceptive responses in the central nervous system of goldfish (Carassius auratus) and trout (Oncorhynchus mykiss).* The journal of pain, 6(9),pp. 561–568. https://doi.org/10.1016/j.jpain.2005.02.010; Broom, D. M. (2007). *Cognitive ability and sentience: which aquatic animals should be protected?* Diseases of aquatic organisms, 75(2), pp.99–108. https://doi.org/10.3354/dao075099; Sneddon, L. U., Lopez-Luna, J., Wolfenden, D. C. C., Leach, M. C., Valentim, A. M., Steenbergen, P. J., Bardine, N., Currie, A. D., Broom, D. M., & Brown, C. (2018). *Fish sentience-denial:muddying the waters.* Animal Sentience, 3(21), pp.1-11. https://animalstudiesrepository.org/animsent/vol3/iss21/1/

2.2.3 Assessing fish welfare: important definitions

Addressing fish welfare in aquaculture requires an understanding of the key factors that constitute it and allow its measurement. However, one of the significant challenges in defining fish welfare has been the lack of consensus on measurable parameters that could indicate good or poor welfare. This occurred, and still occurs, for various reasons.
First of all, although fish and mammals (e.g. humans) are both vertebrates, they do not belong to the same classification and exhibit entirely different physiological and behavioral features. Therefore, humans cannot use their own experiences or intuition as a basis for assessing fish welfare.
In the second place, much of the research conducted so far has focused on species of particular importance to humans, such as salmon and trout. However, as mentioned earlier, more than 30,000 fish species exist, each with its unique set of features. Consequently, the knowledge gained from studies on one species cannot necessarily be applied to others.

Before delving into the theoretical aspects governing the assessment of fish welfare, it is essential to emphasise the critical role of the people working in fish farms, as the well-being of fish relies entirely on them.
Ensuring fish welfare involves counting on well-trained personnel, as highlighted by Dimitris Papapanagiotou, Greek biologist and General Manager of KITO Marine Farm SA[119]. This includes not only a deep understanding of the biological and environmental needs of the fish species being farmed, but also of fish behaviour. Staff must be able to particularly recognise abnormalities that could signal welfare issues, immediately identify signs of stress or disease and know how to react within a short time.

That being said, the discussion now focuses on how fish welfare can be assessed, drawing upon the framework proposed by Stien et al. (2020)[120], which emphasises the importance of understanding several key definitions. According to their work, measuring fish welfare directly depends on the concept of "welfare state", which is defined by both positive and negative feelings experienced by the fish. These feelings arise from various “welfare needs”, which can be categorised into five primary groups[121]:

1. Adequate nutrition, which encompasses the needs of the fish related to feed and nutritional intake.

---

[119] Interview conducted on October 17th, 2024.
[120] Stien, L. H., Bracke, M. B. M., Noble, C., & Kristiansen, T. S. (2020). *Assessing fish welfare in aquaculture*. In T. S. Kristiansen, A. Fernö, M. A. Pavlidis, & H. van de Vis (Eds.), The Welfare of Fish; Vol. 20, No. 1, 303-321. Springer. https://doi.org/10.1007/978-3-030-41675-1_13
[121] Ibid, p.308

2. Appropriate water quality, which covers the necessary environmental conditions that support the fish's bodily functions, such as osmoregulation, respiration, and thermoregulation. This category also includes maintaining water free from harmful metabolites, chemicals, and particles that could impact fish welfare and physiology.
3. Good health, namely the absence or low level of malformations, diseases, parasites and injuries.
4. Behavioural freedom, which refers to the fish's ability to live in accordance with natural behaviors, such as the freedom to move as wanted, to have social interactions with other species, to rest, migrate and reproduce at the appropriate life stage.
5. Safety, which involves all the needs related to physical protection, such as the ability to hide from perceived dangers and avoid injury.

It is important to note that the list is not exhaustive and the boundaries between these welfare needs can overlap. Additionally, the urgency and impact of each need can vary. For example, while the first three categories are essential for the survival and long-term welfare of the fish, the same cannot be affirmed for behavioural freedom, which may not be as crucial, but still plays a role in the fish's overall well-being.
In order to understand whether these needs are fulfilled, and thus evaluate the derived animal's welfare state, Stein et al. affirm that "welfare indicators" (WIs) can be used. These are observable parameters characterised by specific features. Firstly, it should be possible to rate WIs on a scale with two or more levels giving positive or negative information on the welfare state. Although this approach can be considered as very intuitive, setting the exact boundaries between the different levels requires careful judgment, as the user could have some difficulties in deciding where the level starts and ends (e.g. when an injury is moderate or severe). Secondly, a WI is only valid when it actually shows whether at least a welfare need is being met. For instance, if the welfare need is good health, a valid WI for it might be the fish's physical condition, like the absence of injuries or disease. On the contrary, a WI like water temperature would not be considered as valid since temperature doesn't directly show whether the fish are healthy. Thirdly, a WI should be reliable, providing consistent results no matter who measures it or when it is measured. For example, if fish injuries are used as a WI, two different observers should agree on how many fish appear injured, and if they check again at a later stage, the score should remain consistent if the conditions haven't changed.
In addition to this, WIs can be based on an input or a result.
As the name suggests, input-based WIs measure the conditions or resources provided to animals, such as food or water quality, that can affect fish welfare. In other words, these describe what the fish is exposed to, e.g. whether the water quality meets certain standards to support fish health. Since they assess aspects of the environment, input-based indicators can also be called "environment-based" or "indirect" indicators.

In contrast, outcome-based WIs evaluate how well fish welfare needs are met by observing features of the fish itself, e.g. the amount of injuries. These WIs are also called "animal-based" or "direct" welfare indicators because they measure welfare outcomes as they appear in the animal's condition or actions.
According to Stien et al., when creating a welfare assessment scheme for fish, it's essential to ensure that all welfare needs are considered. A common approach is to use both input-based and outcome-based welfare indicators: given that monitoring every single input-based WI that is required to ensure all welfare needs are met results to be almost impossible[122], outcome-based WIs are used as a supplement to catch issues that might not be noticed through input-based WIs alone. Another crucial step when developing a welfare assessment scheme is choosing Operational Welfare Indicators (OWIs) that are practical for on-farm use and that can be directly assessed by the farmer. These should be easy to measure and give clear insights into the fish's welfare status. In this context, Dimitris Papapanagiotou outlined several Operational Welfare Indicators (OWIs) regularly monitored at the farm where he works, including salinity, turbidity, oxygen levels, food quality, the appetite of the fish, temperature, the presence of injuries, growth and mortality rate and the behaviour of the fish[123]. In some cases, farmers might also need to use Laboratory-based Welfare Indicators (LABWIs), which involve sending samples to a laboratory for detailed analysis. LABWIs can be useful if they provide reliable, timely information on aspects of fish welfare that are hard to assess at the farm.

2.2.4 The life-cycle of farmed fish and fish welfare-related issues

Farmed fish often spend much more time in the farm than terrestrial animals, with some species requiring up to six years to reach the desired market size[124]. The production process consists of several key phases, including rearing in controlled hatcheries, growing-on (which can take place in different farming systems), transport and slaughter.
In the sections below, the description of the life-cycle of farmed fish is complemented by the identification of the main welfare-related challenges[125] commonly associated with each step. However, it is important to recognise that the list of welfare issues discussed here is likely not exhaustive. As mentioned earlier, fish welfare has long been neglected, or even denied as a significant

[122] However, some input-based WIs, such as appropriate water temperature and adequate oxygen, should always be included.
[123] Interview conducted on October 17th, 2024.
[124] Mancuso, M. (Last update: June 22, 2022). *Allevamento di pesci: 5 foto per capire cos'è e come funziona l'acquacoltura*. Essere Animali. https://www.essereanimali.org/2021/06/5-foto-acquacoltura/
[125] These strongly depend on factors such as the type of aquaculture system (intensive, semi-intensive, or extensive), the specific species being farmed, and the location of the farm.

concern, leaving gaps in detailed knowledge. As the field gains attention, further research is expected to uncover additional welfare issues and contribute to their resolution.

2.2.4.1 Rearing

The initial stage of the fish farming process takes place in hatcheries, specialised facilities designed to breed large numbers of fish in a controlled environment. Here, operators ensure that fish eggs develop and hatch by carefully managing WIs, such as water temperature, oxygen levels, disease prevention and feed quality.

The term "broodstock" refers to the mature fish used to produce eggs for the farm. This fish can either be wild-caught[126], as seen with species like sea bass and sea bream, or derived from the farm's own fish population, after an initial broodstock has been established. At some point, farmers monitor the female broodstock for signs of ovulation, using visual checks, handling, or sampling with a catheter put into the fish's genital opening. During ovulation, a process known as stripping is performed[127]: broodstock are taken out of the water and eggs are extracted from the female's abdomen[128] (see Figure 8 below). Similarly, male fish are handled outside of the water to collect milt (seminal fluid). This involves wiping down the fish to prevent the eggs getting wet, holding it over the egg container and massaging its abdomen to trigger the release of the seminal fluid. The manual handling of fish during this procedure can cause both physical and psychological damage. For this reason, EFSA highlights the importance of minimising such stress, recommending that broodstock be handled with extreme care and under anaesthesia to reduce harm[129]. For instance, it suggests "single stripping followed by slaughter" for salmon males, as this avoids repeated interventions that compromise fish welfare[130]. For what concerns broodstock welfare, it can be added that this is directly linked to the welfare of their offspring. In other words, stress experienced by broodstock can negatively affect its eggs and juveniles, leading to weakened immunity and greater susceptibility to disease later in life.

---

[126] Wild-caught broodstock are often preferred in order to maintain genetic diversity.
[127] Stripping is not always performed, as some systems allow for a more natural spawning process: in this case, males and females are kept together in a tank, so that males can directly fertilise the eggs, as they would in the wild. Nevertheless, whether using natural spawning or stripping, the process is very stressful for the fish as both male and female fish are typically injected with hormones to regulate spawning timing and ensure the best yield.
[128] For some fish, such as the sturgeon, this is not possible because of the anatomy of the female fish. Instead, the fish is anaesthetised and the eggs are surgically removed. The female is often euthanised after this procedure.
[129] EFSA. (2008a). *Scientific Opinion of the Panel on Animal Health and Welfare on a request from the European Commission on Animal welfare aspects of husbandry systems for farmed Atlantic salmon*. The EFSA Journal, 736-Annex II, p.19. https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2008.736
[130] Ibid

Figure 8: *Handling during stripping*

Source: Fu, J. (March 6, 2019).*The first hotly contested batch of GM salmon eggs hits the U.S.* The Counter. https://thecounter.org/aquabounty-genetically-engineered-salmon-eggs-aquadvantage-egg-shipment-fda/

Once collected, the eggs are incubated in various containers, such as silos, buckets, or tanks, with capacities ranging from 5 to 200 litres[131].
Water circulates around the eggs and any dead or non-viable eggs are removed to prevent contamination or fungal infection. Alternatively, eggs can be incubated in shallow trays or baskets stacked in a tiered system, where cascading water helps maintain proper circulation[132]. The design of the tanks and parameters like water temperature, salinity and flow are adjusted depending on the specific features of the fish (e.g. whether it is freshwater or marine).
Following the incubation of the eggs, hatching can be considered as "the most important environmental change fish experience during their lives", marking the transition from the embryonic to the larval stage[133]. Hatching trays are kept indoors, away from direct sunlight, and are used to house the eggs, which are placed in baskets with perforated sides. After hatching, the fry (juvenile fish) swim through the perforations and settle on the substrate in the tray. At this point, the juvenile fish begin to learn how to feed[134]. The design and size of first-feed tanks can vary based on species, and artificial lighting may be used to accelerate growth, similar to practices in other forms of intensive farming, such as in poultry production.
To conclude, during the step of rearing, grading, can be considered as another critical practice threatening fish welfare. Grading involves separating fish into different groups based on their size[135] (see Figure 9 below) and offers several

[131] Eurogroup for Animals. (2018). *Looking Beneath the Surface: Fish Welfare in European Aquaculture.* p.21. https://www.eurogroupforanimals.org/library/looking-beneath-surface-fish-welfare-european-aquaculture
[132] Freshwater Fisheries Society of BC. (March 8, 2011). *Go Fish BC: Trout egg incubation* [Video]. YouTube. https://www.youtube.com/watch?v=fF2oqubO9Ow
[133] Korwin-Kossakowski, M. (2012). *Fish hatching strategies: A review.* Reviews in Fish Biology and Fisheries, 22(1), p.1. https://doi.org/10.1007/s11160-011-9233-7
[134] Prior to this, they rely on the yolk sac they absorbed from the egg.
[135] Fish can also be sorted by species or gender, depending on the needs of the business.

advantages, such as "reducing fish losses through cannibalism" and improving feeding efficiency by ensuring appropriate food rations for each group[136]. However, all grading methods, despite their benefits, can cause extreme stress and physical harm to the fish, as the process often involves capture, handling and removal from water[137]. For example, in mechanical grading, fish are sorted by their width as they pass through a machine designed to differentiate them based on their thickness and direct them into appropriate bins. Alternatively, grading can be done by weight or even visually, where a human manually assesses the fish and categorises them accordingly.

Figure 9: *A worker using a fish grader*

Larger fish remain on the surface while smaller fish pass through the perforations in the grader, separating them by size. Source: AQUACULTURE ID. (n.d.). *Fish grading equipment.* https://www.aquacultureid.com/products/fish-grading-equipment/

2.2.4.2 Growing-on

In aquaculture, the growing-on step refers to the stage where fish are raised to market size. It typically follows the rearing step and constitutes the main period of growth for the fish. This process can involve multiple stages[138] and occurs in various systems (which can also be used in combination), depending on the species being farmed and the geographical conditions.

---

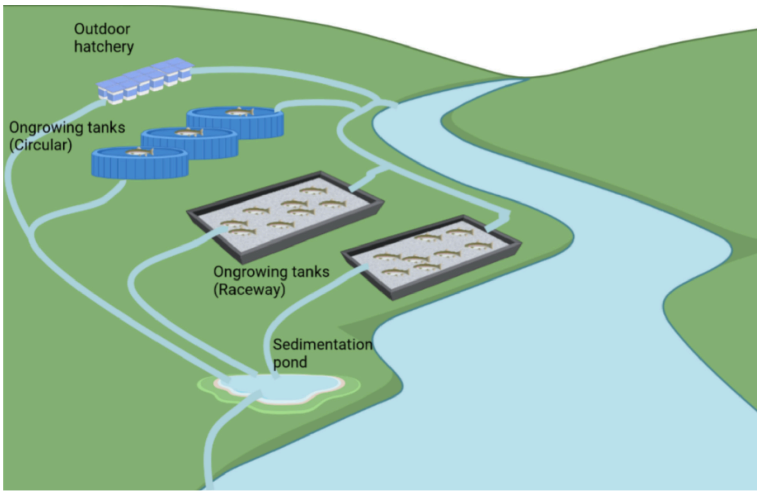
[136] FAO. (n.d.). *Simple Methods for Aquaculture.* Handbook on fish farming. Chapter 12. https://www.fao.org/fishery/static/FAO_Training/FAO_Training/General/x6709e/Index.htm

[137] EFSA, 2008a, p.20

[138] For instance, the growing-on process for salmon includes several stages, as they undergo physiological changes that enable them to transition from a freshwater to a saltwater environment (they are said to "smoltify" after hatching).

1) **Land-based flow-through systems**. These were originally developed for salmonids and are still widely used in Europe to raise fish, such as rainbow trout and juvenile Atlantic salmon, which are fed exclusively on manufactured feed. They consists of special inland tanks, ponds or raceways, where a steady supply of clean, cool water with good flow is available from wells, reservoirs, or streams[139]. The tanks can vary in size depending on the fish's life stage, with larger tanks (around 100 square metres) used for growing bigger fish. They are built with concrete, wood, or earth, and some earthen tanks are lined with plastic to make cleaning easier. Each tank has an inlet for fresh water and an outlet to remove used water, ensuring the fish have enough oxygen and that waste is constantly removed.

Figure 10: *An overview of a land-based flow-through system*



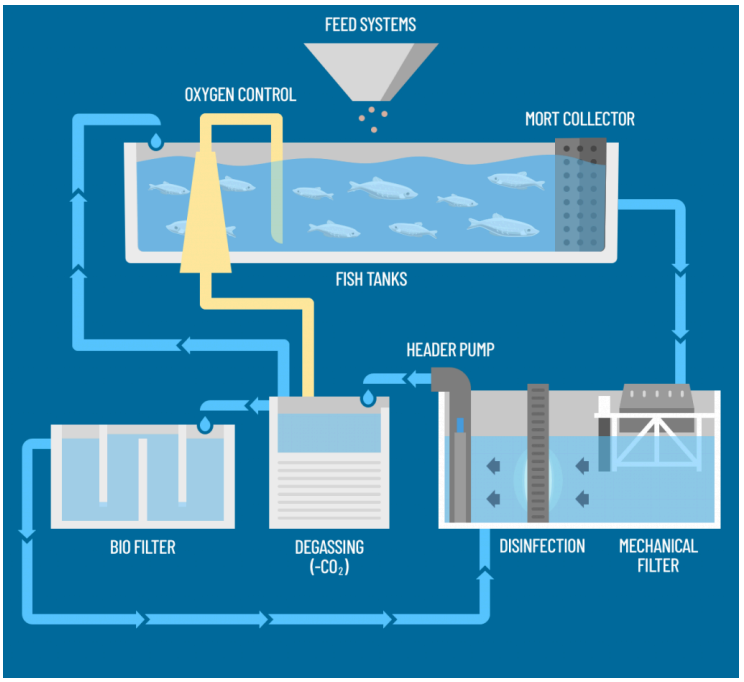
Source: Pavlidis, M., et al., 2023, p.23.

2) **Recirculating aquaculture systems (RAS)**. They are land-based aquaculture facilities, either outdoors or indoors, that minimise water consumption by filtering, adjusting and reusing the water[140]. This water management approach is what mainly differentiate it from flow-through systems. The water recirculation allows for more precise control over water quality and culture conditions, such as temperature, oxygen levels and pH, enabling fish farming in a wider range of environments, including areas without natural water sources. In fact, the enclosed design of RAS makes farming in urban or landlocked areas possible, allowing fish production closer to market locations, which shortens transport distances

[139] Gravity is often used to keep water flowing without pumps and help the waste to flow out naturally.
[140] European Commission. (n.d.). *What are the advantages and key challenges of Recirculating Aquaculture Systems (RAS)?* EU Aquaculture Assistance Mechanism. https://aquaculture.ec.europa.eu/faq/8-what-are-advantages-and-key-challenges-recirculating-aquaculture-systems-ras

and potentially reduces the environmental footprint[141]. Moreover, RAS reduces the risk of escapees and minimises the spread of disease to the surrounding environment, which is common with open-water systems. Despite these advantages, RAS is energy-intensive due to the need for constant filtration, aeration and temperature control, leading to higher operational costs. Waste management can also be challenging, as waste can accumulate within the system and must be effectively treated to prevent pollution[142].

Figure 11: *How RAS works*



Source: Dibaq Group (April 16, 2019). *Main advantages of recirculating aquaculture systems.* https://dibaq.com/en/advantages-recirculating-aquaculture-systems/

3) **Floating cage open-flow systems.** During the growing-on phase, species such as salmon, trout, sea bream and sea bass can be kept in floating cage open-flow systems, consisting of large nets suspended in open water. Each sea cage is made of a floating frame that holds a net enclosure, where fish are housed and can swim freely. To keep the cages stable during eventual tidal changes or currents, they are anchored in place, remaining secure. These cages vary in size, with some reaching up

[141] EUFOMA. (December 2020). *Recirculating aquaculture systems.* Publications Office of the European Union. Luxembourg. p.1. https://eumofa.eu/documents/20178/84590/RAS+in+the+EU.pdf

[142] Wageningen University and Research. (n.d.). *Recirculating aquaculture systems (RAS).* https://www.wur.nl/nl/onderzoek-resultaten/leerstoelgroepen/dierwetenschappen/aquaculture-and-fisheries/wageningen-aquaculture-research-education-w-are/recirculating-aquaculture-systems-ras.htm

to 160 metres in diameter, while the nets can be set at depths ranging from 5 to 50 metres depending on environmental conditions and the type of system used. Some farms employ antifouling chemicals[143] to maintain water quality, and predator nets are typically placed around and beneath the cages to protect the fish from marine predators.

Figure 12: *Sea bass cage underwater*

Source: Eurogroup for Animals, 2018, p.28

4) **Ponds**. They are considered "the oldest fish farming activity in Europe"[144]. They are man-made fresh water bodies where fish are reared. They constitute a system of choice for fish with lower commercial value per animal and can be adapted to fish that are able to survive in stagnant water, such as common carp[145] or trout.

[143] Pesticides which require prior agreement from the relevant authorities before being used.
[144] EUFOMA, April 2021, p.21.
[145] The practice of raising common carp in ponds has ancient origins, gaining widespread popularity throughout the Middle Ages. In the 19th century, it evolved significantly, reaching its peak development and popularity.

Figure 13: *An area of carp ponds*

Source: EUROFISH. (December 11, 2020). *Pond fish farming in Poland, a century-old activity, is adapting to changes at many levels.* https://eurofish.dk/pond-fish-farming-in-poland-a-century-old-activity-is-adapting-to-changes-at-many-levels/

During the growing-on step, several factors can affect fish welfare. Among these, water quality stands out as the most crucial. In fact, fish are entirely dependent on water for survival and any deviation from optimal conditions can significantly impact their health and growth. Different fish species require different water quality parameters (e.g. temperature, pH, conductivity, oxygen concentration) that need to be closely monitored to be kept at optimal levels. In this regard, technical equipment and alarm systems must function correctly to detect and report rapid changes of water parameters, allowing for corrective actions[146]. The flow speed and direction of the water within a specific system (e.g. a tank) are critical factors that impact water quality and should be arranged in a way to ensure regular exchange throughout the system to prevent the formation of "dead zones" where water stagnates[147]. In light of this, the flow rate plays a dual role when it is correctly regulated: it restores fresh oxygen levels while diluting and effectively removing metabolic waste.
Water quality is also closely interconnected with stocking density within the aquaculture system, whether in nets, tanks, or cages. This is typically expressed as kilograms of fish per cubic metre (kg/m³), which reflects "the number or mass of fish in a given amount of water"[148]. Stocking density significantly affects

[146] Water quality must be kept at optimal conditions in all cases, including emergencies, in order to ensure the survival of the fish.
[147] Such areas are particularly problematic because they result in reduced oxygen levels and localised accumulation of harmful substances, like ammonia, due to the sedimentation of waste and uneaten feed.
[148] Jones, M., & Sloman, K. A. (2024). *Fish welfare.* In S. L. Alderman & T. E. Gillis (Eds.), Encyclopedia of Fish Physiology (Second Edition), pp. 429–436. Academic Press. https://www.sciencedirect.com/topics/immunology-and-microbiology/stocking-density#:~:text=Stocking%20density%20refers%20to%20either,inhabit%20a%20three%2Ddimensional%20environment

not only water quality, but also fish growth and stress and social interactions among different individuals. In fact, when a lot of fish are kept in confined environments, the animals compete for food, or even for areas of water where the quality is better, because there is more oxygen and less debris. This clearly causes stress to the animals, which can react by attacking each other, as some pictures of cannibalism between fish show. For instance, fin-chewing, a form of aggression observed in species like salmon and trout, has been indicated as one of the results of high stocking density[149]. Fin injuries are particularly painful for the affected fish, which may not be able to correctly swim, and may even result in secondary bacterial infections[150].

Additionally, the stocking density varies depending on species-specific needs[151] and technical considerations, such as the water flow rate. On one hand, the stocking density should ensure adequate water quality and, on the other hand, support healthy social dynamics. For example, some species, such as rainbow trout and other salmonids, thrive in densities where they form a cohesive community. Nevertheless, excessively low densities can provoke dominant behaviours, with some fish becoming aggressive toward others. Species-specific social behaviours also play a role, considering that fish that naturally live in large groups may prefer higher stocking densities, while solitary species might become stressed or aggressive in crowded environments[152]. Adjusting stocking densities to accommodate these natural tendencies is essential for promoting welfare in aquaculture systems. However, the identification of the optimal stocking density for fish can result in a more difficult task than for terrestrial animals, since fish live in a three-dimensional environment[153].

During the growing-on stage, fish may also become susceptible to diseases or parasites, which need to be addressed to guarantee proper welfare. In this regard, operators should dispose of an effective fish health plan that includes preventive measures, disinfection and cleaning procedures, biosecurity protocols and strategies to minimise setbacks. In the case of disease, preventing the introduction of pathogens can be achieved by avoiding the transfer of infected fish, using properly sanitised equipment and ensuring hygiene among personnel. During outbreaks, infected populations should be isolated and fish carcasses should be promptly removed to prevent the spread of pathogens or attraction of predators. While antibiotics are commonly "used for treatment therapy, prophylactic reasons, or growth promotion", their overuse can contribute to

---

[149] Broom, D.M. (2017). *Animal Welfare in the European Union*. Directorate-General for Internal Policies. Policy Department for Citizens' Rights and Constitutional Affairs. European Union. p.50. https://www.europarl.europa.eu/RegData/etudes/STUD/2017/583114/IPOL_STU(2017)583114_EN.pdf

[150] Braithwaite, V. (2010). *Do fish feel pain?* Oxford University Press. p.160

[151] Bergqvist, J., Gunnarsson, S. (2013). *Finfish Aquaculture: Animal Welfare, the Environment, and Ethical Implications*. Journal of Agricultural and Environmental Ethics, 26, p.80. https://doi.org/10.1007/s10806-011-9346-y

[152] Ashley, P. (2007). *Fish welfare: Current issues in aquaculture.* Applied Animal Behaviour Science, 104, p.211. https://doi.org/10.1016/j.applanim.2006.09.001

[153] Ibid.

antimicrobial resistance, posing risks to both fish health and human health through the potential spread of resistant bacteria, and environmental damage[154]. Another method is vaccination, a proactive measure used to prevent outbreaks of bacterial and viral diseases. However, the number of available vaccines for fish is relatively limited[155] and the vaccination process is likely to induce stress or injury to the fish, particularly during handling. In any case, preventative care plays a crucial role in maintaining optimal conditions in the growing-on environment: measures like ensuring high water quality and reducing stressors such as overcrowding, help sustain immune performance and appetite, contributing to the overall health and well-being of the fish.
Parasites, such as sea lice in salmon farming (see Figure 14 below), present other welfare challenges. Sea lice, which have become very common in aquaculture, attach to the fish's skin, feeding on blood and mucus and causing painful lesions that can lead to secondary infections and, eventually, mortality. They are favoured by high densities and can spread easily from farm to farm and even outside, among wild fish populations. Treatments, including the use of laser, chemical baths, heat shock (thermolicer)[156]and mechanical removal (hydrolicer)[157], can be effective but are highly stressful and can result in injuries or deaths[158]. Alternative methods, such as using cleaner fish like ballan wrasse and lumpfish to remove parasites from the skin of the infected fish, are beneficial for the latter, but result in poor welfare for the cleaner fish, which often face poor conditions in captivity and early mortality[159].

---

[154] Hoseinifar, S.H., Ashouri, G., Marisaldi, L., Candelma, M., Basili, D., Zimbelli, A., Notarstefano, V., Salvini, L., Randazzo, B., Zarantoniello, M. et al. (2024). *Reducing the Use of Antibiotics in European Aquaculture with Vaccines, Functional Feed Additives and Optimization of the Gut Microbiota*. Journal of Marine Science and Engineering. 12, 204, p.2.
https://iris.univpm.it/retrieve/be4fb3f7-4fc7-4308-bd00-a43f7226d284/Hoseinifar_Reducing-Use-Antibiotics-European-Aquaculture_2024.pdf
[155] Rasul, M. & Majumdar, B. (2017). *Abuse of antibiotics in aquaculture and its effects on human, aquatic animal and environment*. The Saudi Journal of Life Sciences, 2(3), p.84.
https://saudijournals.com/media/articles/SJLS-2381-88.pdf
[156] For further details, see: Laastad, T. (November 22, 2022). *Thermolicer effectively treats sea lice with thermal technology.* Business Norway.
https://businessnorway.com/solutions/thermolicer-effectively-treats-sea-lice-with-thermal-technology
[157] For further details, see: *Hydrolicer*™. (n.d.). Smir.
https://smir.no/products/hydrolicer/?lang=en
[158] European Commission. (April 29, 2022). *Removing lice with PHOTOLICER is no lousy job*. Directorate-General for Maritime Affairs and Fisheries.
https://oceans-and-fisheries.ec.europa.eu/news/removing-lice-photolicer-no-lousy-job-2022-04-29_en
[159] Ibid.

Figure 14: *Live sea lice on the skin of a salmon*

Source: Keane, K. (August 9, 2018). *Sea lice 'breakthrough' for salmon farmers.* BBC. https://www.bbc.com/news/uk-scotland-45110143

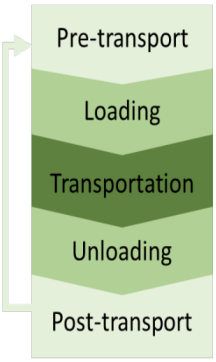
Another important element influencing fish welfare in the growing-on step is the limitation of their ability to express natural behaviours. Farmed fish are confined to cages, tanks, ponds or other closed environments and are unable to migrate, hunt, forage, or create social bonds as they would in the wild. For this reason, farm operators should design aquaculture systems that meet the biological needs of the fish. This includes considering environmental factors such as exposure to natural light, noise and vibrations, as well as providing environmental enrichments (EE) through structures like hiding places[160].
Although EE can sometimes make tank cleaning complex and increase the risk of disease, empty tanks and cages fail to offer farmed fish a quality life. Without adequate stimulation, fish may engage in repetitive, aimless swimming, which can contribute to stress and aggression. In this sense, EE introduces stimuli that fulfil fish's physiological, behavioural and psychological needs, aligning with the core aspects of animal welfare: ensuring proper biological functioning, providing natural living conditions and fostering positive experiences[161].
Besides, fish farms should protect farmed fish from predators while preventing escapes. At high stocking densities, fish become an attractive target for predators and the lack of escape options in fish farms can cause them stress or even depredation. Welfare issues also affect the predators themselves, as they may be killed by farmers to safeguard the fish stock or be captured in anti-predator nets, leading to injury or death.

[160] For example, sea bass and bream naturally forage on the seabed to look for food, and seek shelter in the sand, while salmonids typically hide among rocks to escape predators and harsh weather conditions.
[161] Arechavala-Lopez, P., Cabrera-Álvarez, M.J., Maia, C.M., Saraiva, J.L. (2022). *Environmental enrichment in fish aquaculture: A review of fundamental and practical aspects*. Reviews in Aquaculture, 14, p.705. https://doi-org.ezproxy.library.wur.nl/10.1111/raq.12620

2.2.4.3 Transport

Like terrestrial farm animals, also farmed fish undergo live transport. This stage occurs when juvenile fish are moved to a growing-on farm, mature fish are transferred to another facility, or marketable fish are sent to slaughter and processing sites. In the EU, data on the transport of live fish are limited. This is largely because trade statistics are often reported by weight rather than by the actual number of fish, making it challenging to estimate the total headcount, especially considering the diversity of fish sizes[162].
An essential aspect to take into account is that "transporting live fish is a multiple-phase operation"[163](see Figure 15), including the initial preparation of the fish, through handling and loading, the journey itself and the eventual unloading and acclimation to the new environment. At every stage, fish welfare can be compromised due to potential physical injuries, suboptimal environmental conditions and stress[164].

Figure 15: *The transportation steps*



Source: Saraiva, J. L., et al. (2021). p.15.

First of all, good fish welfare conditions cannot be guaranteed without clear and detailed planning of every aspect regarding the whole transportation procedure. In this respect, it is essential that operators act knowing the nature and expected duration of the journey, the type of fish that can be transported and their health and fitness status, removing the individuals which cannot withstand the journey. Additionally, the staff should take into account the number of fish that can be transported to avoid overloading, which can lead to social stress and

[162] Rojek, B. (July 2021). *Protection of animals during transport.* European Parliamentary Research Service (EPRS). p.5. https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/690708/EPRS_BRI(2021)690708_EN.pdf
[163] Saraiva, J. L., Arechavala-Lopez, P., Cabrera-Álvarez, M. J. & Waley, D. (2021). Research for ANIT Committee – *Particular welfare needs in animal transport: aquatic animals*. European Parliament. Policy Department for Structural and Cohesion Policies. Brussels. p.14. https://www.europarl.europa.eu/RegData/etudes/STUD/2021/690875/IPOL_STU(2021)690875_EN.pdf
[164] Ibid.

negative changes in water quality parameters, such as temperature and oxygen imbalances, resulting in increased mortality rates. Pre-transport starvation is another factor to consider. While this practice is aimed at clearing the fish's gut, reducing oxygen demand and waste production and maintaining better water quality during transit[165], in commercial practice, it often happens that animals are deprived of feed beyond what is technically necessary[166]. This practice can weaken fish immune system, energy reserves and overall body condition, significantly affecting fish welfare and clashing with the concept of the five freedoms[167], especially considering that, in aquaculture, fish are used to being regularly fed. In some cases, transported fish are introduced into enclosures with pre-existing populations: the resulting increase in group size can disrupt social dynamics and water quality, inducing stress both in the transported and resident fish. To mitigate such risks, it is vital to carefully prepare the transport system, ensuring a suitable environment is maintained. Proper testing of equipment prior to the transportation step is equally important, as failure of it can lead to severe outcomes such as hypoxia, CO2 accumulation, or oxidative damage due to hyperoxia, potentially causing mass mortalities.
Once the transportation procedure has been planned, the process moves to the actual loading of fish into the transport container, one of the most stressful phases for farmed fish. The process begins by crowding the fish into a smaller area using nets. As noted by EFSA, if not performed correctly, this practice can cause extreme stress for fish[168], which normally "show escape behaviour, splashing and gasping"[169]. The more fish are stressed, the more they are active, rapidly consuming large amounts of oxygen, another critical concern associated with crowding[170]. Consequently, it is essential that skilled staff manage the process with care and in a species-specific way, ensuring smooth coordination between fish owners and transporters to avoid delays or extended periods of crowding. Subsequently, fish are loaded into transport containers, typically using hand nets, brail nets, or pumps. Each of these methods has the potential to compromise welfare if not handled properly. For instance, pumping at high speeds or without sufficient water can cause fish to collide with walls, joints, or sharp edges, resulting in physical injuries[171], or even to be trapped within the pump. Similarly, manual handling and netting can damage the fish's scales, fins, or mucus layer, increasing their susceptibility to infections and parasites. Further challenges arise during the net lifting stage, where fish positioned at the bottom

---

[165] Lines, J. A., & Spence, J. (2012). *Safeguarding the welfare of farmed fish at harvest. Fish physiology and biochemistry*, *38*, p.155. https://doi.org/10.1007/s10695-011-9561-5
[166] Ibid.
[167] Ibid, p.156.
[168] The negative impact on fish physiology can persist also in the days following crowding.
[169] EFSA. (2009a). *Scientific Opinion of the Panel on Animal Health and Welfare on a request from the European Commission on welfare aspect of the main systems of stunning and killing of farmed seabass and seabream*. The EFSA Journal, 1010, p.13. https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2009.1010
[170] Lines, J. A., & Spence, J., 2012, p.156
[171] Ibid, p.157.

of the net may be injured from the weight of those above. Besides, the fish that are lifted from the water and exposed to air, suffer from hypoxia: in its scientific opinion concerning sea bass and sea bream, EFSA specifically mentions that fish should not be out of the water for more than 10 seconds, as prolonged exposure causes "aversive behaviour"[172].

Another critical consideration is maintaining optimal water quality during loading. While oxygen levels must be controlled to prevent hypoxia or hyperoxia, attention should also be given to the accumulation of metabolites like ammonia, which can potentially create toxic environments, further endangering the fish.

Depending on whether the fish are bound for sea-water, cage-culture or inland pond-farming, as well as the distance of the route, fish are finally transported by road, by sea or by air.

Transport by road is very common. The closed tanks mounted on the truck are usually fibreglass, with a sealable hatch and a discharge point, and are equipped with sensors, which monitor water parameters, such as temperature and oxygen levels. Additionally, water should be provided with additional oxygen and compressed air[173], considering that the fish are kept inside closed systems with no water exchange for the whole journey, which can last for a quite extended period of time. For instance, the European Commission reports that sea bream and sea bass juveniles are transported for up to 36 hours from Spain and France to Italy[174]. In Germany, common carps for slaughter can be transported more than eight hours, while in Poland common carps and rainbow trout for slaughter can face trips exceeding 12 hours[175].

Transport by sea uses well-boats with built-in tanks for fish. Contrary to the tanks placed on trucks for road transport, the ones on the boat may either be open or closed systems[176], depending on whether or not there are fish biosecurity issues, or regulatory and safety requirements along the journey. Although less common, another method of sea transport consists in towing the cages in which wild fish have been caught to transport them to a land-based processing plant where the fish are going to be slaughtered.

Finally, farmed fish can also be transported by air, although it is quite rare. In general, it is used in two cases: the short-term transfer of Atlantic salmon smolts from land-based facilities to on-growing sites at sea and the long-distance transport of fry or fingerlings.

For all these methods of live transport, efficiency and cost-effectiveness remain

---

[172] EFSA, 2009a, p.14

[173] Dalla Villa, P., Marahrens, M., Velarde Calvo, A., Di Nardo, A., Kleinschmidt, N., Fuentes Alvarez, C., Truar, A., Di Fede, E., Otero, J.L., Müller-Graf, C. (2009). *Project to develop Animal welfare. Risk Assessment Guidelines on Transport.* EFSA Supporting Publication, 6(9):EN-21, p.58. https://efsa.onlinelibrary.wiley.com/doi/abs/10.2903/sp.efsa.2009.EN-21

[174] European Commission. (2017). *Welfare of farmed fish: Common practices during transport and at slaughter.* Final Report. p.94. https://www.slu.se/globalassets/ew/org/centrb/scaw-nationellt-centrum-for-djurvalfard/kontaktpunkter/kontaktpunkt-slakt/efsa-fisk/welfare-of-farmed-fish.pdf

[175] Ibid, p.105

[176] Dalla Villa, P. et al., 2009, p.60.

priorities, which often result in high stocking densities[177].
The choice of transport system certainly plays a crucial role in maintaining water quality, one of the main concerns during this step. In light of this, while air freight and road transport exclusively rely on closed systems, well-boat transport allows for the use of open systems, which can provide better oxygenation and remove metabolites like CO2 and ammonia. Nevertheless, open systems can also pose some risks, such as exposure to polluted waters and parasite transfer from the wild to the transported fish.
The unloading phase has the same welfare implications of loading. The most commonly used method, which ensures that fish are not exposed to air, involves pumping the fish into their new tank. However, also this procedure is not free from implications from animal welfare. As explained by Elisa Bianco, one of Essere Animali's investigations clearly showed that "fish were thrown from transport trucks into the water, from more than a metre high, where the impact with the water was clearly harmful"[178].
Lastly, the post-transport phase involves careful monitoring of fish welfare to identify any physical damage, stress, or health issues resulting from transport. This stage also includes assessing losses and observing for signs of disease in the days following unloading. After the fish are delivered, the transport equipment is cleaned and disinfected to remove organic material and ensure biosecurity, while proper disposal or treatment of transport water is undertaken to prevent contamination or disease spread.

2.2.4.4 Slaughter with or without prior stunning

In Europe, the available information on slaughter practices for farmed fish in aquaculture is limited, primarily due to a lack of comprehensive data collected on the field[179]. As a starting point, it can be said that humane killing of fish requires that they are rendered immediately unconscious, ensuring they do not experience fear or pain[180]. In this respect, nowadays, some stunning methods exist, including electrical stunning, percussive stunning and carbon dioxide narcosis. The first one involves applying specific parameters, such as voltage or electrical current, to the different fish species to disrupt their normal neural

---

[177] Tang, S., Thorarensen, H., Brauner, C.J., Wood, C.M., Farrell A.P. (2009). *Modeling the accumulation of CO2 during high density, re-circulating transport of adult Atlantic salmon, Salmo salar, from observations aboard a sea-going commercial live-haul vessel.* Aquaculture 296, p. 102. https://www.sciencedirect.com/science/article/pii/S0044848609006553?via%3Dihub
[178] Interview conducted on October 15th, 2024.
[179] Clemente, G. A., Tolini, C., Boscarino, A., Lorenzi, V., Dal Lago, T. L., Benedetti, D., Bellucci, F., Manfrin, A., Trocino, A., & Rota Nodari, S. (2023). *Farmed fish welfare during slaughter in Italy: Survey on stunning and killing methods and indicators of unconsciousness*. Frontiers in Veterinary Science, 10:1253151, p.1. https://doi.org/10.3389/fvets.2023.1253151
[180] Erikson, U. (2011). *Assessment of different stunning methods and recovery of farmed Atlantic salmon (Salmo salar): isoeugenol, nitrogen and three levels of carbon dioxide.* Animal Welfare, 20(3), p.365. https://doi.org/10.1017/S096272860000292X

activity[181]. If not properly applied, this technique can cause paralysis, leaving the fish conscious while being killed. Currently, electrical stunning within the EU is commercially used for species like Atlantic salmon, rainbow trout and common carp[182] and can occur in or out of water. For dry stunning, correct fish orientation (head-first) is crucial for an immediate effect, and care must be taken to avoid pre-shocks. In light of this, the difference with wet stunning is that, during electrical stunning out of water, the exposure to air may be even more stressful than the electrical stunning itself. Another method consists in delivering a blow to the head to induce cerebral concussion, leading to a loss of consciousness. In the EU, this method is used for species like Atlantic salmon, rainbow trout and carp, either with specific equipment or manually. The effectiveness of manual percussive stunning largely depends on the skill of the operator to conduct the blow. Instead, with automated percussive stunning systems, it often happens that some fish are only partially stunned because targeting and hitting the exact stunning location on the head results to be difficult, especially considering the different sizes of the fish. As Elisa Bianco explained, "in some cases, the fish are not being stunned effectively: you see animals that, at the end of their life, keep moving out of the water for long minutes, so it is clear that they are suffocating. It is a death that is neither quick nor, above all, pleasant"[183]. This clearly underscores the importance of operators checking for signs of consciousness, such as the eye reflex, to confirm successful stunning. Lastly, carbon dioxide narcosis is a method that allows for the stunning of large groups of fish within a short period of time with relatively low labour and economic cost. In practice, fish are put into water infused with carbon dioxide, which creates an acidic mixture that induces a narcotic effect on the animals. However, this stunning method does not always lead to a total loss of consciousness, leading to instances where they may be mistakenly believed to be unconscious during slaughter. A study evaluating various stunning methods for Atlantic salmon found that none of the carbon dioxide concentrations tested met all the criteria for welfare and stress reduction, concluding that this practice cannot be recommended due to its inability to consistently induce a total and irreversible loss of consciousness[184].

In the EU, a significant portion of farmed fish, including species like rainbow trout, sea bream and sea bass, is not stunned before being slaughtered, resulting in unacceptable suffering. These fish are commonly removed from the water and killed by asphyxiation, either through air exposure or ice slurry immersion, methods that are cost-effective and low-effort for producers.

---

[181] Lines, J. A., & Spence, J. (2014). *Humane harvesting and slaughter of farmed fish.* Revue scientifique et technique (International Office of Epizootics), 33(1), p.259. https://doi.org/10.20506/rst.33.1.2284

[182] European Commission. (2018). *Report from the Commission to the European Parliament and the Council on the possibility of introducing certain requirements regarding the protection of fish at the time of killing*. p.4. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52018DC0087

[183] Interview conducted on October 15th, 2024.

[184] Erikson, U., 2011, p.374.

Besides, asphyxiation in ice slurry is also very practical because it not only kills the fish but also cools and preserves them simultaneously. Nevertheless, this process can lead to a slow death for the fish, with evidence showing that it takes around 14 minutes to kill rainbow trout[185], approximately 30 minutes for sea bream and sea bass[186], and up to 50 minutes for common carp[187]. Asphyxiation in air (see Figure 16 below) is similarly protracted: for instance, sea bass may take up to two hours to die[188], and some carp can take nearly five hours to cease gill movements when left in air[189].

Figure 16: *Fish left to suffocate*

Source: Eurogroup for Animals. (July 19, 2022). *New investigation exposes harsh reality of Spanish aquaculture sector*. https://www.eurogroupforanimals.org/news/new-investigation-exposes-harsh-reality-spanish-aquaculture-sector

Live chilling is another common practice where fish are transferred from water into solid ice or ice-cold water between 0–2°C. Although frequently categorised as a stunning method, EFSA clarifies that live chilling is actually an immobilisation technique as it does not cause unconsciousness[190]. The fish only experience a thermal shock: they become almost paralysed due to the rapid reduction of their body temperature and metabolic rate[191]. In some instances, ice slurries can even be fatal for Mediterranean fish species like sea bream and sea bass, which are accustomed to warmer water temperatures above 12°C[192].
For certain fish species, such as common carp, another method is employed: they are beheaded while being fully conscious. After cutting, the fish are often placed in ice water slurry, where they are left for more than two hours, to let them bleed completely.

[185] Ashley, P., 2007, p.210.
[186] EFSA, 2009a, p.18.
[187] Lines, J. A., & Spence, J, 2014, p.258.
[188] EFSA, 2009a, p.15.
[189] Lines, J. A., & Spence, J, 2014, p.258.
[190] EFSA. (2009b). *Scientific Opinion of the Panel on Animal Health and Welfare on a request from the European Commission on welfare aspect of the main systems of stunning and killing of farmed turbot*. The EFSA Journal, 1073, p.2. https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2009.1073
[191] Ibid.
[192] EFSA, 2009b, p.16.

2.2.5 Public perception of fish welfare

This final section sets the stage for the subsequent analysis of the international and EU legal frameworks on the protection of fish welfare by examining how societal attitudes are evolving and why they matter. Public awareness and stakeholder engagement are the engines behind legislative progress: therefore, the growing interest in the subject offers a unique opportunity for meaningful reform.

Data gathered from recent surveys and interviews with stakeholders reflect a mixed picture of public perception.

On one hand, many consumers seem to perceive fish consumption as more ethical than eating meat, as shown by a recent 1% increase in pescatarians[193] among EU consumers[194]. The reasons for this are various and uncertain, but some can be very simple. For instance, since fish live underwater, humans don't have a strong relationship with them: there is no interaction as strong as that with terrestrial animals. This is linked with the fact that their different living environment and biological needs pose challenges to our understanding of their experiences. In this respect, studies highlight that the further animals are from men on the evolutionary chain, the less likely humans are to try to protect them[195]. Furthermore, it's much more difficult to understand them because they cannot make facial expressions or noises, like most farmed terrestrial animals do.

On the other hand, as Elisa Bianco highlights, public understanding of fish sentience, including their capacity to feel pain and positive emotions, has now largely improved, compared to a few years ago[196]. Similarly, Javier Ojeda, manager of APROMAR, who has been actively involved in fish welfare for around 20 years, remarked that "undoubtedly, social concern has been growing for animal welfare, and fish welfare too, although less so than terrestrial animals"[197].

In 2018, a survey released by Compassion in World Farming and Eurogroup for Animals confirmed these affirmations showing that 91% of people polled across nine EU countries believe the welfare of fish should be protected to the same or greater extent as other farmed animals, while 71% agree that fish can feel pain. The same research also informs that people admit that they don't know the details of the subject, but have a holistic view of what fish welfare is, indicating

---

[193] The Cambridge Dictionary defines the term "pescatarian" as "someone who eats fish but not meat". https://dictionary.cambridge.org/dictionary/english/pescatarian

[194] Guadarrama, E., Spahic, A., Nosten, P., Alexandre, M., Faber, I., Schouteten, J., Rini, L., Bom Frøst, M., de Steur, H. (2023). *Evolving appetites: an in-depth look at European attitudes towards plant-based eating*. Smart protein project. ProVeg International, Innova Market Insights, University of Copenhagen, & Ghent University. Chapter 1, p.16. https://smartproteinproject.eu/wp-content/uploads/Smart-Protein-European-Consumer-Survey_2023_overview.pdf

[195] Miralles, A., Raymond, M. & Lecointre, G. (2019). *Empathy and compassion toward other species decrease with evolutionary divergence time.* Scientific Reports 9, 19555, p.3. https://doi.org/10.1038/s41598-019-56006-9

[196] Interview conducted on October 15th, 2024.

[197] Interview conducted on October 18th, 2024.

clean water (95%), fish health (94%), natural behaviours (93%), minimum suffering (89%), humane slaughter (89%), enjoying life (82%) as essential aspects for fish welfare[198]. Moreover, in the previous year, the survey by Zander and Feucht explained that more than 30% of European consumers rate fish welfare as one of the most important aspects of sustainable aquaculture[199]. More recently, an online survey, designed by Eurogroup for Animals and Compassion in World Farming, collected data from the answers of 12.301 respondents[200] from 12 different countries within (Italy, France, Germany, the Netherlands, Czech Republic, Greece, Poland, Spain, Sweden) and outside (United Kingdom, United States and China) the EU[201]. Also in this case, the results demonstrate that, in the EU, most people agree that fish feel pain (71%), although there is some doubt on the emotional/intelligence statements. Furthermore, 81% of the participants believe that fish welfare should be safeguarded to the same extent as for the other animals destined for human consumption.

The growing interest in fish welfare also extends to industry stakeholders, with companies and producer associations increasingly acknowledging and responding to the growing demand for better fish welfare standards. Being a biologist, Dimitris Papapanagiotou, emphasises the direct link between fish welfare and the quality of production, affirming that, at the end of the day, farming fish with care means having a very good production"[202]. Similarly, Javier Ojeda thinks that "producers have an advantage if they take good care of their animals because they will be able to boast about it, and it will not have negative repercussions on their reputation"[203]. Nevertheless, both of them agree that consumer engagement remains limited: while younger and more sensitive people show interest in fish welfare, most buyers prioritize cost over ethical considerations. As Ojeda puts it, at the moment, "people have an idea about animal welfare, but they are not going to pay for it when they buy the fish"[204]. On the contrary, the 2024 online survey reported that for 27% of EU consumers, fish welfare has a "great impact" on the fish they purchase, while 34% declares that it has "some impact".

In any case, a slow yet evident interest for fish welfare clearly exists and is demonstrated by some public initiatives, such as the 2022 petition sent to the European Commission demanding new standards to protect fish welfare signed

---

[198] Eurogroup for Animals & Compassion in World Farming. (2018). *European public perceptions of fish welfare: Factsheet*. Data from research conducted by ComRes, April 30 – May 8, 2018. https://www.eurogroupforanimals.org/library/european-public-perceptions-fish-welfare

[199] Zander, K., & Feucht, Y. (2017). *Consumers' Willingness to Pay for Sustainable Seafood Made in Europe*. Journal of International Food & Agribusiness Marketing, 30(3), p.259. https://doi.org/10.1080/08974438.2017.1413611

[200] The fieldwork lasted from March 20th to April 5th 2024.

[201] Catch Welfare Platform. (November 21, 2024). *CWP24: Douglas Waley - Public attitudes to aquatic animal welfare from around the world.* [Video]. YouTube. https://www.youtube.com/watch?v=WVLfmO7kbBM

[202] Interview conducted on October 17th, 2024.

[203] Interview conducted on October 18th, 2024.

[204] Interview conducted on October 18th, 2024.

by 150.001 individuals. The petition, launched by Compassion in World Farming and supported by Essere Animali and WeMove, highlighted the absence of enforceable rules "to ensure some minimal level of welfare" for the billion of fish that are farmed every year in the EU, as explained by Olga Kikou, Head of Compassion in World Farming EU. As Elisa Bianco claims, while "the indications of what should and what should not be done are clear", " they are not yet legally binding, as they are for terrestrial species", allowing a situation of stalemate to continue[205]. Haven King-Nobles, co-founder of Fish Welfare Initiative (FWI), advocates learning from past successes and failures from other animal welfare actions to advance fish welfare protections[206]. Using the example of the EU mandatory labelling of table eggs[207], Ojeda points out how market forces can drive change: "I don't know anyone who buys eggs from caged hens anymore. It's not that they are banned, but people have changed. And if the market changes, the producer must change too. The same will work for fish"[208].

[205] Interview conducted on October 15th, 2024.
[206] Torrella, K. (March 2, 2021). *The next frontier for animal welfare: Fish.* Vox. https://www.vox.com/future-perfect/22301931/fish-animal-welfare-plant-based
[207] In the EU, the mandatory method-of-production label was introduced in 2008 by Regulation (EC) No 589/2008 on marketing standards for eggs. The latter establishes that all table eggs must be marked with a code indicative of the method of production in place in the farms where the eggs originate from, and defines four categories of farming methods for eggs, each associated with a number: organic eggs" (0); "free range eggs" (1); "barn eggs" (2); "eggs from caged hens" (3).
[208] Interview conducted on October 18th, 2024.

CHAPTER 3 : THE BROADER PICTURE: FISH WELFARE FROM AN INTERNATIONAL LEGAL PERSPECTIVE

This chapter aims to explore the international legal framework for fish welfare, setting the stage for the analysis of the EU framework. Although the focus of this thesis is on the latter, looking at the broader picture can be useful to compare it with the EU one and see which framework is more comprehensive regarding the protection of fish welfare. To this end, the analysis focuses on key international instruments, such as the Aquatic Animal Health Code by the World Organisation for Animal Health (WOAH), the 2005 Recommendation, the 1978 European Convention for the Protection of Animals Kept for Farming Purposes and the 1968 Convention for the Protection of Animals During International Transport by the Council of Europe (CoE).

3.1 The World Organisation for Animal Health (WOAH)

The WOAH[209] is an intergovernmental organisation with a century-long history. Although its name suggests a primary focus on animal health, its mission extends to promoting a global commitment to enhancing animal welfare, recognising this as a fundamental aspect of animal health itself.
For this reason, in 2002, WOAH's International Committee formally incorporated animal welfare into the organisation's mandate through a dedicated resolution[210]. Two years later, the first Animal Welfare Global Conference took place in Paris, bringing together national delegates, international organisations, private sector stakeholders and civil society. This collaboration led to the adoption of the first standards on animal transport and slaughter, which were subsequently integrated into the WOAH's Terrestrial Animal Health Code in 2004 and the Aquatic Animal Health Code in 2008. Since the WOAH is not an enforcement body, the standards included in its codes are only voluntary recommendations: however, by accepting and adopting them, WOAH member countries, including all EU member states, commit to align their national practices with the principles and guidelines established within the organisation's framework.

[209] At its birth, the organisation was called Office International des Epizooties (OIE). In 2003, it changed name and became the World Organisation for Animal Health (WOAH).
[210] WOAH. (29 May 2002). Resolution No. XIV. https://www.woah.org/en/who-we-are/structure/framework/basic-texts/new-mandates/

3.1.1 The Aquatic Animal Health Code

The Aquatic Animal Health Code provides internationally recognised "standards for the improvement of aquatic animal health and farmed fish welfare worldwide"[211]. For the purpose of this thesis, the analysis focuses on Chapter 7 of the Code, which specifically addresses the welfare of farmed fish during the steps of transport, stunning and killing.
It is worth noting that the Code does not include a dedicated section on the rearing phase: Article 7.1.2 (1) only mentions that the welfare of farmed fish depends on "handling methods appropriate to the biological characteristics of the fish and a suitable environment to fulfil their needs", without providing further specific guidance.
Chapter 7.2, however, offers an exceptionally comprehensive framework for fish welfare during national and international transport by air, sea and land, addressing all the transportation steps (see section 2.2.4.3 above), and specifying that "all personnel handling fish throughout the transportation process are responsible for ensuring that consideration is given to the potential impact on the welfare of the fish"[212].
First of all, the Code emphasises the importance of proper planning before transport, making reference to relevant practices affecting fish welfare, such as fasting prior to transport (Article 7.2.4.(4)). Article 7.2.4 specifically outlines the need to consider aspects like species-specific needs, water quality, journey duration and transport systems, ensuring that all the elements are tailored to the welfare of the fish during transit. Planning also requires that fish are in good health, as highlighted in Article 7.2.4 (4), which mandates an assessment of fish fitness prior to transport, prohibiting the transport of sick or unfit individuals to minimize risks during the journey. The completeness of this section is demonstrated by the mentioning of detailed contingency plans to address potential welfare challenges, outlining roles, responsibilities and the procedures to be followed in case of emergencies, and keeping track of what has been done for each situation. Article 7.2.5 provides additional information on the documentation required, which has to ensure transparency and facilitate oversight by relevant authorities. Secondly, the loading step is carefully described in Article 7.2.6. This provision considers practices, such as crowding, the safety of the equipment used, water quality and the optimal stocking density, which can all affect fish welfare. Thirdly, Article 7.2.7 refers to the actual transport of fish, highlighting the need of periodic inspections to ensure that the

[211] WOAH. (2024). *Aquatic Animal Health Code* (26th Ed.). p.v. https://www.woah.org/en/what-we-do/standards/codes-and-manuals/aquatic-code-online-access/

[212] In particular, the Code does not only mention the various responsibilities of the different actors involved in the transport of live fish, but also highlights the importance of relying on personnel that is competent. On this point, Article 7.2.3 clarifies that the parties involved should possess a set of fish welfare competences, which may be gained through "formal training and/or practical experience".

fish are travelling in an acceptable welfare condition. The provision even requires the reduction of abrupt movements of the means of transport (Article 7.2.7.1(c)), which may cause stress and injury to the fish, and explains how the driver should act in cases of injured or sick fish, which should be humanely killed if necessary. With respect to unloading, Article 7.2.8 refers to the "principles of good fish handling during loading", which should be applied equally to the unloading procedure. Finally, the Chapter extends to post-transport observations: according to Article 7.2.9, if fish are found with abnormal clinical signs, they should be isolated and checked by a veterinarian or qualified personnel, or "humanely killed" in accordance with Article 7.3.5.2(b). Furthermore, the evaluation of significant problems related to the transport is required in order to prevent reoccurrence.
Chapter 7.3 on the welfare aspects of stunning and killing of farmed fish for human consumption is also very complete, including all the aspects covered in section 2.2.4.4 above. For instance, Article 7.3.2 concerns the required knowledge and experience of the personnel, while Article 7.3.4 regards the design of holding facilities. In Article 7.3.1, there is one of the most relevant paragraphs of the Code, stating that:

> "As a general principle, farmed fish should be stunned before killing, and 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" [213].

In light of this, the Code emphasises the need to verify the effectiveness of the stunning by checking whether the fish have lost consciousness, with Article 7.3.6.1 (f) specifically listing the signs to recognise correct stunning. What is particularly interesting is that Article 7.3.6.1 refers to a "backup stunning system", which mandates that "any fish mis-stunned, or regaining consciousness before death, should be re-stunned as soon as possible". The Chapter also explains the main stunning and killing methods[214], stressing that practices such as "chilling with ice and CO2 in holding water; salt or ammonia baths; asphyxiation by removal from water; exsanguination without stunning" should not be used if it is possible to use other methods[215], namely electrical or mechanical stunning/killing.
Finally, the Code dedicates an entire chapter to the killing of farmed fish in cases of disease control. In particular, Articles 7.4.5 and 7.4.6 outline the approved methods for this purpose, which include using an overdose of an anaesthetic agent and decapitation or maceration, depending on the circumstances.

---

[213] WOAH. Art. 7.3.1, Chapter 7.3: Welfare aspects of stunning and killing of farmed fish for human consumption. Aquatic Animal Health Code.
[214] Article 7.3.7 illustrates mechanical and electrical stunning/killing methods using a table, making reference to advantages, disadvantages and key welfare concerns/requirements for each practice.
[215] Article 7.3.6.4 of the Aquatic Animal Health Code

In conclusion, while Chapter 7 of the Aquatic Animal Health Code does not include any section on the welfare of farmed fish during the rearing step, it still represents a robust framework for their welfare. Its provisions clearly reflect the Code's commitment to ensuring that welfare considerations are integrated at critical stages of the farmed fish life cycle, such as the transport, the stunning and the slaughter. By providing clear and practical guidance, Chapter 7 of the Code significantly contributes to advancing the legal protection of fish welfare on an international level.

3.2 The Council of Europe (CoE)

The CoE, founded in 1949 and based in Strasbourg, is an international organisation with 46 Member States, which aims to promote democracy, human rights and the rule of law across Europe. In addition to this, the CoE has also made significant strides in addressing animal protection through the development of various conventions that serve as foundational legal instruments. These are the European Convention for the Protection of Animals kept for Farming Purposes, the European Convention for the Protection of Vertebrate Animals used for Experimental and other Scientific Purposes, the European Convention for the Protection of Pet Animals, the European Convention for the Protection of Animals for Slaughter and the European Convention for the protection of animals during international transport. These represent "the first international legal instruments laying down ethical principles for the transport, the farming, the slaughtering of animals as well as for their use for experimental purposes and as pets"[216], and have historically influenced all the relevant legislation in Europe. Since 1988, the CoE has focused on monitoring the implementation of these conventions, aiming to improve and harmonise the conditions for animal welfare mainly in agriculture and scientific research, while adapting legal frameworks to reflect new scientific knowledge and technological advances. The CoE's approach has involved close collaboration with various stakeholders, including veterinarians, animal protection groups, animal behaviour experts, farmers and scientists, as well as with the European Union to ensure the effectiveness and relevance of its legal instruments.
The following sections examine the CoE Recommendation concerning farmed fish and the relevant European Conventions to assess the extent of their protection of fish welfare. The European Convention for the Protection of Animals for Slaughter (1979) is not analysed since it only applies to "domestic solipeds, ruminants, pigs, rabbits and poultry", as its Article 1.1 proclaims.

[216] Council of Europe. (n.d.). *Protection of Animals*. https://www.coe.int/en/web/cdcj/protection-of-animals

3.2.1 The European Convention for the protection of animals kept for farming purposes

The European Convention for the protection of animals kept for farming purposes was adopted by the CoE in 1976. While it does not specifically list the animal species covered, Article 1 broadly refers to "animals bred or kept for the production of food (…)", which inherently includes fish.
The Convention incorporates general principles of animal welfare, such as the provision of food (Article 3), the freedom of movement (Article 4), appropriate environmental conditions (Article 5) and the periodicity of inspections of the farm and the technical equipment used (Article 7).
According to Article 2, the Convention shall be implemented by each contracting party, including all EU Member States, following the detailed provisions of Chapter II.

3.2.2 The Recommendation concerning farmed fish

The Recommendation, adopted in 2005 by the CoE Standing Committee under the European Convention for the Protection of Animals Kept for Farming Purposes[217], outlines several provisions aimed at ensuring the welfare of farmed fish.
As a general and guiding principle, Article 2 declares that:

> "All fish species kept for farming purposes, including new species and those already farmed [...] shall be farmed without detrimental effects on their welfare, including health, taking into account their biological characteristics, the scientific evidence and the practical experience available, and the farming system used".

The following provisions comprehensively address key aspects, such as ownership and staff responsibilities, the design of farming facilities and equipment and the management of farmed fish, echoing similar principles found in Chapter 7 of the Aquatic Animal Health Code by the WOAH. Interestingly, Article 5 states that "[E]nclosures containing fish shall be inspected at least once a day, preferably more frequently, [...] with minimal disturbance to the fish". Furthermore, relevant practices potentially affecting fish welfare are mentioned. For example, Article 9.1 refers to grading, which "shall be done with a minimum of handling and shall cause a minimum of stress", while Article 13 concerns stripping, determining that "anaesthesia or sedation should be used as

[217] CoE recommendations require unanimous approval by the Standing Committee of the Farming Convention. In other words, all CoE parties involved, including the EU Member States, must consent to its provisions. Since all EU Member States have ratified the Convention, each of them has agreed on the implementation of this COE Recommendation concerning farmed fish.

necessary for the species concerned". Article 14.4, instead, focuses on crowding, which should last as little as possible and should trigger "immediate action", if undue stress is observed. The Recommendation also deals with the use of medicines, declaring in Article 9.5 that the regular use of them should be forbidden if they are used "to compensate for poor hygienic conditions, poor management practices, or to mask signs of poor welfare such as pain and distress". Finally, Article 16 refers to the responsibility of the operator to maintain detailed records to support responsible management.
Besides, the Recommendation also touches upon sensitive issues like the modification of genotypes (Article 17) and the mutilation of fish (Article 18). However, only Article 19 and 11 touch upon aspects related to the killing of fish: the first one refers to emergency killing, while the second emphasises limiting fasting prior to "certain management procedures", including slaughter and transport.
For what concerns the transport step, Article 15 establishes that fish are to be examined prior to the actual journey, removing those that are "unfit or unhealthy", which can be transported only for "therapeutic reasons". In this context, Article 19 states that if treatment of ill or injured fish "is no longer feasible and transport would cause additional suffering, they must be killed on the spot and without delay by a person properly trained and experienced (...)". Article 15 also requires periodic checks, with special attention on the environmental conditions, which must ensure species-specific oxygen levels, low carbon dioxide levels and stable water temperature and pH during transport.
In conclusion, it is worth specifying that the recommendation is not binding, but establishes a policy framework that can be implemented by governments on the national level.

3.2.3 The European Convention for the protection of animals during international transport

The European Convention for the protection of animals during international transport was signed on 13 December 1968 in Paris and was subsequently revised on 6 November 2003 in Chișinău by the CoE.
According to Article 2, the Convention applies to "all vertebrate animals", including fish. Nevertheless, the provisions primarily focus on terrestrial farmed animals and some are not even applicable to fish (e.g. Article 16 on floors and bedding). In any case, as clarified in Article 1.1, the Convention does not apply to "movements between Member States of the European Community".

CHAPTER 4: FISH WELFARE IN THE EU LEGAL FRAMEWORK

Despite its significant impact on animal suffering, the modern food system has witnessed notable advancements in the protection of animal welfare over the past decades. Since 1974, when the first European animal welfare legislation was adopted[218], "animal welfare requirements have evolved on the basis of established scientific knowledge, improving the quality of life of animals in accordance with citizens' expectations and market demands"[219].
Nowadays, the EU boasts one of the world's most comprehensive frameworks for animal welfare, which has also gained a place at the heart of sustainability, demonstrated by legal initiatives, such as the Farm to Fork (F2F) Strategy, which explicitly addressed the need to revise and improve animal welfare legislation[220].
Nevertheless, progress in this field has not extended equally to fish. Despite being bred and killed in large numbers, in the EU, but also in the rest of the world, they have long remained outside of the moral circle granted to terrestrial farmed animals. This exclusion raises questions about the adequacy of the current EU framework to address the unique welfare challenges faced by farmed fish, which constitutes the main focus of this chapter. The latter is divided in two sections: the first one examines EU binding legislation, while the second one explores some soft law initiatives, including recommendations, codes of conduct and guidelines. Furthermore, the chapter considers the role of selected EU Member States in supplementing and enforcing these protections, providing a comprehensive analysis of the current legal landscape.

4.1 EU binding legislation related to fish welfare

The starting point of this section is to be found in EU primary law, and in particular, under Article 13 of the TFEU, in which animals, including fish, are recognised for the first time as "sentient beings", and their welfare becomes a shared value in the European Community and, thus, one of the objectives to be pursued through Union policies.
The EU secondary law includes the animal welfare legislation, namely Council

[218] The law in question was the Council Directive 74/577/EEC of 18 November 1974 on stunning of animals before slaughter, which, however, did not include fish in its scope.
[219] European Union. (n.d.). *Animal welfare*. https://eur-lex.europa.eu/EN/legal-content/glossary/animal-welfare.html
[220] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and The Committee of the Regions. A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system. COM/2020/381 final. (May 20, 2020). p.5. https://food.ec.europa.eu/document/download/472acca8-7f7b-4171-98b0-ed76720d68d3_en?filename=f2f_action-plan_2020_strategy-info_en.pdf

Directive 98/58/EC concerning the protection of animals kept for farming purposes, Council Regulation (EC) 1/2005 on the protection of animals during transport and related operations and Council Regulation (EC) 1099/2009 on the protection of animals at the time of killing. All of these are analysed below, focusing on the points related to fish welfare. Regulation (EU) No 1380/2013 of 11 December 2013 on the Common Fisheries Policy (CFP) and Regulation EU 2016/429 (Animal Health Law) are also taken into account[221].

4.1.1 Council Directive 98/58/EC concerning the protection of animals kept for farming purposes

Council Directive 98/58/EC, adopted on 20 July 1998, establishes the welfare conditions for farmed animals in the EU, setting forth the minimum standards under which they may be bred or kept, as stated in Article 1.1.
Its provisions also extend to fish "bred or kept for the production of food (...)" since they fall within the definition of "animal" under Article 2.1.
Nevertheless, when it comes to farmed fish, the Directive imposes only the general obligation set out in Article 3, which requires "Member States [...] to ensure that owners or keepers take all reasonable steps to ensure the welfare of animals under their care and to ensure that those animals are not caused any unnecessary pain, suffering, or injury". Farmed fish are explicitly excluded from Article 4, and thus from the Annex, which provides additional requirements on the farming conditions of animals.
For what concerns the compliance with Council Directive 98/58/EC, Article 6.2 refers to "an annual report", which shall be submitted by Member States to the European Commission by 31 August each year. This document includes the details of national inspections carried out by competent authorities during the previous year to verify adherence to the Directive's provisions. Article 6.2 also mandates that Member States provide "an analysis of the most serious findings of non–compliance and a national action plan to prevent or decrease their occurrence for the forthcoming years".
Finally, Article 10.1 required Member States to transpose the Directive into their national legal frameworks by 31 December 1999: after this date, according to Article 10.2, they can establish "stricter provisions" than those specified in the Directive, provided they notify the Commission of any such measures.

[221] The thesis only covers the main laws connected to the topic of fish welfare. For this reason, the list is not exhaustive: among others, Regulation (EC) 178/2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety, Regulation (EU) 2019/4 for placing medicated feed on the market and use of medicated feed and Regulation (EU) 6/2019 on veterinary medical products are not mentioned.

4.1.2 Council Regulation (EC) 1/2005 on the protection of animals during transport and related operations

On 22 December 2004[222], Regulation (EC) 1/2005 was adopted to regulate the transport of vertebrate animals[223] for economic purposes, as affirmed in Article 1.5. However, while the Regulation contains detailed provisions for various species, only its general rules apply to fish, as specific transport requirements for them are lacking. At the core of this legal text, Article 3 states that "no person shall transport animals or cause animals to be transported in a way likely to cause injury or undue suffering to them". In particular, it requires that transport procedures are planned in advance, ensuring that "the animals are fit for the journey"[224]. Furthermore, among others, the provision refers to the means of transport and the loading and unloading facilities, which must "avoid injury and suffering and ensure the safety of the animals"[225][226], and the role of the actors involved, who should not use "violence or any method likely to cause unnecessary fear, injury or suffering"[227], should regularly check fish welfare and should guarantee no delay to the place of destination[228].
Article 4.1 mandates that transporters carry the relevant documentation, including details on the animals' origin, ownership, place of departure, destination and the expected journey duration. Article 6 lays down other rules for transporters, distinguishing between journeys under and over 65 Km, for which official authorization is required under Article 11(1). Moreover, although a certificate of competence is not mandatory for personnel handling fish[229], training on relevant provisions from Annexes I and II is required for journeys exceeding 65 km[230]. Besides, Article 5.3 focuses on the organiser's duty to effectively coordinate transport stages to guarantee animal welfare, taking into account weather conditions and appointing a person responsible for providing journey details to the authorities when required. Interestingly, unlike other farmed animals, no journey log is required for the long-distance transport of farmed fish[231]. Therefore, not only the organiser is not obliged to submit a proper planning of long distance transports of fish to the competent authorities[232], but also, the latter doesn't have to verify if the planning of such long transports is realistic and in compliance with Regulation (EC) 1/2005[233]. This

[222] The Regulation entered into force three years later, on 1 January 2007.
[223] As mentioned in section 1.3.3 of Chapter 1 of this thesis, fish belong to the group of vertebrates. Consequently, this Regulation also applies to the transport of live fish.
[224] Article 3 (b) of Council Regulation (EC) 1/2005
[225] Article 3 (c) of Council Regulation (EC) 1/2005
[226] Article 3 (d) of Council Regulation (EC) 1/2005
[227] Article 3 (e) of Council Regulation (EC) 1/2005
[228] Article 3 (f) of Council Regulation (EC) 1/2005
[229] Article 6.5 of Council Regulation (EC) 1/2005
[230] Article 6.7 of Council Regulation (EC) No 1/2005
[231] Annex II concerns the journey log, but does not apply to the transport of fish according to Article 5.4 and Article 8.2.
[232] Article 5.4 of Council Regulation (EC) No 1/2005
[233] Article 21.2 (b)(i) of Regulation (EU) 2017/625, amending Regulation EC 1/2005.

is required only when "domestic equidae other than registered equidae and domestic animals of the bovine, ovine, caprine and porcine species" are transported.
In case of infringement of the provisions of Regulation 1/2005, Article 25 requires Member States to establish "effective, proportionate and dissuasive" penalties and take all the necessary measures to implement them, while in terms of compliance, Article 27 lays down the same requirements and conditions of Article 6 of Council Directive 98/58/EC, referring to the "annual report", the "analysis of the major deficiencies detected and an action plan to address them", which Member States have to submit to the European Commission by 31 August each year.
For what concerns technical rules, these are to be found in Annex I, cited in provisions like Article 6.3, which affirms that "transporters shall transport animals in accordance with the technical rules set out in Annex I", and Article 8.1, which claims that the "keepers of animals at the place of departure, transfer or destination shall ensure that the technical rules set out in Chapters I and III, section 1, of Annex I in respect of the animals being transported are met".
The chapters included in Annex I contain some provisions that can be seen as relevant for fish transport. For instance, point 1 of Chapter I affirms that only the animals that are "fit for the intended journey" can be transported, "in conditions guaranteed not to cause them injury or unnecessary suffering". Chapter II concerns the requirements for the means of transport, which, among others, shall "be cleaned and disinfected"[234]. Annex I also addresses transport practices in its Chapter III, where some requirements should also apply to fish. The latter should "become acclimated to the mode of transport prior to the proposed journey"[235], and when the loading and unloading steps last over four hours, an authorised veterinarian should be there to supervise them, and "particular precautions shall be taken to ensure that the welfare of the animals is properly maintained during these operations"[236]. Additionally, the facilities of loading, unloading and handling must be built and used in such a way to "prevent injury and suffering and minimise excitement and distress during animal movements as well as to ensure the safety of the animals"[237].
Chapter III also prohibits handling animals, including fish, in such a way to inflict unnecessary pain or suffering on them, especially by putting pressure onto highly sensitive body parts[238]. Furthermore, following points (a) and (b) of point 1.12, fish of different species and significantly different sizes or ages, or species, should not be transported together to avoid harm, unless "the animals have been raised in compatible groups" and "are accustomed to each other"[239].
There are no further requirements that could be valid for the transport of live fish. Only point 2.3 of Chapter V adds that species like fish "shall be transported

[234] Annex I, Chapter II, 1.1 (c)
[235] Annex I, Chapter III, 1.1
[236] Annex I, Chapter III, 1.2 (b)
[237] Annex I, Chapter III, 1.3 (a)
[238] Annex I, Chapter III, 1.8 (b)
[239] Annex I, Chapter III, 1.13

in accordance with the written instructions about feeding [...][240] and taking into account any special care required".

4.1.3 Council Regulation (EC) 1099/2009 on the protection of animals at the time of killing

Council Regulation (EC) 1099/2009 on the protection of animals at the time of killing was adopted on 24 September 2009. While it applies to all "animals bred or kept for the production of food (...)", farmed fish are essentially excluded from its scope. This may be due to the challenge of developing a regulation that adequately addresses both fish and terrestrial animals: their significant physiological differences and the distinct methods required for their slaughter make a unified approach difficult to conceive. Furthermore, the research and technological developments regarding fish slaughter fall behind compared to the other farmed animals[241]. In practice, only Article 1.1 refers to fish, declaring that only the requirements laid down in Article 3(1) have to be followed. In particular, they "shall be spared any avoidable pain, distress or suffering during their killing and related operations".

4.1.4 Regulation (EU) No 1380/2013 on the Common Fisheries Policy (CFP)

On 11 December 2013, the EU enacted the Regulation (EU) No 1380/2013, which introduced a new CFP[242], aimed at ensuring the long-term environmental, economic and social sustainability of fishing and aquaculture activities. Nevertheless, when analysing its provisions, it becomes clear that fish welfare is not considered as a primary concern: the term "welfare" is entirely absent from the legal text. This omission aligns with a statement from 2012 by Ms. Damanaki, representing the European Commission, who clarified that animal welfare was not a goal of the CFP, as farmed fish were already included in the scope of existing animal welfare legislation[243].

4.1.5 Regulation (EU) 2016/429 (Animal Health Law)

Regulation (EU) 2016/429 of the European Parliament and of the Council on transmissible animal diseases and amending and repealing certain acts in the

---

[240] No explanation is given regarding who should issue these written instructions.
[241] Paragraph 11 of the preamble of Regulation (EC) 1099/2009
[242] Since its birth in 1983, the CFP has been reformed three times, in 1992, 2002 and 2013.
[243] She affirmed this in response to a Written Parliamentary Question (E-012243/2011). Accessed at: https://www.europarl.europa.eu/doceo/document/E-7-2011-012243-ASW_EN.html?redirect

area of animal health was adopted on 9 March 2016. It is also known as the "Animal Health Law", since its rules mainly focus on "the prevention and control of animal diseases which are transmissible to animals or to humans", according to Article 1.1. However, as EFSA explains, "the concept of animal health covers animal diseases, as well as the interplay between animal welfare, human health, environmental protection, and food safety"[244]. Therefore, even if it is not specifically concerned with the subject of animal welfare, this Regulation is still relevant considering the strict relationship between animal health and animal welfare, cited in Article 1.2 (b)(i).

4.2 Soft law initiatives related to fish welfare

While the laws mentioned before are called hard for their strongly binding nature, the soft ones, which are analysed below, are quasi-legal instruments for their consultative or voluntary use. Since the welfare of farmed fish has become an issue of increasing interest to the public, producers, the scientific community and public authorities, various recommendations, guidelines and codes of conduct have been elaborated. The main driver for these publications was to fill the gap between the outcomes from the recent research initiatives and the operational measures in place in aquaculture practices. In the following section, the study is focused on some examples of soft law initiatives by public and private actors that contribute to the field of fish welfare.

4.2.1 The role of EFSA: the recommendations included in its scientific opinions

Following a series of food crises in the late 1990s[245], in 2002, Regulation 178/2002, also known as the General Food Law (GFL), established the European Food Safety Authority (EFSA). This law created a European food safety system that divided responsibilities in the field of risk analysis, as explained in Article 6 of the GFL. In particular, EFSA operates as an independent entity providing scientific advice on various subjects, including animal welfare, but lacks legal authority and the capacity to generate new scientific research. Instead, its role involves collecting and analysing existing scientific data to ensure that its risk assessments are based on the most comprehensive and reliable information

[244] EFSA. (Last reviewed date: 10 December 2024). *Animal health*. https://www.efsa.europa.eu/en/topics/topic/animal-health#:~:text=The%20concept%20of%20animal%20health,environmental%20protection%2C%20and%20food%20safety

[245] Among these crises, Bovine Spongiform Encephalopathy (BSE), also known as "mad cow disease", gained global attention due to its devastating impact on the cattle industry and its link to human health. This was first diagnosed in the United Kingdom in 1986, and is a fatal neurodegenerative disease linked to the progressive accumulation of a pathological isoform of the Prion Protein in the Central Nervous System (CNS), causing lesions that give the tissue a 'spongy' appearance.

available. Another key aspect of EFSA's mandate is risk communication: EFSA delivers clear, accurate and timely information to various audiences, including policymakers and the general public, to bridge the gap between complex scientific findings and consumer understanding.

According to Article 22.5 (b) of the GFL, among the various tasks related to its mission, EFSA is in charge of delivering "scientific opinions on [...] matters relating to animal health and welfare (...)", which "will serve as the scientific basis for the drafting and adoption of Community measures in the fields falling within its mission"[246]. In light of this, EFSA has issued several scientific opinions, which incorporate conclusions and recommendations on fish welfare. These are outlined below in chronological order.

In 2004, the European Commission asked for an opinion of the Scientific Panel on Animal Health and Welfare (AHAW)[247] related to the welfare of animals during transport[248]. Hereby, EFSA explained that loading and unloading should be conducted without exposing fish to air[249], that fish can be deprived of feed for a period of time that "should be adapted to the fish species, the size of the fish and the temperature"[250], and that water quality and the condition of the fish should not only be checked regularly during transport, but also logged in writing[251].

In 2008, at the request of the European Commission, EFSA published five scientific opinions covering six fish species[252], where general recommendations are given for a better protection of farmed fish. In particular, EFSA stated that "measures to improve welfare should be adapted to different production systems and should take into consideration the specific requirements of each life stage"[253], and that "(…) efforts should be made to maintain the fish in water of sufficient oxygen content, either by removing the fish as quickly as possible or by introducing fresh, oxygen-rich water into the catchpit"[254].

In 2009, EFSA addressed the general approach to fish welfare and the concept of sentience in fish. Its scientific opinion highlighted disparities in the study of fish

---

[246] Article 22.6 of GFL

[247] Animal health and welfare are particularly addressed by the Panel on Animal Health and Welfare (AHAW), which provides independent scientific advice to risk managers on these issues, with a focus on food-producing animals, including fish.

[248] EFSA. (2004a). *Opinion of the Scientific Panel on Animal Health and Welfare (AHAW) on a request from the Commission related to the welfare of animals during transport*. The EFSA Journal, 2(5):44, 1-36. https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2004.44

[249] Ibid, p.32

[250] Ibid

[251] Ibid

[252] These are Atlantic salmon, trout, carp, European seabass, European gilthead seabream and European eel.

[253] EFSA, 2008a, p.31.

[254] EFSA, 2008c, p.27.

welfare compared to mammals and birds[255], despite evidence that some fish species possess brain structures capable of experiencing pain and fear[256]. In this respect, EFSA recognised that there is lack of "clearly defined protocols for fish welfare evaluation"[257] and recommended establishing species-specific welfare indicators that are "validated, reliable, and feasible and auditable"[258].
Besides, during the same year, the AHAW Panel expanded its earlier work[259] by issuing seven species-specific scientific opinions[260] on the welfare aspects of stunning and killing methods for farmed fish. Among the recommendations provided, EFSA declared that the killing of fish should be done by operators who are "trained and hence skilled in handling and welfare"[261], highlighted the importance of having in place backup systems to address stunning failures[262], and the prohibition of "exsanguination without prior stunning", considered as inhumane[263]. Lastly, it also mentioned the practice of crowding, which "should be synchronised with the subsequent slaughter processes so that the fish are not crowded for longer than is necessary"[264].

Despite the significant contributions EFSA has made through its earlier scientific opinions, the absence of further publications on fish welfare over the past 15 years underscores a concerning gap in ongoing research and policy development in the EU.

---

[255] EFSA. (2009). *Scientific Opinion of the Panel on Animal Health and Welfare on a request from European Commission on General approach to fish welfare and to the concept of sentience in fish*. The EFSA Journal, 954, p.7. https://doi.org/10.2903/j.efsa.2009.954
[256] Ibid, p. 12.
[257] Ibid, p.8.
[258] Ibid, p.9.
[259] EFSA. (2004b). *Opinion of the Scientific Panel on Animal Health and Welfare on a request from the Commission related to welfare aspects of the main systems of stunning and killing the main commercial species of animals*. The EFSA Journal, 45, 1–29. https://doi.org/10.2903/j.efsa.2004.45
[260] These species covered are rainbow trout, carp, Atlantic salmon, seabass and seabream, tuna, turbot and eel.
[261] EFSA. (2009c). *Scientific Opinion of the Panel on Animal Health and Welfare on a request from the European Commission on Species-specific welfare aspects of the main systems of stunning and killing of farmed rainbow trout*. The EFSA Journal, 1013, p.31. https://doi.org/10.2903/j.efsa.2009.1012
[262] EFSA. (2009d). *Scientific Opinion of the Panel on Animal Health and Welfare on a request from the European Commission on welfare aspect of the main systems of stunning and killing of farmed Atlantic salmon*. The EFSA Journal, 1012, p.38. https://doi.org/10.2903/j.efsa.2009.1011
[263] Ibid
[264] EFSA, 2009a, p.32.

4.2.2 Guidelines on Water Quality and Handling for the Welfare of Farmed Vertebrate Fish

The European Commission established the Expert Group known as the "Platform on Animal Welfare" on 24 January 2017[265].
Among its main tasks, the platform should serve as a forum for fostering dialogue among diverse stakeholders, including government authorities, businesses, civil society, academia, scientific experts and international organisations, on topics relevant to animal welfare in the Union, as stated in Article 2 (d) of Commission Decision 2017/C 31/12.
Interestingly, in 2020, the EU Platform on Animal Welfare Own Initiative Group on Fish voluntarily produced the Guidelines on Water Quality and Handling[266] for the Welfare of Farmed Vertebrate Fish[267], addressed to "aquaculture operators and the relevant competent authorities"[268]. It is important to note that the positions and recommendations outlined in these guidelines do not constitute the official legal stance of the European Commission but serve as non-binding, practical advice for promoting welfare in aquaculture practices.
Both the section on water quality and the one concerning handling include an introductory part with the related provisions from the 2005 Recommendation concerning farmed fish by the CoE (see section 3.2.2 above), which are used as a point of reference to establish the so-called "guides to animal welfare practice". Besides, both sections refer to the application of the recommendations of the Aquatic Animal Health Code by the WOAH.
The guidelines section on water quality defines the latter as "the physical and chemical environment that the fish are exposed to and comprises a complex set of interacting factors", which are to be managed by aquaculture operators, who should regularly check both the behaviour and condition of the fish and the specific water quality parameters[269]. Point 10 of the section regarding water quality mentions oxygen, ammonia, carbon dioxide, pH and temperature as the most relevant parameters that should be monitored. The guidelines provide specific information for each of them, considering their connection with fish welfare. Whenever possible, the operators should check these water quality

---

[265] Commission Decision of 24 January 2017 establishing the Commission Expert Group 'Platform on Animal Welfare'.
https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32017D0131(01)
[266] Other critical aspects such as transport, slaughter, feeding regimes, housing, and breeding practices are not covered by the guidelines, which assume that good welfare practices for these areas are already established.
[267] The guidelines do not refer to specific fish species, but can rather be applied to fish species in general.
[268] EU Platform on Animal Welfare Own Initiative Group on Fish. (2020). *Guidelines on Water Quality and Handling for the Welfare of Farmed Vertebrate Fish*. p.5.
https://food.ec.europa.eu/system/files/2022-07/aw_platform_plat-conc_guide_farmed-fish_en.pdf
[269] Ibid, point 2, p.7

parameters "in an automated manner"[270], using sophisticated technology, including "alarm systems and backup generators"[271], which should be "maintained and calibrated at appropriate intervals"[272]. Point 28 stresses the importance of the different water quality requirements associated with the various aquaculture systems, such as the RAS, which should be given "special attention"[273].

For what concerns handling, this normally causes stress and "can lead to injury, pain, distress, and suffering", if conducted in an inappropriate way[274]. For this reason, handling procedures should be minimised as much as possible and be successfully adapted to the different fish species. Moreover, prior to handling, fish fitness should be checked to evaluate if they would bear the handling procedures "without risking adverse welfare and health implications"[275].

The guidelines also highlight the relevance of implementing measures for fish recovery in case they show "signs of oxygen deficiency or signs of avoidable stress"[276], and having in place a contingency plan in case of unforeseen events that may affect handling[277]. In addition to this, common practices like fasting, crowding, removal from water, grading and pumping are specifically mentioned, establishing the criteria to maintain a good level of fish welfare. In the case of fasting, crowding and removal from water, for instance, the duration of them should be simply kept as short as possible. Moreover, the guidelines indicate that "fish should not be allowed to asphyxiate under any circumstances"[278], "to be thrown onto solid objects or onto each other or hit solid objects" and "to fall from a height that would compromise welfare", and "should be inspected during and after handling"[279]. The equipment's impact on fish welfare is also pointed out, highlighting the relevance of its fitness to the fish to be handled, its maintenance, disinfection and cleaning[280], while the noise and vibrations generated from it should be limited[281].

[270] Ibid, point 9, p.9
[271] Ibid, point 10, p.9
[272] Ibid, point 9, p.9
[273] Ibid, p. 13
[274] Ibid, point 2, p.15
[275] Ibid, point 9, p.16
[276] Ibid, point 6, p.15
[277] Ibid, point 8, p.16
[278] Ibid, point 13, p.17
[279] Ibid, point 14, p.17
[280] Ibid, point 20, p. 18
[281] Ibid, point 17, p.18

4.2.3 Code of conduct for the Mediterranean Marine Fish Farming (MMFF) sector

The Mediterranean Fish Farmers' Associations[282] created a code of conduct for the Mediterranean Marine Fish Farming (MMFF) sector, as part of the €7 million EU funded PerformFISH project. The latter, launched in May 2017 and officially concluded in October 2023, was created to address the stagnation in the MMFF sector by investigating its root causes and implementing targeted solutions. The resulting code of conduct has a voluntary nature, combining relevant requirements referred to in mandatory EU legislation and good practices on the farming of marine Mediterranean species. Its aim is not only to raise consumer awareness and promote the social and environmental responsibility of the MMFF industry, but also to advocate for the animal welfare in production[283], considering the specific needs of fish species[284]. In this respect, among the fish welfare requirements, the code stresses the importance of:

a. Ensuring optimal environmental conditions to grow the fish.
b. Adoption of a veterinary health plan based on prevention and vaccination to minimise the incidence and spread of diseases.
c. Adoption and sharing among farmers, and staff training on good husbandry and management practices, including quarantining, vaccination, handling, feeding, transport, confinement, and harvesting.
d. Responsible use of therapeutic agents – always administered under veterinary control – only where essential for disease treatment to avoid the risk of antimicrobial resistance and to improve animal welfare.
e. Implementation and application of Operational Welfare Indicators (OWIs) and tools to measure and report on fish welfare.
f. Inspection of behavioral and physical changes and mortalities, with prompt action if alterations are detected.
g. Implementation of science-based, effective, humane and safe stunning and slaughtering procedures, to minimise stress and suffering.
h. Encouraging the application of smart solutions and digital tools to enhance innovation and improve farm monitoring and production management[285].

In addition to this, the code also underlines that MMFF should "provide training programs [...] related to the production process"[286], including fish welfare.

---

[282] These are FGM (Federation of Greek Mariculture), APPROMAR (Asociación empresarial de acuicultura española), API (Associazione Piscicoltori Italiani), SFAMN (Syndicat Français de l'Aquaculture Marine et Nouvelle), and CEE-CAA (Central and Eastern Europe Coastal Aquaculture Authority).
[283] PerformFISH. (n.d.). *Mediterranean marine fish farming sector. Code of conduct*. p.6. http://performfish.eu/wp-content/uploads/2022/05/Performfish_MMFF-CoC.pdf
[284] Ibid, p.11.
[285] Ibid
[286] Ibid, p. 14

4.2.4 The Mediterranean Fish Welfare Guide

In 2020, the University of Crete, in collaboration with the Scientific Technical Team of the Hellenic Aquaculture Producers' Organisation (HAPO), developed the Mediterranean Fish Welfare Guide. This initiative represents a producer-driven, species-specific welfare guide designed for the production cycles of European sea bass and gilthead sea bream, the two predominant species in Mediterranean aquaculture. The primary objective of the guide is to provide an operational framework for fish farming workers and stakeholders, ensuring that their practices align with the latest scientific insights on fish welfare and established aquaculture expertise. The guide offers a comprehensive review of fish welfare considerations, beginning with an overview of current scientific findings and ethical perspectives. It delves into the specific needs of European sea bass and gilthead sea bream at various production stages, identifying OWIs and LABWIs, assessing their advantages and limitations, and adapting welfare practices to different production systems and husbandry methods. Additionally, the guide emphasises the importance of refining practices to enhance fish welfare, provides resources for further employee training on welfare issues, and promotes a systematic approach to welfare monitoring.
By requiring adherence to these recommendations among HAPO members, the guide not only establishes a high standard of fish welfare practice, but also highlights the potential of industry-led initiatives to complement the EU legal framework in advancing fish welfare within the aquaculture sector.

4.2.5 Guidelines on Fish Welfare in Spanish Aquaculture

Javier Ojeda, manager of APROMAR, underscored the dedication of the Spanish aquaculture sector to enhancing fish welfare, stressing that Spanish companies recognise the importance of making progress in this area and are committed to achieving meaningful improvements[287].
This commitment materialised in 2022 with the publication of Spain's first consensual guidelines on animal welfare in aquaculture, developed by APROMAR in collaboration with experts in the field, and destined for aquaculture companies and professionals, as well as public administrations, legislators, researchers, educators and the broader public. The document, which outlines the state of aquaculture in Spain and encourages a more coordinated and ethical approach to animal welfare, represents the first volume in a series of voluntary guides designed to assess and promote fish welfare across species and production systems. To date, two additional guides have been released, both in 2024: one addressing the welfare of European sea bass and the other focusing on gilthead sea bream. These guides identify WIs, emphasise critical welfare points in production systems and recommend numerous good aquaculture practices. They also include strategies for training and communication while exploring the

[287] Interview conducted on October 18th, 2024.

challenges and opportunities in advancing fish welfare. Recognising the rapid evolution of scientific knowledge and technological innovation, Ojeda remarked that APROMAR and the organisations involved in the creation of the guides consider the latter as dynamic texts, subject to regular updates to incorporate the latest advancements[288]. He pointed out that in a few years, revisions will be made to reflect improved knowledge, and revealed that a new guide focusing on trout is already in its final stages and will be completed soon, further demonstrating Spain's commitment to advancing fish welfare in aquaculture.

4.3 The role of EU Member States

The EU plays a crucial role in setting standards that protect the welfare of the animals raised for food on its territory. However, the EU does not act alone: it is also the responsibility of its Member States to ensure animal welfare in the daily implementation of EU law[289]. For what concerns EU hard law, the regulations are binding and must be directly enforced by Member States, while directives require transposition into the different national legal systems, but Member States have the discretion to go beyond the minimum standards outlined in the directives. Regardless of whether the legal instrument is a regulation or a directive, Member States must ensure proper implementation by providing technical instructions, logistical arrangements and effective sanctions. Their responsibilities include educating stakeholders about new norms, issuing technical and legal guidance, training officials, and developing systems to monitor and report on implementation progress.
This section focuses on how specific Member States contribute to the protection of the welfare of farmed animals, including fish, throughout the production process, from rearing to slaughter, highlighting their role in advancing implementation and compliance with EU standards.

As explained earlier, Article 3 of Council Directive 98/58/EC imposes a general obligation for Member States to guarantee that "the owners or keepers take all reasonable steps to ensure the welfare of animals under their care and to ensure that those animals are not caused any unnecessary pain, suffering or injury".
In this respect, Member States have adopted different types of laws in order to apply this provision. There are some countries, such as Germany[290], Austria[291]

---

[288] Interview conducted on October 18th, 2024.
[289] Martinez, J., & Nolting, C. von. (2023). *Review: "Animal welfare" – A European concept*. Animal, 17, 100839, p.1. https://doi.org/10.1016/j.animal.2023.100839
[290] Article 20(a) of German Constitution states that "(...) the State shall protect the natural foundations of life and animals by legislation and, in accordance with law and justice, by executive and judicial action, all within the framework of the constitutional order". Translated by DeepL Translate.
https://www.gesetze-im-internet.de/gg/art_20a.html
[291] Article 11.1(8) of the Austrian Constitution explicitly mentions "animal protection".
https://www.constituteproject.org/constitution/Austria_2013.pdf?lang=en

and Slovenia[292], which have included the protection of animals in their Constitution.
Germany also stands out for including cruelty towards vertebrate animals in Article 17 of its Animal Welfare Act, which stipulates that individuals who kill a vertebrate without a justified reason, or who inflict considerable pain or suffering either out of cruelty or through persistent or repeated severe actions, can face penalties of up to three years imprisonment or a fine[293]. Similarly, countries like Italy[294] and Spain[295] employ criminal law to punish certain acts of cruelty against animals.
The national legislation of Germany, France, Italy and Spain also include binding provisions related to specific animal welfare requirements. In Germany, Regulation (EC) 178/2002, Regulation (EU) 2016/429, Regulation (EC) 1/2005 and Regulation (EC) No 1099/2009 are implemented by several national laws, such as the Animal Welfare Act, the Animal Protection Livestock Ordinance[296], the Animal Protection Transport Ordinance[297] and the Animal Welfare Slaughter Ordinance[298]. In France, the health authority has issued various orders related to animal welfare, including the one of 4 November 2008 on the approval or authorisation of establishments (including aquaculture sites) placing on the market products of animal origin or foodstuffs containing products of animal origin[299]. In Italy, Council Directive 98/58/EC is implemented by Legislative Decree no 146 of 26 March 2001[300], in Spain, by the Royal Decree 348/2000[301], while in Greece by Presidential Decree 374/2001[302] and Ministerial Decision 2481/289147/2020[303], whose Article 2 affirms that "each aquaculture production business [...] shall obtain a veterinary health approval".

National regulations on animal transport generally follow Council Regulation (EC) No 1/2005. For instance, Italy has not added specific provisions for live fish transport, leaving it to the sector's operators to adapt to the existing law.

---

[292] Article 72 of the Constitution of the Republic of Slovenia refers to the protection of animals against cruelty. https://www.constituteproject.org/constitution/Slovenia_2016
[293] Accessible online at: https://www.gesetze-im-internet.de/tierschg/
[294] See title IX bis of the Italian Criminal Code. https://www.gazzettaufficiale.it/sommario/codici/codicePenale
[295] See title XVI bis of the Organic Law 10/1995 of the Spanish Criminal Code. https://www.boe.es/buscar/act.php?id=BOE-A-1995-25444
[296] Accessible online at: https://www.gesetze-im-internet.de/tierschnutztv/
[297] Accessible online at: https://www.gesetze-im-internet.de/tierschtrv_2009/
[298] Accessible online at: https://www.gesetze-im-internet.de/tierschlv_2013/
[299] Accessible online at: https://www.legifrance.gouv.fr/loda/id/JORFTEXT000019732796
[300] Accessible online at: https://www.normattiva.it/uri-res/N2Ls?urn:nir:stato:decreto.legislativo:2001-03-26;146!vig=
[301] Accessible online at: https://www.boe.es/buscar/act.php?id=BOE-A-2000-4698
[302] Accessible online at: https://www.e-nomothesia.gr/kat-agrotike-anaptukse/ktenotrophia/pd-374-2001.html
[303] Accessible online at: https://www.e-nomothesia.gr/kat-agrotike-anaptukse/upourgike-apophase-2481-289147-2020.html

However, fish transport is significantly different from the one of terrestrial animals, and aquaculture operators experienced some difficulties in translating the law to the procedures to follow for the transport of fish. In this respect, the explanatory notes by the Ministry of Health and useful tools, such as the Italian "Manual for the management of fish welfare control during road transport"[304], have been supporting the staff working in the sector and all those who carry out activities in the field of prevention and control of violations of protections for animals during transport. In Spain, Royal Decree 990/2022 determines the rules on animal health and animal protection during transport[305], while Royal Decree 728/2007[306] establishes and regulates the General Registry of Livestock Movements and the General Registry of Individual Animal Identification.
In Greece, Joint Ministerial Decision 314754/2009[307] adopts necessary supplementary measures for the implementation of Council Regulation (EC) No. 1/2005: for instance, it establishes the Competent Veterinary Authorities and their responsibilities, and clarifies the requirements for the permits of transporters undertaking long journeys.

As discussed before, in the EU, slaughter of animals intended for human consumption is regulated by Regulation (EC) 1099/2009 for the protection of animals at the time of killing, which excludes farmed fish from its scope. In this regard, most EU Member States do not include specific provisions on fish stunning and killing in their national legal framework.

[304] Spezzani, C., Ruffo, G., Fabris, A., Mordenti, O., Manfrin, A., Salati, F., Giorietto, F., Salogni, C. (2018). *Manuale per la gestione del controllo del benessere dei pesci durante il trasporto su strada*. Ministero della Salute. Nota protocollo N. 2705/2017/436-317CS. https://www.salute.gov.it/imgs/C_17_pubblicazioni_2848_allegato.pdf
[305] Accessible online at: https://www.boe.es/buscar/doc.php?id=BOE-A-2022-19912
[306] Accessible online at: https://www.boe.es/buscar/act.php?id=BOE-A-2007-12694
[307] Accessible online at: https://www.e-nomothesia.gr/kat-zoa-suntrophias-prostasia-zoon/koine-upourgike-apophase-314754-2009.html

CHAPTER 5: CRITICAL ANALYSIS OF THE CURRENT EU LEGAL FRAMEWORK REGARDING THE PROTECTION OF FISH WELFARE IN AQUACULTURE

5.1 The legal gaps in the EU legislation regarding the protection of farmed fish

Fish possess unique biological features and have extremely different needs compared to terrestrial animals (see section 2.2.3 above). Nevertheless, EU hard law has opted to address fish welfare within the same binding legal instruments that govern the welfare of terrestrial farmed animals, placing significantly more emphasis on the latter. As a result, the provisions specific to fish are scarce and primarily impose general obligations, often overlooking the recommendations provided by EFSA.
In the following sections, Council Directive 98/58 on the protection of animals kept for farming purposes, Regulation 1/2005 on the protection of animals during transport and related operations and Regulation 1099/2009 on the protection of animals at the time of killing are critically examined, also taking into account the international legal instruments mentioned in Chapter 3. This analysis is aimed at identifying the EU legal gaps in the protection of fish welfare, providing a clearer understanding of the necessary steps to improve the EU legislation in this field (see section 5.2 below).

5.1.1 A closer look at the Council Directive 98/58 on the protection of animals kept for farming purposes

Although Council Directive 98/58 on the protection of animals kept for farming purposes was adopted in 1998, almost thirty years ago, Article 3 already established a general obligation to protect fish welfare.
At that time, the EU legislator acknowledged the need for at least a basic level of protection for fish and proved to stay one step ahead compared to the scientific community on this topic, which had yet to seriously explore whether fish could experience pain. At the same time, fish were not legally granted the same level of consideration as terrestrial farm animals, as they were excluded from Article 4 and, thus, from the Annex, which outlines specific provisions on staffing, freedom of movement, breeding procedures, inspections, record-keeping and other key aspects affecting welfare. While this exclusion may have been understandable in 1998, now that scientific understanding has advanced and public awareness has grown, it is striking that the directive has not evolved

accordingly. Today, with over 33,000 fish species identified, 513 of which are farmed globally (see section 1.3 above), it is evident that fish welfare must be addressed on a species-specific basis. The directive itself declares that "the Commission shall submit to the Council [...] any [...] appropriate specific rules" in Article 5.1, but has yet to fulfill this obligation concerning fish welfare.
A turning point could have been expected as early as 2008, when the European Commission asked EFSA for a series of scientific opinions on the welfare aspects of husbandry systems for several commercially farmed fish species. However, the stalemate persisted. This lack of action is particularly disappointing given that EFSA's recommendations, although general in their nature, are explicitly intended to "serve as the scientific basis for the drafting and adoption of Community measures", as stated in Article 22.6 of GFL.

With few and often inadequate laws addressing the welfare of farmed fish, it is also unrealistic to expect Member States to translate EU provisions into detailed and effective national rules and, thus, to "take all reasonable steps" to ensure fish welfare, as imposed by Article 3 of Council Directive 98/58/EC. Consequently, although Article 13 of the TFEU recognises fish as sentient beings and requires the EU and its Member States to "pay full regard" to their welfare, the reality is quite different from the theory, with several stressful and painful aquaculture practices being prevalent across several EU countries.

In comparison, the CoE Recommendation outlines several provisions aimed at ensuring the welfare of farmed fish, explicitly recognising the significant interspecies differences in "water conditions, social behaviour and environmental structures" in Article 2. It even goes further in Article 21, mandating the creation of "species-specific Appendices", which, however, remained unpublished. Again, this feels like a failure in fish welfare protection, since these instruments could have represented a useful tool in providing essential guidance to ensure farming methods are better aligned with the specific needs of farmed fish.

5.1.2 A closer look at the Regulation 1/2005 on the protection of animals during transport and related operations

Following Article 1.1 of Regulation (EC) No 1/2005, fish are included in the scope of this law, being vertebrate animals. Nevertheless, not only does the regulation lack specific provisions related to fish transport, but it also does not mention the word "fish" at all. In fact, the regulation's specific rules mainly refer to terrestrial farm animals[308], as confirmed by a report by the European Commission, and hold

[308] Braak, K., Schrijver, R., Bergevoet, R., Dewar, D., Witkamp, S., Stokkers, R., & Vis, H. (2017). *Welfare of farmed fish: common practices during transport and at slaughter: final report*. European Commission: Directorate-General for Health and Food Safety. Publications Office of the European Union. p.25. https://data.europa.eu/doi/10.2875/172078

little or no relevance for fish. In this regard, an example can be found in Article 3(g), which among the general conditions for the transport, requires that "sufficient floor area and height is provided for the animals, appropriate to their size and the intended journey". Other articles are not just irrelevant, but also inconsistent with fish welfare requirements, and instead of safeguarding them, they potentially put them in danger. For instance, Article 3(h) mandates the provision of feed "at suitable intervals", yet feeding fish before or during transport can degrade water quality in transport tanks, leading to welfare issues and even death.
Annex I, which was added to incorporate more technical rules on animal transport, does not provide special requirements on fish transportation. In light of this, water quality would have been an essential critical element to mention to guarantee proper fish welfare. Instead, point 1.1(e) of Chapter II of Annex I highlights the requirement of ensuring "air quality and quantity appropriate to the species transported", which, again, can only be relevant for terrestrial farmed animals.

Interestingly, eight months before the introduction of the regulation, EFSA adopted a scientific opinion on the welfare of animals during transport. However, EFSA recommendations on fish transport, which could have been used as points of reference for the elaboration of Regulation 1/2005, were never taken into account. This is surprising since it was the European Commission itself which asked EFSA to extend its mandate to cover other species like fish.
Furthermore, on 7 December 2023, the European Commission adopted a proposal for a new Regulation on the protection of animals during transport, intended to replace Council Regulation (EC) No 1/2005[309]. Paragraph 30 of the proposal's preamble declares that, based on the WOAH guidelines, "specific provisions for aquatic animals should be set and updated based on new science when the relevant opinions of EFSA are available". While this commitment may appear promising, doubts arise about its practical application, as numerous relevant EFSA recommendations on fish welfare during transport have already been issued, but were never effectively used to inform the EU legislative developments.

In contrast to EU law, the WOAH's Aquatic Animal Health Code (see section 3.1.1 above) provides a general framework that is nonetheless highly relevant and comprehensive in addressing the welfare requirements of farmed fish during transport. Despite the EU's membership in the WOAH and its commitment to adhere to its standards, none of the Code's recommendations have been transposed into binding EU legislation.

---

[309] Proposal for a Regulation of the European Parliament and of the Council on the protection of animals during transport and related operations, amending Council Regulation (EC) No 1255/97 and repealing Council Regulation (EC) No 1/2005. https://food.ec.europa.eu/system/files/2023-12/aw_in-transit_reg-proposal_2023-770_0.pdf

5.1.3 A closer look at the Regulation 1099/2009 on the protection of animals at the time of killing

According to Article 1.1 of Regulation (EC) 1099/2009, only the requirements laid down in Article 3.1 apply to fish slaughter. In particular, "animals shall be spared any avoidable pain, distress or suffering during their killing and related operations". Considering that the language of this provision is excessively vague, leaving significant ambiguity about what constitutes "avoidable pain, distress, or suffering" in legal terms, Recital (2) of Regulation 1099/2099 can be used to better interpret its meaning. This claims that:

> " (…) Business operators or any person involved in the killing of animals should take the necessary measures to avoid pain and minimise the distress and suffering of animals during the slaughtering or killing process, taking into account the best practices in the field and the methods permitted under this Regulation. Therefore, pain, distress or suffering should be considered as avoidable when business operators or any person involved in the killing of animals breach one of the requirements of this Regulation or use permitted practices without reflecting the state of art, thereby inducing by negligence or intention, pain, distress or suffering to the animals."

Theoretically, considering that no article establishes specific requirements for the slaughter of fish, one could imply that the EU law allows any kind of killing method as long as aquaculture staff follows "the best practices in the field" to spare fish "any avoidable pain, distress or suffering".
Following this interpretation, Article 3.1 should forbid killing methods, such as asphyxiation in air, live chilling in ice, carbon dioxide narcosis, salt or ammonia baths or exsanguination and decapitation without prior stunning (explained in section 2.2.4.4 above), which are scientifically proved to be harmful to the fish and can be replaced by alternative methods, as also explained by EFSA in its species-specific scientific opinions. Nevertheless, these practices are still widespread within the EU, with asphyxia in ice of sea bass and sea bream being "the main practised slaughter technique in Greece, Spain and Italy"[310].
Besides, Article 3.1 does not only mention the actual killing, but extends its protection to related operations, including pre-slaughter practices, such as crowding or fasting. These too are theoretically prohibited but persist in practice mainly for economic reasons, which are prioritised over the protection of fish welfare. Nevertheless, economic concerns cannot excuse inhumane practices, especially because improving animal welfare often has a minimal impact on costs and may even result in labor savings or other economic benefits. On top of that, privileging economic interests over animal welfare constitutes a clear violation of

[310] European Commission, 2018, p.5

Article 13 of the TFEU, which recognises animals as sentient beings and obliges the EU and its Member States to "pay full regard" to their welfare.
It is also noteworthy that Regulation 1099/2009 was adopted just one year after the publication of the WOAH Aquatic Animal Health Code. The latter, which laid down general recommendations for farmed fish during slaughter and related operations (see section 3.1.1 above), has been accepted by all EU Member States, which committed to comply with it. However, the Regulation neither mentions nor considers the Code recommendations, including the provisions on effective stunning, staff competence, species-specific technical requirements and conditions to minimise fish stress and injury. Although the WOAH standards are kept at a general level, they could have served as foundational principles for the enactment of Regulation (EC) 1099/2009.

5.2 Towards a more effective protection of the welfare of farmed fish

The EU boasts a relatively comprehensive legislative framework regarding the safeguard of animal welfare. While Council Directive 98/58 concerning the protection of animals kept for farming purposes, Regulation 1/2005 on the protection of animals during transport and related operations and Regulation 1099/2009 on the protection of animals at the time of killing have a more general scope (which also include fish), the EU legal sphere regarding the welfare of farmed animals also includes species-specific directives regarding the protection of laying hens[311], calves[312], pigs[313] and chickens kept for meat production[314] (see Figure 17 below).

[311] Council Directive 1999/74 laying down minimum standards for the protection of laying hens.
[312] Council Directive 2008/119 laying down minimum standards for the protection of calves.
[313] Council Directive 2008/120 laying down minimum standards for the protection of pigs.
[314] Council Directive 2007/43 laying down minimum rules for the protection of chickens kept for meat production.

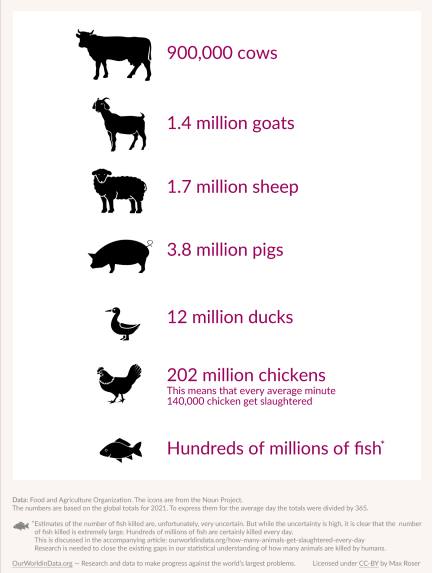
Figure 17: *The current EU regulatory framework on animal welfare*

	Species Covered
Directive 98/58 concerning the protection of **animals kept for farming purposes**	All animals bred or kept for the production of food, wool, skin, fur or other farming purposes including fish, reptiles and amphibians.
Directive 1999/74 laying down minimum standards for the protection of **laying hens**	Commercial egg laying hens
Directive 2008/119 laying down minimum standards for the protection of **calves**	Calves less than 6 months old
Directive 2008/120 laying down minimum standards for the protection of **pigs**	Pigs at all stages of production, except breeding animals
Directive 2007/43 laying down minimum rules for the protection of **chickens kept for meat production**	Commercial broiler chickens on conventional farms with more than 500 chickens
Regulation 1/2005 on the protection of animals during **transport** and related operations	Live vertebrates
Regulation 1099/2009 on the protection of animals at the time of **killing**	Vertebrate animals excluding reptiles and amphibians. Only key principles of the regulation apply to fish.

Source: Di Concetto, A. *Animals in the Farm-to-Fork Strategy*. European Institute for Animal Law & Policy. Lecture on 5 December 2023 at Wageningen University.

Although the existence of such legal instruments for terrestrial farmed animals is admirable, it is surprising that no specific legislation has been developed for farmed fish, the most slaughtered animal species globally, with numbers far exceeding those of terrestrial animals (see Figure 18 below).

Figure 18: *Number of animals slaughtered every day in the world in 2021*



Source: Roser, M. (September 26, 2023). How many animals get slaughtered every day? Our World in Data. https://ourworldindata.org/how-many-animals-get-slaughtered-every-day

In its 2018 report, the European Commission acknowledged that "improvements are still needed in order to increase welfare of some fish species"[315], but also expressed confidence that no specific legal measures were necessary for this purpose, asserting that voluntary actions by the aquaculture industry, supported by Member States when needed, would suffice to raise fish welfare standards. This decision appears rooted in the European Commission conviction that "the

[315] European Commission, 2018, p.13

industry as a whole is gradually but continuously improving fish welfare"[316]. While this may be accurate for certain Member States, the same report highlights widespread failures in meeting fish welfare standards across European aquaculture.

Given the unique nature of fish, stemming from the vast diversity of species, habitats and production systems, protecting their welfare demands a fundamentally different approach from that used for terrestrial animals. For this reason, the present analysis disregards the option of simply adding specific provisions to the current relevant EU laws, and indicates as the most effective solution the establishment of EU legislation dedicated to concrete, binding and tailored-made provisions for the welfare of farmed fish, in line with the already-existing recommendations by EFSA and the efforts of international organisations, such as the WOAH and the CoE. According to the present study, the most suitable EU legal instrument would be a directive, ensuring that the overarching standards for fish welfare are upheld across the EU while allowing for national implementation that considers regional specificities, such as variations in aquaculture practices or environmental conditions.
Overall, the new law should be based on a holistic, science-based, progressive approach, shifting from merely avoiding suffering to actively fostering a good quality of life for fish throughout their entire lifecycle in aquaculture, from rearing to slaughter. As Elisa Bianco points out, this would be "the biggest challenge" in the sector since, up to the present, the prevailing view has been to treat animals as part of a production system that is exclusively focused on volume and efficiency[317].
Instead, the aim of the new directive would be to establish clear requirements for the protection of the welfare of farmed fish, proving that higher welfare standards lead to a more thriving, competitive industry, as Dimitris Papapanagiotou explains[318]. The law should include clear and enforceable definitions to ensure consistent interpretation and application across Member States, and establish general principles, emphasising that fish should be bred or kept "having regard to their species and to their degree of development, adaptation and domestication, and to their physiological and ethological needs in accordance with established experience and scientific knowledge", echoing Article 4 of Council Directive 98/58.
Additionally, provisions should determine general requirements for the different life stages of the fish, with fish species-specific information being available in the annexes.
For the rearing step, handling methods that minimise out-of-water exposure and reduce stress should be mandatory, and the use of equipment should prioritise the avoidance of pain and injury. Specific limits should also be set for stocking

[316] Ibid.
[317] Interview conducted on October 15th, 2024.
[318] Interview conducted on October 17th, 2024.

densities to prevent overcrowding, ensuring that fish can swim freely and engage in natural behaviors. Moreover, there should be specific articles about the prevention of the spread of disease and parasites through low-stress management and optimal husbandry practices.
In the context of transport, mandatory monitoring systems should be required to regulate water quality parameters, such as oxygen levels and temperature, throughout the journey. Pre-transport practices, such as fasting and crowding, must be clearly regulated to minimise their impact on welfare, while contingency plans should be obligatory in case of emergencies during transport. Besides, requirements for vehicle and container design must be introduced, ensuring that these are adapted to fish welfare needs, with features to prevent injury and maintain stable conditions.
Slaughter is arguably the most critical stage for fish welfare, implying the highest levels of regulatory oversight. One of the most important requirements is that fish should be rendered unconscious and insensible to pain before slaughter, using effective stunning methods. Furthermore, harmful practices, such as chilling in ice, asphyxiation by air exposure, or the use of carbon dioxide, should be explicitly prohibited.
Moreover, regular inspections by competent authorities, including veterinary experts, should be mandated across all stages of aquaculture. These checks would involve not only scheduled visits but also unannounced on-the-spot checks to ensure that welfare standards are upheld consistently and without the opportunity for temporary adjustments to mask non-compliance.
Competent authorities should be tasked with evaluating adherence to welfare requirements in all the life stages of farmed fish, and should fill in inspection reports, which should be transparent and accessible, with key findings summarised in a publicly available format to enhance accountability. Operators found in violation of welfare standards should face proportionate penalties, including mandatory corrective actions, fines, or even suspension of the business activity in cases of severe or repeated breaches.
Another aspect which should be included regards the responsibilities of the aquaculture operators, who should be competent. In light of this, all stakeholders, including farmers, transporters and slaughterhouse staff, should be obliged to follow uniform and obligatory certification and training programs focused on fish welfare, behaviour and handling, equipping personnel with the knowledge and skills needed to uphold high welfare standards.
The EU’s efforts should also extend beyond its borders. While maintaining high standards within European aquaculture, the EU should require the WOAH standards for fish welfare to be met for aquaculture products imported into the Union, as part of the chapters related to animal welfare in trade agreements.
In addition to this, the new directive should actively promote innovation by encouraging investment in new scientific research and technologies aimed at improving fish welfare. EU funding should prioritise projects exploring advanced husbandry techniques, appropriate equipment and methods to enhance the overall quality of life for farmed fish. Partnerships between policymakers,

industry stakeholders and researchers should be encouraged to foster the rapid adoption of these innovations. In light of this, the law should also have a dynamic character, requiring regular updates to incorporate new scientific insights and adapt to the evolving needs of the aquaculture industry.
In conclusion, it is important to emphasise that the recommendations outlined here are merely examples of key elements that could form the foundation of a new EU law on the welfare of farmed fish. They are not exhaustive and do not cover every aspect that such legislation should address. The complexities of aquaculture and the diversity of fish species require a comprehensive and nuanced approach, meaning that additional provisions and specific measures are necessary to ensure the law is both effective and flexible.

5.3 Advances in Fish Welfare: How Far Have We Come?

This study concludes with an optimistic outlook, recognising that while significant gaps still exist within the EU legal framework concerning the protection of the welfare of farmed fish, there remains a big opportunity to address these gaps and make improvements. Progress can already be observed through various recent initiatives.

For example, fish welfare has begun to be addressed in several European Commission documents. Elisa Bianco cites the 2022 Fitness Check of the EU Animal Welfare Legislation[319], which explicitly recognises gaps in the legal framework, particularly concerning farmed fish, and highlights that "current provisions are not specific and detailed enough and therefore not adapted to their needs"[320].
In February 2023, the European Commission demonstrated its commitment to improving fish welfare with the introduction of the Fisheries Policy Package (FPP), including a set of "measures to improve the sustainability and resilience of the EU's fisheries and aquaculture sector"[321]. At its 3960th meeting held on 26 June 2023, the Council of the EU examined the draft Council conclusions on the FPP, which contained a clear reference to fish welfare. The text reads as follows:

> "we note that animal welfare improvements are necessary to strengthen the sustainability of the fisheries and aquaculture sectors; we encourage the Commission to provide guidance on improving aquatic animal welfare, taking into account the practical feasibility in the fisheries and aquaculture management, and we call on the Commission to further increase

[319] Interview conducted on October 15th, 2024.
[320] European Commission. (October 4, 2022). *Fitness Check of the EU Animal Welfare Legislation.* p.62. https://food.ec.europa.eu/system/files/2022-10/aw_eval_revision_swd_2022-328_en.pdf
[321] European Commission. (n.d.) *Common Fisheries Policy (CFP).* https://oceans-and-fisheries.ec.europa.eu/policy/common-fisheries-policy-cfp_en

science-based knowledge on animal welfare of aquatic animals and to take this research into consideration in policy development; we welcome the fact that the Commission has launched a call for the selection and designation of a European Union reference centre for the welfare of aquatic animals and we encourage the Commission to include provisions to improve the welfare of farmed fish in its announced proposals to revise EU animal welfare legislation"[322].

While this paragraph constitutes an important step forward for the introduction of norms that improve the fish welfare, the text was not adopted as Council Conclusions, which required unanimity[323], but as Presidency Conclusions supported by 26 Member States.

The recent proposal for a new Regulation on the protection of animals during transport to replace Council Regulation (EC) No 1/2005 also introduced some relevant advancements, with fish being cited in certain provisions. For instance, Article 4.2 (j) requires that aquatic animals, which by definition of Article 3.6 include fish, "are provided with water in sufficient volume and quality". Besides, according to Article 44(f), transporting aquatic animals without checking water parameters constitutes a serious infringement "when committed deliberately or negligently". Moreover, while Annex I focuses on the transport conditions for terrestrial animals, Annex II is entirely dedicated to aquatic animals, covering important aspects, such as pre-loading inspections, monitoring and maintaining the key water quality parameters, and post-unloading evaluation.

Furthermore, by way of Commission Implementing Decision 2024/266, in January 2024, further progress was made with the establishment of the fourth[324] EU Reference Centre for the welfare of aquatic animals (EURCAW-Fish).
The centre is led by the University of Crete (Greece) and is composed of the Biology Centre of the Czech Academy of Sciences, the Institute of Parasitology (Czechia) and the Universitat Autònoma de Barcelona (Spain). Among the multiple tasks of EURCAW-Fish, the latter has the responsibility of supporting horizontal activities of the Commission and of the Member States in meeting welfare requirements for aquatic animals, and helps in developing animal-based indicators for a better monitoring of their welfare.

Around the same period, during the plenary session of 18 January 2024, the European Parliament called on the European Commission to insert animal

---

[322] Council of the European Union. (June 26, 2023). *Presidency Conclusions on the Fisheries policy package for a sustainable, resilient and competitive fisheries and aquaculture sector.* p.22.
https://data.consilium.europa.eu/doc/document/ST-11053-2023-INIT/en/pdf

[323] All delegations except Italy, supported the text in its entirety.

[324] The other reference centres are dedicated to pigs (EURCAW-Pigs), poultry and other small farmed animals (EURCAW-Poultry SFA) and ruminants and equines (EURCAW Ruminants & Equines).

welfare considerations for both farmed and wild-caught fish in the next CFP, when it will be reviewed[325]. Considering the Presidency Conclusions on the CFP of June 2023, the one of the European Parliament is an important call for the EU, which shows that awareness in the topic is changing, together with the willingness to progress in the sector.

An historic victory is owed to the #EUforAnimals campaign, an initiative vigorously pursued by GAIA Belgium, in collaboration with Animal Equality and more than 60 other groups: in October 2023, they officially presented a petition to the European Parliament and the European Commission (that collected 310,000 signatures of citizens) in support of the appointment of a European Commissioner for Animal Welfare[326]. Their request was soon achieved because on 17 September 2024, during the presentation of the new structure of the European Commission, Ursula von der Leyen announced that animal welfare will be officially included in the title of the new Commissioner for Animal Health and Welfare, the Hungarian Oliver Várhelyi. This great milestone could potentially represent a step forward also for the improvement of the legal protection of fish welfare, considering that, among the new Commissioner's responsibilities, he is tasked with "modernising the rules on animal welfare (...)"[327].

As proven by the power of #EUforAnimals campaign, animal welfare organisations play a crucial role in carrying on relevant initiatives, which demand urgent action to the EU, while raising public awareness, especially on neglected topics, such as fish welfare. For instance, on 24 September 2024, Eurogroup for Animals and Compassion in World Farming, two important animal welfare organisations, sent an open letter[328] to the Commissioner-candidates responsible for Animal Welfare and for Fisheries, asking them to prioritise the publication of the remaining animal welfare proposals and to ensure high levels of protection for farmed fish and other aquatic animals. This move was backed by 4 out of 5 people polled across nine EU countries (Czechia, France, Germany, Greece, Italy, Poland, Spain, Sweden and The Netherlands), which demonstrated to be supportive of legislation that promotes best practices and the latest science to meet the unique welfare needs of farmed aquatic animals.
Moreover, due to the lack of legislation regarding important aspects that impair

---

[325] European Parliament resolution of 18 January 2024 on the state of play in the implementation of the Common Fisheries Policy and future perspectives (2021/2169(INI)).
https://www.europarl.europa.eu/doceo/document/TA-9-2024-0045_EN.pdf
[326] #EUforAnimals. (n.d.). *Give animals a stronger voice in Europe.*
https://www.euforanimals.eu/en
[327] European Commission. (n.d.). *Olivér Várhelyi.*
https://commission.europa.eu/about/organisation/college-commissioners/oliver-varhelyi_en
[328] The letter can be accessed here:
https://www.ciwf.org.uk/media/7458821/20240924-it-is-high-time-the-european-union-pays-attention-to-fish-welfare-open-letter-ciwf-and-efa-docx-1.pdf

fish welfare, some NGOs, such as Compassion in World Farming, Eurogroup for Animals, Royal Society for the Prevention of Cruelty to Animals (RSPCA), Aquaculture Stewardship Council, Conservative Animal Welfare Foundation, Fish Welfare Initiative, Aquatic Animal Alliance have elaborated recommendations themselves, claiming, for instance, that environmental conditions should meet animals' physical, mental and ethological needs and overall accommodation, acceptable stocking densities should be specified, water quality parameters should be determined, an appropriate diet should be guaranteed to meet the nutritional needs of farmed fish according to species and stage of life.
In Italy, the organisation Essere Animali launched a campaign, called "Anche i pesci"[329], which is aimed at eliminating the main causes of suffering for certain fish species, such as trout, sea bass and sea bream, and especially focuses on effective stunning at the end of the cycle.

In conclusion, while there is still much work to be done, positive developments show that the welfare of farmed fish is gradually being addressed. Recent legislative advances, increased public awareness and the continued efforts of animal welfare organisations all suggest that the future holds promise for a more effective protection of fish welfare.

Conclusion

This thesis set out to assess the extent to which the welfare of farmed fish is protected under EU legislation. The study ultimately revealed that while the EU boasts an extensive body of laws addressing animal welfare, fish, the largest group among farmed animals[330], are significantly neglected. The few provisions applying to them are very general, leaving considerable room for interpretation. In some cases, they are even irrelevant or contradictory to the principles of their welfare, making the latter's implementation difficult. This can mainly be attributed to the fact that most EU laws were designed with terrestrial farmed animals in mind.
Considering the rapid growth of the aquaculture industry and the enormous number of fish involved, the study also concluded that there is an urgent need to safeguard these animals by creating a comprehensive law, which takes into account their species-specific needs. While this may seem too ambitious and unrealistic, especially considering that legal gaps still exist even for terrestrial animals, Article 13 of the TFEU obligates the EU to take into account their welfare in its legislation.

---

[329] To know more about the campaign, see: https://www.essereanimali.org/ancheipesci/
[330] While, in 2023, the EU farmed 133 million pigs, 74 million bovine animals, 58 million sheep and 11 million goats, it is estimated that the number of farmed fish in the EU is around one billion for each year.
Data accessible online at:
https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20240521-2#:~:text=In%202023%2C%20the%20EU's,sheep%2C%20and%2011%20million%20goats

Change, however, is not only about laws; it is also about people. The same spirit of curiosity and compassion that drove this thesis is what will drive the next generation of thinkers and doers to question the status quo and demand better for all animals, including fish. As Dr Albert Schweitzer once said, "the thinking person must oppose all cruel customs, no matter how deeply rooted in tradition or surrounded by a halo". It is through such opposition—and through action—that real progress is born.

In the end, perhaps the greatest lesson from this thesis is not simply that we can do better, but that we must. With each new scientific discovery, each legal change, and each shift in public consciousness, the invisible becomes visible. And in that visibility lies the hope of a world where every creature, no matter how small or misunderstood, is afforded the dignity and care they deserve.

List of References

Altmayer, A. (June 2024). *EU aquaculture: State of play.* European Parliamentary Research Service (EPRS). https://www.europarl.europa.eu/RegData/etudes/BRIE/2024/762336/EPRS_BRI(2024)762336_EN.pdf

Answer given by Ms Damanaki on behalf of the Commission. (March 1, 2012). Parliamentary Question - E-012243/2011(ASW). European Parliament. https://www.europarl.europa.eu/doceo/document/E-7-2011-012243-ASW_EN.html?redirect

Arechavala-Lopez, P., Cabrera-Álvarez, M.J., Maia, C.M., Saraiva, J.L. (2022). *Environmental enrichment in fish aquaculture: A review of fundamental and practical aspects*. Reviews in Aquaculture, 14(2):704-728. https://doi-org.ezproxy.library.wur.nl/10.1111/raq.12620

Ashley, P. (2007). *Fish welfare: Current issues in aquaculture.* Applied Animal Behaviour Science, 104(3-4):199-235. https://doi.org/10.1016/j.applanim.2006.09.001

Atlantic Salmon. (n.d.). American Oceans. https://www.americanoceans.org/species/atlantic-salmon/

Bagni, M. (2005). *Dicentrarchus labrax.* Cultured Aquatic Species Information Programme. FAO Fisheries and Aquaculture Department. Rome. https://www.fao.org/fishery/en/culturedspecies/dicentrarchus_labrax/en

Barton, B.A., & Iwama, G.K. (1991). *Physiological changes in fish from stress in aquaculture with emphasis on the response and effects of corticosteroids*. Annual Review of Fish Diseases, 1:3-26. https://www.sciencedirect.com/science/article/pii/095980309190019G

Bergqvist, J., Gunnarsson, S. (2013). *Finfish Aquaculture: Animal Welfare, the Environment, and Ethical Implications*. Journal of Agricultural and Environmental Ethics, 26:75-99. https://doi.org/10.1007/s10806-011-9346-y

Boudouresque, C.F., Blanfuné, A., Pergent, G., Pergent-Martini, C., Perret-Boudouresque, M. and Thibaut, T. (2020). *Impacts of Marine and Lagoon Aquaculture on Macrophytes in*

Mediterranean Benthic Ecosystems. Frontiers in Marine Science, 7:218, 1-19. https://www.frontiersin.org/journals/marine-science/articles/10.3389/fmars.2020.00218/full

Braak, K., Schrijver, R., Bergevoet, R., Dewar, D., Witkamp, S., Stokkers, R., & Vis, H. (2017). *Welfare of farmed fish: common practices during transport and at slaughter: final report*. European Commission, Directorate-General for Health and Food Safety. Publications Office of the European Union. https://data.europa.eu/doi/10.2875/172078

Braithwaite, V. (2010). *Do fish feel pain?* Oxford University Press.

Brambell F. W. R. & Technical Committee to Enquire into the Welfare of Animals kept under Intensive Livestock Husbandry Systems. (1965). *Report of the technical committee to enquire into the welfare of animals kept under intensive livestock husbandry systems*. Her Majesty's Stationery Office. London. https://archive.org/details/b3217276x/page/n1/mode/2up

Branson, E.J. (2008). *Fish Welfare*. Blackwell Publishing Ltd. https://onlinelibrary-wiley-com.ezproxy.library.wur.nl/doi/book/10.1002/978047069761

Broom, D.M. (1986). *Indicators of poor welfare*. The British Veterinary Journal, 142(6):524-526. https://www.sciencedirect.com/science/article/pii/0007193586901090

Broom, D. M. (2007). *Cognitive ability and sentience: which aquatic animals should be protected?* Diseases of aquatic organisms, 75(2):99–108. https://doi.org/10.3354/dao075099

Broom, D.M. (2017). *Animal Welfare in the European Union*. Directorate-General for Internal Policies. Policy Department for Citizens' Rights and Constitutional Affairs. European Union. https://www.europarl.europa.eu/RegData/etudes/STUD/2017/583114/IPOL_STU(2017)583114_EN.pdf

Cai, J., Galli, G., and Zhou, X. (2023). *Top 10 species groups in global aquaculture 2021*. FAO Fisheries and Aquaculture Division. https://openknowledge.fao.org/server/api/core/bitstreams/8f5e7023-4522-4162-a65a-e91fa834d193/content#:~:text=Thanks%20to%20a%20major%20disaggregation,to%20513%20in%20world%20aquaculture

Celano, T. (ca.1229). *The first life of St. Francis* (par. 60, ch. 21). In M. L. Cameron (Ed.), *The inquiring pilgrim's guide to Assisi* (A. G. Ferrers Howell, Trans.). Retrieved 14 September 2024 from Indiana University at https://dmdhist.sitehost.iu.edu/francis.htm

CERES. (n.d.). *Case study 1: Rainbow Trout in north-west Europe.* https://ceresproject.eu/wp-content/uploads/2019/11/20191113Storyline-1-Rainbow-trout-FB-MP_2.pdf

Chandroo, K.P., Yue, S. and Moccia, R.D. (2004). *An evaluation of current perspectives on consciousness and pain in fish.* Fish and Fisheries, 5, 281-295. https://doi-org.ezproxy.library.wur.nl/10.1111/j.1467-2679.2004.00163.x

Chatain, B. & Chavanne, H. (2009). *Genetics of European seabass (Dicentrarchus labrax L.).* Cahiers Agricultures, 18(2-3):249-255. https://doi.org/10.1684/agr.2009.0296

Clemente, G. A., Tolini, C., Boscarino, A., Lorenzi, V., Dal Lago, T. L., Benedetti, D., Bellucci, F., Manfrin, A., Trocino, A., & Rota Nodari, S. (2023). *Farmed fish welfare during slaughter in Italy: Survey on stunning and killing methods and indicators of*

unconsciousness. Frontiers in Veterinary Science, 10:1253151. https://doi.org/10.3389/fvets.2023.1253151

Commission Decision of 24 January 2017 establishing the Commission Expert Group 'Platform on Animal Welfare'. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32017D0131(01)

Commission Implementing Decision 2024/266 of 17 January 2024 designating a European Union reference centre for the welfare of aquatic animals in accordance with Regulation (EU) 2017/625 of the European Parliament and of the Council. https://eur-lex.europa.eu/eli/dec_impl/2024/266/oj/eng

Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and The Committee of the Regions. A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system. COM/2020/381 final. (May 20, 2020). https://food.ec.europa.eu/document/download/472acca8-7f7b-4171-98b0-ed76720d68d3_en?filename=f2f_action-plan_2020_strategy-info_en.pdf

Compassion in World Farming. (2023). *2023 EU AQUACULTURE INVESTIGATION SUMMARY*. https://www.ciwf.org/media/7455622/trout-investigation-summary_web.pdf

Compassion in World Farming. (2023). *Rethinking EU Aquaculture for people, planet, and animals.* https://www.ciwf.org/resources/reports-position-papers-briefings/rethinking-eu-aquaculture-for-people-animals-and-the-planet/

Council of Europe. (n.d.). *Protection of Animals*. https://www.coe.int/en/web/cdcj/protection-of-animals

Council of the European Union. (June 26, 2023). *Presidency Conclusions on the Fisheries policy package for a sustainable, resilient and competitive fisheries and aquaculture sector.* https://data.consilium.europa.eu/doc/document/ST-11053-2023-INIT/en/pdf

Dalla Villa, P., Marahrens, M., Velarde Calvo, A., Di Nardo, A., Kleinschmidt, N., Fuentes Alvarez, C., Truar, A., Di Fede, E., Otero, J.L., Müller-Graf, C. (2009). *Project to develop Animal welfare. Risk Assessment Guidelines on Transport.* EFSA Supporting Publication, 6(9):EN-21. https://efsa.onlinelibrary.wiley.com/doi/abs/10.2903/sp.efsa.2009.EN-21

Diggles, B. K., Cooke, S., Rose, J. D. & Sawynok, W. (2011). *Ecology and welfare of aquatic animals in wild capture fisheries.* Reviews in Fish Biology and Fisheries, 21(4):739–765. https://www.researchgate.net/publication/226363396_Ecology_and_welfare_of_aquatic_animals_in_wild_capture_fisheries

Directorate-General for Parliamentary Research Services & Weissenberger, J. (2017). *Aquaculture: Overview for the EU.* European Parliament. https://data.europa.eu/doi/10.2861/650792

Dunlop, R., & Laming, P. (2005). *Mechanoreceptive and nociceptive responses in the central nervous system of goldfish (Carassius auratus) and trout (Oncorhynchus mykiss).* The journal of pain, 6(9): 561–568. https://doi.org/10.1016/j.jpain.2005.02.010

EFSA. (Last reviewed date: 10 December 2024). *Animal health*. https://www.efsa.europa.eu/en/topics/topic/animal-health#:~:text=The%20concept%20of%20animal%20health,environmental%20protection%2C%20and%20food%20safety

Erikson, U. (2011). *Assessment of different stunning methods and recovery of farmed Atlantic salmon (Salmo salar): isoeugenol, nitrogen and three levels of carbon dioxide.* Animal Welfare, 20(3):365–375. https://doi.org/10.1017/S096272860000292X

Essere Animali. (n.d.). ANCHE I PESCI. https://www.essereanimali.org/ancheipesci/

#EUforAnimals. (n.d.). *Give animals a stronger voice in Europe.* https://www.euforanimals.eu/en

EUFOMA. (December 2020). *Recirculating aquaculture systems.* Publications Office of the European Union. Luxembourg. https://eumofa.eu/documents/20178/84590/RAS+in+the+EU.pdf

EUMOFA. (April 2021). *Freshwater aquaculture in the EU.* Publications Office of the European Union. Luxembourg. https://www.aquafeed.com/documents/229/0012954001617121663.pdf

EUMOFA. (2021). *The EU fish market 2021 edition.* Publications Office of the European Union. Luxembourg. https://doi.org/10.2771/563899

EUFOMA. (May 2023). *Case study - Large trout in the EU*. Publications Office of the European Union. Luxembourg. https://eumofa.eu/documents/20124/35623/PTAT_Large+trout.pdf/4923045b-73a7-e7ce-16ec-bd33301286a8?t=1686569699668

EUFOMA. (2023). *THE EU FISH MARKET*. Publications Office of the European Union. Luxembourg. https://eumofa.eu/documents/20124/35668/EFM2023_EN.pdf

EUFOMA. (March 2024). *Case Study: Fresh European Seabass in the EU*. Publications Office of the European Union. Luxembourg. https://eumofa.eu/documents/20124/99991/PTAT+fresh+seabass+in+EL+ES+IT_EN.pdf/9ded129d-bfac-fdd0-6bfc-0c120e9303a7?t=1711556054886

EUFOMA. (May 2024). *Monthly Highlights*. No.5/2024. Publications Office of the European Union. Luxembourg. https://eumofa.eu/documents/20124/118634/MH+5+2024+EN_Final.pdf/79d6b70a-4854-5fcc-1393-e70009c59a48?t=1719841957604

EUFOMA. (June 2024). *STUDY ON THE CHALLENGES OF AQUACULTURE PRODUCTS IN FOOD OUTLETS*. Publications Office of the European Union. Luxembourg. https://eumofa.eu/documents/20124/115068/Aquaculture+outlets+study+_final.pdf

Eurogroup for Animals. (2018). *Looking Beneath the Surface: Fish Welfare in European Aquaculture.* https://www.eurogroupforanimals.org/library/looking-beneath-surface-fish-welfare-european-aquaculture

Eurogroup for Animals & Compassion in World Farming. (2018). *European public perceptions of fish welfare: Factsheet*. Data from research conducted by ComRes, April 30 – May 8, 2018. https://www.eurogroupforanimals.org/library/european-public-perceptions-fish-welfare

European Commission. (n.d.). *Aquaculture types*. EU Aquaculture Assistance Mechanism. https://aquaculture.ec.europa.eu/about/aquaculture-types

European Commission. (n.d.) *Common Fisheries Policy (CFP).* https://oceans-and-fisheries.ec.europa.eu/policy/common-fisheries-policy-cfp_en

European Commission. (n.d.). *Olivér Várhelyi.* https://commission.europa.eu/about/organisation/college-commissioners/oliver-varhelyi_en

European Commission. (n.d.). *What are the advantages and key challenges of Recirculating Aquaculture Systems (RAS)?* EU Aquaculture Assistance Mechanism. https://aquaculture.ec.europa.eu/faq/8-what-are-advantages-and-key-challenges-recirculating-aquaculture-systems-ras

European Commission. (2017). *Welfare of farmed fish: Common practices during transport and at slaughter.* Final Report. https://www.slu.se/globalassets/ew/org/centrb/scaw-nationellt-centrum-for-djurvalfard/kontaktpunkter/kontaktpunkt-slakt/efsa-fisk/welfare-of-farmed-fish.pdf

European Commission. (2018). *Report from the Commission to the European Parliament and the Council on the possibility of introducing certain requirements regarding the protection of fish at the time of killing*. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52018DC0087

European Commission. (April 29, 2022). *Removing lice with PHOTOLICER is no lousy job*. Directorate-General for Maritime Affairs and Fisheries. https://oceans-and-fisheries.ec.europa.eu/news/removing-lice-photolicer-no-lousy-job-2022-04-29_en

European Commission. (October 4, 2022). *Fitness Check of the EU Animal Welfare Legislation.* https://food.ec.europa.eu/system/files/2022-10/aw_eval_revision_swd_2022-328_en.pdf

European Parliament resolution of 18 January 2024 on the state of play in the implementation of the Common Fisheries Policy and future perspectives (2021/2169(INI)). https://www.europarl.europa.eu/doceo/document/TA-9-2024-0045_EN.pdf

European Union. (n.d.). *Animal welfare*. https://eur-lex.europa.eu/EN/legal-content/glossary/animal-welfare.html

EUROSTAT. (May 21, 2024). *Decline in EU livestock population in 2023*. https://ec.europa.eu/eurostat/web/products-eurostat-news/w/ddn-20240521-2#:~:text=In%202023%2C%20the%20EU%27s,sheep%2C%20and%2011%20million%20goats

EUROSTAT. (2024). *Aquaculture statistics.* https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Aquaculture_statistics#EU_Aquaculture

Fabrice, T. (2021). *Fish domestication in aquaculture: 10 unanswered questions*. Animal Frontiers, 11(3):87-91. https://doi.org/10.1093/af/vfab012

FAO. (n.d.). *Aquaculture*. Fisheries and Aquaculture. https://www.fao.org/fishery/en/topic/16064

FAO. (n.d.). *Common carp - Natural food and feeding habits.* https://www.fao.org/fishery/affris/species-profiles/common-carp/natural-food-and-feeding-habits/en/

FAO. (n.d.). *Simple Methods for Aquaculture.* Handbook on fish farming. Chapter 12. https://www.fao.org/fishery/static/FAO_Training/FAO_Training/General/x6709e/Index.htm

FAO. (2000). *The State of World Fisheries and Aquaculture.* Part 1. https://www.fao.org/4/x8002e/x8002e04.htm#:~:text=Starting%20from%20an%20insignificant%20total,percent%20per%20year%20since%201990

FAO. (2009a). *Oncorhynchus mykiss*. In: Cultured aquatic species fact sheets. Text by Cowx, I. G. Edited and compiled by Crespi, V. and New, M. https://www.fao.org/fishery/docs/CDrom/aquaculture/I1129m/file/en/en_rainbowtrout.htm

FAO. (2009b). *Salmo salar*. In: Cultured aquatic species fact sheets. Text by Jones, M. Edited and compiled by Crespi, V. and New, M. https://www.fao.org/fishery/docs/CDrom/aquaculture/I1129m/file/en/en_atlanticsalmon.htm#:~:text=Sea%20cage%20culture%20was%20first,Chile%20and%20Australia%20(Tasmania)

FAO. (2022). *The State of World Fisheries and Aquaculture 2022*. *Towards Blue Transformation*. Rome. https://doi.org/10.4060/cc0461en

FAO. (2025). *Cyprinus carpio.* Cultured Aquatic Species Information Programme. Text by Peteri, A. In: *Fisheries and Aquaculture*. Updated 2005-07-12. https://www.fao.org/fishery/en/culturedspecies/cyprinus_carpio/en

FAO. (2024). *The State of World Fisheries and Aquaculture 2024*. *Blue Transformation in action*. Rome. https://doi.org/10.4060/cd0683en

Farrow, H. (2023, April 14). *What is aquaculture? It may be the solution to overfishing.* National Geographic. https://www.nationalgeographic.com/environment/article/aquaculture-explainer-seaweed-fish-benefits-challenges

FAWC. (1996). *Report on the welfare of farmed fish*. https://assets.publishing.service.gov.uk/media/5a7dfff2ed915d74e6223727/FAWC_report_on_the_welfare_of_farmed_fish.pdf

FAWC. (October 2009). *Farm Animal Welfare in Great Britain: Past, Present and Future.* https://assets.publishing.service.gov.uk/media/5a7d89fe40f0b64fe6c24508/Farm_Animal_Welfare_in_Great_Britain_-_Past__Present_and_Future.pdf

FEAP. (2023). *European Aquaculture Production Report 2015-2021*. https://feap.info/wp-content/uploads/2023/04/2023-04-05-production-report-2023.pdf

Fraser, D. (2009). *Assessing animal welfare: different philosophies, different scientific approaches.* Zoo biology, 28(6):507-518. https://doi.org/10.1002/zoo.20253

FSBI. (2002). *Fish Welfare.* Briefing Paper 2, 82A High Street, Sawston, Cambridge. https://www.fsbi.org.uk/wp-content/uploads/2018/02/brief-welfare-norefs.pdf

Garlock, T., Asche, F., Anderson, J., Bjørndal, T., Kumar, G., Lorenzen, K., Ropicki, A., Smith, M.D., Tveterås, R. (2019). *A Global Blue Revolution: Aquaculture Growth Across Regions, Species, and Countries.* Reviews in Fisheries Science & Aquaculture, 28(1), 107–116. https://doi-org.ezproxy.library.wur.nl/10.1080/23308249.2019.1678111

Gimenéz-Candela, M., Saraiva, J.L., Bauer, H. (2020). *The legal protection of farmed fish in Europe – analysing the range of EU legislation and the impact of international animal welfare standards for the fishes in European aquaculture*, dA. Derecho Animal (Forum of Animal Law Studies) 11/1, 71. https://doi.org/10.5565/rev/da.460

Guadarrama, E., Spahic, A., Nosten, P., Alexandre, M., Faber, I., Schouteten, J., Rini, L., Bom Frøst, M., de Steur, H. (2023). *Evolving appetites: an in-depth look at European attitudes towards plant-based eating*. Smart protein project. ProVeg International, Innova Market Insights, University of Copenhagen, & Ghent University. Chapter 1, 8-18. https://smartproteinproject.eu/wp-content/uploads/Smart-Protein-European-Consumer-Survey_2023_overview.pdf

Harrison, R. (1964). *Animal machines– the new factory farming industry*. Vincent Stuart Publishers Ltd. London. https://archive.org/details/animalmachines0000harr/page/n9/mode/2up

Hellenbrecht, L. M., Utne, K. R., Karlsen, Ø., Glover, K. A., & Wennevik, V. (2023). *Diet analysis of Atlantic salmon (Salmo salar) post-smolts after the ecological regime shift in the Northeast Atlantic*. Fisheries Research, 262:106672. https://doi.org/10.1016/j.fishres.2023.106672

Hoseinifar, S.H., Ashouri, G., Marisaldi, L., Candelma, M., Basili, D., Zimbelli, A., Notarstefano, V., Salvini, L., Randazzo, B., Zarantoniello, M., Pessina, A., Sojan, J.M., Vargas, A., Carnevali, O. (2024). *Reducing the Use of Antibiotics in European Aquaculture with Vaccines, Functional Feed Additives and Optimization of the Gut Microbiota*. Journal of Marine Science and Engineering, 12, 204. https://iris.univpm.it/retrieve/be4fb3f7-4fc7-4308-bd00-a43f7226d284/Hoseinifar_Reducing-Use-Antibiotics-European-Aquaculture_2024.pdf

Hu, F., Zhong, H., Wu, C., Wang, S., Guo, Z., Tao, M., Zhang, C., Gong, D., Gao, X., Tang, C., Wei, Z., Wen, M., & Liu, S. (2021). *Development of fisheries in China.* Reproduction and Breeding, 1(1):64-79. https://doi.org/10.1016/j.repbre.2021.03.003

Hydrolicer™. (n.d.). Smir. https://smir.no/products/hydrolicer/?lang=en

Jones, M., & Sloman, K. A. (2024). *Fish welfare.* In S. L. Alderman & T. E. Gillis (Eds.), Encyclopedia of Fish Physiology (Second Edition), 429–436. Academic Press. https://www.sciencedirect.com/topics/immunology-and-microbiology/stocking-density#:~:text=Stocking%20density%20refers%20to%20either,inhabit%20a%20three%2Ddimensional%20environment.

Key, B. (2016). Why fish do not feel pain. *Animal Sentience, 3*(1), 1-17. https://doi.org/10.51291/2377-7478.1011

Kiessling, A., van de Vis, H., Flik, G., & Mackenzie, S. (2012). *Welfare of farmed fish in present and future production systems*. Fish physiology and biochemistry, 38, 1-3. https://doi.org/10.1007/s10695-011-9594-9

Korwin-Kossakowski, M. (2012). *Fish hatching strategies: A review.* Reviews in Fish Biology and Fisheries, 22, 225-240. https://doi.org/10.1007/s11160-011-9233-7

Laastad, T. (November 22, 2022). *Thermolicer effectively treats sea lice with thermal technology.* Business Norway. https://businessnorway.com/solutions/thermolicer-effectively-treats-sea-lice-with-thermal-technology

Lines, J. A., & Spence, J. (2012). *Safeguarding the welfare of farmed fish at harvest. Fish physiology and biochemistry*, 38, 153-162. https://doi.org/10.1007/s10695-011-9561-5

Lines, J. A., & Spence, J. (2014). *Humane harvesting and slaughter of farmed fish.* Revue scientifique et technique (International Office of Epizootics), 33(1):255-264. https://doi.org/10.20506/rst.33.1.2284

Lovely, G. (March 16, 2023). *Pescetarians are responsible for many more animal deaths than regular meat eaters*. VOX. https://www.vox.com/future-perfect/23639475/pescetarian-eating-fish-ethics-vegetarian-animal-welfare-seafood-fishing-chicken-beef-climate

Lund, V., M. Mejdell, C., Röcklinsberg, H., Anthony, R., Håstein, T. (2007). *Expanding the moral circle: farmed fish as objects of moral concern.* Diseases of Aquatic Organisms, 75:109–118. https://www.int-res.com/articles/dao_oa/d075p109.pdf

Lymbery, P. (1992). *The welfare of farmed fish*. Compassion in World Farming. Petersfield, Hampshire.

Mancuso, M. (Last update: June 22, 2022). *Allevamento di pesci: 5 foto per capire cos'è e come funziona l'acquacoltura*. Essere Animali. https://www.essereanimali.org/2021/06/5-foto-acquacoltura/

Martinez, A. S., Willoughby, J. R., & Christie, M. R. (2018). *Genetic diversity in fishes is influenced by habitat type and life-history variation*. Ecology and evolution, 8(23):12022–12031. https://doi.org/10.1002/ece3.4661

Martinez, J., & Nolting, C. von. (2023). *Review: "Animal welfare" – A European concept*. Animal, 17(4), 100839. https://doi.org/10.1016/j.animal.2023.100839

Medway, L. (1980). *Report of the panel of inquiry into shooting and angling* (1976–1979). Panel of Enquiry into Shooting and Angling. Horsham.

Miralles, A., Raymond, M. & Lecointre, G. (2019). *Empathy and compassion toward other species decrease with evolutionary divergence time.* Scientific Reports 9, 19555. https://doi.org/10.1038/s41598-019-56006-9

Mood, A., Lara, E., Boyland, N.K., Brooke, P. (2023). *Estimating global numbers of farmed fishes killed for food annually from 1990 to 2019*. Animal Welfare, 32, e12, 1–16 https://doi.org/10.1017/awf.2023.4

MOWI. (2024). *Salmon Farming Industry Handbook.* *https://mowi.com/wp-content/uploads/2024/05/2024-Salmon-Industry-Handbook.pdf*

Müller, T., Ferincz, Á., Weiperth, A. , Ivánovics, B., Tóth B, Bógó, B., Horváth, J., Urbányi, B., Specziár, A. (2024). *Uncommon life history and winter spawning of common carp (Cyprinus carpio) in a natural thermal spring, under temperate climate*. Fish Physiology and Biochemistry, 50, 2043–2051. https://doi.org/10.1007/s10695-024-01305-w

Mylonas, C. C. & Pavlidis M. A. (2011). (Eds.): *'Sparidae: biology and aquaculture of gilthead sea bream and other species'.* Aquaculture International, 19, 809–810. https://doi.org/10.1007/s10499-011-9455-7

Oddsson, G. (2020). *A Definition of Aquaculture Intensity Based on Production Functions—The Aquaculture Production Intensity Scale (APIS)*. Water, 12(3), 765. https://doi.org/10.3390/w12030765

Pavlidis, M., Papaharisis, L., Adamek, M., Steinhagen, D., Jung-Schroers, V., Kristiansen, T., Theodoridi, A., Otero Lourido, F. (2023). *Animal welfare of farmed fish*. Research for PECH Committee, European Parliament, Policy Department for Structural and Cohesion Policies, Brussels. https://www.europarl.europa.eu/RegData/etudes/STUD/2023/747257/IPOL_STU(2023)747257_EN.pdf

Pottinger, T.G. (1995). *Fish welfare literature review*. Institute of Fresh Water Ecology, IFE Report No. WI/T11063f7/1. https://nora.nerc.ac.uk/id/eprint/7223/1/Fish_Welfare_Literature_Review_-_TG_Pottinger_-_1995.pdf

Proposal for a Regulation of the European Parliament and of the Council on the protection of animals during transport and related operations, amending Council Regulation (EC) No 1255/97 and repealing Council Regulation (EC) No 1/2005. https://food.ec.europa.eu/system/files/2023-12/aw_in-transit_reg-proposal_2023-770_0.pdf

Rainbow Trout. (n.d.). National Geographic. https://www.nationalgeographic.com/animals/fish/facts/rainbow-trout#:~:text=They%20are%20torpedo%2Dshaped%20and,on%20their%20back%20and%20fins

Rasul, M. & Majumdar, B. (2017). *Abuse of antibiotics in aquaculture and its effects on human, aquatic animal and environment*. The Saudi Journal of Life Sciences, 2(3):81-88. https://saudijournals.com/media/articles/SJLS-2381-88.pdf

Regan, T. (1983). *The case for animal rights.* Routledge & Kegan Paul. London.

Rogers, A.J. (2024). *Aquaculture in the Ancient World: Ecosystem Engineering, Domesticated Landscapes, and the First Blue Revolution*. Journal of Archaeological Research, 32, 427–491. https://doi.org/10.1007/s10814-023-09191-1

Rojek, B. (July 2021). *Protection of animals during transport.* European Parliamentary Research Service (EPRS). https://www.europarl.europa.eu/RegData/etudes/BRIE/2021/690708/EPRS_BRI(2021)690708_EN.pdf

Rollin, B. (1989). *Studies in bioethics. The unheeded cry: animal consciousness, animal pain and science.* Oxford University Press. New York.

Rose, J. D. (2002). *The neurobehavioral nature of fish and the question of awareness and pain.* Reviews in Fisheries Science 10(1):1-38. https://www.researchgate.net/publication/247933362_The_Neurobehavioral_Nature_of_fish__and_the_Question_of_Awareness_and_Pain

Rose, J. D., Arlinghaus, R., Cooke, S.J., Diggles, B.K, Sawynok, W., Stevens, E.D., Wynne, C.D.L. (2014). *Can fish really feel pain?* Fish and Fisheries, 15(1):97-133. https://doi.org/10.1111/faf.12010

Salmon. (n.d.). National Geographic. https://www.nationalgeographic.com/animals/fish/facts/salmon

Sánchez-Suárez, W., Franks, B., & Torgerson-White, L. (2020). F*rom Land to Water: Taking Fish Welfare Seriously.* Animals, 10(9), 1585. https://doi.org/10.3390/ani10091585

Saraiva, J. L., Arechavala-Lopez, P., Cabrera-Álvarez, M. J. & Waley, D. (2021). Research for ANIT Committee – *Particular welfare needs in animal transport: aquatic animals*. European Parliament. Policy Department for Structural and Cohesion Policies. Brussels. https://www.europarl.europa.eu/RegData/etudes/STUD/2021/690875/IPOL_STU(2021)690875_EN.pdf

Schiewe, M. H., & Kareiva, P. (2001). *Salmon*. In S. A. Levin (Ed.), Encyclopedia of Biodiversity, 5:233-243. Elsevier. https://doi.org/10.1016/B0-12-226865-2/00239-X

Schreck, C.B. (1981). *Stress and Compensation in Teleostean fish : Response to Social and Physical Factors*. In: Pickering, A.D., Ed., *Stress and Fish*, Academic Press, London.

Schreck, C.B. (1990). *Physiological, behavioral, and performance indicators of stress.* American Fisheries Society Symposium, 8:29-37.

Segner, H., Reiser, S., Ruane, N., Rösch, R., Steinhagen, D. and Vehanen, T. (2019). *Welfare of fishes in aquaculture*. FAO Fisheries and Aquaculture Circular No. 1189. Budapest, FAO. https://openknowledge.fao.org/server/api/core/bitstreams/b9f2e11b-d893-47be-96b7-957952f49148/content

Shahbandeh, M. (March 12, 2024). *Salmon industry - statistics & facts.* Statista. https://www.statista.com/topics/7411/salmon-industry/#topicOverview

Singer, P. (1975). *Animal liberation. A new ethics for our treatments of animals.* Harper Collins, New York.

Sneddon, L. U. (2002). *Anatomical and electrophysiological analysis of the trigeminal nerve in a teleost fish, Oncorhynchus mykiss*. Neuroscience letters, 319(3):167–171. https://doi.org/10.1016/s0304-3940(01)02584-8

Sneddon, L. U., Braithwaite, V. A., & Gentle, M. J. (2003). *Do fishes have nociceptors? Evidence for the evolution of a vertebrate sensory system*. Proceedings. Biological sciences, 270(1520): 1115–1121. https://doi.org/10.1098/rspb.2003.2349

Sneddon, L. U., Lopez-Luna, J., Wolfenden, D. C. C., Leach, M. C., Valentim, A. M., Steenbergen, P. J., Bardine, N., Currie, A. D., Broom, D. M., & Brown, C. (2018). *Fish sentience-denial:muddying the waters.* Animal Sentience, 3(21): 1-11. https://animalstudiesrepository.org/animsent/vol3/iss21/1/

Species - Rainbow Trout. (n.d.). NewTechAqua. https://www.newtechaqua.eu/specie/rainbow-trout/

Spezzani, C., Ruffo, G., Fabris, A., Mordenti, O., Manfrin, A., Salati, F., Giorietto, F., Salogni, C. (2018). *Manuale per la gestione del controllo del benessere dei pesci durante il trasporto su strada*. Ministero della Salute. Nota protocollo N. 2705/2017/436-317CS. https://www.salute.gov.it/imgs/C_17_pubblicazioni_2848_allegato.pdf

Stien, L. H., Bracke, M. B. M., Noble, C., & Kristiansen, T. S. (2020). *Assessing fish welfare in aquaculture*. In T. S. Kristiansen, A. Fernö, M. A. Pavlidis, & H. van de Vis (Eds.), The Welfare of Fish; Vol. 20, No. 1, 303-321. Springer. https://doi.org/10.1007/978-3-030-41675-1_13

Streeter, E. C. (2023). *A Short Anthology of Short Poems*. Selected Readings Editions. https://static1.squarespace.com/static/631b84989ceff12e89eb0633/t/648b79575021fe1b1034e7ce/1686862167737/b+Poetry+-+sample+-+GP.pdf

Tang, S., Thorarensen, H., Brauner, C.J., Wood, C.M., Farrell A.P. (2009). *Modeling the accumulation of CO2 during high density, re-circulating transport of adult Atlantic salmon, Salmo salar, from observations aboard a sea-going commercial live-haul vessel.* Aquaculture 296(1-2):102-109. https://www.sciencedirect.com/science/article/pii/S004484860900655 3?via%3Dihub

Torrella, K. (March 2, 2021). *The next frontier for animal welfare: Fish.* Vox. https://www.vox.com/future-perfect/22301931/fish-animal-welfare-plant-based

Vandeputte, M., Gagnaire, P. A., & Allal, F. (2019). *The European sea bass: a key marine fish model in the wild and in aquaculture.* Animal genetics, 50(3):195-203. https://doi.org/10.1111/age.12779

Wageningen University and Research. (n.d.). *Recirculating aquaculture systems (RAS).* https://www.wur.nl/nl/onderzoek-resultaten/leerstoelgroepen/dierwetenschappen/aquaculture-and-fisheries/wageningen-aquaculture-research-education-w-are/recirculating-aquaculture-systems-ras.htm

Webster J. (2016). *Animal Welfare: Freedoms, Dominions and "A Life Worth Living".* Animals, 6(6), 35, 1-6. https://doi.org/10.3390/ani6060035

Who is the salmon? (n.d.). CIWF. https://www.compassionfoodbusiness.es/media/7440680/who-is-the-salmon.pdf

WOAH. (29 May 2002). Resolution No. XIV. https://www.woah.org/en/who-we-are/structure/framework/basic-texts/new-mandates/

Zander, K., & Feucht, Y. (2017). *Consumers' Willingness to Pay for Sustainable Seafood Made in Europe*. Journal of International Food & Agribusiness Marketing, 30(3):251–275. https://doi.org/10.1080/08974438.2017.1413611

Multimedia sources:

Animal Equality Italia. (August 4, 2021). *Sofferenza senza voce: inchiesta negli allevamenti di pesce in India.* [Video]. Youtube. https://www.youtube.com/watch?v=5AjcNGknzSY

Catch Welfare Platform. (November 21, 2024). *CWP24: Douglas Waley - Public attitudes to aquatic animal welfare from around the world.* [Video]. YouTube. https://www.youtube.com/watch?v=WVLfmO7kbBM

De Augustinis, F. (2024). *Until the end of the world* [Film]. ONE EARTH.

Essere Animali. (October 18, 2018). *Allevamenti intensivi di pesci: prima indagine in Europa* [Video]. YouTube. https://www.youtube.com/watch?v=wImDWAA_ALc

Essere Animali. (January 15, 2020). *Le problematiche degli allevamenti intensivi di pesci in Grecia.* [Video]. Youtube. https://www.youtube.com/watch?v=zZXu1LtYbkA

Essere Animali. (March 23, 2021). *immagini shock: indagine negli allevamenti di salmoni in Scozia.* [Video]. Youtube. https://www.youtube.com/watch?v=1kZTqbwne0Q

Essere Animali. (May 11, 2021). *Nuova indagine: il lato oscuro degli allevamenti di pesci in Grecia.* [Video]. Youtube.

Essere Animali. (June 28, 2022). I pesci negli allevamenti europei. [Video]. Youtube. https://www.youtube.com/watch?v=Yun0u5ynRoY

EU Environment. (May 17, 2016). *Aquaculture & Sustainability – Science for Environment Policy*. [Video]. Youtube. https://www.youtube.com/watch?v=40ABPqP6Rc8

Tabrizi, A. (2021). *Seaspiracy* [Film]. A.U.M. Films, Disrupt Studios. Netflix.

Freshwater Fisheries Society of BC. (March 8, 2011). *Go Fish BC: Trout egg incubation* [Video]. YouTube. https://www.youtube.com/watch?v=fF2oqubO9Ow

Will Media. (2022, January 12). *L'acquacoltura è una soluzione per una pesca più sostenibile?* [Video]. Youtube. https://www.youtube.com/watch?v=j-DDoSPQv8M&t=2s

Legal references:

International legal instruments:

- European Convention for the protection of animals during international transport, adopted by Council of Europe on 13 December 1968. CETS No. 065. https://www.coe.int/en/web/conventions/full-list/-/conventions/treaty/065

- European Convention for the protection of animals kept for farming purposes, adopted by the Council of Europe on 10 March 1976. CETS No. 087. https://www.coe.int/en/web/conventions/full-list/-/conventions/treaty/087

- Recommendation concerning farmed fish, adopted by the Standing Committee of the European Convention for the Protection of Animals kept for Farming Purposes on 5 December 2005. https://www.coe.int/t/e/legal_affairs/legal_co-operation/biological_safety_and_use_of_animals/farming/rec%20fish%20e.asp

- WOAH. (2024). *Aquatic Animal Health Code* (26th Ed.). https://www.woah.org/en/what-we-do/standards/codes-and-manuals/aquatic-code-online-access/

- WOAH. (2024). *Terrestrial Animal Health Code.* (31st Ed.). https://www.woah.org/en/what-we-do/standards/codes-and-manuals/terrestrial-code-online-access/

EU Binding Legislation:

- Consolidated Version of the Treaty on the Functioning of the European Union (2016/C 202/1). https://eur-lex.europa.eu/resource.html?uri=cellar:9e8d52e1-2c70-11e6-b497-01aa75ed71a1.0006.01/DOC_3&format=PDF

- Council Directive 74/577/EEC of 18 November 1974 on stunning of animals before slaughter. (Date of end of validity: 01/01/1995). https://eur-lex.europa.eu/eli/dir/1974/577/oj/eng

- Council Directive 98/58/EC of 20 July 1998 concerning the protection of animals kept for farming purposes. https://eur-lex.europa.eu/eli/dir/1998/58/oj

- Council Directive 1999/74/EC of 19 July 1999 laying down minimum standards for the protection of laying hens. https://eur-lex.europa.eu/eli/dir/1999/74/oj/eng

- Council Directive 2007/43/EC of 28 June 2007 laying down minimum rules for the protection of chickens kept for meat production. https://eur-lex.europa.eu/eli/dir/2007/43/oj/eng

- Council Directive 2008/119/EC of 18 December 2008 laying down minimum standards for the protection of calves. https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A32008L0119

- Council Directive 2008/120/EC of 18 December 2008 laying down minimum standards for the protection of pigs. http://eur-lex.europa.eu/eli/dir/2008/120/oj/eng

- Council Regulation (EC) No 788/96 of 22 April 1996 on the submission by Member States of statistics on aquaculture production. (Date of end of validity: 31/12/2008). https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:31996R0788

- Council Regulation (EC) No 1/2005 of 22 December 2004 on the protection of animals during transport and related operations and amending Directives 64/432/EEC and 93/119/EC and Regulation (EC) No 1255/97. https://eur-lex.europa.eu/eli/reg/2005/1/oj/eng

- Council Regulation (EC) No 1099/2009 of 24 September 2009 on the protection of animals at the time of killing. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02009R1099-20191214

- Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety.

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02002R0178-20240701

- Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02013R1380-20230101

- Regulation (EU) 2016/429 of the European Parliament and of the Council of 9 March 2016 on transmissible animal diseases and amending and repealing certain acts in the area of animal health (Animal Health Law). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02016R0429-20210421

- Regulation (EU) 2018/848 of the European Parliament and of the Council of 30 May 2018 on organic production and labeling of organic products and repealing Council Regulation (EC) No 834/2007. https://eur-lex.europa.eu/eli/reg/2018/848/oj

Soft law initiatives:

- APROMAR. (2022). *A guide on fish welfare in Spanish aquaculture - Volume 1: Concepts and generalities*. Spanish Aquaculture Business Association. https://apromar.es/wp-content/uploads/2024/04/guia_wellfare_eng_web.pdf
- APROMAR. (2024a). *A guide on fish welfare in Spanish aquaculture - Volume 2: Welfare of European sea bass.* Spanish Aquaculture Business Association. https://drive.google.com/file/d/1jTrcY6PZP2UFYXMYiDKeyaMRWYcW2hua/view
- APROMAR. (2024b). *A guide on fish welfare in Spanish aquaculture - Volume 3: Welfare of gilthead sea bream.* Spanish Aquaculture Business Association. https://drive.google.com/file/d/1Xp7Z-H53U_ZRmLf-cTFjCvs3dnHA-vOg/view

- EFSA:

    - EFSA. (2004a). *Opinion of the Scientific Panel on Animal Health and Welfare (AHAW) on a request from the Commission related to the welfare of animals during transport*. The EFSA Journal, 2(5):44, 1-36. https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2004.44

    - EFSA. (2004b). *Opinion of the Scientific Panel on Animal Health and Welfare on a request from the Commission related to welfare aspects of the main systems of stunning and killing the main commercial species of animals*. The EFSA Journal, 45, 1–29. https://doi.org/10.2903/j.efsa.2004.45

    - EFSA. (2008a). *Scientific Opinion of the Panel on Animal Health and Welfare on a request from the European Commission on Animal welfare aspects of husbandry systems for farmed Atlantic salmon*. The EFSA Journal, 736-Annex II, 1–31. https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2008.736

- EFSA. (2008b). *Scientific Opinion of the Panel on Animal Health and Welfare on a request from the European Commission on animal welfare aspects of husbandry systems for farmed European seabass and Gilthead seabream*. The EFSA Journal, 844, 1-21. https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2008.844

- EFSA. (2008c). *Scientific Opinion of the Panel on Animal Health and Welfare on a request from the European Commission on animal welfare aspects of husbandry systems for farmed fish: carp*. The EFSA Journal, 843, 1-28. https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2008.843

- EFSA. (2008d). *Scientific Opinion of the Panel on Animal Health and Animal Welfare on a request from the European Commission on the Animal welfare aspects of husbandry systems for farmed trout*. The EFSA Journal, 796, 1-22. https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2008.796

- EFSA. (2008e). *Scientific Opinion of the Panel on Animal Health and Welfare on a request from the European Commission on Animal Welfare Aspects of Husbandry Systems for Farmed European Eel*. The EFSA Journal, 809, 1-18. https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2008.809

- EFSA. (2009). *Scientific Opinion of the Panel on Animal Health and Welfare on a request from European Commission on General approach to fish welfare and to the concept of sentience in fish*. The EFSA Journal, 954, 1–26. https://doi.org/10.2903/j.efsa.2009.954

- EFSA. (2009a). *Scientific Opinion of the Panel on Animal Health and Welfare on a request from the European Commission on welfare aspect of the main systems of stunning and killing of farmed seabass and seabream*. The EFSA Journal, 1010, 1-52. https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2009.1010

- EFSA. (2009b). *Scientific Opinion of the Panel on Animal Health and Welfare on a request from the European Commission on welfare aspect of the main systems of stunning and killing of farmed turbot*. The EFSA Journal, 1073, 1-34. https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2009.1073

- EFSA. (2009c). *Scientific Opinion of the Panel on Animal Health and Welfare on a request from the European Commission on Species-specific welfare aspects of the main systems of stunning and killing of farmed rainbow trout*. The EFSA Journal, 1013, 1-55. https://doi.org/10.2903/j.efsa.2009.1012

- EFSA. (2009d). *Scientific Opinion of the Panel on Animal Health and Welfare on a request from the European Commission on welfare aspect of the main systems of stunning and killing of farmed Atlantic salmon*. The EFSA Journal, 1012, 1-77. https://doi.org/10.2903/j.efsa.2009.1011

- EFSA. (2009e). *Scientific Opinion of the Panel on Animal Health and Welfare on a request from the European Commission on Species-specific*

welfare aspects of the main systems of stunning and killing of farmed carp. The EFSA Journal, 1013, 1-37. https://efsa.onlinelibrary.wiley.com/doi/abs/10.2903/j.efsa.2009.1013

- EFSA. (2009f). *Scientific Opinion of the Panel on Animal Health and Welfare on a request from the European Commission on Species-specific welfare aspects of the main systems of stunning and killing of farmed tuna*. The EFSA Journal 1072, 1-53. https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2009.1072

- EFSA. (2009g). *Scientific Opinion of the Panel on Animal Health and Welfare on a request from the European Commission on welfare aspect of the main systems of stunning and killing of farmed eel (Anguilla anguilla).* The EFSA Journal 1014, 1-42. https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2009.1014

- EU Platform on Animal Welfare Own Initiative Group on Fish. (2020). *Guidelines on Water Quality and Handling for the Welfare of Farmed Vertebrate Fish*. https://food.ec.europa.eu/system/files/2022-07/aw_platform_plat-conc_guide_farmed-fish_en.pdf
- Pavlidis M. & Samaras A. (2020). *Mediterranean Fish Welfare: Guide to Good Practices and Assessment* Indicators. https://aquaculture.ec.europa.eu/system/files/2023-08/HAPO%20mediterranean%20fish%20welfare%20guide.pdf
- PerformFISH. (n.d.). *Mediterranean marine fish farming sector. Code of conduct*. http://performfish.eu/wp-content/uploads/2022/05/Performfish_MMFF-CoC.pdf

National Legislation:

- Basic Law for the Federal Republic of Germany in the revised version published in the Federal Law Gazette Part III, classification number 100-1, as last amended by the Act of 20 December 2024 (Federal Law Gazette 2024 I, no. 439). https://www.gesetze-im-internet.de/englisch_gg/englisch_gg.html#:~:text=The%20Parliamentary%20Council%2C%20meeting%20in,than%20two%20thirds%20of%20the
- Federal Constitutional Law of Austria (B-VG). https://www.ris.bka.gv.at/Dokumente/Erv/ERV_1930_1/ERV_1930_1.html
- Constitution of the Republic of Slovenia. https://www.constituteproject.org/constitution/Slovenia_2016
- Animal Welfare Act (TierSchG). https://www.gesetze-im-internet.de/tierschg/
- Italian Criminal Code. https://www.gazzettaufficiale.it/sommario/codici/codicePenale
- Organic Law 10/1995 of the Spanish Criminal Code. https://www.boe.es/buscar/act.php?id=BOE-A-1995-25444
- Animal Protection Livestock Ordinance. https://www.gesetze-im-internet.de/tierschnutztv/
- Animal Protection Transport Ordinance. https://www.gesetze-im-internet.de/tierschtrv_2009/
- Animal Welfare Slaughter Ordinance. https://www.gesetze-im-internet.de/tierschlv_2013/

- Order of 4 November 2008 amending the order of 8 June 2006 on the approval or authorisation of establishments placing on the market products of animal origin or foodstuffs containing products of animal origin. https://www.legifrance.gouv.fr/loda/id/JORFTEXT000019732796
- Legislative Decree No. 146 of 26 March 2001, implementing Directive 98/58/EC on the protection of animals kept for farming purposes. https://www.normattiva.it/uri-res/N2Ls?urn:nir:stato:decreto.legislativo:2001-03-26;146!vig=
- Royal Decree 348/2000 of 10 March 2000 transposing Directive 98/58/EC on the protection of animals kept for farming purposes. https://www.boe.es/buscar/act.php?id=BOE-A-2000-4698
- Presidential Decree 374/2001. Government Gazette 251/A/22-10-2001. https://www.e-nomothesia.gr/kat-agrotike-anaptukse/ktenotrophia/pd-374-2001.html
- Ministerial Decision 2481/289147/2020. Government Gazette 4646/B/21-10-2020. https://www.e-nomothesia.gr/kat-agrotike-anaptukse/upourgike-apophase-2481-289147-2020.html
- Royal Decree 990/2022 of 29 November 2022 on animal health and protection regulations during transport. https://www.boe.es/buscar/doc.php?id=BOE-A-2022-19912
- Royal Decree 728/2007 of 13 June 2007 establishing and regulating the General Register of Livestock Movements and the General Register of Individual Animal Identification. https://www.boe.es/buscar/act.php?id=BOE-A-2007-12694
- Joint Ministerial Decision 314754/2009 - Government Gazette 2025/B/18-9-2009. https://www.e-nomothesia.gr/kat-zoa-suntrophias-prostasia-zoon/koine-upourgike-apophase-314754-2009.html#google_vignette