AQUATIC LIFE INSTITUTE

Key Animal Welfare Recommendations for Aquaculture

March 2022

Statement of Purpose

Historically, aquatic animals have been excluded from meaningful animal welfare consideration. The best available evidence clearly establishes that most aquatic animals used for commercial production possess the neuroanatomical, behavioral, and physiological attributes that allow them to experience pain and suffering.[1,2] For this reason, the welfare of all farmed aquatic animals should be given ample consideration and respect within the aquaculture industry. Their treatment in farm systems must be rigorously reassessed with a focus on the individual qualitative experience of these animals.

This document aims to outline the Aquatic Animal Alliance's current positions based on the best available research and evidence-based interventions to improve on-farm fish welfare. We recognize that the recommendations discussed here are preliminary and will be updated as new information becomes available. Additionally, as global production is composed of both large and small-scale aquaculture facilities, welfare guidance should be adjusted accordingly.

This document provides context and justification for the AAA's positions on aquatic animal welfare. For a brief overview of our position on these concerns, please see our summary here.

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[1]Chandroo, Kris P., Ian JH Duncan, and Richard D. Moccia. "Can fish suffer?: perspectives on sentience, pain, fear and stress." Applied Animal Behaviour Science 86.3-4 (2004): 225-250.
[2]Sneddon, L. et al. "Do fishes have nociceptors? Evidence for the evolution of a vertebrate sensory system." Proceedings of the Royal Society of London. Series B: Biological Sciences 270 (2003): 1115 - 1121.

Contents:

Our definition of animal welfare

Animal welfare refers to the physical and mental state of an animal in relation to the conditions in which they live. In order to promote good welfare in captive animals, it is necessary to first determine what constitutes “good welfare” for a particular species using science-based measurements and assessment protocols. The most widely accepted paradigm is The Five Domains Model[3], a modernized version of the original Five Freedoms Model of animal welfare assessment developed in the mid 1960s[4]. The Five Domains Model is regularly updated to reflect significant developments in animal welfare science thinking, such as the emerging interactions between physiological (biological health) and psychological (subjective experience) aspects of animal welfare[5] and the critical importance of promoting positive experiences in addition to reducing pain and suffering in captivity[6]. The Five Domains Model is generally considered the gold standard of holistic animal welfare assessment criterion and is extensively used to monitor welfare across a vast variety of species and contexts, including animals living in zoos, laboratories, farms, and private homes around the world[7].

The Five Domains Model is outlined as follows:

1. Nutrition - the quality, quantity, and method of delivery of the water and food available to animals.
2. Physical Environment - the affective impacts of physical, sensory, and atmospheric conditions to which animals are exposed.
3. Health - the physiological and affective impacts of injury, disease, and varying levels of physical fitness.
4. Behavioural Interactions - behavioural evidence of hindered and/or enhanced expression of agency when animals interact with (1) their environment, (2) other non-human animals, and (3) human beings.
5. Mental State - psychological and affective consequences of domains 1-4.

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[3] Mellor DJ, Beausoleil NJ, Littlewood KE, McLean AN, McGreevy PD, Jones B, Wilkins C. The 2020 Five Domains Model: Including Human-Animal Interactions in Assessments of Animal Welfare. Animals (Basel). 2020 Oct 14;10(10):1870. doi: 10.3390/ani10101870.
[4] Mellor DJ. Updating Animal Welfare Thinking: Moving beyond the "Five Freedoms" towards "A Life Worth Living". Animals (Basel). 2016;6(3):21. Published 2016 Mar 14. doi:10.3390/ani6030021
[5] Fraser, D. (2008). Understanding animal welfare. *Acta Veterinaria Scandinavica*, 50(1), 1-7.
[6] Fraser, D., & Duncan, I. J. (1998). ‘Pleasures’,‘pains’ and animal welfare: toward a natural history of affect.
[7] Mellor DJ, Beausoleil NJ, Littlewood KE, McLean AN, McGreevy PD, Jones B, Wilkins C. The 2020 Five Domains Model: Including Human-Animal Interactions in Assessments of Animal Welfare. Animals (Basel). 2020 Oct 14;10(10):1870. doi: 10.3390/ani10101870.

The first four domains focus attention on factors that induce specific negative or positive subjective experiences, which contribute to the animal's mental state, as evaluated in the fifth domain.[8]

General principles

The following general principles underpin our welfare recommendations and policy positions.

- Animal welfare assessments must take into account physiological, psychological, behavioral and relational parameters. In practice, this means that striving to provide captive animals with a "life worth living"[9] involves engaging in appropriate husbandry practices (maintaining optimal environmental conditions, providing all individuals with a nutritionally balanced diet, providing appropriate health care and monitoring, etc.) as well as providing animals with opportunities for positive experiences, (provide animals with the opportunity to exercise choice, including access to environmental variability and species-appropriate enrichment and housing animals in species-appropriate social groups that minimize aggression while promoting appropriate social interaction). Together, these interventions should aim to provide animals with a significantly higher quality of life than that previously experienced in captivity.

- Where possible, consideration should be given to cultivating species that experience less dissatisfaction in captive environments (e.g. carps that naturally live in small ponds rather than highly migratory species)[10].

- Due to concerns regarding both animal welfare and resource efficiency, a shift towards herbivorous species is preferable. Every effort should be made to minimize the number of animals in the supply chain. This includes animals which are partially or fully utilized in the formulation of so-called 'aquafeed', and co-farming species such as cleaner fish. The only exception to this should be agroecological, integrated multi-trophic aquaculture (IMTA), integrated agriculture-aquaculture (IAA) systems[11], or other systems where species are co-farmed (polyculture), and the welfare of both animal species is improved by the inclusion of the other.

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[8] Ibid.

[9] Mellor DJ. Updating Animal Welfare Thinking: Moving beyond the "Five Freedoms" towards "A Life Worth Living". Animals (Basel). 2016;6(3):21. Published 2016 Mar 14. doi:10.3390/ani6030021

[10] T. Torgersen. Ornamental fish and aquaria. T.S. Kristiansen, A. Fernö, M.A. Pavlidis, H. van de Vis (Eds.), The Welfare of Fish, Springer (2020), pp. 363-374.

[11] Agroecology can be defined as the application of ecological principles to agricultural systems and practices.

- ➢ Every aquatic animal should be treated as a conscious individual with consideration given to their qualitative experience in every stage of the production cycle. Aquatic animals should be counted in heads of stock (number of individual animals), instead of by mass.

- ➢ Our methodology in reaching positions and conclusions relied on an effective altruism analysis, and interventions have been selected using an effective altruist framework:

    - More fish are farmed than any other animal group, by several orders of magnitude. Commercial fish production is a highly intensive process with up to millions of individuals being cultured during a single production cycle. As such, on a dollar-for-dollar basis, interventions aimed at improving fish welfare have the potential to be highly cost effective. Low survival rates, suboptimal growth, and prevalent disease outbreaks caused by poor welfare management can be extremely costly. Many of the measures we recommend are not only cost-effective for charitable donors, but have the potential to improve farm performance by promoting innovations.

- ➢ Where there is any doubt, the precautionary principle should be applied.

Current Priorities

Environmental Enrichment

Significance

The need for a holding environment with adequate enrichment is arguably one of the most neglected areas of aquatic animal welfare. The duration of time spent in the rearing environment (as compared to in transport, for example) makes the need for environmental enrichment (EE) a particularly important priority.

In order to be able to express their natural behaviors, aquatic animals must be provided with an enabling environment that is specific to their species and life-stage. To the extent that it is feasible, holding environments should be based on the preferred natural environment (in the wild) of the culture species thereby permitting the individuals to express behaviors important for their welfare (e.g., foraging, nesting, exhibiting choice and agency).

For understudied species for which literature is scarce or nonexistent, farmers should attempt different types of enrichment and monitor outcomes whilst encouraging further scientific studies.

Elements of Enrichment

Every effort should be made to give aquatic animals an environment which is suitable to their needs. This includes giving due consideration to the categories of enrichment presented by Näslund & Johnsson (2016).[12]

1. Social enrichment: Animals must have an appropriate amount of contact with conspecifics (members of their species) as determined by the species' life history combined with behavioral data collected in captivity. This includes sufficient access to schooling for shoaling species (such as Arctic charr), and appropriate stocking densities for species which may display aggressive or cannibalistic behaviour at certain density levels (such as Atlantic salmon). In any social interaction, animals should be provided with the choice to safely engage with, shelter/shield, hide, etc. from any other individual within the enclosure.
2. Occupational / physical enrichment: Animals should have the freedom to obtain the physical and mental stimulation required for the fulfillment of behavioral needs and desires. This can involve play, interactive feeding opportunities, and sufficient room to swim.
3. Structural enrichment: The animals' environment should provide species-appropriate structural complexity (e.g. shelter, suspended objects, substrate which can be used for nesting or burrowing).
    a. When providing structural enrichment, care must be taken to distribute it evenly in order to avoid the creation of higher-value areas of the holding environment thereby driving competition between conspecifics;
    b. The use of the enrichment by the animals should be monitored on an ongoing basis to ensure that it is not promoting aggression or territorial behaviour; and
    c. Structures should not impede any individual animals' access to essentials such as food and shelter..
4. Animals should have a diversity of visual, auditory, olfactory, tactile and taste stimuli ('sensory enrichment') in order to facilitate their proper development (e.g. appropriately colored walls in place of barren walls).
5. Animals should be provided 'dietary enrichment', meaning that their food is not only sufficiently nutritious but that the quantity of food, variety of food and the frequency of feeding is in line with the animal's natural feeding behaviour. Moreover, the feed delivery system should be suitably interactive.

[12] Näslund, J., & Johnsson, J. I. (2016). Environmental enrichment for fish in captive environments: effects of physical structures and substrates. Fish and Fisheries, 17(1), 1-30.

A fully annotated position statement on environmental enrichment is available [here](#).

Actionable strategy to improve environmental suitability:

Existing literature exploring the effects of environmental conditions and enrichment on fish welfare support our position that — appropriate lighting, partial tank covers, appropriate tank color, complexified feed delivery, appropriate in-water shelter and substrate provision necessary for behavioral expression, etc. — are likely to provide some level of benefit to most species of farmed aquatic animals[13,14].

Forms of environmental enrichment can be integrated into existing farm structures, requiring minimum disruption and capital investment. Implementing these interventions is a win-win situation for producers since they increase the welfare of the fish whilst also improving productivity through improved growth performance, body condition, resilience and reduced mortality.[15]

For producers that are just starting to implement environmental enrichment, it would make the most sense to start with the following seven interventions depending on the production system in question.:

1. Enclosure coloration
   - Tank colours, patterns or supplemental 2D impressions.
2. Substrate provision
   - Range of rock sizes from gravel to boulder.
3. Lighting
   - Optimal/natural photoperiods with access to natural or simulated daylight at intensities appropriate to the species in question.
4. Water flow
   - Introducing variations in the direction/velocity of the water current, interactive bubbles.
5. Structures
   - Submerged, mid-water column arrangements hanging from the surface or anchored to the bottom.
6. Shelter
   - Visual/physical barriers providing refuge from conspecifics (where appropriate) or adverse environmental conditions.
7. Feeding System
   - Suitable technique providing nutritional choice, optimal feeding intervals, and/or self-feeding adaptability.

All enrichment must be based on the best available science, be species- and life-stage relevant, and respond to emerging evidence.

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[13]Näslund, J. *et al*. "Hatchery tank enrichment affects cortisol levels and shelter-seeking in Atlantic salmon (*Salmo salar*)." *Canadian Journal of Fisheries and Aquatic Sciences* 70 (2013): 585-590.
[14]Gerber, B. *et al*. "Environmental Enrichment and its effects on welfare in fish." (2015).
[15] Aquatic Life Institute, *Environmental Enrichment Position Statement*, available at: https://tinyurl.com/y3n8gaq2

For species-specific EE recommendations see Appendix A.

Feed Composition

Significance

To reduce the suffering of sentient beings, the number of animals used in the fish-feed supply chain should be minimized. From a welfare perspective, feeding fish to other fish produces a huge amount of suffering. We calculate that more than a trillion aquatic animals are used as feed in aquaculture systems each year. These animals are sentient individuals with their own welfare concerns. Many are caught at sea, and/or slaughtered in a poorly regulated environment.

Early studies suggest that in some cases feed can be fully replaced by alternative protein with no evidence of welfare consequences for the animals.[16] We propose that animal-based fish feed should be replaced with alternative proteins to the extent that the evidence suggests this will not have a deleterious impact on the health and wellbeing of the fish, and the ecosystem.

In order to reduce the number of animals in the supply chain, producers must move toward the use of alternative feed products, mandating better feed efficiency ratios, farm extractive species, and use integrated agriculture-aquaculture systems where fish and their feed are co-produced. The industry as a whole should promote refraining from farming obligate carnivores such as Atlantic salmon, who require a significant amount of marine-based products in their food. These marine products, Fish Meal/Fish Oil (FMFO), must be prohibited in the feed of herbivorous and omnivorous aquatic species/life stages, where alternatives do not affect the animals and the ecosystem. Reducing the amount of FMFO used by the aquafeed industry would alleviate pressure on wild reduction fisheries and spare substantial suffering. Where obligate carnivores are farmed, the minimum amount of FMFO should be used while still ensuring good health and welfare.

Where animal products are required, the maximum proportion of animal products used should be sourced from industrial byproducts and offcuts from animal product consumption. The use of alternative feed products, such as algal oils, bio processed soybean meal, and lima bean flour, should be maximised to the extent that they do not impair health and welfare.

Producers must keep accurate records of what kinds of feed are being used, and justify the ration *qua* the welfare of the fish.

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[16] McLean, E., et al. "Complete replacement of fishmeal by soybean and poultry meals in Pacific whiteleg shrimp feeds: Growth and tolerance to EMS/AHPND and WSSV challenge." *Aquaculture* (2020): 735383.

Intervention Summary:

1. Where possible, the use of obligate carnivores in farming systems should be substituted for herbivores or omnivores which are fed a more herbivorous diet.
2. Extractive species should be preferred over all other species.
3. The use of Fish Meal/Fish Oil (FMFO) in the feed of herbivorous aquatic species/life stages should be prohibited.
4. Where obligate carnivores are farmed, the minimum amount of FMFO should be used while still ensuring good health.
5. Where FMFO is used, the maximum proportion of animal products used should be sourced from offcuts and byproducts of human animal consumption.
6. Alternative feed products, such as algal oils, bio processed soybean meal, and lima bean flour, should be used in the place of fish products, to the extent they do not impair health and welfare. The most sustainable alternative feed product should be preferred.
7. FMFO should be identified and quantified by the number of individual animals consumed per individual farmed aquatic animal. The animals used in fishmeal should be recorded by species and geographical sourcing.
8. Equal considerations must be given to all animals in the supply chain.

Note:

Appropriate feeding is critical for good fish welfare. Insufficient amounts of feed, or feed in an unavailable form (e.g. excessively large pellets or feeding in a location where smaller fishes are outcompeted) can result in poor health and welfare. Providing too much feed can cause poor water quality, which in turn will affect health and welfare. Producers should strive to provide appropriate feed formulations, in appropriate amounts. Feed must remain available to all fishes kept in the farm. Feeding practices should ensure that all feed inputs are sustainable, traceable, and minimized.

Starvation periods should only be used when absolutely necessary and when advised by a vet. Fasting should not exceed the minimum duration sufficient to ensure clearing of the guts, with 72 hours as the absolute maximum. Records need to be kept about why, when, and for how long feed was withheld from aquatic animals. Fasting may not be extended due to logistical concerns or off-flavor issues.

For species-specific feed recommendations see Appendix A.

Space Requirements & Stocking Density

Significance

As with terrestrial animals, the amount of space available to each animal, and the density at which the animals are stocked is highly important.

Stocking density is of utmost importance to fish welfare, as it produces a dynamic interplay with several critical welfare factors: water quality, conspecific aggression, and incidence of disease. Furthermore, fishes and other aquatic animals must have sufficient space to engage in important behaviors and species-appropriate social interactions[17]. Inappropriate stocking densities are associated with decreased growth, diminished nutritional uptake, reduction in feed conversion efficiency, fin erosion, gill damage, immunosuppression, inter-fish aggression[18], and disturbed movement activity.[19] It is also one of the most tractable areas of welfare, as no infrastructural investment is required to adjust stocking density. In most cases, the legal limits on stocking density are above the density recommended by the best available evidence.[20] Producers must keep records of both density and total space available to animals.

Ideal stocking densities are highly variable and largely dependent on species and life-stage[21]. For a full list of species-specific stocking density recommendations, see Appendix A.

Intervention Summary:

1. Individual aquatic animals must have access to sufficient space and total volume of water to exhibit their natural behaviors (e.g. foraging, nesting, etc.).
2. Aquatic animals should be stocked at a density no higher than the level which is shown to produce the lowest stress, lowest maladaptive behaviors, and lowest conspecific aggression. This is to be determined by the best available evidence.

For species-specific stocking density recommendations, see Appendix A.

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[17] Huntingford, F. A., Adams, C., Braithwaite, V. A., Kadri, S., Pottinger, T. G., Sandøe, P., & Turnbull, J. F. (2006). Current issues in fish welfare. Journal of fish biology, 68(2), 332-372.
[18] Ashley, Paul J. "Fish welfare: current issues in aquaculture." *Applied Animal Behaviour Science* 104.3-4 (2007): 199-235. p212.
[19] Anras, Marie-Laure Bégout, and Jean Paul Lagardère. "Measuring cultured fish swimming behaviour: first results on rainbow trout using acoustic telemetry in tanks." *Aquaculture* 240.1-4 (2004): 175-186.
[20] *Supra note 17.*
[21] "M. Borthwick, Salmon Welfare Report | Fish Welfare Initiative." https://www.fishwelfareinitiative.org/salmon-welfare.

Water Quality

Significance

Water quality is a generally accepted high priority welfare issue as it directly relates to animal survival. It is imperative to understand and adjust the quality of water according to specific needs of the animals in order to protect their welfare and ensure optimal health[22]. Principal water parameters to consider include the concentration of dissolved oxygen (DO), temperature, carbon dioxide, pH, turbidity, carbonate and total hardness, ammonia, salinity, nitrite, nitrate, phosphorus and dissolved metals.

While the optimal values of some water parameters such as pH, hardness, salinity and temperature are largely species-specific, some values are generally consistent across species and contexts. The following are examples of parameters that fall in the latter category.

Dissolved Oxygen (DO): DO distribution is highly variable within individual cages, with a high degree of vertical, horizontal, and temporal fluctuation. As a result of overcrowding, competition, or poor tank design, fishes are not always able to successfully navigate to a higher-oxygen area of their enclosure, an outcome associated with poor welfare and impaired growth[23].

The ideal dissolved oxygen concentration for most finfish is between 7 and 9 mg/l, though some species require slightly higher concentrations, such as brown trout (*Salmo trutta*), who require a concentration between 9 and 12 mg/l. Most fish cannot survive at concentrations below 3 mg/l of dissolved oxygen[24].

Nitrogenous wastes: The accumulation of nitrogenous waste products in closed aquaculture systems pose a significant threat to fish welfare[25]. Ammonia (NH_3), a product of protein catabolism and decomposition of organic materials in the environment, is toxic to finfish when present in sufficient quantities. Chronic exposure to low concentrations of ammonia can result in various undesirable sublethal effects, including tissue irritation, reduced growth, poor feed conversion and reduced disease resistance, while high concentrations of ammonia can lead to death[26]. Nitrite (NO_2^-) the result of ammonia nitrification, is also extremely toxic and can lead to severe hypoxia and death in relatively low concentrations[27].

[22] Segner, H., Sundh, H., Buchmann, K., Douxfils, J., Sundell, K. S., Mathieu, C., ... & Vaughan, L. (2012). Health of farmed fish: its relation to fish welfare and its utility as a welfare indicator. Fish physiology and biochemistry, 38(1), 85-105.
[23] Solstorm, David, et al. "Dissolved oxygen variability in a commercial sea-cage exposes farmed Atlantic salmon to growth limiting conditions." *Aquaculture* 486 (2018): 122-129.
[24] https://www.enr.gov.nt.ca/sites/enr/files/dissolved_oxygen.pdf
[25] J. Colt, D. Armstrong. Nitrogen toxicity to fish, crustaceans and molluscs, Bioengineering Symposium for Fish Culture, American Fisheries Society, Bethesda, MD (1981), pp. 34-47
[26] Randall, D. J., & Tsui, T. K. N. (2002). Ammonia toxicity in fish. Marine pollution bulletin, 45(1-12), 17-23.
[27] W.M. Lewis Jr., D.P. Morris. Toxicity of nitrite to fish: a review. Trans. Am. Fish. Soc., 115 (2) (1986), pp. 183-195

Carbon dioxide (CO_2): High levels of CO_2 are also detrimental to fish welfare. High CO_2 concentrations induce stress responses, increase nephrocalcinosis incidence, reduce feed intake and conversion, damage body condition and impair growth[28,29,30].

Intervention Summary:

Aquaculture sites should be carefully chosen or designed so as to ensure the adequate flow of clean water of suitable quality according to species' requirements. Water quality parameters must be regularly monitored at various depths and maintained in an optimal range for the species. The water quality risk assessment must be coupled with an action plan once poor water quality is detected. Producers must maintain accurate records of water quality parameters and publish data periodically and centrally.

1. Water quality (at least turbidity, total dissolved solids, oxygen, ammonia, carbon dioxide, temperature, pH, salinity and, in the freshwater context, nitrate) must be monitored regularly using an appropriate technical device for each parameter, with a frequency appropriate for both the species and the system in order to avoid deleterious impacts on welfare. Suboptimal water quality must be rectified as quickly as possible.
    a. Water quality parameters important to welfare include but are not limited to: dissolved oxygen (DO), temperature, carbon dioxide, pH, turbidity, carbonate and total hardness, ammonia, salinity, nitrite, nitrate, phosphorus and dissolved metals.
2. New facilities should be designed so as to ensure an adequate flow of clean water of suitable quality in the enclosures, according to the characteristics of the farm system and to the species' requirements.
3. Water parameters should remain stable whenever possible.

For species-specific water quality recommendations see Appendix A.

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[28]S. Fivelstad. Long-term carbon dioxide experiments with salmonids. Aquac. Eng., 53 (2013), pp. 40-48.
[29]C. Good, J. Davidson, C. Welsh, K. Snekvik, S.Summerfelt. The effects of carbon dioxide on performance and histopathology of rainbow trout Oncorhynchus mykiss in water recirculation aquaculture systems. Aquac. Eng., 42 (2010), pp. 51-56.
[30]D. Moran, J. Støttrup. The effect of carbon dioxide on growth of juvenile Atlantic cod Gadus morhua L. Aquat. Toxicol., 102 (2011), pp. 24-30.

Stunning and Slaughter

Significance

While stunning and slaughter represent a short duration of time in an aquatic animal's life, this is often a high suffering stage. This is another area where practices regarding aquatic animal welfare often lag far behind terrestrial animal practices, without any scientific justification for this disparate treatment. The World Organisation for Animal Health (OIE) 'Aquatic Animal Health Code' outlines conditions for humane slaughter of fish. This code states that "Effective stunning should be verified by the absence of consciousness",[31] and fishes should not regain consciousness before death.[32]

This means that the method used for stunning should be adequate for each species and shall render the aquatic animal immediately and fully unconscious (i.e. within one second by a scientifically-validated method) and not just immobilize the animal. Death must be induced without consciousness recovery. All stunning and slaughter equipment must be calibrated appropriately for the specific species to be processed, in order to achieve immediate and irreversible stun. A back-up system must be provided in case of primary equipment failure.

There has been a long debate among the members of the Alliance whether to include 'percussive stunning' as an acceptable slaughter technique. Our concern is that percussive stunning lacks consistency,[33] and that operators are unable to visually identify cases in which aquatic animals have been incorrectly stunned.[34] While percussive stunning is preferable to many other ways in which aquatic animals can be killed, our hope is to promote a more consistent and higher-welfare slaughter method. Our position on both percussive stunning and electrocution is grounded in contemporary science, and is subject to change if new evidence suggests otherwise.

It is also imperative that we acknowledge "pre-slaughter handling" as a crucial part of the animals' experience during the overall slaughtering process, which could include sudden disturbances, removal from water, withdrawal of food, crowding, and any associated transportation.

Intervention Summary:

A promising welfare ask for the slaughter of fish is to require stunning methods which are also the slaughter method, and so continuously lead from stunning to death with minimal chance of the animal regaining consciousness in the interim. The Humane

[31] 7.3.6.1(c)
[32] 7.3.6.1(d)
[33] European Food Safety Authority (EFSA). "Species-specific welfare aspects of the main systems of stunning and killing of farmed Atlantic Salmon." *EFSA Journal* 7.4 (2009): 1011.
[34] Lambooij, E., et al. "Percussion and electrical stunning of Atlantic salmon (Salmo salar) after dewatering and subsequent effect on brain and heart activities." *Aquaculture* 300.1-4 (2010): 107-112.

Slaughter Association recommends electrocution as a stunning method which also causes death, and the first such commercial machines have just entered into the market.[35,36]

Another higher-welfare solution for some species involves machines which electrically stun and then immediately decapitate. This is because electrical stunning methods (especially in-water pipeline stunning) are amongst the methods with the lowest rates of failure of all stunning methods, and immediate decapitation after stunning both kills faster than exsanguination and has a shorter window within which consciousness can be regained. There are commercial machines using this method already in use for many species.[37]

Other methods show promise as higher-welfare slaughter solutions, such as Single-Pulse Ultra-High Current (SPUC), and food-grade anaesthetic-based stunning (e.g. Aqui-S). We welcome developments such as these, so long as they offer reliable and effective stunning, and are implemented in low-handling systems where the chance of fishes recovering consciousness before full brain death is minimal.

1. Any recommendations are in addition to rather than in lieu of compliance with the OIE's 'Aquatic Animal Health Code' (2010).
2. Slaughter should be performed directly at the rearing facility to prevent additional handling and transport. New facilities should have on-site slaughtering with effective stunning.
3. In order to minimize the risk of consciousness being recovered, time elapsed between stunning and slaughter must be minimized. Concurrent methods of stunning and slaughter (e.g. electronarcosis leading congruently into electrocution) are preferred, but processes where death supervenes without significant risk of recovery of consciousness are acceptable.
4. All stunning and slaughter equipment must be calibrated appropriately for the specific animals to be processed (in terms of species, body size, and life stage), in order to achieve immediate and consistent loss of consciousness.
5. 'Loss of consciousness' and 'full brain death' are terms to be determined under lab conditions using an electroencephalogram.
6. Invertebrates, who lack a central nervous system and as such cannot be killed by decapitation, must not be decapitated or spiked.[38]
7. Animals who are killed outside of harvest (e.g. sick or injured fish) must also be killed humanely.
8. CCTV must be installed to provide clear footage of the back-up stun process.
9. Fish should be kept in water as much as possible before and during the process of stunning while they are still conscious. If air exposure is unavoidable, it

[35] Humane Slaughter Association, 'Effects of Electricity". Available at: https://www.hsa.org.uk/humane-harvesting-of-fish-electrical-stunning/effects-of-electricty
[36] These are routinely used for fish which are not fed to humans, as the high voltages can cause 'blood spotting', an unappealing blemish in the filet which can alter the taste of the meat.
[37] EG the Ace Aquatec Electric Stunner. See: https://aceaquatec.com/products/electric-stunning/?gclid=CjwKCAjw0On8BRAgEiwAincsHLjYr8m5TNtZ1Bj21IhX7wGbzLSKZJglv3xDqNXABym2PnHGkqCzQBoCQywQAvD_BwE
[38] Electrocution has been demonstrated as an effective slaughter method in decapods, but its efficacy has yet to be proven in other classes, e.g. cephalopods.

should be kept as short as possible and should not exceed 15 seconds to avoid oxygen deprivation.

10. Direct handling of fishes should be avoided as much as possible.
11. All staff should be properly trained to conduct slaughter operations effectively and to identify signs of unconsciousness and signs of consciousness.
12. Fish showing signs of consciousness after stunning, be it due to a mis-stun or recovery of consciousness before death, should be re-stunned. Emergency stunning can be performed manually, with methods which have been proved to be effective and appropriate for the species.[39]
13. Slaughter plants should regularly perform auto-controls by checking for signs of consciousness, and assessing the effectiveness of their procedures and equipment. Any oddity in stunning failure rates should lead to stopping the slaughter line until the problem is investigated and fixed.
14. Immersion of conscious fish in ice slurry or icy water, asphyxia by air exposure, exsanguination without prior stunning, salt baths, and immersion in CO2 saturated water are all prohibited.
15. All mortality events must be recorded, and centrally published. See section on 'Data Driven Approach', below.

For species-specific slaughter and stunning recommendations, see Appendix A.

Other Areas of Concern

A) Transportation and Handling

Significance

Transportation of aquatic animals involves collection, loading, transport, unloading and stocking and can induce significant stress responses from which the animals will need to recover[40]. Poor conditions during transport, such as overcrowding and inadequate water quality, can cause irreparable damage or death to the animals. The circulation of low-volume water means transport is fundamentally a risky activity, as there is little room for error if standards lapse or equipment fails. As such, live transport should be minimized wherever possible in favor of on-site slaughter, and minimal time spent in transportation boats.

[39] Robb, D. H. F., et al. "Commercial slaughter methods used on Atlantic salmon: determination of the onset of brain failure by electroencephalography." *Veterinary Record* 147.11 (2000): 298-303.
[40]STRESS CONCEPT IN TRANSPORTATION ... - ResearchGate." 24 Mar. 2019, https://www.researchgate.net/publication/331974700_STRESS_CONCEPT_IN_TRANSPORTATION_OF_LIVE_FISHES_-A_REVIEW.

Intervention Summary:

1. All recommendations are in addition to respective OIE standards on fish transportation.
2. Handling of fish at all times must be minimized. Any handling taking longer than fifteen seconds requires sedation.[41]
3. All new facilities should be constructed with slaughter facilities on-site, or access to a mobile slaughter facility that minimizes live transport.
4. Water quality (e.g. oxygen, carbon dioxide and ammonia levels; pH; temperature; and salinity) should be appropriate for the species being transported and the method of transportation.
5. Monitoring, maintaining, and reporting these water quality parameters is required. Contingency plans (e.g. bottled oxygen) must be in place on site in case of a lapse in quality.
6. The documentation accompanying the consignment (transport log) should include: a) description of the consignment (e.g. date, time, and place of loading; species; and biomass load); b) description of the transport plan (e.g. route; water exchanges; expected time, date and place of arrival and unloading; and receiver contact information).
7. Animals should not be loaded until the required log documentation is complete.
8. The transport log should be made available to the dispatcher and the receiver of the consignment. Transport logs should be centrally and regularly published.
9. As transport distance is minimized, there is less need to lower the metabolic rate of fishes in transport. As such, temperature change during transport should be minimized.[42]
10. Appropriate stocking densities during transportation must be respected. If transport-specific stocking densities are not specified, we recommend defaulting to standard holding stocking densities.

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[41] Humane Slaughter Association. "Humane Harvesting of Salmon and Trout.(Guidance notes no 5)." *HSA & CJA. Wheathampstead. UK.* (2005).

[42] Lowering the temperature under which fish are transported increases the stocking density that the fish can tolerate, since lower temperature slows the metabolism (reducing oxygen requirements), but abrupt temperature changes are stressful to fish. The temperature changes to which fish are exposed during transport are highlighted as a major fish welfare problem during transport in a stakeholder forum organized by the Humane Slaughter Association, as were the transfer of smolt to seawater before they are capable of coping physiologically, and mechanical breakdowns, which result in “significant mortalities” during transport.

B) Health and Medical Treatment

Significance

Parasites and cleaner fish

The welfare of all sentient animals in the supply chain, including those which do not end up in the ultimate food product, must be given consideration. This includes cleaner fish introduced as symbiotes to prevent infestation of sea lice in salmon farming.

Sea lice (*Lepeophtheirus salmonis*) are parasitic copepods that pose a significant threat to the welfare of farmed Atlantic salmon (*Salmo salar*) grown in sea pens. Sea lice attach to and feed on the salmon, causing pain, physical damage, including secondary infections resulting in mass mortalities and chronic stress, which negatively impact both fish welfare and profitability. A number of interventions have been proposed and implemented, however lice are rapidly developing resistance to existing treatment methods.[43]

Methods used for removal of parasites, such as sea lice, must provide rigorous, scientific documentation and reduce any adverse effects on the welfare of the fish. Methods such as thermal delousing machines are not recommended: ulcers, lesions, and crush injuries are routinely reported among fish who have been been exposed to thermal delousing procedures,[44] and delayed mortality is more common in thermal delousing systems than the alternatives.[45] Recent findings show that thermal treatments are painful and cause panic reactions in Atlantic salmon.[46,47] The Norwegian Food Safety Authority recently recommended a ban on thermal delousing,[48] and activists are currently petitioning for a similar ban in Scotland.[49] Evidence suggests mechanical delousers are also deleterious to welfare.[50]

The addition of “cleaner fish'' species - such as the ballan wrasse (*Labris bergylta*) and lumpfish (*Cyclopterus lumpus*) - as a means of controlling existing lice populations is a popular alternative to notoriously harmful intervention methods such as thermal delousing. Unfortunately, existing literature evaluating the effectiveness of cleaner fish

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[43] Jones, P. G., et al. "Detection of emamectin benzoate tolerance emergence in different life stages of sea lice, L epeophtheirus salmonis, on farmed Atlantic salmon, Salmo salar L." Journal of Fish Diseases 36.3 (2013): 209-220.
[44] Hjeltnes, B. "Fish health report 2018" *Norwegian Veterinary Institute: Norwegian*. (2019), p.32.
[45] *Ibid.,* p. 85.
[46] Nilsson, J., Moltumyr, L., Madaro, A., Kristiansen, T.S., Gåsnes, S.K., Mejdell, C.M., Gismervik, K. & Stien, L.H. (2019). Sudden exposure to warm water causes instant behavioural responses indicative of nociception or pain in Atlantic salmon. Veterinary and Animal Science, 8: 100076.
[47] Gismervik, K., Gåsnes, S.K., Gu, J., Stien, L.H., Madaro, A. & Nilsson J. (2019). Thermal injuries in Atlantic salmon in a pilot laboratory trial. Veterinary and Animal Science, 8: 100081.
[48] Moira Kerr, *The Herald*, “ Scottish Government is urged to ban ‘painful’ salmon delicing tech”, 14th October 2019. Available at: https://www.heraldscotland.com/news/17966373.scottish-government-urged-ban-painful-salmon-delicing-tech/
[49] Don Staniford, *Green Around the Gills*, “Video Nasty: Thermolicer - the Heated Torture Chamber for Scottish Salmon”, 10th September 2019. Available here: https://donstaniford.typepad.com/my-blog/2019/10/video-exclusive-thermolicer-tortures-salmon-.html.
[50] Scientific citation: Overton K, Dempster T, Oppedal F, Kristiansen TS, Gismervik K, Stien LH. Salmon lice treatments and salmon mortality in Norwegian aquaculture: a review. Rev Aquac. 2018;1–20.

in controlling lice outbreaks present mixed results, with predominantly negative results when implemented on a commercial scale.[51] [52] Moreover, numerous studies have found that housing cleaner fish in sea pens results in negative welfare outcomes such as unacceptably high mortality rates.[53]

For these reasons, we oppose the use of cleaner fish as a method of lice control in Atlantic salmon sea pens. Instead, we support preventative approaches to salmon lice, specifically the implementation of shielding 'skirts', which have been shown to reduce lice infestations up to 80% when implemented at a commercial scale[54]. Lice skirts not only improve salmon welfare by restricting exposure to lice but also reduce the total number of animals involved in the production process, including the lice themselves.

Routine mutilations

We oppose the use of routine mutilations, such as fin-clipping in fish and the practice of eyestalk ablation in crustaceans[55].

Sufficient evidence exists to show that ablation causes animals to become "disorientated, flick their tail (an escape reflex) and rub the traumatised area",[56] all behaviors associated with pain.[57] Given the advent of commercially viable ablation-free crustaceans, we see no reason for this practice to continue.

Intervention Summary:

1. Currently aquatic animals are treated as a 'batch', with most treatments being applied to every animal in the batch. From a welfare point of view, aquatic animals should be given individualized health plans[58], and given appropriate treatment as an individual when they are at risk of getting sick.
2. In order to maximize welfare and reduce the risk of population-level infection or infestation, treatments should be prioritized in this order: non-medical measures which prevent disease > allopathic treatments > metaphylactic treatments.
3. Due to the risk of antimicrobial resistance, prophylactic use of antimicrobials is only allowed where there is no alternative. Disease outbreaks must be properly

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[51] Overton, K., Barrett, L. T., Oppedal, F., Kristiansen, T. S., & Dempster, T. (2020). Sea lice removal by cleaner fish in salmon aquaculture: a review of the evidence base. Aquaculture Environment Interactions, 12, 31-44

[52] Barrett, Luke T., et al. "Prevention not cure: a review of methods to avoid sea lice infestations in salmon aquaculture." *Reviews in Aquaculture* (2020).

[53] Fjelldal, Per Gunnar, Tom J. Hansen, and Ørjan Karlsen. "Effects of laboratory salmon louse infection on osmoregulation, growth and survival in Atlantic salmon." *Conservation Physiology* 8.1 (2020)

[54] Stien, L. H., Lind, M. B., Oppedal, F., Wright, D. W., & Seternes, T. (2018). Skirts on salmon production cages reduced salmon lice infestations without affecting fish welfare. Aquaculture, 490, 281-287.

[55] Ablation is a hatchery technique of mascerating or destroying the eye stalk gland in female broodstock shrimp/prawns to encourage spawning

[56] Diarte-Plata, Genaro, et al. "Eyestalk ablation procedures to minimize pain in the freshwater prawn Macrobrachium americanum." *Applied Animal Behaviour Science* 140.3-4 (2012): 172-178.

[57] Elwood, Robert W., Stuart Barr, and Lynsey Patterson. "Pain and stress in crustaceans?." *Applied Animal Behaviour Science* 118.3-4 (2009): 128-136.

[58] Emerging technologies make this possible: radio tags for fish in RAS systems, or visual recognition of fish by systems such as iFarm.

managed through rapid diagnosis and treatment, and when necessary, humane slaughter.

4. All mass mortality events must be reported. This should include the number, weight and age of deceased animals; their cause of death; and all remedial measures taken to prevent further mortalities.
5. Before prescribing the metaphylactic use of antibiotics, efficacy tests to ensure bacteria are not resistant should be conducted prior to prescription where possible.
6. A primary indicator of sickness in the aquaculture setting is mortality. From an animal welfare perspective, metaphylactic treatment will usually come too late to be effective. Standards should require routine testing for diseases to thereby establish appropriate metaphylactic treatment protocols. Every effort should be made to identify and treat isolated cases before they spread to the population.
7. Vaccination (injectable, oral, dip, etc.) shall be done with minimal distress and/or with the animal anesthetized, and only by certified veterinarians or aquatic animal health professionals. Vaccination administration must be consistent with RSPCA guidelines.
8. The use of sacrificial symbiotic species, such as cleaner fish, should be banned. Co-housing of different species is only permitted where the welfare of neither species is compromised.
9. Sea lice to be kept at a level of below 0.5 female sea lice per salmon[59]. This is to be measured from a sample of 30 salmon weekly. 0.5 lice is the treatment threshold, any measurement more than 8 is a critical noncompliance.
10. For new facilities, the farming location shall be chosen so as to minimize the presence and spread of parasites (such as sea lice) and provide for optimal water quality and temperature conditions for the animals.
11. Sea cages to be designed with an internal skirt to encourage salmon to use deeper water, to prevent sea lice contraction.
12. Routine mutilations, such as eyestalk ablation or fin-clipping, are not permitted.
13. Wherever possible, the production facility must be biosecure, and the impact on other species in the vicinity must be minimized.
14. Health management procedures must be described in a manual, reviewed and approved by a fish health professional, and must include BMPs, measures to prevent introduction of diseases, protocols for water quality management and health monitoring.

C) Impact on Wildlife

Significance

Finfish in farm pond environments and in sea pens are particularly vulnerable to the effects of predation. As well as the risk of injury or death, the presence of birds (e.g.

[59] "Code of Good Practice for Scottish Finfish Aquaculture (CoGP)." http://thecodeofgoodpractice.co.uk/.

cormorants, ospreys and fish-eating eagles) or mammals (e.g. mink, otters and seals) in aquaculture can induce significant stress in fishes. This is manifested by behavioral changes and reduction in feeding. Therefore, protecting fish farms from predators can help to safeguard animal welfare and productivity. However, regard should also be given to the welfare of the predatory animals themselves. The use of preventive measures is preferred. In any aquaculture system where predation is likely to be an issue, a risk assessment of the deployment of anti-predator measures should take account of the animal welfare impact on the farmed fish, on the predators themselves, and on any nontarget species that may be affected, such as harbor porpoises.[60]

Lethal predator control techniques should not be used on any species, regardless of their endangerment status. Harmful or lethal measures to control predators should be banned, and the use of preventative measures e.g. double netting to ensure wild animals cannot get into farms should be promoted. Therefore, shooting predators, such as seals, is prohibited.

Welfare consideration must be given to any wild fishes and other wild animals impacted by aquaculture. Important impacts include but are not limited to: escapes leading to competition for resources between wild and farmed fish, genetic dilution, and pathogens such as bacteria, amoebas, parasites, and viruses spreading to wild species.

Intervention Summary:

1. Lethal predator controls are not permitted.
2. Use of acoustic deterrent devices is not permitted.[61,62,63]
3. Passive predator protection, such as double-walled nets, are preferred above active methods.
4. Concern for the welfare of other animals in the local ecosystem must be considered. For example, overhead nets must be safe for piscivorous birds.
5. New farms must be sited in locations which minimize impact on wildlife, e.g. away from seal haul-outs, etc.
6. Consideration must be given to indigineous animals, such as demersal animals. Population levels of these animals must be monitored and maintained. If there is a substantial impact on the number or diversity of wild animals, the farming operation must be scaled back.

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[60] https://www.bbfaw.com/media/1432/investor-briefing-no-23-animal-welfare-in-farmed-fish.pdf

[61] Götz T, Janik V. Acoustic deterrent devices to prevent pinniped depredation: efficiency, conservation concerns and possible solutions. Mar Ecol Prog Ser [Internet]. 2013 Oct 31 [cited 2020 Jun 26];492:285–302. Available from: http://www.int-res.com/abstracts/meps/v492/p285-302/

[62] Brandt MJ, Höschle C, Diederichs A, Betke K, Matuschek R, Witte S, et al. Far-reaching effects of a seal scarer on harbour porpoises , Phocoena phocoena. Aquat Conserv Mar Freshw Ecosyst [Internet]. 2013 Apr 1 [cited 2020 Nov 11];23(2):222–32. Available from: http://doi.wiley.com/10.1002/aqc.2311

[63] Schaffeld T, Ruser A, Woelfing B, Baltzer J, Kristensen JH, Larsson J, et al. The use of seal scarers as a protective mitigation measure can induce hearing impairment in harbour porpoises. J Acoust Soc Am [Internet]. 2019 Dec 12 [cited 2020 Nov 11];146(6):4288–98. Available from: http://asa.scitation.org/doi/10.1121/1.5135303

7. Place trapping devices in effluent/drainage canals or on water outlets to safeguard escapees; prevent water spillage during rainy seasons.
8. Ensure proper timely inspections, mitigation actions and repairs to the culture system, and proper recording of any actions.

D) Adequate Employee Training

Significance

Lack of "stock person" skills or knowledge regarding welfare has been identified as a key concern in farm animal welfare.[64] This includes but is not limited to knowledge about pain recognition and management, humane handling, and other welfare aspects such as species-specific needs.[65]

Contingency Planning

Disasters at aquaculture facilities – including fires, net pen collapse due to weather, technical failures and others – are unfortunately common. Many of these events result in high levels of suffering as well as acute mortality events for the farmed animals. All aquaculture facilities must have a robust and actionable emergency response and contingency plan. The FAO categorizes disasters into three groups as follows:

1. Natural disasters: hydrometeorological hazards (e.g. floods, waves and surges, storms, droughts),
2. Geological hazards (e.g. earthquakes, volcanic eruptions) and Biological hazards (e.g. epidemics, insect infestations).
3. Technological disasters: directly related to human activity, a result of failure of a technology or of management (e.g. oil or chemical pollution from tankers, pipelines and drilling accidents, nuclear disasters).

Intervention Summary:

All contingency plans must include animal welfare consideration including but not limited to relocation planning and an emergency slaughter plan. Farms should also

[64] Studer. Et al. "Development of practical fish welfare criteria for aquaculture", Presentation to the Annual Conference on Applied Ethology in Freiburg, Germany. (2019) Available here: http://fishethobase.net/media/filer_public/3e/6b/3e6bd069-5faa-468b-ad52-e5f2bb68e88e/report_visits_fos.pdf (Accessed 2020-10-29)

[65] https://www.frontiersin.org/articles/10.3389/fvets.2019.00495/full

have an adequate contingency plan relating to emerging and exotic diseases of aquaculture animals.[66]

E) Data-Driven Approach, Record Keeping & Reporting

Significance

All recommendations must respond to the best available science, and producers should actively seek to expand and share knowledge of best practices in aquatic animal husbandry. Availability of data on the wellbeing of animals is in the public interest, even if that data is generated in private facilities. All farms must record and retain records of disease, treatments, transport, mortality rates, and causes of mortality for all animals in their care, and must use these records actively to further improve conditions within their production. Furthermore, it is imperative that farms undergo routine/frequent audits to ensure compliance with guidelines and improve/protect the welfare of aquatic species, via their governing certification scheme or through independent efforts.

Intervention Summary:

1. Standards and practice, both on and off farm, must adapt to the best available evidence.
2. All monitoring and reporting data must be formatted with a relevant pro-forma, and centrally published no more than 30 days after being recorded.
3. Every effort must be made to ensure the traceability of aquaculture products.
4. Water quality records, transport logs, and mass mortality event records must all be made centrally publicly available, and linked to farm data. This will be used to give consumers an assurance of the quality of the aquatic animal products they are purchasing.

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[66] Article 47 of Council Directive 2006/88/EC can give some guidance as to what the plan should entail at a minimum. See: https://www.fishhealth.ie/fhu/health-surveillance/aquaplan-fish-health-management-ireland/contingency-planning for more

Concluding Remarks

While the aforementioned information/interventions are not yet fully comprehensive, the AAA will update this document as and when new materials emerge.

Stand-alone position statements:

- Environmental Enrichment
- Wild-Capture Fisheries
- Welfare and Sustainability
- Blue Loss
- Certification Benchmark *(forthcoming)*

Appendices

Appendix A: Species Specific Recommendations & Detailed EE Interventions

These tables were constructed based on literature reviews of the best available welfare/husbandry standards in our five key strategic areas, for the most commercially relevant farmed aquatic animals.

The literature on fish welfare is extremely preliminary. For this reason, each recommendation comes with a rough certainty rating (5 is high confidence, 1 is low confidence) that reflects how likely in ALI's estimation, the evidence is 1) reliable and complete 2) fully representative of the needs of the species. These tables will be regularly updated as more research is verified.