# Public Comment on Draft Guidance for Marine Net Pen Aquaculture in Washington State

## Introduction

The following comment is submitted on behalf of the Aquatic Animal Alliance (AAA). We are a coalition of animal advocacy organizations that believe aquatic animals should have lives free of suffering. Our primary focus and areas of expertise is to identify key areas where welfare interventions are most needed for animals used in aquaculture and engage with key decision makers to implement these standards.

In the comment below, we offer recommendations to the Washington State Department of Ecology regarding its draft guidance for marine net pen aquaculture in the state. Our main concern is aquatic animal welfare[1] (for animals both within and outside such net pens), as we believe animal welfare is both an issue of importance in and of itself and that, in many cases such as this, improved animal welfare (e.g. appropriate stocking density, responsible feeding practices, good fish health) can lead to improved environmental stewardship (and vice versa).

We would like to thank Ecology for the opportunity to provide feedback, which we hope you may consider as part of your draft guidance. We are excited to contribute our thoughts and appreciate Ecology's efforts to mitigate the impacts of net pen aquaculture and protect Washington's precious natural resources and wildlife.

In the following section, we will provide recommendations on these areas of concern:

1. Escapes
2. Environmental Enrichment
3. Water Quality
4. Stunning and Slaughter
5. Space Requirements and Stocking Density
6. Feed Composition
7. Transportation and Handling
8. Health/Medical Treatment
9. Impacts on Wildlife
10. Adequate Employee Training and Contingency Planning
11. Data-Driven Approach, Record Keeping, and Reporting

[1] To learn more about our definition of animal welfare, please view our welfare guide

## Areas of Concern

### 1. Escapes

Unfortunately, net pen escapes are well documented worldwide,[2] including in the state of Washington.[3] Some of these escapes were the result of natural events such as storms or fires, and another due to poor infrastructure, resulting in the structural collapse of a net pen facility. After the Cypress net pen collapsed in 2017, which resulted in more than 260,000 non-native Atlantic salmon escaping into Puget Sound waters[4], research discovered that nearly every fish that escaped was infected with a pathogenic exotic salmon virus that had been undetected and unreported. Additionally, this failure resulted in the appearance of dead fish carcasses and massive amounts of debris, among other pollutants.

Escapes can lead to deleterious consequences for wild fish populations and the local environment. For instance, feral farmed-fish have been shown to harm ecosystems (e.g. carps in the United States), displace wild populations as the result of ecological interaction (e.g. competition for space or food; predation), reduce the fitness and genetic diversity of wild populations as the result of interbreeding, and spread infectious disease.[5] Moreover, escapes could increase stress levels among captive fish, pose significant health risks to wild fish, and degrade water quality, which would have a negative effect on all fish welfare.

Recommendations

Improved protections and requirements to reduce environmental impacts and increase resiliency of net pen operations could include: increasing underwater video monitoring; conducting regular inspections to assess structural integrity of the net pens and submitting inspection reports certified by an objective third party; requiring improved maintenance and cleaning of the net pens, water quality monitoring, and maintenance procedures; requiring transparent reporting if fish mortality rate exceeds 0.5 - 1%; refraining from self-reporting and instead relying on a third party to assess and disclose pertinent information; developing site-specific response plans for implementation in the event that fish escape; conducting and participating in emergency preparedness training; and maintaining contact information to promptly notify area tribes and state agencies in the event of an escape.

As an adaptive measure to the impacts of climate change, we believe that adequate zoning and site selection through the use of risk analysis is essential for aquaculture. This includes the consideration of exposure to extreme weather events and changes in currents, in addition to long-term trends such as increasing ocean temperature, salinity, and decreasing dissolved oxygen (DO) levels when determining

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[2] See for example, this case in the UK (October 2020) https://www.bbc.com/news/uk-scotland-glasgow-west-54468027, this case in Norway in 2020: https://www.intrafish.com/aquaculture/salmon-that-escaped-from-salmars-offshore-aquaculture-operation-had-contagious-disease/2-1-885991, this case in British Columbia in 2019 https://globalnews.ca/news/6328416/bc-fish-farm-fire-salmon/, this case in 2018 in Chile, https://en.mercopress.com/2020/08/24/chile-slaps-record-fine-of-us-6-million-on-norwegian-salmon-farming-company-for-the-escape-of-700-000-fish etc.

[3] https://crosscut.com/environment/2019/08/still-recovering-escaped-atlantic-salmon-cooke-aquaculture-now-wants-farm

[4] https://kuow.org/stories/preventing-another-salmon-escape-new-rules-for-puget-sound-fish-farms

[5] 2018 FAO Report on the impacts of climate change on fisheries and aquaculture https://reliefweb.int/sites/reliefweb.int/files/resources/i9705en.pdf

aquaculture zoning and site selection. In the coming years, this will be essential for mitigating the likelihood of climate change related escapes.

## 2. Environmental Enrichment

### Significance

The need for a suitably sized and enriched holding environment is 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 environmental enrichment (EE) a particularly important concern.

In order to express their natural behaviors, aquatic animals must be provided with an environment that meets their natural behavioral and other needs in a way which is specific to their species and life-stage. To the extent that it is feasible, holding environments should be based on the preferred environment of the farmed species and allow animals to express behaviors important to welfare (e.g., highly motivated behavior such as foraging and nesting, as well as more general concepts such as providing animals with choice and agency).

For understudied species for which welfare literature is scarce or nonexistent, environmental conditions and enrichment should be tailored to mimic their natural environment as closely as possible and / or provide opportunities for the expression of behaviors known to be important for that species.

### Elements of Enrichment

Every effort should be made to give aquatic animals an environment which is suitable to their needs. This includes attending to the six categories of enrichment presented by Näslund & Johnsson (2016).[6]

1. **Social enrichment**: Animals must have an appropriate amount of contact with conspecifics (i.e members of their species) as determined by the species' life history combined with behavioral data collected in captivity. This includes sufficient access for schooling species (such as Arctic charr), and appropriate stocking densities for species which may display agonistic 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, etc. from any other individual within the enclosure.
2. **Occupational / physical enrichment:** Animals should have the freedom to engage in physical and psychological stimulation required for the fulfilment of behavioral needs and desires. This can involve play, interactive feeding opportunities, and sufficient room to swim in natural behaviours.
3. **Structural enrichment**: The animals' environment should provide species-appropriate structural complexity (e.g. shelter, suspended materials, substrate, silt or other incubation substrates to the floor, which juvenile fish can burrow into).
    a. When providing structural complexities, one must ensure that they are appropriately distributed and monitored, so that higher-value areas of the cage aren't created, which can become points of competition between conspecifics, and structures do not limit equal access to essentials (food, shelter, etc.)

[6] 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.

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 enrichmen**t', meaning that their food is sufficiently nutritious, and also that the amount of food, variety of food available, and also the frequency and delivery system of the food, is suitably interactive and appropriate for the animal's natural feeding behavior.
6. **Cognitive enrichment**

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 the six interventions outlined in the position statement—appropriate lighting, partial tank covers, appropriate tank color, complexified feed delivery, appropriate in-water shelter and substrate provision and materials necessary for behavioral expression—are likely to provide some level of benefit to every farmed fish species[7,8]. Producers must address environmental conditions (interventions 1-3) when designing and stocking systems as well as implement at least one enrichment opportunity from each intervention 4-6.

Environmental improvements can be integrated into existing farm structures, requiring minimum disruption and capital investment. Most of these interventions carry both intrinsic and instrumental benefits: they increase the welfare of the fish, but also improve their performance as a farmed animal, by improving their growth, body condition, resilience and reduced mortality.[9]

Due to the fact that the aim of enriching a captive animal's environment is to ultimately emulate their natural habitat and promote instinctive behaviors (where feasibly possible), we also advocate addressing their 7 immediate enclosure frameworks that fall within the aforementioned enrichment classifications. These include:

1. Enclosure Coloration
    - Tank colours, patterns, or supplemental 2D impressions.
2. Substrate Provisions
    - Range of rock sizes from gravel to boulder.
3. Lighting
    - Optimal/natural photoperiods with access to natural or simulated daylight at appropriate intensities.
4. Water Augmentation
    - Fitting 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 or other environmental conditions.

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[7] 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.
[8] Gerber, Barbara et al. "Environmental Enrichment and its effects on Welfare in fish." (2015).
[9] Aquatic Life Institute, *Environmental Enrichment Position Statement*, available at: https://tinyurl.com/y3n8gaq2

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.

For species-specific EE recommendations see Appendix A.

## 3. Water Quality

Poor animal welfare resulting from high stocking density and inefficient feeding can cause toxic wastewater in fish farms. Left untreated, it can deplete surrounding waters of oxygen, causing algal blooms[10] and dead zones.[11] Aquaculture wastewater can also contain antimicrobials which pose a health risk if consumed by humans. Wastewater is particularly an issue at fish farms with high stocking density and in locations where currents are not strong enough to disperse the effluent.

Discharges of excess nutrients, particularly nitrogen, into Puget Sound from domestic wastewater treatment plants (WWTPs) are contributing to low oxygen levels in Puget Sound. As these WWTPs are contributing human sources of excess nutrients to Puget Sound, the state must take action to control this pollution. On Jan. 30, 2020, The Dept. of Ecology announced their decision to move forward with developing a draft Nutrients General Permit for Puget Sound. The proposed Nutrients General Permit would apply to all facilities discharging to marine and estuarine waters of Puget Sound. The overall nutrient discharge from such open net aquaculture facilities should also be considered under this new initiative.

### Importance of Water Quality

Water quality is a generally accepted high priority welfare issue as it directly relates to animal survival. In order to protect their welfare and ensure optimal health, it is imperative to understand and adjust the quality of water according to specific needs of the animals[12]. 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

[10] What is a harmful algal bloom? (2016). National Oceanic and Atmospheric Administration. https://www.noaa.gov/what-is-harmful-algal-bloom
[11] What is a dead zone? (2020). National Oceanic and Atmospheric Administration. https://oceanservice.noaa.gov/facts/deadzone.html
[12] 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 welfare indicator. Fish physiology and biochemistry, 38(1), 85-105.

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[13].

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 contraction between 9 and 12 mg/l. Most fish cannot survive at concentrations below 3 mg/l of dissolved oxygen[14].

**Nitrogenous wastes**: The accumulation of nitrogenous waste products in closed aquaculture systems pose a significant threat to fish welfare[15]. 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[16]. Nitrite ($NO_2^-$) the result of ammonia nitrification, is also extremely toxic and can lead to severe hypoxia and death in relatively low concentrations[17].

**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[18,19,20].

## Recommendations

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.

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[13] 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.

[14] https://www.enr.gov.nt.ca/sites/enr/files/dissolved_oxygen.pdf

[15] 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

[16] Randall, D. J., & Tsui, T. K. N. (2002). Ammonia toxicity in fish. Marine pollution bulletin, 45(1-12), 17-23.

[17] W.M. Lewis Jr., D.P. Morris. Toxicity of nitrite to fish: a review. Trans. Am. Fish. Soc., 115 (2) (1986), pp. 183-195

[18] S. Fivelstad. Long-term carbon dioxide experiments with salmonids. Aquac. Eng., 53 (2013), pp. 40-48.

[19] 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.

[20] 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.

For species-specific water quality recommendations see Appendix A.

## 4. 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",[21] and fishes should not regain consciousness before death.[22]

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,[23] and that operators are unable to visually identify cases in which aquatic animals have been incorrectly stunned.[24] 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, described below, 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.

### Recommendations

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 Slaughter Association recommends electrocution as a stunning method which also causes death, and the first such commercial machines have just entered into the market.[25,26]

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

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[21] 7.3.6.1(c)
[22] 7.3.6.1(d)
[23] 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.
[24] 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.
[25] Humane Slaughter Association, 'Effects of Electricity". Available at: https://www.hsa.org.uk/humane-harvesting-of-fish-electrical-stunning/effects-of-electricty
[26] 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.

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.[27]

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.[28]
7. Animals who are killed outside of harvest (e.g. sick or injured fish) must be culled in a timely manner, according to species requirements, and with ample consideration to animal welfare.
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 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.[29]
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 $CO_2$ saturated water are all prohibited.
15. All mortality events must be recorded, and centrally published. See section on 'Data Driven Approach', below.

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[27] EG the Ace Aquatec Electric Stunner. See: https://aceaquatec.com/products/electric-stunning/?gclid=CjwKCAjw0On8BRAgEiwAincsHLjYr8m5TNtZ1Bj21IhX7wGbzLSKZJglv3xDqNXABym2PnHGkqCzQBoCQywQAvD_BwE

[28] 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.

[29] 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.

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

## 5. Space Requirements and 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[30]. Inappropriate stocking densities are associated with decreased growth, diminished nutritional uptake, reduction in feed conversion efficiency, fin erosion, gill damage, immunosuppression, inter-fish aggression[31], and disturbed movement activity.[32] 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.[33] 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[34]. For a full list of species-specific stocking density recommendations, see Appendix A.

Recommendations

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.

## 6. Feed Composition

Significance

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. Conversely, providing too much feed can cause poor water quality, which in turn will affect health and welfare.

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[30] 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.
[31] Ashley, Paul J. "Fish welfare: current issues in aquaculture." *Applied Animal Behaviour Science* 104.3-4 (2007): 199-235. p212.
[32] 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.
[33] *Supra note 17.*
[34] "M. Borthwick, Salmon Welfare Report | Fish Welfare Initiative." https://www.fishwelfareinitiative.org/salmon-welfare.

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 decreased welfare for the animals.[35] 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.

Additionally, the Department of Ecology issues Concentrated Animal Feeding Operation (CAFO) General Permits to operations that confine livestock for long periods of time in pens or barns and discharge pollution to surface or groundwater. This same nature and degree of consideration should extend to net pens due to the fact that their excess feed directly contributes to pollution discharge.

## Recommendations

1. Where possible, the use of obligate carnivores in farming systems should be avoided.
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.

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[35] 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.

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.

## 7. 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[36]. 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.

Recommendations

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.[37]
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)

[36] STRESS CONCEPT IN TRANSPORTATION ... - ResearchGate." 24 Mar. 2019, https://www.researchgate.net/publication/331974700_STRESS_CONCEPT_IN_TRANSPORTATION_OF_LIVE_FISHES_-A_REVIEW.

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

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.[38]
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.

## 8. Health/Medical Treatment

Disease outbreaks in fish farms are caused by compromised immune systems due to poor health, nutrition, and rearing conditions. Weakened immune systems increase the possibility of disease outbreaks which is problematic as pathogens and parasites can spread outside of the farm, damaging local fish populations and ecosystems. On salmon farms, sea lice outbreaks have been a serious welfare issue. In Scotland alone, 20% or 9.5 million salmon die each year as a result of disease, parasites, and even chemicals designed to treat them.[39] The salmon industry has moved towards the use of "cleaner fish" to feed off of the lice, however no welfare considerations are given to these cleaner fish, which further compounds the welfare problem.

As temperatures continue to rise, warmer waters could lead to higher rates of pathogenic bacteria, as well as the emergence of new pathogens, an increase in the transmission and virulence of common parasites, an increase in the intensity and duration of algal blooms, and the prevalence and toxicity of various contaminants (e.g. mercury).

### 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

[38] 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.

[39] Adams, B. L. (2019, May 20). Is there a problem with salmon farming? BBC News. https://www.bbc.com/news/uk-scotland-48266480

proposed and implemented, however lice are rapidly developing resistance to existing treatment methods.[40]

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,[41] and delayed mortality is more common in thermal delousing systems than the alternatives.[42] Recent findings show that thermal treatments are painful and cause panic reactions in Atlantic salmon.[43,44] The Norwegian Food Safety Authority recently recommended a ban on thermal delousing,[45] and activists are currently petitioning for a similar ban in Scotland.[46] Evidence suggests mechanical delousers are also deleterious to welfare.[47]

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. Existing literature evaluating the effectiveness of cleaner fish in controlling lice outbreaks present mixed results, with predominantly negative results when implemented on a commercial scale.[48] [49] Moreover, numerous studies have found that housing cleaner fish in sea pens results in negative welfare outcomes such as unacceptably high mortality rates.[50]

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[51]. 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[52].

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[40] 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.
[41] Hjeltnes, B. "Fish health report 2018" *Norwegian Veterinary Institute: Norwegian*. (2019), p.32.
[42] *Ibid.,* p. 85.
[43] 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.
[44] 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.
[45] 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/
[46] 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.
[47] 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.
[48] 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
[49] Barrett, Luke T., et al. "Prevention not cure: a review of methods to avoid sea lice infestations in salmon aquaculture." *Reviews in Aquaculture* (2020).
[50] 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)
[51] 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.
[52] Ablation is a hatchery technique of masceratting or destroying the eye stalk gland in female broodstock shrimp/prawns to encourage spawning

Sufficient evidence exists to show that ablation causes animals to become “disorientated, flick their tail (an escape reflex) and rub the traumatised area”,[53] all behaviors associated with pain.[54] Given the advent of commercially viable ablation-free crustaceans, we see no reason for this practice to continue.

## Recommendations

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[55], 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 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[56]. 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 disease protocols for water quality management and health monitoring.

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[53] 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.
[54] Elwood, Robert W., Stuart Barr, and Lynsey Patterson. "Pain and stress in crustaceans?." *Applied Animal Behaviour Science* 118.3-4 (2009): 128-136.
[55] Emerging technologies make this possible: radio tags for fish in RAS systems, or visual recognition of fish by systems such as iFarm.
[56] "Code of Good Practice for Scottish Finfish Aquaculture (CoGP)." http://thecodeofgoodpractice.co.uk/.

## 9. 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. 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.[57]

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 in the first place) should be promoted. Therefore, shooting predators, such as seals, must be 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.

Recommendations

1. Lethal predator controls are not permitted.
2. Use of acoustic deterrent devices is not permitted.[58,59,60,61]
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.
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.

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

[58] 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/

[59] 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

[60] 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

[61] [Link to Aquatic Life Institute Position Statement]

## 10. Adequate Employee Training and Contingency Planning

Significance

Lack of "stock person" skills or knowledge regarding welfare has been identified as a key concern in farm animal welfare.[62] This includes but is not limited to knowledge about pain recognition and management, humane handling, and other welfare aspects such as species-specific needs.[63]

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).

Recommendations

All contingency plans must include animal welfare consideration including but not limited to relocation planning and an emergency slaughter plan. Farms should also have an adequate contingency plan relating to emerging and exotic diseases of aquaculture animals.[64]

## 11. 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.

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[62] 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)

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

[64] 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

Recommendations

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 reduce information asymmetries by giving consumers the ability to assess the quality of the aquatic animal products they are purchasing.

**Conclusion**

We would like to thank again the Washington State Department of Ecology for the opportunity to comment on the draft guidance for marine net pen aquaculture. Although the recommendations above are not a comprehensive outline, it represents an overview of our main concerns in this context. In this comment, we hope to have shown that robust welfare interventions and smart management practices can not only mitigate the many risks associated with net pen operations, but also improve the conditions of the many fishes that will be reared in these facilities and ensure that they have a life worth living.

To this end, we encourage the Department of Ecology to consider a more holistic approach when examining the implications of net pen operations through not only considering the social and environmental impacts, but also the welfare impacts on native aquatic species and those that will be reared in these facilities. It is essential that we ensure that Puget Sound, the Strait of Juan de Fuca, and all of Washington's waters are preserved for generations to come and always keep in mind the many people and wildlife that depend on these waters.

We look forward to providing recommendations in future comment periods and would be happy to provide further resources as needed.

# Appendices

## Appendix A: Species Specific Recommendations

The tables below 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. A full bibliography is available here.

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.

### 1. Environmental Enrichment

(In alignment with previously mentioned categories/classifications.)

| **Species** | **Environmental Enrichment Recommendation** | **Evidence** | **Level of AAA Certainty** |
|---|---|---|---|
| Atlantic salmon *(Salmo salar)* | Substrate provided at Alevin stage. Partial tank covers provided throughout pelagic stages. Structure to be provided in the tank. Interactive feeding mechanisms provided at saltwater stage. Tanks to be coloured a dark blue. | [Cogliati 2019] [Marr, 1963] [Näslund, 2016] | 3 |
| Nile tilapia *(Oreochromis niloticus)* | Structural enrichment provided, included ability to demonstrate place preference. Provision of artificial water hyacinth and shelter. Use of partial tank covers. Use substrate for feeding. | [Baretto 2013], [Delicio, 2006], [Uddin 2009], [Neto 2020] | 3 |
| Striped catfish *(Pangasianodon hypophthalmus)* | Shelter structures, and floating pond covers to be provided. Dark tank coloration to be used. Feed to be given in dry crumbles at fingerling stage, with night-feed preferred at the adult stage. | [Phelps 1992] [Boerrigter et al., 2016] [Barcellos et al., 2009] | 3 |
| Grass carp *(Ctenopharyngodon idella)* | Multi-colored gravel substrate, cobbles and plants to be provided in the hatchery environment. | [Amina 2020] | 3 |
| Sturgeon | Looking into further research. | | |
| Southern Bluefin tuna *(Thunnus maccoyii)* | Early evidence suggests farming in low light can improve survivability. In the juvenile stage, placing nets farther from shore seems desirable. | [Hilder, 2013], [Kirchoff, 2011] | 3 |
| Catla *(Catla catla)* | Daily rhythm: Further investigation is needed, but 12L:12D increases fish performance. Light intensity: 114±4 lux is optimal, above 2672 lux affects growth performance. Feeding: on the surface; spread uniformly over the tanks; maximum feeding from 6 to 9 am; twice a day for all life stages, feeding once may be most promising (but more research is needed); larvae and fry are fed on finely powdered (<80 µ) feeds that are broadcasted over the water. | [FWI1, 2020] | 3 |
| Rohu *(Labeo rohita)* | Daily rhythm: 12L:12D is optimal for following natural photoperiods. Light intensity: 0.17 and 1.45 W/m2 improve performance. Feeding: planktivorous | [FWI1, 2020] | 3 |

| | | | |
|---|---|---|---|
| | surface feeder during fry stage, zooplankton column feeder from fingerling stage onwards at all depths (can occasionally eat organic detritus from the bottom); three times per day for fry and fingerling, twice per day for adults, one time per day for broodstock; larvae are fed with particle feed size (< 50 um), larvae with 0.5 mm crumble pellet, fingerling, adult, and broodfish with 1.5-2.0 mm, 2.5-3 mm, and 5 mm dry pellet, respectively; feed provided either as dough on trays or feed baskets promote self-feeding, and are consumed after 1-2 hours. | | |
| Whiteleg Shrimp *(Litopenaeus vannamei)* | 50% of pond area should be covered by plants. Recommended plant species are leguminosae trees (e.g. Algorrobo), aloe, mangrove, semi-aquatic herbs and floating grasses for the lower parts of the slopes. Recommended to raise ducks in the pond, expelling intruding birds. | [Naturland,2020] | 3 |
| Bivalves *(clams, mussels, oysters and scallops)* | Management of natural beds will encourage the settlement of juveniles and sustain the fishery. Beds can be raked and tilled on a regular basis to remove silt and ensure that suitable substrates are available for the attachment of the juvenile stages. Adding settlement material, called 'cultch' (old bivalve shells) is beneficial. | [FAO Hatchery] | 2 |

## 2. Feed Composition

| Species | Feed Composition Recommendation | Evidence | Level of AAA Certainty |
|---|---|---|---|
| Atlantic salmon *(Salmo salar)* | Use of animal products in feed to be minimized where possible; trimmings should be prioritized when animal products in feeds are used. | [ALI FMFO report] | 3 |
| Nile tilapia *(Oreochromis* | No animal products are permitted. | [ALI FMFO report] | 5 |

| | | | |
|---|---|---|---|
| *niloticus)* | | | |
| Striped catfish *(Pangasianodon hypophthalmus)* | Animal products not permitted in feed. Medicated feeds not permitted. | [Naturland, 2020] | 5 |
| Grass carp *(Ctenopharyngodon idella)* | Animal products not permitted in feed. For grass carp, integrated & extractive feeding systems only to be used. | [Shaha, 2015] | 2 |
| Sturgeon | Use of animal products in feed to be minimized where possible. | [ALI FMFO report] | 5 |
| Southern Bluefin tuna *(Thunnus maccoyii)* | No information available at this time. | | |
| Catla *(Catla catla)* | Use of animal products in feed to be minimized where possible.<br><br>Crude protein: adults = 25% for good performance. larvae = 34-38%; Crude lipids: adults = 6-7% / larvae = 5%; Energy: Broodstock = 20 KJ/g; Carbohydrates: adults = 20% / larvae = 26%; Inclusion of 1.57 to 1.58 of leucine is recommended. | [FWI1, 2020] | 4 |
| Rohu *(Labeo rohita)* | Use of animal products in feed to be minimized where possible<br><br>Crude protein: adults = 25-30% / fingerlings = 30-40%; Crude lipids: adults = 3.5-16% / fingerling = 5-15%; Energy: adults = 2700-4000 Kcal7kg / fingerlings =<br><4000 Kcal/k; Carbohydrates: adults = 20% / larvae = 30-45%. | [FWI1, 2020] | 4 |
| Whiteleg Shrimp *(Litopenaeus vannamei)* | No live catch permitted. All food to be processed (cooked) prior to feeding. Ideally, no animal material to be fed to shrimp. | (EC) No 889/2008 a. 25k (d) | 4 |
| Bivalves *(clams, mussels, oysters and scallops)* | Feed by filtering mainly phytoplankton, but also some organic detritus in sea water. Mixed algal diets are beneficial. A combination of two or three high nutritional value species including a suitably sized diatom and a flagellate invariably provide improved rates of larval growth and development than do single species diets. They also improve spat yields | [Cheng 2020] | 2 |

| | | | |
|---|---|---|---|
| | and influence the subsequent performance of spat in terms of both growth and survival. | | |

## 3. Space Requirements & Stocking Density

| Species | Space Requirements Recommendation | Evidence | Level of AAA Certainty |
|---|---|---|---|
| Atlantic salmon *(Salmo salar)* | 10kg/$m^3$ | [North 2006] | 5 |
| Nile tilapia *(Oreochromis niloticus)* | 20 kg/$m^3$ | [(EC) No 834/2007] | 3 |
| Striped catfish *(Pangasianodon hypophthalmus)* | 10 kg/$m^3$ | [(EC) No 834/2007] | 3 |
| Grass carp *(Ctenopharyngodon idella)* | Not enough information available at this time. | | |
| Sturgeon | 30 kg/$m^3$ | (EC) 889/2008 Annex XIIIa | 4 |
| Catla *(Catla catla)* | Semi-intensive: Larvae - 3-5 million/ha, Fry - 0.2-0.3 million/ha;<br>Fingerling: 2000-3000/ha, 1 kg/ha when fertilization is used;<br>Intensive: Larvae - 10 million/ha, Fry - >0.2-0.3 million/ha;<br>Fingerling: 5000-10000/ha, 1.5 kg/ha when fertilization is used;<br>Proportion in polyculture: 15-35%.<br>Found to perform well in 1.5 m depths | [FWI1, 2020] | 5 |
| Rohu *(Labeo rohita)* | 3-5 million fry/ha;<br>0.2-0.3 million fingerling/ha;<br>5,000-10,000 adults/ha;<br>0.2-0.3 million fry/ha combined with catla and | [FWI1, 2020] | 5 |

| | | | |
|---|---|---|---|
| | mrigal;<br>Proportion in polyculture: 10-35% with catla and Mrigal.<br>1-1.5 m depth for fry & adults. | | |
| Southern Bluefin tuna *(Thunnus maccoyii)* | Larvae: 5 larvae/L. Spawners: 5-8 ind/$m^3$. | [Chen, 2016] | 2 |
| Whiteleg Shrimp *(Litopenaeus vannamei)* | Seeding: maximum 22 post larvae/$m^2$ Maximum instantaneous biomass: 240 g/$m^2$ | [(EC) 889/2008 Annex XIIIa] | 3 |
| Bivalves *(clams, mussels, oysters and scallops)* | Direct sowing onto the seabed, containerized, or attached to structures on or above the seabed intertidally and subtidally. Water systems of over 5 meters depth may suspend bivalves from longlines, rafts, or other floating structures. Cultivation sites shall be of an appropriate scale and operated so they do not exceed the production carrying capacity of the water body. The rate at which phytoplankton is removed cannot exceed the rate at which the ecosystem refreshes the supply. Note: there may be a predefined limit to an area available for cultivation based on what is known about the productivity and food availability for bivalve shellfish locally. | [Bap Mollusc] | 1 |

## 4. Water Quality

| Species | Water Quality Recommendation | Evidence | Level of AAA Certainty |
|---|---|---|---|
| Atlantic salmon *(Salmo salar)* | pH 6.5-8, calcium above 4 mg/L and Alx below 54 ug/L. DO of between 8.0-9.0 mg/L . This is dependent on temperature: As such, oxygen level not to fall beneath 85% saturation in case water heats up further, or metabolic rate otherwise increases. Hyperoxia not permitted. $CO_2$ levels should not exceed 10 mg/L. | [Sigholt 1995], [Brocksen, 1992], [Wedemeyer 1996] | 4 |
| Nile tilapia *(Oreochromis niloticus)* | Oxygen level not to fall beneath 85% saturation. Hyperoxia not permitted. $CO_2$ levels should not exceed 10 mg/L. Total ammonia nitrogen not permitted to increase beyond 0.05mg/l (ppm). | [Josephson et al 2014] [Durborow 1997] | 4 |
| Striped catfish *(Pangasianodon hypophthalmus)* | Oxygen level not to fall beneath 85% saturation. Hyperoxia not permitted. $CO_2$ levels should not exceed 10 mg/L. Total ammonia nitrogen not permitted to increase beyond 0.05mg/l (ppm). | [Josephson et al 2014], [Durborow 1997] | 4 |
| Grass carp *(Ctenopharyngodon idella)* | Oxygen level not to fall beneath 85% saturation. Hyperoxia not permitted. $CO_2$ levels should not exceed 10 mg/L. Total ammonia nitrogen not permitted to increase beyond 0.05mg/l (ppm). | [Josephson et al 2014], [Durborow 1997] | 4 |
| Sturgeon | Compliant with EU organic standards. | (EC) 889/2008 Annex XIIIa | 4 |
| Catla *(Catla catla)* | Preferred temperature: 30-32ºC; Salinity < 6 ppt; Sensitivity to low $O_2$ levels, best above 5 mg/L; $CO_2$ 2.0 - 5.6 mg/L; pH 6.5 - 8.5 is acceptable but levels between 7- 8 are best; Optimal ammonia is < 1 mg/L; 0.01–0.02 mg/L should be kept; Nitrite <0.01 mg/L. | [FWI1, 2020] | |
| Rohu *(Labeo rohita)* | Preferred temperature: 31-33ºC; Tolerate salinity <5 ppt. 10-12 ppt increases the mortality in fingerlings by 100%; DO: >3.6 mg $L^{-1}$. >6 mg $L^{-1}$ is good against infestation; $CO_2$ <60 mg/L- more research needed, as this value is normally toxic for other fish species; pH 6.5-8.5 is acceptable; Acceptable ammonia values are <0.82 mg/L (with pH = 6.95 and transportation densities of 134 g/L). 1.1 mg/L (with pH = 6.85 and densities of 201 g/L) causes mortality; Nitrite <1 mg/L had no significant change either in hematology or enzymatic parameters, optimal range is likely 0.02 to 0.2. | [FWI1, 2020] | |

| | | | |
|---|---|---|---|
| Southern Bluefin tuna *(Thunnus maccoyii)* | No information available at this time. | | |
| Whiteleg Shrimp *(Litopenaeus vannamei)* | Naturland's guidance to be followed on water quality parameters, saline filtering, organic sediments. | [Naturland, 2020] | 3 |
| Bivalves *(clams, mussels, oysters and scallops)* | pH: 7—9. Temperature: a discharge must not cause the temperature of the waters to exceed by more than 2 °C. A discharge must not cause deviation of more than 10 mg Pt/l from the colour of waters. A discharge must not cause the suspended solid content of the waters to exceed by more than 30%. Salinity ‰: 12 to 38 ‰ Dissolved oxygen (Saturation %): ≥ 80 % | [2006/113/EC] | 2 |

## 5. Stunning & Slaughter

| Species | Stunning and Slaughter Recommendation | Evidence | Level of AAA Certainty |
|---|---|---|---|
| Atlantic salmon *(Salmo salar)* | Electrocution where possible. If not, electrical stunning followed by immediate decapitation. Handling minimized. | [EFSA 2004] [Robb 2000] [Ruff 2002] | 5 |
| Nile tilapia *(Oreochromis niloticus)* | Electrocution where possible. If not, electrical stunning followed by immediate decapitation. Handling minimized. | [EFSA 2004] [Robb 2000] [Ruff 2002] | 5 |
| Striped catfish *(Pangasianodon hypophthalmus)* | Electrocution where possible. If not, electrical stunning followed by immediate decapitation. Handling minimized. | [EFSA 2004], [Robb 2000], [Ruff 2002] | 5 |
| Grass carp *(Ctenopharyngodon idella)* | Electrocution where possible. If not, electrical stunning followed by immediate decapitation. Handling minimized. | [EFSA 2004], [Robb 2000], [Ruff 2002] | 5 |
| Sturgeon | Electrocution where possible. If not, electrical stunning followed by immediate decapitation. Handling minimized. | [EFSA 2004], [Robb 2000], [Ruff 2002] | 3 |

| | | | |
|---|---|---|---|
| Catla<br>*(Catla catla)* | Combination of percussive and electrical is promising. | [FWI1, 2020] | |
| Rohu<br>*(Labeo rohita)* | Combination of percussive and electrical is promising. | [FWI1, 2020] | |
| Southern Bluefin tuna<br>*(Thunnus maccoyii)* | Fish too big to be consistently stunned, spiking if delivered properly kills fish instantly. Surface shooting is not allowed. Crowding to be avoided. | [Peteri, 2004],<br>[EFSA, 2009] | 1 |
| Whiteleg Shrimp<br>*(Litopenaeus vannamei)* | Crustaceans lack a central nervous system so cannot be killed through destruction of the brain. Application of electrical stunning at 110 volts and 5 amps for 5 seconds. | [Neil 2012]<br>[Yue 2008] | 4 |
| Bivalves<br>*(clams, mussels, oysters and scallops)* | Recommendation is minimum level clove oil, and chilling in a refrigerator or freezer at a temperature below 4°C for a minimum of 20 minutes. Bivalves lack a central nervous system so cannot be killed by spiking. | [Australia] | 1 |

**Signatories**

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**Animal Friends Croatia**
**Animals Australia**
**Animal Equality**
**Animal Nepal**
**Aquatic Life Institute**
**Animal Rights Center Japan**
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**Crustacean compassion**
**Equalia**
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**Fish Welfare Initiative**
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