Tilapia Toolkit

Resource 1: Scoring scales

A possible set of scoring scales is presented here in Resource 1, the science of welfare outcome scoring in Tilapia is not yet well developed, and companies and farms showing leadership in this area will work with local expertise to ensure the metrics they choose are realistic and practical.

Source: Pedrazzani, A.S., Quintiliano, M.H., Bolfe, F., Sans, E.C.O. and Molento, C.F.M. (2020): Tilapia On-Farm Welfare Assessment Protocol for Semi-intensive Production Systems. Please see this paper for application method and applicability in different age groups of fish.

Tilapia measures and scales (as proposed by Pedrazzani *et al.* (2020))

Score	1	2	3	4
Eyes	Apparently functional and healthy	Haemorrhage, exopthalmia (eye dislodged), traumatic injury: unilateral	Haemorrhage, exopthalmia (eye dislodged), traumatic injury: bilateral	Bilateral cataract, chronic condition, impaired vision
Jaws	Normal aspect, healthy	Light superior or inferior deformity (aesthetic)	Moderate superior or inferior deformity (affecting feeding)	N/A
Operculum	Normal aspect, healthy	Partially covering the gills (>=75% covered)	Partially covering the gills (<=75% covered)	Unilateral or bilateral absence (missing opercula)
Skin	Normal aspect, healthy	Scar tissue, scale loss, ulcers or superficial injuries <1cm²	Ulcers or superficial injuries >1cm², redness, light necrosis	Severe necrosis, darkening, bleeding, inflammation
Fins	Normal appearance, healthy	Scarred or slightly necrotic tissue	Moderate injury or necrosis (thickening/splitting)	Severe necrosis, bleeding, inflammation
Gills	Normal aspect, healthy	Light injury or necrosis, thickening/splitting	Moderate injury or necrosis, thickening/splitting	Severe necrosis, bleeding, inflammation, pallor, or darkening
Spine	Normal structure	Lordosis or scoliosis, normal weight	Lordosis or scoliosis, weight loss	N/A
Ectoparasites	No infestation	Moderate infestation (<=5 parasites)	Intense infestation (>= 5 parasites)	N/A
Blood glucose (mg/dL)	30-59	60-80	81-120	<30; >120
Mortality	<=10	<=25	<=50	<=75

Behavioural indicators during procedures in Tilapia (as proposed by Pedrazzani *et al.* (2020))

Score	**1**	**2**	**3**	**4**
Feeding	Apprehension of all food in 180-330s	Apprehension of all food in 120-180s	Apprehension of all food in <=120s	No apprehension of all food or >=360s
Capture	Normal swimming, no or low dorsal fins or body parts on surface	Excited swimming behaviour, >20 dorsal fins or body parts on surface	Swimming in different directions or decreasing activity, fish stuck against net	Many fish floating on side, explosion of body to air, exhaustion
Slaughter	Instantaneous loss of VER, BO, EQ, TGR	Total loss of VER and BO in <=10s, instantaneous loss of EQ, TGR	Total loss of VER and BO in <=100s, instantaneous loss of EQ, TGR	Total loss of VER and BO in <=1,000s, progressive loss of EQ, TGR

Resource 2: Examples of animal abuse relevant to aquaculture

Beat, strike, ill-treat; apply pressure to any particularly sensitive part of the body in such a way as to cause unnecessary pain or suffering; handle animals in such a way as to cause unnecessary pain or suffering; use prods or other implements with pointed ends; Unnecessary or cruel use of instruments which administer electric shocks.

Resource 3: Stocking density, glossary

LENGTH 1ft = 0.305m	LENGTH 1m = 3.281ft	AREA 1m^2 = 10.764ft^2
AREA 1ft^2 = 0.0929m^2	WEIGHT 1lb = 0.454kg	WEIGHT 1kg = 2.205lb
LIGHT 20 Lux = 1.858ft candle	LIGHT 0.25ft candle = 2.691 Lux	LIGHT 1ft candle = 10.764 Lux

3b: Tilapia stocking density calculation

Stocking density can be calculated from the following formula: N=W/(G ×a) where:

N = Density (no. of fish/m^2)
W = Expected weight per unit area at harvest (kg/m^2)
a = Survival rate (%)
G = Expected average individual body weight at harvest (kg)

Source: Stocking density for Tilapia identified by Pedrazzani, A.S., Quintiliano, M.H., Bolfe, F., Sans, E.C.O. and Molento, C.F.M., (2020): Tilapia On-Farm Welfare Assessment Protocol for Semi-intensive Production Systems. Please see this paper for stocking applicability in different age groups of fish.

Raising system	Weight (g)	Age (days)	Stocking density (fish/m^2) – no aeration	Stocking density (fish/m^2) – with aeration or renew water system	Food conversion ratio	Crude protein (%)
Excavated pond	1-30	40-80	20-30	40-50	0.8-1.0	36-40
	30-300	80-120	4-5	6-10	1.2-1.3	28-32
	200-1,000	>120	0.8-1.2	2-3	1.4-1.6	28-32
Cage	1-30	40-90	1,200-1,500	1,200-1,500	0.8-1.0	40
	30-200	90-120	450-500	450-500	1.2-1.4	32
	200-1,000	>120	100-150	100-150	1.6-2.0	32

Resource 4: Humane euthanasia, stunning and killing

Emergency/casualty killing

Any seriously sick or injured fish, or fish found not to be recovering, must be humanely killed without delay by either:

a) a priest (heavy weighted stick or rod) of appropriate size for the fish; or
b) a mechanical percussive device (if adapted for use from other farmed fish).

Farmed fish humane killing: mechanical

- The method of killing used must rapidly, and without pain and distress, render the fish insensible, until death supervenes.
- Using an efficiently applied percussive blow.
- Humane mechanical devices must be used in preference to a manual percussive blow (except for emergency killing).
- The use of mechanical devices must be monitored to ensure they are working properly and delivering the stun at the correct location.
- One blow must be delivered to the top of the head, just behind the eyes, of sufficient force to cause immediate loss of consciousness that lasts until death.
- A priest/bonker or secondary stunner must be available throughout the killing process to allow a percussive blow to be administered immediately in the event of a fish not being effectively stunned.

There must be sufficient time after stunning, and safeguards in place to:
a) assess the effectiveness of the stun in all fish; and
b) ensure all fish that have not been effectively stunned are re-stunned immediately.

Bleeding must follow within 10 seconds.

All staff involved with the slaughter/killing process must have received full training and be fully competent in all methods of harvest (dead haul, shore based or cage side).

Checks include:
- Fish have no eye movement
- Fish have no rhythmic opercular movement

- Fish show only mild short-term involuntary muscular twitches
- Fish show no reaction to tail pinch

Farmed fish humane killing: electrical (still experimental for Tilapia, but may follow developments in other farmed fish species once of proven efficacy)

Whatever electrical process is used (batch, continuous flow, etc.) it must be ensured that:

a) insensibility of the fish is achieved immediately;
b) there are no pre-stun shocks; and
c) the stun is maintained until the fish dies, or is insensible to percussive stunning.

Fish must be presented to the stunner in a way that prevent mis-stunning or fish missing the stunner, such as falling from the stun table to the floor.

Staff must be trained and competent to identify signs of an effective stun, and operate the stunning/killing system safely.

All equipment must be operated in accordance with the manufacturer's recommendations or relevant internal protocols. Equipment must be fitted with a visible means of checking that the correct current is being administered throughout the process.

All equipment must be cleaned and maintained regularly and, in any case, at least in accordance with the manufacturer's instructions, and declared fit for purpose.

Contingency plans must be in place to ensure fish welfare is not compromised should there be any equipment or material failure, including an interruption in the electricity supply, loss of water, or breakdown of the water pump.

There must be a humane process in place to ensure no fish are left in the system at the end of the procedure.

Checks include*:

- Fish have no eye movement
- Fish have no rhythmic opercular movement
- Fish show only mild short term involuntary muscular twitches
- Fish show no reaction to tail pinch

*Before the beginning of each harvest, the electrical stunning system must be tested to ensure it is working properly with the first 10 fish.

Unacceptable methods for slaughter of fish (Humane Slaughter Association, See Resource 10)

Recent work on the perception of pain has shown fish have mechanisms for pain perception like those in other vertebrates, including mammals and birds. Fish should therefore be afforded the same welfare considerations as any other animals kept for food. The HSA does not recommend the use of any of the following methods: death in ice slurry; live chilling; gill cut without stunning; or carbon dioxide narcosis. If these methods are currently used as standard practice, they should be replaced as soon as possible with a more humane method.

Death in ice slurry
This process involves fish passing over a de-waterer and into ice slurry. The fish are left until they die through lack of oxygen. In some cases, loss of consciousness can take over nine minutes. When fish are placed in ice slurry, it is difficult to use normal fish reactions (such as escape behaviour or vigorous swimming) as indicators of welfare, as the ice can have an immobilising effect. In these circumstances fish will be relatively still, apart from sporadic flips. The long period for the onset of unconsciousness with this method could result in fish being bled and eviscerated while still conscious, but immobile. If fish are not left for long enough in the ice slurry, or are not bled out effectively, they are likely to recover and regain muscle movement and brain function as they warm up.

Live chilling
This method immobilises fish and reduces the carcass temperature to allow quicker processing. Fish are introduced to temperatures of 2-6°C, where they may show violent movement and escape behaviour. This movement gradually subsides as they become exhausted and/or immobile. After about 30 minutes they are removed from the water and their gills are cut while still fully conscious. Where chilling is used, the rate of chilling should not exceed a drop of 1.5°C at any time. It is essential that the water quality is maintained and that oxygen, carbon dioxide and ammonia levels are measured and controlled by changing the water throughout the day.

Gill cut without pre-stunning
This method involves removing fish from water and then cutting the gills without any pre-stunning. On removal from water, the fish show escape behaviour and flip their tails. Once the cut into the gills is made, these reactions dramatically increase and vigorous head shakes and tail flaps are seen for at least 30 seconds. This movement slowly subsides and, after several minutes, most fish stop moving.

Carbon dioxide narcosis
Loss of consciousness in fish immersed in carbon dioxide saturated water (pH level 4.5), which is highly aversive, can take seven to eight minutes. Fish will show head shaking and vigorous tail shaking for up to two minutes after immersion in the solution. Movement then subsides and the fish become still after approximately five minutes. This is due to exhaustion as opposed to insensibility. Unless fish are kept in a high concentration solution for seven to eight minutes, recovery will begin soon after removal from the solution (such as on the table or in the bin).

High concentrations of carbon dioxide must be used to maintain a pH level of 4.5 for a period of at least ten minutes, to cause unconsciousness in every fish before the gills are cut. If removed before then, or if the pH is altered, signs of recovery may be seen, especially when the gills are cut. It is essential when using this method that the gas concentration is measured and replenished as required.

Resource 5: Medicine purchase and use records

Medicine purchase records to include: identity of medicine; quantity of medicine; date of purchase; name and address of supplier; batch number(s); and expiry date(s).

Medicine use records to include: the name of the vaccine, drug or other substance; lot and batch number; quantity of medicine administered; date of treatment; identification of the fish (or group of fish) to which administered; age of treated animals; number of fish treated; date of administration; name of administrator; name of vet issuing prescription; reason for treatment; route of administration; length of treatment; withdrawal times if appropriate; and date of safe slaughter if appropriate.
Veterinary products must be properly labelled and stored appropriately.
Any treatments which have clearly not worked or have produced an adverse reaction in the treated fish, must be reported to the appropriate local authority.

All farms must have a written pharmaceutical waste policy.

Resource 6: Health and welfare plan

1. The health and welfare plan will be reviewed at the start of every production cycle or on an annual basis by those with responsibility for the health and welfare of the fish, which may include the vet, health manager, stockpersons, nutritionist and other relevant personnel
2. The plan will include future husbandry plans, risk assessment, monitoring and control of fish health and diseases
3. Training in medicine administration and recognition of signs of poor health and welfare
4. Infectious disease control and vaccinations used and planned
5. Parasite control
6. Management of non-infectious (management induced) disease and injury
7. Physical injury, control and monitoring
8. Predator control
9. Fungal infection
10. Algae/bio/jellyfish blooms
11. Gill disease
12. Deformity
13. Health and disease incidence record-keeping
14. Written plan to respond to sudden increases in morbidity or mortality
15. Monitoring of KPIs and KWIs, and action planned to deal with increases in KWI or KPI levels
16. Corrective Action Plan within the health and welfare plan, to bring performance in line with good practice
17. Methods and records of euthanasia and humane slaughter

Resource 7a: Biosecurity plan

1. Emergency contact list
2. Named biosecurity person(s)
3. Employee training in biosecurity
4. Lines of separation (LOS) including fences and separate areas, how they are used to protect the animals and people
5. Biosecurity entry procedures
6. Biosecurity exit procedures
7. Biosecurity requirements for visitors (visitor book, PPE)
8. Biosecurity requirements for feed and other deliveries (recording entry, PPE, disinfection)
9. Cleaning and disinfection operating procedures

10. Disinfectant chemicals used (approvals, safe use, dilutions, replenishment)
11. Control of pathogens that can come from the surrounding environment into the farm (such as predator and vector control)
12. Control of pathogens that can spread from the farm to the surrounding environment (such as effluent filtration/sterilisation, and waste, such as dead fish management)
13. Spreading of pathogens within the farm
14. Vermin, vector and wildlife control
15. Visitors and vehicle movements
16. Movement and disinfection of fixed and movable equipment and staff between sites
17. Stock separation, isolation, sanitary and hygiene procedures between working areas
18. Day-to-day cleaning/disinfection and terminal disinfection of buildings, equipment, enclosures and nets
19. Animal movements (new animals in, movement of animals out)
20. Dealing with sick and dead animals (safe, hygienic disposal)

Resource 7b: Water quality

Guide: water quality parameters for Tilapia (indicative only, water quality very dependent on local conditions including: stocking density, feeding, diurnal temperature changes, water flow rates, turbulence and sediment disturbance, rainfall - data from multiple sources, see publications bibliography for further detailed information regarding water quality).

Tilapia are more tolerant than many farmed species to high salinity, high water temperature, low dissolved oxygen, and high ammonia concentrations.

Visual indicators of poor water quality can include water that is heavily soiled.

Fish behavioural indicators of poor water quality can include fish gasping and/or increased aggression.

Temperatures: 24-34°C (75-94°F) Tilapia are subtropical species, and the lower lethal temperature is about 10°C (50°F). They reproduce best at water temperatures higher than 27°C (80°F).

Salinity: Tilapia are tolerant to brackish water, and Nile tilapia (*Oreochromis niloticus*) grows at salinities up to 15 parts per thousand (ppt). Blue and Nile tilapia can reproduce in salinities up to 15ppt, but do better at salinities below 5ppt.

Dissolved oxygen: Tilapia are quite tolerant of low dissolved oxygen DO levels (down to 0.3 milligrams per litre (mg/l). Although tilapia can survive short-term low DO concentrations for several hours, tilapia ponds are usually managed to maintain DO concentrations above 1mg/l, and preferably above 4mg/l.

CO2: The limit of carbon dioxide for most cultured animals, such as fish, could be 15-20mg/l, but 10mg/l is preferable (fish in recirculating aquaculture systems may appear lethargic, as carbon dioxide increases in recirculating aquaculture systems (RAS) systems above 50mg/l).

pH: Tilapia can survive in the water pH range from 5 to 10, but do best in a pH range of 7 to 8.4.

Three forms of toxic nitrogen

1. **Ammonia** takes two forms in water: a unionised form **(NH_3)**, which is toxic, and an ionized form (**NH_{4+})**, which is non-toxic.

At a lower pH, there is more of the ionized form of ammonia and less unionized form. As the pH increases, the percentage of unionised ammonia increases. The upper limit for unionised ammonia in RAS systems has been reported to be less than 0.05mg/l. Prolonged exposure (several weeks) to unionised ammonia concentration greater than 1mg/l causes increased mortalities, especially in fry and juvenile fish in water with low DO concentration.

2. **Nitrite** formed from ammonia by autotrophic and heterotrophic bacteria.

The upper safe limit for nitrite is less than 2mg/l for species like tilapia. Tilapia are more tolerant of nitrite than many cultured freshwater fish, but, for freshwater culture the nitrite concentration is usually kept below 27mg/l as nitrite. To help protect fish from nitrite toxicity in recirculating tank systems, chloride concentrations are often maintained at 100 to 150mg/l chloride.

3. **Nitrate** is the end product of aerobic toxic nitrogen transformation. The upper limit to prevent toxicity would be <200mg/l.

Resource 8: Links to assurance standard organisations involved in aquaculture

RSPCA (UK) Assured Standards

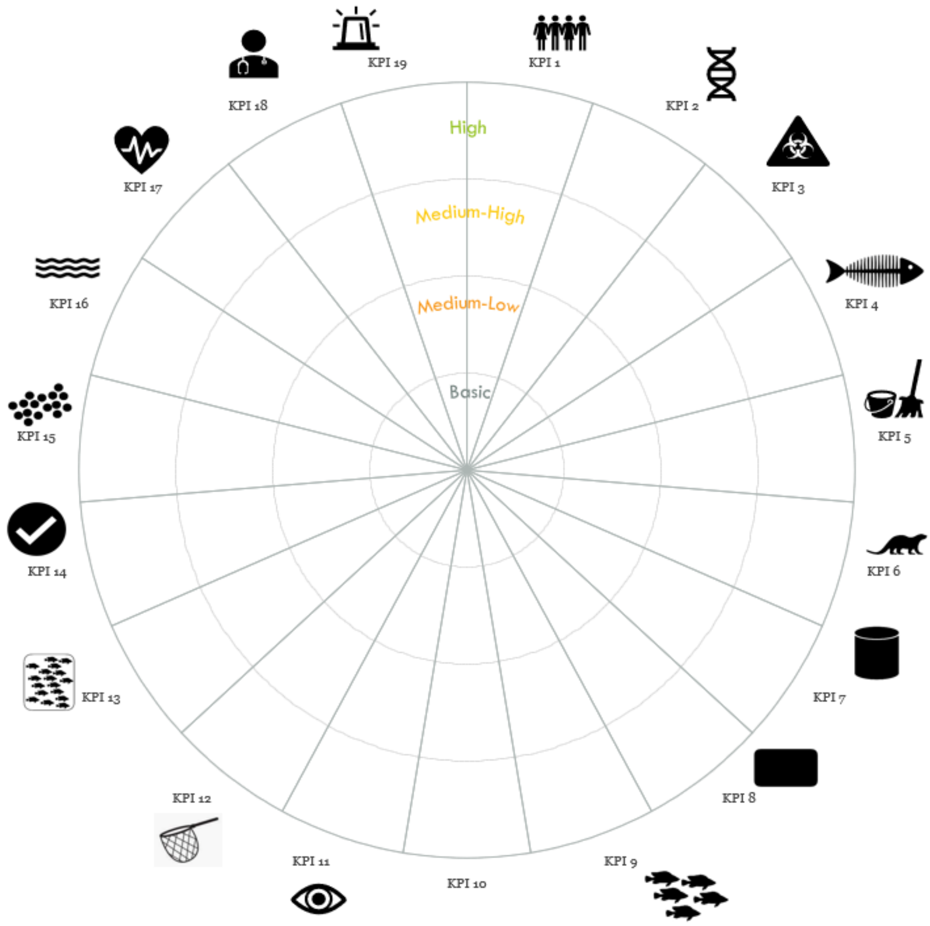
Aquaculture Stewardship Council

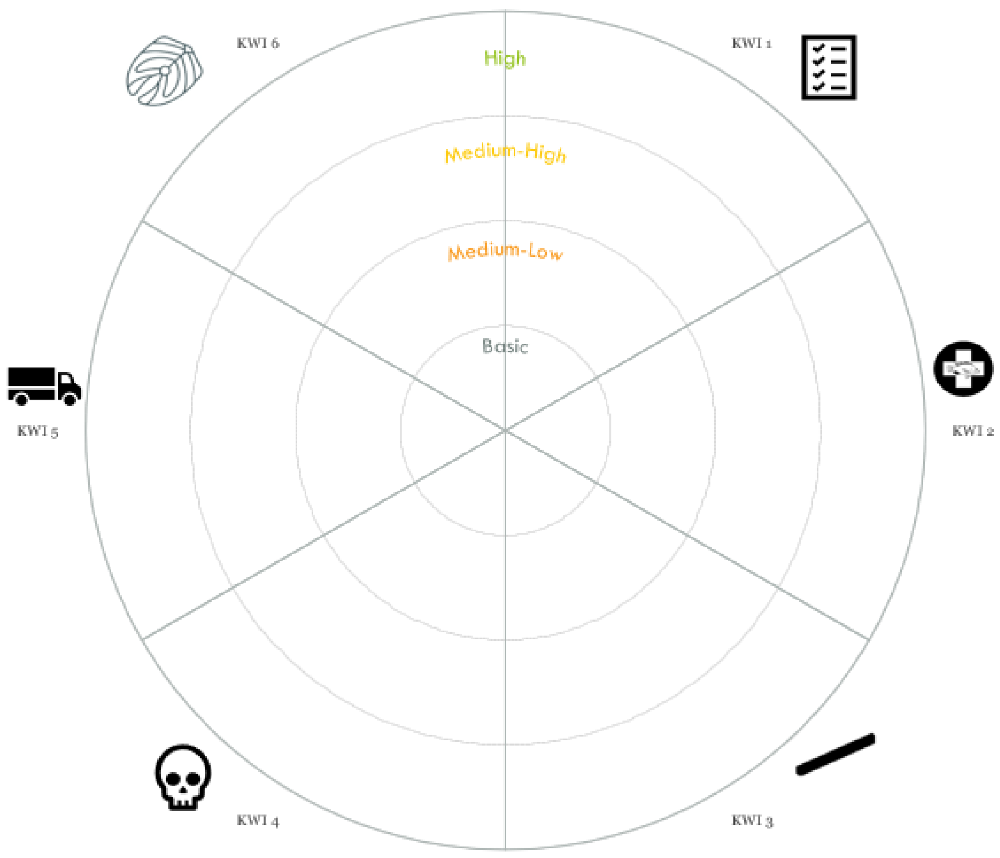
GLOBALGAP aquaculture standards

Best Aquaculture Practices

Scottish Salmon Producers' Organisation Code of Good Practice for Scottish fin fish culture

Resource 9: Blank radar charts to be filled in by assessor (in absence of Excel tool)





Resource 10: Published resources and further reading

General welfare and fish welfare

Ashley, P.J., Sneddon, L.U., and McCrohan, C.R., (2007): Nociception in fish: stimulus-response properties of receptors on the head of trout Oncorhynchus mykiss (Brain Research, 116:47-54)

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BBFAW Investor Briefing (August 2015): How are Investors Using the Business Benchmark on Farm Animal Welfare?

BBAFW Investor Briefing (November 2017): How Companies Are Using the Business Benchmark on Farm Animal Welfare

BBFAW: The Business Benchmark on Farm Animal Welfare Report 2019

Braithwaite, V., (2010): Do Fish Feel Pain? (Oxford University Press)

Compassion in World Farming, Strategic Plan 2013–2017, For Kinder, Fairer Farming Worldwide

Ellis, T., North, B., Scott, A.P., Bromage, N.R., Porter, M., and Gadd, D., (2002): The relationships between stocking density and welfare in farmed rainbow trout Journal of Fish Biology, 61: 493-531)

Ellis, T., Yildiz, H.Y., López-Olmeda, J., Spedicato, M.T., Tort, L., Øverli, Ø., and Martins, C.I.M., (2012): Cortisol and finfish welfare (38:163-188)

Galhardo, L., Almeida, O., and Oliveira, R.F., (2011): Measuring motivation in a cichlid fish: An adaptation of the push-door paradigm (Applied Animal Behaviour Science, 130:60-70)

Gov UK: The Welfare of Farmed Animals (England) Regulations 2007

Gov UK: Animal Welfare Act 2006

Humane Slaughter Association: Slaughter methods

Huntingford, F.A., Adams, C., Braithwaite, V.A., Kadri, S., Pottinger, T.G., Sandøe, P., and Turnbull, J.F., (2006): Current issues in fish welfare (Journal of Fish Biology, 68:332-372)

IFC (2014): Good Practice Note: Improving Animal Welfare in Livestock Operations (2014)

Martins, C.I.M., Galhardo, L., Noble, C., Damsgård, B., Spedicato, M.T., Zupa, W., Beauchaud, M., Kulczykowska, E., Massabuau, J.C., Carter, T., Planellas, S.R., and Kristiansen, T., (2012): Behavioural indicators of welfare in farmed fish (Fish Physiology and Biochemistry, 38:17-41)

Nordgreen, J., Garner, J.P., Janczak, A.M., Ranheim, B., Muir, W.M. and Horsberg, T.E., (2009, a): Thermonociception in fish: effects of two different doses of morphine on thermal threshold and post-test behaviour in goldfish (Carassius auratus). Applied Animal Farmed fish welfare practices: salmon farming as a case study (Behaviour Science, 119:101-107)

Nordgreen, J., Kolsrud, H.H., Ranheim, B., and Horsberg, T.E., (2009, b): Pharmacokinetics of morphine after intramuscular injection in common goldfish Carassius auratus and Atlantic salmon Salmo salar (Diseases of Aquatic Organisms, 88:55-63)

OIE: Terrestrial Animal Health Code (2019)

OIE Terrestrial Animal Health Code (2019): Chapter 7.5, Slaughter of Animals

OIE: Aquatic Animal Health Code (2019)

OIE: The OIE Strategy on Antimicrobial Resistance and the Prudent Use of Antimicrobials (2016)

Poli, M.M., (2009): Farmed fish welfare-suffering assessment and impact on product quality (Italian Journal of Animal Science, 8:sup1, 139-160, DOI: 10.4081/ ijas.2009.s1.139)

RSPCA (2018): RSPCA Welfare Standards for farmed Atlantic salmon

RSPCA (2018): RSPCA Welfare Standards for farmed rainbow trout

Sneddon, L.U., (2003, a): Trigeminal somatosensory innervation of the head of a teleost fish with particular reference to nociception (Brain Research, 972:44-52)

Sneddon, L.U., (2003, b): The evidence for pain in fish. Use of morphine as an anaesthetic (Applied Animal Behaviour Science, 83:153-162)

Share Action: What we do

Turnbull, J., Bell, A., Adams, C., Bron, J., and Huntingford, F., (2005): Stocking density and welfare of cage farmed Atlantic salmon: application of a multivariate analysis (Aquaculture 243:121-132)

Vet Sustain (2019): The Veterinary Sustainability Goals

World Bank Group: General Environmental, Health and Safety (EHS) Guidelines, (April 2007)

World Vet Antimicrobial Stewardship: McDonald's Corporation – Vision for Antimicrobial Stewardship in Food Animals (March 2015)

Tilapia

Algers B, Blokhuis HJ, Bøtner A, Broom DM, Costa P, Domingo M, et al., (2009): Species-specific welfare aspects of the main systems of stunning and killing of farmed carp. Scientific Opinion of the Panel on Animal Health and Welfare (Question N° EFSA-Q-2008-439) EFSA J. 1013:1-37)

ASC (2019): Audit Manual ASC Tilapia Standard (Version 1.3)

ASC (2019): Tilapia Standard (Version 1.2)

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BAP (2014): Aquaculture Facility Certification, Finfish, Crustacean, Mollusk Hatcheries and Nurseries

Boyd, C.E. (2004): Farm-Level Issues in Aquaculture Certification: Tilapia

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Conte, F.S., (2004): Stress and the welfare of cultured fish (Applied Animal Behaviour Science. 86:205-23)

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FAO (2018): Tilapia Trade, Global and Regional Trends

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Freshwater Aquaculture (2019): Water Quality in Aquaculture

Government of Malawi: Tilapia Grow Out Manual

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Lymbery, P., (2002): In Too Deep: The Welfare of Intensively Farmed Fish - a Report for Compassion in World Farming Trust (Petersfield: Compassion in World Farming Trust p.65)

Magnoni, L.J., Martos-Sitcha, J.A., Prunet, P., and Mancera, J.M., (2020): Editorial: welfare and stressors in fish: challenges facing aquaculture (Frontiers in Physiology 11:162. doi: 10.3389/fphys.2020.00162)

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Robb, D., and Kestin, S.C., (2002): Methods used to kill fish: field observations and literature reviewed (Animal Welfare, 11:269-82)

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