Opinion on the Welfare of Farmed Fish at the Time of Killing

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FAWC Opinions

FAWC Opinions are short reports to Government[1] on contemporary topics relating to farm animal welfare. They are based on evidence and consultation with interested parties. They may highlight particular concerns and indicate issues for further consideration by Governments and others.

The Farm Animal Welfare Committee is an expert committee of the Department for Environment, Food and Rural Affairs in England and the Devolved Administrations in Scotland and Wales. The Committee and its predecessor Council (1979-2011) both use the acronym FAWC.

Opinions published by the Farm Animal Welfare Committee

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Welfare of Farmed and Park Deer, 2013
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Lameness in sheep, 2011
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Welfare of the dairy cow, 2009
Policy instruments for protecting and improving farm animal welfare, 2008
Welfare of farmed gamebirds, 2008
Enriched cages for laying hens, 2007
Beak trimming of laying hens, 2007

[1] Where we refer to "Government" we are addressing the Department for Environment, Food and Rural Affairs in England, the Scottish and Welsh Governments, the Northern Ireland Assembly and other responsible Government Departments and Agencies.

Opinion on the Welfare of Farmed Fish at the Time of Killing

Scope

1. The 1996 FAWC Report on the Welfare of Farmed Fish[2] contained a section on 'Killing and Slaughter', confirming the principle that "farmed fish must be killed humanely" (para 233). The considerable expansion of fish farming over the last 18 years, scientific advances, the introduction of new technologies and changes to the national and European regulatory and legislative context regarding both fish farming and killing, mean that updated comment is necessary.

2. European Council Regulation 1099/2009 on the protection of animals at the time of killing[3], which came into force on 1 January 2013, specifically excludes farmed fish from its detailed provisions. This Opinion gives the Farm Animal Welfare Committee (FAWC) an opportunity to contribute to an EU Commission report on the protection of farmed fish at the time of killing. The EU Commission report should take into account the possibility of introducing certain requirements regarding the protection of fish at the time of killing, taking into account animal welfare aspects as well as the socioeconomic and environmental impacts, and is due to be submitted to the European Parliament and Council no later than 8 December 2014.

3. FAWC has reviewed the scientific literature, conducted a written consultation, met with experts and visited farmed fish production systems in the UK. Current industry codes of practice and welfare accreditation schemes have been reviewed against the 1996 FAWC report to assess whether practices have been improved.

4. Objectives of the Opinion:
   a) To ensure that there is adequate, science based understanding of the welfare issues relevant to the priority topics highlighted in the text and identify any gaps in scientific investigation.
   b) To assess whether current welfare standards are sufficiently defined to accommodate any concerns raised in the literature.
   c) To identify if there are any gaps in the legislation, codes of practice, or welfare accreditation schemes where poor welfare practices may remain.

Background

5. This Opinion is restricted to species of fish farmed in the UK for human consumption. Practices in wild caught fisheries, ornamental fish production and angling activities are beyond the scope of this Opinion. A separate Opinion has been produced by FAWC on the Welfare of Farmed Fish,

[2] Farm Animal Welfare Council. Report on the Welfare of Farmed Fish. 1996 http://webarchive.nationalarchives.gov.uk/20120607165549/http://www.fawc.org.uk/reports/fish/fishrtoc.htm

[3] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:303:0001:0030:EN:PDF

containing comments and recommendations on general fish welfare issues, which will not be repeated here.

6. This Opinion focuses on Atlantic salmon and rainbow trout - on which species most scientific literature and practical guidance is based - and covers all killing operations. We will make reference to other currently farmed species (e.g. halibut, tilapia) and basic principles for future, alternative species and processing systems as appropriate.

7. Although the bulk of FAWC's work to date on animal slaughter has focussed on terrestrial species, which present significant differences to fish in both the processes and the broader context of killing, we maintain that there are a number of concerns that are common to both fish and terrestrial farmed animals. Slaughter or killing is the final event in any farmed animal's life. The following principles should be observed if slaughter or killing of fish or terrestrial farmed animal is to be humane with minimal pain, distress or suffering:

i. All personnel involved with slaughter or killing of animals have a duty of care and must be trained and competent;
ii. Only those animals that are fit and healthy should be caught, loaded and transported to the slaughter site;
iii. Any handling of animals prior to slaughter must be done with consideration for the animal's welfare;
iv. In the slaughter facility, only equipment that is fit for the purpose must be used;
v. Prior to killing an animal, either it must be rendered unconscious and insensible to pain instantaneously or unconsciousness must be induced without pain or distress; and
vi. Animals must not recover consciousness until death ensues.

8. Despite the differences between fish and terrestrial mammals (and differences between fish species), including the fact that many management operations necessitate two activities that invoke the maximal stress response in fish (crowding, and removal from water), it is widely accepted that fish (and specifically salmonids) are suitable for farming and food production purposes, and that some degree of stress is unavoidable although it should be minimised through husbandry practice and operating system design.

9. This Opinion assumes that the decision to kill has been made (whether for harvest for human consumption, to reduce the population or for emergency purposes and regardless of the ethical, legal or economic reasons for or against that decision) and will only cover the actions occurring from that decision point onwards.

10. While not farmed for human consumption, the use of wrasse and other species as 'cleaner-fish' to alleviate sea-lice infections in seawater on-growing operations continues to develop, and numbers involved are predicted to exceed 2 million per year within the next three years. There are a number of welfare issues surrounding this practice which were considered in FAWC's

Opinion on the Welfare of Farmed Fish. This advice will consider the separation of 'cleaner-fish' from farmed fish at harvest and subsequent disposal.

Number of animals involved and extent of the welfare issues

11. The UK farmed salmon industry is concentrated in Scotland, one of the world's three largest producers after Norway and Chile. Trout farms are found across the UK. Throughout the UK there are over 750 registered sites where farmed fish of all species are reared. While there has been an increasing centralisation (falling numbers of companies but increased production) of salmon and trout enterprises, other forms of fish farming have accompanied processes of small-scale agricultural diversification. Many small to medium sized farms kill fish on-site or nearby, but there are increasing numbers of centralised processing plants, especially for salmon, to which fish are moved often by well-boat.

12. About 34.7 million salmon were harvested in Scotland in 2012[4]. UK farmed fish production for table and restocking in 2010 was: salmon – 154,633 tonnes; rainbow trout – 13,593 tonnes; brown trout – 574 tonnes; sea bass – 473 tonnes; carp – 248 tonnes; tilapia – 135 tonnes; halibut – 130 tonnes[5]. Without knowing the proportions of fish grown to different weights for sale whole or filleted it is difficult to translate production tonnages into numbers of individuals, but for illustration a tonne of 450g whole trout comprises around 2200 individuals whilst a tonne of 3kg trout for portions comprises around 330 individuals. Production is dominated by salmon, but less so numerically than by weight, as salmon are the heaviest individual fish (up to 10kg). It is estimated that across all the species listed above, there will be in excess of 100 million fish being grown in farms at any particular time.

13. There is a variety of killing methods used in aquaculture globally, although not all are used in the UK. Some of these involve pre-stunning, others not. These methods are discussed later and feature in tables 1-6. Each has specific welfare issues, which include:

- *the nature and extent of non-stunning in fish killing, particularly the use of asphyxia in air or on ice;*
- *adverse reactions of fish to the use of carbon dioxide;*
- *adverse reactions of fish to removal from water;*
- *adequacy of stunning by manual percussion;*
- *adequacy of stunning in semi-automated percussion systems;*
- *adequacy of electrical stunning systems.*

[4] Marine Scotland Science Survey Report 2012
[5] Cefas FinFish News summer-autumn 2012

Legal context, including current and imminent legislation or regulations produced by the GB Governments or the EU

14. The Animal Welfare Act 2006, the Animal Health and Welfare (Scotland) Act 2006 and the Welfare of Animals Act (Northern Ireland) 2011 cover fish (as vertebrates) that are commonly domesticated in the British Isles, that are under the control of humans or are not living in a wild state. This offers farmed fish protection against unnecessary suffering and places a duty on a person responsible for the fish to ensure their needs are met. Nothing in the Acts applies in relation to anything which occurs in the normal course of fishing (interpreted as any legitimate form of fishing, including angling).

15. Council Directive 98/58/EC concerning the protection of animals kept for farming purposes (including fish), requires that *"owners or keepers take all reasonable steps to ensure the welfare of animals under their care and to ensure that those animals are not caused any unnecessary pain, suffering or injury"*. This is covered by the Animal Welfare Acts. However, the Directive excludes fish from the detailed provisions set out in its Annexes. The definition of farmed animal under the Welfare of Farm Animals (England) Regulations 2007 (and similar legislation in Northern Ireland, Scotland and Wales), which applies Directive 98/58/EC, explicitly excludes fish. Farmed fish are, therefore, not offered the more detailed welfare protection during production afforded to most terrestrial farm animals. FAWC's Opinion on the Welfare of Farmed Fish (2014) has called for this to be addressed.

16. The Welfare of Animals (Transport) (England) Order 2006 (WATO) (and equivalent legislation in Northern Ireland, Scotland and Wales) applies to all vertebrate animals, including fish; applying Council Regulation (EC) No 1/2005 on the protection of animals during transport and related operations. Not all of the detailed provisions are best suited to the transport of fish, e.g.:

> *"(g) sufficient floor area and height is provided for the animals, appropriate to their size and the intended journey;*
> *(h) water, feed and rest are offered to the animals at suitable intervals and are appropriate in quality and quantity to their species and size."*

17. As there is no detailed legislation that protects the welfare of farmed fish during production there is, consequently, no statutory Government code. However, the UK aquaculture industries, have adopted codes of practice prepared by the main industry bodies. The Scottish Salmon Producers Organisation (SSPO), in conjunction with Government and other bodies produced the Code of Good Practice for Scottish Finfish Aquaculture[6] and the British Trout Association (BTA) developed Quality Trout UK[7]. RSPCA welfare standards for salmon[8] are implemented through its Freedom Food assurance scheme. Other relevant standards include organic standards, Global G.A.P.,

[6] http://www.thecodeofgoodpractice.co.uk/cogp/preface-to-the-2010-edition
[7] http://www.qualitytrout.co.uk/
[8] http://www.rspca.org.uk/ImageLocator/LocateAsset?asset=document&assetId=1232731074670&mode=prd

and Aquaculture Stewardship Council. Focus on fish welfare within these latter schemes is variable.

18. There is high take-up of both the Code of Good Practice for Scottish Finfish Aquaculture and of the Freedom Food assurance scheme for salmon (the latter covering 60% of Scottish salmon production in 2012[9], with the expectation expressed in 2013 that this will rise to 90% in the next two years[10]). An RSPCA welfare standard for trout was published in February 2014[11]. Of course, any standard requires good implementation, inspection and compliance to be effective.

19. The Aquatic Animal Health (England and Wales) Regulations 2009 (and similar legislation in Scotland and Northern Ireland) require records of observed mortality to be maintained as a condition of a farm's authorisation. A relevant person is guilty of an offence if that person knows or suspects that increased (and unexplained) mortality has occurred or is occurring in aquaculture animals and fails immediately to notify the competent authority or a veterinarian of that knowledge or suspicion. Inspection of fish farms and enforcement for health purposes are carried out by the Fish Health Inspectorates. The Inspectorates have no formal role in fish welfare but will often give advice and guidance to farmers where the situation demands. In England and Wales the Fish Health Inspectorate is required to inform Defra of any concerns with regard to fish welfare on fish farms. We were told that in Scotland Fish Health Inspectors receive training in farmed fish welfare from the Animal Health Veterinary Laboratory Agency (AHVLA).

20. Where it is deemed that a case of poor welfare exists on a farm, the circumstances are reported to AHVLA colleagues. Where a listed or notifiable disease is identified on a farm site, options for control are limited. In order to reduce or remove the risk of the infection spreading to other uninfected populations of fish, the farmer may be required to slaughter or kill and destroy or dispose of any farmed aquatic animal. The official authorities will oversee such operations. Prior to the commencement of any statutory killing or slaughter operation, veterinary advice will be sought to ensure that the method is acceptable with regard to welfare, whilst considering the need for the operation to be carried out as quickly as reasonable and in a biosecure manner.

21. European Council Regulation No. 1099/2009 on the protection of animals at the time of killing came into force on 1 January 2013 and will be supported by domestic legislation (2012 in Scotland and 2014 in England, Wales and Northern Ireland). Under the Regulation fish are covered by the key principle that "*Animals should be spared any avoidable pain, distress or suffering during their killing and related operations*" (Article 3(1)). However, Regulation 1099/2009 specifically excludes detailed provisions for fish on the

[9] Freedom Food Impact Report 2012
[10] Scottish Salmon Producers Organisation Website 2013
[11] http://www.rspca.org.uk/ImageLocator/LocateAsset?asset=document&assetId=1232734642791&mode=prd

grounds that "*there is a need for further scientific opinion and economic evaluation in this field*" (paragraph 6).

22. An EU Commission report on the possibility of introducing certain requirements regarding the protection of fish at the time of killing, taking into account animal welfare aspects as well as the socioeconomic and environmental impacts, is due to be submitted to the European Parliament and to the EU Council no later than 8 December 2014. This may be accompanied by legislative proposals for the protection of farmed fish at the time of killing. Until this time, farmed fish will continue to have only generic legislative protection at slaughter and killing.

23. There may be requirements of EU Regulation 1099/2009 that should logically be applied to fish killing establishments, but there may also be aspects that are not suitable for fish. Requirements that might equally be applied to fish killing establishments could include Standard Operating Procedures, training and Certificates of Competence, maintenance of holding and stunning equipment, monitoring and recording of electrical stunning equipment, animal welfare monitoring processes and Fish Welfare Officers.

Previous Advice by FAWC relating to the topic

24. FAWC's 1996 Report on the Welfare of Farmed Fish covered slaughter or killing of salmon and trout. It argued that the commitment to humane slaughter, which was applied to farmed terrestrial animals, should also be applied to farmed fish. The general principles that the Report recommended were that:

> *"235. If a fish is to be stunned, the stun must cause immediate loss of consciousness which lasts until death.*
>
> *236. A fish must not be stunned unless it can be bled or otherwise killed without delay.*
>
> *237. If a fish cannot be stunned, any killing method must result in rapid and irreversible loss of consciousness.*
>
> *238. Transfer from the pen or tank to the killing facility should cause a minimum of avoidable excitement, pain or suffering to the fish."*

25. Specific slaughter and killing issues addressed by the report included exsanguination alone, percussive stunning or killing and narcosis followed by exsanguination for salmon and electrical stunning or killing, percussive killing and narcosis for trout. The 1996 Report recommended that for salmon:

> *"245. Fish must be stunned or killed before their blood vessels (gill arches) are severed for bleeding and when stunned remain insensible until death supervenes."*

and for trout:

"254. Trout must be killed in a humane way and the widely used method of leaving the animals to suffocate in air is not acceptable."

26. The FAWC Report of 1996 is widely acknowledged as having had a significant impact in raising the issue of fish welfare at slaughter in the UK and elsewhere, leading to significant changes in both the understanding and the practice of humane killing of farmed fish. It also called for more research into slaughter methods and pre-slaughter handling, a call reiterated by EFSA in their 2004 Opinion which specifically identified as a 'high research priority', the need to develop commercially acceptable methods for an effective stun or stun/kill of farmed fish species.

National and/or international considerations

27. In 2005 the Council of Europe published a general recommendation concerning farmed fish, which included recommendations on emergency killing[12]. The Standing Committee of the European Convention for the Protection of Animals Kept for Farming Purposes was working on species-specific texts concerning fish at the time of its suspension in 2010.

28. The OIE *Aquatic Animal Health Code*[13] makes recommendations that cover: Introduction to recommendations for the welfare of farmed fish; The welfare of farmed fish during transport; The welfare aspects of stunning and killing of farmed fish for human consumption; and Killing of farmed fish for disease control purposes. This guidance is a baseline for farmed fish production on a global basis.

29. In 2009 EFSA published several Opinions on the welfare at killing of farmed Atlantic salmon[14], turbot[15], carp[16], eel[17], sea bass[18], trout[19] and tuna[20]. Also in 2009 EFSA published Opinions on the general approach to fish welfare and the concept of sentience in fish[21] and on knowledge gaps and research needs for the welfare of farmed fish[22].

30. Defra announced work on planning for sustainable growth in English aquaculture with a consultation in January 2012[23]. The Welsh Government has recently announced an aim to double Wales' annual finfish aquaculture output (from 1,000 to 2,000 tonnes) by 2020[24]. The Scottish Government has

[12] http://www.coe.int/t/e/legal_affairs/legal_co-operation/biological_safety_and_use_of_animals/farming/Rec%20fish%20E.asp
[13] http://www.oie.int/en/international-standard-setting/aquatic-code/access-online/
[14] http://www.efsa.europa.eu/en/efsajournal/pub/1011.htm
[15] http://www.efsa.europa.eu/en/efsajournal/pub/1073.htm
[16] http://www.efsa.europa.eu/en/efsajournal/pub/1013.htm
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[19] http://www.efsa.europa.eu/en/efsajournal/pub/1012.htm
[20] http://www.efsa.europa.eu/en/efsajournal/pub/1072.htm
[21] http://www.efsa.europa.eu/en/efsajournal/pub/954.htm
[22] http://www.efsa.europa.eu/en/efsajournal/pub/1145.htm
[23] http://www.defra.gov.uk/consult/files/120112-aquaculture-consult-doc.pdf
[24] http://wales.gov.uk/newsroom/environmentandcountryside/2013/131126marine/?lang=en

enacted the Aquaculture and Fisheries (Scotland) Act 2013[25], and is committed to help the industry to increase farmed finfish production substantially but sustainably by 2020.

Ethical issues

31. FAWC believes that society should provide farmed animals with "a life worth living" and an increasing number with "a good life". We affirm that these principles should extend to farmed fish. Both "a life worth living" and "a good life" encompass a whole life up to and including death.[26] Indeed, only once a creature has died may the quality of its whole life be appraised.

32. Since FAWC's 1996 Report, understanding of fish welfare within aquaculture has grown. As a result, it has become clearer that key elements of the Five Freedoms relevant to harvesting and killing apply to finfish: (a) Hunger (and/or stress related to habituation to feeding) may result from prolonged feed withdrawal; (b) At least some species, including trout, have a sensory experience of pain[27]; (c) There are indications of a cognitive process, at least in rainbow trout, for the experience of fear.

33. Evidence also exists from perceptual and cognitive awareness in fish for a degree of sentience[28]. Indeed, in many fish species there is growing scientific evidence for behaviour that requires quite complex cognition, such as learning from positive reinforcement. This evidence gives added weight to the factors in the previous paragraph.

34. Fish are generally viewed at the group level rather than as individuals. Nevertheless, if their welfare during harvest and at the point of killing is to be protected, it is important that all involved in these processes regard finfish as individuals and recognise that their killing requires taking responsibility for the ending of individual lives. This applies even if it is not possible or practicable to handle fish individually.

35. There is increasing consensus within aquaculture that welfare should be a matter of concern and FAWC agrees. FAWC also works from the precautionary principle that animals should be given the benefit of any moral or scientific doubt about their welfare. The killing technologies and practices employed in aquaculture generally exceed public expectations and may already be in advance of those in use in other agricultural sectors. Where they exist, high standards are to be commended.

36. The public expectation of the minimum ethical standard for finfish killing may typically be lower than for other animals and lower than expectations

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[25] http://www.legislation.gov.uk/asp/2013/7/contents/enacted

[26] Farm Animal Welfare Council 2009. Report on farm animal welfare in Great Britain: past, present and future.

[27] FAWC, Opinion on the Welfare of Farmed Fish, 2014

[28] EFSA Opinion of 2009 General approach to fish welfare and to the concept of sentience in fish *The EFSA Journal* (2009) 954, 1-27

within aquaculture[29]. This is because fish are less likely than other animals to elicit emotionally-based ethical responses such as empathy or compassion. The image of fish caught in the wild or at sea (killed by asphyxiation) is the norm. Greater public understanding of the welfare issues and their ethical implications, rationally informed by scientific evidence specifically regarding finfish, is needed in order to motivate ethical consumer choice.

Welfare at Routine, Control and Emergency Killing

37. Fish may be intentionally killed in the course of routine husbandry, for example in order to remove slow growing fish. Individual fish may be removed from tanks for health sampling and post-mortem examination. Adult female fish are generally anaesthetised before stripping and not allowed to recover. In each of these procedures, the time from removal of the fish from water to unconsciousness and killing should be kept to a minimum and humane methods should be applied to kill the fish.

Emergency killing

38. There are some circumstances that necessitate the slaughter of fish for legal, health or welfare reasons. These include: the detection of a notifiable disease by the competent authority; irreparable failure of a life-supporting production system where welfare compromise might be inevitable; in the event of a serious and untreatable disease or parasite infection.

39. This operation could involve fish at all life cycle stages, and may occur on sites where normal harvest killing equipment is unavailable. The procedures for detecting such fish, and for their subsequent removal and killing, should be set out in a Veterinary Health Plan.

40. In the event of regulatory intervention (i.e. demand from the competent authority), swift implementation of culling may be required to prevent risk to greater numbers of fish.

41. Emergency killing for disease control is commonly undertaken using high doses of anaesthetic or manual or mechanical percussive stunning, depending on the size of the fish. EFSA, in their 2009 Opinion, acknowledge that for the use of anaesthetic to be humane, the recommended dosage and exposure times need to be regulated according to the size and body weight of the fish and to the water temperature. EFSA suggests that there is, at present, insufficient knowledge of these parameters to ensure consistently humane emergency killing. Asphyxia, hypoxia or chilling on ice are not acceptable methods of killing farmed fish.

Routine or production culling

42. This typically occurs in the juvenile stages, and generally involves the removal of fish deemed unlikely to thrive through to harvest.

[29] Muir, R. et al. (2013) Attitudes towards catch-and release recreational angling, angling practices and perceptions of pain and welfare in fish in New Zealand. Animal Welfare 22, 323-329

43. Culling can also be necessary for some commercial companies where overproduction means some stock is unsold (this is especially relevant to salmon, where the window of sale for smolts (seawater adapted juveniles) is quite restrictive. In both cases, fish are usually killed with an overdose of anaesthetic or by percussive killing depending on the size of the fish.

Health or quality assessment sampling

44. Routine health sampling is carried out for quality assessments, regulatory health sampling and population screening. Sampling typically involves small numbers of fish at any life cycle stage and is usually invasive, necessitating killing at the start of the operation.

Removal of moribund fish during routine husbandry

45. Dead fish are generally removed either daily or up to weekly depending on the holding system and accessibility. Moribund fish are often extracted at the same time, or may be removed at other times if they are seen, again depending on the system. In some systems sick fish can be caught with a dip net. Elsewhere, it may be impossible to catch, or even notice, a sick fish in a sea pen, and problems like this may become more difficult as pens of larger size are used[30].

46. Catching and culling sick fish can have an adverse impact on the behaviour and perhaps welfare of the rest of the population, but leaving them will compromise their own welfare and can be a disease risk. This generally involves low numbers except at very early life cycle stages. These killing procedures are often not relevant to or in proximity to normal slaughter systems. It is suggested that more research is needed to ensure humane methods are available to detect, retrieve and kill sick or moribund fish.

47. FAWC believes that all routine and emergency killing of farmed fish should be carried out in as humane a manner as possible to reduce pain, aversive responses and suffering. Asphyxiation does not result in immediate unconsciousness and has been shown to be stressful to farmed fish and therefore should be avoided. Pharmaceutical methods should ensure a rapid and effective kill. All fish should be stunned prior to killing or reach unconsciousness without distress or delay.

Cleaner-fish

48. It is important that wrasse or other cleaner-fish can be removed from sea pens when feed is withdrawn from salmon or larger trout prior to harvest to prevent the risk of predation.

49. The original intention was that wrasse or other cleaner-fish be used for ecto-parasite control in a single population of salmon or trout before being

[30] FAWC Opinion on the Welfare of Farmed Fish, 2014

disposed of. It is understood that an application to the Fish Health Inspectorate in Scotland has resulted in agreement that cleaner-fish may be re-used once, subject to disease testing and their remaining in the same area.

50. We are told that most wrasse can be removed from a sea pen with baited creels. They would be killed by anaesthetic or percussive killing.

Welfare at Harvesting

51. There are four distinct stages to the pre- slaughter process that can have welfare implications. These overlap with FAWC's Opinion on the Welfare of Farmed Fish (2014) since they involve activities inherent in routine husbandry and lifecycle operations. However, these areas must also be addressed here as they are critical steps in the harvest process with direct effects on subsequent stages. The key stages are described below.

Feed withdrawal

52. Feed withdrawal reduces metabolic activity and thereby reduces stress and oxygen demand during handling and transport. This will also improve water quality during the crowding and transport stages and has food hygiene implications during post slaughter processing.

53. Negative effects on welfare are probably less than in warm-blooded animals (wild fish may go for long periods without feeding). However, farmed fish may have become habituated to regular feeding and satiation and removal of feeding may be stressful as a result. Sudden feed withdrawal may reduce welfare because aggression may increase, including predation on cleaner-fish where stocked.

54. Maximum periods of feed withdrawal are detailed in most codes and standards, following a recommendation in FAWC's 1996 Report (less than 72 hours). There is still little scientific basis for these precise figures, and research effort should be applied to identifying limits that balance the welfare impacts, but where they are given in degree days this seems more appropriate than absolute time.

Crowding

55. Crowding is an essential operation to contain and capture fish, although it is observed to invoke a high stress response. This process, if poorly managed, can also lead to physical damage through abrasion on nets or contact with other fish. The presence of fish scales in the water may be taken as an indicator of excessive crowding, along with extensive air gasping, lateral rotation and a decreasing number of turns and tail beats. The post-mortem identification of recent snout damage as fish seek to move away from each other may also be an indication of excessive pre-slaughter crowding.

56. The period of time fish are crowded prior to removal should be kept to a minimum to avoid stress and injury. Both the RSPCA and the Humane

Slaughter Association recommend that the period fish are crowded be limited to a maximum of 2 hours. The RSPCA additionally recommends that water oxygen levels within the area of crowding be monitored. All necessary staff and equipment should be available to complete operations in this time.

57. Crowd density should also be controlled, as high densities will lead to stress. This will result in rapid swimming, depletion of oxygen in the water and eventual collapse from hypoxia. Operators should be trained to balance the crowd density to control stress whilst ensuring the fish can be captured.

Handling and Manipulation

58. Removal from water into air is, for most aquatic species, likely to induce a stress response (although reflex responses are not necessarily indicators of poor welfare) and can result in injury. Where it is essential, the time out of water should be as short as possible. For example, the current RSPCA standard is that salmon should only be kept out of water for a maximum of 15 seconds, unless anaesthetised. The density of fish out of water is also a concern when large nets (brails) are used. A high density of fish in such a net will cause damage and stress to the fish at the bottom of the net and so should be avoided. Large numbers of fish are likely to increase the time individuals are out of the water.

59. It should be questioned in designing systems and practices whether removal of fish from water is necessary at all. Many of the procedures, which previously required handling, may be achieved in other ways, often with the application of technology such as fish pumps. Where stress is reduced or removed, there is a clear benefit in improved product quality as high stress levels prior to slaughter have been shown to contribute to poorer texture and soft flesh or muscle gaping. Ideally fish should be handled or pumped in water at the lowest effective pressure.

Transport

60. Most slaughter operations for salmon or large trout kept in pens in the sea or freshwater lochs are now not carried out at pen side. In a major change from the situation in 1996, transport (in water) is almost always necessary. Transport should not injure or stress fish.

61. For salmon and large trout, movement over distance is almost exclusively by wellboat, where due regard needs to be paid to crowding prior to loading (see above), the pumping rate and pressures, pipe diameters relative to fish size and the final stocking density in the transport tanks. In some cases, fish may be towed in their pens over short distances to killing sites.

62. Smaller trout are generally either pumped or channelled to the killing equipment on farm, though on occasion they are moved by road to off-farm killing facilities.

63. Transfer of fish to a killing facility should deliver fish to the point of killing at a rate consistent with rapid and immediate stunning and killing. Appropriate communication is required between the point of killing and the wellboat or other delivery system. The method of unloading the transport vessel should be adapted to the method and rate of killing the fish so that fish are not out of water inside the killing facility unduly long.

64. The loading/unloading of fish by pump or net can be stressful. Vibration, noise, water quality, pressure change, temperature change and physical damage are factors that should be taken into account by operators during transport and loading/unloading operations.

65. Water quality should be monitored during transport and maintained within acceptable limits, e.g. monitoring of water quality by remote meters, using oxygen tanks or compressed air to supplement dissolved gases. Damping and/or insulation for tanks or wells can reduce vibration and noise.

Welfare at killing for human consumption

66. Under EC Regulation 1099/2009, Article 2, the definition of slaughter is "the killing of animals intended for human consumption". Stunning is defined as "any intentionally induced process which causes loss of consciousness and sensibility without pain, including any process resulting in instantaneous death". Killing, from the same source, means: "any intentionally induced process which causes the death of an animal".

Stunning/killing

67. The humane stunning of farmed fish is necessary to remove fear, pain and distress at the time of killing. FAWC believes that all farmed fish should be stunned before killing, whether or not death accompanies the stun (as in stun/kill methods) or when death follows some short time after the stun but before the fish has the time to regain consciousness.

68. Fish should be delivered to the killing facility in a manner that is consistent with the speed and operation of the electrical or percussive stunning machinery and personnel and at a rate that minimises the time delay before killing, especially if fish are (partially) out of water. Fish should be positioned for stunning with the minimum of handling.

69. In the UK industry, the normal method of stunning/killing salmon and larger trout is to apply a mechanical percussive stun from which the fish will not recover. Salmon are usually also bled for quality purposes, but this would also cause death if the percussive stun did not already achieve this.

70. Percussive stunning requires sufficient force to cause instantaneous unconsciousness and/or death. FAWC notes the increasingly generalised use of automated percussive stunning for salmon and large trout. Manual percussive stunning becomes less efficient with operator fatigue.

71. For percussive stunning/killing of roundfish, the blow must be delivered to the top of the head, just behind the eyes. The blow should be of sufficient force to induce immediate, non-recoverable unconsciousness.

72. Flatfish are usually stunned/killed with a percussive blow. Staff need to be trained and competent to ensure the blow is delivered to the appropriate area above the cerebral structures. This location varies between species, which flatten from their roundfish stage either left or right handed.

73. Automated killing facilities must have available in the killing area, a method of manual percussion (e.g. a 'priest') in the case of a mis-stun or breakdown of the stunning system. Automated killing facilities should be set up according to the size of fish they are to kill and operators should routinely check that all fish are killed appropriately. Any adjustments to the setup to accommodate different fish sizes should be made immediately.

74. Smaller trout are normally stunned electrically with sufficient current and duration to disrupt their respiration for long enough to cause death. Small trout are electrically stunned, because there are too many fish to mechanically stun and they are too small to handle for this purpose.

75. Electrical stunning requires sufficient current and duration to prevent recovery before death, but there is the possibility of tissue damage. It is understood that electrical stunning cannot directly kill fish, failing to stop the heart through ventricular fibrillation. The stunning/killing process needs to ensure respiratory failure before recovery from the electrical stun. Electrical stunning can make removal of fish from water unnecessary.

76. Effectiveness of stunning must be monitored. Operators should be trained to recognise the signs of ineffective percussive or electrical stunning, i.e. rhythmic motion of the opercula, the vestibule-ocular reflex (eye roll reflex), struggling, swimming activity or efforts to remain upright or regain equilibrium. Staff should check that fish are being killing effectively by assessing a periodic sample. Death can be recognised by a lack of opercular movement or the absence of the eye roll reflex for at least 10 minutes.

77. Fish farms and other sites killing fish should appoint or identify a suitable person, e.g. a Fish Welfare Officer (FWO), with sufficient technical competence to be responsible for animal welfare on site and during killing and related procedures, and with the authority to provide guidance to other personnel.

78 There is anecdotal evidence that farmed fish, in the EU and beyond, are killed using either water saturated with carbon dioxide, cutting of blood vessels without stunning or asphyxiation without prior stunning in air or on ice. We are also informed that rapid chilling causes significant stress. All of these methods are considered highly aversive and/or involve a long period to loss of consciousness and are all considered to cause unacceptable levels of pain and suffering for fish.

79. Although EC Regulation 1099/2009 does not identify permitted or prohibited methods of farmed fish slaughter, it does require that "Animals shall be spared any avoidable pain, distress or suffering during their killing and related operations". As such, methods described in paragraph 78 should not be used under any circumstances for farmed fish.

80. Emergency killing at slaughter, where automated stunning or other methods fail, should not be by methods considered inhumane at other times.

81. This Opinion makes no mention of maceration or decapitation of fish as we are not aware of these processes being used to kill fish.

82. The following Tables 1-6, for salmon, trout, halibut and tilapia describe the principal slaughter methods that have been researched for these species. The information has been collated from peer-reviewed publications[31]. For each method, we identify:

- the principal characteristics;
- the conditions for use;
- the key parameters; and
- any specific requirements of the method.

83. The tables are set out in the format of Annex 1 of European Council Regulation 1099/2009 on the protection of animals at the time of killing to indicate how parameters for fish might be included in welfare at killing legislation. Parameters from the experimental work for methods not considered humane by the researchers or FAWC are included firstly for reasons of comparability and completeness and, second, because such methods are still used in other EU Member States and more widely.

84. Consideration should be given by the EU Commission to the inclusion in EU law of detailed requirements for the welfare of farmed fish at the time of killing in line with the parameters described in Tables 1-6.

Stunning parameters

85. The electrical parameters given in Table 5 are values that have been demonstrated in the literature to result in effective stunning when applied to fish. They are reproduced as a guide rather than as the minimum values to stun fish. In addition, electrical stunning of fish in water must take into account the conductivity of the water, where fresh water conductivity may vary from 20 – 1,000 µS/cm and seawater ≤50,000 µS/cm, which will influence the strength of the electric field and consequently the efficacy of the stun.

[31] References to research findings used in the tables are contained in Appendix 4. This is by no means an exhaustive list of references used during the preparation of this Opinion as a whole.

Bleeding

86. In salmon and large trout, where the percussive blow stuns but does not kill (simple stunning) bleeding (although done primarily for quality purposes) will kill the fish post stunning. If this is the case then there is a need to cut sufficient blood vessels (such as the aorta or the majority of gill arches) to ensure death by bleeding before the fish recovers.

87. Bleeding without stunning leads to aversive reactions and long period to unconsciousness so should not be practised.

Recommendations

88. All personnel involved with slaughter or killing must be trained, competent and aware of their duty of care.

89. Research effort should be applied to:

- identifying feed withdrawal limits that balance the welfare impacts of hunger/habituation to feeding and reduction in metabolism.
- detecting, retrieving and killing sick and moribund fish.

90. For killing procedures that require it the time from removal of the fish from water to unconsciousness and killing should be kept to a minimum.

91. Cleaner-fish should be removed from sea pens when feed is withdrawn from salmon or larger trout prior to harvest to avoid the risk of predation.

92. Water quality should be monitored regularly and recorded and should be maintained at acceptable levels during the transport of fish.

93. Transfer to the killing facility should be by a method and at an appropriate rate to avoid stress and injury but also to prevent delay prior to killing, especially if fish are (partially) out of water.

94. All farmed fish must be stunned before killing, whether or not death accompanies the stun (as in stun/kill methods), or follows a short time after the stun but before the fish has the time to regain consciousness.

95. Operators killing fish should be able to demonstrate that the key parameters identified in this Opinion (including Tables 1-6) are properly taken into account.

96. Emergency killing, including where automated stunning or other methods fail, should not be by methods considered inhumane at other times. A backup method of manual stunning, such as a priest, must be available in the killing facility.

97. Pharmaceutical methods of killing should take account of dosage, exposure time, size and weight of fish, water temperature and other relevant factors to ensure a rapid and effective kill.

98. Operators should be trained to recognise the signs of ineffective percussive or electrical stunning

99. Fish farms and other sites killing fish should appoint a suitable person to be responsible for animal welfare.

100. Slow chilling only sedates cold water fish so is not an acceptable method of stunning and should not be used. Warm water fish eventually become sedated and even killed, but the time is relatively long and the water quality will affect the stress levels of the fish.

101. Asphyxiation does not result in immediate unconsciousness and has been shown to be stressful to farmed fish. It should not be an allowable method of killing.

102. The use of CO_2 saturated water, live chilling (with or without CO_2) and the cutting of the gills of conscious fish are not considered humane methods of killing and should not be used.

103. The stunning, slaughter and killing of fish should be included in EU welfare legislation.

Table 1. Methods and parameters for the killing of farmed salmon

	Name	Description	Conditions of use	Key parameters	Specific requirements
a	Penetrative captive bolt device	Severe and irreversible damage of the brain provoked by the shock and the penetration of a hollow punch or a spike or iki jime killing method	Slaughter, depopulation and other situations	Position of the blow Appropriate velocity, exit length and diameter of bolt Maximum stun to stick time	Accurate positioning of the device is required if injury and suffering is to be avoided
b	Percussive blow to the head	Severe and irreversible damage of the brain provoked by a percussive blow to the head (stun or stun/kill depending on force) delivered by the non-penetrating device or hand held priest	Slaughter, depopulation and other situations	Position and direction of the blow. Appropriate mass and velocity of the non-penetrating bolt according to animal size and species.	
c	Head-only electrical stunning	Exposure of the brain to a current outside the water (Electric dry stunning) resulting in an immediate loss of consciousness. Simple stunning	Slaughter, depopulation and other situations	Minimum current (A or mA). Minimum voltage (V). Maximum frequency (Hz). Minimum time of exposure. Frequency of calibration of the equipment. Optimisation of the current flow. Prevention of electrical shocks before stunning. Position and contact surface area of electrodes. Maximum time between water exit and stun application	Paragraph 85, Table 5 The stun should be immediately followed by bleeding if recovery is to be avoided
d	Head-to body electrical stunning	Exposure of the body to a current outside water, resulting in immediate loss of consciousness	Slaughter, depopulation and other situations	Minimum current (A or mA). Minimum voltage (V). Maximum frequency (Hz). Minimum time of exposure. Frequency of calibration of the equipment. Optimisation of the current flow. Prevention of electrical shocks before stunning. Position and contact surface area of electrodes. Maximum time between water exit and stun application	Paragraph 85, Table 5

e	Electrical stunning in water	Exposure of the entire body causing immediate loss of consciousness	Slaughter, depopulation and other situations	Electric field (e.g. V/cm) Water conductivity Maximum frequency (Hz). Minimum time of exposure. Field orientation Frequency of calibration of the equipment. Prevention of electrical shocks before stunning. Position and contact surface area of electrodes. Killing method	Paragraph 85, Table 5
Methods not considered humane					
f	CO_2 saturated water		Will eventually kill the fish, but there is no evidence of a stun and the reactions of the fish show it is highly aversive	CO_2 saturation should be achieved before fish are added to the water	On immersion in the CO_2 saturated water, salmon show vigorous aversive reactions, swimming very rapidly and making escape attempts
g	Live chilling + moderate CO_2		The combination sedates salmon but does not stun		Rapid live chilling ±CO_2 does not stun salmon and the CO_2 is stressful
h	Gill cut conscious	Exsanguination	Cutting the gill arches can take 4.5 - 6 minutes to produce brain death therefore fish must be stunned	Severance of all gill arches on both sides of the fish, or the isthmus, or piercing the heart directly, appears to be the best methods for killing by bleeding out unconscious fish.	Exsanguination without prior stunning is not humane and should not be used

Table 2 Methods and parameters for the killing of farmed trout

	Name	Description	Conditions of use	Key parameters	Specific requirements
a	Percussive blow to the head	Severe and irreversible damage to the brain provoked by a firm and accurate percussive blow to the head delivered by a non-penetrating device	Slaughter, Depopulation and other situations.	Position of the blow Energy transfer (force) of the blow	Practical for large (>1kg trout but seldom practical for smaller fish)
b	Head-only electrical stunning	Exposure of the brain to a current generating a generalised epileptic form on the Electro-Encephalogram (EEG). Simple stunning.	Slaughter, depopulation and other situations	Minimum current (A or mA). Minimum voltage (V). Maximum frequency (Hz). Minimum time of exposure. Frequency of calibration of the equipment. Optimisation of the current flow. Prevention of electrical shocks before stunning. Position and contact surface area of electrodes. Maximum time between water exit and stun application Killing method	Paragraph 85, Table 5
c	Electrical stunning in water	Exposure of the entire body causing immediate loss of consciousness and death Simple stunning.	Slaughter, depopulation and other situations	Electric field (e.g. V/cm) Water conductivity Maximum frequency (Hz). Minimum time of exposure. Frequency of calibration of the equipment. Direction of electric field Prevention of electrical shocks before stunning. Position and contact surface area of electrodes. Killing method	Paragraph 85, Table 5

	Name	Description	Conditions of use	Key parameters	Specific requirements
d	N_2 in water (O_2 <1mg/l)	Direct exposure to water saturated with N_2 Death caused by anoxia	Depopulation and other situations N2 stunning produces less muscle activity during slaughter than asphyxiation Does not result in frenzied escape behaviour Other gasses or gas mixtures are worth investigation Long exposure times required	Gas concentration Duration of exposure Quality of the gas 6-8 min to loss of posture.	
Methods not considered humane					
e	CO_2 saturated water	Direct exposure to water saturated with CO_2 Industry codes suggest that because the fish stop moving before loss of consciousness a min exposure time of 4-5 min before exsanguination. Aversion ≤30 s – can include cooling the CO_2 saturated water to 1˚C. Brain function lost at 4.7 min. Not permitted for routine use.	Slaughter, depopulation and other situations, where no other stun/killing methods are available.	Carbon dioxide concentration Quality of the gas pH of 4.5 Temperature / cooling to 1oC Duration of exposure	
f	Asphyxia	Removal from water resulting in death as a result of a lack of oxygen.	Not recommended Taking a fish out of water falls short of the welfare requirement for stunning	(a) H_20 temp 2˚C - 9.6 min to loss of VER (b) H_20 temp 14˚C – 3.0 min to loss of VER (c) H_20 temp 20˚C – 2.6 min to loss of VER	

	Name	Description	Conditions of use	Key parameters	Specific requirements
g	Asphyxia in ice slurry	Reduction of the core temperature to produce sedation followed by exsanguination to cause death	Not recommended Sedation in ice slurry will not necessarily result in the death of the trout. The objective is to chill, sedate and kill the fish by asphyxia – at 2˚C asphyxiation takes 9.6 min Fish should be exsanguinated to cause death Fish transferred from iced water immediately after loss of VERs or SERs to water at normal temperature recovered quickly	Temperature Chilling to exsanguination time	

Table 3. Methods and parameters for the killing of farmed halibut

	Name	Description	Conditions of use	Key parameters	Specific requirements
a	Percussive blow to the head	Severe damage of the brain by the shock of a captive bolt or hand held priest without penetration. Simple stunning	Slaughter, depopulation and other situations	Position of the shot dependent on dextro-sinistral location of the head Appropriate energy, velocity, diameter and shape of bolt according to fish size. Maximum time from removal of water to stun Maximum stun to stick time or other killing method	Some authorities suggest that stunning with a manual priest is more effective when the head is not directly resting on a hard surface.
b	Head to body electrical stunning	Exposure of the body to a current outside water, resulting in immediate loss of consciousness	Slaughter, depopulation and other situations	Minimum current (A or mA). Minimum voltage (V). Maximum frequency (Hz). Minimum time of exposure. Frequency of calibration of the equipment. Optimisation of the current flow. Prevention of electrical shocks before stunning. Position and contact surface area of electrodes. Maximum time between water exit and stun application Maximum stun to stick time or other killing method	Table 5 Fish should be bled immediately after stunning
c	Electrical stunning in water	Exposure of fish in water to an electric field	Slaughter, depopulation and other situations	Electric field (e.g. V/cm) Water conductivity Maximum frequency (Hz). Minimum time of exposure. Frequency of calibration of the equipment. Direction of electric field relative to fish. Prevention of electrical shocks before stunning. Killing method	Paragraph 85, Table 5 Fish should be bled immediately following stunning

	Name	Description	Conditions of use	Key parameters	Specific requirements
Methods not considered humane					
d	CO_2 saturated water	Direct exposure to water saturated with a high concentration of CO2	Not a recommended method because fish find the immersion in CO2 saturated water aversive. Exposure to high levels of CO2 is potentially a killing method but in commercial practice it is used to sedate fish		
e	Bled cutting several gill-arches or caudal vein	Gill cut conscious	Not a recommended method	Cutting the gill arches can take several minutes to produce brain death therefore fish must be stunned	Severance of the gill arches and the caudal vein of the fish would appear to be the best method for killing by bleeding out unconscious fish i.e. stunned fish.

Table 4. Methods and parameters for the killing of farmed tilapia

	Name	Description	Conditions of use	Key parameters	Specific requirements
a	Penetrative captive bolt device	Severe and irreversible damage of the brain provoked by the shock and the penetration of a penetrative captive bolt.	Slaughter, depopulation and other situations.	Position and direction of the shot. Appropriate velocity, exit length and diameter of bolt according to fish size Strength of the cartridge used Maximum stun to stick/kill interval(s)	Some authorities consider that this is possible under practical conditions with farmed tilapia. However the brain is small and well protected. Inaccurate positioning can lead to injuries to fish.
b	Percussive blow to the head	Severe damage of the brain by the shock of a captive bolt without penetration using mechanical device or hand held priest.	Slaughter, depopulation and other situations.	Position of the blow Energy transfer (force) of the blow	Tilapia have bony structures that protect the brain from percussive blows. Where the energy transferred to the brain is not sufficient to cause unconsciousness injury and suffering may result.
c	Electrical stunning in water	Exposure of the entire body causing immediate loss of consciousness and death	Slaughter, depopulation and other situations.	Electric field (e.g. V/cm) Water conductivity Maximum frequency (Hz). Minimum time of exposure. Frequency of calibration of the equipment. Prevention of electrical shocks before stunning. Position and contact surface area of electrodes. Killing method	Paragraph 85, Table 5. Rapid bleeding and/or immersion in ice is necessary to avoid recovery.

	Name	Description	Conditions of use	Key parameters	Specific requirements
Methods not considered humane					
d	Live chilling	Live chilling to the point of death Slow to achieve brain sedation / death.		Sufficient thermal capacity to chill core of all fish Water quality of ice water mix – especially oxygen concentration whilst fish are not sedated.	

Table 5. Electrical stunning parameters that have been demonstrated in the literature to deliver sufficient energy to stun.

Stunning Methods	Salmon	Trout	Tilapia	Halibut
Head-only electrical stunning	0.7 A 95 VAC + 35 VDC at 100 Hz 0.5 s	77 mA 44 VAC at 50Hz		0.7 – 1.8 A 80 VAC 50 Hz for 10 s
Head-to body electrical stunning	0.7 A 95 VAC + 35 VDC at 100 Hz 0.5 s			
Electrical stunning in water*	The electric field strength is inversely proportional to the current duration, dropping from 200 V/m at 0.8 s to 25 V/m at 6-12 s 1000 Hz applied longitudinally in fresh water with conductivity > 400uS/cm)	3 V/cm AC applied laterally for 30-60 s 1000 Hz in freshwater with conductivity > 400uS/cm)	3.75 V/cm for 20 s 125 Hz applied longitudinally AC in freshwater with conductivity > 400uS/cm)	1.25 V/cm 125 Hz applied laterally AC for 5 s in sea water

* at higher water conductivity, loss of consciousness can be achieved at a lower field strength. At water conductivities lower than 400uS/cm the required field strength rises rapidly. Fish are generally found to be more sensitive to a longitudinal electric field (head to tail) than for a laterally applied field

Table 6 – Methods of killing fish for situations other than slaughter for human consumption

No	Name	Description	Conditions of use	Key parameters	Specific requirements
a	Tricaine Methanesulfonate (MS-222)	Topical euthanasia agent	MS-222 is acidic in solution and must be buffered by adding an equal weight of sodium bicarbonate or titrating to pH=7.0-7.5	Minimum concentration for fish = 250 mg/l Immerse until death is achieved. Time to death is proportional to MS-222 solution concentration	Paragraph 42
b	Benzocaine Hydrochloride	Topical euthanasia agent	Benzocaine-HCl is acidic in solution and must be buffered by adding an equal weight of sodium bicarbonate or titrating to pH=7.0-7.5	Minimum concentration for fish = ≥250 mg/L; immerse until death is achieved Both TMS/MS222 and benzocaine hydrochloride may be used as a bath or delivered by intracoelomic or dorsal lymph sac injection.	Paragraph 42
c	2-phenoxyethanol	Topical euthanasia agent	Phenoxyethanol is an organic chemical compound and a colourless oily liquid in appearance	Minimum concentration for fish = 0.5–0.6 mL/L or 0.3–0.4 mg/L. Immerse until death is achieved	Paragraph 42
d	Percussive blow - manual	Severe and irreversible damage of the brain provoked by a percussive blow to the head delivered manually using a wooden or polypropylene priest	Back-up for normal slaughter, depopulation and other situations	Position and direction of the blow Appropriate velocity and weight of the priest according to animal size and species – or energy transfer/force to the brain	Paragraph 70

e	Electrical stunning in water	Exposure of the entire body causing immediate loss of consciousness	The electric field strength required to stun the fish is inversely proportional to the current duration, dropping from 200 V/m at 0.8 s to 25 V/m at 6-12 s	Electric field (e.g. V/cm) Water conductivity Maximum frequency (Hz). Minimum time of exposure. Frequency of calibration of the equipment. Optimisation of the current flow. Prevention of electrical shocks before stunning. Position and contact surface area of electrodes. Maximum time between water exit and stun application Killing method	Table 5 and Paragraph 86

* Medicines at b & c are not licensed for fish in the UK

Appendix 1 - FAWC Membership – Spring 2014

Peter Jinman - Chairman
Professor Michael Appleby
Professor Richard Bennett
Professor Henry Buller
Dr Andy Butterworth
Dr Joanne Conington
Huw Davies
Mike Elliott
Professor Laura Green
Dr David Grumett
Richard Jennison
Gwyn Jones
Professor Richard Moody
Dr Philip Scott
Mark White
Steve Wotton

Advisors
Charles Allan – Marine Scotland
Tim Ellis – Cefas
Dr Rebeca Garcia – Defra/AHVLA
Dr Sophia Hepple – Defra/AHVLA
Dr Jeff Lines – Silsoe Livestock Systems Ltd
Neil Manchester – ex-FAWC and Landcatch Natural Selection
Dr David Robb - Aquaculture Specialist, The Sultanate of Oman
Andrew Voas – Scottish Government
Collin Willson – FSA

FAWC Secretariat
Richard Aram
Louise Mulcahy
Brenda Rawson

Appendix 2 - Those who gave evidence and assistance

Aquaculture Innovation
Artilus Consultancy and Research
British Marine Finfish Association
British Trout Association
Centre for Environment, Fisheries and Aquaculture Science
Compassion in World Farming
Defra
Fish Vet Group
Fish Veterinary Society
Fisheries Society of the British Isles
GLOBAL G.A.P.
Humane Slaughter Association
Humane Society International/UK
Landcatch Natural Selection Ltd
LANTRA
Moulton College
Pharmaq
Royal Society for the Prevention of Cruelty to Animals
Scottish Government
Scottish Salmon Producers Association
Seafish Industry Authority
Silsoe Livestock Systems Ltd
UK Aquaculture Forum
University of Bristol
University of Stirling
World Aquatic Veterinary Medical Association
World Society for the Protection of Animals

We would also like to thank the individuals who have given evidence and the farmers and their staff who hosted visits by the Committee to fish farms in Great Britain.

Appendix 3 – Glossary

AHVLA Animal Health and Veterinary Laboratories Agency

Asphyxia/asphyxiation
Suffocation as a result of too little oxygen or too much carbon dioxide in the blood, in fish often caused by removal from water

Bathing Chemical treatment of fish where the chemical is introduced to the water

Biosecurity Prevention of disease-causing agents entering or leaving any place where farm animals are present

BTA British Trout Association

Cefas Centre for Environment, Fisheries and Aquaculture Science

DARDNI Department of Agriculture and Rural Development, Northern Ireland

Degree days A value used to estimate and predict the various stages of development. Calculated by multiplying the average temperature in Celsius by the number of days. For example, 300 degree days may be 30 days at 10^{o}C or 100 days at 3^{o}C

Electrical stunning
Method of stunning in which electrical current is passed through fish (usually in water) in order to induce immediate unconsciousness

European Council Regulation 1099/2009
Regulation on the protection of animals at the time of killing

EFSA European Food Safety Authority

Exsanguination
Removal of blood from an animal (to cause death)

FHI Fish Health Inspectorate/Inspector

Hypoxia Deficiency in the amount of oxygen reaching the tissues

Ike Jime Insertion of a spike quickly and directly into the hind brain

Isthmus A narrow organ, passage, or piece of tissue connecting two larger parts

MSS Marine Scotland Science

Moribund In terminal decline; lacking vitality or vigour

Narcosis A state of stupor, drowsiness, or unconsciousness produced by a chemical/drug

NGO Non-governmental organisation

OIE *trans.* World Organisation for Animal Health

Percussive stunning/killing
Blow to the head, applied either manually or mechanically, intended to cause immediate unconsciousness (often non-recoverable)

Priest Manual instrument for percussive stunning

RSPCA Royal Society for the Prevention of Cruelty to Animals

SSPO Scottish Salmon Producers Organisation

SSPCA Scottish Society for the Prevention of Cruelty to Animals

Sea-lice Ectoparasites of finfish

Sedation (on ice)
Hypothermia – lowering the water temperature will tranquilize or immobilise fish. Lower water temps also increase the oxygen-carrying capacity of water and reduce the activity

Smolt Young salmon at the stage when it physiologically adapts from fresh to sea water

Stripping The artificial removal of sperm and eggs from fish by gentle pressure applied to the abdomen of the fish

Veterinary Health Plan
Comprehensive health and welfare planning process for farmed livestock, drawn up in consultation with a veterinarian and other professionals

Wellboat vessels designed and constructed to move fish between sea water sites and for related operations; e.g. to transfer smolts to sea at the beginning of the marine production phase, to grade fish, to transport fish for harvest and to carry out bath treatments for sea lice as an alternative to treatment in pens.

Appendix 4 – References used in the tables of stunning methods (this is by no means an exhaustive list of references used during the preparation of this Opinion as a whole)

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