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# SCIENTIFIC OPINION

# Species-specific welfare aspects of the main systems of stunning and killing of farmed carp[1]

## Scientific Opinion of the Panel on Animal Health and Welfare

**(Question N° EFSA-Q-2008-439)**

**Adopted on 20th of March 2009**

**PANEL MEMBERS**

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**SUMMARY**

Following a request from the European Commission, the Panel on Animal Health and Welfare was asked to deliver a scientific opinion on welfare aspects of the main systems of stunning and killing of farmed carp in the EU.

A semi-quantitative risk assessment approach was used to rank the risks of poor welfare associated with the different commercially applied stunning and killing methods for carp. Areas of welfare concern were identified, as well as guidance for future research. The risk assessment was mainly based on expert opinion, due to the limited amount of quantitative and published peer reviewed data on the effects of the hazards associated with the stunning and killing of carp. Pre-slaughter stages, immediately before stunning and killing, which had a direct impact on carp welfare, were included in the risk assessment. Stunning and killing

[1] For citation purposes: Scientific Opinion of the Panel on Animal Health and Welfare on a request from the European Commission on Species-specific welfare aspects of the main systems of stunning and killing of farmed carp. The EFSA Journal (2009) 1013, 1-37.

methods that are not commercially used in the EU, or used only on small scale were briefly described but excluded from the risk assessment.

There are three methods currently practiced in the EU: asphyxia followed by percussion, percussion and whole body electrical stunning in water. All are methods followed by evisceration.

This Scientific Opinion on common carp stunning and killing evaluated the methods currently used in farmed common carp in Europe. Methods used in other fish species other than those described in this Opinion may also be applicable to carp. The opportunity to develop new methods for slaughtering common carp is considerable and should be encouraged.

Although limited data are available, there is a common understanding that the majority of carp are sold alive or as a whole fish by retailers (supermarkets, market sale) or at the farm and that less than 15% carp produced for human consumption is processed in commercial processing plants. Thus 85% of carp are slaughtered outside a regulatory framework and other forms of guidance that control stunning and killing methods.

Based on the risk assessment the most important hazards in the pre-slaughter phase are associated with netting of carp. Handling, therefore, should be minimised, and care taken not to harm the fish.

The practice of exposing carp to air for extended periods of time and in large batches (awaiting stunning) is identified as a major welfare hazard. A method for percussive stunning of carp with minimal exposure to air should be developed.

For electrical stunning methods the most important hazard is exposure to insufficient current/voltage for a prolonged period and this is not compatible with causing immediate unconsciousness. Further research on electrical stunning methods should be carried out to ensure an immediate loss of consciousness.

To the experts' knowledge emergency killing of carp for disease control has not occurred. If it is required then killing could be performed with an overdose of an anaesthetic.

Standard operating procedures to improve the control of the slaughter processes to prevent impaired welfare should be introduced, and validated, robust and practically feasible welfare indicators should be developed.

**Key words:** **Common carp, *Cyprinus carpio*, animal welfare, risk assessment, stunning and killing systems**

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## BACKGROUND AS PROVIDED BY EUROPEAN COMMISSION

Directive 93/119/EC[2] provides conditions for the stunning and killing of farm animals. Fish are legally part of the scope of the EU legislation but no specific provisions were ever adopted.

Following a previous request from the Commission, EFSA issued in 2004 a scientific opinion on the welfare aspects of the principal methods for stunning and killing the main commercial species of animals[3], including farmed fish. As regards farmed fish, this opinion concluded that *"Many existing commercial killing methods expose fish to substantial suffering over a prolonged period of time."* Furthermore, *'for many species, there is not a commercially acceptable method that can kill fish humanely".*

Moreover, this EFSA report[4] highlighted that different methods for stunning and killing of farmed fish must be developed and optimised according to the species specific different needs and welfare aspects:

*"Fish are often treated as one species when it comes to regulations and legislation governing welfare during farming or at slaughter. But, it is important to realise that a very wide number of species of fish are farmed, with an equally wide variety of ecological adaptations and evolutionary developments. These differences mean that different species fish reacts differently to similar situations. For example, at a given environmental temperature, some species like trout die relatively quickly when removed form water into air, whilst others like eel or marine flatfish can take several hours. Similarly, in electrical stunning situations, eel require a much larger amount of stunning current than trout or salmon to render them unconscious species differences need to be taken into account when adopting particular procedures. Processes must be developed and optimised with respect to welfare specifically for each species. For example, it would be as unreasonable to assume that a process developed for killing trout in freshwater would be suitable for killing tuna in the sea as it would be to assume that a system developed for quail would be effective on ostriches."*

## TERMS OF REFERENCE AS PROVIDED BY EUROPEAN COMMISSION

In view of the above, the Commission requests EFSA to issue a scientific opinion on the species-specific welfare aspects of the main systems of stunning and killing of farmed fish. The opinion should assess whether the general conclusions and recommendations of the 2004 opinion apply to the species of fish specified below. Furthermore, the above mentioned conclusions and recommendations should be updated in a species specific approach, integrating where possible reference to welfare indicators and to new scientific developments. Where relevant, the animal health and food safety aspects should be taken into account.

The following species should be considered:

- Atlantic salmon *(Salmo salar)*
- rainbow trout *(Oncorhynchus mykiss)*
- European eel *(Anguilla anguilla)*
- gilthead seabream *(Sparus auratus)*
- European seabass *(Dicentrarchus labrax)*
- European turbot *(Psetta maxima)*
- common carp *(Cyprinus carpio)*
- farmed tuna *(Thunnus spp.)*

2 OJ L 340, 31.12.1993, p. 21–34

3 http://www.efsa.europa.eu/cs/BlobServer/Scientific_Opinion/opinion_ahaw_02_ej45_stunning_en.pdf?ssbinary=true

4 http://www.efsa.europa.eu/cs/BlobServer/Scientific_Opinion/opinion_ahaw_02_ej45_stunning_report_v2_en1,1.pdf?ssbinary=true

ACKNOWLEDGEMENTS

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The AHAW Panel also would like to thank the Member States and stakeholders organisations for their valuable comments which were taken into consideration by the WG Members in producing the Scientific Opinion.

The scientific coordination for this Scientific Opinion has been undertaken by the EFSA AHAW Panel Scientific Officers Ana Afonso, Franck Berthe, Sofie Dhollander, Jordi Tarrés-Call and particularly Oriol Ribó and Tomasz Grudnik.

ASSESSMENT

## 1. Scope and objectives of the Scientific Opinion

The scope of this report is the animal welfare aspects of stunning and killing common carp (*Cyprinus carpio)* farmed in Europe.

Welfare aspects of the farming of carp were not included in this report as they were considered in the EFSA's scientific report on animal welfare aspects of husbandry systems for farmed common carp (EFSA, 2008).

The pre-slaughter process is only considered where evidence exists for a direct impact on welfare at stunning and killing. Where fish welfare, immediately before and during killing or stunning and slaughter, is affected, it has also been considered as part of the slaughter process. Therefore, the welfare aspects of the farming phase of carp as well as the transport of carp are not included in this report.

Emergency killing for disease control or other reasons is included in the report. However, humane killing of individual fish, in the course of farming operations (i.e. sorting, grading, or background morbidity) is not included.

Food safety issues are addressed by the BIOHAZ panel.

In drafting this Scientific Opinion, the panel did not take into consideration any ethical, socio-economic, human safety, cultural or religious or management issues, the emphasis has been to look at the scientific evidence and to interpret that in the light of the terms of reference. Nevertheless, it is acknowledged that such aspects can have an important impact on animal welfare.

## 2. Husbandry systems for farmed carp

See the scientific report of the animal welfare aspects of husbandry systems for farmed common carp (EFSA, 2008), for an overview of carp farming systems in Europe.

## 3. Slaughter process

### 3.1. Domestic/indigenous slaughtering aspects (home slaughter)

Carp were introduced into Central Europe in the medieval ages by monks, and it has become part of some local traditions to be consumed mainly on Christmas Eve as well as at other times, and in some regions the "carp season" lasts from autumn to spring. The majority of carp are sold alive or as a whole fish in supermarkets and minor retailers (market sale or at the farm). The minority (estimated 5-7 % total of production, depending on the countries) is sold alive to fish restaurants and processed there. As an example, the total carp production in Poland (major producer in EU) for 2008 was estimated to be 17 000 tonnes and the estimated sale of carp by supermarkets was 50 % of the production. The rest of the carp production was sold by minor retailers or at fish farms. There are no published data on the number of carp killed in commercial processing plants but it may be just 10 % of total production. (Lirski and Myszkowski, 2009). A survey of experts in Germany, Czech Republic, and Austria indicated that less than 10 % of carp for human consumption are processed in commercial processing plants. There are no substantive data on the killing methods used.

Home slaughter may involve a series of welfare issues connected with prolonged transport without water, asphyxia, temperature shock, excessive handling, and ineffective stunning. Carp may be often kept alive for few days in homes in *ad hoc* water tanks. In this case serious welfare deterioration may be expected. A similar situation may be observed at supermarkets where fish are killed on demand but there is little reliable information. From total EU production of 66 000 (in 2006; Eurostat, 2009) the proportion of carp processed commercially increased from 5 to around 15 % in the last 10 years.

## 3.2. Pre-slaughter process

There are many pathways involved in the stunning, killing and slaughter processes due to the variety of sale methods and means of distribution.

Pathways are especially diverse in case of home slaughter and cannot be investigated in a coherent way without further information. Commercial slaughter involves fewer steps and is more standardised between processing farms, however certain steps of the process depend on the facilities available and methods used.

The Figure 1 illustrates the most common pathways during the pre-slaughter period at a processing farm and includes activities, related to handling and lairage of fish exposing carp to the series of hazards listed in Table 1.

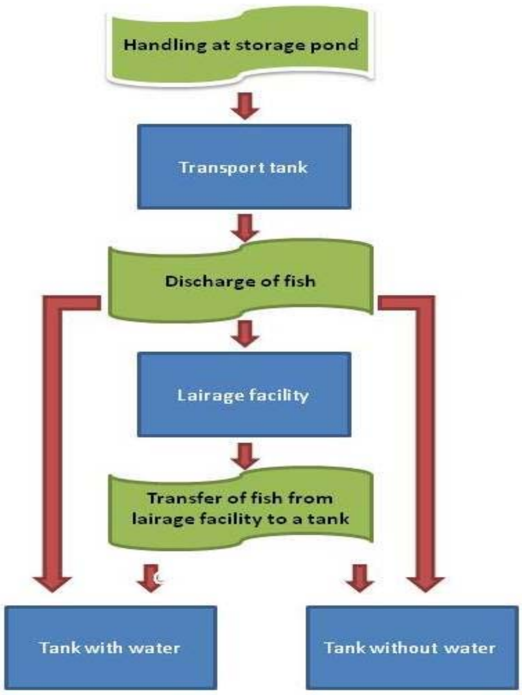



Figure 1. **Graphical representation of processes involved during the pre-slaughter period**

The pre-slaughter process starts with hand-netting of carp from a pond into a transport container and at the processing plant they are taken out by a hand-net (hazard#1) or the container is emptied by opening outlet of a slide or flexible sleeve. Netting may cause damage to the carp as the nets can be abrasive (h#2b). Serious damage leading to death may occur if a fish is hit with the net frame or stepped on by an operator (h#2a). In the case of emptying the container, a fall of 1 m may occur. The fish can hit the lairage tank walls, other fish or water surface and experience serious impact causing pain (h#3). Sudden changes in pressure to swim bladder is an additional adverse effect when unloading ('discharging') the fish (h#3). Discharge of fish may also cause temperature shock when the water temperatures of lairage tank and transport tank are different (h#4). Digestive disorders leading to fish death have been reported when feeding fish were transferred into cold water stopping digestion of food in the gut (h#5). Transfer of fish from the (usually dimmed) transport tank happens in daylight, thus fish are exposed to a sudden light change which is an additional negative stressful stimulus (h#6). In the case of small fish batches designated for immediate slaughter, the lairage stage may be omitted as they go directly into a pre-slaughter container. Carp that stay in the lairage tank may be exposed to poor water quality if the water exchange is not sufficient and metabolic products (such as ammonia and carbon dioxide) build up (h#9). Excessive fish biomass and increased water temperature (fish respiration) may lead to oxygen depletion in the water and cause asphyxia (h#10) and a series of physiological responses. The design of the lairage tank is an important factor as concrete abrasive walls of the tank and sharp objects can cause skin lesions, eye damage and other injuries (h#8). If the tank cover is rigid, jumping fish can hit it and be injured (h#7). Lack of a proper cover can allow fish to jump out of the tank, so they fall onto the floor (h#3) and are exposed to air (h#10). Excessive biomass of fish in the lairage tank leads to crowding (h#11) which is a well-documented stressor for fish (Montero et al., 1999; Ellis et al., 2002; Portz et al., 2006). In some cases, the lairage tanks are located indoors and so are exposed to vibration coming from devices or equipment used at the slaughter house. The noise, especially if sudden, is an adverse stimulus to the fish (h#12). Fish to be slaughtered are usually hand netted from the lairage tank into a container (with or without water) or into a water tank where they wait to be electrically stunned. This process induces similar hazards as netting fish from the transport container to the lairage tank. Injuries (h#2b) caused by hand-nets or handling can be lethal (h#2a). Improper discharge of fish from the hand-net e.g. dropping fish into the container will lead to broken, bones, skin lesions and pain (h#3), especially if there is no water in the container. Regardless of water presence in the container, carp may be exposed to conditions that lead to asphyxia (h#10). In addition, carp in the lower parts of the container may be subjected to mechanical pressure due to the weight of fish above.

Table 1. **List of pre-slaughter hazards with description of adverse effect used in the RA**

| # | **Hazard** | **Description of the adverse effect** |
|---|---|---|
| 1 | netting | distress, |
| 2a | netting causing injuries, fish not surviving 1 hour | distress, abrasions, broken fin-rays (bones and/or cartilages) |
| 2b | netting causing injuries, fish surviving > 1 hour | distress, abrasions, broken finrays |
| 3 | dropping fish from net or tank | fish hitting each other, fish hitting water surface, pressure changes in swim bladder, |

| | | |
|---|---|---|
| | | pain |
| 4 | sudden change of temperature (in general) | distress |
| 5 | sudden change of temperature (not starved, put into cold water) | distress, digestive disorders, eventually leading to death |
| 6 | sudden exposure to strong light | distress |
| 7 | fish jumps out of tank or into cover | injuries, asphyxia if they land outside tank |
| 8 | abrasive material (in tank or from other fish) | skin lesions, eye damage |
| 9 | poor water quality | gill irritation, increased mucus production/loss of mucus |
| 10 | low oxygen content | increased metabolic rate, increased ventilation |
| 11 | crowding, not being able to show normal behaviour | distress, increased respiration |
| 12 | loud noises and vibrations | distress, increased respiration |

## 3.3. Stunning and killing methods for carp

EFSA sent a questionnaire to all Member States inquiring about the methods in use for the slaughter of carp. Asphyxia followed by percussion, electrical stunning, and percussive method were reported as the most common methods. Asphyxia, as well as, chilling were reported as methods used for carp slaughter in only two countries.

### 3.3.1. Recognition of consciousness, unconsciousness and death

In order to ensure humane killing of carp, it is important to be able to recognise whether a stunning operation has rendered a fish unconscious. As with in other fish, this is extremely difficult in carp as although the presence of, opercula movements, eye roll and pupillary light reflex may all be used as evidence of consciousness, all may be absent under certain conditions without necessarily indicating a loss of consciousness.

The only reliable method to assess unconsciousness in carp is on the basis of EEG (including evoked responses) recordings. It is almost impossible to confirm death without resort to combined measurements of ECG and EEG over time (Lambooij et al., 2007; Lambooij et al., in press) however, this is only possible under experimental conditions. Consequently, physical damage to an unconscious fish that leads to brain destruction or complete exsanguination are the only reliable guarantees of death.

### 3.3.2. Asphyxia followed by percussion

Basic principles

When fish are removed from water and exposed to air, the gills collapse and there is a reduced oxygen intake resulting in anoxia. The time to death is temperature and moisture dependent and can take up to several minutes (Robb and Kestin, 2002). Under certain condition of low temperature and high humidity, delay before death in carp may even be many hours (Oberle personal communication).

Cerebral concussion is generally agreed to be a traumatically induced derangement of the nervous system, resulting in an instantaneous diminution or loss of consciousness without gross anatomical changes in the brain (EFSA, 2004)

A blow on the head with a blunt instrument can be used to kill carp and acts in a similar way to the non-penetrating captive bolt.

Commercial method

Carp are hand netted from lairage tank and placed into a container without water or with a limited volume of water. Waiting period varies and the interval between first and last fish stunned within a batch may be up to 20 min. Stunning can be further delayed, if necessary, to calm down agitated fish. Fish are stunned one by one with blows to the skull using a wooden or plastic club (‘priest’). The procedure is followed by evisceration (Białowąs et al., 2007).

Hazards related with asphyxia and improper manual handling have been considered in RA. A mis-hit in the wrong place or with insufficient force has been also considered as a potential hazard as well as further processing after a mis-hit with the fish still conscious (Table 2).

Method under research and development

A spring loaded captive bolt gun has been developed and evaluated for killing of carp (Hewitt, 1999). A rounded nylon cylinder of 60g is fired mid-dorsally with an air pressure 7.5 bars on the skull slightly rostral to the eyes. Not all the carp are rendered unconsciousness by this captive bolt gun (Hewitt, 1999; Lambooij et al., 2007)

Table 2. **List of hazards used in the RA related to Asphyxia followed by percussion.**

| # | Hazards | Description of the adverse effect |
|---|---|---|
| 1 | Dropping fish into tank without water | trauma, pain, loss of scales, (broken bones/finrays) |
| 2 | Fish out the water | severe distress asphyxia |
| 3 | pressure from other fish on top | Pain from bruising and skin lesions, loss of scales |
| 4 | manual handling (normal) | loss of mucus and scales, distress |
| 5 | improper manual handling | loss of mucus and scales, distress + additional trauma, pain |
| 6 | falling off the table, slipping out of hands | trauma, pain, loss of scales |
| 7 | mis-hit (hit in the wrong place) | injuries, pain, distress |
| 8 | mis-hit (on the head with insufficient force) | injuries, pain, distress |
| 9 | further processing (evisceration) after mis-hit and fish still conscious | severe trauma, pain, distress |

### 3.3.3. Electrical stunning

Electrical stunning applied to carp is carried out by immersing the whole body in a water tank and passing an electric current.

Basic principles

Electrical stunning is based on the induction of a general epileptiform insult ('grand mal' or seizure-like state) by the flow of an electrical current through the head and brain. Provided that sufficient current is administered through the head of an animal a general epileptiform insult (spreading across parts of the brain stimulating many cells) will occur (Lambooij et al., 2007).

Commercial method

For the whole body electrical stunning method, carp are placed in a fresh water tank and an electrical current is passed through the tank.

There are two systems as follows.

- Two plate electrodes are placed on the opposite sides of the tank. These electrodes cover the whole area of two opposite sides of stunner tank. Different voltages and duration are applied but equipment using higher than 50V needs special safety measurements (Directive, 2006/95/EC).
- Electrodes are mounted in a handle device manually operated. For stunning, both electrodes are submerged and an electric current (with 42V) applied. The fish (up to approximately 50 kg per stunning cycle) are placed in a plastic container with water (http://members.nextra.at/aquaculture/processing.htm)

Practical experience and experts' opinion indicate that time of current applied varies from 10 to 60 sec which is not compatible with a definition of instantaneous unconsciousness (less than one second).

Hazards for carp welfare used in risk assessment related with electrical stunning are listed in Table 3.

Method under research and development

It was observed that carp could be rendered unconscious instantaneously by passing an electrical current through fresh water. For an instantaneous stun in individual carp, 113 V is applied across the electrode plates at 16 cm distance for 1 second. These conditions resulted in an overall current density of 0.14 $A/dm^2$ in water of 200 µS/cm conductivity. Recovery of carp could be prevented by applying the current for 5 seconds in combination with chilling of the stunned carp in flaked ice or in slurry of ice and water (Lambooij et al., 2007).

Table 3. **List of hazards used in the RA related to electrical stunning**

| | **Hazards** | **Description of the adverse effect** |
|---|---|---|
| 10 | dropping fish into tank with water | distress, |
| 11 | new adverse environment (when transferred from lairage tank to stunner) | distress, aversion |
| 12 | insufficient current/voltage leading to mis-stun (normal time) | pain, distress, broken bones, muscle bleeding |
| 13 | prolonged exposure to insufficient current/voltage (delayed stun) | pain, distress, broken bones, muscle bleeding, exhaustion |

| | | |
|---|---|---|
| 14 | further handling and processing after mis-stun; still conscious | severe trauma, pain, distress |
| 15 | further handling and processing after stun; regaining consciousness | severe trauma, pain, distress |

#### 3.3.4. Percussive stunning

Basis and commercial methods of percussive stunning have been already described in section 0. For the risk assessment same hazards apply. Time of exposure fish to air is limited due to small number fish in a batch and stunning is applied shortly after netting fish out of the water.

### 3.4. Other stunning / killing methods

Apart from the above described stunning/killing methods that are applied in commercial conditions there are some additional methods that are either only used on small scale or are still under development. These are briefly described below but are not included in the Risk Assessment. Other methods commonly used for stunning and killing of other fish species (e.g. $CO_2$, maceration) are not used neither experimented in carp.

#### 3.4.1. Chilling

The basic effect of cooling down is inactivation of vital enzymes. Exposure of carp (*Cyprinus carpio*) to a rapid drop in temperature of 9 ºC resulted in a time-dependent cortisol response and induced a differential expression of both the pro-opiomelanocortin (POMC) and mRNAs. Plasma cortisol levels increased up to 6 times the control level 20 min after the start of the experiment and remained high until the end of the temperature shock (Arends et al., 1998).

## 4. Emergency killing for disease control purposes

In Council Directive 2006/88/EC it is stated that the member states shall ensure that fish that show clinical signs of disease are removed and disposed of under the supervision of the competent authority in accordance with Regulation (EC) No 1774/2002. (Art 34). Member states shall take appropriate measures to control an emerging disease situation and prevent that disease from spreading. (Art 41). In the regulation (EC) 1774/2002 fish killed to eradicate an epizootic disease belongs to Category 2 (Article 5) and the method of dealing with the dead fish and their disposal is addressed. But neither in the Directive 2006/88/EC nor in the regulation 1774/2002/EC is there a description of methods for emergency killing and stunning of fish. Since KHV[5] disease is listed as a non-exotic disease in Annex IV of the Directive 2006/88/EC, the emergency killing of carp can be ordered by the competent authority in the member states. Spring Viraemia of Carp has been recently removed from annex IV of Directive 2006/88/EC (Commission Decision 2008/685/EC).

Depending on whether it is a disease outbreak or destruction of a population due to a production error, emergency slaughter is often carried on site or fish are transported to a designated slaughter facility. For fish designated for human consumption, emergency slaughter may follow the normal pattern and fish of low quality will be rejected after stunning.

[5] Also named CyHV-3

In cases where the whole population is unfit for human consumption, emergency killing would be carried out at the production site. The choice of methods will vary depending on the amount of fish being killed, and facility equipment.

There are no disease control methods commonly used for carp. Methods such as pharmacological, electrical, and maceration could be used for carp as for other species, and such methods should be considered as part of contingency plans. Stunning should be carried out prior to killing. Signs of consciousness in fish should be monitored before final disposal of the fish e.g. by destruction.

An overdose of an anaesthetic could be used to kill large numbers of carp. It is concluded from laboratory experiments using EEG (Lambooij et al., in press) that when common carp were exposed to water containing 2 ml/l Propiscin they were immobilised and sedated but analgesia was not obtained. Carp exposed to water containing 0.5 ml/l 2-Phenoxyethanol became immobilised and sedated but when exposed for a long time analgesia was also achieved and the agent is used for veterinary intervention. Absorption through the fish gills of both anaesthetics may be lowered by the dramatic fall in breathing and heart rate during exposure which might diminish the anaesthetic effect.

Other used anaesthetics are MS222 and clove oil. Effects on unconsciousness by using EEG are lacking.

## 5. Reference to welfare indicators

Welfare indicators for carp have not been satisfactorily assessed and validated so far. Nevertheless, observation of fish responses were taken into account in this report and may be used for field monitoring of welfare. Further validation of input and outcome measures is needed.

## 6. Risk assessment

The general risk assessment guidelines used to assess the risk to welfare at the time of stunning / killing of farmed fish are described in Appendix A. The risk assessment applied to the stunning and killing of farmed carp is described in the following section.

### 6.1. Application of the risk assessment approach

The risk assessment was applied to the stunning and slaughter of common carp. The pre-slaughter events preceding stunning and slaughter start with netting in order to gather the fish and transfer them to the place of slaughter. The hazards associated with typical pre-slaughter management were assessed in relation to their effect on stunning and killing in general.

The assumption that exposure to the hazard resulted in all the fish suffering the adverse effect held for all hazards.

Definitions of intensity of an adverse effect for hazards occurring pre- and post-stunning were defined (Table 4).

**Table 4. Intensity categories of adverse effects arising from hazards associated with pre-slaughter and slaughter operations in common carp**

| Evaluation | Score | In water | In air |
|---|---|---|---|
| **MILD**<br>The animal is minimally affected as evidenced by minor changes in behaviour | 1 | Signs include rapid swimming away from stimulus and then slowing down. Increased ventilation. Colour change on the back. | Periods out of water less than 10 minutes under cold conditions (<10 ºC) will cause stress but is not defined, for carp, as asphyxia (fish will recover rapidly if returned to water). |
| **MODERATE** | 2 | Not in mild or severe categories | Not in mild or severe categories. |
| **SEVERE**<br>Marked changes from normal behaviour | 3 | Reduced movement due to excessive crowding.<br><br><u>Pre-stunning:</u> Gasping in the surface or lying flat with no movement (loss of equilibrium), rapid eye rolling or reduction of eye movement while there is still movement of the operculum.<br><br>Injuries.<br><br><u>Post-stunning:</u> Slow eye movement, tremor, active swimming or loss of equilibrium with or without injuries like bleeding gills, broken jaws. | Asphyxia = severe Any signs (non-reflexive) of consciousness post-stunning = severe<br><u>Pre-stunning:</u> Stressed directly when taken out of water. Body flapping. rapid gill movements. Mouth movement<br><br>Injuries.<br><br><u>Post-stunning:</u> Slow eye movement, tremor, body flapping; with or without injuries like bleeding gills, broken jaws. |

Different categorisation for duration of the adverse effect was used for pre-slaughter and slaughter / stunning hazards, as presented in Table 5 and Table 6.

Table 5. **Duration categories for adverse effects arising from hazards associated with pre-slaughter operations in common carp**

| Duration (minutes) | Score |
|---|---|
| <5min* | 1 |
| 5-15min | 2 |
| 15-60 min | 3 |
| >60min | 4 |

*adverse effects with a duration of less than one second are not scored

Table 6. **Duration categories for adverse effects arising from hazards associated with slaughter of common carp**

| Duration (minutes) | Score |
|---|---|
| <0.17 min (<10 sec)* | 1 |
| 0.17-1 min | 2 |
| 1-2 min | 3 |
| >2min | 4 |

*adverse effects with a duration of less than one second are not scored

## 6.2. Risk Assessment results and discussion

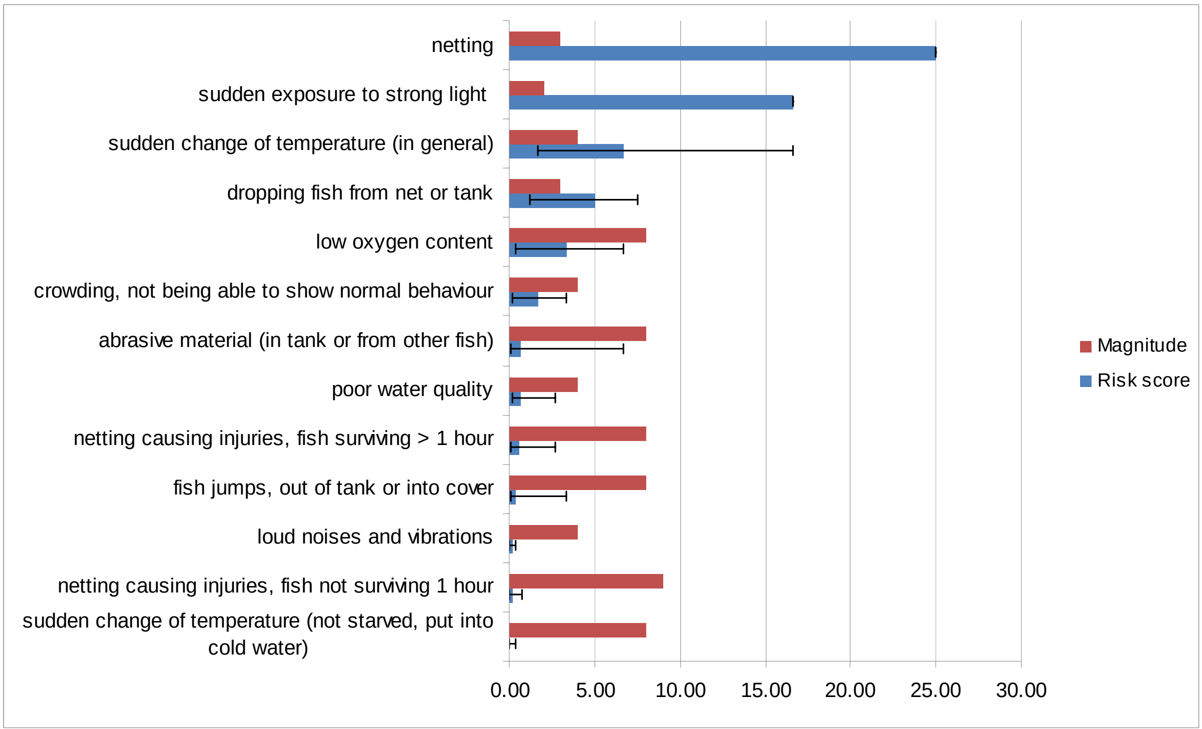
### 6.2.1. Pre-slaughter hazards

Twelve hazards were identified (**Error! Not a valid bookmark self-reference.**)(details in Appendix B) when carp arrive at an abattoir. One of the hazards was assessed at two different intensities. The risk scores ranged from 0.07 to 25.0. The highest ranking risk was netting and even though the severity of this hazard was regarded as mild, it had the highest score because all carp are exposed to it. The second highest risk score was 16.67, seen for the sudden exposure to strong light when the tank is opened or uncovered. However, both these hazards had a fairly low magnitude score (3 and 2 respectively) whereas other hazards ranked higher in this respect, indicating a more severe impact on the fish that were affected. The hazard with the highest magnitude scores was being severely injured in conjunction with netting (Figure 2). The sum of the risk scores of all the hazards was 60.92.

Table 7. **Risk and magnitude scores for welfare hazards associated with preslaughter management in carp.**

| Hazard ID | Pre-slaughter hazards | Description of adverse effects | Risk score | Magnitude |
|---|---|---|---|---|
| 1 | netting | distress, | 25.0 | 3 |
| 2a | netting causing injuries, fish not surviving 1 hour | distress, abrasions, broken finrays | 0.15 | 9 |
| 2b | netting causing injuries, fish surviving > 1 hour | distress, abrasions, broken finrays | 0.53 | 8 |
| 3 | dropping fish from net or tank | fish hit each other and water surface, pressure change of swim bladder, pain, | 5.00 | 3 |
| 4 | sudden change of temperature (in general) | distress, | 6.67 | 4 |
| 5 | sudden change of temperature (not starved, put into cold water) | distress, digestive disorders, eventually leading to death | 0.07 | 8 |
| 6 | sudden exposure to strong light | distress | 16.67 | 2 |
| 7 | fish jumps, out of tank or into cover | injuries, asphyxia if they land outside tank | 0.33 | 8 |
| 8 | abrasive material (in tank or from other fish) | skin lesions, eye damage | 0.67 | 8 |
| 9 | poor water quality | gill irritation, increased mucus production/loss of mucus | 0.67 | 4 |
| 10 | low oxygen contents | increased metabolic rate, increased ventilation | 3.33 | 8 |
| 11 | crowding, not being able to show normal behaviour | distress, increased respiration | 1.67 | 4 |
| 12 | loud noise and vibrations | distress, increased respiration | 0.17 | 4 |
| | | | 60.92 | |

Figure 2. **Risk score and magnitude of adverse welfare effect for individual hazards associated with pre-slaughter management in carp in Europe.**




Hazards are ranked by risk score. Black bars show the estimated minimum and maximum values for the risk score, reflecting the uncertainty about the probability of exposure to the hazard.

### 6.2.2. Variability and uncertainty

Variability is captured by estimates of the minimum and maximum values of the probability of exposure to the hazard. For the highest scored hazards, netting and sudden exposure to strong light, the minimum and maximum values were the same as the most likely value (equal to one), because the entire population was considered to be exposed. Most of the remaining hazards had low most likely values but were estimated with substantial imprecision. For hazards in the mid range of risk scores, this indicates that the rank could be slightly different. For the hazard ‘sudden change in temperature’ there was considerable uncertainty regarding the probability of exposure to the hazard and the risk score could be in line with what was seen for ‘sudden exposure to strong light’.

For most hazards the score regarding the uncertainty about the adverse effect was 3, indicating that there is limited evidence within the scientific community about these effects on carp. The exceptions were temperature change, low oxygen contents and netting, where some data that are relevant for carp exist.

### 6.2.3. Slaughter and stunning hazards

Three methods of stunning and slaughter were assessed (details in Appendix B). Between six and nine hazards were identified for each method. The risk and magnitude scores for the hazards for each method were summed (Table 8).

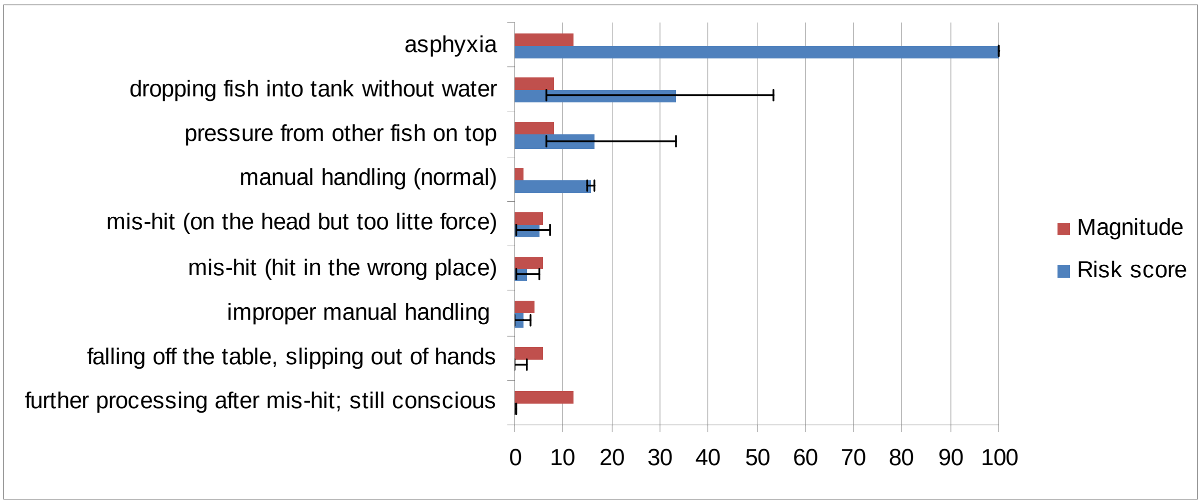
The summary risk scores range from 23.9 (for percussive stunning) to 171.8 (for asphyxia followed by percussive stunning). The risk score for electrical stunning was more in range with the latter, having a summary risk score of 135.3 (Figure 3). A higher summary risk score indicates that the method in question is associated with more hazards, that the hazards have a more severe adverse effect and/or that there is a higher probability that fish slaughtered by the method will be exposed to the hazards.

Table 8. **Risk and magnitude scores for welfare hazards associated with the main stunning/killing methods in carp in Europe.**

| Hazard ID | Slaughter hazards | Description of adverse effects | Risk score | Magnitude |
|---|---|---|---|---|
| ***A*** | ***asphyxia + percussive stunning*** | | | |
| 1 | dropping fish into tank without water | trauma, pain, loss of scales, (broken bones/finrays) | 33.33 | 67 |
| 2 | asphyxia | severe stress | 100.00 | 100 |
| 3 | pressure from other fish on top | pain, skin lesions, loss of scales | 16.67 | 67 |
| 4 | manual handling (normal) | loss of mucous and scales, stress | 15.83 | 17 |
| 5 | improper manual handling | loss of mucus and scales, stress + additional trauma, pain | 1.67 | 33 |
| 6 | fall off the table, slipping out of hands | trauma, pain, loss of scales | 0.50 | 50 |
| 7 | mis-hit (hit in the wrong place) | injuries, pain, stress | 1.25 | 25 |
| 8 | mis-hit (on the head but too little force) | injuries, pain, stress | 2.50 | 25 |
| 9 | further processing after mis-hit; still conscious | severe trauma, pain, stress | 0.10 | 100 |
| | | | ***171.85*** | |
| ***B*** | ***electrical stunning*** | | | |
| 10 | dropping fish into tank with water | stress | 16.67 | 17 |
| 11 | new adverse environment (when transferred from lairage tank to stunner) | stress, aversion | 16.67 | 17 |
| 12 | insufficient current/voltage leading to mis-stun (normal time) | pain, distress, broken bones, muscle bleeding | 5.00 | 100 |
| 13 | prolonged exposure to insufficient current/voltage (delayed stun) | pain, distress, broken bones, muscle bleeding, exhaustion | 47.50 | 50 |
| 14 | further handling and processing after mis-stun; still conscious | severe trauma, pain, stress | 2.00 | 100 |
| 15 | further handling and processing after stun; regained consciousness | severe trauma, pain, stress | 47.50 | 100 |
| | | | ***135.33*** | |

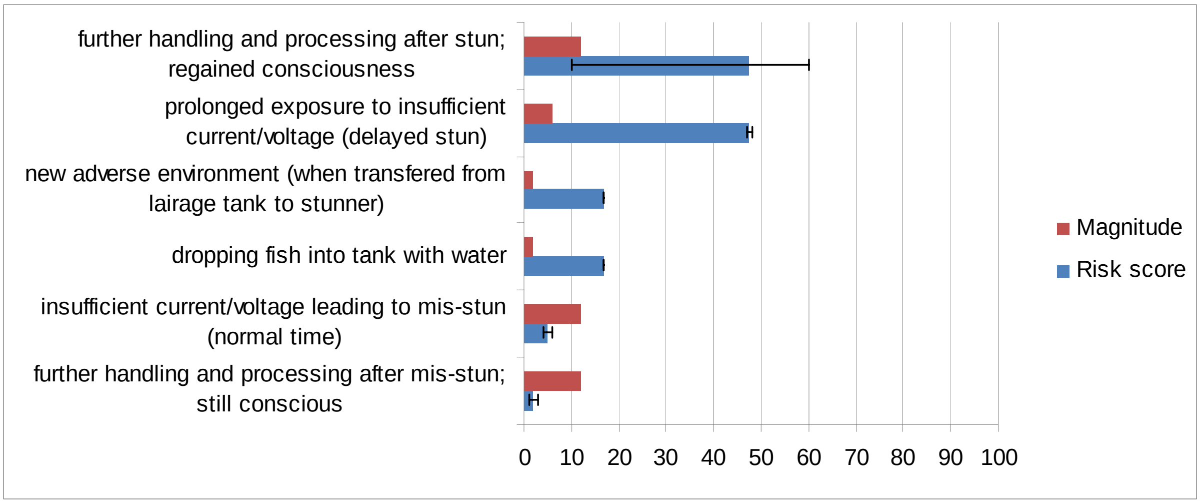
| C | percussive stunning | | | |
|---|---|---|---|---|
| 16 | Dropping fish on to table | trauma, pain, loss of scales | 0.67 | 33 |
| 17 | manual handling (normal) | loss of mucous and scales, stress | 16.17 | 17 |
| 18 | improper manual handling | loss of mucous and scales, stress + additional trauma, pain | 1.00 | 33 |
| 19 | Falling off the table, slipping out of hands | trauma, pain, loss of scales | 1.00 | 50 |
| 20 | mis-hit (hit in the wrong place) | injuries, pain, stress | 1.25 | 25 |
| 21 | miss-hit (on the head but too little force) | injuries, pain, stress | 3.75 | 25 |
| 22 | further processing after mis-hit; still conscious | severe trauma, pain, stress | 0.10 | 100 |
| | | | ***23.93*** | |

Figure 3**. Risk score and magnitude of adverse welfare effect for individual hazards associated with asphyxia follow by percussion method ***



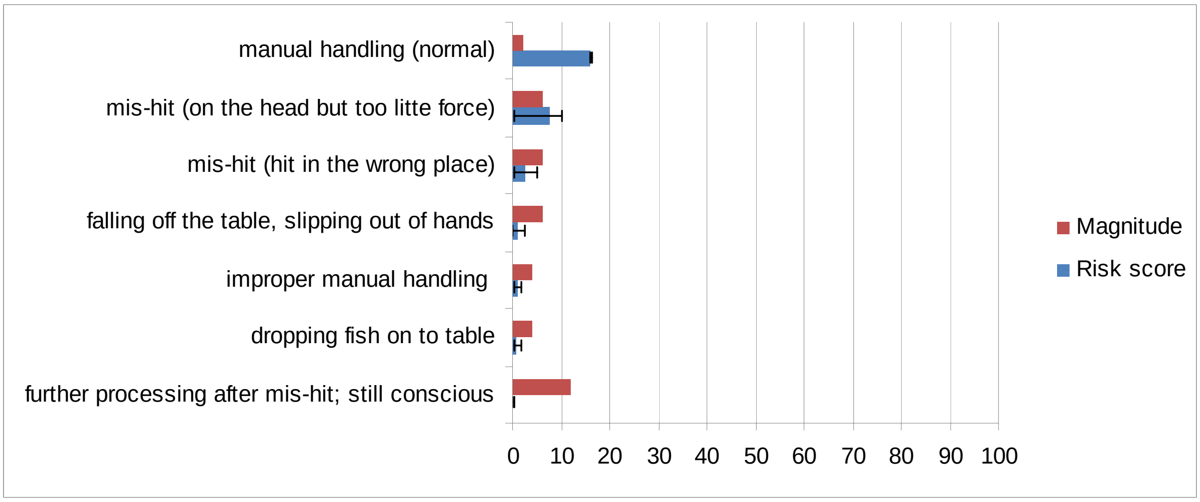

*Hazards are ranked by risk score. Black bars show the estimated minimum and maximum values for the risk score, reflecting the uncertainty about the probability of exposure to the hazard.

Figure 4. **Risk score and magnitude of adverse welfare effect for individual hazards associated with electrical stunning***




*Hazards are ranked by risk score. Black bars show the estimated minimum and maximum values for the risk score, reflecting the uncertainty about the probability of exposure to the hazard.

Figure 5. **Risk score and magnitude of adverse welfare effect for individual hazards associated with electrical stunning***




*Hazards are ranked by risk score. Black bars show the estimated minimum and maximum values for the risk score, reflecting the uncertainty about the probability of exposure to the hazard.

The method where percussive stunning is preceded by a period of asphyxia had the highest risk score because of the high magnitude (max=100) of the adverse effect, in combination with all fish being exposed to this if they are slaughtered by this method. Taken together this indicates a major welfare hazard. The fact that fish also may be dropped into a tank without water and experience pressure from other fish on top adds to the different risk scores seen with this method compared with when fish are taken directly from water onto a table for manual percussive stunning (the method with the lowest risk score). One more hazard of the asphyxia follow by percussive stunning method, which had a maximum magnitude of the adverse effect, is that a fish could still be conscious when processed further. The probability of exposure to this hazard was, however, very small.

For percussive stunning *per se*, the hazard with the highest risk score was in fact the normal manual handling, a hazard with low magnitude of the adverse effect but with a high probability of exposure.

For the electrical stunning method, two hazards were predominant; prolonged exposure to insufficient current/voltage leading to a delayed stun, and further handling and processing after a stun where a fish had time to regain consciousness. The latter was also scored with a maximum magnitude of the adverse effect, and a rather high probability of exposure (most likely value just below 0.5).

### 6.2.4. Variability and uncertainty

For percussive stunning there was very little variability around the risk score estimates. For the other two methods, considerable variability was seen around some of the hazards that ranked among the highest (asphyxia followed by percussive stunning; 'dropping fish into tank without water' and 'pressure from other fish on top'; electrical stunning; 'further handling and processing after stun, where the fish have had time to regain consciousness') which could indicate that more data should be collected in order to correctly prioritise hazards to be targeted for intervention. For five of the hazards of the asphyxia + percussive stunning and the electrical stunning methods, the entire or most (>95%) of the population was considered as exposed hence most likely, minimum and maximum values for the probability of exposure to the hazard were close to or equal to one.

From the scoring of uncertainty of severity and duration it can be judged that for carp, very limited scientific knowledge about adverse effects of welfare hazards is available. Of 22 hazards, 17 had a score 3. The methods with most high uncertainty scores were the percussive stunning methods, both with or without preceding asphyxia.

Table 9. **The overall ranking of methods for carp stunning and killing**

| **Method** | **Asphyxia follow by percussive stunning** | **Electrical stunning** | **Percussive stunning** |
|---|---|---|---|
| Pre-slaughter score | 60.92 | 60.92 | 60.92 |
| Slaughter score | 171.85 | 135.33 | 23.93 |
| **Total** | **232.77** | **196.25** | **84.85** |

## CONCLUSIONS AND RECOMMENDATIONS

### CONCLUSIONS

1. This Scientific Opinion on common carp stunning and killing evaluated the methods currently used in farmed common carp in Europe. Methods used in other fish species other than those described in this Opinion may also be applicable to carp.
2. Although limited data are available, there is a common understanding that the majority of carp are sold alive or as a whole fish by supermarkets and minor retailers (a market sale or at the farm) and that less than 15 % of carp the produced for human consumption are processed in commercial processing plants.
3. If carp are taken out of water before stunning, the result is poor welfare, and the magnitude of poor welfare becomes greater with increasing time out of water.
4. An experimental percussion method for stunning carp by using a form of spring-loaded captive bolt gun (tacker) has been tested; however it is not certain that there was an instantaneous loss of consciousness.
5. The most common commercial electrical stunning method in carp is to place them into a fresh water tank and pass an electrical current. Based on the duration of application these methods do not seem to be compatible with instantaneous unconsciousness.
6. Experimental results showed that carp can be rendered immediately unconscious by passing an electrical current density of 0.14 $A/dm^2$ in water of 200 µS/cm conductivity. Commercial methods of stunning often do not involve currents with the efficacy of stunning provided by this procedure. Recovery of consciousness can be prevented by applying the current for 5 seconds in combination with chilling.
7. The killing of carp by chilling is not widely used but adverse effects on the fish are apparent.
8. An overdose of anaesthetic can be applied for emergency killing of carp.
9. The practice of exposing carp to air for extended periods of time, and in large batches (awaiting stunning) is identified as a major welfare hazard.
10. For electrical stunning methods, an area for technical improvement is to prevent carp from being exposed to insufficient current/voltage for prolonged periods of time
11. Recovery of consciousness due to delay of further processing after stunning was identified as an important hazard.
12. The risk assessment showed that the percussive method without asphyxia, if carried out properly, has the lowest welfare impact.
13. At present there are no validated and robust indicators available to evaluate in practice the welfare of carp associated with slaughter procedures.

## RECOMMENDATIONS

1. Standard operating procedures to improve the control of the slaughter process to prevent impaired welfare should be introduced and relevant practical welfare indicators developed.
2. Since the welfare of all farmed fish species studied has been found to be poor when they are killed by being left in air (asphyxia) or when they are exposed to carbon dioxide in water, these methods should generally not be used for any species as alternative methods are available.
3. A surveillance (monitoring) programme should be initiated for all the fish species so that data is available in the future for an improved risk assessment and for determining improvements over time and also for benchmarking for those involved in the slaughter of fish.
4. The opportunity to develop new methods for slaughtering carp is considerable and should be encouraged.
5. Valid, robust and practically feasible indicators to evaluate the welfare of carp during slaughter procedures need to be developed.
6. Persons involved in killing fish should be trained and hence skilled in handling and welfare.
7. Standard procedures that take into consideration the humane aspect of slaughtering should be required for carp home slaughtering.
8. A method for percussive stunning of carp with minimal exposure to air should be developed.
9. The welfare of carp should be improved by targeting hazards that occur in each method. In particular there should be minimal handling of carp before stunning and care should be taken not to harm fish during any handling that does occur.
10. The time between electrical stunning and bleeding should be kept to minimum to avoid carp regaining consciousness.

## RECOMMENDATION FOR FURTHER RESEARCH

1. Research on a percussive method to obtain an instantaneous loss of consciousness and sensibility in carp should be conducted.
2. Further research on electrical stunning method to obtain an instantaneous loss of consciousness should be conducted.
3. Further research on the effectiveness of anaesthetics to cause unconsciousness and death should be conducted.

## REFERENCES

EFSA (European Food Safety Authority), 2008. Scientific report on animal welfare aspects of husbandry systems for farmed common carp. *EFSA Journal* (2008) 843, Annex I

EFSA (European Food Safety Authority), 2004. Opinion of the Scientific Panel on Animal Health and Welfare (AHAW) on a request from the Commission related to welfare aspects of the main systems of stunning and killing the main commercial species of animals. *EFSA Journal* (2004) 45, 1-81.

Directive 2006/95/EC of the European Parliament and of the Council of 12 December 2006 on the harmonisation of the laws of Member States relating to electrical equipment designed for use within certain voltage limits (OJ L 99, 27.12.2006, p. 10).

Council Directive 2006/88/EC of 24 October 2006 on animal health requirements for aquaculture animals and products thereof, and on the prevention and control of certain diseases in aquatic animals (OJ L 328, 24.11.2006, p. 14).

Regulation (EC) No 1774/2002 of The European Parliament and of The Council of 3 October2002 laying down health rules concerning animal by-products not intended for human consumption (OJ L 273, 10.10.2002, p. 1).

Commission Decision of 20 August 2008 amending the Annex to Council Decision 90/424/EEC as regards Spring viraemia of carp (SVC) (OJ L 224, 22.8.2008, p. 11).

Arends, R. J., Gaag, R., van der Martens, G. J. M., Wendelaar Bonga, S. E. and Flik, G., . 1998. Differential expression of two proopiomelanocortin mRNAs during temperature stress in common Carp (*Cyprinus carpio* L.). *Journal of Endocrinology* 159: 85-91.

Białowąs, H., Pilarczyk, M., Kazuń, K. and Lirski, A., 2007. Sprzedaż detaliczna karpia w świetle dobrostanu. In: Wybrane zagadnienia dobrostanu karpia. A. Lirski, A. Siwicki and J. Wolnicki. Wydawnictwo IRS, Olsztyn, 149-160.

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 (3): 493-531.

Hewitt, L., 1999 A novel stunning system for the slaughter of poultry. In: Poultry Meat Science. R. I. Richardson and G. C. Mead. CABI Publishing, Wallingford, Oxon, UK,

Kamphuis, L., 1983. High voltage stunning and safety maesures. In: Stunning of animals for slaughter. G. Eikelenboom. Martinus Nijhoff, Hague, 35-50.

Kestin, S. C., van deVis, J. W. and Robb, D. H., 2002. Protocol for assessing brain function in fish and the effectiveness of methods used to stun and kill them. *The Veterinary Record* 150 (10): 302-307.

Lambooij, E., Pilarczyk, M., Bialowas, H., Reimert, H., André, G. and Van de Vis, J. W., in press. Anaesthetic properties of propiscin (etomidate) and 2-phenoxyethanol in the common carp (*Cyprinus carpio* L.); neural and behavioural measures. *Aquaculture Research* in press:

Lambooij, E., Pilarczyk, M., Bialowas, H., Van den Boogaart, J. G. M. and Van de Vis, J. W., 2007. Electrical and percussive stunning of the common carp (*Cyprinus carpio* L.): neurological and bahavioural assessment. *Agricultural Engineering* 37: 171 - 179.

Lirski, A. and Myszkowski, L., 2009. Produkcja i sprzedaż karpia w 2008 roku. *XIV Krajowa Konferencja Hodowców Karpia,18 luty 2009*, Dębe k. Warszawy, Materiały konferencyjne, 5-9

Montero, D., Izquierdo, M. S., Tort, L., Robaina, L. and Vergara, J. M., 1999. High stocking density produces crowding stress altering some physiological and biochemical parameters in gilthead seabream, Sparus aurata, juveniles. *Fish Physiology And Biochemistry* 20 (1): 53-60.

Portz, D. E., Woodley, C. M. and Cech, J. J., 2006. Stress-associated impacts of short-term holding on fishes. *Reviews In Fish Biology And Fisheries* 16 (2): 125-170.

Robb, D. H. F. and Kestin, S. C., 2002. Methods Used to Kill Fish: Field Observations and Literature Reviewed. *Animal Welfare* 11 (3): 269-282.

Vose, D., 2000. Risk analysis - a quantitative guide. Editor. John Wiley &Sons, Chichester,

## APPENDIX A

### RISK ASSESSMENT APPROACH

### Introduction

Overall the risk assessment was constrained due to limited scientific data and consequently a semi-quantitative assessment was carried out often based on expert opinion. Because of this lack of data, the Panel on Animal Health and Welfare recommends that a surveillance / monitoring programme should be initiated for all the fish species so that in the future it may be possible to carry out a quantitative risk assessment.

In this section, the risk assessment method used to assess the risk to welfare of farmed fish at the time of killing is described.

Risk assessment is a systematic, scientifically based process to estimate the probability of exposure to a hazard, and the magnitude of the effects (consequences) of that exposure. A hazard in animal welfare risk assessment may be defined as a factor with the potential to cause a negative animal welfare effect (adverse effect). Risk is a function of both the probability that the hazard and the consequences (characterised by the adverse effect) occur.

Three parameters were scored to assess the importance of a hazard; the intensity of the adverse effect that the hazard causes, the duration of the adverse effect and the probability of exposure to the hazard. The population in question is the fish killed in the EU by the selected method of stunning and slaughter.

The probability of exposure to the hazard corresponds to the percentage of all fish exposed to the hazard. Thus if 4 % of the all the fish killed by a particular method are exposed to a hazard there is a probability of 0.04 that any randomly selected fish within that population is exposed. The consequence of exposure can be assessed by scoring the intensity and the duration of the adverse effect in the individual. The risk assessment was based on two assumptions;

1. all fish exposed to the hazard experienced the same intensity and duration of the adverse effect.
2. in the absence of any evidence to the contrary, it is assumed that all fish exposed to the hazard experience the adverse effect[6].

Factors which adversely affect fish welfare are considered in the risk assessment. In absence of reliable data, the volume of fish slaughtered by each method is not taken into account. Thus the results are not weighted by the volume of fish slaughtered by each method.

The definitions of intensity and the categories for duration of the adverse effect used for the fish species considered in this scientific opinion are in the relevant section in each Scientific Opinion.

In the following paragraphs the risk assessment process for hazard identification and characterization and the probability of exposure to the hazard are described as well as the way they were scored. Finally the risk scoring process is described.

The general risk assessment is in line with the approach previously used in the EFSA welfare reports (EFSA, 2007a; EFSA, 2007b; EFSA 2007c; EFSA 2007d; EFSA, 2008a; EFSA,

[6] if this assumption was not found to be sound for a particular hazard an additional parameter (probability that exposure resulted in the adverse effect) was used.

2008b; EFSA, 2008c; EFSA, 2008d; EFSA, 2008e) with some modifications according to the risk question posed.

## Hazard identification

The objective of the hazard identification is to identify potential welfare hazards associated with each stunning and killing method. The identification was based on a review of the literature and field observations. The scope of the risk assessment included the period leading up to killing (which may be the time spent in lairage for fish killed in a slaughterhouse). The adverse effect caused by each hazard is described. In order to consistently identify hazards associated with stunning and killing, the relationship between the time from applying a stun method, unconsciousness and the point at which the killing method was applied are illustrated graphically (Figure 1).Various scenarios (A to E) in which hazards may arise were identified as follows:

'A' where a fish is killed in some potentially painful way (asphyxia, bleeding out) while it is conscious i.e. before it has been made unconscious; and

'B' represents a fish that has been stunned and is killed or it dies after it is unconscious;

'C' where a fish has been stunned but it recovers consciousness and is killed in some potentially painful way (asphyxia, bleeding out).

'D' represents a fish that, like B is killed in some potentially painful way (asphyxia, bleeding out) while it is conscious but has also suffered from the aversive nature of the stunning method; and

'E' represents a fish that has been stunned and is killed or it dies after it is unconscious but has also suffered from the aversive nature of the stunning method.

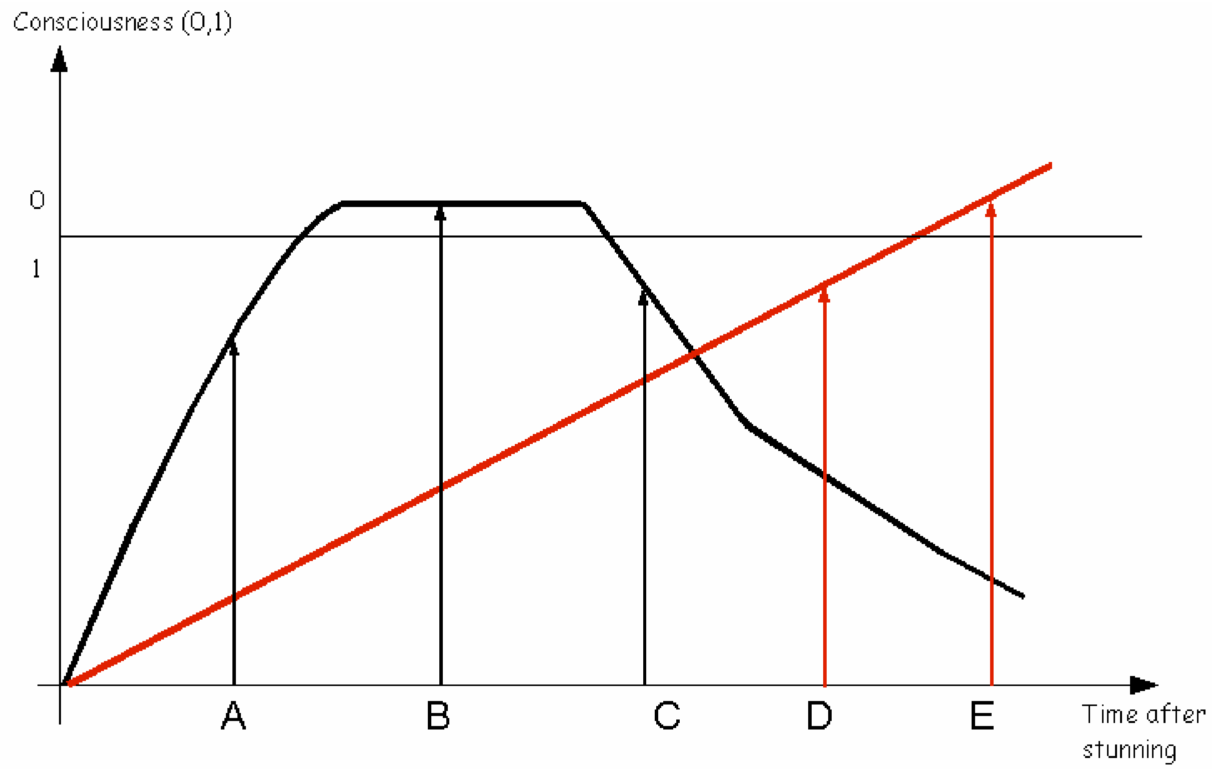



**Figure 1. Time to unconsciousness (insensibility) following stunning / killing** (horizontal grey line indicates consciousness threshold above which killing takes place without an adverse effect).

The scenarios above do not take into account hazards arising from gathering animals during pre-slaughter or killing without stunning

## Hazard characterisation

### Intensity

If a fish is unconscious, by definition there is no adverse welfare effect at that time. Therefore, before assessing the intensity of any adverse effects, consideration must be given as to whether the fish is conscious or not; this is a binary judgement (i.e. degrees of un/consciousness are not assessed). There is evidence that signs associated with consciousness and unconsciousness at the time of killing apply to all fish species as they do for general anaesthesia (Kestin et al., 2002). If it is conscious, the appropriate score for the degree of intensity of the adverse effect must be selected: mild, moderate or severe. If unconsciousness is achieved or induced with no suffering, or any pain or distress is for less than one second, then it is assumed that there was no welfare hazard. The issue of consciousness is mainly relevant to hazards associated with the killing method. If unconsciousness was achieved immediately (less than one second) then it is assumed that there was no hazard associated with the proper and effective application of that method and so this was not included in the risk assessment.

Generic guidelines for defining intensity categories for pre-slaughter hazards and slaughter hazards are given in Table 1. The approach taken has been to define only the mild and severe categories; the moderate is defined as being neither mild nor severe. Thus, by default hazards which are considered to have welfare consequences which are not in the severe or mild category fall into the moderate category. This approach was taken as scientists are reasonably confident in recognising the extreme states of intensity but as these states are on a continuum, allocating a distinct moderate banding is more difficult and contentious. Appropriate descriptions for the categories of intensity will vary between species and are given for each species in the Scientific Opinion.

Additionally, different definitions of intensity for the same species may be required for hazards that occur before killing, compared with at the time of killing. The descriptions of intensity for these pre-slaughter adverse effects are given for each species in the Scientific Opinion.

Table 10. **Observable signs considered by experts when scoring the intensity of an adverse effect in farmed fish arising from hazards associated with the pre-slaughter or slaughter period**

| Evaluation | Score | Description |
|---|---|---|
| Mild | 1 | The animal is minimally affected as evidenced by minor changes in behaviour (e.g. rapid swimming away from stimulus and then slowing down, eye position normal). |
| Moderate | 2 | The animal is affected as evidenced by behaviour changes which can be considered moderate (more pronounced than minor but not severe). |
| Severe | 3 | The animal is affected greatly, as evidenced by marked changes from normal behaviour (e.g. energetic and purposeful escape behaviour, eyes rolling, rapid and erratic swimming, swimming upside down or tilted, colliding with the net, stopping swimming for more than 5 sec, crowding of fish) |

Finally, each hazard was assessed and ranked by magnitude and occurrence independently of other hazards. For some hazards there may be more than one adverse effect. For example, all fish netted will be exposed to air, but in addition they may be injured e.g. skin lesions due to contact with the net or other fish.

**The duration of the adverse effect**

The time during which an animal will on average experience the adverse effect was estimated in minutes. The duration of an adverse effect can be longer than the duration of the hazard, for example a miss-stun takes a fraction of a second but the adverse effect lasts until the animal is unconscious or dies. Thus the duration of the hazard is included in the duration of the adverse effect.

Different time periods may be used for the adverse effects arising from pre-slaughter hazards compared with the hazards associated with slaughter. The definitions of duration used are given in the relevant section of the Scientific Opinion (Table 5 and Table 6).

**Exposure assessment**

The exposure assessment is performed by assessing the proportion of the population of interest (i.e all fish in the EU being killed by the method in question) that is likely to experience the hazard. This proportion is equal to the probability of exposure to the hazard (*P_hazard*). It is recognised that the proportion of the population exposed to a selected hazard will vary depending on the farm of origin and slaughterhouse. Estimates of the most likely, maximum and minimum values for this proportion are required. The range of values provides an indication of the uncertainty of the estimate (see next section).

**Uncertainty and variability**

The degree of confidence in the final estimation of risk depends on the uncertainty and variability (Vose, 2000). Uncertainty arises from incomplete knowledge and/or when results are extrapolated from one situation to another (e.g. from experimental to field situations) (Vose, 2000). Uncertainty can be reduced by carrying out further studies to obtain the necessary data, however this may not always be a practical possibility. It can also be appraised by using expert opinion or by simply making a judgment.

Variability is a statistical and biological phenomenon and is not reducible by gathering further information. The frequency and severity of welfare hazards will inevitably vary between farms and countries and over time, and fish will vary individually in their responses. However, it is not always easy to separate variability from uncertainty. Uncertainty combined with variability is generally referred to as total uncertainty (Vose, 2000).

Total uncertainty associated exposure to the hazard was captured by estimates of the maximum and minimum estimates of the most likely value of the proportion of the population exposed to the hazard. For the other parameters (intensity and duration of the adverse effect) total uncertainty was scored on a scale of 1-3 (Table 11).

Table 11. **Scoring system for total uncertainty in intensity and duration of effect**

| Evaluation | Score | Description |
|---|---|---|
| low | 1 | • Solid and complete data available; strong evidence in multiple references with most authors coming to the same conclusions, or<br>• Considerable and consistent experience from field observations. |
| medium | 2 | • Some or only incomplete data available; evidence provided in small number of references; authors' or experts' conclusions vary, or<br>• Limited evidence from field observations, or<br>• Solid and complete data available from other species which can be extrapolated to the species being considered |
| high | 3 | • Scarce or no data available; evidence provided in unpublished reports, or<br>• Few observations and personal communications, and/or<br>• Authors' or experts' conclusions vary considerably |

## Risk Characterisation

### The scoring process

The scoring was undertaken by the working group in plenary. The estimates were based on current scientific knowledge, published data, field observation and experience (as summarised in this report).

### Calculation of the risk score

All three factors (probability of exposure to the hazard; intensity of adverse effect; duration of adverse effect), were included in calculating the final risk score of a hazard. The score for each parameter was standardised by dividing the score by the maximum possible score for that parameter. Thus all parameters have a maximum value of one. The risk score is the product of the standardised scores multiplied by 100 (for ease of comparison) and thus has a maximum value of 100.

Risk score = [*(I_adverse_effect /3) * (D_adverse_effect / 4)* (P_hazard)*] * 100

Where the following are defined:

the intensity of the adverse effect *(I_adverse_effect)*

the duration of the adverse effect *(D_adverse_effect)*

the probability of exposure to the hazard *(P_hazard)*

The minimum, most likely and maximum values for *P_hazard* were used to generate minimum, most likely and maximum estimates of the risk score. If only one risk score is given it refers to the most likely. It is also assumed that hazards usually occur independently of each other.

### Calculation of magnitude of adverse effect

The magnitude of the adverse effect is the product of the scores for intensity and duration according to the following formula:

Magnitude score = [(*I_adverse_effect* /3) * (*D_adverse_effect* / *4*)] * 100

It has a maximum score of 100. The magnitude provides an indication of the impact of the hazard on the fish which are exposed to the hazard and experience the adverse effect. Thus a hazard that causes a prolonged and severe adverse effect but which affects only a small proportion of the population will have a low risk score but a high magnitude of severity score**.**

**Worked example – mis-stun**

Mis-stun may result when a concussive stunning method is used. This will give rise to an adverse effect. It was estimated that the adverse effect had a intensity score equal to 3. The duration (time from mis-stun to death or re-stun) was judged to last between one and two minutes, hence a score of 3. It was estimated that the probability that the hazard occurs was 0.04 (i.e. 4% of fish suffer a mis-stun), with minimum and maximum estimates of 0.01 and 0.10, respectively. In summary:

- score for the intensity of the adverse effect (*I_adverse_effect*) = 3
- score for the duration of the adverse effect (*D_adverse_effect*) = 3 (between one and two minutes)
- the probability that the hazard occurs (*P_hazard*) = 0.04 (ranging from a minimum estimate of 0.01 to a maximum estimate of 0.10)

Thus the risk score for this example mis-stun is:

(3/3 * 3/4 *0.04) * 100 = (1 * 0.75 * 0.04) * 100 = 3

This score has a range that is determined by the minimum and maximum estimates of the probability that the hazard occurs (*P_hazard*), 0.01 and 0.10 respectively.

Minimum score = (3/3 * 3/4 *0.01) * 100 = 0.75

Maximum score = (3/3 * 3/4 *0.1) * 100 = 7.50

The magnitude equals intensity score/3 * duration score/4 * 100; and in this example is 75:

(3/3 * 3/4) *100 = 75

**Interpretation of the risk score**

Due to the limited amount of quantitative data on many effects of hazards on fish stunning and killing, the risk assessment was mainly based on expert opinion. The methodology used does not give a precise numerical estimate of the risk attributed to certain hazards; however the output can be used to rank the problems and designate areas of concern, as well as, guidance for future research. The methodology does not take into account interactions between factors and assumes linearity in the scores. These assumptions cannot be tested. Secondly, the risk scoring is semi-quantitative. Thus the scores allow a ranking but the absolute figures are not on a linear scale (e.g. a risk score of 12 should not interpreted as being twice as important as a risk score of 6).

One key objective of this work is to compare different methods of stunning and slaughter within each species. This will be achieved by summing the risk scores for all the hazards arising for each method of stunning and slaughter. This figure will be used to rank and compare the methods. Risk scores are given for the commonly used methods (Table 9).

However, it should be noted that insufficient data were available to calculate the overall exposure to the hazard within the European population, i.e. how commonly are those methods actually used within the member states of the EU. For comparison purposes, this calculation is important as it quantifies more precisely the number of fish at risk for that particular method of slaughter. Moreover, a hazard with a small risk score but a high magnitude may still have serious welfare effects for a large number of fish. The converse is also true.

## APPENDIX B

Table 12. **Parameters used in producing risk and magnitude scores for welfare hazards associated with preslaughter management in carp in Europe.**

| Haz. ID | Pre-slaughter hazards | Intensity | Duration (time) | Duration (score[a]) | Uncertainty | Probability of (exposure) | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Most likely | Min | Max |
| 1 | netting | 1 | 30 min | 3 | 2 | 1 | 1 | 1 |
| 2a | netting causing injuries, fish not surviving 1 hour | 3 | 60 min | 3 | 3 | 0.002 | 0.0002 | 0.01 |
| 2b | netting causing injuries, fish surviving > 1 hour | 2 | 36 hours | 4 | 3 | 0.008 | 0.0008 | 0.04 |
| 3 | drop of fish from net or tank | 1 | 30 min | 3 | 3 | 0.2 | 0.05 | 0.3 |
| 4 | sudden change of temperature (in general) | 1 | 3 hours | 4 | 1 | 0.2 | 0.05 | 0.5 |
| 5 | sudden change of temperature (not starved, put into cold water) | 2 | 2 days | 4 | 3 | 0.001 | 0.0001 | 0.005 |
| 6 | sudden exposure to strong light | 1 | 10 min | 2 | 3 | 1 | 1 | 1 |
| 7 | fish jumps, out of tank or into cover | 2 | 24 hours | 4 | 3 | 0.005 | 0.001 | 0.05 |
| 8 | abrasive material (in tank or from other fish) | 2 | 24 hours | 4 | 3 | 0.01 | 0.001 | 0.1 |
| 9 | poor water quality | 1 | 2 days | 4 | 3 | 0.02 | 0.005 | 0.08 |
| 10 | low oxygen contents | 2 | 6 hours | 4 | 2 | 0.05 | 0.005 | 0.1 |
| 11 | crowding, not being able to show normal behaviour | 1 | 6 hours | 4 | 3 | 0.05 | 0.005 | 0.1 |
| 12 | strong noise and vibrations | 1 | 3 hours | 4 | 3 | 0.005 | 0.0005 | 0.01 |

[a] 1 = <5min, 2 = 5-15min, 3 = 15-60 min, 4 = >60min

Table 13 **Parameters used in producing risk and magnitude scores for welfare hazards associated with slaughter methods applied to carp in Europe.**

| Haz. ID | Pre-slaughter hazards | Intensity | Duration (time) | Duration (score[a]) | Uncertainty | Probability of (exposure) | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Most likely | Min | Max |
| *A* | *asphyxia + percussive stunning* | | | | | | | |
| 1 | drop of fish into tank without water | 2 | 15 | 4 | 3 | 0.5 | 0.1 | 0.8 |
| 2 | asphyxiation | 3 | 20 | 4 | 3 | 1 | 1 | 1 |
| 3 | pressure from other fish on top | 2 | 15 | 4 | 3 | 0.25 | 0.100 | 0.5 |
| 4 | manual handling (normal) | 1 | 0.17 | 2 | 3 | 0.95 | 0.9000 | 0.999 |
| 5 | improper manual handling | 2 | 0.17 | 2 | 3 | 0.05 | 0.001 | 0.1 |
| 6 | fall off the table, slipping out of hands | 3 | 0.17 | 2 | 2 | 0.01 | 0.001 | 0.05 |
| 7 | mis-hit (hit in the wrong place) | 3 | 0.03 | 1 | 3 | 0.05 | 0.01 | 0.1 |
| 8 | mis-hit (on the head but too litte force) | 3 | 0.03 | 1 | 3 | 0.1 | 0.01 | 0.15 |
| 9 | further processing after mis-hit; still conscious | 3 | 5 | 4 | 3 | 0.001 | 0.0001 | 0.005 |
| *B* | *electrical stunning* | | | | | | | |
| 10 | drop of fish into tank with water | 1 | 1 | 2 | 3 | 1 | 1 | 1 |
| 11 | new adverse environment (when transfered from lairage tank to stunner) | 1 | 1 | 2 | 3 | 1 | 1 | 1 |
| 12 | insufficient current/voltage leading to mis-stun (normal time) | 3 | 5 | 4 | 2 | 0.05 | 0.04 | 0.06 |
| 13 | prolonged exposure to insufficient current/voltage (delayed stun) | 3 | 1 | 2 | 1 | 0.95 | 0.94 | 0.96 |
| 14 | further handling and processing after mis-stun; still conscious | 3 | 5 | 4 | 3 | 0.02 | 0.01 | 0.03 |
| 15 | further handling and processing after stun; regained consciousness | 3 | 3 | 4 | 2 | 0.475 | 0.1 | 0.6 |
| *C* | *percussive stunning* | | | | | | | |
| 16 | drop of fish on to table | 2 | 0.17 | 2 | 3 | 0.02 | 0.01 | 0.05 |
| 17 | manual handling (normal) | 1 | 0.17 | 2 | 3 | 0.97 | 0.95 | 0.99 |
| 18 | improper manual handling | 2 | 0.17 | 2 | 3 | 0.03 | 0.01 | 0.05 |
| 19 | fall off the table, slipping out of hands | 3 | 0.17 | 2 | 2 | 0.02 | 0.001 | 0.05 |
| 20 | mis-hit (hit in the wrong place) | 3 | 0.03 | 1 | 3 | 0.05 | 0.01 | 0.1 |
| 21 | mis-hit (on the head but too litte force) | 3 | 0.03 | 1 | 3 | 0.15 | 0.01 | 0.2 |
| 22 | further processing after mis-hit; still conscious | 3 | 5 | 4 | 3 | 0.001 | 0.0001 | 0.005 |

[a] 1 = <0.17 min (10 sec), 2 = 0.17-1 min, 3 = 1-2 min, 4 = >2min

## Glossary / Abbreviations

| | |
|---|---|
| Adverse effect | The welfare consequences for an animal in terms of pain and distress when exposed to a hazard. |
| Asphyxia | A process where fish die from hypoxia. This may happen in some species by: taking them out of water; by partially bleeding animals out; by preventing gill movements e.g. crushing; and by reducing oxygen content of the water. |
| Crowding | Keeping animals at stocking densities that are high or that reduce swimming volume e.g. by hoisting a net. |
| Depopulation (Emergency killing for disease control) | A process of killing animals for public health, animal health, animal welfare or environmental reasons, sometimes under the supervision of the competent authority. |
| Dip-net | A net used to dip into a tank or cage to catch fish for the purpose of transfer of fish to another pond or facility or to market or for slaughter. |
| Duration | Specifically used with 'intensity' in the context of evaluating the magnitude of the adverse effect. |
| Emergency killing | The killing of animals that are injured or have a disease associated with severe pain or suffering and where there is no other practical possibility to alleviate this pain or suffering. |
| Exposure Assessment | The quantitative and qualitative evaluation of the likelihood of hazards to welfare occurring in a given fish population. |
| Hazard | Any factor with the potential to cause an adverse welfare effect on fish. |
| Hazard characterisation | The qualitative and quantitative evaluation of the nature of the adverse effects associated with the hazard. |
| Hazard Identification | The identification of any factor capable of causing adverse effects on fish welfare. |

| | |
|---|---|
| Hyperoxia | A condition with oxygen saturation above 100% of the normal atmospheric equilibrium for a given temperature and salinity. |
| Hypoxia | A condition with low oxygen saturation in the water or a condition with low oxygen saturation in the water (blood). |
| Intensity | The quality of pain or distress per unit time |
| Killing | Any intentionally induced process that causes the death of an animal. |
| Lairage | Short-term storage of fish in a tank or other facility before slaughter. Fish may be subjected to high stocking densities or materials for short periods. |
| Magnitude of the adverse effects | A function of intensity and duration of welfare impairment for fish. |
| Pre-slaughter | Anything happening just before stunning, killing or slaughter. |
| Risk | A function of the probability of an adverse effect and the intensity of that effect, consequent to a hazard for fish. |
| Risk Assessment | A scientifically based process consisting of the following steps: i) hazard identification, ii) hazard characterisation, iii) exposure assessment and iv) risk characterisation. |
| Risk Characterisation | The process of determining the qualitative or quantitative estimation, including attendant uncertainties, of the probability of occurrence and severity of known or potential adverse effects on welfare in a given fish population based on hazard identification, hazard characterisation, and exposure assessment. |
| Severity | Sometimes used to denote intensity. |
| Slaughter | The killing of animals for human consumption. |
| Slaughterhouse | Any establishment used for slaughtering fish. |
| Starvation | A period of food deprivation such that the animal metabolises tissues that are not food reserves but are functional tissues. |
| Stocking density: | Number of fish in a defined volume of water. |

| | |
|---|---|
| Stunning | Any intentionally induced process that causes loss of consciousness and sensibility without pain, including any process resulting in instantaneous death. |
| Uncertainty analysis | Uncertainty refers to the extent to which data are supported by published evidence. A method used to estimate the uncertainty associated with model inputs, assumptions and structure/form. This includes also uncertainty, due to the lack of reliable publications, uncertainty in the scientific results etc. |
| Variability | The natural biological variation that occurs in a population of animals. Not to be confused with uncertainty as it cannot be reduced by simply decreasing uncertainty. |
| Vestibulo-ocular reflex (VOR) | A reflex where eye movement occurs in a conscious fish when rocked from side to side (commonly called eye roll). |
| Visual evoked reflexes (VER) | Evoked EEG activity in the brain with a visual stimulus. |