SCIENTIFIC OPINION

Animal welfare aspects of husbandry systems for farmed European Eel [1]

Scientific Opinion of the Panel on Animal Health and Animal Welfare

(Question No EFSA-Q-2006-150)

Adopted on 11 September 2008

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PANEL MEMBERS[*]

The Scientific Panel for Animal Health and Welfare (AHAW) of the European Food Safety Authority adopted the current Scientific Opinion on 11 September 2008. The Members of the AHAW Scientific Panel were:

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[*] A minority opinion was expressed from Prof. Donald Broom based on the view that the accepted Report and adopted Opinion are incomplete and that in order to answer the mandate from the European Commission, the introductory chapters on the welfare, biological functioning and farming of fish should be included (Annex II).

SUMMARY

Following a request from European Commission, the Panel on Animal Health and Welfare was asked to deliver a scientific opinion on animal welfare aspects of husbandry systems for farmed fish. Council Directive 98/58/EC concerning the protection of animals kept for farming purposes lays down minimum standards for the protection of animals, including fish. The Scientific Opinion on welfare of European eel was adopted on the 12th of September 2008.

Eel is a significant cultured species in Europe. The juvenile stock is obtained by capture from the wild as there is no closed cycle of production. Although it is a cultured species albeit captured from the wild, the European eel (*Anguilla anguilla*) is also listed as an endangered species and is subject to EU Council Regulation EC No 1100/2007 establishing measures for the recovery of the stock in view of protection and sustainable exploitation of this species. Another specific feature of eel production is that it is the only fish species that is caught in large quantities at the larval stage (glass eels) before they can make any contribution to the reproduction of the species. In addition, the existence of a human consumption market for (dead) glass eels does not favour good welfare practices as dead and animals in poor condition can still have a high market value.

It is recommended that research be supported that is directed towards completion of the eel life cycle under artificial conditions as such research has high potential impact on recovery of endangered stocks and sustainability of an important aquaculture sector.

The various life stages of eel that were considered are: glass eels and juveniles, on-growers, and marketable fish. A review of environmental conditions and factors that were identified as possibly affecting the welfare of European eel at those different life stages has been conducted. These factors are grouped as: abiotic environmental conditions, biotic factors (including behavioural interactions), food and feeding, husbandry and management, genetics, and the impact of disease and disease control measures. It is however important to realise that the environmental conditions are always defined by a range of inter-related factors. While each specific variable is described separately, there are very few occasions in reality where only a single factor is involved in any fish welfare issue relating to environmental conditions. For this reason, only ranges of acceptable levels for the various factors can be given and always these must be considered in the context of the other variables involved.

There are various methods for the capture of glass eels for farming purposes which have varying levels of welfare concern for the subsequent maintenance of the stocks in the farm. Currently, in Europe, extensive culture systems have been almost entirely replaced by the high technology high density intensive systems.

There is very little scientific literature that specifically addresses the welfare of eel under farming conditions. However, it was possible to overcome such a paucity by extrapolating from existing peer reviewed publications, and using expert opinion, in a risk assessment approach.

Major welfare issues for glass eels were identified as being: skin damage associated with consequent osmoregulatory failure, tail damage and damage to the caudal sinus associated with secondary infections, stress and demucinisation during storage and handling (post capture). These hazards occur frequently (if not invariably), affect a high proportion of the glass eel population, and are severe. Injuries and mortalities are recorded amongst fished glass eel and the number of mortalities is linked to the speed, depth and net used in active trawling. It is recommended that the capture of glass eels for farming purposes be addressed

to reduce the highly significant poor welfare of glass eels during the process. During capture and post-capture storage, temperature is a critical hazard for glass eels.

For juveniles, the most significant hazards identified are: weaning, artificial food training, parasitic infections and disease management methods (exposure to herpes virus). Ineffective weaning and artificial food training received a relatively low score in our analysis because only a small minority of farms would be affected. Nevertheless the hazard is severe, prolonged and results in death in the eels affected.

For on-growers, infectious diseases remain a significant problem during this life-stage; but this is normally less severe compared with the juvenile stage.

Among the hazards that were identified for marketable fish, rapid reduction in water temperature was seen as the most important.

For all life stages of the European eel, water pH is important, mainly to control the level of ammonia. Also for all life stages, infectious diseases are a primary source of poor welfare despite good management. The lack of efficient treatment and vaccines increases the significance of this hazard. It is recommended that research be directed toward these issues.

Where parameters have been identified as having a welfare implication for eel, it is recommended that these parameters be monitored. Without continuous recording and monitoring, the use of alarm systems, and a reliable emergency backup even relatively small failures in husbandry systems can produce disastrous outcomes in terms of welfare.

It is also recommended to develop contingency plans to protect fish welfare from exposure to rare and brutal hazards.

Key words: **European eel, *Anguilla anguilla*, animal welfare, risk assessment, fish farming, husbandry system, aquaculture, environmental conditions, biotic factors, feeding, disease.**

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BACKGROUND AS PROVIDED BY EUROPEAN COMMISSION

Council Directive 98/58/EC concerning the protection of animals kept for farming purposes lays down minimum standards for the protection of animals bred or kept for farming purposes, including fish.

In recent years growing scientific evidence has accumulated on the sentience of fish and the Council of Europe has in 2005 issued a recommendation on the welfare of farmed fish[2]. Upon requests from the Commission, EFSA has already issued scientific opinions which consider the transport[3] and stunning-killing[4] of farmed fish.

TERMS OF REFERENCE AS PROVIDED BY EUROPEAN COMMISSION

In view of this and in order to receive an overview of the latest scientific developments in this area the Commission requests EFSA to issue a scientific opinion on the animal welfare aspects of husbandry systems for farmed fish. Where relevant, animal health and food safety[5] aspects should also be taken into account. This scientific opinion should consider the main fish species farmed in the EU, including Atlantic salmon, gilthead sea bream, sea bass, rainbow trout, carp and European eel and aspects of husbandry systems such as water quality, stocking density, feeding, environmental structure and social behaviour.

Due to the great diversity of species it was proposed that separate scientific opinions on species or sets of similar species would be more adequate and effective. It was agreed to subdivide the initial mandate into 5 different questions in relation to Atlantic salmon, trout species, carp, sea bass and gilthead sea bream, and European eel. This Scientific Opinion refers only to the fifth question.

ACKNOWLEDGEMENTS

The European Food Safety Authority wishes to thank the members of the Working Group for the preparation of the Scientific Report which has been used as the basis of this Scientific Opinion. The Working Group was chaired by Ronald Roberts (member of the panel) and consisted of Edmund Peeler (Risk Assessor), Bernd Sures, Hans Van de Vis, and Derek Evans. This report also received special contribution from Peter Wood.

[2] Recommendation concerning farmed fish adopted by the Standing Committee of the European Convention for the protection of animals kept for farming purposes on 5 December 2005.

[3] Opinion adopted by the AHAW Panel related to the welfare of animals during transport -30 March 2004.

[4] Opinion of the AHAW Panel related to welfare aspects of the main systems of stunning and killing the main commercial species of animals- 15 June 2004.

[5] Food Safety aspects of fish welfare are addressed by a Scientific Opinion of the BIOHAZ Panel ("Food Safety aspects of Animal welfare aspects of husbandry systems for farmed fish", Question N° EFSA-Q-2008-296).

OUTCOMES FROM THE DATA PRESENTED IN THE SCIENTIFIC REPORT

1. European eel, its importance to European aquaculture, and present status of stocks

Eel is a significant cultured species in Europe. The juvenile stock is obtained by capture from the wild as there is no closed cycle of production. Although it is a cultured species albeit captured from the wild, the European eel (*Anguilla anguilla*) is also listed as an endangered species and is subject to EU Council Regulation EC No 1100/2007 establishing measures for the recovery of the stock in view of protection and sustainable exploitation of this species. Another specific feature of eel production is that it is the only fish species that is caught in large quantities at the larval stage (glass eels) before they can make any contribution to the reproduction of the species. In addition, the existence of a human consumption market for (dead) glass eels does not favour good welfare practices as dead and animals in poor condition can still have a high market value.

It is recommended that research be supported that is directed towards completion of the eel life cycle under artificial conditions as such research has high potential impact on recovery of endangered stocks and sustainability of an important aquaculture sector.

2. Overview of eel production systems in Europe

This opinion covers the welfare aspects of the capture operations and transport of the glass eels to the farm, as well as the different culture systems to which the various life stages of eels are then exposed. These systems were analysed in some detail and the various areas within eel husbandry where specific welfare risks exist have been defined and analysed in relation to the different life stages and production systems.

The scientific report, which was used as a basis for this opinion defines the systems used for culture of the European eel, and highlights areas where such systems may increase the likelihood of negative effects on the welfare of the eel.

There are various methods for the capture of glass eels for farming purposes which have varying levels of welfare concern for the subsequent maintenance of the stocks in the farm. Currently, in Europe, extensive culture systems have been almost entirely replaced by the high technology high density intensive systems.

There is very little scientific literature that specifically addresses the welfare of eel under farming conditions.

3. Identification of factors potentially affecting the welfare of European eel

The various life stages of eel that are considered in this opinion are: glass eels and juveniles, on-growers, and marketable fish.

A review of environmental conditions and factors that were identified as possibly affecting the welfare of European eel at those different life stages has been conducted.

Farming systems inevitably introduce a number of stressors to the organism. Potential stressors may include inappropriate water chemistry (NH_3 NO_2, NO_3, pH, Dissolved Oxygen, CO_2) temperature, handling, physical damage, diseases or disease treatments and inappropriate nutrition. It is impossible to avoid many of the procedures known to induce stress responses in eel farming. Netting, grading and transport are integral components of the eel farming routine and, at best, all the farmer can do is to minimize the effects of this type of stress. In general, the duration of the stress response is proportional to the duration of the stress. Thus, reducing the time-course of the event (netting, grading, transport etc.) will encourage a more rapid recovery of the fish.

Welfare factors are grouped as: abiotic environmental conditions, biotic factors (including behavioural interactions), food and feeding, husbandry and management, genetics, and the impact of disease and disease control measures. It is however important to realise that the environmental conditions are always defined by a range of inter-related factors. While each specific variable is described separately, there are very few occasions in reality where only a single factor is involved in any fish welfare issue relating to environmental conditions. For this reason, only ranges of acceptable levels for the various factors can be given and always these must be considered in the context of the other variables involved.

A review of environmental conditions and factors that may affect welfare of eels is given in the following sections.

3.1. Abiotic factors

3.1.1. Light period and intensity

Eel, like virtually all fish, react to light changes. The effect on welfare is uncertain. There is a view, supported by expert opinion, that sudden changes in light levels produce a “fright and flight” reaction.

3.1.2. Noise and vibrations

From the scientific literature review no information was found but industry experience would indicate that eels are susceptible to sudden changes in noise and to vibrations.

3.1.3. Water oxygen content

In order to ensure optimal feeding and growth water oxygen concentrations should be maintained at 100 % saturation in tank outlets. This will minimise the risk of areas of low oxygen levels developing in the system. In all culture systems the oxygen level is often the most critical factor and as such is monitored closely. However, oxygen deficiency problems leading to both mortality and impaired welfare are difficult to completely avoid unless each tank is alarmed and provided access to backup oxygenation. This can be a significant welfare issue but difficult to recognise.

3.1.4. Water temperature

Eels are naturally adapted for survival across the range of European temperature conditions. However, at temperatures below 1 to 3 C, eels were shown to enter a state of torpor.

With sudden lowering of temperature it has been observed that a percentage of the population loses its thigomotactic response. Recovery may take 2 to 4 days.

Normally, glass eels are not exposed to low temperatures. Industrial experience indicates that holding or transporting glass eels at temperatures below 4 °C can lead to significant mortality. It has been observed that there is no feed consumption below 10 C for glass eels.

Under intensive farming conditions, at temperatures below 22-24 C, advantage generally appears to be for pathogen against the host. Under intensive conditions at temperatures of 19 C appetite is very significantly suppressed.

3.1.5. Water pH

Eels tolerate a wide range of pH although extreme values reduce feeding activity and thus growth rates. Optimum pH values for the eel are reported as being between 7 and 8. Under intensive conditions, pH is maintained below 6 in order to minimise the risk of ammonia toxicity. Industrial experience indicates that for intensive systems a pH range of 4.8 to 5.8 is tolerated

3.1.6. Suspended solids

The removal of solids greater than 40 µm limits exposure of fish to the parasitic monogenean trematode *Pseudodactylogyrus* sp. by exclusion of its eggs.

3.1.7. Ammonia, nitrite and nitrate content of water

Compared with other freshwater fish species *A. anguilla* is rather tolerant to nitrite but concentrations should be below 30 mg/l. Industrial experience would indicate that levels higher than 10 mg/l should be avoided. Water nitrate levels greater than 300 mg/l create a more challenging environment for some external parasites.

3.1.8. Tank and pond design

There is no indication that specific tank or pond designs are significant in relation to eel welfare. Eels have a natural need to have mechanical contact with a solid substrate while resting (thigmotaxis). It has been shown to be important to provide adequate resting area for all of the fish in the tank at resting time.

3.1.9. Substrate of ponds

The natural substrate of a pond is normally the basis for extensive lagoons or ponds in Europe. An area concreted for the purposes of feeding or harvesting is desirable for hygiene and management.

3.1.10. Environmental pollutants

There are recommendations with regards to the safe levels of wild eel consumption because of environmental pollution. However farmed eels do not have such problems because of their reduced exposure to polluted waters.

3.2. Biotic factors

3.2.1. Behavioural interactions

After the glass eel stage, eel change from a shoaling fish into a ‘territorial’ species which can be aggressive at low densities. It is important to maintain uniformity of size within the population since cannibalism rapidly ensues when size discrepancy develops. Such uniformity should be maintained by regular grading and sorting.

3.2.2. Food and feeding

First feeding is with cod roe is one of the most critical periods in the rearing cycle at which the glass eels are transferred from the cold water storage system and introduced into the warm water juvenile system for the following twelve weeks of on-growing.

As with any carnivorous fish, the wild eels are physiologically well adapted to withstand prolonged periods of feed deprivation. Fish are normally deprived of feed for a few days prior to grading or transport in order to reduce the metabolism and thus mortality. Where eels are destined for final dispatch to market, food will normally be withheld for 2 to 3 days. On farms any change in the daily feeding routine will be to some extent stressful to the fish and is avoided if possible. .

Overfeeding, especially where demand feeders are in use, is a significant welfare issue because of the effect that wasted food disintegrating into the water column can have on the oxygen levels and water quality. Use of mechanical feeders correctly loaded for the biomass of fish avoids this risk.

3.2.3. Impact of infectious diseases on welfare

There is a large group of pathogens including numerous parasites, fungi, bacteria, and viruses infecting eel and causing disease. However, in aquaculture only a few disease agents result in disease outbreaks that, amongst other signs, decrease growth or increase mortality.

In this opinion, only selected diseases of cultured European eel were considered because of their potential significance to eel welfare (severity of effect on physiological integrity of fish, known frequency of occurrence in farming systems, and impact of preventive and/or curative measures).

3.2.4. Impact of disease control measures on welfare

When eel culture was essentially an extensive industry, the use of veterinary medicines was not a practical option because of lack of control in food intake, quantities of medicine to use, risk of re-contamination.. As the industry grew into an intensive production system, the process of eel farming allowed treatments. However, the management of recirculation systems, and particularly the filters, often restricts the way in which therapeutics can be used. Also products are generally not licensed specifically for eel, but used under the cascade system or other arrangements. Used carefully, medicinal treatments can be of value and assist in maintaining good welfare.

Currently juvenile eels are deliberately exposed to water contaminated with *Herpesvirus anguillae* in order to induce an infection which will cause some welfare issues and some mortality (2 to 25 %). Bacterial vaccines (immersion, oral) exist against the *Vibrio* pathogens of eels and can be used under the present cascade mechanism. The immersion vaccines which require high concentration of antigen in limited water volumes can lead to stress due to overcrowding foaming of the water, demucination and result in reduction of feeding. The oral vaccines have no associated significant welfare issues although efficacy may not be so high.

3.3. Husbandry and management

3.3.1. Stocking densities

The optimal stocking density is, to a large extent, dependent upon the production system in use the technical specification of the system (water flows/available oxygenation) and the life-stage of the eel being cultured. There is no published evidence that these stocking levels compromise welfare.

3.3.2. Handling

Nets cause abrasion and secondary infections especially where tails get stuck within the mesh. Eels are ideally handled with the minimum of water and are either piped or pumped out of the system without the use of nets.

4. Risk assessment approach to welfare of European eel

The risk scores based on expert advice were used to compile a risk ranking by category such as abiotic or biotic to obtain an idea which hazards are the more important for each life stage in the various production systems considered, and also to enable the comparison of the different production systems.

4.1. Glass eels

The different capture methods for glass eels (active trawling, and fixed nets) have been considered as separate production systems to allow for comparison. This life stage also includes a quarantine period referred to as post-capture storage.

Trawling and fixed nets in high currents have the following hazards, all of which received high scores:

- skin damage incurred at capture – osmo-regulatory failure within 7-10 days
- tail damage incurred at capture - damage to the caudal sinus, secondary infections
- stress, demucinisation during storage (post capture)
- stress, skin damage, demucinisation during handling (post capture)

These hazards have high scores because they occur frequently (if not invariably), affect a high proportion of the populations and are severe (severity score = 3 or 4). Inappropriate handling post capture has the highest score because the duration of the effect (skin damage and demucinisation) lasts up to 20 days (time when all affected individuals would eventually die). The damage caused to the tail results in a very high degree of mortality (however, this does not account for the high hazard score that is attributable to the effect on the eels prior to death). It is only noticed 48 hours after capture. It should also be noted that trawling results in high mortality within the first hour after capture (which has a low hazard score due to short duration of the effect). Mortality that occurs at capture (mainly due to crushing) can be considerable (order of magnitude around 50 % within a few hours following capture) but is not considered as a welfare issue in this analysis.

There can be an adverse synergistic effect of poor storage conditions following stress caused by poor capture methods which cannot be captured by the risk assessment method. Poor storage leads to exposure to air, adverse water quality, confinement leading to loss of mucous and stress. Eels are held in the storage buckets for approximately 4 hours after capture.

Low current fixed nets and hand netting resulted in two significant hazards post-capture:

- stress, demucinisation during storage
- stress, skin damage, demucinisation during handling

These hazards received the same score across all capture methods. Skin and tail damage may also result from low current fixed netting but with a lower frequency (frequency score = 1).

Table 1. Glass eel hazards ranking

trawling	fixed netting/trapp - high current	Glass-eels fixed netting/trapp - low current	Glass-eels hand netting
inappropriate handling,	inappropriate handling	inappropriate handling,	inappropriate handling
sourcing trawling (tail damage - damage caudal sinus)	sourcing fixed netting/trapp - high current (tail damage - damage caudal sinus)	storge	storge
sourcing trawling (skin damage)	sourcing fixed netting/trapp - high current (skin damage)	sourcing fixed netting/trapp - low current (tail damage) s	
storge	storge	sourcing fixed netting/trapp - low current (skin damage)	
sourcing trawling (physical damage - death in 1h)	sourcing fixed netting/trapp - high current(physical damage, death in 1h)	sourcing fixed netting/trapp - low current (physical damage, death in 1h)	

4.2. Juveniles

For this, only intensive production system was considered as it is currently the most dominant farming system in Europe. Extensive farming contribution to the European production is becoming anecdotal.

The identified hazards are weaning, artificial food training, parasitic infections and disease management methods (exposure to herpesvirus).

Infection with *Pseudodactylogyrus* ranked high as a hazard because it occurs frequently (80% of farms), affects a large proportion of the population for a long period and with severe effects. Control methods have low effectiveness. In addition, the parasite also causes a high level of mortality.

Another high ranked hazard is also disease-related. At this life stage farmers expose eels to herpesvirus (to avoid losses later in production). Infection results in stress, poor feeding and other clinical signs in a majority of the population (it had a severity score = 3), albeit with low mortality (< 20 %). Other external parasites, handling, water quality parameters also ranked relatively highly. Other ecto-parasites are generally managed effectively under normal conditions.

Ineffective weaning and artificial food training received a relatively low score because only a small minority of farms were affected and on these farms <40 % of the eels starve post weaning. Nevertheless the hazard is severe, prolonged and results in death in the eels affected.

Handling was another highly ranked hazard. Handling juveniles will cause stress, skin damage and demucinisation. As the fish at this stage are relatively robust the severity score given was low (severity score = 1).

Table 2. Juveniles hazards ranking

Juveniles
external parasites - Dactylogyrus
disease management practice – herpes virus exposure
handling
external parasites
low pH, high pH/Ammonia
uneffecitive weaning and artificial food training
Vibrio
Fungal infections, Aeromonas
rapid increase water temperature

4.3. On-growers

This stage lasts for 18 months. In accordance with the statement in the previous section (7.9.4), only intensive system was considered in this analysis.

Pseudodactylogyrus remains a significant problem during this life-stage but is less severe compared with the juvenile stage. It nevertheless remains a highly ranked hazard for on-growers. Other diseases are also highly ranked hazards, e.g. vibriosis and herpesvirus infection. Herpesvirus is present on all farms, however disease occurs on about 50 % of farms (where exposure of juveniles did not result in a sufficiently high level of 'herd immunity'). When outbreaks occur most eels are affected, and high mortalities can occur. The disease is exacerbated by poor environmental conditions.

Table 3. On-growers hazards ranking

On-growers
external parasites - Dactylogyrus
herpes virus disease
handling
Vibrio
low pH, high pH/Ammonia
external parasites
Aeromonas

4.4. Marketable fish

Fish are moved into marketing tanks for a few days before being sold. Three hazards were identified: handling, fasting and a rapid reduction in temperature. Handling at this stage is significantly reduced as eels have been graded prior to reaching marketable size. Eels are generally fasted during this period for 2 days; they need to be fasted for longer (5 days) if there is a problem with taint. They are kept at a cooler temperature during this period. There is a sudden drop in water temperature which is known to be stressful, behavioural changes are seen. This is the most important hazard identified for this life stage, attributable to its higher severity compared with the other two hazards.

Table 4. Marketable fish hazards ranking

Marketable fish
rapid temperate reduction
fasting
handling

4.5. Discussion

Two main categories of hazards stand out from our risk assessment analysis: those associated with the capture methods and those with infectious diseases, notably *Pseudodactylogyrus* and herpesvirus.

The capture method is critical to the health and productivity of eels in aquaculture. Trawling (as currently practised) and fixed nets in strong currents result in a high level of stress and trauma resulting in subsequent mortality both acutely and over the next 20 days. An obvious solution is to amend the current capture practices to reduce their impact on the welfare of eels, or to use capture methods identified as having fewer, less severe hazards associated with them. Two post-capture hazards were identified associated with storage and handling. Improved storage methods would be relatively easily implemented with significant improvements in both welfare and survival.

The hazards associated with diseases were identified as serious welfare related issues. Current control methods are at best only partially successful under current farming methods. Research is needed to develop improved control strategies. In the absence of a vaccine, exposure of juveniles to herpesvirus is the most effective method of controlling disease (if not infection). Nevertheless, this practice was a highly ranked hazard for juveniles. Again, research is required to develop a vaccine and other control methods.

Other hazards are arguably amenable to improved management. Most farmers successfully wean juveniles onto proprietary feed, so presumably best practice would improve the problem on affected farms. Inappropriate handling occurs at all life-stages. It leads to loss of mucous, stress and skin damage. Handling occurs frequently during the production period and was a relatively highly ranked hazard in a number of life-stages. Better handling methods, and a reduction in handling especially of juveniles, promoted through codes of practice, may therefore improve eel welfare.

There are very few welfare issues for eels at the marketable stage; one of them being the sudden drop in water temperature as they enter the marketable phase. Practices should be employed to ensure that the temperature change is gradual.

A number of the identified hazards can be reduced significantly through changes in capture method or management. Research is required before significant improvements in the disease related hazards could be realised.

CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations are based on the scientific literature review and the performed risk assessment.

Conclusions

1. Serious injuries occur during active trawling of glass eels with 30-40 % being killed during capture with a further 10-15 % dying later.
2. The removal of the protective mucous coat from eel can be lethal with 97 % of dead eel showing demucinisation.
3. Tail damage caused by inappropriate net mesh size can be lethal due to damage to the caudal sinus.
4. Hand netting causes little damage.
5. The value of dead glass eel is not the same disincentive to avoid poor welfare as with other farmed species
6. Sudden changes in light levels produce a fright and flight reaction in eel.
7. Expert opinion is that eel are susceptible to vibrations and sudden changes in noise.
8. Oxygen deficiency problems lead to both mortality and poor welfare can be avoided by alarming each tank and provided access to backup oxygenation.
9. Holding or transporting glass eel at temperatures below 4 °C can lead to significant mortality.
10. The removal of suspended solids greater than 40 m is beneficial for eel welfare
11. Water nitrate levels as high as 500 mg/l are tolerated and levels greater than 300 mg/l create conditions less favourable for infestation by external parasites.
12. Improper tank or pond design to facilitate the movement of fish for grading and harvesting will lead to eel having to be netted or pumped out of water which will cause significant injuries and stress, impair growth and predispose to secondary infections.
13. Farmed eels are seldom exposed to polluted waters and so not normally exposed to environmental pollutants which are a food safety concern.
14. Lack of size uniformity within the population often leads to cannibalism and so regular grading and sorting are required.
15. The life cycle of the European eel remains obscure and attempts at artificial reproduction are not well developed. Eel aquaculture is wholly dependent upon the capture of wild glass eel.
16. The European eel stock is currently considered to be under threat because fishing has placed them outside safe conservation limits.
17. The major welfare issues for glass eels were identified as: damage to the skin, tail and caudal sinus associated with secondary infections, stress and demucinisation during storage and handling. These hazards occur frequently and affect a high proportion of glass eels, and lead to very poor welfare.

18. A synergistic effect of poor storage conditions following stress caused by poor capture methods may occur.
19. Very high injuries and mortalities are recorded amongst trawled glass eel and are linked to the speed, depth and net used in active trawling.
20. During capture and post-capture storage, temperature is an important hazard for glass eels.
21. The most significant hazards identified for juveniles are: weaning, training to artificial feed, parasitic infestations, and disease management methods.
22. Ineffective weaning and artificial feed training received a relatively low score in the RA because only a small minority of farms are affected. Nevertheless the hazard is severe, prolonged and results in death of eels.
23. Infectious diseases are a significant problem for on-growers but less severe compared with the juvenile stage.
24. Rapid reduction in water temperature is the most important hazards identified for marketable fish.
25. For all life stages of the European eel, water pH is important, mainly to control the level of ammonia.
26. For all life stages, infectious diseases are a primary source of poor welfare despite good management. There is a lack of good treatment.
27. The optimum stocking density for eel has not been determined to the extent that an equation for space requirements of eel can be provided in this report.

Recommendations

28. The trawling methods for the capture of glass eel should be modified or adapted to reduce drastically the high mortality of glass eels.
29. Water nitrite concentrations should normally be below 30 mg/l.
30. Eels should be graded and sorted regularly to maintain uniformity of size in the population
31. Farms and farming sites should have handling equipment and procedures that ensure minimal impact on the welfare of eel.
32. Research should be undertaken into completing the eel life cycle under artificial conditions. Such research would allow for production of juveniles in aquaculture conditions and avoid exposure to fishing hazards leading to poor welfare.
33. The methods for the capture of glass eels should be modified or adapted to reduce drastically the high mortality of glass eels.
34. With regards to conclusions 1 - 27: Research is needed to improve efficiency and availability of veterinary medical products and vaccines.
35. It is recommended that oxygen, nitrite, nitrate, temperature should be continuously recorded and monitored. The use of alarm systems, and a reliable emergency backup is also recommended.
36. It is recommended to develop contingency plans to protect fish welfare from exposure to rare and severe welfare hazards.

37. Research should be carried out into the welfare impact of production systems and their husbandry in European eel.
38. As it is difficult to set appropriate levels of stocking density the monitoring of the conditions of the fish (such as injury, growth rate, behaviours expressed and overall health) should be used.