

BVA and FVS response to the Animal Welfare Committee Call for Evidence on farmed fish killing

Who we are

1. The British Veterinary Association (BVA) is the national representative body for the veterinary profession in the United Kingdom and has over 18,000 members. Our primary aim is to represent, support and champion the interests of the veterinary profession in this country, and we therefore take a keen interest in all issues affecting the profession, including animal health and welfare, public health, regulatory issues and employment matters.
2. The Fish Veterinary Society (FVS) is a specialist division of the BVA for veterinary surgeons with an interest in fish, as well as fish health professionals and veterinary students. It also promotes fish welfare and an increasing stake in the health management of fish whether farmed, used in research, in public aquaria or in the ornamental sector including fish kept as pets.

Introduction

3. We welcome the opportunity to respond to this Call for Evidence to inform AWC's update to the Opinion on the welfare of farmed fish at the time of killing.
4. Slaughter processes should result in a humane death for animals, minimising avoidable pain, distress, fear, and suffering. Welfare at slaughter (including the harvesting of fish) begins on-farm, starting with preparation of animals for slaughter, ensuring they are fit for transport, and ending with slaughter at the abattoir or harvesting station.
5. We support the Farm Animal Welfare Committee's principles of humane slaughter as set out in previous FAWC opinion reports on the welfare of fish and terrestrial farmed animals at slaughter or killing^{1,2}:

"Slaughter [...] is the final event in a farm animal's life. The following principles must be observed if slaughter [...] is to be humane with minimal pain, suffering and distress:

- All personnel involved with slaughter [...] must be trained, competent and caring
 - Only those animals that are fit should be caught [or penned], loaded and transported to the slaughter site
 - Any handling of animals prior to slaughter must be done with consideration for the animals' welfare
 - In the slaughter facility, only equipment that is fit for the purpose must be used
 - Prior to slaughter of an animal, either it must be rendered unconscious and insensible to pain instantaneously or unconsciousness must be induced without pain or distress
 - Animals must not recover consciousness [before] death ensues."
6. In 2020 we published the [BVA position on the welfare of animals at slaughter](#), this included specific recommendations to improve welfare at slaughter for farmed fish. Having considered

¹ FAWC, 2014. Opinion on the welfare of farmed fish at the time of killing. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/319331/Opinion_on_the_welfare_of_farmed_fish_at_the_time_of_killing.pdf

² FAWC, 2003. Report on the welfare of farmed animals slaughter or killing. Available at: <https://www.gov.uk/government/publications/fawc-report-on-the-welfare-of-farmed-animals-at-slaughter-or-killing>

existing evidence, the 2014 FAWC Opinion on the welfare of farmed fish at time of killing and industry best practice, we recommended the following and explore these recommendations in more detail in this response:

- The UK Governments should provide specific legislative protections for the welfare of farmed finfish at slaughter.
- There should be further research into the use of pre-slaughter sedation for fish in the UK to improve welfare at the time of harvesting.
- The UK governments should include the stunning of farmed fish (including detailed requirements of key parameters), alongside general welfare protections at slaughter in UK Welfare of Animals at the Time of Killing regulations.
- There should be further research into electrical stunning methods to determine the minimum effective parameters for different types and sizes of finfish and decapods.
- There should be further research to develop effective, humane and commercially viable methods of stunning cephalopods.
- Once effective, humane and commercially viable methods of stunning decapods and cephalopods are developed, the UK governments should include the stunning of commercially caught (and farmed where applicable) decapods and cephalopods alongside general welfare protections at slaughter in UK Welfare of Animals at the Time of Killing regulations.
- There should be further research to develop effective, humane and commercially viable methods of stunning for wild-caught fish.
- Once effective, humane and commercially viable methods of stunning wild-caught fish are developed, the UK governments should include the stunning of wild-caught fish in commercial fisheries alongside general welfare protections at slaughter in UK Welfare of Animals at the Time of Killing regulations.

7. We recognise that many of AWC's future recommendations will pertain specifically to salmon and trout as the most commonly farmed species of fish in the UK. However, consideration should also be given to minor species of farmed fish that are produced in the UK, and any species-specific needs that should be reflected in AWC's recommendations.

Legislative protections for farmed finfish

8. We recognise that the UK aquaculture sector has adopted several industry-led codes of practice and assurance scheme standards to protect fish welfare at slaughter.^{3,4,5}, including the [Code of Good Practice from Scottish Finfish Aquaculture](#) and [RSPCA Assured scheme standards for Salmon and Trout](#). However, we note there is currently no detailed legislation to protect the welfare of farmed finfish at slaughter. Instead, provisions for farmed finfish in UK and EU legislation are limited to key principles, as opposed to detailed protections. EU Regulation (EC) 1099/2009 on the protection of animals at the time of killing states:

“Separate standards should be established on the protection of fish at killing. Therefore, provisions applicable to fish should, at present, be limited to the key principle.”

³ FAWC, 2014. Opinion on the welfare of farmed fish at the time of killing. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/319331/Opinion_on_the_welfare_of_farmed_fish_at_the_time_of_killing.pdf

⁴ All members of the Scottish Salmon Producers Organisation (SSPO) subscribe to [The Code of Good Practice from Scottish Finfish Aquaculture](#)

⁵ RSPCA Assured state that around 70% of total Salmon production in Scotland is RSPCA Assured.

9. Given the number of fish harvested in UK aquaculture each year⁶, the UK Governments should introduce specific legislative protections for the welfare of farmed fin fish at the time of killing to reinforce existing good practice by the aquaculture industry.

The welfare of farmed fish during harvesting operations

7. There are several key stages during the pre-slaughter harvesting process that can impact on fish welfare⁷, these are:
 - feed withdrawal
 - crowding
 - handling and removal from water;
 - transportation from pen to harvesting station
8. We strongly recommend that all those involved in the harvesting of fish familiarise themselves with, and adhere to, best practice to promote positive fish welfare during harvesting, as set out in the following documents:
 - [Humane Slaughter Association guidance on the Humane Harvesting of Fish](#)
 - [RSPCA Assured standards](#) for salmon and trout
 - [The Code of Good Practice from Scottish Finfish Aquaculture](#)

Feed withdrawal

9. Withdrawing feed from fish before handling and slaughter reduces faecal contamination, reduces metabolic activity and can reduce distress and oxygen demand during handling operations. There is currently nothing set in legislation to specify maximum withdrawal food periods.
10. We support RSPCA Assured standards and Humane Slaughter Association guidance that stipulates a maximum of 72 hours withholding of food to completely empty the gut, while minimising any negative welfare implications. There may be circumstances where a longer withdrawal period is appropriate, however withdrawal periods should only be extended under the guidance of a veterinary surgeon.
11. However, we note that there is a discrepancy in how feed withdrawal is measured in the RSPCA Assured standards for salmon and trout. In the salmon standards feed can be withheld for a maximum of 72 hours, whereas in the trout standards feed can be withheld for a maximum of 54 degree days.
12. See [Noble, C. et al. \(2018\). Welfare Indicators for farmed Atlantic salmon: tools for assessing fish welfare](#), for more information on the welfare implications of fasting in fish across different time periods.
13. Before feed withdrawal takes place, it is also important that the welfare of cleaner fish is taken into account eg the risk of predation. Protective measures, such as the potential removal of cleaner fish from pens at this stage, should be specifically addressed in the farm's veterinary health plan.
14. In addition, further consideration should be given to the welfare implications of intermittent feeding pre-slaughter and the potential need to restrict this. With this in mind, it would be useful

⁶ Scottish Government, 2019. [Scottish fish farm production survey 2018](#).

⁷ FAWC, 2014. Opinion on the welfare of farmed fish at the time of killing. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/319331/Opinion_on_the_welfare_of_farmed_fish_at_the_time_of_killing.pdf

for AWC to consider recommending potential maximum number of fasting periods pre harvest. See Bermejo-Poza et al. (2015) The effect of intermittent feeding on the pre-slaughter fasting response in rainbow trout.

Crowding

15. Crowding is the process in which the area available to fish is reduced to capture and remove them from the water before slaughter. As recognised in the previous FAWC opinion, if poorly managed, the process of crowding can invoke a high distress response in fish by decreasing oxygen levels, and also lead to physical damage through abrasion on nets or other fish if there is overcrowding.⁸
16. With the correct management, the risk of distress and injury due to crowding can be reduced. To safeguard the welfare of fish during the crowding process:
 - crowding should be undertaken gradually with no sudden or rapid movements;
 - as per RSPCA Assured standards and HSA guidance, the duration of crowding should not exceed a maximum of two hours except under veterinary guidance;
 - crowding pens should make use of the natural behaviour of fish to minimise distress eg. set up so they can swim against the tide and into a shaded area;
 - there should always be at least one member of staff monitoring the crowding pen who is responsible for the welfare of the fish, controlling stocking density, and can recognise and act upon any welfare issues;
 - water oxygen levels in the area of crowding should be monitored and not fall below species-specific minimum levels.
 - RSPCA Assured crowd intensity scales should be used as a guide to managing acute stress.⁹ At present, these scales are only specified in the RSPCA Assured standards for salmon.
17. It is important to note that crowding during sea lice treatment often exceeds the period of two hours as recommended above for pre-slaughter crowding, with crowding lasting up to 8 hours in some cases.

Handling and removal from the water

18. Fish should not be removed from water for a significant period of time. We note that the use of systems with fish pumps, when used at the lowest effective pressure, can improve fish welfare, reducing the need for removal from the water and handling. Where systems do not permit the use of fish pumps, we support the RSPCA Assured standards for salmon and trout on removing fish from water (HP.1.1-1.3):
 - Removal from water and handling must only be carried out when absolutely necessary.
 - If fish must be handled adequate support must be given to the body and live fish must never be held by the tail only or thrown onto solid objects.
 - Time out of water must be kept to the minimum possible and never exceed 15 seconds for a live fish (unless anaesthetised).

Rested harvesting

19. We note that in some countries iso-eugenol is licensed as a means of pre-slaughter sedation for fish before they are removed from the water. This process is known as 'rested harvesting', with

⁸ FAWC, 2014. Opinion on the welfare of farmed fish at the time of killing. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/319331/Opinion_on_the_welfare_of_farmed_fish_at_the_time_of_killing.pdf

⁹ <https://science.rspca.org.uk/documents/1494935/9042554/RSPCA+welfare+standards+for+farmed+Atlantic+salmon+%28PDF%29.pdf/60ae55ee-7e92-78f9-ab71-ffb08c846caa?t=1618493958793>

the anaesthetic solution delivered into the water before removal for slaughter. As the fish are sedated, they do not experience the welfare risks or stressors associated with handling or removal from water. Anaesthetic concentration, exposure time, water temperature, and fish size and weight are factors that need to be carefully considered when using this method. However, this method of harvesting is currently not permitted in the UK as iso-eugenol is not licensed for use.

20. Given the welfare benefits of rested harvesting, we would support further research into the use of pre-slaughter sedation for fish in the UK to improve welfare at the time of harvesting. This should include consideration of appropriate anaesthetic concentrations, exposure times, water temperature and fish size, weight, as well as whether it is safe for this product to be licensed for use in fish entering the UK food chain. In addition, it will be important to consider that use of iso-eugenol under Cascade would invoke a withdrawal period of 500 degree days, which could prove impractical in a harvesting setting.

Transportation from pen to harvesting station

21. Transport to a harvest station, or point of slaughter remote from the production unit, should be in accordance with general safe transport guidance as set out in RSPCA Assured standards and [The Code of Good Practice from Scottish Finfish Aquaculture](#).
22. In particular, to safeguard the welfare of fish during these transport operations, we support the following principles based on guidance set out in the previous FAWC opinion, and by the Humane Slaughter Association:
 - Due regard should be paid to pumping rate and pressures, pipe diameters relative to fish size and final stocking density in transport tanks.
 - Water quality should be monitored during transport and maintained within acceptable limits, which will be species-specific
23. Transfer from a transport vessel or vehicle to the point of slaughter should deliver the fish to that point at a rate consistent with rapid and immediate stunning and killing. The period between removal from the water and slaughter should be minimal, in accordance with RSPCA Assured standards and [The Code of Good Practice from Scottish Finfish Aquaculture](#). For trout, it is important to note that electrical stunning is the most common method used for stunning and this is carried out in the water.

Effective stunning of farmed fish

All farmed fish should be stunned before slaughter

24. We continue to support the 2014 FAWC recommendation that “all farmed fish should be stunned before killing, whether or not death accompanies the stun (as in stun/kill methods) or when death follows some short time after the stun but before the fish has the time to regain consciousness.”
25. In the UK aquaculture industry percussive stunning is used to stun larger trout and salmon, and electrical stunning is usually employed for smaller fish, for example portion trout. When used as per the key parameters and conditions as set out in Tables 1-6 of the [FAWC Opinion on the Welfare of Farmed Fish](#), we consider these methods will deliver an effective stun.
26. The 2014 FAWC opinion recognised that electrical stunning may cause tissue damage to fish, since then we are aware that electrical stunners are being developed to address this issue, using both AC and DC currents which delivers an effective stun to fish, while avoiding potential tissue

damage.^{10,11}

27. Automated percussive stunning systems are now widely used in Scottish salmon farming operations. These systems, when properly maintained and monitored, are considered humane and effective. However, it is important that such systems have staff in place to check and manually stun and bleed any fish not effectively stunned by the automatic system.
28. However, EC Regulation 1099/2009 and UK Welfare of Animals at the Time of Killing regulations do not identify permitted or prohibited methods of farmed fish slaughter and do not require fish to be stunned before slaughter. This means methods of slaughter that are not considered to be humane and do not deliver an effective stun are still permitted, including:
 - leaving fish to asphyxiate or bleed to death without prior stunning;
 - killing in carbon dioxide saturated water; and
 - killing by rapid chilling.
29. As the 2014 FAWC opinion outlines¹², these methods are not considered humane methods of slaughter and should not be used. Consequently, the UK governments should include the stunning of farmed fish (including detailed requirements of key parameters), alongside general welfare protections at slaughter, in UK Welfare of Animals at the Time of Killing regulations.
30. Given the rise in small farms of tropical species (eg. tilapia and in particular shrimp), it would be useful for FAWC to further assess the welfare impact of chilling on warm water fish. We note that in the 2014 FAWC Opinion it was highlighted that warm water fish eventually become sedated and even killed during slow water chilling, but the time is relatively long and the water quality will affect the stress levels of the fish.
31. Despite the omission of stunning farmed fish before slaughter in EU and UK welfare legislation, it is important to recognise that humane stunning methods are widely employed by the UK aquaculture industry due to the good uptake of industry-led codes of practice and assurance scheme standards to protect fish welfare at slaughter.

Cleaner fish

32. The welfare of cleaner fish should also be considered as part of the overall picture of fish welfare at slaughter. A large number of cleaner fish, principally Lumpfish and Ballan Wrasse, are now being farmed to provide ectoparasite control on salmon farms. These cleaner fish are not slaughtered to enter the food chain. Culling, at the end of their working lives, is generally by anaesthetic overdose via a bath (immerse fish until death), although percussive stunning of individuals is also practised. We consider these methods of culling to be humane.

¹⁰ https://aceaquatec.com/products/electric-stunning/?dyn=Humane%20Fish%20Slaughter&utm_term=fish%20slaughter&utm_campaign=Electric+Stunning+-+English+SRCH&utm_source=adwords&utm_medium=ppc&hsa_acc=1233039888&hsa_cam=12796656855&hsa_grp=121370774396&hsa_ad=515953705197&hsa_src=g&hsa_tgt=kwd-1233593538138&hsa_kw=fish%20slaughter&hsa_mt=p&hsa_net=adwords&hsa_ver=3&qclid=EAlaQobChMIwIPTIbie8glVVe7tCh10VwP8EAAYASAAEgJm8_D_BwE

¹¹ <https://www.smith-root.com/aquaculture/humane-fish-harvester>

¹² FAWC, 2014. Opinion on the welfare of farmed fish at the time of killing. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/319331/Opinion_on_the_welfare_of_farmed_fish_at_the_time_of_killing.pdf

33. However, it is important to note that research by Readman et al (2013)¹³ concluded that tricaine (MS222) and benzocaine were aversive to adult zebrafish, and that for ethical best practice, compounds that are aversive, even at low concentration, should no longer be used routinely for anaesthesia or indeed the first step of humane euthanasia of adult zebrafish. With this evidence in mind, it would be useful to review the impact of these anaesthetics on salmon, trout and cleaner fish, to assess how they are tolerated to inform anaesthetic protocols and euthanasia best practice going forward. As part of this, it will be important to recognise that current Cascade rules do not permit the use of anything other than tricaine and benzocaine in fish. Also see Schroeder P, Lloyd R, McKimm R, et al. (2021) [Anaesthesia of laboratory, aquaculture and ornamental fish: Proceedings of the first LASA-FVS Symposium](#).

Routine or production culling

34. With regard to culling, the 2014 FAWC Opinion states that:

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

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

35. We note that the main killing method for the culling of trout during the first grade is now overdose of anaesthetic due to the size of the fish.

Methods of killing fish for situations other than slaughter for human consumption

36. We note that “Table 6 Methods of killing fish for situations other than slaughter for human consumption” of the 2014 FAWC opinion makes no mention of the use of clove oil as a method of killing.

Commercially caught decapods and cephalopods

37. While we recognise that AWC is considering evidence relating to farmed fish, it is also paramount that the welfare of decapods and cephalopods at slaughter is given due consideration.
38. Evidence indicates that decapods (eg lobsters, crabs) and cephalopods (eg octopus, squid) are sentient, and experience pain and distress.^{14, 15, 16, 17, 18, 19, 20, 21} We therefore support the principle that commercially caught decapods and cephalopods should be stunned before

¹³ Readman GD, Owen SF, Murrell JC, Knowles TG. Do fish perceive anaesthetics as aversive? PLoS One. 2013 Sep 23;8(9):e73773. doi: 10.1371/journal.pone.0073773. PMID: 24086294; PMCID: PMC3781131.

¹⁴ European Food Safety Authority, 2005. [EFSA “Opinion on the “Aspects of the biology and welfare of animals used for experimental and other scientific purposes”](#) Available at:

https://ec.europa.eu/environment/chemicals/lab_animals/pdf/efsa_opinion.pdf

¹⁵ Barr, S., Laming, P. R., Dick, J. T. A., & Elwood, R. W., 2008. Nociception or pain in a decapod crustacean? *Animal Behaviour*, 75(3), 745–751.

¹⁶ Elwood, R. W., 2012. Evidence for pain in decapod crustaceans. *Animal Welfare*, 21(1), 23–27.

¹⁷ Elwood, R. W., & Appel, M., 2009. Pain experience in hermit crabs? *Animal Behaviour*, 77(5), 1243–12

¹⁸ Magee, B., & Elwood, R. W., 2013. Shock avoidance by discrimination learning in the shore crab (*Carcinus maenas*) is consistent with a key criterion for pain. *Journal of Experimental Biology*, 216 (3), 353–358.

¹⁹ Magee, B., & Elwood, R. W., 2016. Trade-offs between predator avoidance and electric shock avoidance in hermit crabs demonstrate a non-reflexive response to noxious stimuli consistent with prediction of pain. *Behavioural Processes*, 130, 31–35.

²⁰ Sneddon, L. U., 2004. Evolution of nociception in vertebrates: Comparative analysis of lower vertebrates. *Brain Research Reviews*, 46 (2), 123–130

²¹ Sneddon, L. U., 2015. Pain in aquatic animals. *The Journal of experimental biology*, 218 (7), 967–976.

slaughter.

39. At present, EC Regulation 1099/2009 and UK Welfare of Animals at the Time of Killing regulations do not cover decapods or cephalopods. It is therefore legal to slaughter these animals (particularly decapods) without first rendering them insensible to pain and with methods that are likely to cause pain and suffering^{22,23}. Such methods include:
- Placing live decapods in cold water and heating the water to boiling point.
 - Placing live decapods into hot or boiling water.
 - Placing live marine decapods in fresh water and drowning
 - Live carving and dismemberment
40. Electrical stunning of decapods may represent an effective, humane and commercially viable option for stunning decapods in restaurants or commercial slaughter processing plants. Scientific evidence suggests that electrical stunning is an effective stunning method^{24,25,26, 27}; however, we note that further research on electrical methods is needed to indicate the minimum effective parameters for different types and sizes of decapods.
41. We would also welcome the development of effective, humane and commercially viable methods of stunning cephalopods before slaughter. We are aware that the [Humane Slaughter Association \(HSA\) is making over £1.7 million available to support scientific research to improve the welfare of farmed finfish, decapod crustaceans and/or cephalopods during slaughter](#), and look forward to the results of this research.

Wild-caught fish in commercial fisheries

42. While we recognise that AWC is considering evidence relating to farmed fish, it is important to emphasise that at present, EC Regulation 1099/2009 and UK Welfare of Animals at the Time of Killing regulations do not cover wild-caught fish in commercial fisheries. It is therefore legal to leave a significant period between capture and slaughter, which can result in unnecessary suffering.
43. Evidence indicates that wild-caught fish (cod, haddock, dab, plaice) may remain conscious and therefore experience significant suffering for long periods during on-board storage.²⁸ As sentient animals, like farmed fish, we support the principle that wild-caught fish in commercial fisheries should be stunned and immediately slaughtered as soon as possible after capture.
44. To achieve this, there should be further research to develop effective, humane and commercially viable methods of stunning for wild-caught fish.

²² In 2005 the [EFSA “Opinion on the “Aspects of the biology and welfare of animals used for experimental and other scientific purposes”](#) identified these methods as ‘likely to cause pain and distress’ to decapods and cephalopods.

²³ Roth, B., & Øines, S., 2010. Stunning and killing of edible crabs (*Cancer pagurus*). *Animal Welfare*, 19(3), 287-294.

²⁴ Albalat, A., Gornik, S., Theethakaew, C., & Neil, D., 2008. Evaluation of the quality of Langoustines after being killed by the Crustastun. *University of Glasgow*. Available at: <http://eprints.gla.ac.uk/81427/>

²⁵ Fregin, T., & Bickmeyer, U., 2016. Electrophysiological investigation of different methods of anesthesia in lobster and crayfish. *PloS one*, 11(9), e0162894.

²⁶ Neil, D., 2010. The effect of the Crustastun on nerve activity in crabs and lobsters. Available at: <http://eprints.gla.ac.uk/81428/>

²⁷ Roth, B., & Grimsbø, E., 2013. Electrical Stunning of Edible Crabs. Available at: <https://www.nofima.no/filearchive/Rapport%2018-2013.pdf>,

²⁸ E. Lambooi, H. Digre, H.G.M. Reimert, I.G. Aursand, L. Grimsmo, J.W. van de Vis., 2012. Effects of on-board storage and electrical stunning of wild cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) on brain and heart activity, *Fisheries Research*, Volumes 127–128, 2012, pp. 1-8. Available at: <https://doi.org/10.1016/j.fishres.2012.04.004>.

45. We note that existing research suggests that cod and haddock can be humanely killed with a 52 V_{RMS} dry stun lasting over 3 seconds and followed immediately by bleeding, and dab and plaice can be humanely killed with a longer dry stun (15 seconds) followed immediately by normal slaughter processing (bleeding and then chilling).²⁹
46. In addition, [HSA has recently commissioned a Systematic Review and Feasibility Study into Stunning or Killing of Wild-Caught Fish in Commercial Fisheries](#) and we look forward to seeing the results of this review. The aim of this research is to investigate the feasibility of the development and use of methods of humane stunning or stun/killing for wild-caught fish in order to minimise pain or distress in wild-capture commercial fisheries.

²⁹ E. Lambooj, H. Digre, H.G.M. Reimert, I.G. Aursand, L. Grimsmo, J.W. van de Vis,, 2012. Effects of on-board storage and electrical stunning of wild cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) on brain and heart activity, Fisheries Research, Volumes 127–128, 2012, pp. 1-8. Available at: <https://doi.org/10.1016/j.fishres.2012.04.004>.