Expert opinion consultation – weighting routes of disease introduction to and spread from salmonid freshwater finfish farms in England and Wales

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Contents

1 Executive summary

An expert consultation exercise was conducted to elicit information to support the weighting of different routes of introduction and spread used by the farm risk ranking model applied by the Fish Health Inspectorate (FHI). In this exercise we were interested in the relative importance of routes for the spread of notifiable salmonid pathogens not present in the UK, i.e. viral haemorrhagic septicaemia virus (VHSV), infectious haematopoietic necrosis virus (IHNV) and *Gyrodactylus salaris* (Gs).

A questionnaire was developed by Cefas epidemiologists (in collaboration with the FHI) and presented to fish farmers, fish health inspectors and other fish health experts through a series meetings. In addition, key researchers (both within and outside of Cefas), fish vets and other health advisors with a working knowledge of the UK salmonid industry were approached directly and asked to complete the questionnaire electronically. The questionnaire focused on the spread of a pathogen once established (and before detection). Routes of introduction and spread were grouped by category: i) mechanical, ii) water-borne and iii) live fish and egg introduction. The importance of routes within each category were assessed and then the groups of routes were compared. The questions were not pathogen specific so participants were asked to identify if there were specific routes which were more important for one exotic pathogen compared with others.

The total number of respondents was 25, 5 of these were fish farmers the remaining 15 were grouped as aquatic animal health (AAH) experts. The scores of the AAH professionals and farmers were broadly similar for ranking routes within categories and for ranking between categories, therefore pooled results of both groups may be used to inform the farm risk ranking model. Routes which involved the introduction of fish (alive or dead) or fish waste were considered to be most important for pathogen introduction and spread. Both groups considered routes involving vehicles entering the farm to be most important for mechanical transmission. Upstream farms and processing of fish upstream were seen as the most important routes for exposure via water. One of the key differences between the two groups was their opinion on the effectiveness of mitigation measures; particularly for mechanical routes (fish farmers were more cautious about the impact of mitigation than AAH professionals). The importance of routes for VHS and IHN were generally considered to be similar. A greater focus was given to mechanical routes (including animal predators), water movements and the risks posed by fisheries and wild fish for Gs.

We recommend that future research should be directed at evaluating the importance of routes for which the farm risk ranking model is most sensitive. A sensitivity analysis would allow us to determine how the categorisation of farms near threshold values may change as the weighting of routes varies.

2 Introduction

European legislation (EC directive 2006/88) requires that fish farms are ranked based on the risk of disease introduction and spread as part of a risk-based surveillance system (RBS). The principle of RBS is that more resources are directed towards high risk geographic zones, types of farms and animal strata (Stärk et al., 2006). This should ensure the most efficient use of resources and maximise the confidence in disease freedom generated by the outputs of the system.

A risk ranking model which takes into account the relative importance of the most important routes of pathogen introduction and spread has been developed by Cefas (Oidtmann et al., accepted for publication). The model includes the capacity to weight the importance of the different routes of introduction and spread. However, very little evidence exists on which to base the weighting. In the absence of evidence, expert opinion has been used in aquatic animal health (Gustafson et al., 2005; Gustafson et al., 2010; Panel and Working, 2010).

We have therefore consulted with fish farmers, vets and others providing animal health services to fish farmers. In this exercise we are interested in the relative importance of routes for the spread of notifiable salmonid pathogens not present in the UK, i.e. viral haemorrhagic septicaemia virus (VHSV), infectious haematopoietic necrosis virus (IHNV) and *Gyrodactylus salaris* (Gs).

3 Materials and methods

3.1 Questionnaire development

The questionnaire (Appendix 1) was developed by Cefas epidemiologists in consultation with the Fish Health Inspectorate (FHI). It was designed to support the choice of weightings in the fish farm risk ranking model as currently implemented by the FHI. The model was developed under a project to implement the new fish health directive following a series of workshops organised within the UK and at European meetings (Oidtmann et al, submitted for publication). For the current study, routes were grouped by category: i) mechanical, ii) water-borne and iii) live fish and egg introduction. The importance of routes within each category were assessed and then the groups of routes were compared. Mechanical routes were first scored as though there were no measures in place to reduce the risk. Secondly, a reduced score due to risk mitigation measures (as currently practised in England and Wales) was given.

The questionnaire was trialled by two inspectors. Following comments from the inspectors changes to the questionnaire were made. The questionnaire mainly explored spread of an exotic pathogen after introduction but before detection. Participants were asked to use their understanding of current practices in salmonid farming in England and Wales in answering the questions.

The format of the scoring was the allocation of 100 points between the routes under consideration to reflect their relative importance. The importance of a route can be considered as having two elements. Firstly at a national level; how common is the route (e.g. the proportion of farms that buy in live fish). Secondly, if the route is present the likelihood that it results in pathogen introduction. This exercise focused on the second part (data on the presence or absence of routes for each farm has been collected from existing data and at farm visits). Thus it was made clear to participants that in their choice of scores they should assume that all farms are exposed via all routes.

The questions were not pathogen specific so participants were asked to identify if there were specific routes which were more important for one exotic pathogen compared with others. The questionnaire focused on the spread of a pathogen once established (and before detection). A free text question on the importance of routes of exotic disease introduction was asked towards the end of the questionnaire.

3.2 Farmers' meeting

The questionnaire was presented to a meeting of fish farmers at the AGM of the British Trout Association (BTA). There were approximately 30 fish farmers in the audience. Everyone at the meeting was given a copy of the questionnaire which was discussed question by question. Time was allowed for discussion.

3.3 Fish Health Inspectorate meeting

The questionnaire was presented to a meeting of the FHI. There were 12 fish health inspectors in the audience. Everyone at the meeting was given a copy of the questionnaire which was discussed question by question. Time was allowed for discussion.

3.4 Other fish health professionals

A number of key researchers (both within and outside of Cefas), fish vets and other health advisors with a working knowledge of the UK salmonid industry were also approached directly and asked to complete the questionnaire electronically.

4 Participants

The total number of submissions was 25, of these only 5 were fish farmers, the rest were those surveyed in Cefas and other external respondents including fish health inspectors, epidemiologists, disease experts and other staff working in aquatic animal health (collectively referred to as aquatic animal health (AAH) experts). Fish farmers' experience ranged from 10 to 36 years in the profession, while the AAH professionals ranged from 3 to 34 years. Four AAH professionals stated former Fish Farming experience. The primary species farmed by the current fish farmers was rainbow trout (3 out of the 5) with brown trout also listed in 3 out of the 5 farm submissions. Brown trout production was mainly for restocking.

5 Results

5.1 Pathogen introduction: Mechanical routes of introduction

In this section routes that may introduce the pathogen onto a farm via contamination, i.e. mechanical routes (e.g. on a vehicle) are compared (Table 1).

Table 1 Mechanical routes of pathogen introduction scores (AAH professionals) (n=20)

Route (mitigation method in parentheses)	**No mitigation**			**reduction with mitigation (of mean)**
	mean	**min**	**max**	**%**
1. Vehicles delivering live fish (i.e. contamination of the vehicle) **(cleaning and disinfection)**	22	3	70	58
2. Other vehicles entering site (e.g. delivering feed, collecting carcasses) **(cleaning and disinfection)**	11	3	20	56
3. Farm's vehicles used to deliver fish for other farms **(cleaning and disinfection)**	16	5	25	63
4. Avian predators **(bird netting in place and well maintained)**	6	0	20	45
5. Mammalian predators (e.g. otters) (**measures to prevent entry in place**)	5	0	16	44
6. Staff working on other fish farms **(different clothing and boots used)**	11	4	20	70
7. Sharing (or purchase) of equipment with (from) other farms **(cleaning and disinfection)**	14	2	25	66
8. General public [1] visiting the farm (e.g. shop, feed fish, footpaths) **(footbaths used)**	3	0	13	54
9. Salmonid fishery on site **(angling gear cleaned & disinfected)**	12	0	25	58

[1] excluding anglers (accounted for in route 9)

Table 2 Mechanical routes of pathogen introduction scores (Fish Farmers) (n=5)

Route (mitigation method in parentheses)	**No mitigation**			**reduction with mitigation (of mean)**
	mean	**min**	**max**	**%**
1. Vehicles delivering live fish (i.e. contamination of the vehicle) **(cleaning and disinfection)**	17	5	40	15
2. Other vehicles entering site (e.g. delivering feed, collecting carcasses) **(cleaning and disinfection)**	8	5	10	32.5
3. Farm's vehicles used to deliver fish for other farms **(cleaning and disinfection)**	17	10	40	27
4. Avian predators **(bird netting in place and well maintained)**	6	0	10	53
5. Mammalian predators (e.g. otters) (**measures to prevent entry in place**)	5	0	10	60
6. Staff working on other fish farms **(different clothing and boots used)**	18	5	30	61
7. Sharing (or purchase) of equipment with (from) other farms **(cleaning and disinfection)**	16	0	30	63
8. General public [1] visiting the farm (e.g. shop, feed fish, footpaths) **(footbaths used)**	5	0	10	52
9. Salmonid fishery on site **(angling gear cleaned & disinfected)**	8	5	10	33

[1] excluding anglers (accounted for in route 9)

The scores of the AAH professionals and farmers were broadly similar. Both groups considered vehicles delivering live fish and the farm's vehicles delivering fish for others to be the most important route. However, there was a large variation in weight given to the importance of vehicles delivering live fish in both groups. The AAH professional gave more weight to the presence of a fishery on site, whilst farmers more heavily weighted staff working on other sites. AAH professionals considered that mitigation reduced risk by between 44 and 70% (depending on the route). The farmers were more cautious about the impact of mitigation, especially cleaning and disinfection of vehicles (routes 1-3) and angling gear (route 9). Overall AAH professionals considered that mitigation measures reduced risk by 57% compared to a 44% reduction estimated by farmers.

5.2 Pathogen Introduction via water

Pathogens may enter a farm via untreated river water. In this section we compare the importance of sources of infection for exposure via water, which are listed in Table 3.

Table 3 Sources of infection for introduction via water (AAH professional) (n=20)

Source	Score		
	mean	min	max
1. upstream farms holding susceptible species	31	15	70
2. downstream farms holding susceptible species	10	4	20
3. processing of fish upstream (with untreated waste water discharge into the river)	27	8	40
4. wild susceptible species in river upstream	9	3	15
5. flooding (farms in EA flood zones are at risk of flooding)	9	0	25
6. stocking of hatchery reared fish upstream	16	2	30

Table 4 Sources of infection for introduction via water (Fish Farmers) (n=5)

Source	Score		
	mean	min	max
1. upstream farms holding susceptible species	27	20	30
2. downstream farms holding susceptible species	13	0	20
3. processing of fish upstream (with untreated waste water discharge into the river)	25	15	30
4. wild susceptible species in river upstream	7	0	15
5. flooding (farms in EA flood zones are at risk of flooding)	10	5	20
6. stocking of hatchery reared fish upstream	18	10	40

The weightings given by the two groups are very similar. Both groups identify upstream farms (route 1) and processing of fish upstream (3) as the main routes (followed by stocking of hatchery reared fish (6)). There was greater variation in the AAH professional scores but

this may be explained by the greater sample size. The route were there was greatest variation in scoring was upstream farms holding susceptible species (1).

6 Live fish and egg introductions

The relative risk of a consignment of live fish or eggs (disinfected or not disinfected) is compared in Table 5 and Table 6.

Table 5 Live fish and egg introductions (AAH professionals) (n=20)

Consignment	**Score**		
	mean	min	max
1. Consignment of live fish	67	40	95
2. Consignment of eggs – not disinfected	23	4	45
3. Consignment of eggs – disinfected	10	1	30

Table 6 Live fish and egg introductions (Fish Farmers) (n=5)

Consignment	**Score**		
	mean	min	max
1. Consignment of live fish	62	60	70
2. Consignment of eggs – not disinfected	28	20	30
3. Consignment of eggs – disinfected	10	10	10

The agreement in the weightings between the two groups was high. A consignment of live fish was considered 2.5 – 3 times more likely to introduce a pathogen than undisinfected eggs, which were 2-3 times more likely to introduce a pathogen than disinfected eggs.

7 Comparison of groups of routes of introduction

The relative importance of groups of routes were compared (Table 7): i) mechanical routes, ii) exposure via water, iii) live fish and egg introductions (already discussed) and two additional routes: i) introduction of fish waste from other farms for composting and ensiling and ii) processing of bought in fish (alive or dead) in close proximity to the fish rearing units. Fishery on site was excluded from mechanical routes and scored separately.

Table 7 Comparison of groups of routes of pathogen introduction (AAH professionals) (n=20)

Routes of introduction	**Score**		
	mean	Min	max
1. Mechanical routes (as listed in Table 1 – excluding fishery on site)[1]	11	2	40
2. Fishery on site[1]	6	1	10
3. Introduction via water (sources listed in Table 3)	14	3	30
4. Live fish and egg introductions	38	10	70
5. Fish waste introduced for composting or ensiling	12	5	25
6. Processing of brought in fish (live or dead fish) on site	19	10	30

[1]Assuming measures in place to reduce risk as they currently exist on salmonid farms in England and Wales

Table 8 Comparison of groups of routes of pathogen introduction (Fish Farmers) (n=5)

Routes of introduction	**Score**		
	mean	min	max
1. Mechanical routes (as listed in Table 1 – excluding fishery on site)[1]	12	3	20
2. Fishery on site[1]	6	3	10
3. Introduction via water (sources listed in Table 3)	19	3	30
4. Live fish and egg introductions	42	30	90
5. Fish waste introduced for composting or ensiling	8	0	10
6. Processing of brought in fish (live or dead fish) on site	14	1	20

[1]Assuming measures in place to reduce risk as they currently exist on salmonid farms in England and Wales

Again the results for the comparison of route of pathogen introduction are very similar for both groups. Forty percent of introductions were attributed to live fish and eggs. However, there was a large variation in the scores given to this route. No other route was given a mean weighting greater than 20%. Of the other routes, processing of fish for consumption (6) or fish waste (for composting or ensiling) (5) was given a slightly higher weighting by AAH professionals, compared with the farmer group.

8 Pathogen Spread

The same routes by which a pathogen may be introduced into a farm may also lead to spread from a farm, and their relative importance was scored (Table 9). The main difference between introduction and spread lay in the routes associated with water. The sources of infection which may result in pathogen introduction via water are listed in Table 3 (and these were scored). For pathogen spread flooding was separated out and scored at the group level. Effluent from fish farming was scored separately to effluent from fish processing on site.

Table 9 Comparison of groups of routes of pathogen spread from an infected farm (AAH professionals) (n=20)

Routes of spread	**Score**		
	mean	min	max
1. Mechanical routes (listed in Table 1 but excluding fishery on site) [1]	12	2	50
2. Fishery on site[1]	5	0	10
3. Live fish and egg movements	41	10	70
4. Fish processing on site (and untreated waste water discharged into river)	12	0	25
5. Flooding (farm in EA flood zone)	6	0	25
6. Untreated farm effluent water discharged into river	14	5	25
7. Waste moved to other farms	11	4	20

[1]Assuming measures in place to reduce risk as they currently exist on salmonid farms in England and Wales

Table 10 Comparison of groups of routes of pathogen spread from an infected farm (Fish Farmers) (n=5)

Routes of spread	**Score**		
	mean	min	max
1. Mechanical routes (listed in Table 1 but excluding fishery on site) [1]	13	5	30
2. Fishery on site[1]	4	0	5
3. Live fish and egg movements	49	25	90
4. Fish processing on site (and untreated waste water discharged into river)	14	0	30
5. Flooding (farm in EA flood zone)	5	0	10
6. Untreated farm effluent water discharged into river	13	0	25
7. Waste moved to other farms	2	0	10

[1]Assuming measures in place to reduce risk as they currently exist on salmonid farms in England and Wales

Once again there is broad agreement across the two groups of professions, movements of live fish and eggs are seen as the largest risks in pathogen spread, with fisheries and flooding the lowest. The main difference between the two groups was the weight given to the movement of waste to other farms, which was accorded a higher weight (11%) by AAH professional compared with farmers (2%).

9 Comparison between pathogens, first introduction and other routes

9.1 Importance of routes by pathogens

The questionnaire was not pathogen specific. Participants were therefore asked whether the importance of the routes of introduction and spread will be very different for viral haemorrhagic septicaemia virus (VHSV), infectious haematopoietic necrosis virus (IHNV) and *Gyrodactylus salaris* (Gs).

Fifteen of 20 AAH professionals considered that the importance of some routes varied between pathogens. Seventeen participants provided more information in the free text box provided (summarised in Table 11).

Table 11 Routes of particular importance for each pathogen

Pathogen	**Route**
VHSV	AAH Professionals noted – Live fish Movements and Waste and processing as the main routes of importance, the comments from fish farmers were concerning live fish movements and that VHS will not survive on eggs. A general comment that VHS and IHN will have similar routes of importance was also noted.
IHNV	The same routes were highlighted as for VHS in most cases, the only additions being that there is an increased risk with the introduction of eggs.
G. salaris (Gs)	Much more focus was given to mechanical routes including animal predators for Gs, as was water movements and the risks posed by fisheries and wild fish. It was noted that formalin treatment can be used to reduce the risk of introduction of Gs.

9.2 Other important routes of mechanical introduction

Other important routes of mechanical introduction mentioned by participants but not covered in the questionnaire include boating and anglers equipment (which was included in the questionnaire only with respect to having a fishery on a fish farm). The main routes noted related to watersports.

9.3 First introduction

A free text box was provided to allow participants to identify important routes of entry of exotic pathogens into the country in order of importance, given the current biosecurity measures (e.g. live fish must come from countries or zones of equivalent or higher health status). Twenty two out of the 25 participants provided information. A score for each route was calculated (rank 1 = 3 pts, rank 2 = 2 pts, rank 3= 1pt). The results are summarised in Table 12.

Table 12 Routes of introduction of exotic pathogens into the UK

Route	**Total score***
illegal fish movements	31
processing of fish products/waste	24
live egg introductions (legal)	19
ornamental fish introductions/imports	14
surveillance breakdowns	*11*
live fish introductions (legal)	10
mechanical processes (boats, angling equipment, etc)	9
transportation services (delivery lorries)	7
novel diseases – lack of regulation	*2*
predators	1

*sum of ranking points; *grey, italicised* entries are not routes of introduction

Illegally imported fish/eggs received more nominations and more in the Rank 1 category (8 mentions) this demonstrates the general concern across AAH professionals. Three fish farmers submitted data to this table – and none listed Illegal imports. The farmers' main concerns were live fish and egg introductions, product processing and mechanical introductions (boats, etc). This could suggest the slightly wider view taken by the AAH professionals with respect to future issues (such as Epizootic ulcerative syndrome (EUS)), illegal imports, and the possibility of breakdowns in the surveillance operations of other states. The results of this table are weighted more in the favour of the AAH professionals' view due to the number of submissions.

10 Other comments

Space was provided for participants to make any other comments. Below is a summary of the main points made.

'alternative route - Fish for processing from compartments with a lower heath status'

'All current biosecurity relies on the efficacy of other countries regulators and the honesty of suppliers. Overall improvement within the industry would be best driven if the results of ranking are publicly available. Farms need to know the risk ranking of potential suppliers and other farms on the same watercourse. If untreated fish processing waste is being discharged into rivers (Q4) then the FHI and the EA are completely failing to protect us!!'

'Surveillance should focus on those sites most likely to spread and not get as these are what will drive an epidemic, the others can be picked up through passive'

'Emerging diseases spreading faster than diagnostic capability can emerge and thus listing'

‘The route of introduction of pathogens should be heavily biased towards fish movements in very practical terms it's no use disinfecting a vehicle if the fish travelling in it are infected in the first place - however, a drive towards better biosecurity will reduce the risk of disease’

11 Discussion

The nature of this consultation was problematic. Participants were asked about the likely importance of routes for the spread of exotic pathogens; whilst the farmer- participants had first hand experience and knowledge of biosecurity on fish farms, the exercise required them to apply this information to a hypothetical situation (i.e. a pathogen has become established and is spreading undetected). It is possible that many participants did not feel well placed to make these abstract judgements. Arguably AAH professionals are more comfortable speculating based on their knowledge. Future expert elicitation exercises should be adapted to increase the level of participation of fish farmers and draw directly on their knowledge of diseases and the industry. In addition, future exercises should allow enough time for participants to complete the questionnaire during the session.

The key objective of the exercise was to generate an evidence base for the weighting of routes in the farm risk ranking model applied by the FHI. It was reassuring that the responses of the AAH professionals were in good agreement with the farmers. Thus we can use the pooled results of all participants to inform the model. There was agreement that vehicles entering the farm were the most important mechanical routes of transmission (3 routes accounted for almost 50% of the total score). Contact with other farms via staff or equipment was also rated highly (especially by the farmers). One of the key differences between the two groups was the effectiveness of mitigation measures, particularly disinfection of vehicles. It is possible that AAH professionals based their judgements more on the theoretical reduction in contamination that could be achieved whilst farmers used their knowledge of current practices. Water borne introduction of pathogens via processing, wild fish upstream and farms upstream with susceptible species were rated approximately equally and were allocated over 50% of the total score. At the group level, routes which involved the introduction of fish (alive or dead) or fish waste (routes 4-6) accounted for almost 70% of the total score.

We did not attempt to capture uncertainty for each participant in this exercise, in part because we considered the increased time taken to complete the questionnaire would not have been acceptable. Ideally participants would be asked to give the most likely, highest and lowest plausible values (pert distribution), and additionally the probability that the true value of the figure lies between the interval created (Speirs-Bridge et al., 2010). In this exercise variability was only captured in the variation between respondents as reported. In a Delphi consultation, variation between participants is reduced when scores are revised by each participant having seen aggregated responses. Uncertainty may result from true or stochastic variability or lack of knowledge, however these are difficult to separate (Vose,

2000). Stochastic variability is inherent in the biological system, thus in this case the importance of routes of spread will vary between outbreaks depending on the index farm or river, the time of year and chance events (e.g. mechanical transmission).

12 Recommendations

We recommend that the importance of the weighting for each route is further explored through sensitivity analysis. The output of the model is a risk score for each farm. These scores have no inherent meaning and can only be used to rank farms. Based on the farm ranking, farms are allocated a category (high, medium or low). Sensitivity analysis would allow us to determine how the categorisation of farms near threshold values may change as the weighting of routes varies. Future research could be directed at evaluating the importance of routes for which the model is most sensitive.

13 Acknowledgements

We gratefully acknowledge the assistance of the British Trout Association's participation in the study. We thank all participants for their time and patience. The input from Cefas colleagues, in particular Birgit Oidtmann, Kevin Denham, Paul Stebbing and Mike Gubbins is acknowledged.

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Appendix 1 Questionnaire

Expert opinion consultation – weighting routes of disease introduction to and spread from salmonid freshwater finfish farms in England and Wales

European legislation requires that fish farms are ranked based on the risk of disease introduction and spread. A risk ranking model which includes the most important routes has been developed which takes into account the relative importance of different routes. However, very little information exists on which to compare (i.e. weight) different routes. We therefore wish to consult with fish farmers, vets and others providing animal health services to fish farmers. In this exercise we are interested in routes for the spread of notifiable salmonid pathogens not represent in the UK, i.e. viral haemorrhagic septicaemia virus (VHSV), Infectious haematopoietic necrosis virus (IHNV) and *Gyrodactylus salaris* (Gs)

In Sections B and C below you are asked about routes of spread of an exotic salmonid disease after it has been introduced into England and Wales but before it has been detected (so no special measures have been taken to eliminate it or reduce its rate of spread, e.g. movement restrictions from suspected infected farms or rivers) and given current practices on salmonid farms in England and Wales

If you have any queries please contact Ed Peeler: ed.peeler@cefas.co.uk, tel 01305 206746 or Mark Thrush: mark.thrush@cefas.co.uk, tel 01305 206723.

Your details will be kept confidential. No individual responses will be disclosed. An analysis of all responses will be made available on the eFishBusiness (and BTA) websites and hard copies will be available on request.

The collaboration of the British Trout Association in this consultation is warmly acknowledged.

We are extremely grateful to you for taking the time to assist us in this work.

A. YOUR DETAILS

Profession (please circle)

What is your profession? (indicate with a X)	Fish farmer	
	aquatic animal health professional	
	other	

If other, please state _____

Years spent in profession _____

Other relevant experience _____

If farming,

Please list species farmed _____

_____

_____

What is the farm's main business (indicate with a X)	Table production	
	Restocking	
	Hatchery	
	Other	

What is the average annual production of fish (in metric tonnes)? _____

Name (optional): _____

Address & email (optional):

B. PATHOGEN INTRODUCTION

Section B concerns the introduction into a farm of a pathogen once it has been introduced to England and Wales but not detected, so <u>no controls</u> have been put in place.

1. Mechanical routes of introduction

In this section we want to compare only the routes that may introduce the pathogen onto a farm via contamination, i.e. mechanical routes (e.g. on a vehicle). Please compare the likelihood that the routes in Table 1 will introduce a pathogen by allocating a total of 100 points between the routes (i.e. assuming all routes are applicable to all farms, if you consider one route responsible for 25% of 'mechanical' introductions, allocate 25 points). Please score for routes as though there were no measures in place to reduce the risk. Secondly, can you estimate the impact of mitigation measures (**in bold**) as currently practised in England and Wales by revising the score (the total will not add up to 100)

Table 13 Mechanical routes of pathogen introduction

Route	No mitigation	With mitigation
10. Vehicles delivering live fish (i.e. contamination of the vehicle) **(cleaning and disinfection)**		
11. Other vehicles entering site (e.g. delivering feed, collecting carcasses) **(cleaning and disinfection)**		
12. Farm's vehicles used to deliver fish for other farms **(cleaning and disinfection)**		
13. Avian predators **(bird netting in place and well maintained)**		
14. Mammalian predators (e.g. otters) (**measures to prevent entry in place**)		
15. Staff working on other fish farms **(different clothing and boots used)**		
16. Sharing (or purchase) of equipment with (from) other farms **(cleaning and disinfection)**		
17. General public [1] visiting the farm (e.g. shop, feed fish, footpaths) **(footbaths used)**		
18. Salmonid fishery on site **(angling gear cleaned & disinfected)**		
Total	100	

[1] excluding anglers (accounted for in route 9)

2. Introduction via water

Pathogens may enter a farm via untreated river water. In this section we want to compare the importance of sources of infection for exposure via water, which are listed in Table 2. Please indicate the relative importance of these sources of infection by allocating a total of 100 points between the sources.

Table 14 Sources of infection for introduction via water

Source	**Score**
7. upstream farms holding susceptible species	
8. downstream farms holding susceptible species	
9. processing of fish upstream (with untreated waste water discharge into the river)	
10. wild susceptible species in river upstream	
11. flooding (farms in EA flood zones are at risk of flooding)	
12. stocking of hatchery reared fish upstream	
Total	**100**

3. Live fish and egg introductions

What is the difference in the likelihood of pathogen introduction with the purchase of live fish compared with eggs from an infected farm? In Table 3 please indicate the relative importance of the introduction a single consignment of live fish and eggs (disinfected and not disinfected) by distributing 100 points between each type of consignment.

Table 15 Live fish and egg introductions

Consignment	**Score**
4. Consignment of live fish	
5. Consignment of eggs – not disinfected	
6. Consignment of eggs – disinfected	
Total	**100**

4. Comparison of groups of routes of introduction

In sections 1-3 we have considered: mechanical routes (Table 1), exposure via water (Table 2), and live fish and egg introductions (Table 3).

In this section we want to compare the importance of these routes with two additional routes: i. introduction of fish waste from other farms for composting and ensiling and ii. processing of bought in fish (alive or dead) in close proximity to the fish rearing units.

Please compare routes 1-6 in Table 4 by distributing 100 points between the routes to reflect their relative importance (e.g. assuming all farms are exposed via all routes, if you think one route might be responsible for 25% of farms becoming infected, allocate 25 points). **Remember we are still concerned with introduction of a pathogen into a farm once the disease is in the country but not detected. Please base your response on your understanding of current practices in salmonid farming in England and Wales.**

Table 16 Comparison of groups of routes of pathogen introduction

Routes of introduction		**Score**
7.	Mechanical routes (as listed in Table 1 – excluding fishery on site)[1]	
8.	Fishery on site[1]	
9.	Introduction via water (sources listed in Table 2)	
10.	Live fish and egg introductions	
11.	Fish waste introduced for composting or ensiling	
12.	Processing of brought in fish (live or dead fish) on site	
	Total	100

[1]Assuming measures in place to reduce risk as they currently exist on salmonid farms in England and Wales

C. PATHOGEN SPREAD

Section C concerns the spread of the pathogen from an infected farm to an uninfected farm (or fishery). The pathogen has not been detected by the farmer and no special measures have been put in place to prevent its spread.

5. Comparison of groups of routes of spread

We need to also compare the importance of the routes of spread listed in Table 5.

Please score the relative importance of routes 1-7 in Table 7 by distributing 100 points between the routes (assuming a farm may spread via all routes listed, if one route might be responsible for 25% of spread, allocate 25 points). **Remember we are concerned with spread of a pathogen from an infected farm once the disease is in the country but not detected.**

Table 5 Comparison of groups of routes of pathogen spread from an infected farm

Routes of spread	**Score**
8. Mechanical routes (listed in Table 1 but excluding fishery on site) [1]	
9. Fishery on site[1]	
10. Live fish and egg movements	
11. Fish processing on site (and untreated waste water discharged into river)	
12. Flooding (farm in EA flood zone)	
13. Untreated farm effluent water discharged into river	
14. Waste moved to other farms	
Total	**100**

[1]Assuming measures in place to reduce risk as they currently exist on salmonid farms in England and Wales

D. COMPARISON BETWEEN PATHOGENS, FIRST INTRODUCTION AND OTHER ROUTES

6. Differences between pathogen

Do you think that the importance of the routes of introduction and spread will be very different for viral haemorrhagic septicaemia virus (VHSV), infectious haematopoietic necrosis virus (IHNV) and *Gyrodactylus salaris* (Gs).

Yes / No

If yes, can you indicate which routes should have additional weighting for each pathogen:

VHSV	IHNV	G.s.

7. Other routes

If you think that there are other important mechanical routes of pathogen introduction or spread that have not been covered please describe in the box below.

8. First introduction

In this section can you list what you think are the 3 most important routes of entry of exotic pathogens into the country in order of importance, **given the current biosecurity measures (e.g. live fish must come from countries or zones of the same health status).** Please indicate if you think any of the routes are particularly important for a specific pathogen (i.e. VHSV, IHNV and *G. salaris*).

	Route
1	
2	
3	

E. OTHER COMMENTS

Feel free to use the space below and overleaf to comment on this consultation or make any further remarks on routes of disease introduction and spread.