A model for risk ranking fish farms to inform disease risk-based surveillance

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Introduction

Until recently, fish farms involved in disease surveillance programmes in the EU have been visited and samples collected following a prescribed, non-risk based approach. The recent European Council Directive 2006/88/EC on aquatic animal health requires that risk-based animal health surveillance is applied to each aquaculture production business (APB) in the EU. The frequency of visits should take account of the likelihood that the fish farm contracts and spreads disease and this requires an assessment to be made of the level of risk applying to each APB. To assist in making such assessments, we have developed a model for risk ranking of fish farms that can also be applied to a large range of other types of APBs.

Risk factors

Through stakeholder consultation and assessment by aquatic animal disease experts and epidemiologists, we have identified a range of risk factor themes (Table 1):

Table 1: Risk factor themes

1	Live fish movements on /off site
2	Exposure via water
3	On site processing
4	Biosecurity
5	Management practices
6	Geographical factors
7	Mechanical transmission
8	Other routes

Some of these risk factor themes are more amenable to quantification than others. Risk of introduction associated with live fish movements is an example of a theme that can be readily assessed.
We suggest how the information regarding the various risk factors can be assessed and combined to achieve risk scores for introduction and spread. For the purpose of demonstrating the model, only the first two themes are presented in their application. One or more of the other themes will need to be taken into account to calculate the overall risk scores.
A fish farm can only be at risk of becoming infected, if the farm is free from the disease. Therefore, our scheme only applies to fish farms free from infection.
To allow some degree of quantification of risk against a denominator, we assessed the risk of the farm becoming infected or spreading disease for the period of 1 year.

Box 3: Factors influencing the likelihood that movements from a single supplier result in transmission are considered to be:

- time between pathogen introduction and detection on a supplying farm (time in which movements of infected fish may occur)
- frequency of movements
- seasonality of movements
- probability that a single movement will result in transmission, which depends on tank level prevalence in the population at the supplying farm, fish level prevalence at the supplying farm, etc.

Risk factor “Live fish movements”

The likelihood of a farm becoming infected due to live fish movements (LFM) largely depends on the disease status of the source farms.
Under Directive 2006/88/EC, movements of fish onto a site declared free from listed diseases can only originate from farms of equivalent status. This implies that there is no risk associated with such LFMs. However, fish farms may become infected through various routes and may (until the infection is detected) supply farms declared disease free with infected fish. The risk associated with live fish movements is therefore clearly not equal to zero.
The number of fish suppliers a given farm is using is the main factor for assessing the risk associated with live fish movements onto a site (Box 1):

Box 1 Calculation of risk of becoming infected associated with LFM within 1 year

$Risk_{(LFM\ on)}$ = probability of any supplying farm being infected
x number of suppliers

The probability of any given farm being infected is based on historic information (Box 2).

Box 2: Calculation of probability of suppliers being infected

Number of fish farms in country A	= 250
Number of fish farms that have become infected with pathogen x over the past 20 years	= 1

The risk of any one of the 250 farms being infected within a year is therefore:

$$1 \times 250^{-1} \times 20^{-1} = 0.02\%$$

The risk for a farm becoming infected depends on the number of suppliers and the movements from each supplier.
A number of factors influence the likelihood that the movements from a single supplier result in transmission (Box 3). These factors can all be built into a model. However, for demonstration purposes here, we have assumed that a single movement of live fish from an infected supplier is sufficient for transmission. Based on this assumption, an example showing how to calculate the overall risk of a farm becoming infected due to live fish movements is presented in Box 4.

Box 4: Calculation of risk of becoming infected within 1 year via live fish movements - example farm B

Number of suppliers of farm B within a year = 10
All suppliers are located within country A (see box 2 for calculation of probability of suppliers being infected).

$Risk_{(LFM\ on)}$ = 0.02% x 10 = 0.2% $year^{-1}$

The calculation can easily be adapted if the information regarding the probability of infection of the farms within a country changes.
The example illustrates how the risk can be easily calculated for domestic live fish movements.
The model can also easily be expanded to account for suppliers from abroad; the probability of farm breakdowns in a given country C will need to be entered into the calculation.

Risk factor “Exposure via water”

A farm will be at risk from becoming infected via water, if the farm is sourcing water from a river, particularly if there are other fish farms present upstream.
If all farms upstream are also declared free from disease x, the likelihood of any of the upstream farms being infected is as shown under risk factor “Live fish movements onto site”. However, the likelihood that the disease is spread from an infected upstream farm to our example farm B will not be equal to one. The likelihood of farm B becoming infected depends on a number of factors, such as the amount of pathogen released from the infected farm upstream, dilution of the pathogen, distance from upstream farm, duration of pathogen release, etc.
For the purposes of illustration (Box 5), we have assumed that the likelihood of downstream spread from an infected farm in a period of a year is 0.25.

Box 5: Calculation of the risk of becoming infected from upstream farms within a year

$Risk_{(upstream\ fish\ farms)}$ =
probability of any upstream farms being infected
x number of upstream farms
x 0.25 (probability of downstream spread)

Box 6: Calculation of risk of becoming infected in 1 year associated with presence of upstream farms – Example: farm B

Number of upstream farms. = 10

see Box 2 for calculation of probability of upstream farms being infected

$Risk_{(upstream\ fish\ farms)}$ =
0.02% x 10 x 0.25 = 0.05% $year^{-1}$

Combining risk of becoming infected

Risk scores calculated for live fish movements and upstream risks can easily be combined to an overall score, since they use the same denominator (probability x $year^{-1}$):

Overall risk of becoming infected
= $Risk_{(LFM\ on)}$ + $Risk_{(upstream\ fish\ farms)}$ + $Risk_C$ + $Risk_D$

Continuing with our example farm B, the overall risk of becoming infected based on live fish movements and upstream risks = 0.2% + 0.05% = 0.25% $year^{-1}$

A method for combining risk for becoming infected and risk of spreading disease has been proposed under guidelines provided by European Commission Decision 2008/896/EC. However, the competent authority of a country may use the information on risk of contracting disease and spread separately to focus surveillance efforts depending on whether the main concern is to detect infection as early as possible or to prevent spread, which they are entitled to do provided they meet surveillance requirements specified under EU Directive 2006/88.

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Summary and conclusions

- A quantitative model is presented to rank farms within a country with regards to the risk of becoming infected or spreading disease
- The unit used to assess risk in the various risk factor themes is the “risk of becoming infected / spreading disease within 1 year”
- By using a common unit of measurement, risk estimates for Aquaculture Production Businesses become comparable and meaningful
- The score calculated for a farm may not represent an accurate estimate of the true likelihood of introduction or spread of disease. However, it is sufficient for the purpose of risk ranking farms to provide a means to allocate resources for surveillance
- The model provides fish farms with information of how they can reduce their risk score by avoiding activities that involve a risk of becoming infected or spreading.
- The likelihood estimates of any farm being infected within a country can be based on historic data, providing a meaningful basis for estimating likelihood. The country specific estimates can be updated as new information becomes available.
- We used the risk factors “Live fish movements onto site” and “Exposure via water” to illustrate how the principles of the model are applied.
- Some of the other risk themes are dependant on type of aquaculture business and criteria may need to be tailored to production type.