Risk analysis for import of lumpsucker *Cyclopterus lumpus* eggs

into Ireland from Norway, UK or Iceland.

1. **Identification of hazards:** identification of pathogens that: (a) are notifiable and/or (b) could potentially cause disease in farmed lumpfish *Cyclopterus lumpus* or in farmed Atlantic salmon *Salmo salar* in co-habitation with lumpfish.

1.1. Viruses:
- 1.1.1. Viral haemorrhagic septicaemia virus (VHSv)
- 1.1.2. Epizootic haematopoietic necrosis virus (EHNv)
- 1.1.3. Infectious salmon anaemia virus HPR deleted (ISAv-HPR deleted)
- 1.1.4. Infectious haematopoietic necrosis virus (IHNv)
- 1.1.5. Salmonid alphavirus (SAV)
- 1.1.6. Infectious pancreatic necrosis virus (IPNv)
- 1.1.7. Piscine reovirus (PRV)
- 1.1.8. Piscine myocarditis virus (PMCV)
- 1.1.9. Viral nervous necrosis virus (VNNv)
- 1.1.10. Novel viral infections of lumpfish

1.2. Bacteria:
- 1.2.1. *Piscirickettsia salmonis*
- 1.2.2. *Renibacterium salmoninarum*
- 1.2.3. *Aeromonas salmonicida* (atypical subspecies)
- 1.2.4. *Aeromonas salmonicida* (typical subspecies)
- 1.2.5. *Pasteurella* sp.
- 1.2.6. *Vibrio anguillarum*
- 1.2.7. *Vibrio ordalii*
- 1.2.8. *Vibrio salmonicida*
- 1.2.9. *Pseudomonas anguilliseptica*
- 1.2.10. *Tenacibaculum maritimum*
- 1.2.11. *Moritella viscosa*
- 1.2.12. *Francisella* spp.
- 1.2.13. *Mycobacterium* spp.
- 1.2.14. Novel bacterial infections of lumpfish

1.3. Parasites:
- 1.3.1. *Gyrodactylus salaris*
- 1.3.2. *Neoparamoeba perurans*
- 1.3.3. *Kudoa islandica*
- 1.3.4. *Myxobolus albi*

1.4. Fungi:
- 1.4.1. *Nucleospora cyclopteri*

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1.4.2. *Tetramicra brevifilum*
1.4.3. *Exophiala angulospora*
1.4.4. *Exophiala psychrophila*
1.4.5. *Ichthyophonus hoferi*

2. Risk of introduction and potential consequences:

2.1. Risk of introduction: estimation of the probability (i.e. likelihood) that a hazard will be introduced as a result of the importation of lumpfish eggs into Ireland from Norway, UK or Iceland.

Table 1: terms used to describe the probability of an event occurring (i.e. risk of introduction)

Scale for risk of introduction	
High	Event would be expected to occur
Moderate	There is a less than even chance of the event occurring
Low	Event would occur occasionally
Very low	Event would occur very rarely
Negligible	Chance of event occurring is so small it can be ignored.

2.2. Consequence assessment: identification of the nature of any adverse effects regarding animal health, national disease status or economic impact which may result from the introduction of the identified hazards.

Table 2: terms used to describe the significance of consequences

Scale for significance of consequences	
High	Associated with diseases that would have serious biological effects (e.g. high mortality or morbidity). Such effects would be expected to be felt for a prolonged period and would not be amenable to control measures. Such diseases would be expected to result in significant economic losses at an industry level, or they may cause serious harm to the environment.
Moderate	Associated with diseases that have less pronounced biological effects. Such effects may harm economic performance at an enterprise/regional level. These diseases may be amenable to control measures at a significant cost, or their effects may be temporary. They may affect the environment, but such harm would not be irreversible.
Low	Associated with diseases that have mild biological effects and would normally be amenable to control measures. Such diseases would be expected to harm economic performance at an enterprise/regional level. Effects on the environment would be minor or temporary.
Negligible	Associated with diseases that have no significant or only transient biological effects. Such diseases may be readily amenable to control measures. The

	economic effects would be low at an enterprise level and insignificant at a regional level. Effects on the environment would be insignificant.

3. **Risk estimation (RE):** overall risk is calculated from the combination of probability (i.e. risk of introduction) and consequence. The risk determined is the unrestricted estimate of risk (i.e. the risk based on the absence of risk management) associated with the hazards identified. Each hazard is considered separately in the risk evaluation.

*True vertical transmission refers to when the infection occurs inside the fertilised egg and subsequent offspring, in contrast to egg-associated transmission (i.e the pathogen is only present on the egg surface).

Table 3: risk estimation for the specific hazards identified.

Pathogen	Risk of introduction	Significance of consequences	Overall RE	Comments
Viruses				
***1.1.1 (VHSv)**	Moderate	High	Moderate	• Detected in lumpfish in Iceland. • Very rarely isolated from Atlantic salmon (susceptibility unclear). • Can affect RBT (present in RBT in Norway) and wrasse species (detected in wrasse in UK). • Vertical transmission unknown. • Notifiable.
***1.1.2 (EHNv)**	Negligible	High	Low	• Not present in Europe. • Not detected in lumpfish to date. • Can affect redfin perch and RBT (freshwater). • Atlantic salmon only infected experimentally. • Vertical transmission unlikely. • Notifiable
***1.1.3 (ISAv-HPR deleted)**	Very low	High	Low	• Present in Norway (AS). • Not detected in lumpfish to date. • Can affect Atlantic salmon. • Vertical transmission unlikely. • Notifiable.
***1.1.4 (IHNv)**	Negligible	High	Low	• Not present in Europe. • Not detected in lumpfish to date. • Can affect Atlantic salmon. • Vertical transmission suggested. • Notifiable.
1.1.5 (SAV)	Low	Low	Low	• Present in Ireland (AS and wild fish). • Not detected in lumpfish to date. • Can affect Atlantic salmon. • Vertical transmission unknown.
1.1.6 (IPNv)	Low	Moderate	Low	• Present in Ireland (AS). • Not detected in lumpfish to date. • Can affect Atlantic salmon. • Vertical transmission possible.
1.1.7 (PRV)	Low	Low	Low	• Present in Ireland (AS and possibly wild fish). • Not detected in lumpfish to date. • Can affect Atlantic salmon. • Vertical transmission unlikely.
1.1.8 (PMCV)	Low	Low	Low	• Present in Ireland (AS). • Not detected in lumpfish to date. • Can affect Atlantic salmon. • Vertical transmission unknown.
1.1.9 (VNNv)	Low	Moderate	Low	▪ Present in UK and Norway (halibut and cod). ▪ Not detected in lumpfish to date. ▪ Does not affect Atlantic salmon. ▪ Vertical transmission possible.

1.1.10 (Novel viruses)	Unknown	Unknown	Unknown	▪ Unknown
Bacteria				
1.2.1 *(P. salmonis)*	Moderate	Low	Low	▪ Detected in lumpfish in Ireland. ▪ Present in Ireland, Norway and UK (AS). ▪ Can affect Atlantic salmon. ▪ Vertical transmission possible.
1.2.2 *(R. salmoninarum)	Very low	High	Low	▪ Present in UK and Norway (AS and rainbow trout). ▪ Not detected in lumpfish to date. ▪ Can affect Atlantic salmon. ▪ Vertically transmitted. ▪ Notifiable.
1.2.3 *(A. salmonicida* atypical*)*	Very low	Low	Low	• Present in Ireland (wrasse and AS). • Detected in lumpfish in Norway and UK. • Can affect wrasse and AS. • Not vertically transmitted.
1.2.4 *(A. salmonicida* typical*)*				▪ Present in Ireland (AS). ▪ Rarely detected in lumpfish. ▪ Can affect Atlantic salmon. ▪ Not vertically transmitted.
1.2.5 *(Pasteurella* sp.*)*				▪ Detected in lumpfish in Norway. ▪ Unknown effect to Atlantic salmon. Related to *Pasteurella skyensis* (pathogen of AS). ▪ Not vertically transmitted.
1.2.6 (*V. anguillarum*)				• Present in Ireland (cod). • Detected in lumpfish in Norway and UK. • Can affect Atlantic salmon and wrasse. • Not vertically transmitted.
1.2.7 *(V. ordalii)*				• Detected in lumpfish in Norway. • Can affect Atlantic salmon. • Not vertically transmitted.
1.2.8 *(V. salmonicida)*				• Present in Ireland (AS). • Not detected in lumpfish to date. • Can affect Atlantic salmon. • Not vertically transmitted.
1.2.9 *(P. anguilliseptica)*				• Detected in lumpfish in Norway. • Can affect Atlantic salmon. • Not vertically transmitted.
1.2.10 *(T. maritimum)*				• Present in Ireland (AS). • Detected in lumpfish in Norway. • Can affect Atlantic salmon. • Not vertically transmitted.
1.2.11 *(M. viscosa)*				• Detected in lumpfish in Ireland. • Can affect Atlantic salmon. • Not vertically transmitted.

1.2.12 ***(Francisella* spp.)**	Low	Low	Low	• Present in Ireland (cod). • Not detected in lumpfish to date. • Does not affect Atlantic salmon. • Vertical transmission suggested.
1.2.13 ***(Mycobacterium* spp.)**	Low	Low	Low	• Present in Ireland (ornamental and wild fish). • Not detected in lumpfish to date. • Can affect Atlantic salmon. • Vertical transmission possible.
1.2.14 **(Novel bacteria)**	Unknown	Unknown	Unknown	▪ Unknown
Parasites				
1.3.1** ***(G. salaris)	Negligible	High	Low	▪ Present in Norway (AS). ▪ Only in freshwater - No threat to lumpfish or other marine species. ▪ Can affect Atlantic salmon in freshwater. ▪ Not vertically transmitted. ▪ Notifiable.
1.3.2 ***(N. perurans)***	Negligible	Low	Low	▪ Present in Ireland (AS). ▪ Detected in lumpfish in Norway and UK. ▪ Can affect Atlantic salmon. ▪ Not vertically transmitted.
1.3.3 ***(K. islandica)***	Negligible	Low	Low	▪ Detected in lumpfish in Norway. ▪ Does not affect Atlantic salmon. ▪ Not vertically transmitted.
1.3.4 ***(M. albi)***	Negligible	Low	Low	▪ Detected in lumpfish in Norway. ▪ Does not affect Atlantic salmon. ▪ Not vertically transmitted.
Fungi				
1.4.1 ***(N. cyclopteri)***	Low	Moderate	Low	▪ Detected in lumpfish in Iceland, Norway and UK. ▪ Does not affect Atlantic salmon. ▪ Vertical transmission unknown.
1.4.2 ***(T. brevifilum)***	Low	Low	Low	▪ Detected in lumpfish in Ireland. ▪ Does not affect Atlantic salmon. ▪ Vertical transmission unknown.
1.4.3 ***(E. angulospora)***	Low	Moderate	Low	▪ Detected in lumpfish in Ireland and UK. ▪ Does not affect Atlantic salmon. ▪ Vertical transmission unknown.
1.4.4 ***(E. psychrophila)***	Low	Moderate	Low	▪ Detected in lumpfish in Iceland. ▪ Does not affect Atlantic salmon. ▪ Vertical transmission unknown.
1.4.4 ***(I. hoferi)***	Low	Low	Low	▪ Present in Ireland (wild fish) ▪ Detected in lumpfish in Norway. ▪ Vertical transmission unknown.

AS = Atlantic salmon

RBT = Rainbow trout

* = notifiable disease

4. **Risk management:** implementation of sanitary measures to reduce the risks posed by the particular hazards to an acceptable level.

4.1. **Disease status of country of origin:**

- As a first step towards reducing the risk of disease transfer through lumpfish eggs these should be sourced from a hatchery or hatcheries which

  a) have a high health status, and

  b) screen for the pathogens of most concern (viruses and bacteria) on a regular basis.

  Certificates of testing of broodstock should be available with each batch of eggs with particular emphasis for screening on VHSV.

4.2. **Testing of pathogens:**

- Based on the conducted risk assessment the pathogen identified with a higher overall risk estimation is VHSv. Broodstock (wild-caught or farmed) should be tested as follows:
  - VHSv: PCR from kidney and heart samples (individual fish).
  - For novel/unknown viruses: inoculation of kidney, spleen and heart material into tissue culture cell lines: i.e. BF-2 (bluegill fry) and EPC (epithelial papilloma of carp) (maximum of 5 fish per pool).
  - For novel/unknown bacteria: inoculation of kidney material from loop/swab into bacteria culture media: i.e. tryptone soya agar (TSA), tryptone soya agar plus salt (TSASA), Columbia blood agar (BCA) and thiosulfate citrate bile salts sucrose agar (TCBS) (individual fish).
  - ISAv: PCR from kidney and heart samples (individual fish).
- Eggs from different females should be kept separately until test results are available. If any male or female broodstock test positive for any of the above tests/pathogens, their eggs/fertilised eggs should be discarded.
- Certificates of testing of broodstock should be available with each batch.
- In addition to the described testing, all broodstock showing signs of disease/lesion, etc. should be sampled for histology.
- PCR testing for VNNv, *Exophiala* spp. and *Nucleospora cyclopteri* is also suggested. It is unknown if lumpfish are susceptible to nodavirus, however, vertical transmission is possible in other species and it affects species such as Atlantic cod and halibut. The

potential for vertical transmission of *Exophiala* and *N. cyclopteri* is unknown but their effect on lumpfish stocks can be significant.

4.3. **Biosecurity measures and health management at importing facilities:**

- All imported eggs should be disinfected at origin and again at arrival.
- All imported eggs should be kept in isolation at arrival. Units must be isolated with respect to other egg units, fish tanks, equipment, feed and water supply lines. Ideally, all effluent and wastes generated by the quarantine unit should be treated in a manner that effectively destroys all pathogens.
- All equipment used should be thoroughly disinfected after use, and no equipment should be shared between eggs and other stages (juveniles/broodstock).
- Veterinary inspections should be carried out monthly (routine visits) and when morbidity or mortalities are observed (diagnostic visits).

4.4 **Movement of lumpfish eggs in Ireland after import**

- Following biosecurity measures as 4.3 eggs which are imported should not come in contact with other fish livestock, fish livestock products or wild caught fish during the holding period prior to delivery.
- Any staff involved in care and monitoring of eggs should adhere to best practice biosecurity (hygiene and disinfection).
- Records should be maintained of quantities of eggs arriving, source, certification as well as quantities dispatched, destination and method of delivery.
- No batches of eggs that exhibit fungal infection, or other abnormalities, should be transported.

It should be noted that this risk analysis, while qualitative, has been undertaken with reference to the available scientific literature and data from industry partners from Ireland, UK, Norway and Iceland. This risk analysis is based on the current state of our knowledge, however, lumpfish farming is very recent and therefore available information on pathogens affecting this species is scarce. Available information on the potential for vertical transmission of certain listed pathogens is also limited.

The risk assessment framework used here has been adapted from AQUIS (1999) and based on the guidelines for import risk analysis published by the World Organisation for Animal Health (Office International des Epizooties, O.I.E.) (O.I.E. 2015).

AQIS (Australian Quarantine and Inspection Service) (1999) Import risk analysis on non-viable salmonids and non-salmonid marine finfish. AusInfo, GPO Box 1920, Canberra ACT 2601.

O.I.E. (Office International des Epizooties) (2015) Section 2. Chapter 2.1. Risk analysis. Aquatic Animal Health Code, World Animal Health Organisation, Paris. http://www.oie.int/en/international-standard-setting/aquatic-code/access-online/

5.0 Summary and conclusions

The main pathogens that have presented disease problems for lumpfish are the bacterial diseases atypical furunculosis (*Aeromonas salmonicida*), vibriosis (*Vibrio anguillarum)*, *Pasteurella* sp. and amoebae (*N. perurans*).

i) Atypical furunculosis has been recorded in farmed salmon since farming began in Ireland, but has rarely been a significant clinical disease problem. The strains of atypical furunculosis affecting lumpfish are variants of the salmonid ones and have not been reported in salmon, as they appear to be host species specific. The risk therefore of species cross-over is considered low. *Aeromonas* sp. bacteria are not known to be vertically transmitted in disinfected eggs.

ii) Vibrio vaccines and high levels of farm husbandry have ensured that vibriosis has not been a concern in finfish aquaculture in Ireland for over 20 years. Vaccination of lumpfish prior to transfer to pens should assist in this being the case with lumpfish. Vaccinated salmonid susceptibility to vibriosis is low or insignificant. *Vibrio* sp. bacteria are not known to be vertically transmitted in disinfected eggs.

iii) *Pasteurella* sp. have not been isolated or observed in Ireland in farmed fish, and although *P. skyensis* has been observed in a low number of salmon sites in Scotland (with minimal clinical impact) it is not clear at the time of writing what the exact species of Pasteurella is that has caused problems in lumpfish in Norway. Routine bacteriology of lumpfish broodfish as suggested should detect infected fish and eggs from these fish should not be used. *Pasteurella* sp. bacteria are not known to be vertically transmitted in disinfected eggs.

iv) *N. perurans,* the causal agent of amoebic gill disease, is endemic in Ireland in farmed salmon and has also been detected in lumpfish in Norway and Scotland. There is no evidence to indicate vertical transmission of this parasite.

This risk analysis is based on the current state of our knowledge, however, lumpfish farming remains, and requires, to be fully tested over time in the Irish environment. As more data regarding the farming and behaviour of lumpfish in Ireland becomes available, there may be a need to reassess the current knowledge to enable adequate risk management.

The farming of lumpfish and cohabitation with salmon has been conducted in Norway over the past five years and more recently in Scotland and in both countries to date there have been no recorded incidents of significant disease problems arising as a result of disease transmission between the species. In general, and as far as the current state of knowledge has established, the disease risks associated with farming and cohabiting the species in Ireland are considered low.