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FishVet Group

Risk analysis for the import of lumpfish (*Cyclopterus lumpus*) eggs into Ireland from Norway, the UK and Iceland

Scope of risk analysis: the primary purpose of this assessment is to provide a guidance for stakeholders on potential risks associated with the import of lumpfish eggs into Ireland and to advise on best practice to mitigate those risks. This guidance goes beyond, and is not intended to replace, the legal requirements prescribed in EU 2006/88. Operators should primarily consult with the responsible veterinarian over their specific requirements if there is deviation from the best practice.

This analysis includes an identification of potential hazards based on current knowledge, a risk assessment posed by potential hazards identified, risk management recommendations and a summary and conclusions section.

1. **Identification of hazards:** identification of pathogens that a) are notifiable and/or b) could potentially cause disease in lumpfish (*Cyclopteris lumpus*) or in Atlantic salmon (*Salmo salar*) cohabited 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. Betanodavirus
- 1.1.10. European North Atlantic Ranavirus (ENARV)
- 1.1.11. Lumpfish flavivirus (LuFV)
- 1.1.12. Cyclopterus lumpus totivirus (CluTV)
- 1.1.13. Cyclopterus lumpus coronavirus (CluCV)
- 1.1.14. Novel viral infections of lumpfish

1.2. Bacteria:

- 1.2.1. *Renibacterium salmoninarum*
- 1.2.2. *Aeromonas salmonicida* (atypical subspecies)
- 1.2.3. *Aeromonas salmonicida* (typical subspecies)
- 1.2.4. *Vibrio anguillarum*
- 1.2.5. *Vibrio ordalii*
- 1.2.6. *Aliivibrio salmonicida*
- 1.2.7. *Moritella viscosa*
- 1.2.8. *Francisella* spp.
- 1.2.9. *Mycobacterium* spp.
- 1.2.10. *Piscirickettsia salmonis*
- 1.2.11. *Pseudomonas anguilliseptica*
- 1.2.12. *Tenacibaculum* sp.
- 1.2.13. *Pasteurella* sp.

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*
1.3.5. Novel parasitic infections of lumpfish

1.4. Fungi:

1.4.1. *Exophiala* spp.
1.4.2. *Ichtyophonus hoferi*
1.4.3. *Nucleospora cyclopteri*
1.4.4. *Tetramicra brevifilum*
1.4.5. Novel fungal infections of lumpfish

2. Risk of introduction and consequence assessment:

2.1. **Risk of introduction (R):** 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, the UK or Iceland.

Table 1: Terms used to describe the probability of an event occurring / risk of introduction

		Consequence assessment			
		Negligible	Low	Moderate	High
Risk of introduction	High	N	L	M	H
	Moderate	N	L	M	M
	Low	N	L	L	L
	Very Low	N	VL	L	L
	Negligible	N	N	N	N

2.2. **Consequence assessment (C):** 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. These 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 any 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.

Table 3. Risk estimation matrix, expressed as N (negligible), VL (very low), L (low), M (moderate), H (high).

		Consequence assessment			
		Negligible	Low	Moderate	High
Risk of introduction	High	N	L	M	H
	Moderate	N	L	M	M
	Low	N	L	L	L
	Very Low	N	VL	L	L
	Negligible	N	N	N	N

Table 4: risk estimation for each specific hazard identified in section 1, expressed as N (negligible), VL (very low), L (low), M (moderate), H (high) or U (unknown).

Pathogen	R	C	RE	Comments
Viruses				
1.1.1 VHSV	M	H	M	• Notifiable • Some genotypes present in northern European marine environment • Detected in lumpfish in Iceland (genotype IV, likely novel subgroup). Genotype 3 is endemic in wild fish stocks in the North Sea and the North Atlantic, has been detected in WR in the UK. Very rarely isolated from AS, susceptibility unclear. Trials with the LF isolate indicate low risk to AS. Can affect RBT (present in RBT in Norway) • Vertical transmission unknown, considered unlikely

1.1.2 EHNV	N	-	N	• Notifiable, listed as exotic disease in EU • Not present in Europe • Not detected in LF to date. Can affect redfin perch and RBT (freshwater). AS only infected experimentally • Vertical transmission unknown, considered unlikely
1.1.3 ISAV-HPR deleted	VL	H	L	• Notifiable • Present in Norway. Not currently present in Ireland, Iceland or the UK • No data on ISAV in LF to date, AS are susceptible • Vertical transmission unlikely
1.1.4 IHNV	N	-	N	• Notifiable • Not present in Europe • Not detected in lumpfish to date, can affect AS • Vertical transmission suggested
1.1.5 SAV	VL	L	VL	• Reported in Ireland (AS and wild fish including wrasse), the UK and parts of Norway • No data on SAV in LF to date, no reports despite cohabitations with positive AS. AS are susceptible • Vertical transmission unknown
1.1.6 IPNV	VL	M	L	• Reported in Ireland, the UK, Iceland and Norway • Not detected in LF apart from experimental infections. These indicate that LF can potentially act as reservoirs, though the risk was considered very low. AS are susceptible • Vertical transmission possible
1.1.7 PRV	L	L	L	• Reported in Ireland (AS and possibly wild fish), the UK and Norway • Not detected in LF to date but no testing data available. • AS are susceptible • Vertical transmission unlikely
1.1.8 PMCV	VL	M	L	• Reported in Ireland, the UK and Norway • Not confirmed in LF to date, AS are susceptible to disease, detected in WR. Has been detected in wild fish populations • Vertical transmission suggested
1.1.9 Betanodavirus	L	M	L	• Reported in the UK and Norway, likely present in northern European marine environment but not detected in Ireland to date • Lumpfish are experimentally susceptible, but no natural infections are documented. Can infect WR, cod and halibut for example, does not affect AS • Vertical transmission possible
1.1.10 ENARV	VL	L	VL	• Reported in LF in Ireland, the UK and Iceland • Likely same virus detected in cod and turbot. Significance uncertain, experimental IP infections can cause mortality in juvenile LF. Experimental data indicates low risk to AS • Vertical transmission unknown
1.1.11 LuFV	VL	U	U	• Not detected in Ireland to date • Reported in LF in Norway and Scotland • Descriptions of liver pathology and encephalitis in LF. Significance in AS unknown, first studies indicate that AS are not infected by cohabited LF • Vertical transmission unknown

1.1.12 CluTV	VL	L	VL	• Not detected in Ireland to date • Reported in lumpfish in Norway, prevalence unknown. No reported clinical impact • Vertical transmission unknown
1.1.13 CluCV	VL	U	U	• Not detected in Ireland to date • Reported in LF in Norway. Prevalence, distribution and clinical significance unknown, anecdotal reports of pathogenicity • Vertical transmission unknown
1.1.14 Novel viruses	U	U	U	• Unknown
Bacteria				
1.2.1 *R. salmoninarum*	VL	H	L	• Notifiable • Not known to be present in Ireland, present in the UK, Iceland and Norway (AS and RBT) • Not detected in LF to date, AS susceptible • Vertical transmission possible
1.2.2. *A. salmonicida (atypical)*	VL	L	VL	• Present in Ireland, Iceland, the UK and Norway • LF, WR, AS susceptible. Research indicates that AS are not susceptible to the same subtypes as LF and WR Anecdotal reports if subtype 3 in both AS and LF • Not vertically transmitted
1.2.3 *A. salmonicida* (typical)				• Present in Ireland, the UK, Norway • AS, LF, WR are susceptible • Not vertically transmitted
1.2.4. *V. anguillarum*				• Present in Ireland, Iceland, the UK and Norway • AS, LF and WR are susceptible • Not vertically transmitted
1.2.5. *V. ordalii*				• Reported in LF in Norway and the UK • LF and AS susceptible • Not vertically transmitted
1.2.6 *A.. salmonicida*				• Present in Ireland (AS), the UK, Iceland and Norway • Isolated from LF in Scotland and Ireland, AS susceptible. No research available on possible strain variations • Not vertically transmitted
1.2.7 *M. viscosa*				• Present in Ireland, Iceland, the UK and Norway • AS susceptible, has been detected in LF, clinical significance remains uncertain. Reports of differing subtypes infecting AS and LF • Not vertically transmitted
1.2.8 *Francisella* sp.				• Present in Ireland (cod), the UK and Norway • Has been detected in LF, AS not susceptible • Vertical transmission suggested
1.2.9 *Mycobacterium* sp.				• Present in Ireland, the UK and Norway • Not detected in LF to date, can affect AS • Vertical transmission possible
1.2.10 *P. salmonis*	L	L	L	• Present in Ireland, Norway and the UK • Infections in LF only described in Ireland to date, AS susceptible • Vertical transmission possible
1.2.11 *P. anguilliseptica*	VL	L	VL	• Present in Ireland, Norway, Iceland and the UK • LF susceptible, susceptibility of AS uncertain. One infection recorded in AS (Finland 1990), but no reports in AS despite outbreaks in cohabited LF suggests low risk

				• Not vertically transmitted
1.2.12 *Tenacibaculum* sp.				• Present in Ireland, the UK and Norway • LS and AS susceptible, common opportunistic infection • Not vertically transmitted
1.2.13 *Pasteurella* sp.				• Reported in Norway and the UK, not detected in Ireland to date • LF susceptible, relationship to AS infecting *Pasteurella* species uncertain • Not vertically transmitted
1.2.14 Novel bacteria	U	U	U	• Unknown
Parasites				
1.3.1. *G. salaris*	N	-	N	• Notifiable • Not detected in Ireland, present in Norway • Can affect AS in freshwater. No threat in marine environment • Not vertically transmitted
1.3.2. *N. perurans*	N	-	N	• Present in Ireland, the UK and Norway • LF, AS and WR susceptible, endemic in Ireland • Not vertically transmitted
1.3.3 *K. Islandica*	N	-	N	• Present in Norway and Iceland, not detected in Ireland to date • LF susceptible, transmission to AS not documented • Not vertically transmitted
1.3.4 *M. Albi*	N	-	N	• Not detected in Ireland to date, reported in Iceland and the UK • LF susceptible, AS not affected • Not vertically transmitted
1.3.5 Novel parasites	U	U	U	• Unknown
Fungi				
1.4.1. *Exophiala* spp.	L	M	L	• Present in Ireland (AS, LF), Iceland, the UK and Norway • LF susceptible, indications of infections being opportunistic. Regular incidental finding in AS, isolated cases of mortalities reported • Vertical transmission unknown
1.4.2 *I. hoferi*	VL	L	VL	• Present in Ireland (wild fish), Iceland, the UK and Norway • Detected in LF in Norway • Vertical transmission unknown
1.4.3 *N. cyclopteri*	L	M	L	• Present in Iceland, Norway and the UK (high prevalence in some areas), not detected in Ireland to date • Only LF known to be susceptible • No evidence of vertical transmission to date
1.4.4 *T. brevifilum*	VL	M	L	• Detected in LF in Ireland, suspected cases in the UK • Not known to infect salmon • Vertical transmission unknown
1.4.5 Novel fungal infections	U	U	U	• Unknown

*Key: AS: Atlantic salmon, RBT: Rainbow trout, LF: lumpfish, WR: wrasse.

Evaluation of risk

Based on this risk assessment, the pathogen posing the highest risk is VHSV. The risk posed by all other pathogens is very low, low or unknown. This assessment applies solely to true vertical transmission, when the infection occurs inside the fertilized egg and is passed to subsequent offspring. This is different to egg-associated transmission, where the pathogen is only present on the egg surface. Effective thorough disinfection of eggs is a prerequisite to eliminate this source of risk. The import of eggs is not considered acceptable **in the absence of risk management measures** outlined under 4.

Pathogen classification based on risk assessment

Pathogens have been divided into 3 categories based on the above risk assessment and further considerations, such as presence in the marine environment in Ireland (refer to section 5 below for further discussion). Categories are as follows:

1: Testing is strongly recommended due to unacceptably high potential impact, significant risk of introduction if pathogens are not known to be present in Ireland to date, or if introduction would significantly alter the overall situation regarding this pathogen in Ireland. Includes all notifiable diseases with R not considered negligible.

- VHSV, (ISAV-HPR deleted), IPNV, LuFV, LuCV, *Pasteurella* sp., *N. cyclopteri*

2: The risk of introduction is considered low but testing should be considered due to potential commercial impact. Includes pathogens seen regularly in Irish aquaculture and that are not confined to a limited area or pathogens with a low potential impact. A site-specific risk assessment is recommended for importers.

- SAV, PRV, PMCV, ENARV, LuTV, betanodavirus, novel viral infections, *P. salmonis*, *A. salmonicida* (atypical), *A. salmonicida* (typical), *V. anguillarum*, *V. ordalii*, *V. salmonicida*, *P. anguilliseptica*, novel bacterial infections, *Exophiala* spp., *T. brevifilum*

3: The overall risk is considered negligible or very low and testing is not considered advisable. If R is not negligible, these pathogens are very rare in lumpfish based on current knowledge, unlikely to be transmitted through true vertical transmission if present and are widespread in the marine environment with a limited impact and basic risk management measures are likely to guard against transmission.

- EHNV, IHNV, *V. splendidus*, *M. viscosa*, *Francisella* sp., *Mycobacterium* spp., *Tenacibaculum* spp., *G. salaris*, *N. perurans*, *K. islandica*, *M. aeglefini*, novel parasite infections, *I. hoferi*, novel fungal infections of lumpfish.

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 hatchery 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/or secure biosecurity protocol for procedures surrounding wild caught fish
b. are screened for the pathogens of most concern (viruses and bacteria) on a regular basis.

4.2. **Testing for pathogens:**

As a minimum requirement for import, milt and ovarian fluid (or suitable organs) should be tested for:

- VHSV, (ISAV-HPR deleted, IPNV, LuFV, LuCV, *Pasteurella* sp., *N. cyclopteri* by PCR.
- A kidney or heart sample should be tested for VHSV in addition to milt/ovarian fluid.

Additional screening of broodstock (wild-caught or farmed) as follows should be considered:

- ISAV: PCR from kidney and heart samples (individual fish).
- PCR testing of milt and ovarian fluid for SAV, PRV, PMCV, ENARV, LuTV, betanodavirus, *P. salmonis*, *A. salmonicida* (atypical), *A. salmonicida* (typical), *V. anguillarum, V. ordalii, V. salmonicida, P. anguilliseptica, Exophiala* spp. and *T. brevifilum.*
- 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).
- All broodstock showing signs of disease/lesion, etc. should be sampled for histology.

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 pathogens, their eggs/fertilized eggs should be discarded. Certificates of testing of the broodstock should be available with each batch.

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

- All imported eggs should be disinfected at origin and again at arrival.
- Eggs should not come in contact with other fish livestock, fish livestock products or wild caught fish during the holding period prior to delivery.
- No batches of eggs that exhibit fungal infection, or other abnormalities, should be transported.
- All imported eggs should be kept in effective quarantine at arrival, effluent water and waste should be treated in a manner that prevents potential pathogen release.
- All equipment used should be thoroughly disinfected after use, and no equipment should be shared between eggs and other stages (juveniles/broodstock).
- Any staff involved in care and monitoring of eggs should adhere to best practice biosecurity (hygiene and disinfection).
- Any mortalities in fish imported from abroad as eggs should be subject to a veterinary investigation. Monthly veterinary inspections to the importing facility should be carried out (routine visits) and when morbidity or mortalities are observed (diagnostic visits).
- Records should be maintained of quantities of eggs arriving, source, certification as well as quantities dispatched, destination and method of delivery.

4.4. Updating of risk analysis

- This risk analysis, while qualitative, has been undertaken with reference to the available scientific literature and data from industry partners from Ireland, the UK, Norway and Iceland and is based on the current state of our knowledge. The risk analysis should be updated on a yearly basis to incorporate new research and descriptions of new pathogens.

5. **Summary and conclusions:** The overall risk posed by the introduction of lumpfish eggs is largely considered low, based on test results to date and on this risk assessment, providing eggs are disinfected prior to entry into Ireland and best practice is observed. However, there are notable exceptions which require testing to rule out the possibility of introduction. The main pathogens that have presented disease problems for lumpfish, based on published information and industry reports to date, are as follows:

Viruses: VHSV, ENARV (syn. Lumpfish ranavirus), Lumpfish flavivirus, Cyclopterus lumpus coronavirus (CluCV).

VHSV has been detected in at least 80 marine and freshwater species and can be divided into 4 genotypes. Different types are endemic to northern hemisphere marine waters, correlating to geographic area rather than to fish species. A new subtype of genotype 4 has been isolated from lumpfish in Iceland. Research indicates that the strain induces pathology in lumpfish but not in Atlantic salmon. The risk posed through introduction is significant but is considered acceptable if qPCR samples test negative.

A ranavirus has been isolated from lumpfish experiencing high mortality in Ireland, and from clinically healthy lumpfish fish in Scotland, the Faroe Islands and Iceland. Research indicates that isolates are the same species as that which has been isolated from cod and turbot in northern European marine waters, and the name European North Atlantic ranavirus (ENARV) has been proposed. Research indicates possible strain variations and IP injection could induce mortality in juvenile lumpfish. Results to date indicate that ENARV is not a pathogen of salmon and there is no indication of vertical transmission. The virus is present in Ireland and the European marine environment, though descriptions in lumpfish are very rare despite ENARV growing on standard cell lines. The overall increase in risk posed by introduction through imported stocks is considered acceptable if best practice guidelines are followed.

A flavivirus (LuFV), reportedly associated with liver pathology and mortality, has been isolated from lumpfish in Norway and Scotland. Preliminary results indicate that the virus does not infect salmon. This virus has not been confirmed in lumpfish in Ireland and potential vertical transmission is unknown. The risk is considered acceptable if qPCR samples test negative.

A coronavirus (CluCV) has been repeatedly detected in lumpfish in Norway, anecdotally associated with mortality in some cases. This virus has not been confirmed in lumpfish in Ireland and the overall risk increase posed by introduction through imported stocks is considered significant but acceptable if imported fish are screened as outlined. The risk is considered acceptable if qPCR samples test negative.

Bacteria: typical *Aeromonas salmonicida*, Atypical *Aeromonas salmonicida* A-layer types 5 and 6, *Vibrio anguillarum*, *Piscirickettsia salmonis*, *Pasteurella* sp., *Pseudomonas anguilliseptica*, *V. splendidus*, *V. ordali*, *Tenacibaculum* species.

Typical furunculosis (*Aeromonas salmonicida* subspecies *salmonicida*) is a significant disease of salmon and lumpfish. The disease is comparatively rare in lumpfish, but outbreaks have occurred in Ireland, Norway and the UK. Most salmon stocks are vaccinated. This species is present in Ireland and *Aeromonas* sp. bacteria are not known to be vertically transmitted in disinfected eggs. The risk is considered acceptable if best practice guidelines are followed, but testing can be considered.

Atypical furunculosis has been recorded in farmed salmon and lumpfish at sea in Ireland, although isolation of atypical isolates from lumpfish in Ireland is very rare and has not been linked to high mortalities to date. Mortalities in lumpfish have been attributed to atypical strains in Norway and the

UK. The strains of atypical *Aeromonas salmonicida* affecting wrasse and lumpfish are subtypes that have not been reported in salmon to date and which appear to be host species specific, though there are recent anecdotal reports of subtype 3 in both salmon and lumpfish (not connected). The risk of species cross-over is considered low and atypical strains are known to be common in some wild fish populations in Ireland. *Aeromonas* sp. bacteria are not known to be vertically transmitted in disinfected eggs. The risk is considered acceptable if best practice guidelines are followed, but testing can be considered.

Vibrio vaccines and appropriate husbandry practices have ensured that vibriosis has not been a concern in finfish aquaculture in Ireland for over 20 years. Vaccinated salmonid susceptibility to vibriosis is low or insignificant. *V. anguillarum* has been isolated from lumpfish in sea pens in Ireland and the possibility of increasing the overall risk posed by this pathogen in Ireland is considered low. *Vibrio* sp. bacteria are not known to be vertically transmitted in disinfected eggs. The risk is considered acceptable if best practice guidelines are followed, but testing can be considered.

Piscirickettsia salmonis has caused mortalities in lumpfish in Ireland, but no cases have been described in the UK or Norway despite the presence of the bacteria in salmon. The risk of lumpfish broodstock being infected in consequently considered very low. Together with the ubiquitous presence of *P. salmonis* in Ireland, the overall risk increase posed by importing lumpfish eggs is considered very low, despite vertical transmission being possible. Screening can be considered.

Pasteurella sp. have caused high mortality in lumpfish in Norway and the UK. *Pasteurella* sp. have not been isolated from lumpfish or salmon in Ireland to date and the introduction would potentially have a significant impact on lumpfish and/or salmon health. The relationship between lumpfish and salmon infecting is currently unknown. *Pasteurella* sp. bacteria are not known to be vertically transmitted in disinfected eggs. The risk is considered acceptable if qPCR samples test negative

P. anguilliseptica has caused high mortality in lumpfish at sea in Ireland and Norway. This species is not known as being a problem for salmon, though one infection is documented in 1988. *P. anguilliseptica* has been isolated from lumpfish in sea pens in Ireland and the overall risk increase posed by introducing this pathogen with eggs is considered very low. *P. anguilliseptica* is not known to be vertically transmitted in disinfected eggs. The risk is considered acceptable if best practice guidelines are followed, but testing can be considered.

Tenacibaculum spp. have caused high mortality in lumpfish, species identified include *T. maritimum*, *T. dicentrarchi, T. finnmarkense* and *T. ovolyticum*. Research shows high genetic variability between and within *Tenacibaculum* outbreaks in lumpfish in Norway, indicating opportunistic infection. *Tenacibaculum spp.* are common in the marine environment in Ireland and infections are common in lumpfish in Ireland. The overall risk increase posed by introduction with imported eggs is considered very low and acceptable if eggs are disinfected and treated according to best practice.

Parasites and fungi: *N. perurans, Exophiala* species, *Tetramicra brevifilum, Nucleospora cyclopteri.*

N. perurans, the causal agent of amoebic gill disease, is endemic in farmed salmon in Ireland and has also been problematic in lumpfish, both in hatcheries and at sea. There is no evidence to indicate vertical transmission of this parasite and the risk is considered acceptable if best practice guidelines are followed.

Exophiala species are ubiquitous in the environment and infections are common in adult lumpfish in captivity. The overall risk increase posed by importing eggs is considered minimal and acceptable if best practice guidelines are followed.

Tetramicra brevifilum infection has been diagnosed on several occasions in lumpfish in Ireland, to date

there are no confirmed cases in Norway or the UK. The overall risk increase posed by importing fish is considered minimal and acceptable if best practice guidelines are followed.

Nucleospora cyclopteri is common in some lumpfish populations. This species has not been diagnosed in Ireland to date, though no PCR screening has been done. A research project in Norway was unable to demonstrate vertical transmission. The risk is considered acceptable if qPCR samples test negative

Finally, with the exception of an experimental trial using *N. perurans* originally isolated from salmon, to date there have been no recorded incidents of significant disease arising as a result of disease transmission from lumpfish to salmon. 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.

The risk assessment framework used here has been adapted from AQUIS (1999) and and based on Annex 3, code of good practice, Scottish fin fish aquaculture (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) (2019) 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/