

## Risk analysis for the import of captive reared lumpfish (*Cyclopterus lumpus*) into Ireland for use as cleaner fish on Atlantic salmon farms

**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 captive reared lumpfish 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 cause disease in lumpfish or farmed Atlantic salmon (*Salmo salar*) in co-habitation with lumpfish.

Potential hazards:

### 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 myocarditis virus (PMCV)
- 1.1.8. Piscine reovirus (PRV)
- 1.1.9. Betanodavirus (syn. NNV)
- 1.1.10. European North Atlantic Ranavirus (ENARV) (syn. lumpfish ranavirus)
- 1.1.11. Lumpfish flavivirus (LFV)
- 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* (subspecies *salmonicida*)
- 1.2.4. *Vibrio anguillarum*
- 1.2.5. *Vibrio splendidus*
- 1.2.6. *Vibrio ordalii*
- 1.2.7. *Aliivibrio salmonicida*
- 1.2.8. *Moritella viscosa*
- 1.2.9. *Francisella* sp.
- 1.2.10. *Mycobacterium* sp.
- 1.2.11. *Piscirickettsia salmonis*
- 1.2.12. *Pseudomonas anguilliseptica*

April 2020

- 1.2.13. *Tenacibaculum* spp.
- 1.2.14. *Pasteurella* sp.
- 1.2.15. 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 aeglefini* (syn. *M. albi*)
- 1.3.5. *Ichtyobodo necator* complex
- 1.3.5. Novel parasitic infections of lumpfish

### 1.4. Fungi:

- 1.4.1. *Exophiala* spp.
- 1.4.2. *Ichthyophonus hoferi*
- 1.4.3. *Nucleospora cyclopteri*
- 1.4.4. *Tetramicra brevifilum*
- 1.4.2. Novel fungal infections of Lumpfish

**2. Risk assessment:** the risk assessment for every hazard is made using the 5 components outline below.

#### 2.1 Release assessment (R)

This is an estimation of the probability (i.e. likelihood) of fish movement resulting in hazard introduction. Biological risk factors, source risk factors and item risk factors are considered. See table 1 for definition of terms. **If the risk is considered negligible the assessment is ended at this point.**

#### 2.2. Exposure assessment (E)

The probability of a pathogen release resulting in infection of Atlantic salmon or other lumpfish stocks. Biological risk factors, destination risk factors and item risk factors are considered. See table 1 for definition of terms. If there are differences in risk for salmon and lumpfish the higher risk category is used. **If the risk is considered negligible the assessment is ended at this point.**

**Table 1:** terms used to quantify risk in 2.1, 2.2 and 2.3.

Scale for release assessment, exposure assessment and the probability of establishment	
High (H)	Event would be expected to occur
Moderate (M)	There is a less than even chance of the event occurring
Low (L)	Event would occur occasionally
Very low (VL)	Event would occur very rarely
Negligible (N)	Chance of event occurring is so small it can be ignored.

### 2.3. Probability of establishment (PE)

The risk of a disease being introduced, calculated through a conversion chart using the release assessment and the exposure assessment (figure 1). See table 1 for definition of terms.

		Exposure assessment (E) →				
		Negligible (N)	Very Low (VL)	Low (L)	Moderate (M)	High (H)
↑ Release assessment (R)	High (H)	N	VL	L	M	H
	Moderate (M)	N	VL	L	M	M
	Low (L)	N	N	VL	L	L
	Very Low (VL)	N	N	N	VL	VL
	Negligible (N)	N	N	N	N	N

**Figure 1:** Conversion chart used to calculate the probability of establishment (2.3) of a pathogen / hazard

### 2.4. Consequence assessment (C)

An evaluation of the consequences of introduction considering potential hazards to human health, fish health and the environment (see table 2 for definition of terms).

**Table 2:** Terms used to describe the significance of consequences

Scale for significance of consequences	
<b>High</b>	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.
<b>Moderate</b>	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.
<b>Low</b>	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.
<b>Negligible</b>	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.

### 2.5. Risk estimation (Risk)

This is an estimation of the overall risk posed by a hazard, calculated from the probability of establishment and the consequence assessment through a conversion table (figure 2). If the result is “Yes”, the risk is considered acceptable, “No” means the risk is not acceptable **in the**

April 2020

**absence of risk management measures** and “Yes/No” means the risk is uncertain. The risk determined is the **unrestricted estimate of risk, i.e. the risk based on the absence of risk management**). Each hazard is considered separately in the risk evaluation below (table 3).

		Significance of Consequences →			
		Negligible (N)	Low (L)	Moderate (M)	High (H)
↑ Probability of Establishment	High (H)	Yes	No	No	No
	Moderate (M)	Yes	No	No	No
	Low (L)	Yes	Yes	No	No
	Very Low (VL)	Yes	Yes	Yes/No	No
	Negligible (N)	Yes	Yes	Yes	Yes

**Figure 2:** Risk estimation matrix

**Table 3:** Risk evaluation for the specific hazards identified in section 1 (see table 1 for risk quantifying abbreviations)

Hazard	R	E	PE	C	Risk	Notes
<b>Viruses</b>						
1.1.1 (VHSV)	VL	H	VL	H	Not acceptable	<ul style="list-style-type: none"> <li>• Notifiable</li> <li>• Some genotypes present in northern European marine environment</li> <li>• 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 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)</li> <li>• Vertical transmission unknown, considered unlikely</li> </ul>
1.1.2 (EHNV)	N	-	-	-	Acceptable	<ul style="list-style-type: none"> <li>• Notifiable, listed as exotic disease in EU</li> <li>• Not present in Europe</li> <li>• Not detected in LF to date. Can affect redfin perch and RBT (freshwater). AS only infected experimentally.</li> <li>• Vertical transmission unknown, considered unlikely</li> </ul>
1.1.3 ISAV – HPR deleted	VL	H	VL	H	Not acceptable	<ul style="list-style-type: none"> <li>• Notifiable</li> <li>• Present in Norway. Not currently present in Ireland, Iceland or the UK</li> <li>• No data on ISAV in LF to date, AS are susceptible</li> <li>• Vertical transmission unlikely</li> </ul>
1.1.4 IHNV	N	-	-	-	Acceptable	<ul style="list-style-type: none"> <li>• Notifiable</li> <li>• Not present in Europe</li> <li>• Not detected in LF to date, can affect AS</li> <li>• Vertical transmission suggested</li> </ul>
1.1.5 SAV	VL	H	VL	M	Uncertain	<ul style="list-style-type: none"> <li>• Present in Ireland (AS and wild fish including WR), the UK and parts of Norway</li> <li>• No data on SAV in LF to date, no reports despite cohabitations with positive AS. AS are susceptible</li> </ul>

April 2020

						<ul style="list-style-type: none"> <li>Vertical transmission unknown</li> </ul>
1.1.6 IPNV	VL	H	VL	H	Not acceptable	<ul style="list-style-type: none"> <li>Reported in Ireland, Iceland, the UK and Norway</li> <li>Experiments have shown that LF can potentially act as reservoirs, though the risk was considered very low, AS are susceptible</li> <li>Vertical transmission possible</li> </ul>
1.1.7 PMCV	VL	H	VL	H	Not acceptable	<ul style="list-style-type: none"> <li>Reported in Ireland, the UK and Norway</li> <li>Not confirmed in LF to date, AS are susceptible to disease, detected in WR and wild fish populations</li> <li>Vertical transmission suggested</li> </ul>
1.1.8 PRV	VL	H	VL	M	Uncertain	<ul style="list-style-type: none"> <li>Reported in Ireland (AS and possibly wild fish), the UK and Norway</li> <li>Not detected in LF to date but no testing data available AS are susceptible</li> <li>Vertical transmission unlikely</li> </ul>
1.1.9 Betanodavirus	VL	M	VL	M	Uncertain	<ul style="list-style-type: none"> <li>Reported in the UK and Norway, likely present in the northern European marine environment but not detected in Ireland to date</li> <li>Lumpfish experimentally susceptible but no natural infections are documented. Can infect WR, cod and halibut for example, does not affect AS</li> <li>Vertical transmission possible</li> </ul>
1.1.10 ENARV	VL	M	VL	U	Uncertain	<ul style="list-style-type: none"> <li>Reported in LF in Ireland, the UK and Iceland</li> <li>Likely same virus detected in cod and turbot</li> <li>Significance uncertain, experimental IP infections can cause mortality in juvenile LF. Experimental data indicates low risk to AS</li> <li>Vertical transmission unknown</li> </ul>
1.1.11 LuFV	VL	U	U	U	Uncertain	<ul style="list-style-type: none"> <li>Not detected in Ireland to date</li> <li>Reported in LF in Norway and Scotland.</li> <li>Descriptions of liver pathology and encephalitis in LF. Significance in AS unknown, first studies indicate that AS are not infected by cohabited LF</li> <li>Vertical transmission unknown</li> </ul>
1.1.12 CluTV	U	U	U	U	Uncertain	<ul style="list-style-type: none"> <li>Not detected in Ireland to date</li> <li>Reported in lumpfish in Norway, prevalence, distribution and clinical significance unknown</li> <li>Vertical transmission unknown</li> </ul>
1.1.13. CluCV	U	U	U	U	Uncertain	<ul style="list-style-type: none"> <li>Not detected in Ireland to date</li> <li>Reported in LF in Norway. Prevalence, distribution and clinical significance unknown</li> <li>Vertical transmission unknown</li> </ul>
1.1.14. Novel viruses	U	U	U	U	Uncertain	<ul style="list-style-type: none"> <li>Unknown</li> </ul>

Hazard	R	E	PE	C	Risk	Notes
<b>Bacteria</b>						
1.2.1 <i>R. salmoninarum</i>	VL	L	N	H	Acceptable	<ul style="list-style-type: none"> <li>Notifiable</li> <li>Not present in Ireland, present in the UK, Iceland and Norway (AS and RBT)</li> <li>Not detected in LF to date, AS susceptible</li> <li>Vertical transmission possible</li> </ul>

April 2020

1.2.2 <i>A. salmonicida</i> (atypical)	VL	H	VL	M	Uncertain	<ul style="list-style-type: none"> <li>• Present in Ireland, Iceland, the UK and Norway</li> <li>• 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</li> <li>• Not vertically transmitted</li> </ul>
1.2.3 <i>A. salmonicida</i> (typical)	VL	H	VL	M	Uncertain	<ul style="list-style-type: none"> <li>• Present in Ireland, the UK and Norway</li> <li>• AS, LF, WR are susceptible</li> <li>• Not vertically transmitted</li> </ul>
1.2.4 <i>V. anguillarum</i>	L	H	VL	M	Uncertain	<ul style="list-style-type: none"> <li>• Present in Ireland, Iceland, the UK and Norway</li> <li>• AS, LF and WR are susceptible</li> <li>• Not vertically transmitted</li> </ul>
1.2.5 <i>V. splendidus</i>	H	L	L	L	Acceptable	<ul style="list-style-type: none"> <li>• Ubiquitous in marine environment</li> <li>• Frequently isolated from moribund LF but research indicates that it is an opportunistic pathogen</li> <li>• Considered opportunistic in AS</li> </ul>
1.2.6 <i>V. ordalii</i>	VL	H	VL	M	Uncertain	<ul style="list-style-type: none"> <li>• Reported in LF in Norway and the UK</li> <li>• LF and AS susceptible</li> <li>• Not vertically transmitted</li> </ul>
1.2.7 <i>Aliivibrio salmonicida</i>	L	H	L	M	Not acceptable	<ul style="list-style-type: none"> <li>• Present in Ireland, Iceland, the UK and Norway</li> <li>• Isolated from LF in Scotland and Ireland, AS susceptible. No research available on possible strain variations</li> <li>• Not vertically transmitted</li> </ul>
1.2.8 <i>M. viscosa</i>	VL	H	VL	M	Uncertain	<ul style="list-style-type: none"> <li>• Present in Ireland, Iceland, the UK and Norway</li> <li>• AS susceptible, significance in LF unknown, reports of differing subtypes infecting AS and LF</li> <li>• Not vertically transmitted</li> </ul>
1.2.9 <i>Francisella</i> sp.	VL	H	VL	M	Uncertain	<ul style="list-style-type: none"> <li>• Present in Ireland, the UK and Norway</li> <li>• Has been detected in LF, AS not susceptible</li> <li>• Vertical transmission suggested</li> </ul>
1.2.10 <i>Mycobacterium</i> sp.	VL	L	N	M	Acceptable	<ul style="list-style-type: none"> <li>• Present in Ireland, the UK and Norway</li> <li>• Not detected in LF to date, can affect AS</li> <li>• Vertical transmission possible</li> </ul>
1.2.11 <i>P. salmonis</i>	VL	H	VL	M	Uncertain	<ul style="list-style-type: none"> <li>• Present in Ireland, Norway and the UK</li> <li>• Infections in LF only described in Ireland to date, AS susceptible</li> <li>• Vertical transmission possible</li> </ul>
1.2.12 <i>P. anguilliseptica</i>	VL	H	VL	M	Uncertain	<ul style="list-style-type: none"> <li>• Present in Ireland, Norway and the UK</li> <li>• 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</li> <li>• Not vertically transmitted</li> </ul>
1.2.13 <i>Tenacibaculum</i> spp.	L	H	L	L	Acceptable	<ul style="list-style-type: none"> <li>• Present in Ireland, Iceland, the UK and Norway</li> <li>• LS and AS susceptible, common opportunistic infection</li> <li>• Not vertically transmitted</li> </ul>
1.2.14 <i>Pasteurella</i> sp.	VL	H	VL	M	Uncertain	<ul style="list-style-type: none"> <li>• LF infections in Norway and the UK, not detected in Ireland to date</li> <li>• LF susceptible, relationship to AS infecting <i>Pasteurella</i> species uncertain</li> <li>• Not vertically transmitted</li> </ul>
1.2.15	U	U	U	U	Uncertain	<ul style="list-style-type: none"> <li>• Unknown</li> </ul>

April 2020

Novel bacteria						
----------------	--	--	--	--	--	--

Hazard	R	E	PE	C	Risk	Notes
<b>Parasites</b>						
1.3.1 <i>G. salaris</i>	N	-	-	-	acceptable	<ul style="list-style-type: none"> <li>• Notifiable</li> <li>• Not detected in Ireland, present in Norway</li> <li>• Can affect AS in freshwater. No threat in marine environment</li> <li>• Not vertically transmitted</li> </ul>
1.3.2 <i>N. perurans</i>	H	H	H	M	Not acceptable	<ul style="list-style-type: none"> <li>• Present in Ireland, the UK and Norway</li> <li>• LF, AS and WR susceptible, endemic in Ireland</li> <li>• Not vertically transmitted</li> </ul>
1.3.3 <i>K. Islandica</i>	VL	H	VL	L	Acceptable	<ul style="list-style-type: none"> <li>• Not detected in Ireland to date, detected in LF in Norway and Iceland</li> <li>• Transmission to AS not documented</li> <li>• Vertical transmission unknown</li> </ul>
1.3.4 <i>M. aeglefini</i> (syn. <i>M. albi</i> )	VL	H	VL	L	Acceptable	<ul style="list-style-type: none"> <li>• Not detected in Ireland to date, reported in Iceland and the UK</li> <li>• Reported in LF and wild marine fish, AS not affected</li> <li>• Vertical transmission unknown</li> </ul>
1.3.5 Novel parasites	U	U	U	U	Uncertain	<ul style="list-style-type: none"> <li>• Unknown.</li> </ul>

Hazard	R	E	PE	C	Risk	Notes
<b>Fungi</b>						
1.5.1 <i>Exophiala</i> spp.	H	H	H	M	Not acceptable	<ul style="list-style-type: none"> <li>• Present in Ireland (AS, LF), Iceland, the UK and Norway</li> <li>• LF susceptible, indications of infections being opportunistic. Cases documented in AS</li> <li>• Vertical transmission unknown</li> </ul>
1.5.2 <i>I. hoferi</i>	VL	M	VL	L	Acceptable	<ul style="list-style-type: none"> <li>• Present in Ireland (wild fish), Iceland, the UK and Norway</li> <li>• Detected in LF in Norway</li> <li>• Vertical transmission unknown</li> </ul>
1.5.3 <i>N. cyclopteri</i>	L	H	L	L	Acceptable	<ul style="list-style-type: none"> <li>• Not detected in Ireland to date, present in Iceland, Norway and the UK (high prevalence in some areas)</li> <li>• Only LF known to be susceptible</li> <li>• No evidence of vertical transmission to date</li> </ul>
1.5.4 <i>T. brevifilum</i>	L	H	L	L	Acceptable	<ul style="list-style-type: none"> <li>• Detected in LF in Ireland, suspected cases in the UK</li> <li>• Not known to infect salmon</li> <li>• Vertical transmission unknown</li> </ul>
1.5.2 Novel fungi	U	U	U	U	Uncertain	<ul style="list-style-type: none"> <li>• Unknown</li> </ul>

\*Key: AS: Atlantic salmon, RBT: Rainbow trout, LF: Lumpfish, WR: wrasse, UNK: Unknown

The risks posed by following pathogens are rated “not acceptable” or “uncertain” **in the absence of risk management measures:**

April 2020

VHSV, ISAV – HPR deleted, SAV, IPNV, PMCV, PRV, Betanodavirus, ENARV, LuFV, CluTV, CluCV, novel viruses, *A. salmonicida* (atypical), *A. salmonicida* (typical)), *V. anguillarum*, *V. ordalii*, *A. salmonicida*, *M. viscosa*, *Francisella* sp., *P. salmonis*, *P. anguilliseptica*, *Pasteurella* sp., novel bacteria, *Neoparamoeba perurans*, novel parasites, *Exophiala* sp and novel fungi.

Some of the pathogens listed above are widespread in the marine environment and in Irish salmon aquaculture (SAV, PMCV, PRV, *V. splendidus*, *M. viscosa*, Atypical *Aeromonas salmonicida* spp., *N. perurans*, *Exophiala* spp.). The risk posed by introduction through imported lumpfish is not always a significant overall increase in risk, depending on health and vaccination status of salmon, level of prevalence and severity of infections detected. To account for the varying significance of pathogen introduction, **consequences of non-notifiable pathogen identification should always be subject to a case specific veterinary evaluation.** This should take into account the nature of the pathogen, severity of infection detected in lumpfish and the health status/vaccination status of salmon on site. Risk management measures should be determined and implemented following evaluation of all factors.

**3. Risk management:** Implementation of measures to reduce the risks posed by the particular hazards to an acceptable level.

### 3.1. Screening of stock prior to movement

The following scenarios should be considered when assessing the risk posed by a lumpfish import into Ireland to inform an appropriate screening protocol:

- a) Imports from a facility from which fish have not been introduced within the last year, or which cannot provide proof of regular veterinary health assessments, or
- b) Imports from a facility from which fish are imported regularly (at least once/year), or from which fish have been imported and tested within the last year, and which can provide documentation of regular veterinary health assessments with a satisfactory sampling protocol.

**Scenario a)** Disease screening of fish (from all systems holding fish destined for transfer) should be conducted to test for the presence of pathogens of concern. 60 fish should be tested as follows:

- Bacteriology: inoculation of kidney material from loop/swab onto appropriate bacteria culture media such as tryptone soya agar (TSA), tryptone soya agar plus salt (TSASA), Columbia blood agar plus salt (CBASA) and thiosulfate citrate bile salts sucrose agar (TCBS).
- Virology: 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).
- Histology: any fish showing signs of disease and a minimum of 20 fish should be sampled for histology.
- Parasitology: skin and gill samples of 20 fish should be examined by light microscopy.
- PCR for VHSV, ISA, IPNV
- If indicated by histology findings: PCR for LuFV, LuCV, Betanodavirus, *Francisella*, *P. salmonis* or others.

**Scenario b)** If a review of veterinary records indicates no infectious diseases of concern and the routine veterinary health assessment protocol is considered satisfactory, a reduced screening

protocol is acceptable (half of all samples outlined under scenario A above). If a review of veterinary records indicates diseases of concern, mitigation measures taken should be subjected to a review.

No fish should be stocked on to salmon farms before results are evaluated.

### **3.2. Testing of broodstock**

- Records of testing carried out on broodstock, milt, ovarian fluid or eggs should be reviewed for batches considered for import. Testing and results should comply with minimum requirements outlined in the “risk assessment for import of lumpfish eggs into Ireland”.
- If results are not compliant, this import should be subject to a case specific risk assessment of results and implications. Import may be acceptable if subsequent testing and/or mitigation measures are considered satisfactory.

### **3.3. Quarantine**

- It is advisable to keep imported lumpfish under supervision in a separate facility for 6 weeks after import, though this may not be practically feasible.
- If quarantine is not practically feasible, any mortality or clinical disease seen during the first 6 weeks at sea should be subject to a veterinary assessment. A veterinary health assessment between 4 and 6 weeks post transfer is advisable regardless of mortalities.

### **3.4. Biosecurity and continuous health monitoring of lumpfish in sea cages**

- Disease outbreaks in lumpfish stocks are often stress associated and the welfare of lumpfish should be maintained at the highest level possible and in accordance with available guidelines and reference material.
- Lumpfish mortalities should be monitored continuously, as with salmon, and categorised by clinical signs (e.g. emaciation, lesions, gill disease, predation, other). Infectious agents should be identified as early as possible to maximise chances of successful treatment and recognition of diseases of concern.
- Staff on sites stocking lumpfish should receive training and reference material on lumpfish husbandry and recognition of diseases.
- Lumpfish should be screened for *Neoparamoeba perurans* regularly and a treatment protocol should be in place if AGD is confirmed (freshwater or hydrogen peroxide following advice from the responsible veterinarian).
- If possible, diseases should be treated at an early stage to maximise welfare and survival.
- Veterinary inspections should be carried out on a monthly basis (routine visits) and when morbidity or mortalities are observed (diagnostic visits). As a minimum requirement, it is suggested that the health status of lumpfish stocks on site should be assessed as in section 3.1 once a year for every site.

### **3.5. Movement of lumpfish between sites or re-use of lumpfish**

- The movement of lumpfish between sea sites is not advised.

- If movement is to take place or lumpfish are to be re-used after one production cycle, a review of data from the production cycle and a veterinary health investigation (as in 3.1) should be taken into account.
- This does not apply to lumpfish moved to a new site together with the cohabited salmon.

### 3.6. Vaccination

- Vaccinating salmon is advised if commercial vaccines are available for diseases that have proven problematic in the area.
- Vaccinating lumpfish is advised if vaccines for pathogens of concern are available.

### 3.7. Consequences of hazard detection

- If hazards are detected, the movement of fish is to be suspended pending a case specific veterinary evaluation and risk management proposal.
- Risk management measures should be implemented if:
  - a) movement of lumpfish results in a significant risk increase for salmon, or
  - b) stress associated with movement and stocking, in combination with pathogen detected, presents a significant disease or welfare concern for the lumpfish.
- Appropriate measures can include treatment, postponing movement, advising against movement or culling.

### 3.8. 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. I

**4. Summary and conclusions:** The main pathogens that have presented disease problems for lumpfish, based on published information and industry reports to date, are as follows:

**Viruses:** Viral haemorrhagic septicaemia virus (VHSV), European North Atlantic Ranavirus (ENARV, syn. LuRV), Lumpfish flavivirus (LuFV), 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 as VHSV is notifiable, the risk is considered acceptable if imported fish are screened as outlined.

A ranavirus has been isolated from lumpfish experiencing high mortality in Ireland, and from clinically healthy lumpfish in Scotland and Iceland. Research indicates that isolates are the same species as 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. The virus is present in Ireland and the overall risk increase posed by introduction through imported stocks is considered acceptable if fish are screened as outlined.

A flavivirus, 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 the overall risk increase posed by introduction through imported stocks is considered significant but acceptable if imported fish are screened as outlined.

A coronavirus 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, Iceland or the UK and the overall risk increase posed by introduction through imported stocks is considered significant but acceptable if imported fish are screened as outlined.

**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 the risk of introduction is considered low and acceptable if imported stocks are screened as outlined.

Atypical furunculosis has been recorded in farmed salmon and lumpfish at sea in Ireland, though 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. The risk of introducing new strains or increasing the overall risk posed by atypical furunculosis in Ireland is considered low and acceptable if imported stocks are screened as outlined.

*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 risk of increasing the overall risk posed by this pathogen in Ireland is considered low and acceptable if imported stocks are screened as outlined.

*Piscirickettsia salmonis* has caused mortalities in lumpfish in Ireland, but no cases have been described in lumpfish outside of Ireland. Infections in salmon at sea are common and the overall increase in risk posed by importing lumpfish is considered low and acceptable if imported stocks are screened as outlined.

*Pasteurella* sp. has caused high mortality in lumpfish in Norway and the UK. *Pasteurella* sp. has not been isolated from lumpfish in Ireland to date and the introduction would potentially have a significant

impact on lumpfish health. The relationship between lumpfish and salmon infecting is currently unknown. The risk is considered acceptable if imported stocks are screened as outlined.

*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 historically. *P. anguilliseptica* has been isolated from lumpfish in sea pens in Ireland and the overall risk increase posed by introducing this pathogen with imported stocks is considered low and acceptable if imported stocks are screened as outlined.

*V. splendidus* is the most commonly isolated pathogen from moribund lumpfish and mortalities, but research has indicated that infections are more likely individual opportunistic infections rather than one strain being horizontally transmitted. *V. splendidus* has commonly been isolated from lumpfish in Ireland and the consequences of introduction are considered low and the risk acceptable if imported stocks are screened as outlined.

*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 widespread in the marine environment and infections are common in lumpfish at sea. The overall risk increase posed by introduction with imported stocks is considered low and acceptable if imported stocks are screened as outlined.

**Parasites and fungi:** *Neoparamoeba 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. *N. perurans* is endemic in Irish salmon farming and the overall risk increase posed by introduction through imported stocks is considered very low and acceptable if imported stocks are screened as outlined.

*Exophiala* species are ubiquitous in the environment and infections are common in adult lumpfish in captivity. The overall risk increase posed by importing fish is considered minimal and acceptable if stocks are screened as outlined.

*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 stocks are screened as outlined.

*Nucleospora cyclopteri* is common in some lumpfish populations in the UK and Norway. This species has not been diagnosed in Ireland to date, though no PCR screening has been done. The overall risk increase posed by importing fish is considered acceptable if stocks are screened as outlined.

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 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/>