



September 2019

**REPORT OF THE OIE *AD HOC* GROUP ON SUSCEPTIBILITY
OF FISH SPECIES TO INFECTION WITH OIE LISTED DISEASES¹**

November 2018–September 2019

This report covers the work of the OIE *ad hoc* Group on Susceptibility of fish species to infection with OIE listed diseases (the *ad hoc* Group) between November 2018 and September 2019.

The list of participants and the Terms of Reference are presented in [Annex II](#) and [Annex III](#), respectively.

During this period the *ad hoc* Group had worked electronically and had applied the criteria to host species to determine susceptibility to infection with viral haemorrhagic septicaemia virus (VHSV). This was done by the three-stage approach, outlined in Article 1.5.3. of the *Aquatic Code*, to assess susceptibility of a species to infection with VHSV, as described below:

- 1) criteria to determine whether the route of transmission is consistent with natural pathways for the infection (as described in Article 1.5.4.);
- 2) criteria to determine whether the pathogenic agent has been adequately identified (as described in Article 1.5.5.);
- 3) criteria to determine whether the evidence indicates that presence of the pathogenic agent constitutes an infection (as described in Article 1.5.6.)

Stage 1: criteria to determine whether the route of transmission is consistent with natural pathways for the infection (as described in Article 1.5.4.)

Route of infection Key

N: Natural infection.

E: Experimental (non-invasive).

EI: Experimental (invasive).

References that reported invasive experimental procedures as the route of transmission were not used as evidence for infection (i.e. Article 1.5.4.).

Stage 2: criteria to determine whether the pathogenic agent has been adequately identified as described in Article 1.5.5.

Accurate pathogenic agent identification might not have been carried out in older publications because molecular typing techniques were not available at the time. In these circumstances a weight of evidence approach, using combined data from relevant studies, were considered and used to assess susceptibility.

¹ Note: This *ad hoc* Group report reflects the views of its members and may not necessarily reflect the views of the OIE. This report should be read in conjunction with the February 2020 report of the Aquatic Animal Health Standards Commission because this report provides its considerations and comments. It is available at <http://www.oie.int/en/standard-setting/specialists-commissions-working-ad-hoc-groups/aquatic-animals-commission-reports/meeting-reports/>

Stage 3: criteria to determine whether the evidence indicates that presence of the pathogenic agent constitutes an infection as described in Article 1.5.6.

Criteria A to D in Article 1.5.6. were used to determine if there was sufficient evidence for infection with the pathogenic agent in the suspect host species. Evidence to support criterion A alone was sufficient to determine infection. In the absence of evidence to meet criterion A, satisfying at least two of criteria B, C or D were required to determine infection.

- A. The pathogenic agent is multiplying in the host, or developing stages of the pathogenic agent are present in or on the host;
- B. Viable pathogenic agent is isolated from the proposed susceptible species, or infectivity is demonstrated by way of transmission to naïve individuals;
- C. Clinical or pathological changes are associated with the infection;
- D. The specific location of the pathogen corresponds with the expected target tissues.

Table 1. Criteria for susceptibility to infection with VHSV

A: Replication	B: Viability / Infectivity	C: Pathology / Clinical signs	D: Location
Sequential virus titration showing increase in viral titres or high virus titres in internal organs ($>10^5$ TCID ₅₀ /g) OR TEM OR Immunohistochemistry OR Product of virus replication detected	Isolation of virus from internal organs by cell culture OR Passage to a susceptible host	The occurrence of the following signs should lead to extended clinical examination for VHS: rapid onset of mortality, lethargy, darkening of the skin, exophthalmia, anaemia (pale gills), haemorrhages at the base of the fins, gills, eyes and skin, petechial haemorrhages in muscle, abnormal swimming such as flashing and spiralling, and a distended abdomen due to oedema in the peritoneal cavity (from the <i>Aquatic Manual</i>)* <u>Microscopic methods</u> The kidney and liver are prime targets and examination of histological sections from diseased fish reveals degeneration and necrosis of haematopoietic tissues of the kidney (and the spleen) with focal degeneration and necrosis of the liver. Sections of the skeletal muscle may show many foci of red blood cells, while the muscle fibres remain undamaged.	Recover virus from internal organs OR RT-PCR from internal organs

*not all the clinical signs will be found in all species

Pathogen identification for VHSV:

Pathogen isolation on BF-2, EPC, FHM, or CHSE cell lines with confirmation using immunological or molecular test. Immunological test could include virus neutralization, IFAT, or ELISA. Molecular tools include RT-PCR, DNA probes, sequencing. RT-PCR could also be done directly on infected tissues.

Evidence of infection Key Stage 3

- Y: Demonstrates criterion is met.
- N: Criterion is not met or was not assessed.
- ND: Not determined

o Outcome key used by the *ad hoc* Group when assessing the susceptibility of the species:

1.	<i>Species that were classified as susceptible (as described in Article 1.5.7.) were proposed for inclusion in Article 10.10.2. of Chapter 10.10. Infection with viral haemorrhagic septicaemia virus (VHSV) of the Aquatic Code and Section 2.2.1. of Chapter 2.3.10. Viral haemorrhagic septicaemia (VHSV) of the Aquatic Manual.</i>
2.	<i>Species that were classified as species for which there is partial evidence for susceptibility (as described in Article 1.5.8.) were proposed for inclusion in Section 2.2.2. Species with incomplete evidence for susceptibility of Chapter 2.3.10. Viral haemorrhagic septicaemia (VHSV) of the Aquatic Manual.</i>
3.	<i>Species that were found not to meet the criteria were not proposed for inclusion in either the Aquatic Code or Aquatic Manual. The exceptions were species where there had been reported pathogen-specific positive PCR results. These species were included in a separate paragraph in Section 2.2.2. Species with incomplete evidence for susceptibility of Chapter 2.3.10. Viral haemorrhagic septicaemia (VHSV) of the Aquatic Manual.</i>
4.	<i>There is evidence of non-susceptibility and the species is not proposed for inclusion in either the Aquatic Code or Aquatic Manual.</i>

The *ad hoc* Group recommended that invertebrate species and turtle species assessed and listed in Table 2 be included in Section 2.2.6. Vectors of Chapter 2.3.10. Viral haemorrhagic septicaemia (VHSV) in the *Aquatic Manual*. These species were considered to be vectors for transmission of VHSV rather than true susceptible species because it was difficult to determine viral replication within the invertebrate and turtle species.

Where there is conflicting evidence in the scientific literature for the same host species, or assessments differed (e.g. assessments ranging between '1' and '3'), the *ad hoc* Group provided some explanatory text in the relevant Annex as to their rationale for the final outcome.

The *ad hoc* Group considered that if only a single publication provided evidence for a score of 1, some form of corroborating evidence was required in addition, specifically:

- 1) Internal corroboration in the published study. Multiple lines of evidence within the same publication. This could result from i) a research cruise that amasses positive fish from multiple dates and locations or ii) an experimental study testing several isolates or routes of exposure (e.g. immersion and cohab). In these instances, assuming the research is sound, the species was scored a 1 from a single peer-reviewed publication.
- 2) External corroboration: evidence from other publications or sources. Examples might include data found in a government website, a separate publication that scores a 2 or better, or evidence of expert judgement (e.g., source for a permissive cell line, or records from a reference lab).

The detailed assessments for VHSV assessed by the *ad hoc* Group are provided in [Annex I](#).

ASSESSMENT OF HOST SUSCEPTIBILITY TO INFECTION WITH VIRAL HAEMORRHAGIC SEPTICAEMIA VIRUS (VHSV)

The assessments for host susceptibility to infection with VHSV are provided in [Table 2](#).

Table 2. Outcome of assessments for host susceptibility to infection with VHSV

Common name	Genus	Species	Genotype	Stage 1: Transmission	Stage 2: Pathogen identification	Stage 3: Evidence for infection				Outcome	References
						A	B	C	D		
Score 1											
American gizzard shad	<i>Dorosoma</i>	<i>cepedianum</i>	IVb	N	Virus isolation, RT-PCR, sequencing	ND	Y	Y	Y	1	Faisal 2012; USGS/NACSE database
Atlantic cod	<i>Gadus</i>	<i>morhua</i>	Ib, III	N	Viral isolation, cell culture and ELISA	ND	Y	Y	Y	1	Smail, 2000; Skall <i>et al.</i> , 2005
Atlantic herring	<i>Clupea</i>	<i>harengus</i>	Ib, III	N	Cell culture, ELISA, RT-PCR	ND	Y	N	Y	1	Dixon <i>et al.</i> , 1997; Mortensen <i>et al.</i> , 1999; King <i>et al.</i> , 2001a
Atlantic salmon	<i>Salmo</i>	<i>salar</i>	Ia, Ib, II, III, IVa	N, E	Cell culture, ELISA and RT-PCR, IHC	Y	Y	Y	Y	1	King <i>et al.</i> , 2001b, Lovy <i>et al.</i> , 2013
Atlantic stargazer	<i>Uranoscopus</i>	<i>scaber</i>	Ie	N	Cell culture, ELISA and PCR	ND	Y	N	Y	1	Ogut & Altuntas, 2014
Ballan wrasse	<i>Labrus</i>	<i>bergylta</i>	III	N	Virus isolation, ELISA, RT-PCR and sequencing	ND	Y	y	Y	1	Hall <i>et al.</i> , 2012; Munro <i>et al.</i> , 2015

Annex I (contd)

Common name	Genus	Species	Genotype	Stage 1: Transmission	Stage 2: Pathogen identification	Stage 3: Evidence for infection				Outcome	References
						A	B	C	D		
Bastard halibut	<i>Paralichthys</i>	<i>olivaceus</i>	IVa	N	Viral isolation, PCR, cell culture	ND	Y	ND	Y	1	Isshiki <i>et al.</i> , 2001; Takano <i>et al.</i> , 2000 and 2001
Black crappie	<i>Pomoxis</i>	<i>nigromaculatus</i>	IVb	N	Virus isolation, PCR, sequencing	ND	Y	ND	Y	1	Faisal, 2012; USGS/NACSE database
Blue Whiting	<i>Micromesistius</i>	<i>poutassou</i>	Ib, III	N	Cell culture, ELISA and PCR	N	Y	N	Y	1	Mortensen <i>et al.</i> , 1999; Brudeseth <i>et al.</i> , 2002
Bluegill	<i>Lepomis</i>	<i>macrochirus</i>	IV, IVb	N	Virus isolation RT-PCR, IHC	Y	Y	Y	Y	1	Al-Hussinee <i>et al.</i> , 2011; Department of Wisconsin Natural Resources, 2007
Bluntnose minnow	<i>Pimephales</i>	<i>notatus</i>	IVb	N	VI, RT-PCR	ND	Y	N	Y	1	Frattini, 2011; Department of Wisconsin Natural Resources, 2007
Brown bullhead	<i>Ameiurus</i>	<i>nebulosus</i>	IVb	N	Virus isolation, RT-PCR, sequencing	ND	Y	N	Y	1	Faisal <i>et al.</i> , 2012; USGS/NACSE database
Brown trout	<i>Salmo</i>	<i>trutta</i>	Ia, Ib	N	Virus isolation	ND	Y	Y	N	1	Ogut & Altunas, 2011; Jørgensen, 1980
Chinook salmon	<i>Oncorhynchus</i>	<i>tshawytscha</i>	IVa, IVb	N	Cell culture, sequencing	ND	Y	ND	Y	1	Faisal <i>et al.</i> , 2012; Garver <i>et al.</i> , 2013
Coho salmon	<i>Oncorhynchus</i>	<i>kisutch</i>	IVa	N	Cell culture, neutralization and immunoblot assay	ND	Y	N	Y	1	Winton <i>et al.</i> , 1989; Meyers & Winton, 1995

Annex I (contd)

Common name	Genus	Species	Genotype	Stage 1: Transmission	Stage 2: Pathogen identification	Stage 3: Evidence for infection				Outcome	References
						A	B	C	D		
Common dab	<i>Limanda</i>	<i>limanda</i>	Ib	N	Cell culture, ELISA	ND	Y	N	Y	1	Skall <i>et al.</i> , 2005
Common whitefish	<i>Coregonus</i>	<i>lavaretus</i>	Ia	N/E	Virus isolation, ELISA, cell culture and neutralization	ND	Y	Y	Y	1	Meier <i>et al.</i> , 1986; Skall <i>et al.</i> , 2004
Corkwing wrasse	<i>Symphodus</i>	<i>melops</i>	III	N	Virus isolation, ELISA, RT-PCR and sequencing	ND	Y	y	Y	1	Hall <i>et al.</i> , 2012; Munro <i>et al.</i> , 2015
Cuckoo wrasse	<i>Labrus</i>	<i>mixtus</i>	III	N	Virus isolation, ELISA, RT-PCR and sequencing	ND	Y	y	Y	1	Hall <i>et al.</i> , 2012; Munro <i>et al.</i> , 2015
Emerald shiner	<i>Notropis</i>	<i>atherinoides</i>	IVb	N	Cell culture and PCR	ND	Y	Y	Y	1	Boonthai <i>et al.</i> , 2018
Eulachon	<i>Thaleichthys</i>	<i>pacificus</i>	IVa	N	Cell culture and RT-PCR	ND	Y	N	N	1	Hedrick <i>et al.</i> , 2003
European anchovy	<i>Engraulis</i>	<i>encrasicolus</i>	Ie	N	Cell culture, ELISA and PCR	ND	Y	N	Y	1	Ogut & Altuntas, 2014
European Flounder	<i>Platichthys</i>	<i>flesus</i>	Ib	N	Cell culture, ELISA	ND	Y	N	Y	1	Skall <i>et al.</i> , 2005

Annex I (contd)

Common name	Genus	Species	Genotype	Stage 1: Transmission	Stage 2: Pathogen identification	Stage 3: Evidence for infection				Outcome	References
						A	B	C	D		
European plaice	<i>Pleuronectes</i>	<i>platessa</i>	III	N	Cell culture, ELISA, sequencing	ND	Y	N	Y	1	Skall <i>et al.</i> , 2005; Wallace <i>et al.</i> , 2015
European sprat	<i>Sprattus</i>	<i>sprattus</i>	Ib	N	Cell culture, ELISA and PCR	N	Y	N	Y	1	Mortensen <i>et al.</i> , 1999; Skall <i>et al.</i> , 2005
Fathead Minnow	<i>Pimephales</i>	<i>promelas</i>	IVb	E	Virus isolation, RT-PCR, IHC	Y	Y	Y	Y	1	Al-Hussinee <i>et al.</i> , 2010
Freshwater drum	<i>Aplodinotus</i>	<i>grunniens</i>	IVb	N	Virus Isolation, Rt-PCR, IHC	Y	Y	Y	Y	1	Lumsden <i>et al.</i> , 2007; Al-Hussinee & Lumsden, 2011
Goldsinny wrasse	<i>Ctenolabrus</i>	<i>rupestris</i>	III	N/E	Virus isolation, ELISA, RT-PCR and sequencing	Y	Y	Y	Y	1	Munro <i>et al</i> 2015; Matejusova <i>et al.</i> , 2016
Grayling	<i>Thymallus</i>	<i>thymallus</i>	I	N/E	Cell culture, neutralization, IFAT	ND	Y	Y	ND	1	Meier & Wahli, 1988
Lake cisco	<i>Coregonus</i>	<i>artedi</i>	IVb	N/E	Cell culture, PCR/sequence	Y	Y	Y	Y	1	Weeks <i>et al.</i> , 2011; USGS/NACSE database
Lake trout	<i>Salvelinus</i>	<i>namaycush</i>	Ia, IVa, IVb	N/E	Virus isolation, sequencing	ND	Y	Y	Y	1	Dorson <i>et al.</i> , 1991; USGS/NACSE database
Lake whitefish	<i>Coregonus</i>	<i>clupeaformis</i>	IVb	N	Virus isolation, RT-PCR, sequencing	ND	Y	Y	Y	1	Faisal 2012; USGS/NACSE database
Largemouth bass	<i>Micropterus</i>	<i>salmoides</i>	IVb	N/E	Virus isolation, RT-PCR, sequencing	ND	Y	ND	Y	1	Faisal, 2012; Throckmorton <i>et al.</i> , 2017
Lumpfish	<i>Cyclopterus</i>	<i>lumpus</i>	IVd	N/E	Virus isolation, RT-PCR and sequencing	y	Y	Y	Y	1	Guðmundsdóttir <i>et al.</i> , 2018

Annex I (contd)

Common name	Genus	Species	Genotype	Stage 1: Transmission	Stage 2: Pathogen identification	Stage 3: Evidence for infection				Outcome	References
						A	B	C	D		
Marble trout	<i>Salmo</i>	<i>marmoratus</i>	Ia	E	Cell culture and RT-PCR	ND	Y	Y	Y	1	Pascoli <i>et al.</i> , 2015
Mediterranean horse mackerel	<i>Trachurus</i>	<i>mediterraneus</i>	Ie	N	Cell culture, ELISA and PCR	ND	Y	N	Y	1	Ogut & Altuntas, 2014
Mummichog	<i>Fundulus</i>	<i>heteroclitus</i>	IVc	N	Virus identification, RT-PCR, sequencing, serum neutralization	ND	Y	Y	Y	1	Gagne <i>et al.</i> , 2007
Muskellunge	<i>Esox</i>	<i>masquinongy</i>	IVb	N/E	Virus isolation, RT-PCR, IHC, cell culture	Y	Y	Y	Y	1	Al-Hussinee & Lumsden, 2011; Kim & Faisal, 2012
Northern pike	<i>Esox</i>	<i>lucius</i>	IVb	N	Virus isolation, RT-PCR, sequencing	ND	Y	Y	Y	1	Faisal, 2012
Norway pout	<i>Trisopterus</i>	<i>esmarkii</i>	III, Ib	N	Cell culture, ELISA and PCR	N	Y	N	Y	1	Mortensen <i>et al.</i> , 1999; King <i>et al.</i> , 2001a
Pacific chub mackerel	<i>Scomber</i>	<i>japonicus</i>	IVa	N	Cell culture RT-PCR	ND	Y	N	Y	1	Hedrick <i>et al.</i> , 2003
Pacific cod	<i>Gadus</i>	<i>macrocephalus</i>	IVa	N	Neutralization, immunoblot assay, DNA probe	ND	Y	N	Y	1	Meyers <i>et al.</i> , 1992; Meyers & Winton, 1995
Pacific herring	<i>Clupea</i>	<i>pallasii pallasii</i>	IVa	N	Cell culture and neutralisation	N	Y	Y	Y	1	Meyers <i>et al.</i> , 1993; Meyers <i>et al.</i> , 1994
Pacific sand lance	<i>Ammodytes</i>	<i>hexapterus</i>	IVa	N/E	Cell culture	Y	Y	Y	Y	1	Kocan <i>et al.</i> , 2001

Annex I (contd)

Common name	Genus	Species	Genotype	Stage 1: Transmission	Stage 2: Pathogen identification	Stage 3: Evidence for infection				Outcome	References
						A	B	C	D		
Pilchard	<i>Sardina</i>	<i>pilchardus</i>		N	Cell culture, ELISA and PCR	ND	Y	N	Y	1	Ogut & Altuntas, 2014
Pontic shad	<i>Alosa</i>	<i>immaculata</i>	le	N	Cell culture, ELISA and PCR	ND	Y	N	Y	1	Ogut & Altuntas, 2014
Pumpkinseed	<i>Lepomis</i>	<i>gibbosus</i>	IVb	N	Cell culture, RT- PCR	ND	Y	N	Y	1	Cornwell <i>et al.</i> , 2015
Rainbow trout	<i>Oncorhynchus</i>	<i>mykiss</i>	la-e, III, IVb	E	Virus isolation, RT-PCR, IHC	Y	Y	Y	Y	1	Dale <i>et al.</i> , 2009
Rainbow trout X coho salmon hybrids	<i>Oncorhynchus</i>	<i>mykiss X kisutch</i>	la	E	Cell culture	Y	Y	Y	Y	1	Ord <i>et al.</i> , 1976
Red mullet	<i>Mullus</i>	<i>barbatus</i>	le	N	Cell culture, ELISA and PCR	ND	Y	N	Y	1	Ogut & Altuntas, 2014
River lamprey	<i>Lampetra</i>	<i>fluviatilis</i>	II	N	VI, RT-PCR, sequencing	ND	Y	N	Y	1	Gadd <i>et al.</i> , 2010
Rock bass	<i>Ambloplites</i>	<i>rupestris</i>	IVb	N	Cell culture, RT- PCR	ND	Y	N	Y	1	Cornwell <i>et al.</i> , 2015
Rock cook wrasse	<i>Centrolabrus</i>	<i>exoletus</i>	III	N	Virus isolation, ELISA, RT-PCR and sequencing	ND	Y	y	Y	1	Hall <i>et al.</i> , 2012; Munro <i>et al.</i> , 2015
Round goby	<i>Neogobius</i>	<i>melanostomus</i>	IVb	N	Cell culture, RT- PCR	ND	Y	Y	Y	1	Groocock <i>et al.</i> , 2007
Sand goby	<i>Pomatoschistus</i>	<i>minutus</i>	Ib	N	Cell culture ELISA	ND	Y	N	Y	1	Skall <i>et al.</i> , 2005a
Senegalese sole	<i>Solea</i>	<i>senegalensis</i>	III	N	Cell culture, ELISA and PCR	ND	Y	Y	Y	1	Lopez-Vazquez <i>et al.</i> , 2011

Annex I (contd)

Common name	Genus	Species	Genotype	Stage 1: Transmission	Stage 2: Pathogen identification	Stage 3: Evidence for infection				Outcome	References
						A	B	C	D		
Shiner perch	<i>Cymatogaster</i>	<i>aggregata</i>	IVa	N	Neutralization, IFAT	ND	Y	Y	Y	1	Meyers & Winton, 1995
Smallmouth bass	<i>Micropterus</i>	<i>dolomieu</i>	IVb	N	Virus isolation RT-PCR, IHC	Y	Y	Y	Y	1	Al-Hussinee <i>et al.</i> , 2011
South American pilchard	<i>Sardinops</i>	<i>sagax</i>	IVa	N/E	Cell culture PCR	ND	Y	Y	Y	1	Traxler <i>et al.</i> , 1999; Hedrick <i>et al.</i> , 2003
Spottail shiner	<i>Notropis</i>	<i>hudsonius</i>	IVb	N/IP	Virus isolation, PCR, sequencing	ND	Y	N	Y	1	Faisal, 2012
Striped bass	<i>Morone</i>	<i>saxatilis</i>	IVb, IVc	N	VI, RT-PCR, sequencing, serum neutralization	ND	Y	N	Y	1	Gagne <i>et al.</i> , 2007
Thornback ray	<i>Raja</i>	<i>clavata</i>	Ie	N	Cell culture, ELISA and PCR	ND	Y	N	Y	1	Ogut & Altuntas, 2014
Three-bearded rockling	<i>Gaidropsarus</i>	<i>vulgaris</i>	Ie	N	Cell culture, ELISA and PCR	ND	Y	N	Y	1	Ogut & Altuntas, 2014
Three-spine stickleback	<i>Gasterosteus</i>	<i>aculeatus</i>	IVc	N	VI, RT-PCR, sequencing, serum neutralization	ND	Y	Y	Y	1	Gagne <i>et al.</i> , 2007
Turbot	<i>Psetta</i>	<i>maxima</i>	Ib, III	N	Cell culture, ELISA and PCR	Y	Y	Y	Y	1	King <i>et al.</i> , 2001b; Snow & Smail, 1999

Annex I (contd)

Common name	Genus	Species	Genotype	Stage 1: Transmission	Stage 2: Pathogen identification	Stage 3: Evidence for infection				Outcome	References
						A	B	C	D		
Walleye	<i>Sander</i>	<i>vitreum</i>	IVb	N	Virus isolation, PCR, sequencing	ND	Y	Y	Y	1	Faisal, 2012
White Bass	<i>Morone</i>	<i>chrysops</i>	IVb	N	Virus isolation, sequencing	ND	Y	ND	Y	1	Bain <i>et al.</i> , 2010; USGS/NACSE database
White Perch	<i>Morone</i>	<i>americana</i>	IVb	N	qRT-PCR and cell culture	N	Y	N	Y	1	Bain <i>et al.</i> , 2010; USGS/NACSE database
Whiting	<i>Merlangius</i>	<i>merlangus</i>	Ie	N	Cell culture, ELISA and PCR	ND	Y	N	Y	1	Ogut & Altuntas, 2014
Yellow perch	<i>Perca</i>	<i>flavescens</i>	IVb	N	Virus isolation, qRT-PCR	ND	Y	Y	Y	1	Olson <i>et al.</i> , 2013
Zebra fish	<i>Danio</i>	<i>rerio</i>	IVa	E	VI, RT-PCR	ND	Y	Y	Y	1	Cho <i>et al.</i> , 2019; Novoa <i>et al.</i> , 2006
Score 2											
Alaska pollock	<i>Theragra</i>	<i>chalcogramma</i>	IVa	N	Cell culture and PCR	ND	Y	Y	Y	2	Meyers <i>et al.</i> , 1999
Alewife	<i>Alosa</i>	<i>pseudoharengus</i>	IVb	N	RT-PCR	ND	N	N	Y	2	Cornwell <i>et al.</i> , 2015
Arctic charr	<i>Salvelinus</i>	<i>alpinus</i>	Ia	N	Virus isolation, IFAT	N	Y	N	Y	2	Knuesel <i>et al.</i> , 2003
Armoured cusk	<i>Hoplobrotula</i>	<i>armata</i>	IV	N	PCR	ND	N	N	Y	2	Lee <i>et al.</i> , 2007
Atlantic Halibut	<i>Hippoglossus</i>	<i>hippoglossus</i>	III	E	Cell culture and ELISA	ND	Y	Y	Y	2	Bowden <i>et al.</i> , 2003
Banded Killifish	<i>Fundulus</i>	<i>diaphanus</i>	IVb	N	qRT-PCR and cell culture	N	N	N	Y	2	Bain <i>et al.</i> , 2010
Black scorpionfish	<i>Scorpaena</i>	<i>porcus</i>	Ie	N	Cell culture, ELISA and PCR	ND	Y	N	Y	2	Ogut & Altuntas, 2014
Blackfin flounder	<i>Glyptocephalus</i>	<i>stelleri</i>	IVa	N	PCR	ND	N	N	Y	2	Lee <i>et al.</i> , 2007

Annex I (contd)

Common name	Genus	Species	Genotype	Stage 1: Transmission	Stage 2: Pathogen identification	Stage 3: Evidence for infection				Outcome	References
						A	B	C			
Brook trout	<i>Salvelinus</i>	<i>fontinalis</i>	1e	E	Virus isolation, ELISA	ND	Y	N	N	2	Ogut & Altunas, 2011
Burbot	<i>Lota</i>	<i>lota</i>	IVb	N	Cell culture, sequencing	ND	Y	ND	Y	2	Department of Wisconsin Natural Resources, 2007
Channel catfish	<i>Ictalurus</i>	<i>punctatus</i>	IVb	N	Cell culture, sequencing	ND	Y	N	Y	2	USGS/NACSE database
Cloudy catshark	<i>Scyliorhinus</i>	<i>torazame</i>	IV	N	PCR	ND	N	N	Y	2	Lee <i>et al.</i> , 2007
Cubed snailfish	<i>Liparis</i>	<i>tessellatus</i>	IV	N	PCR	ND	N	N	Y	2	Lee <i>et al.</i> , 2007
European eel	<i>Anguilla</i>	<i>anguilla</i>	III	N	Viral isolation, neutralization test	ND	Y	ND	N D	2	Jorgensen <i>et al.</i> , 1994
European sea bass	<i>Dicentrarchus</i>	<i>labrax</i>	1e	E	Cell cultivature and ELISA	ND	N	N	Y	2	Ogut & Altuntas 2014
Fallfish	<i>Semotilus</i>	<i>corporalis</i>	IVb	N	RT-PCR	ND	N	N	Y	2	Cornwell <i>et al.</i> , 2015
Flathead grey mullet	<i>Mugil</i>	<i>cephalus</i>	IVa	N	PCR	ND	N	N	Y	2	Lee <i>et al.</i> , 2007
Fourbeard rockling	<i>Enchelyopus</i>	<i>cimbrius</i>	1b	N	Cell culture, ELISA	ND	Y	N	Y	2	Mortensen <i>et al.</i> , 1999
Garfish	<i>Belone</i>	<i>belone</i>	1e	N	Cell culture, ELISA and PCR	ND	Y	N	Y	2	Ogut & Altuntas, 2014
Golden shiner	<i>Notemigonus</i>	<i>crysoleucas</i>	IVb	N	RT-PCR	ND	N	N	Y	2	Cornwell <i>et al.</i> , 2015
Gray gurnard	<i>Eutrigla</i>	<i>gurnardus</i>	III	N	Cell culture, ELISA, sequencing	ND	Y	N	Y	2	Wallace <i>et al.</i> , 2015
Greater amberjack	<i>Seriola</i>	<i>dumerili</i>	IVa	N	PCR, cell culture, IFAT	ND	Y	Y	Y	2	OIE, 2013

Annex I (contd)

Common name	Genus	Species	Genotype	Stage 1: Transmission	Stage 2: Pathogen identification	Stage 3: Evidence for infection				Outcome	References
						A	B	C			
Greenland halibut	<i>Reinhardtius</i>	<i>hippoglossoides</i>	III	N	Cell culture, IFAT, RT-PCR	ND	Y	N	Y	2	Dopazo <i>et al.</i> , 2002
Haddock	<i>Melanogrammus</i>	<i>aeglefinus</i>	III	N	Cell culture IFAT and ELISA	ND	Y	N	N	2	Smail, 2000
Izu scorpionfish	<i>Scorpaena</i>	<i>izensis</i>	IV	N	PCR	ND	N	N	Y	2	Lee <i>et al.</i> , 2007
Japanese fluvial sculpin	<i>Cottus</i>	<i>pollux</i>	IVb	E	RT-PCR and cell culture	ND	Y	Y	Y	2	Ito & Olesen, 2013
Japanese rice fish	<i>Oryzias</i>	<i>latipes</i>	IVb	E	RT-PCR and cell culture	ND	Y	Y	Y	2	Ito & Olesen, 2013
Largehead hairtail	<i>Trichiurus</i>	<i>lepturus</i>	IVa	N	PCR	ND	N	N	Y	2	Lee <i>et al.</i> , 2007
Lesser Argentine	<i>Argentina</i>	<i>sphyraena</i>	Ib	N	Cell culture, ELISA and PCR	N	Y	N	Y	2	Mortensen <i>et al.</i> , 1999
Marine medaka	<i>Oryzias</i>	<i>dancena</i>	IVa	E	Ref. strain FYoesu05	ND	Y	Y	ND	2	Wi-Sik Kim <i>et al.</i> , 2013 (Marine medaka)
North Pacific hake	<i>Merluccius</i>	<i>productus</i>	IVa	N	Cell culture and neutralisation	N	Y	Y	Y	2	Meyers <i>et al.</i> , 1999
Poor cod	<i>Trisopterus</i>	<i>minutus</i>	III	N	Virus isolation, cell culture and ELISA	ND	Y	ND	Y	2	King <i>et al.</i> , 2001a
Rainbow trout X arctic charr hybrids	<i>Oncorhynchus X Salvelinus</i>	<i>mykiss X alpinus</i>	Ia	E	Ref strains (07- 71, 34-86, 23-75)	ND	Y	Y	Y	2	Dorson <i>et al.</i> , 1991
Rainbow trout X lake trout hybrids	<i>Oncorhynchus X Salvelinus</i>	<i>mykiss X namaycush</i>	Ia	E	Ref strains (07- 71, 34-86, 23-75)	ND	ND	Y	ND	2	Dorson <i>et al.</i> , 1991
Rainbow trout X brown trout hybrids	<i>Oncorhynchus X Salmo</i>	<i>mykiss X trutta</i>	Ia	E	Ref strains (07- 71, 34-86, 23-75)	ND	N	Y	N	2	Dorson <i>et al.</i> , 1991

Annex I (contd)

Common name	Genus	Species	Genotype	Stage 1: Transmission	Stage 2: Pathogen identification	Stage 3: Evidence for infection				Outcome	References
						A	B	C			
Sandeel	<i>Ammodytes</i>	<i>personatus</i>	Ib	N	Cell culture ELISA	ND	Y	N	Y	2	Skall <i>et al.</i> , 2005
Shorthead redhorse	<i>Moxostoma</i>	<i>macrolepidotum</i>	IVb	E	Virus isolation, RT-PCR, sequencing	ND	Y	Y	Y	2	Bowser, 2009
Silver pomfret	<i>Pampus</i>	<i>argenteus</i>	IV	N	PCR	ND	N	N	Y	2	Lee <i>et al.</i> , 2007
Silver redhorse	<i>Moxostoma</i>	<i>anisurum</i>	IVb	N	Virus isolation, RT-PCR, sequencing	ND	Y	Y	N	2	Faisal, 2012
Silvery pout	<i>Gadiculus</i>	<i>argenteus</i>	Ib	N	RT-PCR, sequencing	ND	N	N	Y	2	Sandlund <i>et al.</i> , 2014
Striped mullet	<i>Mugil</i>	<i>cephalus</i>	IVa	N	Viral isolation, PCR	ND	Y	ND	Y	2	Kim & Park, 2004
Surf smelt	<i>Hypomesus</i>	<i>pretiosus</i>	ND	N/E	Cell culture and RT-PCR	ND	Y	Y	Y	2	Hedrick <i>et al.</i> , 2003
Tiger muskellunge X Northern pike hybrids	<i>Esox</i>	<i>masquinongy X lucius</i>	IVb	N	Cell culture, PCR	ND	Y	N	Y	2	Getchell <i>et al.</i> , 2013
Trout Perch	<i>Percopsis</i>	<i>omiscomaycus</i>	IVb	N	Virus isolation, sequencing	ND	Y	ND	Y	2	USGS/NACSE database
White Crappie	<i>Pomoxis</i>	<i>annularis</i>	IVb	N	Virus isolation RT-PCR, IHC	Y	Y	Y	Y	2	Al-Hussinee <i>et al.</i> , 2011
White sucker	<i>Catostomus</i>	<i>commersonii</i>	IVb	N	RT-PCR, sequencing	ND	N	N	Y	2	Cornwell <i>et al.</i> , 2011
Yellow croaker	<i>Larimichthys</i>	<i>polyactis</i>	IV	N	PCR	ND	N	N	Y	2	Lee <i>et al.</i> , 2007
Yoshinobori (Japanese goby)	<i>Rhinogobius</i>	<i>Sp.</i> (undescribed species)	IVb	N	Virus isolation, RT-PCR	ND	Y	Y	Y	2	Ito & Olesen, 2013

Annex I (contd)

Common name	Genus	Species	Genotype	Stage 1: Transmission	Stage 2: Pathogen identification	Stage 3: Evidence for infection			Outcome	References	
						A	B	C			
Score 3											
Black cod = Sablefish	<i>Anoplopoma</i>	<i>fimbria</i>		N	PCR	ND	ND	ND	Y	3	Hedrick <i>et al.</i> , 2003
Score 4											
No species were found to be non-susceptible to infection with VHSV											
Vectors											
Amphipod	<i>Hyalella</i>	<i>spp.</i>	IVb	N	rRT-PCR	ND	N	N	N	3	Throckmorton <i>et al.</i> , 2017
Amphipod	<i>Diporeia</i>	<i>ssp.</i>	IVb	N	Virus isolation, RT-PCR, sequencing	ND	Y	N	N	3	Faisal & Winters, 2011
Common snapping turtle	<i>Chelydra</i>	<i>serpentina</i>	IVb	IP/E	RT-PCR	ND	N	N	Y	2	Goodwin & Merry, 2011
Leech	<i>Myzobdella</i>	<i>lugubris</i>	IVb	N	Virus isolation, RT-PCR, sequencing	ND	Y	N	N	3	Faisal & Schultz, 2009
Northern map turtle	<i>Graptemys</i>	<i>geographica</i>	IVb	IP/E	Cell culture, RT- PCR	ND	Y	N	Y	2	Goodwin & Merry, 2011
Water flea	<i>Moina</i>	<i>macrocopa</i>	Ia	N	Cell culture and RT-PCR	N	Y	N	N	3	Ito & Olesen, 2017
Species that were assessed but not scored due to insufficient or absence of scientific evidence											
Black rockfish	<i>Sebastes</i>	<i>inermis</i>									
Blackhead seabream	<i>Acanthopagrus</i>	<i>schlegeli</i>									
Chum salmon	<i>Oncorhynchus</i>	<i>keta</i>									
English sole	<i>Parophrys</i>	<i>vetulus</i>									

Annex I (contd)

Common name	Genus	Species	Genotype	Stage 1: Transmission	Stage 2: Pathogen identification	Stage 3: Evidence for infection			Outcome	References
						A	B	C		
Golden trout	<i>Oncorhynchus</i>	<i>aguabonita</i>								
Goldfish	<i>Carassius</i>	<i>auratus</i>								
Hong Kong grouper	<i>Epinephelus</i>	<i>akaara</i>				Not scored				
Japanese amberjack	<i>Seriola</i>	<i>quinqueradiata</i>				Not scored				
Korean rockfish	<i>Sebastes</i>	<i>schlegeli</i>				Not scored				
Marbled flounder	<i>Pleuronectes</i>	<i>yokohamae</i>				Not scored				
Pacific lamprey	<i>Entosphenus</i>	<i>tridentatus</i>				Not scored				
Red sea bream	<i>Pagrus</i>	<i>major</i>				Not scored				
Sea lamprey	<i>Petromyzon</i>	<i>marinus</i>				Not scored				
Sockeye salmon	<i>Oncorhynchus</i>	<i>nerka</i>				Not scored				
Splake: Hybride (<i>Salvelinus</i> <i>namaycush</i> x <i>Salvelinus</i> <i>fontinalis</i>)	<i>Salvelinus</i>	<i>namaycush</i> X <i>fontinalis</i>				Not scored				
Tube-snout	<i>Aulorhynchus</i>	<i>flavidus</i>				Not scored				
Yellowback seabream	<i>Dentex</i>	<i>tumifrons</i>				Not scored				

The common names of fish species are in line with FAOTERM (<http://www.fao.org/faoterm/collection/faoterm/en/>) and scientific fish names with the Fishbase (<https://www.fishbase.se/search.php>). Where the common fish name was not found in FAOTERM the species naming was done in line with the Fishbase.

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**REPORT OF THE OIE AD HOC GROUP ON SUSCEPTIBILITY
OF FISH SPECIES TO INFECTION WITH OIE LISTED DISEASES**

November 2018–September 2019

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**REPORT OF OF THE OIE *AD HOC* GROUP ON SUSCEPTIBILITY OF
FISH SPECIES TO INFECTION WITH OIE LISTED DISEASES
November 2018–September 2019**

Terms of reference

Background

A new Chapter 1.5. ‘Criteria for listing species as susceptible to infection with a specific pathogen’ was introduced in the 2014 edition of the *Aquatic Code*. The purpose of this chapter is to provide criteria for determining which host species are listed as susceptible in Article X.X.2. of each disease-specific chapter in the *Aquatic Code*. The criteria are to be applied progressively to each disease-specific chapter in the *Aquatic Code*.

These assessments will be undertaken by *ad hoc* Groups and the assessments will be provided to Member Countries for comment prior to any change in the list of susceptible species in Article X.X.2. of the disease-specific chapters in the *Aquatic Code*.

For species where there is some evidence of susceptibility but insufficient evidence to demonstrate susceptibility through the approach described in Article 1.5.3., information will be included in the relevant disease-specific chapter in the *Aquatic Manual*.

Purpose

The *ad hoc* Group on Susceptibility of fish species to infection with OIE listed diseases will undertake assessments for the ten OIE listed fish diseases.

Terms of Reference

1. Consider evidence required to satisfy the criteria in Chapter 1.5.
2. Review relevant literature documenting susceptibility of species for OIE listed fish diseases.
3. Propose susceptible species for OIE listed diseases for fish based on Article 1.5.7.
4. Propose susceptible species for OIE listed diseases for fish based on Article 1.5.8.

Expected outputs of the *ad hoc* Group

1. Develop a list of susceptible species for inclusion in the relevant Article X.X.2. of fish disease-specific chapters in the *Aquatic Code*.
 2. Develop a list of species with incomplete evidence for susceptibility for inclusion in Section 2.2.2. of the *Aquatic Manual*.
 3. Draft a report for consideration by the Aquatic Animals Commission at their September 2019 meeting.
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