

AUSTRALIAN AQUATIC VETERINARY EMERGENCY PLAN

# **AQUAVETPLAN**

## **Disease Strategy**

### **Infectious salmon anaemia**

#### **Version 1.0, 2009**

AQUAVETPLAN is a series of technical response plans that describe the proposed Australian approach to aquatic animal disease incursions. The documents provide guidance based on sound analysis, linking policy, strategies, implementation, coordination and emergency-management plans.

**Primary Industries Ministerial Council**

**This disease strategy forms part of:**

**AQUAVETPLAN**

**This strategy will be reviewed regularly. Suggestions and recommendations for amendments should be forwarded to:**

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**AQUAVETPLAN is available on the internet at:**  
<http://www.daff.gov.au/animal-plant-health/aquatic/aquavetplan>

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**IMPORTANT NOTE:** Important regulatory information for infectious salmon anaemia is contained in the *OIE Aquatic Animal Health Code (OIE 2007a)*, which is updated annually and is available on the internet at the OIE website: [http://www.oie.int/eng/normes/fcode/en\\_sommaire.htm](http://www.oie.int/eng/normes/fcode/en_sommaire.htm). Further details are given in Appendix 1 of this manual.

**DISEASE WATCH HOTLINES**

These telephone numbers connect callers to the relevant state or territory officer to report concerns about any potential emergency disease situation. Anyone suspecting an emergency disease outbreak should use this number for immediate advice and assistance.

|                        |  |                           |                     |
|------------------------|--|---------------------------|---------------------|
| <b>New South Wales</b> | <b>1800 675 888</b>  | <b>Northern Territory</b> | <b>1800 720 002</b> |
| <b>Queensland</b>      | <b>07 3830 8550 (after hours)<br/>13 25 23 (DPI&amp;F Call Centre Mon–Fri, business hours)</b> | <b>Victoria</b>           | <b>1800 675 888</b> |
| <b>South Australia</b> | <b>1800 065 522</b>  | <b>Western Australia</b>  | <b>1800 815 507</b> |
| <b>Tasmania</b>        | <b>1800 675 888</b>  |                           |                     |

# Preface

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This disease strategy for the control and eradication of infectious salmon anaemia (ISA) is an integral part of the **Australian Aquatic Veterinary Emergency Plan**, or **AQUAVETPLAN**.

AQUAVETPLAN disease strategy manuals are response manuals and do not include information about preventing the introduction of disease.

The Australian Quarantine and Inspection Service (AQIS) provides quarantine inspection for international passengers, cargo, mail, animals, plants and animal or plant products arriving in Australia, and inspection and certification for a range of agricultural products exported from Australia. Quarantine controls at Australia's borders minimise the risk of entry of exotic pests and diseases, thereby protecting Australia's favourable human, animal and plant health status. Information on current import conditions can be found at the AQIS Import Conditions (ICON) website.<sup>1</sup>

This strategy sets out the disease control principles for use in an aquatic veterinary emergency incident caused by the suspicion or confirmation of ISA in Australia. The strategy was scientifically reviewed by the National Aquatic Animal Health Technical Working Group of the Aquatic Animal Health Committee, before being endorsed by:

- the Aquatic Animal Health Committee of the Primary Industries Standing Committee in March, 2008
- the Primary Industries Standing Committee, out of session PISC-15, in August, 2008.

Infectious salmon anaemia is listed as a notifiable disease in *Australia's National List of Reportable Diseases of Aquatic Animals* (DAFF 2008a)<sup>2</sup> and by the World Organisation for Animal Health (OIE; formerly Office International des Epizooties) in the *Aquatic Animal Health Code* (OIE 2007a).<sup>3</sup>

Detailed instructions for the field implementation of AQUAVETPLAN are contained in the disease strategies, operational procedures manuals and management manuals. Industry-specific information is given in the enterprise manual. The full list of AQUAVETPLAN manuals that may need to be accessed in an emergency is shown below:

#### **Disease strategies**

Individual strategies for each disease

#### **Operational procedures manuals**

Disposal  
Destruction  
Decontamination

#### **Management manual**

Control centres management

#### **Enterprise manual**

Includes sections on:

- open systems
- semi-open systems
- semi-closed systems
- closed systems

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<sup>1</sup> <http://www.aqis.gov.au/icon32/asp/homecontent.asp>

<sup>2</sup> [http://www.daff.gov.au/\\_data/assets/word\\_doc/0003/346521/reportable-diseases-aquatic17nov2008.doc](http://www.daff.gov.au/_data/assets/word_doc/0003/346521/reportable-diseases-aquatic17nov2008.doc)

<sup>3</sup> [http://www.oie.int/eng/normes/fcode/en\\_sommaire.htm](http://www.oie.int/eng/normes/fcode/en_sommaire.htm)

*Aquatic Animal Diseases Significant to Australia: Identification Field Guide* (DAFF 2008b)<sup>4</sup> is a source of information about the aetiology, diagnosis and epidemiology of infection with infectious salmon anaemia virus and should be read in conjunction with this strategy.

This manual was drafted by Dr Mark Crane, AAHL Fish Diseases Laboratory, CSIRO Livestock Industries, Geelong. However, the text was amended at various stages of the consultation and endorsement process, and the policies expressed in this version do not necessarily reflect the views of the author. Contributions made by Drs Iska Sampson and Eva-Maria Bernoth, Department of Agriculture, Fisheries and Forestry, and others not mentioned here are also gratefully acknowledged.

The format of this manual was adapted from similar manuals in AUSVETPLAN (the Australian veterinary emergency plan for terrestrial animal diseases) and from the AQUAVETPLAN **Enterprise Manual**. The format and content have been kept as similar as possible to these documents, in order to enable animal health professionals trained in AUSVETPLAN procedures to work efficiently with this document in the event of an aquatic veterinary emergency. The work of the AUSVETPLAN writing teams and the permission to use the original AUSVETPLAN documents are gratefully acknowledged.

Scientific editing was by Biotext Pty Ltd, Canberra.

The revised manual has been reviewed and approved by the following representatives of government and industry:

**Government**

Department of Primary Industries and  
Water, Tasmania  
Department of Primary Industries and  
Resources, South Australia  
Biosecurity Australia  
Product Integrity, Animal and Plant Health,  
Australian Government Department of  
Agriculture, Fisheries and Forestry

**Industry**

Tasmanian Salmonid Growers  
Association

The complete series of AQUAVETPLAN documents is available on the internet.<sup>5</sup>

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<sup>4</sup> [http://www.daff.gov.au/animal-plant-health/pests-diseases-weeds/aquatic\\_animal\\_diseases\\_significant\\_to\\_australia\\_identification\\_field\\_guide](http://www.daff.gov.au/animal-plant-health/pests-diseases-weeds/aquatic_animal_diseases_significant_to_australia_identification_field_guide)

<sup>5</sup> <http://www.daff.gov.au/aquavetplan>

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# 1 Nature of the disease

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Infectious salmon anaemia (ISA) is a viral disease that is exotic to Australia. It has the potential to cause large-scale mortality in Australian-farmed Atlantic salmon (*Salmo salar*) populations if an outbreak occurs. Thus, it is important that state and territory governments and the salmonid aquaculture industries are adequately prepared to manage a disease outbreak. An incursion of the disease could devastate the Atlantic salmon aquaculture industry in Australia, centred in Tasmania, and valued at approximately AUS\$310 million in 2007–08 (Pheroze Jungalwalla, Executive Officer, Tasmanian Salmonid Growers Association, pers comm, September 2008).

## 1.1 Aetiology

ISA, first recorded in an Atlantic salmon hatchery in Norway in 1984, is caused by infectious salmon anaemia virus (ISAV), which is an enveloped virus, 100–130 nanometres in diameter, with a genome made up of 8 single-stranded, negative-sense RNA segments. Its morphological, biochemical, and genomic properties place it within the family *Orthomyxoviridae* (Krossøy et al 1999) and it has been classified as the type species of the genus *Isavirus*. In North America, another serious disease affecting Atlantic salmon, haemorrhagic kidney syndrome (HKS), is caused by a North American strain of ISAV (Lovely et al 1999).

The ISAV genome has been fully sequenced (Clouthier et al 2002). Analysis of various gene sequences has revealed differences between European and North American isolates of the virus (Cunningham and Snow 2000, Inglis et al 2000, Ritchie et al 2001). Within these two major groups, isolates can be further typed according to variations within a small, hypervariable region of the haemagglutinin gene (Devold et al 2001, Kibenge et al 2001b, Nylund et al 2003, Cook-Versloot et al 2004) and researchers have suggested that differences in virulence and antigenicity of ISAV strains are associated with these genotypic changes (Cunningham et al 2002).

## 1.2 Susceptible species

The first reported natural outbreak of ISA occurred in a Norwegian Atlantic salmon (*S. salar*) hatchery in 1984 and, since then, there have been further natural outbreaks in farmed Atlantic salmon. There have been no reports of ISA in ISAV-infected wild Atlantic salmon. A summary of the susceptible host species is shown in Table 1. Although fish species other than Atlantic salmon are susceptible to infection with ISAV, only Atlantic salmon develop ISA disease following infection with the virus. Wild fish were surveyed following the 1998 outbreak in farmed salmon in Scotland (Rodger et al 1998). The results revealed subclinical infections of sea trout (*Salmo trutta*; brown trout that have migrated into the sea) from which virus was isolated (5 +ve/203 fish tested). In addition, adult salmon (9 +ve/212 fish tested), salmon parr (5/44 pools [211 fish] tested) and juvenile brown trout (5/29 pools [134 fish] tested) gave positive ISA virus test results by reverse transcriptase polymerase chain reaction (RT-PCR). Twenty-five nonsalmon species (n=1447 fish) were negative by virus isolation and RT-PCR (Raynard et al 2001).

In another survey (MacLean et al 2003), 11 species of nonsalmonid marine fish (n=2970 fish) that are common around coastal Maine and Atlantic salmon culture sites showed negative results for fish in the natural environment. As part of this survey, two of 12 pollock (*Pollachius virens*) sampled from within a cage containing ISA-diseased fish showed a weak positive result by RT-PCR for ISAV. In addition, ISAV was isolated in cell culture inoculated with one of 24 tissue pools (n=5 fish per pool) from cod (*Gadus morhua*) sampled from a well-boat that contained ISA-diseased salmon.

Herring (*Clupea harengus*) has been experimentally infected by immersion in ISAV-contaminated water (Nylund et al 2002). Similarly, rainbow trout (*Oncorhynchus mykiss*) became infected by cohabitation with ISAV-infected salmon (Snow et al 2001b).

Sea and brown trout (*S. trutta*), Arctic char (*Salvelinus alpinus*) and rainbow trout (*O. mykiss*) have all been experimentally infected by intraperitoneal injection of the virus (Snow et al 2001a, Nylund and Jakobsen 1995). No mortalities were associated with infection.

ISAV has also been isolated from farmed coho salmon (*Oncorhynchus kisutch*) in Chile (Kibenge et al 2001a), even though experimental studies indicate that Pacific salmon are relatively resistant to the virus (Rolland and Winton 2003).

**Table 1 Current list of fish species known to be susceptible to infectious salmon anaemia virus**

| <b>Species</b>   | <b>Natural infection</b><br>(natural route—via other infected fish, fish products etc) | <b>Experimental infection</b><br>(intraperitoneal injection) | <b>References</b>   |
|--|--|--|---|
| Atlantic salmon ( <i>Salmo salar</i> )                 | Develop clinical disease   | Develop clinical disease                                     | Evensen et al 1991, Nylund et al 1995, Rimstad et al 1999, Simko et al 2000 |
| Pacific (coho) salmon ( <i>Oncorhynchus kisutch</i> )  | Details of clinical disease not provided   | No clinical disease  | Kibenge et al 2001a, Rolland and Winton 2003                                |
| Pacific (chum) salmon ( <i>Oncorhynchus keta</i> )     | –  | No clinical disease  | Rolland and Winton 2003   |
| Arctic char ( <i>Salvelinus alpinus</i> )              | –  | No clinical disease  | Snow et al 2001a  |
| Sea/brown trout ( <i>Salmo trutta</i> )                | No clinical disease  | No clinical disease  | Nylund and Jakobsen 1995, Rodger et al 1998, Raynard et 2001                |
| Steelhead/rainbow trout ( <i>Oncorhynchus mykiss</i> ) | No clinical disease  | No clinical disease  | Nylund et al 1997, Snow et al 2001ab, Rolland and Winton 2003               |
| Herring ( <i>Clupea harengus</i> )                     | No clinical disease  | –  | Nylund et al 2002   |
| Pollock ( <i>Pollachius virens</i> )                   | No clinical disease  | –  | MacLean et al 2003  |
| Cod ( <i>Gadus morhua</i> )                            | No clinical disease  | –  | MacLean et al 2003  |

– = not detected

### 1.3 World distribution

While orthomyxo-like viruses have been isolated from both wild pilchards (*Sardinops sagax neopilchardus*) and farmed Atlantic salmon in Australia (Dr Mark Crane and colleagues, AAHL Fish Diseases Laboratory, CSIRO Livestock Industries, Geelong, unpublished results), neither ISA nor ISAV are present in Australia. The disease has been reported from Norway since the 1980s (Thorud and Djupvik 1988) and subsequently from Canada (Mullins et al 1998, Bouchard et al 1999), United Kingdom (Scotland) (Rodger et al 1998, Rowley et al 1999), the Faroe Islands (OIE 2006a) and USA (Bouchard et al 2001). The virus has been isolated from coho salmon in Chile (Kibenge et al 2001a) and rainbow trout in Ireland (OIE 2006a).

### 1.4 Diagnosis of infection with ISAV

Detailed diagnostic procedures for ISA and for the detection and isolation of ISAV are detailed in the OIE *Manual of Diagnostic Tests for Aquatic Animals* (OIE 2006a). A brief summary is provided here.

Diagnosis of ISAV infection is based on a range of procedures. Presumptive diagnosis is made following clinical and pathological observations. ISA is

confirmed following histopathological examination, demonstration of ISAV antigen in tissues by immunoassay, virus isolation in tissue culture combined with virus identification by either immunofluorescence or immunoperoxidase staining. PCR techniques are also available. Section 1.4.3 provides further details of confirmatory diagnosis.

#### **1.4.1 Field methods: clinical signs and gross pathology**

As with many infectious agents of fish, ISAV-infected fish may not exhibit clinical signs. Onset of disease can be precipitated by any of a number of host (immune status) or adverse environmental conditions, such as increased temperature or poor water quality (Dannevig and Thorud 1999, OIE 2006a). Although no clinical signs are considered specifically diagnostic (pathognomic) for ISA, the following gross signs and lesions are consistent with ISA (Thorud and Djupvik 1988, Evensen et al 1991, Speilberg et al 1995, Rimstad et al 1999):

- exophthalmia (protrusion of the eyeballs)
- ascites (distended abdomen due to fluid in peritoneal and pericardial cavities)
- anaemia
- congestion and enlargement of the liver and spleen
- congestion of the foregut
- petechiae (pinpoint haemorrhages) in the peritoneum and skeletal muscle
- skin haemorrhages
- scale oedema (swollen scales).

During an outbreak, daily mortality ranges between 0.05% and 1% in sea cages and total mortality ranges between 15% and 100% in cages and may occur over a prolonged period rather than as an acute outbreak (OIE 2006a).

After experimental infection, a significant fall in haematocrit value has been reported to occur by day 18 postinfection. This coincided with the first appearance of macroscopic lesions—congestion and darkening of the liver, congestion of the spleen and foregut, and ascites formation. At later stages, peritoneal petechiae, exophthalmia and gill pallor were present (Speilberg et al 1995).

Fall in haematocrit level (< 10 in end stages and 25–30 in less severe cases) can also occur with other conditions (ulcerations and erythrocytic inclusion body syndrome).

#### **1.4.2 Laboratory methods**

##### **Sample submission**

In the first instance, the relevant state laboratory—most likely to be the Department of Primary Industries and Water, Tasmania, since the vast majority of Atlantic salmon is farmed in Tasmania—should be contacted directly to ensure that samples are collected using appropriate techniques.

- *Sample submission for virological examination:* Tissue samples suitable for virological examination at the CSIRO Australian Animal Health Laboratory (CSIRO-AAHL) include kidney, spleen, heart and liver. These samples should be taken aseptically and placed in sterile containers. Samples should not be frozen before processing but should be maintained between 4–10°C. Shipping on wet ice in a CSIRO-AAHL shipping container is appropriate. To maximise sensitivity, samples should be processed and assayed within 24 hours of sampling but, if this is not possible, they must be processed within 72 hours of sampling.
- *Sample submission for histology and electron microscopy:* Samples submitted for histopathology and immunohistochemistry should be formalin-fixed; samples for electron microscopy should be glutaraldehyde-fixed.
- *Sample submission for molecular analysis (eg PCR):* Samples submitted for analysis by PCR should be frozen tissues (or, if this is not possible, tissues preserved in 95% ethanol are suitable).
- *Sample submission for IFAT:* Kidney imprints are useful for indirect fluorescent antibody test (IFAT). Imprints are prepared by taking a small piece of the mid-kidney and blotting the cut surface with absorbent paper to remove excess fluid and then making several imprints within a 2-square centimetre area on poly-L-lysine-coated microscope slides. The imprints are air-dried and fixed in cold 100% acetone (on ice) for 10 minutes and stored at 4°C or, if not used immediately, at -80°C until use.

### **Histopathology**

Histological lesions are present in the liver and kidney in typical cases (Evensen et al 1991, Speilberg et al 1995). In the liver there is multifocal branching haemorrhagic coagulatory necrosis of the parenchyma with necrotic areas often coalescing. However, histological terms used to describe the zonal appearance of liver lesions in mammals are not recommended in fish because there are differences in the functional anatomy of the liver of fish and mammals (Speilberg et al 1995). Blood-filled spaces in the necrotic hepatic parenchyma (peliosis) (Speilberg et al 1995, Simko et al 2000) may be present in later stages of the disease.

In the kidney, multifocal interstitial congestion and haemorrhage may be found in both the anterior (head) and posterior regions (Simko et al 2000). This may be accompanied by multifocal necrosis of haematopoietic tissue in the anterior kidney, and tubular epithelium in the posterior kidney. Splenic congestion with erythrophagocytosis (ingestion of red blood cells by macrophages and other phagocytic cells) may be seen in the late stages of disease (Simko et al 2000), while less consistent changes may affect the heart muscle (myocardium), gills and intestines (Simko et al 2000).

### **Electron microscopy**

Speilberg et al (1995) reported that virus particles were not seen in liver cells by electron microscopy and the observed lesions were secondary lesions caused by the destruction of the endothelial lining of blood capillaries and leakage of blood into the liver tissue. Endothelial cells appear to be the primary target cells for ISAV (Hovland et al 1994, Koren and Nylund 1997).

### **Indirect fluorescent antibody test**

IFAT on kidney imprints using anti-ISAV monoclonal antibodies (supplied by the OIE Reference Laboratory for ISA) can be used to confirm suspected cases of ISA. Similarly, polyclonal anti-ISAV nucleoprotein antiserum can be used in immunohistochemical tests on mid-kidney and heart sections to confirm cases suspected on the basis of pathological signs (OIE 2006a).

### **Molecular techniques**

In experimentally infected fish, for the first 8 days postinfection, positive PCR results were found predominantly in the head kidney and mid-kidney. Subsequently, fish yielding positive results at 13 days postinfection and beyond, were positive in most organs sampled—mid-kidney, head kidney, liver, spleen, intestine, gills, muscle, and heart (Rimstad et al 1999). Since these initial studies, several PCR primer sets have been developed for detection of ISAV. Primer sets, derived from genomic segment 8, have been used to detect ISAV during disease outbreaks as well as in carrier fish (Devold et al 2000, Mikalsen et al 2001). A further primer set derived from genomic segment 6 is also suitable for detecting ISAV strains and may be used for verification of PCR results using genomic segment-8 primers rather than sequencing PCR products (OIE 2006a). Real-time RT-PCR is also available (Munir and Kibenge 2004, Starkey et al 2006).

### **Agent isolation and identification**

Several cell lines—SHK-1 (Dannevig et al 1995), ASK (Devold et al 2000), TO (Wergeland and Jakobsen 2001) and CHSE-214 (Kibenge et al 2000)—are susceptible to various ISAV strains. SHK-1 and ASK are the cell lines of choice since they appear to be susceptible to infection by, and support the replication of, all known ISAV strains (OIE 2006a).

Spleen, heart and kidney tissue should be sampled from affected fish and processed for inoculation onto cell cultures using standard procedures (OIE 2006b, Crane and Williams 2007). Inoculated cell cultures are incubated at 15°C and are examined by light microscopy for the development of cytopathic effect (CPE) typical for ISAV (Dannevig et al 1995, Crane and Williams 2007). At 14 days postinoculation, or earlier if CPE develops, cell culture supernatants are inoculated onto fresh cell cultures and incubated for at least a further 14 days. When CPE develops, the cultures should be processed for ISAV identification by either IFAT or PCR (OIE 2006a). If CPE has not developed after 28 days of incubation, the cultures should always be processed for detection of ISAV by either IFAT or PCR because virus replication may occur without development of apparent CPE (OIE 2006a).

#### **1.4.3 Confirmation of diagnosis**

Presumptive ISA diagnosis will be made on submissions that meet at least one of the following criteria:

- clinical changes consistent with ISA
- pathological changes consistent with ISA, with or without clinical signs
- isolation and identification of ISAV in cell culture from a single sample of fish tissue

- positive results from two independent laboratory tests (eg RT-PCR on fish tissues and IFAT on kidney imprints).

Confirmation of ISA diagnosis will be made on submissions that meet at least one of the following criteria:

- Mortality, clinical signs and pathological changes consistent with ISA, and detection of ISAV by:
  - *either* isolation and identification of ISAV in cell culture
  - *and/or* detection of ISAV by RT-PCR
  - *and/or* detection of ISAV by specific immunoassay.
- Isolation and identification of ISAV in cell culture from at least two independent samples (ie tissue from two different fish or two tissue pools from different fish in the same population).
- Isolation and identification of ISAV in cell culture from at least one sample, and corroborating evidence of ISAV in tissue preparations by RT-PCR or immunoassay from the same animal or different animals within the same population.

#### 1.4.4 Differential diagnosis

None of the clinical signs documented are specifically diagnostic for ISA. However, these signs can be observed singly or in any combination in Atlantic salmon suffering from disease caused by infection with any one of the following pathogens:

- *Aeromonas salmonicida*
- *Renibacterium salmoninarum*
- rickettsia-like organisms such as *Piscirickettsia salmonis*
- viral haemorrhagic septicaemia virus
- infectious haematopoietic necrosis virus
- infectious pancreatic necrosis virus.

## 1.5 Resistance and immunity

Atlantic salmon that have survived an ISAV infection appear to be less susceptible to reinfection, indicating that a protective immune response is elicited. Moreover, it has been demonstrated that convalescent antiserum has ISAV-neutralising activity (Falk and Dannevig 1995). Inactivated viral vaccines have been shown not to be 100% protective (Kibenge et al 2003); immunised fish do not completely eliminate virus and may become carriers. In addition, the existence of different ISAV strains indicates that efficacy of any vaccine against local or introduced ISAV strains needs to be demonstrated.

## 1.6 Epidemiology

ISA is a highly contagious and lethal disease of Atlantic salmon. Natural outbreaks of ISA have only been described in Atlantic salmon. Other fish species, such as

herring (*C. harengus*), rainbow trout (*O. mykiss*), Arctic char (*S. alpinus*), sea and brown trout (*S. trutta*) can be experimentally infected and are considered potential carriers and reservoirs for ISAV (see Table 1). While other wild fish have not been identified as ISAV carriers, researchers suspect that reservoirs of ISAV exist in other species.

### **1.6.1 Incubation period**

The incubation period of the disease is dependent on viral (eg strain and dose), environmental (eg water temperature) and host (eg host age, immune status) factors. A number of experimental infectivity trials have been undertaken using various types of inoculum and different routes of inoculation and under different environmental conditions (eg temperature, salt water, freshwater) (eg Dannevig et al 1994, Totland et al 1996, Rimstad et al 1999, Simko et al 2000). In these studies the earliest fish deaths due to ISA occurred around 15 days after inoculation of the virus and, in some studies, continued for several weeks. The earliest demonstration of viral replication in all tissues examined occurred at around 13 days after inoculation.

### **1.6.2 Persistence of the pathogen**

Little is known about the persistence of ISAV outside hosts and vectors. Persistence of infectious particles in the environment is dependent on local conditions (eg temperature, presence of substances that bind and/or inactivate the virus). Falk et al (1997) showed that ISAV is completely inactivated after 5 minutes incubation (in cell culture medium) at 56°C, greater than 99.99% inactivated after 2 days at 37°C, while there was no reduction in infectivity after 14 days at 4°C or 10 days at 15°C.

Torgersen (1998) showed that ISAV can be inactivated by treating ISA-infected tissue homogenates with physical and chemical disinfectants such as:

- temperatures of 50°C or higher for 2 minutes
- pH < 4.0 for 8 hours, > 11.5 for 48 hours, or > 12.0 for 24 hours
- 100 ppm sodium hypochlorite for 15 minutes
- UV doses of 4 millijoules per square centimetre or higher.

The presence of organic matter reduces the effectiveness of UV and hypochlorite. In a more recent study, Smail et al (2004) tested three different iodophor products at 100 ppm: 1% (w/v) chloramine T, chlorine dioxide, and a peracetic acid (0.02–0.06%)/hydrogen peroxide (0.08–0.25%)/acetic acid (0.04–0.13%) mixture. In each case, a 5-minute contact time reduced ISAV infectivity for SHK-1 cell cultures by greater than 4 log<sub>10</sub>. A summary of these and other data is provided by Bovo et al (2005).

More details on decontamination are provided in Section 2.2.8 and in the AQUAVETPLAN **Decontamination Manual**.

### **1.6.3 Modes of transmission**

Natural infections occur by horizontal transmission of waterborne virus (Totland et al 1996, Jarp and Karlsen 1997). The virus gains entry through the gills of the fish. Salmon lice (*Caligus elongatus* and *Lepeophtheirus salmonis*) have been

implicated as vectors (Nylund et al 1994). Vertical transmission (from parents to offspring) has not been proved and is thought not to occur in any significant manner (Bovo et al 2005). Before the development and use of SHK-1 cells for propagation of the virus, blood, mucus, faeces or tissue homogenates from diseased fish were used as the inoculum. Thus, for these trials, the doses (and hence the tissue culture infective dose; or TCID<sub>50</sub>) administered to the fish are unknown (eg Rolland and Nylund 1998).

Disease can be spread over relatively long distances by transportation of infected smolt (Stagg 2003a). It is likely that equipment used to transport infected fish will be contaminated and use of such equipment is a factor in disease spread (Smail et al 2004).

#### **1.6.4 Factors influencing transmission and expression of disease**

As ISA is transmitted from infected salmonid sources horizontally via seawater, risk factors include geographical proximity to infected sea sites, geographical proximity to slaughterhouses/processing plants releasing unprocessed, contaminated water, and sharing of staff and equipment between lease sites. ISA nucleic acid has been detected by RT-PCR in water samples taken up to 1.5 km from infected sites. Prompt disinfection of affected and contaminated sites is likely to minimise the risk of transmission (Gustafson et al 2005).

Stress factors (eg rising or falling temperatures) appear to play a role in precipitating disease outbreaks in asymptomatic carriers. ISA outbreaks tend to occur during spring (rising water temperatures) or onset of winter (falling water temperatures). Other stress factors include freshwater bathing, a common practice used in Tasmania to control amoebic gill disease in farmed salmonids.

## **1.7 Impact**

ISA is exotic to Australia. The countries and regions where it has had most impact are Norway, Scotland, North America and the Faeroe Islands. In Norway, ISA has been present since 1984 and the highest number of outbreaks occurred between 1989 and 1992 (with an average of about 70 outbreaks per year). ISA has been in North America since 1996. In Scotland, ISA occurred in 1998 and was successfully eradicated by 2000. However, while the disease was eradicated, it is likely that the virus remains in the environment.

The impact of ISA has been more severe in countries where it is considered endemic (eg Norway) than in countries where it has occurred as an exotic incursion but has been eradicated (eg Scotland)<sup>6</sup>. The annual cost of infectious salmon anaemia outbreaks among farmed fish in 1999 was reported to be US\$11 million in Norway and US\$14 million in Canada; the 1998–99 epidemics in Scotland cost US\$32 million (Hastings et al 1999).

In the Scottish outbreak, infection was confirmed on 11 farms and suspected in a further 18 farms, out of a total of 340 salmon farms. Impacts affected 25% of Scottish production, with approximately 15% loss in turnover and a loss of more

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<sup>6</sup> An immediate notification of the reoccurrence of ISA in Scotland was provided to the OIE on 02/02/2009 (Report reference: Ref OIE: 7717).

than 10% jobs and further impacts upstream (eg smolt producers) and downstream (eg feed companies, processors, service providers) (Scottish Parliament 1999).

Apart from the direct impact of lost production due to death caused by disease and deaths due to enforced depopulation, the following control measures during and after the outbreak have further impacts on the industry (Stagg 2003abc):

- withdrawal of fish from the farm
- disposal or marketing of all fish
- disinfection and cleaning
- fallowing
- surveillance of adjacent farms in established zones
- improving disease awareness
- further development of slaughter, processing plant and disinfection protocols
- consolidation of industry participants
- increased government/industry expenditure on surveillance, and research and development.

## 2 Principles of control and eradication

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### 2.1 Introduction

Infectious salmon anaemia (ISA) has caused mass mortality of farmed Atlantic salmon overseas, with significant economic loss to those Atlantic salmon aquaculture sectors affected. An outbreak of ISA in Australia would be a serious threat to the Atlantic salmon farming industry centred in Tasmania, which produced approximately 26 000 tonnes of head-on, gutted (HOG) weight of salmon in 2007–08, with a gross value of production (GVP) of approximately AUS\$310 million (Pheroze Jungalwalla, Executive Officer, Tasmanian Salmonid Growers Association, pers comm, September 2008). Detection of ISA virus (ISAV), even in the absence of clinical signs, would also be cause for serious concern. This section provides background information to enable the choice of the most appropriate response option following detection of ISA/ISAV in Australia.

There are essentially three disease control strategies that could be adopted if ISAV is isolated in Australia:

- *Eradication.* The scale of eradication may be national, state-wide (eradicate ISAV from Tasmania), local (eradicate from a production area within Tasmania, eg Macquarie Harbour).
- *Containment, control and zoning.* Containment, control and zoning includes measures to exclude ISAV from defined geographic areas and unaffected populations (eg by quarantine) and contain the virus to areas with enzootic infection.
- *Control and mitigation of disease.* Control and mitigation measures are aimed at managing the frequency and severity of disease episodes in infected populations and keeping them within acceptable levels.

The third option, control and mitigation of the disease, is not favoured because it could lead to the establishment of ISAV in both the farmed and wild fish species providing a reservoir of infection (latent carrier population) that could be the source of future outbreaks.

The basic principles of eradication and other response options are described in the AQUAVETPLAN **Enterprise Manual** and the AQUAVETPLAN **Control Centres Management Manual**. The AQUAVETPLAN **Enterprise Manual**, Appendix 1 lists the state and territory legislation relating to disease control and eradication.

In any disease outbreak, a number of options are immediately available:

- *Destruction of diseased fish.* Rapid removal and appropriate disposal of diseased fish is considered a high priority for controlling the spread of the disease and causative agent.
- *Quarantine* (restrictions on movement of animals, materials, waste, personnel, vehicles and equipment). This option requires rapid identification of the

affected geographical area, disinfection of personnel and equipment leaving affected sites, and disinfection of waste water from processing plants.

- *Emergency harvest.* Grow-out of fish to harvest size (possibly in a quarantined area) may be an option as is the slaughter and processing of commercial-sized, clinically normal but infected fish for marketing and human consumption.
- *Treatment of affected population* (chemotherapy/vaccination).

Not all of these options are appropriate for a confirmed outbreak of ISA; for example, there are no known treatments (chemotherapy) for viral diseases of aquatic animals and no licensed efficacious vaccines for ISA.

Salmonids are farmed in two phases—both phases using semi-open systems. In Tasmania, the hatcheries (freshwater phase) are located on rivers isolated from the seawater or grow-out phase, which occurs in sea cages at various locations around the state (Huon Estuary, D’Entrecasteaux Channel, Macquarie Harbour, Tasman Peninsula, Tamar River). The main production areas are the Huon Estuary, D’Entrecasteaux Channel and Macquarie Harbour. While control of fish, personnel and equipment movement can be achieved, there can be little, if any, control of water movement. Thus, response options need to be aimed at rapid control of spread. For example, experience from overseas indicates that restricting the large-scale shedding of virus (eg from diseased, dying or dead fish) into the water column plays an important role in limiting transmission.

## **2.2 Methods to prevent spread and eliminate pathogens**

### **2.2.1 Quarantine and movement controls**

Quarantine and movement restrictions should be implemented immediately upon suspicion of ISA.

The following practices must be considered when implementing quarantine and movement controls:

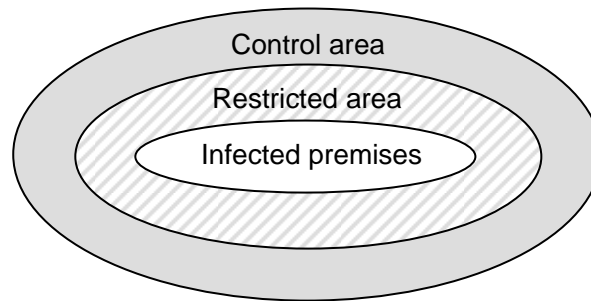
- live salmonid transportation between and within freshwater and marine operations (including broodstock and marine cage towing)
- salmonid harvesting and transportation to processing plants
- discharge of salmonid processing-plant waste and effluent
- transportation of consumer-ready salmonid products
- disposal of dead salmonids.

#### **Establishment of quarantine areas**

Establishment of declared areas shown in Figure 1 (see the AQUAVETPLAN **Enterprise Manual**, Section A for more details), including:

- *infected premises* – premises where ISAV infection has been identified
- *restricted area* – area around infected premises or area

- *control area* – a buffer between the restricted area and free areas
- *free area* – noninfected area (this area is not considered a ‘declared area’ and may include large areas of Australia in which the presence or absence of ISAV remains unassessed).



**Figure 1 Establishment of declared areas to control ISA**

In the declaration of quarantine areas, the following factors need to be taken into account:

- Both freshwater and marine phases of salmonid production.
- Movement of potentially infected wild populations of rainbow trout (*O. mykiss*) and brown trout (*S. trutta*).
- Possibility of the existence and presence of a previously unknown susceptible species of wild fish that may act as an asymptomatic carrier.
- Movement of personnel and equipment involved in other aquatic industries and recreational fishing.

### **Movement controls**

The feasibility of movement restrictions and bans, and extent to which these are able to be enforced, will depend on the location of infection, the location and type of enterprises affected, and the control response option chosen (eg whether the aim is to eradicate the disease agent or to control its spread). Depending on the circumstances, some restrictions may be impractical or unnecessary but others will be of critical importance to eradication or control. In all cases, the implementation of bans and restrictions will be a dynamic process.

Movement controls include:

- bans on the movement of live salmonids out of infected areas
- bans on the movement of live salmonids into disease-free areas
- restrictions or bans on releasing salmonids into river systems or marine locations

- restrictions or bans on the movement of salmonids between different river systems, between marine farm locations and between marine and freshwater farm locations
- restrictions or bans on the use and movement of equipment and personnel within and between river systems and marine farms.

### **Zoning**

If ISA was to become endemic in specific regions of Australia, a zoning policy specific for ISA may be necessary to protect noninfected areas and to prevent further spread of infection. Zones would be based on the distribution of ISAV-susceptible species and of any vector species present (if appropriate), the geographical and hydrological characteristics of water bodies and landform, and predictions of the most likely method of spread of infection. Zoning may rely on the identification of biogeographic barriers. A corresponding surveillance and monitoring program for ISAV would be required to support the zoning policy. Principles of zoning for infected and noninfected zones in Australia are outlined in the *AQUAPLAN Zoning Policy Guidelines* (AFFA 2001)<sup>7</sup> and in the OIE (World Organisation for Animal Health) *Aquatic Animal Health Code* (OIE 2007b).

#### **2.2.2 Tracing**

Tracing a disease outbreak is the process of retrospectively determining the method and pattern of disease spread. Tracing investigations are crucial in determining all confirmed and potential locations of the disease and its causative agent, as well as defining restricted and control areas. The information gathered from tracing will assist in determining the most appropriate response action. The immediate steps required are to trace-back all contacts with infected fish, premises and sites (to establish the origin of the outbreak) and to trace-forward all contacts with infected fish, premises and sites (to establish the current location and potential spread of infection).

The following items must be traced:

- salmonids – broodstock, smolts, etc
- salmonid products – for human consumption, eggs, effluent and waste products from slaughter and processing
- water – input and output
- vehicles – salmonid transport vehicles, feed trucks, visitors' cars, boats
- materials – salmonids cages, nets, other floating installations, tools and instruments
- personnel – farm workers, sales and feed representatives, tradespeople, veterinarians, scientists, technicians and visitors.

In Australia, the following points must be considered during tracing:

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<sup>7</sup>[http://www.daff.gov.au/\\_data/assets/pdf\\_file/0007/146716/zoning-final-aug.pdf](http://www.daff.gov.au/_data/assets/pdf_file/0007/146716/zoning-final-aug.pdf) (Accessed 20 October 2008)

- Infection may have been present in a salmonid population for days or weeks before detection of clinical event, which may have been triggered by a stress event such as grading or freshwater bathing for amoebic gill disease (AGD).
- Salmonids, people, boats, motor vehicles/trucks and birds regularly move between the catchment areas on which salmonid farms are located. In Tasmania, there are three main catchment areas and up to six trucks per day move salmonids between freshwater and seawater operations.

### **2.2.3 Surveillance**

Surveillance is necessary to:

- define the extent of the infection
- detect new outbreaks
- establish restricted and control areas to which quarantine and movement restrictions are applied
- establish infected and noninfected areas and zones for an ISA zoning program and
- monitor the progress and success of an eradication strategy.

As described in Section 1.4.3, examination of diseased fish for gross pathology and histological lesions can provide an initial diagnosis. Confirmatory tests include indirect fluorescent antibody test (IFAT) on kidney imprints, immunohistochemistry, real-time reverse transcriptase polymerase chain reaction (RT-PCR) followed by sequencing of the PCR product and virus isolation in cell culture (OIE 2006a). For detection of subclinical infections, isolation of ISAV in cell culture is the only appropriate test for detecting infectious virus; positive RT-PCR and serology would provide evidence of previous infection but would not confirm the presence of infectious virus (OIE 2006a).

There are a number of factors that require consideration when developing a targeted surveillance scheme to demonstrate freedom from infection, some of which will be dependent on specific characteristics of the disease outbreak, such as time of year, stage of life cycle, location, production system and management practices. Principles and guidelines for survey design and analysis are provided in the *OIE Manual of Diagnostic Tests for Aquatic Animals* (OIE 2006c).

### **2.2.4 Treatment of infected host species**

There are no treatments or licensed efficacious vaccines available for ISA.

### **2.2.5 Treatment of host products and byproducts**

Trade regulations, market requirements, food safety standards and potential spread of the pathogen must be considered when determining the treatment/processing and destiny of salmonid products and byproducts. ISAV does not pose any risk to human health.

Relatively high titres of virus are found in the viscera. Removal and inactivation of viscera at processing will reduce the viral load in products from infected fish.

### **2.2.6 Destruction of hosts**

Overseas experience has indicated that prompt destruction and disposal of diseased fish reduces the risk of disease spread. Diseased salmonids located in sea cages can be killed onsite. For more details on destruction of ISA-affected salmonid fish see the AQUAVETPLAN **Operational Procedures Manual – Destruction**.

### **2.2.7 Disposal of hosts**

Slaughtered animals need to be disposed of in a safe and effective manner. In Australia, best practice has been to bury slaughtered terrestrial animals onsite. Clearly, this is not possible for diseased salmonids. Firstly, culled fish need to be transported safely to the burial (or incineration) site without spreading disease to other sites. Operations will be supervised by state authorities and further details on the most appropriate methods of disposal of host organisms can be found in the AQUAVETPLAN **Operational Procedures Manual – Disposal**.

### **2.2.8 Decontamination**

Due to differences in farming enterprises, disinfection protocols may need to be determined on an individual basis involving the farm manager, the state or territory Chief Veterinary Officer (CVO) and/or director of fisheries. The protocol should take into consideration the factors outlined in Section 1.6, in particular:

- the source and location of infection
- the type of enterprise (eg farm, processing plant, hatchery, grow-out cages, water source)
- the construction materials of the buildings and other structures on the site
- the design of the site and its proximity to other waterways or buildings
- current disinfection protocols
- workplace safety concerns
- environmental impact of the disinfectant protocol
- legislative requirements (occupational health and safety, environmental protection, chemical use)
- availability of approved, appropriate and effective disinfectants.

See the AQUAVETPLAN **Operational Procedures Manual – Decontamination** for details of decontamination methods and their indicators.

### **2.2.9 Vaccination**

Vaccination is not an option for ISA due to the current lack of licensed effective vaccines for the disease. However, the use of vaccines, if they become available in the future, should not be ruled out.

### **2.2.10 Vector control**

Other fish species susceptible to infection with ISAV have been documented in Section 1.2. Any of these species present in Australia should be considered potential carriers of infection and appropriate investigation should be carried out.

In addition, parasitic copepods have been implicated in the spread of ISAV and control of infestation with any such organism should be considered.

## **2.3 Environmental considerations**

Release of potentially infected effluent into the environment needs to be avoided. All potentially infected effluent from slaughter premises and processing plants must be inactivated. See the AQUAVETPLAN **Operational Procedures Manual – Decontamination** for details. During decontamination operations, all legislation and regulations concerning the disposal or discharge of chemicals (eg disinfectants) and cleaning agents into the environment must be observed.

## **2.4 Sentinel animals and restocking measures**

Restocking should only occur after all diseased and potentially exposed salmonids have been removed from the farm sites—either destroyed or processed. The presence of asymptomatic carrier populations of wild fish cannot be discounted. It is likely that, following a significant disease outbreak, it would take several weeks or months for any management program to be completed and for the industry to be in a position to consider restocking. The length of the fallow period would depend on a number of factors—the number of sites in which ISA has been confirmed, the extent of the outbreak and the characteristics of the affected sites (OIE 2007c). In Norway, the fallow period following an ISA outbreak is no shorter than one month (Binde 1998). An active surveillance program that includes sampling of wild fish populations should form part of any restocking program.

## **2.5 Public awareness**

A public awareness campaign emphasising education, surveillance and cooperation from industry and the community is essential. The public should be informed that:

- ISAV does not infect humans
- no health risks are associated with eating fish exposed to ISAV
- fish that have died from infectious disease must not be used as bait or feed for aquatic animals.

## **2.6 Feasibility of control or eradication of ISA virus in Australia**

The feasibility of controlling an outbreak of ISA depends on the nature and location of the outbreak and the management strategy adopted. Essentially, as outlined in Section 2.1, there are three response options:

- eradication

- containment and control
- control and mitigation of disease.

Eradication is the preferred option. If epidemiological investigations determine an obvious point source of infection that has been or may be contained with minimal or no spread of the virus, an eradication strategy may be successful and should be attempted. Compared with the other two response options, eradication has the highest short-term economic costs. However, if ISAV were successfully eradicated, long-term economic benefits could outweigh those short-term costs.

### **2.6.1 Response option 1: Eradication**

In semi-open systems, the success of an eradication strategy would depend on the identification of any susceptible species of wild fish present in the vicinity of the farming sites. Eradication is unlikely to be successful or feasible if epidemiological investigations determine that infection is widespread, has no point source, is unable to be contained or is present in wild fish species inhabiting the surrounding vicinity.

The known host range for ISAV is restricted to a relatively small number of fish species and so eradication may be considered feasible. Thus, if it can be demonstrated that reservoirs of infection have not become established in farmed and wild fish populations eradication may be considered feasible and the following control measures should be put into place. Clearly, where wild reservoirs of infected fish occurs eradication of disease in farmed populations can occur while the virus may remain present.

#### **Unexposed fish**

If unexposed fish can be maintained without any risk of exposure, they can be grown up to harvest size and processed.

#### **Exposed or potentially exposed, clinically normal fish**

Immediate destruction of exposed fish prevents further virus replication and minimises further spread. Emergency harvest of commercial-sized fish, processing and sale for human consumption is an option but must not compromise eradication effort.

#### **Clinically diseased fish**

All diseased and dead fish need to be removed, destroyed and disposed of as soon as possible following their identification. These fish are the main source of ISAV in the environment. Sea-cages with diseased fish need to be totally depopulated whether all or only a proportion of the fish shows clinical disease.

### **2.6.2 Response option 2: Containment, control and zoning**

The relative host specificity of ISAV makes control and containment of the virus feasible. Knowledge of the strain(s) present is required to determine the range in virulence expressed by the virus population. The presence of avirulent virus in infected but clinically healthy fish complicates control and management procedures.

### **Unexposed fish**

If unexposed fish can be maintained without any risk of exposure they can be grown up to harvest size and processed as for the eradication option.

### **Exposed or potentially exposed, clinically normal fish**

A successful zoning program for farmed fish will rely on movement restrictions on exposed or potentially exposed fish to prevent infection spreading to uninfected zones. The feasibility of implementing a zoning program will depend on farm management practices, the extent to which infection has already spread and the location of reservoirs of infection.

### **Clinically diseased fish**

All diseased and dead fish need to be removed, destroyed and disposed of as soon as possible following their identification. These fish are the main source of ISAV in the environment. Sea-cages with diseased fish need to be totally depopulated whether all or only a proportion of the fish shows clinical disease.

#### **2.6.3 Response option 3: Control and mitigation of disease**

In a control and mitigation program, the aim may simply be to reduce the frequency of existing disease to biologically and/or economically acceptable levels. Critically, there may be a level of disease in the population below which the cost of further expenditure on control would be greater than the benefit.

Since ISAV was initially isolated and identified, the number of strains of this RNA virus (with a hypervariable region of the haemagglutinin gene) detected with different levels of virulence has increased considerably (Cunningham et al 2002, Nylund et al 2003, Cook-Versloot et al 2004). Thus, maintaining a situation where virus is constantly present in the environment increases the risk of mutation to a more virulent virus that may be highly pathogenic for local fish stocks under local environmental conditions and husbandry practices. Disease development is dependent on not only virus factors (eg virus genome, virus dose) but also host (eg genetics and immune status) and environmental (eg water quality and temperature) factors.

## **2.7 Trade and industry considerations**

Trade regulations, market requirements and food safety standards must be considered as part of a response strategy. Permits may be required from the relevant authorities to allow products from declared areas to be released and sold for human consumption.

### **2.7.1 Export markets**

ISA is listed by the OIE as a notifiable disease. Some countries may have import conditions in place related to the ISAV, such as requiring imports to be certified free of infection. The AQIS is responsible for the health certification of all exports and should be contacted for further information.<sup>8</sup>

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<sup>8</sup> [export@aqis.gov.au](mailto:export@aqis.gov.au)

### **2.7.2 Domestic markets**

A cautious approach is required for the harvest of exposed or partially exposed product for the domestic market to prevent the spread of infection. Decisions regarding the release of salmonids or salmonid products to the domestic market will depend on the response strategy implemented and will be made by the Aquatic Consultative Committee on Emergency Animal Diseases (AqCCEAD).

## 3 Preferred Australian response options

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### 3.1 Overall policy

Infectious salmon anaemia (ISA) is a serious viral disease of Atlantic salmon that is exotic to Australia. Outbreaks of ISA overseas have been associated with high mortality rates ranging between 15% and 100%. Such a disease has the potential to devastate the Australian salmonid farming industry.

The policy for the response to an outbreak of ISA, or detection of ISA virus (ISAV), in Australia depends upon both the nature of the outbreak and the management strategy adopted. The choice of response option will be decided by the director of fisheries and/or the Chief Veterinary Officer of the state or territory in which the outbreak occurs, following epidemiological investigation and would take into consideration the views of relevant industry groups (eg the Tasmanian Salmonid Growers Association) obtained during consultation at the time .

There are three possible response options for ISA in Australia:

- *option 1 – eradication of ISAV from Australia*
- *option 2 – containment, control and zoning of the virus to areas with endemic infection, prevention of further spread and protection of uninfected areas*
- *option 3 – control and mitigation of disease by implementing management practices that decrease the incidence and severity of clinical outbreaks.*

Each of these options involves the use of a combination of strategies, which may include:

- *quarantine and movement controls on fish, fish products and things in declared areas to prevent spread of infection*
- *destruction of all clinically diseased or dead fish as soon as possible, to prevent further viral shedding*
- *decontamination of facilities, products and things to eliminate the virus on infected premises and to prevent spread of infection*
- *surveillance to determine the source and extent of infection and to provide proof of freedom from the disease*
- *zoning to define and maintain infected and disease-free zones.*

An uncontrolled outbreak of ISA could cause severe, long-term production losses with consequent dislocation and economic losses in the fish farming industry and associated production, sales and export industries. It will therefore be necessary to act immediately to control or eradicate the disease.

The director of fisheries and/or the Chief Veterinary Officer (CVO) in the state or territory in which the outbreak occurs will be responsible for developing an emergency animal disease response plan (EAD Response Plan). This plan will be submitted to the Aquatic Consultative Committee on Emergency Animal Diseases (AqCCEAD), who will provide advice on the technical soundness of the plan and its consistency with AQUAVETPLAN.

Directors of Fisheries and/or CVOs will implement the disease control measures as agreed in the EAD Response Plan and in accordance with relevant legislation. They will make ongoing decisions on follow-up disease response measures in consultation with AqCCEAD. The detailed response measures adopted will be determined using the principles of control and eradication (see Section 2), epidemiological information about the outbreak and the financial feasibility of the option.

For information on the responsibilities of the other state or territory disease control headquarters and local disease control centres, see the **AQUAVETPLAN Control Centres Management Manual**.

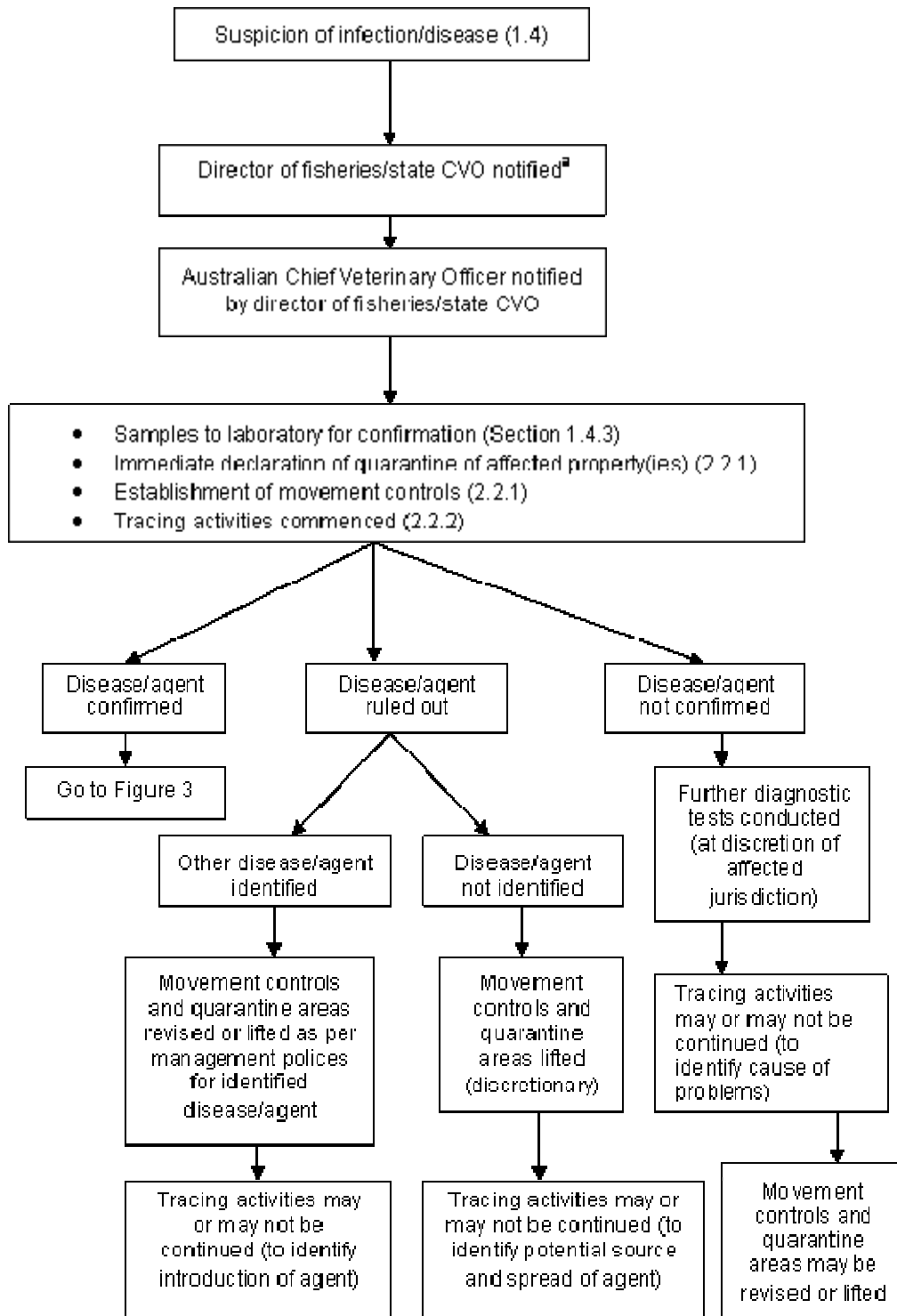
## **3.2 Response options**

The circumstances surrounding an outbreak of ISA will greatly influence selection of the most suitable response option. Figure 2 shows the actions that should occur on initial suspicion of the presence of ISAV. Once the presence of ISA has been confirmed, it is appropriate to refer to Figure 3, which has been developed to help identify the most appropriate response option. These decision trees are flexible, depending on the specific situations experienced. However, in Figure 3, any instance when a response is 'unknown' should be treated in a cautionary manner and the 'no' option should be followed.

### **3.2.1 Option 1—Eradication**

Eradication is the preferred option. Although it has the highest short-term economic costs, these costs could be outweighed by long-term economic benefits if ISAV is successfully eradicated.

In semi-open systems, the success of an eradication strategy would depend on the availability of resources for surveying and destocking farmed and wild hosts in the immediate area.



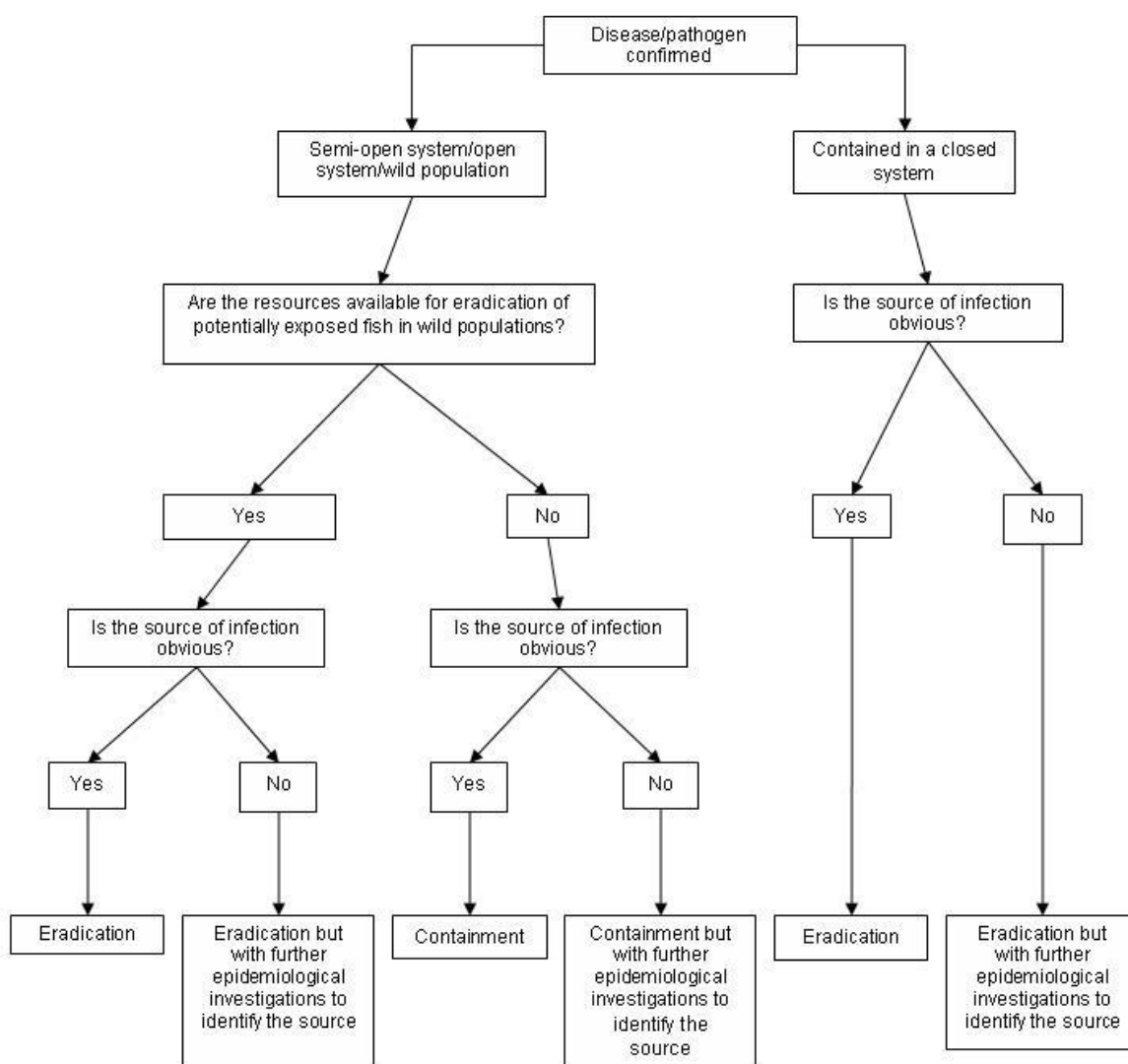
CVO = Chief Veterinary Officer

<sup>a</sup> As appropriate in the affected jurisdiction

**Figure 2** Flow chart of initial response and ongoing activities required when an outbreak of ISA is suspected

An eradication plan must include the following activities:

- Quarantine and movement controls must be declared immediately and stringently enforced on salmonids, salmonid products, water and any vectors located in declared areas. Restrictions must apply to movement out of the infected area of anything capable of transmitting ISAV from infected to uninfected fish, and to aquaculture facilities or processing plants. Movement controls should be maintained until the agent is either eradicated or declared endemic.
- All diseased and dead fish must immediately be removed, destroyed and disposed of.
- Any exposed or potentially exposed salmonids must immediately be removed, destroyed and disposed of. Emergency harvest of market-size fish can be considered but this must not compromise the eradication effort.
- Any product from exposed, or potentially exposed but clinically normal salmonids, must immediately be destroyed and disposed of.
- All buildings, tanks, materials and equipment that may be contaminated—including nets, boats, vehicles, and personal equipment and clothing—must be decontaminated.
- All infected salmonids, wastes, effluent and equipment that cannot be decontaminated effectively must immediately be disposed of safely.
- Effluent must be treated.
- Restocking with sentinel Atlantic salmon can occur only after the site has been thoroughly decontaminated and has remained fallow for a period specified by the state CVO in consultation with the Australian salmonid farming industry.



**Figure 3 Determination of the most appropriate response option**

### 3.2.2 Option 2—Containment, control and zoning

If reservoirs of infection became established in wild fish stocks or in a water system, eradication would be impossible. In this case, containment and prevention of further spread is the preferred control option in order to protect and maintain uninfected areas.

If it were possible to maintain uninfected areas or zones free of ISA/ISAV, the implementation of a zoning program would be advantageous to the Australian Atlantic salmon industry and to the protection of potentially susceptible wild fish species. Restrictions on the movement of fish and fish products, and a surveillance and monitoring program would be necessary to support such a zoning program.

Farms in infected areas would need to consider options for the use of management practices to reduce the severity and incidence of ISA outbreaks. Control measures are only required to prevent transmission of infection to unexposed fish in uninfected areas or zones. Management practices could include:

- containment and treatment of infected blood water and effluent from processing plants for safe disposal
- careful and thorough cleaning and disinfection
- control of movement of staff and equipment
- low stress environment – low stocking densities, minimal handling
- close monitoring of stock health – examination and fresh sampling of any morbidity or mortality event suspicious of ISA or not readily recognisable as any other endemic disease
- immediate removal of dead fish (daily diving if necessary)
- single year-class sites to prevent in-contact ‘vertical’ transmission between year classes
- fallowing of sites between year classes (if possible).

### **3.2.3 Option 3—Control and mitigation of disease**

In some circumstances, establishment of a zoning program for ISA in Australia may not be considered feasible. This would be the case if, for example, infection with ISAV became widespread or enzootic throughout large areas of Australia and/or the financial expenses associated with setting up and maintaining a zoning program (including movement restrictions and a targeted surveillance and monitoring program) were considered prohibitive.

In this situation, control and mitigation of disease may be the only possible response option. Husbandry, management and hygiene practices should be implemented to decrease the incidence and severity of ISA outbreaks.

The options outlined in Section 3.2.2 (with the exception of the restrictions associated with zoning) may be implemented, with the aim of minimising the impact of disease through minimising the infectious load of farms and exposure of the fish to the virus.

## **3.3 Criteria for proof of freedom**

Proof of freedom from ISAV, which may be important for trade, can be demonstrated at the aquaculture establishment, zone and country level. Criteria for proof of freedom at each level are given in the OIE *Aquatic Animal Health Code* (see Appendix 1).

## **3.4 Funding and compensation**

There is currently no cost-sharing agreement in place for ISA.

## Appendix 1 *OIE Aquatic Animal Health Code and Manual of Diagnostic Tests for Aquatic Animals*

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### **OIE Aquatic Code**

The objective of the OIE (World Organisation for Animal Health) *Aquatic Animal Health Code* is to prevent the spread of aquatic animal diseases, while facilitating international trade in aquatic animals and aquatic animal products. This annually updated volume is a reference document for use by veterinary departments, import and export services, epidemiologists and all those involved in international trade of aquatic animals and their products.

The current edition of the OIE *Aquatic Animal Health Code* (10<sup>th</sup> edition) was published in 2007 and is available on the OIE website at:<sup>9</sup>

[http://www.oie.int/eng/normes/fcode/a\\_index.htm](http://www.oie.int/eng/normes/fcode/a_index.htm)

The following chapter is relevant to this manual:

[http://www.oie.int/eng/normes/fcode/en\\_chapitre\\_2.1.9.htm#rubrique\\_anemie\\_infectieuse\\_du\\_saumon](http://www.oie.int/eng/normes/fcode/en_chapitre_2.1.9.htm#rubrique_anemie_infectieuse_du_saumon)

### **OIE Aquatic Manual**

The purpose of the OIE *Manual of Diagnostic Tests for Aquatic Animals* is to contribute to the international harmonisation of methods for the surveillance and control of the most important aquatic animal diseases. Standards are described for laboratory diagnostic tests and the production and control of biological products (principally vaccines) for veterinary use across the globe.

The current edition of the OIE Aquatic Manual (5<sup>th</sup> edition) was published in 2006 and is available on the OIE website at:

[http://www.oie.int/eng/normes/fmanual/A\\_summry.htm](http://www.oie.int/eng/normes/fmanual/A_summry.htm)

The following chapter is relevant to this manual:

[http://www.oie.int/eng/normes/fmanual/A\\_00026.htm](http://www.oie.int/eng/normes/fmanual/A_00026.htm)

### **Further information**

Further information about the OIE Aquatic Code and OIE Aquatic Manual is available on the OIE website at:

[http://www.oie.int/eng/normes/en\\_acode.htm](http://www.oie.int/eng/normes/en_acode.htm)

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<sup>9</sup> The URLs quoted in this appendix were all accessed on 25 February 2009.



## Appendix 2 Approval of chemicals for use in Australia

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The Australian Pesticides and Veterinary Medicines Authority (APVMA) evaluates, registers and regulates agricultural and veterinary chemicals. Before an antibiotic or vaccine can enter the Australian market, it must go through APVMA's rigorous assessment process to ensure that it meets high standards of safety and effectiveness. (In addition, an import permit is required from the AQIS if a product containing biological material is to be sourced from overseas.)

Detailed data about the product and its proposed use pattern must be submitted to the APVMA with the application for registration or permits. Since the assessment process is so detailed, the evaluation may take some time to complete.

### **Minor use permit system**

The minor use permit (MUP) system is a temporary approval system for the use of drugs and chemicals. The system was devised by APVMA for Australia, and allows the restricted use of a limited amount of a drug or chemical in a specified species when inadequate data are available to satisfy APVMA requirements for registration. Conditions are applied to the permit, which often include the collection of data related to the use of the product. The MUP system aims to enable restricted use of a drug or chemical until sufficient data are available to enable full registration.

For example, APVMA may set a temporary withholding period with a wide margin of safety for a MUP. This withholding period may have been extrapolated from data relating to the use of the product in other species. In such cases, a condition of the MUP will be the collection of residue testing data. Results from the data are assessed by APVMA (usually after 12 months—the duration of most permits) and used to more accurately set a withholding period for the product.

### **Emergency-use permits**

The APVMA has a permit system for the emergency use of a product that is either unregistered in Australia or registered for use in a different species or for a different use pattern. The APVMA will verify with the appropriate state and territory coordinators that the emergency is genuine.

For further details or permit application forms, visit the APVMA website.<sup>10</sup>

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<sup>10</sup> <http://www.apvma.gov.au>

## Glossary

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|   |   |
|---|---|
| Aquatic Animal Health Committee                                     | <p>A committee comprising representatives of the Australian Government; state and territory governments; the major aquaculture, wild capture, aquarium and recreational fishing industries; and CSIRO. The committee provides advice to Primary Industries Ministerial Council on aquatic animal health matters, focusing on technical issues and regulatory policy.</p> <p><i>See also</i> Primary Industries Ministerial Council</p>  |
| Australia's National List of Reportable Diseases of Aquatic Animals | <p>The national list is a list of aquatic animal diseases, some exotic to Australia and some occurring in parts of Australia, that forms the basis of Australia's reporting system for aquatic animal diseases.</p>   |
| Australian Chief Veterinary Officer                                 | <p>The nominated senior veterinarian in the Australian Government Department of Agriculture, Fisheries and Forestry who manages international animal health commitments and the Australian Government's response to an animal disease outbreak.</p> <p><i>See also</i> Chief Veterinary Officer</p>   |
| AQUAVETPLAN   | <p><i>Australian Aquatic Veterinary Emergency Plan.</i> A series of technical response plans that describe the proposed Australian approach to an emergency aquatic animal disease incident.</p> <p><i>See also</i> AUSVETPLAN</p>  |
| AUSVETPLAN  | <p><i>Australian Veterinary Emergency Plan.</i> A series of technical response plans that describe the proposed Australian approach to an emergency animal disease incident. The documents provide guidance based on sound analysis, linking policy, strategies, implementation, coordination and emergency-management plans.</p>   |
| Chief Veterinary Officer (CVO)                                      | <p>The senior veterinarian of the animal health authority in each jurisdiction (national, state or territory) who has responsibility for animal disease control in that jurisdiction.</p> <p><i>See also</i> Australian Chief Veterinary Officer</p>  |
| Control area  | <p>A buffer between the restricted area and areas free from disease. Restrictions on this area will reduce the likelihood of the disease spreading further afield. As the extent of the outbreak is confirmed, the control area may reduce in size. The shape of the area may be modified according to circumstances (eg water flows, catchment limits). In most cases, permits will be required to move animals and specified products out of the control area into the free area.</p> |

|                                    |   |
|------------------------------------|---|
| Covert infection                   | Clinically inapparent infection that is transmissible and that may eventually lead to clinical disease.   |
| Dangerous contact premises or area | That which has had a direct, and possibly infectious, contact with an infected premises or area. The type of contact will depend on the agent involved in the outbreak but, for example, may involve animal movements or net/equipment movements.   |
| Declared area                      | A defined tract of land or water that is subjected to disease control restrictions under emergency animal disease legislation. Types of declared areas include <i>restricted area</i> , <i>control area</i> , <i>infected premises</i> , <i>dangerous contact premises</i> and <i>suspect premises</i> .  |
| Decontamination                    | Includes all stages of cleaning and disinfection.   |
| Disease agent                      | A general term for a transmissible organism or other factor that causes an infectious disease.  |
| Disinfectant                       | A chemical used to destroy disease agents outside a living animal.  |
| Disinfection                       | The application, after thorough cleansing, of procedures intended to destroy the infectious or parasitic agents of animal diseases, including zoonoses; applies to premises, vehicles and other objects that may have been directly or indirectly contaminated.   |
| Disposal                           | Sanitary removal of fish carcasses and things by burial, burning or some other process so as to prevent the spread of disease.  |
| Emergency animal disease           | A disease that is (a) exotic to Australia or (b) a variant of an endemic disease or (c) a serious infectious disease of unknown or uncertain cause or (d) a severe outbreak of a known endemic disease, and that is considered to be of national significance with serious social or trade implications.<br><br><i>See also</i> Endemic animal disease, Exotic animal disease |
| Endemic animal disease             | A disease affecting animals (which may include humans) that is known to occur in Australia.<br><br><i>See also</i> Emergency animal disease, Exotic animal disease  |
| Enterprise                         | <i>See</i> Risk enterprise  |
| Epidemiological investigation      | An investigation to identify and qualify the risk factors associated with the disease.  |
| Exotic animal disease              | A disease affecting animals (which may include humans) that does not normally occur in Australia.<br><br><i>See also</i> Emergency animal disease, Endemic animal disease   |

|                                      |   |
|--------------------------------------|---|
| Free area                            | An area known to be free from the disease agent.  |
| Infected premises or area            | A infected area may be all or part of a infected premises (eg an open system, such as an oceanic fish farm lease) in which the disease has been confirmed.  |
| Local disease control centre         | An emergency operations centre responsible for the command and control of field operations in a defined area.   |
| Monitoring                           | Routine collection of data for assessing the health status of a population.<br><br><i>See also Surveillance</i>   |
| Movement control                     | Restrictions placed on the movement of fish, people and other things to prevent the spread of disease.  |
| OIE Aquatic Code                     | OIE <i>Aquatic Animal Health Code</i> (OIE 2007a). Published on the internet at:<br><a href="http://www.oie.int/eng/normes/fcode/en_sommaire.htm">http://www.oie.int/eng/normes/fcode/en_sommaire.htm</a><br><br><i>See Appendix 1 for further details</i>  |
| OIE Aquatic Manual                   | OIE <i>Manual of Diagnostic Tests for Aquatic Animals</i> (OIE 2006a). Describes standards for laboratory diagnostic tests and the production and control of biological products (principally vaccines). The current edition is published on the internet at:<br><a href="http://www.oie.int/eng/normes/fmanual/A_summry.htm">http://www.oie.int/eng/normes/fmanual/A_summry.htm</a><br><br><i>See Appendix 1 for further details</i> |
| Operational procedures               | Detailed instructions for carrying out specific disease control activities, such as disposal, destruction, decontamination and valuation.   |
| Polymerase chain reaction (PCR)      | A method of amplifying and analysing DNA sequences that can be used to detect the presence of DNA from a disease agent.   |
| - reverse transcriptase PCR (RT-PCR) | A PCR method for amplifying a defined piece of ribonucleic acid (RNA). The RNA strand is first reverse transcribed into its DNA complement, followed by amplification of the resulting DNA.   |
| - real-time PCR                      | A PCR method used to amplify and simultaneously quantify a targeted DNA (or RNA) molecule. It enables both detection and quantification of a specific sequence in a DNA (or RNA) sample.  |
| Premises or area                     | A production site, which may range from an aquarium to an aquaculture lease in the open ocean.  |

|   |   |
|---|---|
| Primary Industries Ministerial Council          | The council of Australian national, state and territory, and New Zealand ministers of agriculture that sets Australian and New Zealand agricultural policy (formerly the Agriculture and Resource Management Council of Australia and New Zealand).   |
| Quarantine                                      | Legal restrictions imposed on a place, fish, vehicles or other things, limiting movement.   |
| Restricted area                                 | The area around an infected premises (or area), likely to be subject to intense surveillance and movement controls. It is likely to be relatively small. It may include some dangerous contact premises (or areas) and some suspect premises (or areas), as well as enterprises that are not infected or under suspicion. Movement of potential vectors of disease out of the area will, in general, be prohibited. Movement into the restricted area would only be by permit. Multiple restricted areas may exist within one control area. |
| Risk enterprise                                 | A defined livestock or related enterprise, which is potentially a major source of infection for many other premises. Includes hatcheries, aquaculture farms, processing plants, packing sheds, fish markets, tourist angling premises, veterinary laboratories, road and rail freight depots and garbage depots.  |
| State or territory disease control headquarters | The emergency operations centre that directs the disease control operations to be undertaken in that state or territory.  |
| Surveillance                                    | A systematic series of investigations of a given population of fish to detect the occurrence of disease for control purposes, and which may involve testing samples of a population.  |
| Susceptible animal                              | Animal that can be infected with a particular disease.  |
| Tracing   | The process of locating animals, persons or other items that may be implicated in the spread of disease, so that appropriate action can be taken.   |
| Vector  | A living organism that transmits an infectious agent from one host to another. A <i>biological</i> vector is one in which the infectious agent must develop or multiply before becoming infective to a recipient host. A <i>mechanical</i> vector is one that transmits an infectious agent from one host to another but is not essential to the life cycle of the agent.   |
| Zoning  | The process of defining disease-free and infected areas.  |



## Abbreviations

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|             |   |
|-------------|---|
| AAHL        | Australian Animal Health Laboratory (CSIRO)   |
| APVMA       | Australian Pesticides and Veterinary Medicines Authority                            |
| AqCCEAD     | Aquatic Consultative Committee on Emergency Animal Diseases                         |
| AQUAVETPLAN | Australian Aquatic Veterinary Emergency Plan  |
| AUSVETPLAN  | Australian Veterinary Emergency Plan  |
| CPE         | cytopathic effect   |
| CSIRO       | Commonwealth Scientific and Industrial Research Organisation                        |
| CVO         | Chief Veterinary Officer  |
| DAFF        | Department of Agriculture, Fisheries and Forestry (Australian Government)           |
| DNA         | deoxyribonucleic acid   |
| EAD         | emergency animal disease  |
| GVP         | gross value of production   |
| HOG         | head-on, gutted   |
| IFAT        | indirect fluorescent antibody test  |
| ISA         | infectious salmon anaemia   |
| ISAV        | infectious salmon anaemia virus   |
| MUP         | minor use permit  |
| OIE         | World Organisation for Animal Health (formerly Office International des Epizooties) |
| PCR         | polymerase chain reaction   |
| ppm         | parts per million   |
| RNA         | ribonucleic acid  |
| RT-PCR      | reverse transcriptase polymerase chain reaction                                     |
| UV          | ultraviolet   |

## References

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AFFA (Agriculture, Forestry and Fisheries—Australia) (2001). *AQUAPLAN Zoning Policy Guidelines*, AFFA (now Australian Government Department of Agriculture, Fisheries and Forestry), Canberra.

[http://www.daff.gov.au/\\_data/assets/pdf\\_file/0007/146716/zoning-final-aug.pdf](http://www.daff.gov.au/_data/assets/pdf_file/0007/146716/zoning-final-aug.pdf)

Binde M (1998). ISA control—Critical factors in Norway. In: *Proceedings of the Workshop on Infectious Salmon Anaemia*, November 26, 1997, St Andrews, NB, 79–80.

Bouchard DA, Brockway K, Giray C, Keleher W and Merrill PL (2001). First report of infectious salmon anaemia (ISA) in the United States. *Bulletin of the European Association of Fish Pathologists* 21:86–88.

Bouchard D, Keleher W, Opitz HM, Blake S, Edwards KC and Nicholson B L (1999). Isolation of infectious salmon anemia virus (ISAV) from Atlantic salmon in New Brunswick, Canada. *Diseases of Aquatic Organisms* 35:131–137.

Bovo G, Hill B, Husby Håstein T, Michel C, Olesen NJ, Storset A and Midtlyng PJ (2005). Orthomyxovirus infections: Infectious salmon anaemia (ISA). In: *Work Package 3 report: Pathogen Survival Outside the Host, and Susceptibility to Disinfection*. VESO, Oslo, Norway, 13–15.

Clouthier SC, Rector T, Brown NEC and Anderson ED (2002). Genomic organization of infectious salmon anaemia. *Journal of Virology* 83:421–428.

Cook-Versloot M, Griffiths S, Cusack R, McGeachy S and Ritchie R (2004). Identification and characterisation of infectious salmon anaemia virus (ISAV) haemagglutinin gene highly polymorphic region (HPR) type 0 in North America. *Bulletin of the European Association of Fish Pathologists* 24:203–208.

Crane M StJ and Williams LM (2007). Viruses of salmonids: virus isolation in fish cell lines. Australian and New Zealand Standard Diagnostic Procedure, Australian Government Department of Agriculture, Fisheries and Forestry, Canberra

Cunningham CO, Gregory A, Black J, Simpson I and Raynard RS (2002). A novel variant of the infectious salmon anaemia virus (ISAV) haemagglutinin gene suggests mechanisms for virus diversity. *Bulletin of the European Association of Fish Pathologists* 22:366–373.

Cunningham CO and Snow M (2000). Genetic analysis of infectious salmon anaemia virus (ISAV) from Scotland. *Diseases of Aquatic Organisms* 41:1–8.

DAFF (Australian Government Department of Agriculture, Fisheries and Forestry) (2008a). *Australia's National List of Reportable Diseases of Aquatic Animals*, National Biosecurity Committee, DAFF, Canberra.

[http://www.daff.gov.au/\\_data/assets/word\\_doc/0003/346521/reportable-diseases-aquatic17nov2008.doc](http://www.daff.gov.au/_data/assets/word_doc/0003/346521/reportable-diseases-aquatic17nov2008.doc)

DAFF (Australian Government Department of Agriculture, Fisheries and Forestry) (2008b). *Aquatic Animal Diseases Significant to Australia: Identification Field Guide*, 3<sup>rd</sup> edition, DAFF, Canberra.

<http://www.daff.gov.au/animal-plant-health/pests-diseases-weeds/aquatic-animal-diseases-significant-to-australia-identification-field-guide>

Dannevig B H, Falk K and Namork E (1995). Isolation of the causal virus of infectious salmon anaemia (ISA) in a long-term cell line from Atlantic salmon head kidney. *Journal of General Virology* 76:1353–1359.

Dannevig BH, Falk K and Skerve E (1994). Infectivity of internal tissues of Atlantic salmon, *Salmo salar* L., experimentally infected with the aetiological agent of infectious salmon anaemia (ISA). *Journal of Fish Diseases* 17:613–622.

Dannevig BH and Thorud KE (1999). Other viral diseases and agents of cold-water fish: Infectious salmon anaemia, pancreas disease and viral erythrocytic necrosis. In: *Fish Diseases and Disorders*, Woo PTK and Bruno DW, eds, CABI Publishing, Vol. 3:149–175.

Devold M, Falk K, Dale OB, Krossøy B, Biering E, Aspehaug V, Nilsen F and Nylund A (2001). Strain variation, based on the hemagglutinin gene, in Norwegian ISA virus isolates collected from 1987 to 2001: indications of recombination. *Diseases of Aquatic Organisms* 47:119–128.

Devold M, Krossøy B, Aspehaug V and Nylund A (2000). Use of RT-PCR for diagnosis of infectious salmon anaemia virus (ISAV) in carrier sea trout *Salmo trutta* after experimental infection. *Diseases of Aquatic Organisms* 40:9–18.

Evensen, Ø, Thorud KE and Olsen YA (1991). A morphological study of the gross and light microscopic lesions of infectious salmon anaemia in Atlantic salmon (*Salmo salar*). *Research in Veterinary Science* 51: 215–222.

Falk K and Dannevig BH (1995). Demonstration of a protective immune response in infectious salmon anaemia (ISA)-infected Atlantic salmon *Salmo salar*. *Diseases of Aquatic Organisms* 21:1–5.

Falk K, Namork E, Rimstad E, Mjaaland S and Dannevig BH (1997). Characterization of infectious salmon anemia virus, an orthomyxo-like virus isolated from Atlantic salmon (*Salmo salar* L.). *Journal of Virology* 71:9016–9023.

Gustafson LL, Ellis SK and Bartlett CA (2005). Using expert opinion to identify risk factors important to infectious salmon-anemia (ISA) outbreaks on salmon farms in Maine, USA and New Brunswick, Canada. *Preventive Veterinary Medicine* 70:17–28.

Hastings T, Olivier G, Cusack R, Bricknell I, Nylund A, Binde M, Munro P and Allan C (1999). Infectious salmon anaemia. *Bulletin of the European Association of Fish Pathologists* 19:286–288.

Hovland T, Nylund A, Watanabe K and Endresen C (1994). Observation of infectious salmon anaemia virus in Atlantic salmon, *Salmo salar* L. *Journal of Fish Diseases* 17:291–296.

Inglis JA, Bruce J and Cunningham CO (2000). Nucleotide sequence variation in isolates of infectious salmon anaemia virus (ISAV) from Atlantic salmon *Salmo salar* in Scotland and Norway. *Diseases of Aquatic Organisms* 43:71–76.

Jarp J and Karlsen E (1997). Infectious salmon anaemia (ISA) risk factors in sea-cultured Atlantic salmon *Salmo salar*. *Diseases of Aquatic Organisms* 28:79–86.

Kibenge FSB, Garate ON, Johnson G, Arriagada R, Kibenge MJT and Wadowska D (2001a). Isolation and identification of infectious salmon anaemia virus (ISAV) from Coho salmon in Chile. *Diseases of Aquatic Organisms* 45:9–18.

Kibenge FSB, Kibenge MJT, Joseph T and McDougall J (2003). The development of infectious salmon anaemia vaccines in Canada. In: Technical Bulletin 1902: *International Response to*

*Infectious Salmon Anemia: Prevention, Control and Eradication*, Miller O and Cipriano RC, eds. USDA, APHIS; US Dept Interior, US Geological Survey; US Dept Commerce, National Marine Fisheries Service, Washington DC, USA, 39–49.

Kibenge FSB, Kibenge MJT, McKenna PK, Stothard P, Marshall R, Cusack RR and McGeachy S (2001b). Antigenic variation among isolates of infectious salmon anaemia virus correlates with genetic variation of the viral haemagglutinin gene. *Journal of General Virology* 82:2869–2879.

Kibenge FSB, Lyaku JR, Rainnie D and Hammell KL (2000). Growth of infectious salmon anaemia virus in CHSE-214 cells and evidence for phenotypic differences between virus strains. *Journal of General Virology* 81:143–150.

Koren CWR and Nylund A (1997). Morphology and morphogenesis of infectious salmon anaemia virus replicating in the endothelium of Atlantic salmon *Salmo salar*. *Diseases of Aquatic Organisms* 29:99–109.

Krossøy B, Hordvik I, Nilsen F, Nylund A and Endresen C (1999). The putative polymerase sequence of infectious salmon anemia virus suggests a new genus within the *Orthomyxoviridae*. *Journal of Virology* 73:2136–2142.

Lovely JE, Dannevig BH, Falk K, Hutchin L, Mackinnon AM, Melville KJ, Rimstad E and Griffiths SG (1999). First identification of infectious salmon anaemia virus in North America with haemorrhagic kidney syndrome. *Diseases of Aquatic Organisms* 35:145–148.

MacLean SA, Bouchard DA and Ellis SK (2003). Survey of non-salmonid marine fishes for detection of infectious salmon anemia virus and other salmonid pathogens. In: Technical Bulletin 1902. *International Response to Infectious Salmon Anemia: Prevention, Control and Eradication*, Miller O and Cipriano RC, eds, USDA, APHIS; US Dept Interior, US Geological Survey; US Dept Commerce, National Marine Fisheries Service, Washington DC, USA, 135–143.

Mikalsen AB, Teig A, Helleman A-L, Mjaaland S and Rimstad E (2001). Detection of infectious salmon anaemia virus (ISAV) by RT-PCR after cohabitant exposure in Atlantic salmon *Salmo salar*. *Diseases of Aquatic Organisms* 47:175–181.

Mullins JE, Groman D and Wadowska D (1998). Infectious salmon anaemia in salt water Atlantic salmon (*Salmo salar* L.) in New Brunswick, Canada. *Bulletin of the European Association of Fish Pathologists* 18:110–114.

Munir K and Kibenge FSB (2004). Detection of infectious salmon anaemia virus by real-time RT-PCR. *Journal of Virological Methods* 117:37–47.

Nylund A, Devold M, Mullins J and Plarre H (2002). Herring (*Clupea harengus*): A host for infectious salmon anaemia virus (ISAV). *Bulletin of the European Association of Fish Pathologists* 22:311–318.

Nylund A, Devold M, Plarre H, Isdal E and Aarseth M (2003). Emergence and maintenance of infectious salmon anaemia virus (ISAV) in Europe: a new hypothesis. *Diseases of Aquatic Organisms* 56:11–24.

Nylund A, Hovland T, Hodneland K, Nilsen F and Løvik P (1994). Mechanisms for transmission of infectious salmon anaemia (ISA). *Diseases of Aquatic Organisms* 19:95–100.

Nylund A, Hovland T, Watanabe K and Endresen CP (1995). Presence of infectious salmon anaemia virus (ISAV) in tissues of Atlantic salmon, *Salmo salar* L., collected during three separate outbreaks of the disease. *Journal of Fish Diseases* 18:135–145.

Nylund A and Jakobsen P (1995). Sea trout as a carrier of infectious salmon anaemia virus. *Journal of Fish Biology* 47:174–176.

Nylund A, Kvenseth AM, Krossoy B and Hodneland K (1997). Replication of the infectious salmon anaemia virus (ISAV) in rainbow trout, *Oncorhynchus mykiss* (Walbaum). *Journal of Fish Diseases* 20:275–279.

OIE (World Organisation for Animal Health) (2006a). Infectious salmon anaemia. In: *Manual of Diagnostic Tests for Aquatic Animals*, 5<sup>th</sup> edition, OIE, Paris, 186–201.

OIE (World Organisation for Animal Health) (2006b). Diseases of fish: General information. In: *Manual of Diagnostic Tests for Aquatic Animals*, 5<sup>th</sup> edition, OIE, Paris, 67–81.

OIE (World Organisation for Animal Health) (2006c). Requirements for surveillance for international recognition of freedom from infection. In: *Manual of Diagnostic Tests for Aquatic Animals*, 5<sup>th</sup> edition, OIE, Paris, 31–49.

OIE (World Organisation for Animal Health) (2007). *Aquatic Animal Health Code*, 10<sup>th</sup> edition, OIE, Paris. [See Appendix 1 for further details]

OIE (World Organisation for Animal Health) (2007a). Zoning and compartmentalisation. In: *Aquatic Animal Health Code*, 10<sup>th</sup> edition, OIE, Paris, 42–45. [See Appendix 1 for further details]

OIE (World Organisation for Animal Health) (2007b). Guidelines for fallowing in aquaculture. In: *Aquatic Animal Health Code*, 10<sup>th</sup>, OIE, Paris, 65–66. [See Appendix 1 for further details]

Raynard RS, Murray AG and Gregory A (2001). Infectious salmon anaemia virus in wild fish from Scotland. *Diseases of Aquatic Organisms* 46:93–100.

Rimstad E, Falk K, Mikalsen AB and Teig A (1999). Time course tissue distribution of infectious salmon anaemia virus in experimentally infected Atlantic salmon *Salmo salar*. *Diseases of Aquatic Organisms* 36:107–112.

Ritchie RJ, Cook M, Melville K, Simard N, Cusack R and Griffiths S (2001). Identification of infectious salmon anaemia virus in Atlantic salmon from Nova Scotia (Canada): evidence for functional strain differences. *Diseases of Aquatic Organisms* 44:171–178.

Rodger HD, Turnbull T, Muir F, Millar S and Richards RH (1998). Infectious salmon anaemia (ISA) in the United Kingdom. *Bulletin of the European Association of Fish Pathologists* 18:115–116.

Rolland JB and Nylund A (1998). Infectiousness of organic materials originating in ISA-infected fish and transmission of the disease via salmon lice (*Lepeophtheirus salmonis*). *Bulletin of the European Association of Fish Pathologists* 18:173–180.

Rolland JB and Winton JR (2003). Relative resistance of Pacific salmon to infectious salmon anaemia virus. *Journal of Fish Diseases* 26:511–520.

Rowley HM, Campbell SJ, Curran WL, Turnbull T. and Bryson DG (1999). Isolation of infectious salmon anaemia virus (ISAV) from Scottish farmed Atlantic salmon, *Salmo salar* L. *Journal of Fish Diseases* 22:483–487.

Scottish Parliament (1999). Salmon farming and the impact of the ISA virus. Research Note 99/20, 19 August 1999, The Scottish Parliament: the information centre, 1-7.

Simko E, Brown LL, MacKinnon AM, Byrne PJ, Ostland VE and Ferguson HW (2000). Experimental infection of Atlantic salmon, *Salmo salar* L., with infectious salmon anaemia virus: a histopathological study. *Journal of Fish Diseases* 23:27-32.

Smail DA, Grant R, Simpson D, Bain N and Hastings TS (2004). Disinfectants against cultured infectious salmon anaemia (ISA) virus: the virucidal effect of three iodophors, chloramine T, chlorine dioxide and peracetic acid/hydrogen peroxide/acetic acid mixture. *Aquaculture* 240:29-38.

Snow M, Raynard RS and Bruno DW (2001a). Comparative susceptibility of Arctic char (*Salvelinus alpinus*), rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*) to the Scottish isolate of infectious salmon anaemia virus. *Aquaculture* 196:47-54.

Snow M, Raynard RS, Inglis J and Bruno DW (2001b). Investigation into the potential for seawater rainbow trout (*Oncorhynchus mykiss*) to act as vectors of infectious salmon anaemia virus (ISAV). *Bulletin of the European Association of Fish Pathologists* 21:252-262.

Speilberg L, Evensen Ø and Dannevig BH (1995). A sequential study of the light and electron microscopic liver lesions of infectious salmon anemia in Atlantic salmon (*Salmo salar* L.). *Veterinary Pathology* 32:466-478.

Stagg RM (2003a). Infectious salmon anaemia—an emerging global disease of salmon aquaculture. 1<sup>st</sup> FRDC National Aquatic Animal Health Scientific Conference, Geelong Australia, 8-10 October 2003.

Stagg RM (2003b). Management of an exotic disease outbreak—infectious salmon anaemia in Scotland. 1<sup>st</sup> FRDC National Aquatic Animal Health Scientific Conference, Geelong Australia, 8-10 October 2003.

Stagg RM (2003c). Eradication of VHS and ISA—Scottish experience in an international context. 1<sup>st</sup> FRDC National Aquatic Animal Health Scientific Conference, Geelong Australia, 8-10 October 2003.

Starkey WG, Smail DA, Bleie H, Muir KF, Ireland JH and Richards RH (2006). Detection of infectious salmon anaemia virus by real-time nucleic acid sequence based amplification. *Diseases of Aquatic Organisms* 72: 107-113.

Thorud K and Djupvik HO (1988). Infectious anaemia in Atlantic salmon (*Salmo salar* L.). *Bulletin of the European Association of Fish Pathologists* 8: 109-111.

Torgersen Y (1998). Physical and chemical inactivation of the infectious salmon anaemia (ISA) virus. In: *Proceedings of the Workshop on Infectious Salmon Anaemia*, November 26 1997, St Andrews, NB, 44-53.

Totland GK, Hjeltnes BK and Flood PR (1996). Transmission of infectious salmon anaemia (ISA) through natural secretions and excretions from infected smolts of Atlantic salmon *Salmo salar* during their presymptomatic phase. *Diseases of Aquatic Organisms* 26:25-31.

Wergeland HI and Jakobsen RA (2001). A salmonid cell line (TO) for production of infectious salmon anaemia virus (ISAV). *Diseases of Aquatic Organisms* 44:183-190.

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