Successful aquatic animal disease emergency programmes

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Summary
The authors provide examples of emergency programmes which have been successful in eradicating or controlling certain diseases of aquatic animals. The paper is divided into four parts.

The first part describes the initial isolation of viral haemorrhagic septicemia (VHS) virus in North America in the autumn of 1988 from feral adult chinook (Oncorhynchus tshawytscha) and coho salmon (O. kisutch) returning for spawning. The fish disease control policies at both State and Federal levels in the United States of America required quarantine and emergency eradication measures upon the finding of certain exotic fish pathogens, including VHS virus. The procedures for emergency plans, destruction of stocks and disinfection of facilities are described, as well as challenge experiments with the North American strains of VHS virus and the detection of the virus in marine fish species (cod [Gadus macrocephalus] and herring [Clupea harengus pallasii]) in the Pacific Ocean.

The second part of the paper outlines the aquatic animal legislation in Great Britain and within the European Union, in regard to contingency plans, initial investigations, action on the suspicion of notifiable disease and action on confirmation of infection. The legal description is followed by an account of an outbreak of viral haemorrhagic septicemia in turbot (Scophthalmus maximus) in Great Britain, including the stamping-out process at the affected farm and investigations conducted to screen other farms in the vicinity for possible infection.

The third part provides a historical review of the build-up of infectious salmon anaemia (ISA) in Norway and the attempts to control the disease using legal measures in the absence of detailed knowledge of the aetiology, epizootiology, pathogenesis, etc. of the disease. The measures taken show that the spread of ISA can be controlled using restrictions on the movement of fish, disinfection procedures, etc. However, acceptance and understanding of the chosen strategy by the fish farmers is a pre-requisite to reach that goal.

Finally, the paper summarises future needs for national and international legislation, including the development of standard approaches for control, the creation of appropriate infrastructures and a better understanding of the epidemiology of aquatic animal diseases.

Keywords
Introduction

Over the last decades, several emerging or serious diseases such as viral haemorrhagic septicemia (VHS), infectious haematopoietic necrosis (IHN), infectious salmon anaemia (ISA) and infectious pancreatic necrosis (IPN), have been diagnosed among feral and farmed fish populations in areas of the world where they were previously unknown. These untreatable or exotic diseases have created large problems in the fish farming industry and thus have been the subject of aquatic animal disease emergency programmes in several countries.

The differences between infectious diseases of aquatic animals and those of terrestrial animals mean that emergency eradication efforts also differ. Importantly, effective quarantine areas may be difficult to establish because aquatic animal diseases can spread efficiently in flowing water. In addition, large natural populations of susceptible aquatic species may reside near affected facilities. These animals can become infected to establish reservoirs of disease that are difficult, or impossible, to eradicate. Another problem with many aquatic animal diseases is the general lack of epizootiological knowledge, including information about vectors, reservoirs and controlling features of the host-pathogen relationship. On the positive side, few aquatic animal diseases affect humans, making them less of a threat to those engaged in the eradication efforts.

For essentially all viral and many of the bacterial, protozoan and fungal diseases of aquatic animals, there are no effective vaccines or prophylactic measures other than avoidance of exposure to the pathogen. Avoidance is best achieved through careful husbandry which includes the use of pathogen-free water supplies (wells or fish-free springs) and certified, specific-pathogen-free (SPF) stocks (16). Should these methods fail and animals become infected with an untreatable disease agent, especially a serious exotic pathogen, an emergency situation may exist. In such cases, eradication (stamping-out) procedures must be followed. These consist of removing all infected animals from the premises by sanitary slaughter or by killing and burying the animals in lime-treated landfills, followed by cleaning and disinfection of the entire fish-rearing facility, including pipes, ponds and equipment (16). The facility is generally allowed to remain fallow for a period before being restocked with certified SPF sentinel animals which are sampled extensively. These emergency management plans and detailed procedures need to be carefully worked out and agreed upon by all parties in advance of the emergency situation to facilitate the efficient implementation of the eradication efforts when needed.

Examples of successful emergency programmes for the eradication or control of important aquatic animal diseases are described below.

Eradication of viral haemorrhagic septicemia virus from freshwater facilities in North America

Viral haemorrhagic septicemia virus (VHSV) is considered to be the most significant viral pathogen of salmonids (Salmo spp. and Oncorhynchus spp.) worldwide (36). The virus was formerly believed to be confined essentially to freshwater facilities in western Europe where losses of over US$60 million per year are incurred on rainbow trout (Oncorhynchus mykiss) farms (18). Most countries with fish disease policies require that live, imported salmonid fish and eggs be subjected to certification examinations to prevent the introduction of VHSV and certain other exotic pathogens. The first isolations of VHSV in North America were in the Autumn of 1988 from adult chinook salmon (O. tshawytscha) at Glenwood Springs Hatchery, a private facility on Orcas Island in Washington State which is co-operatively managed by the Washington Department of Fisheries and Wildlife, and from adult coho salmon (O. kisutch) at the Makah National Fish Hatchery, operated by the United States Fish and Wildlife Service on the Makah Tribal Reservation near Neah Bay in north-western Washington State (22). Recovered during routine health examinations of returning salmon, the viruses were initially thought to be isolates of infectious haematopoietic necrosis virus (IHNV), a virus that causes extensive losses in hatchery-reared trout and salmon and which is enzootic among many stocks of anadromous salmon in western North America; however, when tested with antiserum to IHNV, the isolates did not react. The two isolates were sent to the Western Fisheries Research Center Laboratory in Seattle where they were grown in fish cell lines and the viruses concentrated and purified. The virus particles were examined by electron microscopy and the viral proteins were analysed by polyacrylamide gel electrophoresis. These tests indicated that both isolates were rhabdoviruses and were similar to only three agents known to infect fish: VHSV, IHNV and hirame rhabdovirus (HRV), a rhabdovirus believed to be present only in Japan. Further tests, using specific antisera prepared against IHNV, VHSV and HRV confirmed that VHSV antiserum reacted with the five structural proteins of the new isolates and could neutralise infectivity of the isolates. The serum neutralisation test was considered definitive and the virus was confirmed as VHSV on 17 February 1989.

Fish disease control policies were already in place among both State and Federal fisheries agencies that required immediate quarantine and emergency eradication efforts upon the finding of VHSV or other specified exotic fish pathogens. The discovery that VHSV was present in two hatcheries in Washington State set these emergency plans in motion in an effort to eliminate the virus from North America. The plans
called for the establishment of a quarantine zone and the destruction of all 4.5 million fish and eggs at the two affected hatcheries. The fish were buried in lime-treated pits; the complete disinfection of all parts of the hatcheries using high levels of chlorine followed. Before destruction, juvenile chinook and coho salmon and steelhead trout (anadromous O. mykiss) reared at the Makah Tribal Hatchery were tested and found to be infected with the virus although losses in these stocks were very low. An extensive survey of several thousand fish obtained from freshwater and saltwater locations in Washington State and British Columbia, Canada, was conducted by State, Federal and Tribal biologists to determine if other fish in the surrounding area had become infected. These tests gave negative results. The Glenwood Springs Hatchery and the Makah National Fish Hatchery were completely disinfected and sentinel fish were placed in the facilities and sampled at regular intervals. These fish remained normal, indicating that the elimination of the virus from both facilities had been successful.

In laboratories in Seattle and on Marrowstone Island, challenges of chinook, coho, pink (O. gorbuscha), chum (O. keta), sockeye (O. nerka) and Atlantic salmon (Salmo salar) as well as rainbow and steelhead trout were conducted using VHSV isolates from Washington State. These experiments showed the North American strains were less virulent than their European counterparts. Soon, other strains of VHSV were obtained from Pacific cod (Gadus macrocephalus) in Alaska, United States of America (USA) (21) and from Pacific herring (Clupea harengus pallasi) in Alaska, Washington and British Columbia, leading to the realisation that the North American strain of the virus was enzootic among marine fish species along the Pacific coast of North America (22). Although the North American and European strains are related and cannot be distinguished with conventional serological reagents, results from ribonuclease fingerprinting (28) and sequence analysis of the genome (8) showed the strains from North America were different from the European reference strains. In order to increase the speed and precision of the diagnosis of VHS and to distinguish the avirulent North American strain from the exotic European strain were found in juvenile fish that could lead to the establishment of freshwater carriers or selection for increased virulence. A similar increase in virulence (especially for larger fish) was seen with IHNV in Idaho following the introduction and establishment of IHNV on rainbow trout farms. As three species of young salmon and trout at the Makah Hatchery were shown to be infected, the eradication efforts may have been important in preventing the adaptation of the marine virus to freshwater stocks and avoiding problems in the future. Currently, most fish health professionals judge the North American efforts to have been worthwhile and would support renewed eradication efforts if the European strain were found in any stock of fish, or if the North American strain were found in juvenile fish that could lead to the establishment of freshwater carriers or selection for increased virulence.

Disease contingency planning in Great Britain and the application of plans to eradicate viral haemorrhagic septicaemia from a turbot farm in Scotland

Fish disease legislation in Great Britain

Legislation specifically intended to control fish diseases has existed in Great Britain for over 60 years. The Diseases of Fish Act was passed in 1937 in response to a series of outbreaks of a bacterial disease (furunculosis) in wild salmonids and other freshwater fish from 1910 to the 1930s (1). This legislation provided the enforcing authorities with a wide range of statutory powers and established certain legal requirements for fisheries owners, fish farmers and fish importers (19). The main provisions of the Act included restrictions on importation of live fish and eggs into Great Britain, preliminary precautions to be taken on suspicion of a notifiable disease, powers of entry onto land to inspect waters therein or to take samples for examination, and powers to designate any disease as notifiable, publicly designate any waters or area found to be infected by notifiable disease,
prohibit or regulate the transport of live fish, eggs or feed from that area, and order the removal of dead and dying fish and their disposal. From 1937, it became illegal to import live salmonids into Great Britain and this total prohibition remained in force for 46 years. With the added advantage of being an island (and therefore having no cross-border rivers or other bodies of freshwater), this is undoubtedly why Great Britain remained free of certain serious infectious diseases of salmon and trout, such as VHS and IHN, which have spread and become endemic in other countries of Europe.

This legislation gave Great Britain considerable protection against the risk of introducing serious fish diseases from other countries and also provided regulations to control outbreaks of serious (notifiable) diseases within the country. However, this strong package of national legislation for the control of fish diseases was amended with effect from the beginning of 1993 to meet the requirements of the European Union (EU). With the creation of a 'single market' within the EU, there was to be an increase in the free movement of goods, including live animals, between all Member States. However, it was recognised that animal health measures would be required so that trade in live animals did not compromise the animal disease status of countries belonging to the EU. The concern about the possible spread of serious fish diseases, together with the wish to liberate trade, led to the adoption of EC Directive 91/67/EEC which provides a common framework of conditions regulating trade in aquaculture animals and their products both within and between EU Member States and from exporting nations outside the EU (14). Under EU legislation, each EU Member State must amend any national legislation (or introduce new legislation) to allow EU rules to have legal force within that Member State. Great Britain implemented this Directive in the form of the Fish Health Regulations 1992 (2), subsequently replaced by the Fish Health Regulations, 1997 (5).

Fish disease contingency plans

In addition, another important EU Directive, 93/53/EEC, was adopted to establish uniform rules for the control of List I diseases (currently exotic to the EU) and List II diseases (serious diseases affecting some parts of the EU other parts known to be free) (15). The only disease currently on List I is ISA and List II diseases comprise VHS and IHN. These requirements were legally implemented in Great Britain, where they were not already covered by existing legislation, through the Diseases of Fish (Control) Regulations 1994 (3). One of the requirements of Directive 93/53/EEC was that each EU Member State had to draw up a contingency plan specifying how the measures laid down in the Directive would be implemented in the event of an outbreak of a List I disease. Each Member State also had to ensure that a national reference laboratory was designated for fish disease diagnosis. The Government Departments in Great Britain responsible for fish disease matters duly drew up contingency plans for dealing with an outbreak of ISA and, furthermore, in view of the absence of List II diseases (VHS and IHN) from Great Britain, included plans for dealing with outbreaks of either of these two diseases.

The contingency plans require that, in the event of an outbreak of ISA, IHN or VHS, a National Crisis Centre (NCC) will be established to co-ordinate all control measures against the disease in question. Since it would be necessary to co-ordinate the control measures at a local level, local disease control centres, each of which has adequate facilities for this purpose, will have been identified. A co-ordinator will be responsible for supervising the response to an outbreak and the operation of control measures at the local level will be the responsibility of the Fish Health Inspectorate. Inspectors will investigate suspected disease outbreaks, take samples of fish or other materials for laboratory testing, apply disease control measures as specified in the contingency plans, and ensure compliance with all controls. The contingency plans require that the actions to be taken in relation to fish farms on suspicion and confirmation of infection or contamination with IHN or VHS are as follows:

**Initial investigation**

If there is any cause for concern or suspicion that a fish farm may be infected with IHN or VHS, an inspector must immediately visit and carry out an on-site investigation. Such concern or suspicion may arise, for example:
- following a report of suspicious mortalities or clinical signs;
- following a report that fish have been introduced illegally from a non-approved zone or equivalent;
- during an investigation of farms which have received fish from, or have supplied fish to, a site known to be infected or which is in close proximity to a site known to be infected;
- during routine laboratory testing of samples, dubious reactions indicating covert infection may be present.

If, following the on-site investigation, that concern appears to be justified, the inspector or other suitably qualified staff will take a sample of fish and will ensure that this reaches the relevant NCC for laboratory examination as speedily as possible (and certainly within 48 hours) either by delivering it personally or by using a commercial carrier. All sampling and testing for IHN or VHS will be performed in accordance with current EU proposals specified by the relevant Commission Decision.

**Action on 'suspicion of infection'**

If fish from the farm are found to have clinical signs of IHN or VHS, or show post-mortem lesions, or have produced dubious reactions in laboratory tests (or in any tests conducted on site) they shall be regarded as fish suspected of being infected. Laboratory tests will be completed as rapidly as possible on a sample of fish to confirm or rule out the presence of disease. In addition, if fish have been introduced from a site which is known or suspected to have VHS or IHN,
or from a site which is in close proximity to a site known to be suspected, the fish should also be regarded as being suspected of being infected.

The co-ordinator of the relevant NCC will immediately inform the relevant Government Policy Division of the finding of fish suspected as being infected, and will provide a full report explaining all the circumstances and the action taken. The local disease control centre will be placed on full alert and the approved zone status for the affected area suspended as stipulated in Directive 91/67/EEC (14).

As required by Directive 93/53/EEC (15), the relevant Policy

- the European Commission
- the Office International des Epizooties (OIE)
- the EU Reference Laboratory
- the CVO, who will notify CVOs in other Member States.

The co-ordinator of the relevant NCC will ensure that the following action is taken immediately and concurrently:

- That a 30-day notice is served or a DAO (designated area order) is made. The service of a notice or DAO requires the occupier to take specified measures to disinfect the entrances and exits to the farm and requires any person to obtain the written permission of the relevant Minister in order to:
  a) bring onto or remove from the farm all fish (whether alive or dead), eggs or gametes; or
  b) dispose of any dead fish or their offal except under the supervision of the relevant official service; or
  c) bring onto or take from the farm any equipment, material or substances liable to transmit disease; or
  d) enter onto or exit from the farm; or
  e) bring any vehicle onto or take a vehicle from the farm; or
  f) remove any fish (whether alive or dead), eggs or gametes from a farm which is in the same water catchment area or coastal area as the farm on which the outbreak or disease is suspected; or whose owner or occupier has been notified that his farm is under surveillance for disease; and to take any other measures deemed necessary to prevent the spread of infection from the infected site.

- That one or more inspectors are seconded to the relevant local disease control centre to co-ordinate the disease control measures at a local level, and to ensure compliance with those controls.

- That a census is made by an inspector which shows the:
  a) species of fish present on the farm and the disease with which they are suspected of being infected
  b) categories of fish
  c) number of dead fish
  d) number of infected fish
  e) number of fish suspected of being infected or contaminated.

- That a copy of the census is left with the owner or occupier who will be informed of the obligation:
  a) to update the census regularly to take account of any increased population or new mortality
  b) to keep the census available for regular inspection by an inspector
  c) to retain the census for a period of four years after the expiry of the 30-day notice or the revocation of any DAO.

- That an epizootic investigation is carried out by an inspector which deals with the:
  a) likely length of time during which the disease may have existed on the farm before being notified or suspected
  b) possible origin of the disease on the farm and the identification of other farms on which there are eggs, gametes or fish of susceptible species which may have become infected
  c) movement of fish, eggs or gametes, vehicles or substances and persons likely to have carried the disease agent to or from the farms in question
  d) possible existence of carriers of the disease and their distribution.

- That all of the farms and fisheries situated in the same water catchment area or coastal area are placed under official surveillance. The owner or occupier of these farms or fisheries must be notified that this means that no fish, eggs or gametes may leave the premises without written authorisation of the relevant official service.

If the epizootic investigation reveals that the disease could have been introduced to or from another water catchment area or coastal area, the farms in the second area shall be considered as suspect.

Action on 'reasonable grounds for suspicion'

There may be circumstances where there are reasonable grounds for suspecting that fish on a farm may be infected with IHN or VHS but they do not meet the criteria of 'fish suspected of being infected' referred to above. For example, stocks may be known to have, or strongly suspected of having, been exposed to infection but may fail to show any clinical signs or reaction to laboratory tests. This may be due, for example, to an initially low level of infection or the tests may have been conducted at a sub-optimal time for detection of infection (e.g. during the summer for VHS).

In such cases, consideration will be given to applying controls on suspicion of infection for the purposes of the Diseases of Fish Act 1937 (1). The degree of suspicion which allows action to be taken under the 1937 Act is less than that required by Council Directive 93/53/EEC (15). The 1937 Act allows controls to be applied 'on reasonable grounds for suspecting', whereas the EC Directive requires that fish must
show clinical signs, or post-mortem lesions, or dubious reactions in laboratory tests.

If there are 'reasonable grounds for suspecting' a fish farm to be infected with IHN or VHS, the co-ordinator of the relevant NCC and the relevant Policy Division will consider whether movement controls should be applied under the 1937 Act. Controls will be applied by means of a 30-day notice or a DAO. The notice or DAO will normally prohibit the movement of live fish, eggs or feedstuffs for fish to, or from, or within the area covered.

Action on results of testing
The co-ordinator of the relevant NCC will ensure that further tests are conducted as rapidly as possible to either confirm or rule out the presence of infection. If the presence of infection is confirmed, the co-ordinator will ensure that the appropriate action is taken. If the presence of infection is ruled out, the co-ordinator will ensure that any 30-day notice or DAO is lifted as quickly as possible. The local disease control centre will stand down. The CVO and/or relevant Policy Division(s) will inform the bodies listed above (in the sub-section entitled: Action on 'suspicion of infection') of these findings, and restore the suspended areas approved zone status under the provisions of Directive 91/67/EEC (14).

Action on confirmation of infection
If, following the completion of tests, the presence of IHN or VHS is confirmed, the co-ordinator of the relevant NCC will immediately inform the relevant Policy Division and will provide a full report explaining all the circumstances and the action taken to date.

The relevant Policy Division will ensure that a DAO is served, if this has not already been done. The DAO empowers the Minister to exercise controls under the Diseases of Fish Act, 1937, and the Diseases of Fish (Control) Regulations, 1994, in respect of waters covered by the Order (1, 3). The area covered by the DAO will depend on the circumstances of the case, but is likely to cover the entire water catchment or coastal area in which the infection has been detected.

The relevant Policy Division shall take appropriate action to ensure that the requirements of the DAO are brought to the attention of persons affected by the DAO. This will include some or all of the following:
- advertisements in the London Gazette or Edinburgh Gazette and in local newspapers
- writing to known occupiers of land or waters within the area covered
- writing to fish farming and angler organisations
- placing notices on river banks, for example
- notifying local Sea Fisheries Committees/local fishing organisations where the designated area is a coastal area.

The relevant Policy Division will notify the following:
- the European Commission
- the OIE
- the EU Reference Laboratory
- the CVO, who will notify CVOs in other Member States.

The farm will remain subject to the movement controls, etc. referred to above, and the occupier will be required to continue to keep and update the official census referred to above...

The co-ordinator of the relevant NCC will ensure that a notice is served on the occupier of the farm which requires him or her:
- to remove all fish from the waters on the farm immediately
- to drain, clean and disinfect all pools, if it is an inland fish farm
- to destroy all eggs, gametes, dead fish and fish showing clinical infection under the supervision of an inspector and in accordance with the provisions of Directive 90/667/EEC (13)
- either to:
  - kill and destroy all live fish, under the supervision of an inspector, and in accordance with the provisions of Directive 93/53/EEC (15)
  - slaughter all live fish for marketing or processing for human consumption, under the supervision of an inspector, but only if the fish have reached commercial size and show no clinical signs of disease – the operation to be carried out in accordance with the appropriate safeguards set out in Article 6 (a) of Directive 93/53/EEC (15)
- to clean and disinfect or destroy any equipment, materials or substances likely to be contaminated with the disease pathogen, under the supervision of an inspector, and
- to re-populate the farm only when authorised by the Minister.

The co-ordinator of the relevant NCC may authorise an inspector to perform any of the above actions, or to engage a contractor to do so, if the occupier of the fish farm fails to comply with the requirements of the notice. Costs may be recovered from the occupier.

The co-ordinator of the relevant NCC will ensure that, if it has not already been done, a full epizootic investigation is conducted which includes the taking of samples for laboratory examination.

All farms situated in the same coastal area or water catchment area shall be inspected and eradication implemented, as set out above, if the disease is confirmed to be present. An epizootic investigation shall be undertaken for each confirmed site. Fish in waters that are not a fish farm but which are situated in the same coastal area or water catchment
area in close proximity to a known infected site will also be considered suspect.

In accordance with the provisions of Directive 91/67/EEC, if IHN or VHS is confirmed, approved disease-free status shall be withdrawn (14).

**Application of the contingency plans to an outbreak of viral haemorrhagic septicaemia in turbot in Great Britain**

In September 1994, a laboratory investigation of moribund fish from a marine turbot farm on the island of Gigha, Scotland, determined the cause to be VHS following the demonstration of cytopathic effects in tissue culture and neutralisation by specific antiserum (30). The following is a brief account of events and the eradication steps taken as described in full by Munro (23).

As there had been no previous history of VHS in Great Britain, and there was no reason to suspect the presence of the disease on the turbot farm, there had been no application of the 'on suspicion of infection' contingency plans. Instead, the part of the contingency plans specifying action on confirmation of infection was immediately implemented and an NCC was established at the Marine Laboratory in Aberdeen to co-ordinate the control measures. Movement restrictions on fish and other materials were applied to the turbot farm and soon after, to all marine and freshwater farms within a 20-km radius, including one farm which had received fish from the turbot farm the previous year. A census was conducted of the stocks, and of movements of fish into and from all these farms.

The infected turbot farm was situated on Gigha which is situated at approximately 5 km from the mainland of south-west Scotland. It was a land-based tank farm (using pumped seawater) which had been originally intended for salmon farming but which had been raising turbot since 1991. At the time of the outbreak of VHS, the stock of fish on the farm was entirely turbot, some 90 tonnes of which were in the weight range of 1.1 to 1.9 kg; approximately 160,000 fish were of smaller size classes.

To protect the approved zone status of Great Britain with respect to freedom from VHS, it was essential to apply the contingency plans rapidly and efficiently. An order was served under the Diseases of Fish (Control) Regulations to give instructions for destruction, disposal and subsequent disinfection of the farm (3). The smaller fish of non-market size were killed by excess anaesthesia and 14 tonnes were placed in a single sealed container, the outside of which was chemically disinfected before the slaughtered fish were transported to an industrial incinerator. Council Directive 93/55/EEC allows for the fattening of any fish which show no clinical signs of disease until they can be marketed (15). With approximately 90 tonnes of market-size fish, the farm was allowed to market these over a two-month period. However, during this period, all water discharged from the site was treated with chlorine to prevent the spread of infection to wild fish in the vicinity of the farm. A processing facility was established on the farm to eviscerate all fish prior to marketing. The viscera were disposed of on site by incineration and all liquid wastes were treated separately with hypochlorite before discharge.

As soon as VHS had been confirmed, the possibility of other farm sites being infected was investigated. All farms listed in the movement records of the affected turbot farm as having received or supplied fish over the previous twelve months were considered. Taking into account the dispersion and dilution of the discharge from the farm and a calculation of the possible amounts of virus discharged to sea, it was decided to regard all other fish farms within a 20-km radius as being suspected of being infected and movement restrictions were applied, followed by site inspection and testing of the fish stocks for VHS virus. A total of seven sites within the 20-km controlled radius were investigated but the virus was not found to be present in any of the sites, neither were several species of local wild fish which were tested later that year and in 1995 found to be infected. It was concluded, therefore, that the infection had not spread from the turbot farm and the controlled area was therefore reduced to the Island of Gigha and the sea surrounding the island to a distance of 1 km from the coast. The farm was cleaned, disinfected and has been fallow since March 1995.

In compliance with the requirements to maintain approved zone status for the absence of VHS, all fish farms in Great Britain holding species susceptible to VHS must undergo two health inspections annually (except farms without broodstock which need to be inspected only once a year, as of July 1998) and samples are taken for virus testing once every two years at a time of the year when water temperatures favour the development of VHS. There has been no further detection of VHS virus on any fish farm in Scotland or the rest of Great Britain since the application of the contingency plans and successful eradication of the disease from the affected turbot farm.

**The control of infectious salmon anaemia in Norway**

Infectious salmon anaemia is a viral disease of Atlantic salmon. Initially, ISA was reported to occur only in Norway, but in 1996/1997 the disease condition 'haemorrhagic kidney syndrome' reported from Canada was shown to be ISA. In addition, ISA was reported officially from Scotland at the 66th General Session of the OIE in 1998. The disease is now officially recognised to occur in these three countries. Atlantic salmon is the only species affected by ISA, but both rainbow trout and sea trout (S. truttae) (24, 25, 29, 33) have been
shown to act as asymptomatic carriers of the disease agent under experimental conditions.

Infectious salmon anaemia was recognised by the OIE in 1990 and the disease is listed in the OIE International Aquatic Animal Health Code and Diagnostic Manual for Aquatic Animal Diseases as one of the 'Other significant diseases' (26, 27).

Fish affected by ISA are lethargic, anaemic with pale gills, exophthalmus and sometimes show haemorrhages in the eye chamber and on the skin. Internally, the principal pathological features are ascites, dark, pale or yellowish liver, swollen spleen and congested intestinal wall as well as petechiae in the adipose tissue and swimbladder (31, 32).

During the 1980s and the early 1990s, a dramatic increase in ISA outbreaks was recorded in Norway (Fig. 1) with new outbreaks of clinical disease occurring on approximately 90 affected farms (17). Mortality on affected farms varied considerably from insignificant to moderate although some farms suffered losses as high as 80%. Due to the importance of the disease, ISA was made notifiable in Norway in 1986 which was the first milestone in efforts to combat the disease. Based on and with the support of legal texts, measures were taken to combat the disease long before much knowledge existed on the aetiology, epizootiology, pathogenesis, etc., of the disease.

Due to export implications for farmed Atlantic salmon from Norway, including a request in 1989 from the authorities in the USA not to certify fish for export to the USA from ISA-affected farms, followed by the prohibition on importation of ungutted Atlantic salmon into the United Kingdom later the same year, it was evident that something had to be done to control or eradicate the disease from Norwegian fish farms in order to maintain high fish health standards.

One step in that direction was to perform an epidemiological study on risk factors. A questionnaire was sent to affected fish farms in 1988 to obtain information on water quality, disease problems recorded during the year, sources and age of fish, means of transportation, distance to nearby fish farms, fish slaughterhouses, etc. Another step was to make the disease notifiable.

In the beginning, the policy was not defined well and the disease was essentially handled as a 'modified' Norwegian Group A disease (OIE 'notifiable disease') rather than a Group B disease (OIE 'other significant diseases'). However, in 1991, on the basis of the results of epidemiological studies, Norwegian epidemiologists claimed that it would be technically possible to control and eradicate disease and to reduce the number of ISA cases to less than five to ten cases per annum within a few years. This was considered an acceptable figure, compared to more than 80 cases registered in 1991 (34, 35).

These measures would only be feasible if the fish farming industry gave full support to a programme of eradication. On the basis of this acceptance, the Division of Veterinary Services of the Ministry of Agriculture initiated the 'Stop ISA' campaign. The most important preventive measures for eradication of disease focused on interrupting the pathways between the host and the pathogen. Legal measures, including the implementation of health control regulations, movement restrictions, disinfection, etc., taken against one disease might also have repercussions on other diseases. In addition, other advantages, such as the reduced recourse to drugs for the treatment of disease, may be obtained by implementing such measures.

Thus, the introduction of the legal steps, taken in accordance with the Norwegian Fish Disease Act to ensure good production hygiene and health from the egg stage to the slaughter of fish for consumption (4), made it possible to control ISA, a disease for which the causal agent was not identified with certainty until 1994 (10).

Figure 1 illustrates the incidence of new outbreaks of ISA between 1984 and 1998 and highlights important milestones in epidemiology and control.

As clearly illustrated in Figure 1, the spread of an infectious disease, such as ISA, can be controlled without the use of drugs and vaccines and even without knowing the aetiological agent or the epidemiology and pathogenesis of the disease.

Some critical factors had to be considered in the ISA control programme.

Firstly, early detection of the disease is necessary to implement the measures in question. Post-mortem examinations have to be performed on a regular basis to reveal suspected cases. This means that both the fish farmers and the fish health officers at all levels had to be skilled in judging clinical and pathological developments.

Another important factor linked to the successful control of ISA was the establishment of a system that included the collection of dead fish every day during summer and every second day during winter, followed by grinding and ensiling at a pH level of 4, or lower.

The regulations on slaughtering of fish in fish slaughterhouses with approved waste water treatment as well as the treatment of fish offal in connection with the slaughtering process greatly improved the ISA situation. Fish slaughterhouses/production sites increased the risk of ISA if the distance was less than 5 km to the nearest fish farm.

Regulations authorising the transportation of ISA-infected fish for slaughter in closed systems and on approved vessels also reduced the possibility of spreading ISA.
On the farm, the possibility of using the ‘all-in, all-out’ principle to separate year classes, as well as the establishment of ‘combat’ zones around ISA affected farms, also contributed to successful control. In such zones, it was and still is prohibited to introduce new fish into sea cages while the measures to combat ISA are still being implemented. Fallowing of the sites after the fish have been removed is also a compulsory measure within a zone infected with ISA. The duration of the fallowing period should under no circumstances be less than one month.

The increased and intensified official supervision of fish farms, wellboats, transport procedures, slaughterhouses, etc., within a zone, in addition to the co-operation and confidence of the fish farmers, have been important factors in the control of the disease. Without the acceptance and understanding of the fish farmers of the selected strategy to eradicate ISA, the control of the disease would have been much more difficult to achieve (9).

Conclusions and future needs

To achieve disease control through management practices, it is necessary to have an established legal framework which can be used to avoid the introduction and spread of serious
aquatic animal diseases through trade, both on national and international levels. In order to succeed, all disease control strategies need to be based on a legisatory system.

At the international level, the OIE International Aquatic Animal Health Code together with the Diagnostic Manual for Aquatic Animal Diseases outline international standards (26, 27). Both the Code and Manual are updated continuously as scientific knowledge advances.

At the national level, there is a need to establish more detailed legislation in many countries which either do not have any legal framework governing the control of aquatic animal diseases or, in some cases, have the legislation which is more or less inadequate for this purpose. Such legislation should include the following:
- clearly defined procedures for inspection and health control
- import regulations
- quarantine measures
- regulations regarding the introduction of new species
- movement restrictions
- disinfection procedures
- defined procedures for handling notifiable disease outbreaks.

To have a better understanding of the nature and spread of aquatic animal diseases, there is a need for reliable epidemiological knowledge of such diseases, as well as the establishment of effective systems for disease surveillance and control. This is of particular significance in connection with trade between countries, but is also relevant for movement of live aquatic animals between regions within a country.

If a disease outbreak occurs, it is necessary to adopt a standardised approach based on a pre-defined set of actions to be taken. This has been shown to be one of the key elements for improved disease control in aquaculture establishments. Consequently, it is necessary to have well-developed plans available, which are ready to be implemented should a disease outbreak occur. Such procedures cannot be 'invented' after a notifiable disease outbreak has occurred.

Depending on the classification and the importance of a disease, different management practices may be prescribed. Such provisions may comprise the complete slaughter and destruction of all aquatic animals in a population (stamping-out), partial stamping-out, sanitary slaughter and disinfection procedures.

On the farm level, alternative sites may be needed to ensure that infected and non-infected populations are kept separate.

In regard to the establishment of standard procedures for detection, control and eradication of aquatic animal diseases, the OIE Fish Diseases Commission plays an important role by defining the basic principles for such procedures.

Due to the increasing socio-economic significance of aquaculture, the authorities responsible for the national aquaculture industry and disease problems associated with aquatic animals need to have a good understanding of the industry. Thus, it is advisable that the competent authorities work with the industry to establish management practices for disease control that are not only practicable for the industry but also cover the basic needs of disease control. Mutual confidence between the aquaculture industry and the regulatory authorities is an important requirement for successful aquatic animal disease emergency programmes.
Programmes réussis de gestion des urgences en cas de maladies des animaux aquatiques

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Résumé
Les auteurs donnent des exemples de programmes d'urgence ayant donné de bons résultats pour l'éradication ou le contrôle de certaines maladies d'animaux aquatiques. L'article se subdivise en quatre parties.

La première décrit le premier isolement du virus de la septicémie hémorragique virale en Amérique du Nord, au cours de l'automne 1988 chez un saumon quinnat adulte sauvage (Oncorhynchus tshawytscha) et un saumon coho (O. kisutch) de retour pour le frai. Dans le cadre légal de la prophylaxie des maladies des poissons en vigueur aux États-Unis d'Amérique, au niveau fédéral mais aussi à celui des États, une mise en quarantaine est exigée ainsi que l'éradication d'urgence, dès leur découverte, de certains agents exotiques pathogènes pour les poissons, dont le virus de la septicémie hémorragique virale. Les auteurs décrivent les procédures relatives aux plans d'urgence, à l'abattage sanitaire des poissons et à la désinfection des élevages, ainsi que des expériences sur des souches d'épreuve nord-américaines du virus de la septicémie hémorragique virale et la détection de ce virus chez les espèces de poisson de mer (morue [Gadus macrocephalus], hareng [Clupea harengus pallas]) dans l'océan Pacifique.

La deuxième partie de l'article décrit la législation portant sur les animaux aquatiques en Grande-Bretagne et au sein de l'Union européenne, notamment pour ce qui est des plans d'urgence, des enquêtes préliminaires et des mesures adoptées en cas de suspicion de maladie à déclaration obligatoire et de confirmation de l'infection. Cet aperçu des textes de loi applicables est suivi de la description d'un foyer de septicémie hémorragique virale chez le turbot (Scophthalmus maximus) en Grande-Bretagne, avec abattage sanitaire dans l'élevage affecté et enquêtes en vue de détecter une éventuelle présence du virus dans les élevages voisins.

La troisième partie retrace l'évolution de l'anémie infectieuse des salmonidés en Norvège et décrit les mesures légales prises pour tenter de lutter contre cette maladie, en l'absence d'une connaissance approfondie de son étiologie, de son épizootiologie, de sa pathogénie, etc. Les mesures prises montrent qu'on peut lutter contre la propagation de l'anémie infectieuse des salmonidés en restreignant les déplacements de poissons, en recourant à des procédures de désinfection, etc. Toutefois, l'acceptation et la compréhension, par les éleveurs de poissons, de la stratégie choisie sont les conditions sine qua non pour atteindre cet objectif.

Enfin, les auteurs rappellent les progrès restant à accomplir en matière de législation nationale et internationale, mais aussi concernant l'élaboration de méthodes standards de prophylaxie, la création d'infrastructures appropriées et une meilleure compréhension de l'épidémiologie des maladies des animaux aquatiques.

Mots-clés
Resumen
Los autores ofrecen varios ejemplos de programas de emergencias que se han aplicado con éxito a la erradicación o el control de ciertas enfermedades de los animales acuáticos. El artículo se divide en cuatro partes.
Para empezar, los autores recuerdan el primer aislamiento del virus de la septicemia hemorrágica viral en Norteamérica, aparecido en otoño de 1988 en ejemplares adultos de salmón real (Oncorhynchus tshawytscha) y salmón coho (O. kisutch) silvestres que regresaban para frezar. En Estados Unidos de América, las normas tanto estatales como federales de lucha contra las enfermedades de los peces estipulaban cuarentena obligatoria y medidas de erradicación de emergencias en caso de detectarse determinados patógenos piscícolas exóticos, entre otros el virus de la septicemia homorrágica viral. Junto a los procedimientos de aplicación de planes de emergencia, eliminación de poblaciones y desinfección de instalaciones, los autores describen una serie de infecciones de prueba realizadas con las cepas norteamericanas del virus de la septicemia hemorrágica viral, así como la detección del virus en ciertas especies de peces marinos (bacalao [Gadus macrocephalus], arenque [Clupea harengus pallas]) del Océano Pacífico.
La segunda parte del artículo se centra en la legislación sobre animales acuáticos de Gran Bretaña y la Unión Europea, especialmente en lo que atañe a planes de emergencia, investigaciones iniciales, medidas necesarias ante la sospecha de una enfermedad de declaración obligatoria y actuaciones pertinentes una vez confirmada la infección. A la descripción del marco legal sigue la crónica de un brote de septicemia hemorrágica viral en rodaballo (Scophthalmus maximus) de Gran Bretaña, cuya solución pasó por un sacrificio sanitario total en la piscifactoría afectada y el análisis de otras explotaciones vecinas para descartar la posible presencia de la infección.
La tercera parte relata, desde una perspectiva histórica, la creciente presencia de anemia infecciosa del salmón en Noruega, y describe los intentos de dominar la enfermedad recurriendo a medidas legales para compensar la falta de conocimientos detallados sobre su etiología, epizootiología, patogénesis, etc. Las medidas adoptadas demuestran que es posible contener la propagación de la anemia infecciosa del salmón aplicando, por ejemplo, restricciones al desplazamiento de los peces o protocolos de desinfección. Sin embargo, condición previa para alcanzar el éxito es que los piscicultores entiendan y acepten la estrategia elegida.
Para acabar, los autores resumen las necesidades futuras de la legislación nacional e internacional en la materia, entre ellas la adopción de métodos de control estandarizados, la creación de infraestructuras adecuadas y una comprensión más profunda de la epidemiología de las enfermedades de los animales acuáticos.

Palabras clave
References


