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National biosecurity approaches, plans and programmes in response to diseases in farmed aquatic animals: evolution, effectiveness and the way forward

T. Håstein [(1)], M. Binde [(2)], M. Hine [(3)], S. Johnsen [(2)], A. Lillehaug [(1)], N.J. Olesen [(4)], N. Purvis [(5)], A.D. Scarfe [(6)] & B. Wright [(7)]

(1) Ministry of Fisheries and Coastal Affairs, P.O. Box 8118 Dep./National Veterinary Institute, P.O. Box 8156 Dep., N-0033 Oslo, Norway
(2) Norwegian Food Safety Authority, PO Box 383, 2381 Brumunddal, Norway
(3) Investigation and Diagnostic Centre, Biosecurity New Zealand, P.O. Box 40-742, Upper Hutt, 5018 New Zealand
(4) National Veterinary Institute, Technical University of Denmark, Hangøvej 2, 8200- Aarhus N, Denmark
(5) FRS Marine Laboratory, P.O. Box 101, 375 Victoria Road, Aberdeen AB11 9DB, United Kingdom
(6) American Veterinary Medical Association, 1931 N. Meacham Rd, Schaumburg, IL 60173, United States of America
(7) Office of the Chief Veterinary Officer, Australian Government Department of Agriculture, Fisheries and Forestry, GPO Box 858, Canberra ACT 2601, Australia

Summary

The rapid increase in aquaculture production and trade, and increased attention to the negative effects of disease, are becoming stimuli for developing national biosecurity strategies for farmed fisheries, for which the World Organisation for Animal Health (OIE) *Aquatic Animal Health Code* and *Manual of Diagnostic Tests for Aquatic Animals* serve as an excellent framework. Using examples from a few countries and selected diseases, this paper provides a general overview of the development of approaches to implementing biosecurity strategies, including those emerging in the national legislation and regulations of some countries, and those being initiated by industries themselves. The determination of disease status in different epidemiological units (from a farm to a nation), appropriate approaches for preventing the introduction of disease and developing contingencies for disease control and eradication are also discussed. Important to the effectiveness of such strategies are provision of financial, personnel and other resources to implement them, including incentives such as indemnification or compensation in eradication programmes, and practical linkage to regulatory or government policy initiatives.

Keywords

Aquaculture – Biosecurity – Contingency – Disease – Emergency – Guidelines – Plan – Policy – Programme – Regulation – Strategy.

Introduction

Over the past 35 or more years, with the decline and over-harvest of world capture fisheries, aquaculture has undergone a revolution and is now considered a major industry for both seafood production (31) and ornamental fish (pet, aquarium and exhibition) ownership. Aquaculture is a major protein-producing industry that rivals terrestrial livestock industries (34), and a large number of diseases are recognised as important in international trade and movement of aquatic animals and their products (16, 90). Furthermore, aquatic animal disease has become a major stumbling block for optimal production in some aquaculture sectors (71). Consequently, several infectious and contagious diseases have been clearly identified as a priority for action at national, regional or international level and are currently regulated to varying extents in different countries.

While 'biosecurity' is a relatively new concept for aquaculture, it is well accepted in terrestrial animal agriculture and agronomy and is also being applied in human medicine. The term biosecurity refers to many measures that may be implemented to prevent the introduction of unwanted biological agents, particularly infectious and contagious diseases or pathogens. However, it also applies to contingency measures applied in response to disease outbreaks, including disease control and eradication.

As in terrestrial agriculture, biosecurity strategies are more easily implemented in aquaculture than in wild populations. Farms and farming regions are generally well-defined, distinct epidemiological units with intensive management and clear boundaries (a farm, a state/province, or a country); consequently, disease prevention, control and eradication measures are usually more easily implemented. In contrast, wild populations frequently occupy and range through large, interconnected geographical areas (rivers, watersheds, oceans) where there are few opportunities to manage the animals, or prevent, control or eradicate endemic diseases. However, endemic diseases in wild aquatic populations can easily be transmitted to farmed animals, including those in aquaculture systems (66), with potentially disastrous consequences.

Countries are becoming more aware of how vulnerable they may be to purposeful or inadvertent introductions of aquatic animal diseases and the significant impact these may have in disrupting aquaculture production and international trade. No country wants to inadvertently import or export diseases with animals or animal products that may negatively affect animal production, animal health, animal welfare, public health or the safety of human food or animal feed. Consequently, one of the strongest incentives to implementing national biosecurity programmes in aquaculture is the international recognition of a country's ability to demonstrate that it has biosecurity strategies in place to prevent, control and eradicate diseases, and that animals or animal products moved or traded are free of specific diseases or pathogens.

The World Organisation for Animal Health (OIE) *Aquatic Animal Health Code* (*Aquatic Code*) (90) and *Manual of Diagnostic Tests for Aquatic Animals* (*Aquatic Manual*) (89) together serve as an excellent template for developing national biosecurity strategies. Developed under international consensus, the *Aquatic Code* and *Aquatic Manual* are the most important of several international agreements (Table I) that may directly or indirectly affect the national biosecurity strategies that are developed by various countries.

Table I
International agreements that may directly or indirectly affect national biosecurity strategies for the prevention, control and eradication of diseases in aquaculture production and trade
Dates are years of initial adoption (after 68)

Lead organisation	International agreements
World Trade Organization	Agreement on the Application of Sanitary and Phytosanitary Measures, 1995
	Convention on Biological Diversity, 1992, and Cartagena Protocol on Biosafety, 2000
Food and Agriculture Organization of the United Nations	Codex Alimentarius Commission Codes of Hygienic Practice for the Products of Aquaculture, 1981-1999
	Code of Conduct for Responsible Fisheries, 1995
	Code of Conduct for the Import and Release of Exotic Biological Control Agents, 1995
	International Plant Protection Convention, 1997
International Council for the Exploration of the Sea	Code of Practice on Introduction and Transfer of Marine Organisms, 1994
International Maritime Organization	Guidelines for Control and Management of Ships' Ballast Water to Minimize the Transfer of Harmful Organisms and Pathogens, 1997
United Nations	Biological and Toxin Weapons Convention, 1972
International Union for the Conservation of Nature	Guide to Designing Legal and Institutional Frameworks on Alien Invasive Species, 1999
World Organisation for Animal Health	Terrestrial Animal Health Code, 1968
	Manual of Diagnostic Tests and Vaccines for Terrestrial Animals, 1989
	Aquatic Animal Health Code, 1995
	Manual of Diagnostic Tests for Aquatic Animals, 1995

Many countries are at different levels of development in their national biosecurity strategies; in some countries such strategies are non-existent. Before any country claims to have a strategy to protect its aquaculture industries, it is imperative that biosecurity approaches are developed with industry input and made public. Industry input and transparency ensure that biosecurity approaches are practical, valid, and acceptable to the industries and importing countries they affect, and they are essential if strategies are to be fully successful and provide the intended assurance.

The objective of this paper is to examine the national approaches, strategies, programmes or plans that some countries have implemented to protect aquaculture operations from disease. Because most biosecurity approaches are disease-specific and relate to a unique aetiology, pathobiology and epidemiology of the host and disease, as well as specific production methods, selected diseases will be used as case studies to illustrate different biosecurity approaches and their efficacy.

The OIE *Aquatic Code* and *Aquatic Manual*: a framework for biosecurity strategies

Since its establishment in 1924, the OIE has been involved in developing science-based approaches and standards to guide countries in the protection of their national animal resources from important diseases. Pivotal to protecting aquaculture are the OIE *Aquatic Code* (90) and *Aquatic Manual* (89) that together provide the framework and guidelines for countries to use in developing biosecurity programmes that can be implemented at national, regional, local and farm levels. They are specifically intended to allow the determination of the status of diseases of significance in any defined epidemiological unit and outline procedures to prevent, control and eradicate them. They can be tailored by any country to meet specific conditions and diseases, and they can be used for the development and application of harmonised and uniform biosecurity programmes.

In general, the *Aquatic Code* and *Aquatic Manual* provide processes for identifying specific diseases as hazards (hazard assessment), and processes for assessing, mitigating or managing, and communicating disease risks (risk analysis). While the approaches are targeted primarily at those diseases of finfish, crustaceans and molluscs that OIE Member Countries and Territories have agreed should be notifiable when outbreaks occur, the approaches can be applied to other diseases of interest including exotic, endemic and emerging diseases.

Briefly, the regularly updated *Aquatic Code* and *Aquatic Manual* outline the processes and procedures useful for developing national biosecurity strategies, including:

– determining the status of diseases in any defined epidemiological unit

– sampling methods and surveillance programmes for determining disease presence and absence

– issuance of international veterinary health certificates that provide importing countries with the assurance that animals and animal products are not infected with specific diseases

– procedures to prevent disease incursion and contingencies for disease control and eradication in the event of a disease outbreak

– systems for tracing animal movements to assist in managing disease outbreaks

– a process to allow OIE Member Countries and Territories to report and inform others of their disease status.

The *Aquatic Code* and the *Aquatic Manual* also offer guidelines and recommendations about:

– the quality of veterinary services and other personnel necessary to implement biosecurity programmes

– diagnostic laboratory quality assurance and control practices

– standardised disease diagnostic test procedures

– processes for validating diagnostic tests

– procedures for establishing legal powers and crisis centres.

Supplemented with other OIE documents, many of which are accessible online (www.oie.int) at no cost, it is relatively easy for countries to develop effective national biosecurity strategies for aquaculture.

Factors that affect the development of national biosecurity strategies for aquatic animal health

Although the OIE *Aquatic Code* and *Aquatic Manual* serve as an excellent framework for developing national biosecurity strategies for aquaculture, several factors affect the development and implementation of effective strategies (e.g. legislative and regulatory initiatives, industry motivation and actions, etc.) and a good understanding of these factors contributes to the success of any biosecurity strategy.

It should be possible to implement the elements of an effective biosecurity programme for any epidemiological unit – an individual tank, pond, farm, watershed, state/province, or a whole country. To be effective, the critical elements should be adaptable for any disease or any type of aquaculture facility – from closed, self-contained recirculating facilities to extensive pond and open ocean net pens. Irrespective of the level of implementation or technology applied, the development of a biosecurity strategy for aquaculture involves the following two essential processes:

– determination of the disease status of the epidemiological unit (generally through disease surveillance, monitoring and reporting programmes)

– risk analysis (encompassing hazard identification, risk assessment, risk management and risk communication).

While these elements are utilised in developing strategies, they also serve as a foundation for developing legislative, regulatory and industry initiatives.

Legislation and regulations

National programmes are usually initiated by the 'competent authority' (for a definition see reference 84) in a country and endorsed by the national legislative bodies (although they may also be initiated and implemented by an industry). The enactment of the decisions made by legislative bodies typically provides the direction for national regulations to be promulgated by the competent authority, i.e. the government agency that is responsible for, or has legislated authority over, animal health and disease. In most cases this is an animal agriculture agency or ministry (90).

However, in some countries legislation and regulations concerning aquaculture are confounded by the attitude that aquaculture is somehow part of the traditional harvest of wild fisheries, or that it should be handled by agencies that deal with natural resource or environmental management. In general, biosecurity strategies applied to discrete epidemiological units (e.g. a land-based farm) are easier to implement than those applied to broad epidemiological units that are sometimes difficult to define, such as a natural resource (e.g. an entire water catchment) or an open body of water (e.g. an ocean) where there is little or no control of animal movement or the transmission of infectious diseases.

However, legislation and regulations are not always necessary for the development of national biosecurity strategies. Instead, they may be initiated and implemented by an industry without the intervention of government and, in some cases, industry formulates its opinion to guide promulgation of regulations (50).

Whether evolving from government regulations or voluntary industry initiatives, the most useful products for all stakeholders to use in implementing biosecurity programmes are working documents that are published as guides, strategy manuals, codes of practice or codes of conduct, all of which outline procedures to be followed to ensure that animals are free of specific diseases or pathogens (70).

Additional government–industry issues that may be related to legislation and regulations are important for the development of national biosecurity strategies. These include:

– clearly defined and pre-agreed roles and responsibilities for the different groups (e.g. industry, governments – local, regional and national) involved in the response; this includes a clear chain of command and may include the establishment of emergency control centres at the local and national levels

– sufficient and appropriate legal powers to enable the implementation of the plan

– standing instructions (possibly in the form of manuals) for all aspects of the response

– a pre-agreed communication strategy that includes details of both how the necessary information will flow between groups involved in the response, and how those not directly involved (such as the general public, other industries, trading partners, etc.) will be kept informed.

Determining and certifying disease status and freedom

To develop an appropriate biosecurity strategy it is first necessary to know the disease status of the epidemiological unit involved, for each specific disease of interest. As outlined in the *Aquatic Code*, this may lead to evidence allowing a country to declare freedom from specific diseases. This is generally achieved through disease surveillance and monitoring programmes. However, in some circumstances disease freedom can be declared where there is sufficient historical evidence to suggest the absence of the pathogen or where a country does not possess susceptible species, either in wild or farmed populations.

Once disease freedom of the unit has been determined, ongoing surveillance, monitoring and reporting programmes are necessary to indicate whether the biosecurity strategy is working effectively or whether there has been any introduction of new diseases. These ongoing programmes also provide trading partners with confidence in the disease status of an exporting country. Furthermore, they are used to underpin veterinary health and disease status certification.

The OIE provides model certificates for use by trading countries. Many countries have also developed their own certification – both for use as exporters, or as a requirement for other countries wishing to export aquatic animals or their products to them. For example, the new European Union (EU) Aquaculture Health Directive (23) lays down specific rules for the movement of aquaculture animals between EU Member States, zones and compartments with different health status. Placing such animals on the market is subject to animal health certification when the animals are introduced to Member States, zones and compartments that have been declared disease-free or are subject to surveillance or eradication programmes.

Risk analysis

Risk analysis includes hazard identification, risk assessment, risk management and risk communication (88). Hazard identification involves determining which specific diseases are of concern (i.e. considered a 'hazard') to the epidemiological unit. Risk assessment involves determining the level of risk associated with each hazard, i.e. how likely it is to occur and what undesirable consequences could result. Risk management (sometimes thought of as risk mitigation) entails identifying and implementing strategies to manage (or mitigate) the assessed risks. Risk communication occurs throughout the risk analysis process. It includes sharing information on the existing and potential hazards and risks, and on how the country has assessed these risks, what actions are (or will be) taken to manage the assessed risks, and how these will be assessed for effectiveness on an ongoing basis. Communication should occur with all interested parties (such as industry, governments and the general public) within the country and with the country's trading partners.

In essence, it is generally the risk management strategies that are the most readily recognisable elements of a biosecurity plan (e.g. import restrictions, disease control or eradication programmes, and emergency response plans).

Disease control or eradication programmes

Effective biosecurity programmes must, by definition, involve strategic actions applied to mitigate the risks of disease introduction and spread. Therefore, both by default and for practical reasons, biosecurity strategies in aquaculture must include plans and programmes for controlling and, if possible, eradicating the disease. Passive management of any disease after it is introduced or when it is endemic is unacceptable for biosecurity programmes; they require purposeful and active strategies for control and possible eradication of disease.

Emergency response and contingency plans

An emergency response, or contingency plan, can be defined as an established plan for taking rational decisions if emergency situations occur and in which all types of required actions should have been considered and spelled out in advance. The requirements for an effective emergency response must be defined to ensure that the necessary resources (including financial resources) are available at any time from the onset of a disease emergency. An emergency response plan thus includes an action plan and identifies the resources needed for its implementation.

Indemnification and compensation programmes

Indemnification or compensation programmes that pay for government-ordered depopulation of diseased populations are an extremely important motivation for industries to actively participate in national biosecurity strategies; however, most countries do not implement this type of programme (19, 22). A lack of financial compensation for economic losses incurred by farmers as a result of government action is a disincentive to reporting disease outbreaks, making many control programmes ineffective.

The effectiveness of compensation programmes was seen during outbreaks of infectious salmon anaemia (ISA) and spring viraemia of carp (SVC) in the United States of America (USA): indemnification payments were made and farmers actively participated in efforts to rapidly control the outbreaks (49, 82, 83). Similarly, EU Member States were recently allowed to make use of financial contributions from the Community to pay compensation (Council Regulation (EC) No. 1198/2006 of 27 July 2006 on the European Fisheries Fund). The diseases covered are all exotic and non-exotic diseases listed in Council Directive 2006/88/EC (23) but until the Directive is fully implemented on 1st August 2008, only ISA and infectious haematopoietic necrosis (IHN) can be compensated in accordance with Regulation 1198/2006. In Sweden, the eradication of viral haemorrhagic septicaemia (VHS) from the two VHS outbreaks in 1999 and 2001 (75) was compensated, as was the eradication of the first outbreaks of VHS in Finland in 2000 and 2001 (65). In Sweden, the disease was successfully eliminated after the second eradication programme and in Finland the disease was eradicated from the south-eastern coast of Finland, but became endemic in the Åland islands in the south-western Finnish archipelago, where until recently VHS caused severe losses for the farmers in that area (in 2007, however, there was only one outbreak of VHS in Finland, compared to numerous outbreaks in previous years [P. Vennerstrom, personal communication]). The experience from recent VHS outbreaks in Finland, Sweden and the United Kingdom (UK) shows that the success of an eradication programme is very dependent on whether or not it is rapidly and correctly implemented after the infection is detected. The longer the virus persists in the environment the more difficult it is to contain.

From a governmental view, compensation can act as an incentive for farmers to report suspicions of a disease earlier and to be more cooperative in an outbreak situation. Disease control and eradication programmes, as well as emergency response or contingency plans, may also include indemnification or compensation programmes for animal disposal and disinfection requirements.

Examples of national biosecurity strategies for aquatic animal health

Driven by the desire to develop aquaculture production, expand trade and protect their industries from disease, countries are at different levels of progress in the development of national biosecurity strategies. For example, Australia, the USA, Canada and several countries in the EU have initiated national approaches for several diseases. In Central and South America and in some Southeast Asian countries biosecurity approaches are still developing (51). However, little information is available for much of Africa, Eastern Europe and Central Asia, where aquaculture is evolving rapidly as an alternative agriculture endeavour. How countries have approached the development of national biosecurity strategies is best illustrated through examples of programmes that are at different stages of development.

Australia's Aquatic Veterinary Emergency Plan

One element of Australia's national approach to biosecurity is the Australian Aquatic Veterinary Emergency Plan (AQUAVETPLAN), which comprises Australia's national contingency plans for aquatic animal disease emergencies (www.daff.gov.au/aquavetplan). AQUAVETPLAN is modelled on the Australian Veterinary Emergency Plan for diseases of terrestrial animals (AUSVETPLAN) (2). It comprises a series of technical manuals that outline the proposed response in relation to the suspicion or occurrence of an emergency aquatic animal disease incident in Australia. Each disease strategy manual is specific to a priority aquatic animal disease. It contains an overview of technical information on the disease, a discussion of the principles of control of the disease, and the preferred response to the occurrence or suspicion of an outbreak of that disease in Australia. Because these are response manuals they do not include information about preventing the introduction of the disease. A more detailed description of the range of AQUAVETPLAN manuals, and the background to the development of the plan and its manuals, is provided elsewhere in this volume (10).

Since the publication of the initial eight disease strategy manuals there has not been an emergency disease event involving these diseases, nor has there been suspicion of any of the exotic diseases covered. This makes it difficult to evaluate specifically the effectiveness of these plans for emergency disease management in real-life situations. Nevertheless, the development of AQUAVETPLAN and its disease strategy manuals has had tangible benefits for the management of emergency disease events – and aquatic animal health more broadly – in Australia. The range of benefits includes:

– specific identification of the resources required to underpin effective emergency disease management (whether the resources are equipment, personnel, medications, disinfectants, scientific and technical information or other requirements)

– more effective allocation of funding and other resources to priority areas; for example, the identification of the scientific and technical information requirements for effective emergency disease management can lead to the prioritisation of research and development, and so to a more effective allocation of research and development funding to these priority areas

– improved awareness among the range of parties (government, academic, industry, and so on) of the principles of effective emergency disease management

– more realistic expectations of emergency disease responses as a result of improved awareness of the principles of, and resource requirements for, effective emergency disease management

– reduced conflict between the parties involved in an emergency disease response

– improved communication and working relationships among the different parties involved in emergency disease management

– opportunities to measure performance against the objective requirements outlined in the disease strategy manuals by staging disease simulation exercises.

The benefits of implementing a strategy such as AQUAVETPLAN are often inter-related. Over time cumulative benefits have resulted in improved capacity for, and more timely and effective responses to, emergency aquatic animal disease events. This effect is seen not only for those specific diseases covered by a disease strategy manual, but for all aquatic animal disease emergencies. These benefits accrue slowly as the manuals are developed and reviewed through repeated rounds of consultation with a range of scientific and technical, policy, management and industry groups. This development process requires funding and the commitment of staff time to ensure the drafting, review, finalisation and publication of each manual. Despite the effort and costs involved, the continued importance of AQUAVETPLAN and implicit acknowledgement of the benefits gained through the development of such plans is evidenced in Australia by formal endorsement of the plan by a wide range of government and industry groups. Support for the plan is also demonstrated by the continued voluntary engagement of a range of scientific, technical, policy, management and industry groups in the plan's development and review process.

The National Aquatic Animal Health Plan in the United States of America

Currently, both the USA and Canada are developing national aquatic animal health strategies. While the plans are at different stages of development, these countries are in dialogue with each other to ensure harmony and a consistent approach and both are incorporating elements found in the OIE *Aquatic Code* and *Aquatic Manual*. Both countries are also addressing responses to both farmed and wild aquatic animals because the responsibility for these different sectors lies with different government agencies.

Within the USA, according to the Animal Health Protection Act of 2002, livestock issues fall under the jurisdiction of the US Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS). Other legislation delegates responsibility for wild freshwater and marine fisheries respectively to the Department of the Interior, US Fish and Wildlife Service (USFWS) and the Department of Commerce, National Marine Fisheries Services (NMFS).

In the USA, national actions have traditionally been reserved for foreign animal pathogens, i.e. pathogens that are not known to exist within the territorial water of the USA. In addition, emerging pathogens such as a new virulent strain of a known disease agent (32) or an entirely new pathogen might initiate national contingency plans (P.G. Egrie, personal communication). Ubiquitous pathogens or other regionally distributed pathogens are generally under the jurisdiction of individual States rather than under national jurisdiction, and management strategies are left to individual States.

The approach to aquatic animal emergency planning in the USA has traditionally been a reactive one, essentially involving eradication, when possible, of populations deemed infected with the pathogen or affected by the disease. Over the past decade (1997-2007), the USA has been impacted by at least five aquatic animal disease emergencies, including VHS, SVC, koi herpesvirus disease and ISA. Although not declared as national emergencies, the USA has also experienced and responded to outbreaks of Taura syndrome and white spot disease in shrimp. Common to all disease outbreaks is that the USA did not have a contingency plan for any of these cases. Only one of the disease emergencies – ISA – could have been anticipated. It was first detected in Canada in 1996 (55) and eventually spread to the farmed salmon industry in northern Maine. However, even when ISA was discovered in New Brunswick in 1996, and it was clear that the marine ecosystems of New Brunswick and northern Maine were essentially one and the same, the USA developed no contingency plans. Biosecurity measures were increased in addition to surveillance, but the actions taken clearly reflected a perception of inevitability, rightly or wrongly, and a culture of reactivity to emergency situations but not one of contingency planning.

Since 2002, through the efforts of the Joint Subcommittee on Aquaculture (a federal interagency working group authorised under the science advisor to the President), a National Aquatic Animal Health Plan (NAAHP) has been under development. The NAAHP is being developed by the three federal agencies USDA-APHIS; USFWS; and the Department of Commerce, National Oceanic and Atmospheric Administration. When completed, the Plan will be implemented with USDA-APHIS oversight. One of the objectives of the NAAHP is to recommend contingency plans for the Federal Government with respect to emergency planning.

European Union Directives and European Union country initiatives

The EU introduced its first harmonised legislation concerning aquatic animal health (Council Directive 91/67/EEC) in 1991 (20). The legislation includes conditions governing the placing on the market of aquaculture animals and products, lists of the most important diseases, measures for the control of certain diseases of fish and bivalve molluscs, and sampling plans and diagnostic methods for the detection and confirmation of such diseases.

For the listed diseases, decisions regarding approval of farms and zones have been taken to protect disease-free areas. In addition, decisions have been adopted concerning movements of different aquatic animal species and products within and into the Community. The Directive was primarily adopted to protect disease-free areas from infection after the introduction of the open internal market in the European Community. The Directive was later followed by Council Directive 93/53/EEC introducing minimum Community measures for the control of certain fish diseases and minimum criteria for contingency plans (21).

Some Member States are in the process of developing, or have already developed, their own contingency plans to deal with certain aquatic animal health diseases.

In the EU, ISA was listed as exotic and control measures as stated in Council Directive 93/53/EC (21) came into force when the disease was confirmed in Scotland in 1998 (76). During the eradication programme that followed it was realised that the Directive had to be adapted to include more appropriate 'withdrawal' measures for a more cost-effective eradication programme.

These Council Directives were repealed and replaced by a new Council Directive, 2006/88/EC, adopted in October 2006. This new Council Directive on animal health requirements for aquaculture animals and products thereof, and on the prevention and control of certain diseases in aquatic animals, will be fully adopted by Member States from 1 August 2008 (23). The new Directive introduces a large number of changes, including the requirement for an authorisation or registration process with disease categorisation of all aquaculture units, a so-called risk-based surveillance scheme, and a change in listing of diseases. From 1 August 2008, ISA will be regarded as a non-exotic disease in the Community; in case of a re-emergence, the Member States can decide whether they will draw up eradication programmes to regain disease-free status for all or parts of their territory (Category I), or if they will remain infected (Category V).

Within the EU, some Member States have developed contingency plans to deal with outbreaks of specific pathogens. For example, in the UK, Scotland has developed plans for dealing with an outbreak of *Gyrodactylus salaris*. A copy of the plan can be viewed online (http://www.scotland.gov.uk/Resource/Doc/922/0050910.pdf). A brief summary is presented in Table II.

Norwegian contingency plans and disease strategy plans

In Norway, specific contingency plans and disease strategy plans have been developed for ISA, *G. salaris* and salmon lice (*Lepeophtheirus salmonis*), and a new national contingency and strategic plan for the control of pancreas disease has recently been proposed. In general, all diseases are controlled by general management and disease prevention legislation. Applications for achieving disease-free status for bacterial kidney disease (BKD) in continental areas (inland watersheds and catchment areas) and disease-free status for *G. salaris* for the whole country, excepting infected river systems, have been submitted to the European Free Trade Association Surveillance Authority and contain measures for eradication in case of disease confirmation.

Table II
Summary of the development and evaluation of the *Gyrodactylus salaris* contingency plan for Scotland and the key issues addressed

Process	Further details
Development	
Workshop	Multi-country/discipline representation; assessing biology of *Gyrodactylus salaris* (Gs), risks, legislation, draft plans; established requirement for a Working Group
Norwegian experience	Regular consultation with Norwegian authorities involved with Gs in Norway
Designated task force	Encompassing representatives from Government departments/agencies, aquaculture industry, wild fisheries, industrial and recreational water users
Identification of key areas for the Contingency Plan	
Disease response assumptions	Eradication and/or containment strategies
Command and control	Structure and key personnel identified; roles and responsibilities defined
Legislative powers	Identifies existing and required relevant legislative powers
Communications	Within and across government departments; with other stakeholders and relevant personnel
Field operations	Details of operational procedures
Evaluation	
Desktop exercise	Using fictitious scenarios, elements of the plan tested to consider response; gaps in knowledge identified, amendments made
Further recommendations	Addressing gaps in scientific knowledge and unanswered questions; obtaining further information as necessary and required; need for basic training of key personnel

Copies of the plan are available from the Scottish Government website: http://www.scotland.gov.uk/Resource/Doc/922/0050910.pdf

In Norway, initial biosecurity disease prevention measures against diseases such as ISA and BKD have been more effective than the formal contingency plan for ISA and the plan for control and monitoring of BKD that were introduced at a later stage. Furthermore, the alarming situation caused by furunculosis in the late 1980s due to the re-introduction of the disease into Norway was controlled by means of vaccination, improved biosecurity and legislation, without any formal biosecurity plan.

Chilean approach

In Chile, regulations (resolutions) promulgated by SERNAPESCA (the Chilean competent authority) provide the framework for the measures that may be applied in case of suspicion or presence of exotic diseases, and thus for the intervention required for protection from and control of diseases in Chilean aquaculture (M. Casali, personal communication) (3, 7). However, all the measures planned in these regulations – such as zoning for all prevalent diseases – have not yet been implemented. The regulations establish health programmes, both specific and general, which have been approved by resolutions of SERNAPESCA and are related to the surveillance, control and eradication of diseases in aquatic animals. Today, only programmes related to VHS and IHN are in place, because these diseases are considered to be exotic to Chile. However, Chile has recently begun a specific surveillance and monitoring programme for sea lice (*Caligus rogercresseyi*).

General programmes are orientated towards good animal health practices in aquaculture and cover management practices such as egg disinfection, broodstock screening, mortality recording, transportation and harvesting procedures. These general provisions may need to be complemented with other specific rules to control particular diseases.

Other resolutions describe a general health programme and, when an aetiological agent is unknown, research to investigate the cause of disease is undertaken. This programme details the information that should be collected and analysed. From this basis, SERNAPESCA can implement control measures to prevent the spread of disease. Under this system a contingency plan was implemented in early August 2007 to control an outbreak of ISA. So far, no contingency plans or other measures for the control of other emerging diseases are in place.

Japan and Southeast Asia

In Japan, the handling of aquatic animal diseases is based on the Fisheries Resources Conservation Act and the Law to Ensure Sustainable Aquaculture Production. Guidelines on contingency plans for notifiable and emerging diseases have been established, including procedures for communication between Federal and State Governments in the event of an outbreak of a notifiable disease. These guidelines also prescribe diagnostic methods and how to react to emerging diseases. Currently, six fish diseases and five diseases of shrimp are covered (Y. Hood, personal communication).

Arthur *et al.* (8) have highlighted the preparedness for, and response to, aquatic animal health emergencies in Asia. In Southeast Asia, the Thailand Department of Fisheries (DOF) has been developing contingency planning targeting exotic diseases for the past few years (S. Kanchanakhan, personal communication). Currently, DOF, together with the Thai Department of Livestock Development, are defining all necessary legislation (regulation, notification, etc.) to facilitate satisfactory enforcement powers in relation to disease control.

Disease-specific and species-specific contingency plans: case studies

In this section a number of serious fish diseases listed by the OIE or in national legislation are used as examples of national contingency plans/disease strategy manuals. Biosecurity plans for crustaceans and molluscs are also described.

Viral haemorrhagic septicaemia and infectious haematopoietic necrosis

Viral haemorrhagic septicaemia and IHN are serious viral diseases that affect fish in the northern hemisphere. Both viruses belong to the genus *Novirhabdovirus* in the family *Rhabdoviridae*, and both are notifiable to the OIE.

Viral haemorrhagic septicaemia

Most rainbow trout farming countries in Europe have experienced VHS, and the disease is widespread in continental Europe. All Scandinavian countries except Iceland have experienced the disease, but it is now prevalent only in Finland and Denmark. In 2006 the first outbreak of VHS in rainbow trout (*Oncorhynchus mykiss*) in England was observed, and VHS was reported in turbot (*Psetta maxima*, formerly *Scophthalmus maximus*) in Germany, Scotland and Ireland in 1991, 1994 and 1997 respectively (69, 72) (F. Geoghegan, personal communication). In 2007, a VHS outbreak, caused by the marine VHS virus genotype III, was reported in farmed rainbow trout kept in sea water in Norway. The cause of the outbreak is still under investigation, but the disease is suspected to be introduced by wild fish carrying the virus, as genotype III is the only genotype of VHSV previously found in wild fish in the North Atlantic. This is the first reported case of VHS outbreak in rainbow trout caused by this genotype.

The VHS virus (genotypes Ib, II, and III) is prevalent in marine fish throughout the Baltic Sea and the North Atlantic. The disease was not known outside Europe before 1988, when VHS virus (VHSV) was isolated from wild chinook (*O. nerka*) and coho salmon (*O. kisutch*) in the USA (35). The virus has since been isolated from a large number of fish species along the Pacific coast of North America, causing severe mortality in Pacific herring (*Clupea harengus palassi*) (48). In spring 2005, VHSV was isolated from an episode of mortality of freshwater drum (*Aplodinus grunniens*) in Lake Ontario, North America. Subsequently, the virus has been isolated from more than 25 wild fish species and has spread throughout the Great Lake region in North America, causing mortality in several species (28, 32, 85). VHS has also been observed in Asia where the virus was primarily detected in farmed Japanese flounder (*Paralichthys olivaceus*) in Japan (36) and Korea (41) and from wild marine fish caught in Japanese waters (79, 87). All isolates, except the one from Asia and the one from North America, belong to genotype IV (27). In farmed rainbow trout, VHS has so far only been a problem in Europe, where it causes massive mortality; indeed, Europe is the only place where classical freshwater VHSV isolates pathogenic to rainbow trout have been isolated.

Infectious haematopoietic necrosis

Infectious haematopoietic necrosis was first described on the west coast of North America in the 1950s, where it caused high mortality in sockeye salmon at hatcheries in Washington and Oregon. In 1971, IHN virus (IHNV) was reported to have occurred in Japan, probably due to import of sockeye salmon eggs from Alaska (57). In Europe, IHNV was first reported in 1987 when it was detected in both Italy (12) and France (9). The infection most probably originated in eggs imported from North America. Later, the disease spread to other countries in Europe. However, several European countries such as Denmark, Finland, Ireland, Norway, Sweden and the UK are still free of the disease, and it has not so far been reported from Africa or Oceania (89).

Contingency plans

Eradication of VHS from fish farms by stamping-out procedures, involving draining, removal of all fish, cleaning, disinfection, and a fallowing period of a minimum of 4 weeks, followed by repopulation with certified virus-free trout, has proved to be a valuable method for the control of VHS in Denmark (39, 63, 64). In 1965, about 400 out of approximately 600 Danish fish farms were infected with VHS. A private control programme for VHS was initiated on a voluntary basis in 1965 and continued on an official basis from 1970. The result of this programme (as of September 2007) is that 339 farms out of a total of 360 are officially recognised as free from VHS, i.e. only 21 farms remain infected (H. Korsholm, personal communication). Viral haemorrhagic septicaemia is considered to have been successfully eradicated and the virus eliminated from the farms and their surroundings; there has been no recurrence of disease, nor has virus been detected, despite the implementation of intensive virological surveillance for several years after eradication (63).

Both VHS and IHN were included as List II diseases (diseases endemic to different parts of the EU, requiring reporting and control measures) in Council Directive 91/67/EC (20), and several approved free zones and farms have since been established in the EU. All VHS and IHN outbreaks that have occurred thus far in European zones and farms that are designated VHS and IHN free have been controlled and eradicated according to the national contingency plans implied in Council Directive 93/53/EC (21). In Sweden, outbreaks of VHS on a marine farm in 1999 and 2001 led to prompt eradication measures (59, 60) (A. Helstrøm, personal communication). In Denmark, the response to an outbreak on two farms at Fiskbæk Å in the zone approved as VHS-free in 2000 was immediate eradication and the subsequent re-establishment of disease-free status (H. Korsholm, personal communication). In the UK, a VHS outbreak in 2006 led to stamping-out measures and a fallow period, and no recurrence of VHS has been observed to date. The only exception to successful eradication in approved free zones in Europe is in Finland, where the disease has become endemic in the archipelago of Åland. VHS and/or IHN free farm or zone status can only be obtained after the implementation of an officially approved eradication programme (including stamping-out procedures, disinfection, fallowing, restocking with approved disease-free fish, and at least 2 years of intensive clinical inspection and virological examination). Guidelines for achievement of disease-free status are described in EU Commission Decision 2001/183/EC (18).

In most non-approved zones and farms in Europe neither VHS nor IHN has been contained, and this might explain why IHN has continued to spread throughout most of these areas since its first detection in Italy and France in 1987. It is therefore obvious that the measures applied in approved zones (as given in Council Directive 93/53/EC) have proven efficient in preventing non-infected areas from becoming infected with VHS and IHN and have helped to reduce the spread of these diseases despite the opening of the internal market in the Community. The Directive has, however, only resulted in a few programmes for eradication of the diseases in non-approved areas, and several Member States do not apply contingency plans for the two diseases. Table III provides a summary of VHS management worldwide.

Crucial for successful disease eradication is close collaboration and agreement between all involved fish farmers, consultants and competent authorities. The rules for obtaining approved disease-free status in the EU are very rigorous; for example, they require that the whole water catchment is disease free (20), a requirement which is very difficult to meet for large trans-European watersheds. Unfortunately, the present legislation (20, 21) and the new Directive (23) do not provide for an interim disease-free status at a higher risk level, and this might be the reason for the slow expansion of disease-free areas in the EU.

In North America, VHS is primarily a disease of wild fish species, and contingency plans primarily aim to prevent further spread. IHN is a very serious threat to the Atlantic salmon farming industry in North America and has caused severe losses. As a consequence, Canadian authorities authorised the use of DNA vaccines against IHN in 2006 to reduce mortality in the salmon industry. In Europe, all major salmon producing countries are approved as VHS- and IHN-free and are thus protected to prevent the introduction of these diseases. This is probably the reason why the coastal European salmon industries in these countries have not yet contracted IHN, which is widespread in continental European rainbow trout farming.

Spring viraemia of carp

Spring viraemia of carp (SVC) is a rhabdovirus infection caused by *Rhabdovirus carpio*, placed in the genus *Vesiculovirus* (86). The common carp (*Cyprinus carpio*) is

Table III
Management of viral haemorrhagic septicaemia in selected countries worldwide

Country	Case/episode	Contingency plan	Outcome	Fish species (Ref.)
Denmark	Recurrent since the 1950s	Since 1965	Reduction of infected farms from approximately 400 in 1965 to 16 in 2006	Rainbow trout
Finland	2000 – first outbreak in 2 sites (marine farms) 2001-2006	Yes	Disease has been contained in continental areas and has become endemic in Åland Islands	Rainbow trout (65)
France	First description in 1968; new cases every year since, except in 2006	Yes	The disease has been eradicated from two zones and in some farms outside those zones	Rainbow trout Brown trout Pike
Ireland	1997 Cape Clear (McArdle, unpublished)	Yes	Eradicated	Turbot
Japan	1990	No	Endemic	Japanese flounder (*Paralichthys olivaceus*) (58, 79)
Norway	A few serious clinical outbreaks 1964-1974	Yes	Stamping-out procedures were successfully implemented. The disease did not reoccur in Norway until 2007	Rainbow trout
	In 2007 an outbreak was reported in pen-reared rainbow trout. The virus belonged to genotype III		At the beginning of 2008 it was reported that fish worth 200 million NOK (US$ 39 million) were to be slaughtered	
Romania	2005	Yes	Eradicated	Rainbow trout
Sweden	In 1999 and 2001 outbreaks occurred in a net pen close to Gothenburg rearing rainbow trout. VHSV genotype Ib	Yes	Eradicated after second round; change of management procedure (no rainbow trout in winter season and no small fish)	Rainbow trout (57, 58)
Turkey	2004	No	Endemic	Rainbow trout, turbot and maybe sea bass (58)
United Kingdom (England only)	2006	Yes, under implementation	Eradicated. Testing programme in operation to regain approved zone status	Rainbow trout
United Kingdom (Scotland only)	1994 Isle of Ghiga	Yes	Eradicated	Turbot (69)
United States of America	1989	No, and no measures implemented when the first isolations occurred	Casual findings; severe outbreaks primarily in wild fish in the Pacific and, in 2006, also in freshwater fish in the Great Lakes	Salmon, Pacific herring, Pacific cod, drum, and many other species (32, 35)

NOK: Norwegian kroner

considered to be the principal host and is the species most susceptible to SVC. Naturally occurring infections have been reported in a number of other cyprinid species, and experimental infection of non-cyprinid fish has also been reported (38, 89). The disease has been recorded from most European countries and Russia. In 2002, SVC was reported for the first time in the USA from two separate sites (26, 33) and detection of the virus in carp in China was confirmed in 2004 (43). The disease has also been recorded in goldfish imported into Brazil (1).

Little documented evidence is available with respect to contingency plans specific to SVC. The OIE *Aquatic Manual* (89) lists methods to support prevention and control policies. However, according to Jeremic *et al.* (37), in Serbia it is 'practically impossible' to eradicate SVC under the present conditions of carp technology because wild-to-farmed and farmed-to-wild fish interactions are responsible for sustaining infection. Only hatcheries supplied by a protected water supply, with biosecurity and containment measures, are successful when adopting stamping-out policies (37).

In the USA, APHIS indicate that outbreaks of SVC have been linked to the unregulated importation of fish infected with the virus. Measures are now being taken to establish regulations to restrict the importation of live fish, eggs and gametes of fish species susceptible to SVC (84).

As with the reported cases in the USA, it is believed that the majority of SVC outbreaks in the UK can be linked either to legal or illegal imports of ornamental fish or carp used for angling purposes (25, 81).

In the EU, SVC is listed as a List III disease in Annex A of Council Directive 91/67/EEC, and is a disease for which the EU can grant its approval for an importing country to require additional, more stringent guarantees for ensuring susceptible species are free from the disease before they can be imported into an approved disease-free zone. The European Commission approved a control programme for SVC submitted by the UK and granted additional guarantees on imports with respect to SVC under Commission Decision 93/44/EEC (17). The Decision was repealed by Commission Decision 2004/453/EC as the new Commission Decision was an update – it reviewed the guarantees for SVC and other diseases across Member States. The control measures for SVC in the UK are exercised under the Diseases of Fish Acts 1937 and 1983.

The provision for control of SVC in the UK involves the serving of movement restrictions on fish farms or any other locations where the waters are suspected or confirmed to be infected with the SVC virus. These restrictions prohibit the movement of live fish, eggs and gametes of fish with a view to preventing the spread of disease. Certification of live fish, eggs or gametes is also a necessary tool as are requirements to remove dead and moribund fish on a regular basis and dispose of them in accordance with approved methods under animal by-products legislation.

Infectious salmon anaemia

Infectious salmon anaemia is a serious viral infection of Atlantic salmon (*Salmo salar*), caused by a virus belonging to family *Orthomyxoviridae*. The disease was first diagnosed in Norway in 1984 (80), in Canada in 1996 (55), in Scotland in 1998 (67), in the USA in 2000 (11) and in the Faroe Islands in 2000 (89). In all countries where the disease has occurred, outbreaks have caused serious economic losses to salmon farmers due to high fish mortality, statutory slaughter and fallow periods. Furthermore, ISA virus has been reported in coho salmon (*O. kisutch*) in Chile and rainbow trout in Ireland in 2002 (40). Serious outbreaks of ISA in Atlantic salmon were reported from Chile in 2007 (M. Casali, A. Gallardo Lagno, personal communication) (this report can be viewed by consulting the OIE World Animal Health Information Database – http://www.OIE.int/wahid-prod/public.php?page=country_reports). Table IV summarises the outcome of measures against ISA in affected countries.

Table IV
Outcome of disease measures against infectious salmon anaemia in affected countries*

Country	Case/episode	Contingency plan in place	Outcome
Norway	1984	Yes	Contained, but not eradicated
Canada	1996	No	Contained, but not eradicated
Scotland	1998	Yes	Measures strictly implemented and disease eradicated
United States of America	2000	No	Contained, but not eradicated
Faroe Islands	2000	Yes	No strict measures were implemented and the disease has spread throughout the islands. Vaccination initiated
Ireland	2002	Yes (stamping-out procedures carried out)	Disease persists only in rainbow trout – no clinical signs
Chile	2007	Not known	Disease persists in Atlantic salmon

*Revised version of a table from an infectious salmon anaemia report by the Norwegian Scientific Committee for Food Safety (61)

Local health plans for the control of ISA were introduced in Norway in 1990 and 1991, and the first Norwegian national contingency plan was proposed in 1994 (4, 6). According to Council Directive 93/53/EC, all EU Member States shall establish national contingency plans for ISA outbreaks (21). In reality, however, only salmon-producing countries such as the UK, Ireland and Denmark have published such plans (24). ISA was listed as exotic to the EU and control measures as stated in Council Directive 93/53/EC came into force when the disease was confirmed in Scotland in May 1998. During the epizootic, the last confirmed case was diagnosed in May 1999, and the last suspected outbreak was in November of the same year (77). Successful eradication was achieved. As a result of the outbreak, a Joint Government/Industry Working Group produced a final report (73) and a Code of Practice (74). The final report highlights the risks of transmission and provides recommendations regarding coastal catchment management, standard disinfection procedures and detection and diagnosis. The Code of Practice, based on the final report, identified best practice for operators in relation to avoiding and minimising the impact of disease.

A suspicion of ISA in Scotland in 2004 was not confirmed; the same applied to a suspicion of ISA in rainbow trout in Ireland in 2000. In the Faroe Islands, a contingency plan was established in 2002 (5) and a health programme involving vaccination of all salmon smolts on the islands was initiated in 2005/2006. No clinical disease has appeared since September 2007 but polymerase chain reaction (PCR) testing revealed that the virus might still be present in the Faroes (P. Østergård, personal communication). Evidence of an ISA variant strain in wild fish in Scotland has been provided through molecular genetics research (M. Snow, personal communication). The occurrence of ISA in Norway (28) led to improved legislation on husbandry and the introduction of biosecurity measures such as:

– notification

– compulsory health certification

– a ban on the use of sea water in hatcheries

– introduction of combat zones

– disinfection of wastewater from slaughterhouses, processing plants, and intake water in hatcheries

– movement restrictions

– regulations on transport.

These measures have contributed significantly to the striking decrease in the number of outbreaks. However, it is vital to systemise the actions taken to control the disease when it occurs. A risk assessment by the Panel on Animal Health and Welfare of the Norwegian Scientific Committee for Food Safety (Vitenskapskomiteen) concerning the spread of ISA supports the main measures established in the Norwegian ISA contingency plan. It indicates that horizontal spread, well boat transportation and centralised slaughterhouses are considered to be important risk factors (61). However, despite years of practical experience and research on the ISA virus and ISA outbreaks, the source of infection and routes of transmission are still not fully understood and a central issue is screening (61). Because a positive diagnosis of ISA can have significant implications for the farmer, for example culling of stock, any decision taken by the authorities has to be firmly founded in legislation.

Biosecurity strategies for crustacean and mollusc diseases

Crustaceans

Shrimp (also referred to as prawns) are the primary crustacean species cultured. Driven by economic returns largely from international export, shrimp farming has developed rapidly and has become a dominant aquaculture industry in some countries (31). Rapid, large-scale commercial expansion of shrimp farming (12% to 15% p.a.) is well illustrated in several Southeast Asian and Latin American countries and typically involves very large enterprises that use large ponds (68), with little attention paid to disease control. During the early part of this rapid industry expansion, particularly in the late 1980s and early 1990s, little, if any, attention was paid to biosecurity, and several large disease epidemics devastated these industries and spread from one country to another (13). The estimates of economic losses from these diseases (42) are high and are comparable to losses from the spread of significant terrestrial livestock diseases (70) (for examples see Table V).

Table V
Estimated economic losses from shrimp viral diseases (after 40)

Disease	Year discovered	Estimated losses (US$)
White spot disease – Asia	1992	4 to 5 billion
White spot disease – Americas	1999	>1 billion
Taura syndrome	1991/2	1 to 2 billion
Yellowhead disease	1992	0.1 to 0.5 billion
Infectious hypodermal and haematopoietic necrosis	1981	0. 5 to 1 billion

Unlike for many finfish diseases, the biosecurity responses in place for shrimp aquaculture were largely initiated by industry rather than being driven by government legislation and regulations. As such, they were not initially part of a national strategy. However, these industry-driven approaches have in some cases been adopted on a national level, and the approach has spread to other countries. Large commercial and economic investments in these operations were an important driving force for industries to address biosecurity and develop disease prevention strategies, because losses from morbidity and mortality severely impacted on the economic return from international trade in shrimp and shrimp products. An excellent example of industry-driven biosecurity strategies that have been widely adopted is illustrated in the evolution of the approach of the Marine Shrimp Farming Program (USMSFP) in the USA.

Briefly, the USMSFP consists of a consortium of six academic and research institutions in the USA with a focus on providing producers with direct access to reliable captive supplies of high health and genetically improved shrimp stocks as well as advanced disease diagnostic and treatment methods; it is well on its way to developing exemplary biosecurity programmes (15, 42, 52, 53, 54). The initial primary biosecurity strategy involved developing specific pathogen-free (SPF) broodstock, because most broodstock originated from wild-caught animals.

While producing and distributing SPF seed stock (generally termed 'High Health' shrimp) contributed significantly to disease prevention, without specific on-farm biosecurity measures and procedures for preventing disease introduction and maintaining grow-out operations as SPF, and with the emergence and spread of additional shrimp diseases, the approach had limited success. However, once on-farm biosecurity measures were applied (14, 44, 45, 46, 62), significant advances ensued. Fairly early in the programme an interesting contingency for controlling disease involved the development of shrimp strains that were genetically resistant to specific diseases. However, this strategy appears to have been abandoned; presumably because it was recognised that animals resistant to disease are likely to be asymptomatic carriers that may infect disease-naïve, non-resistant animals, but also because infected asymptomatic disease-resistant animals will experience morbidity that directly affects growth and performance.

Importantly, the general approach to utilising SPF brood and grow-out stock has been introduced to the Southeast Asian and Latin American industries through extension and training programmes (78) and now appears to be incorporated into national strategies (47). The approach is also becoming incorporated into national import requirements. New Zealand, for example, now requires shrimp intended for farming to go through a similar SPF process for demonstrating that animals released from import quarantine will not be carriers of specific viruses (56).

Molluscs

Guidelines produced by the Food and Agriculture Organization of the United Nations (FAO) (29, 30) provide advice on how a country or a competent authority can develop an efficient aquatic animal disease emergency response procedure, but they do not provide advice on specific cultured groups, such as fish, crustaceans and molluscs. Similarly, in the OIE *Aquatic Code* (90), contingency planning does not deal specifically with molluscs, and some recommendations, such as fallowing and vaccination, are not relevant to molluscs. However, the OIE *Aquatic Manual* (89) has a comprehensive chapter on farm disinfection, which includes mollusc farms.

The AQUAVETPLAN Disease Strategy Manual for infection with *Candidatus Xenohaliotis californiensis* (withering syndrome of abalone) identifies two control options:

– eradication (unlikely to be successful), or

– containment, control and zoning.

The Manual also notes the need for hydrographical data and the fact that there may be infected wild stocks and neighbouring abalone farms. Tetracycline chemotherapy is possible, and a source of information about anaesthetics is given. It does not give methods of destroying the abalone, and it is not specific about the method of disposal. The use of sentinel abalone for monitoring of disease is recommended.

The AQUAVETPLAN Destruction Manual recommends anaesthetics (Aqui-s™ [benzocaine hydrochloride]) or chilling for euthanasia of molluscs and gives advice on removing contaminated structures from sites. It recognises that treatment cannot be effected on farms in open water systems. The Disposal Manual recommends that boats carrying diseased animals avoid aquaculture facilities, but does not mention possible reservoirs of infection in fouling of the ship's hull. Molluscs may best be disposed of by burial, as ensilage, composting and incineration would be unlikely to destroy the shells.

The guidelines for exotic disease control in aquaculture in New Zealand differ from the other guidelines as they are only partially generic (56). They concern the interaction of government and stakeholders, and the responsibilities of both. Each farm must have a site plan, and each industry (Pacific oysters, flat oysters, mussels and abalone) must develop emergency plans that interface with a generic government response to a suspected exotic incursion. The only content specifically on molluscs is guidelines on disinfection, taken from the OIE *Aquatic Manual* (89), plus information on the known survival parameters of OIE-listed mollusc pathogens.

Emergency planning can only be effective when the degree of seriousness is quickly realised by those administering the plan and if the response is immediate and co-ordinated. In August 2002, a sample of oysters (*Crassostrea virginica*) from a farm in the Bras D'Or Lakes region, Cap Breton (Nova Scotia, Canada), which was experiencing 80% mortality, was sent to the Shellfish Health Program at the Gulf Fisheries Centre in eastern Canada. By 18 October, the cause of the mortality was identified as *Haplosporidium nelsoni*, a then OIE-listed pathogen, which was confirmed by the OIE Reference Laboratory (the Virginia Institute of Marine Science). A team of experts was rapidly assembled to determine the distribution of the parasite, and during November 2002, 3,000 oysters were submitted to the laboratory. Because the oysters were co-infected with a congeneric parasite, *H. costale*, which cannot be distinguished by histopathology, another team was formed to develop molecular tools to distinguish the two species and detect low levels of infection. The success of these teams, using emergency plans to control movement and prevent spread, and the utilisation of expertise, not only in government agencies, but in other organisations such as universities, plus co-operation from the farmers, resulted in an effective response. However, temperature and salinity may also have restricted further spread of the parasite.

Conclusions

Biosecurity strategies for aquaculture are practical and relatively easily implemented at all levels (from the farm to the nation), particularly if the elements outlined in the OIE *Aquatic Code* and *Aquatic Manual* are used as a framework. As aquaculture continues to expand throughout the world, national biosecurity initiatives to protect aquaculture from disease, and those that involve contingencies for controlling and eradicating disease, will become progressively more important. It therefore appears fundamental that, if production and the trade in farmed aquatic animals and products are to continue to develop without major disease problems, countries will have to develop strategies that prevent, protect, control and (whenever possible) eradicate infectious diseases from their aquaculture industries.

In most cases the procedures and processes outlined in the OIE *Aquatic Code* and *Aquatic Manual* will serve as a template for countries to develop their own, specific programmes. From the case studies described above, it can be concluded that, for the most contagious diseases of aquatic animals, contingency plans or other strategic disease management procedures are important for effective control and/or eradication. Once a pathogen has escaped from the farmed environment and established infection in the local wild population, eradication may be much more difficult, if not impossible, irrespective of emergency planning. The success of an eradication programme will be influenced by many factors, including the quantity of pathogen present in the environment, virulence, favourable environmental conditions and susceptibility of the local wild population. Eradication will also depend upon the impact on wild stocks and the extent of the measures enforced by the competent authority.

Speed of detection, identification, and emergency plan implementation are critically important, and it is recommended that emerging diseases are included in national biosecurity strategies on a general basis. Emergency response procedures should in general be developed to be generic for aquatic animals, despite different culture method characteristics. A generic plan can always form the basis and grounding for more disease-specific contingency plans should those be required by individual countries.

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Approches, plans d'urgence et programmes nationaux de biosécurité pour lutter contre les maladies des animaux aquatiques d'élevage : leur évolution, leur efficacité et les perspectives d'avenir

T. Håstein, M. Binde, M. Hine, S. Johnsen, A. Lillehaug, N.J. Olesen, N. Purvis, A.D. Scarfe & B. Wright

Résumé

Parallèlement à l'augmentation exponentielle des productions aquacoles et de leur commerce, une perception accrue des effets néfastes des maladies dans ce secteur a encouragé les pays à mettre au point des stratégies nationales de biosécurité pour les exploitations piscicoles, qui trouvent dans le *Code sanitaire pour les animaux aquatiques* et dans le *Manuel des tests de diagnostic pour les animaux aquatiques* de l'Organisation mondiale de la santé animale (OIE) un excellent cadre de référence. À partir d'exemples portant sur quelques pays et sur des maladies particulières, les auteurs dressent un tableau général des diverses approches suivies pour mettre en œuvre des stratégies de biosécurité, y compris celles récemment introduites dans les législations et les réglementations nationales et celles mises en œuvre par les acteurs de l'aquaculture eux-mêmes. Ils exposent la manière dont le statut sanitaire est établi pour chaque unité épidémiologique (depuis la ferme jusqu'au pays tout entier), ainsi que les approches appropriées pour prévenir l'introduction de maladies et pour élaborer des plans d'urgence à visée prophylactique ou d'éradication. La disponibilité de ressources financières et humaines, entre autres, est une condition garantissant l'efficacité de ces stratégies : en particulier, les programmes d'éradication doivent prévoir l'indemnisation ou le dédommagement des éleveurs ; la corrélation pratique de ces stratégies avec les initiatives gouvernementales d'ordre réglementaire ou politique est également un facteur important.

Mots-clés

Aquaculture – Biosécurité – Évènement imprévu – Ligne directrice – Maladie – Plan – Politique – Programme – Réglementation – Stratégie – Urgence.

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Planteamientos, planes y programas nacionales de seguridad biológica en respuesta a las enfermedades de animales acuáticos criados en cautividad: evolución, eficacia y rumbo futuro

T. Håstein, M. Binde, M. Hine, S. Johnsen, A. Lillehaug, N.J. Olesen, N. Purvis, A.D. Scarfe & B. Wright

Resumen

El rápido crecimiento de la producción acuícola y el comercio de los productos resultantes, así como la creciente preocupación por los negativos efectos de las enfermedades, están actuando como acicates para elaborar estrategias nacionales de seguridad biológica en las piscifactorías, para lo cual el *Código Sanitario para los Animales Acuáticos* de la Organización Mundial de Sanidad Animal (OIE), junto con el *Manual de Pruebas de Diagnóstico para los Animales Acuáticos* que lo acompaña, constituyen un referente idóneo. Ofreciendo ejemplos relativos a unos pocos países y a determinadas enfermedades, los autores trazan una panorámica de la concepción de métodos para poner en práctica estrategias de seguridad biológica, como las que están siendo integradas en la legislación y reglamentación de algunos países o las que están poniendo en marcha los propios industriales del sector. Los autores también examinan la determinación de la situación sanitaria en distintas unidades epidemiológicas (desde una explotación hasta el territorio entero de un país), las soluciones adecuadas para prevenir la introducción de patologías y la elaboración de planes de contingencia para controlar y erradicar enfermedades. Para que tales estrategias sean eficaces es importante que vengan acompañadas de los recursos necesarios para aplicarlas, económicos, humanos y de otra índole (lo que comprende incentivos como las medidas de indemnización o compensación en programas de erradicación), y que en la práctica estén ligadas a otras iniciativas gubernamentales, ya sean reglamentarias o programáticas.

Palabras clave

Acuicultura – Contingencia – Directriz – Emergencia – Enfermedad – Estrategia – Plan – Política – Programa – Reglamento – Seguridad biológica.

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