Proceedings of the OIE Global Conference on Aquatic Animal Health

Aquatic Animal Health Programmes: their benefits for global food security

28–30 June 2011
Panama City (Panama)
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www.oie.int
ISBN: 978-92-9044-897-6
Cover design: Paloma Blandin, OIE
© Photographs: Tomo Yun (www.yunphoto.net/es)
Acknowledgements

To the Steering Committee of the conference for their kind collaboration:

Dr Bernard Vallat (Chair)
Dr Luis Barcos
Dr Daniel Chaisemartin
Dr Alain Dehove
Dr Monique Eloit
Dr Sarah Kahn.

To the Scientific Committee of the conference for their kind collaboration:

Dr Franck Berthe
Dr Ricardo Enriquez
Dr Olga Haenen
Dr Barry Hill
Dr Huang Jie
Dr Sarah Kahn
Professor Donald V. Lightner
Dr Gillian Mylrea
Professor Eli Katunguka-Rwakishaya
Dr Peter Smith
Dr Victor Emilio Vega Barrios
Dr Victor Manuel Vidal.

The World Organisation for Animal Health (OIE) acknowledges with thanks and appreciation the contribution of the following sponsors and partners towards providing financial support to the conference:

The Government of the Republic of Panama
   notably the Ministry of Agriculture Development (MIDA), the Ministry of Health (MINSA),
   the Panama Food Safety Authority (AUPSA) and the Authority for Aquatic Resources (ARAP)
as well as the European Union, the International Organisation of the Americas for Agriculture Health (OIRSA),
   Intervet Schering-Plough Animal Health
   and Merial.
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Aquaculture is one of the world’s fastest growing industries. It already provides nearly 50% of the food derived from aquatic animals that is consumed by humans globally, and aquaculture products are a key source of high-quality animal protein for the growing human population.

As aquaculture develops and expands in all regions of the world, there is an increasing need for improved aquatic animal health to increase production and to facilitate safe trade in aquatic animals and their products. The goal is to help feed the global population while avoiding risks to human health, aquatic animal health, the aquatic environment and biodiversity.

For over 40 years the mandate of the World Organisation for Animal Health (OIE) has included aquatic animals. Mindful of its role as one of the three standard-setting organisations of the World Trade Organization (WTO), the OIE encourages Member Countries to meet the obligations of OIE membership and to implement OIE standards in accordance with the WTO Agreement on the Application of Sanitary and Phytosanitary Standards (the SPS Agreement). Veterinary Services and Aquatic Animal Health Services must be able to implement these standards in order to safeguard health and facilitate trade. However, with most aquaculture production originating in developing countries, there is an ongoing need to build capacity to support the implementation of the international standards by all OIE Members.

This OIE Global Conference ‘Aquatic animal health programmes: their benefits for global food security’ was held from 28 to 30 June 2011 in Panama City, Panama. Around 255 participants from over 70 countries attended this unique international forum. They included representatives from national authorities, international, regional, and national organisations, and the private sector.

The conference presentations highlighted the important contribution that aquatic animal health programmes make in improving the productivity and sustainability of aquaculture and alleviating poverty globally. Healthy aquatic animals can provide the high-quality protein that is urgently needed to nourish growing human populations, particularly in developing countries. The conference also helped to raise awareness of the need for good governance in Aquatic Animal Health Services (both governmental and private sector), and of the involvement of veterinarians and other partners in ensuring that aquaculture products meet international standards and do not harm animal health, human health or the environment.

The work of veterinarians and aquatic animal health professionals is what enables governments to achieve their objectives for aquatic animal health, food safety, public health and environmental sustainability. Efficient aquatic animal health programmes that are consistent with OIE international standards depend on well-governed Aquatic Animal Health Services, comprising both governmental and private sector components. The involvement of veterinarians and aquatic animal health professionals, working in collaboration with partners, is essential for ensuring the production of aquaculture products that are safe for human consumption, avoid unwanted impacts on aquatic animal health and the environment, and are appropriately certified to meet international trade requirements. To achieve these goals, key infrastructure elements (such as good governance, modern and appropriate legislation, professional education, appropriate disease prevention and control methods, and efficient public–private partnerships) must be in place. Noting that developing countries face many challenges in meeting international standards in all of these areas, the OIE has developed initiatives (based on the OIE global PVS [Performance of Veterinary Services] Pathway for good governance) to support Members wishing to improve the governance and performance of their Aquatic Animal Health Services.

This provides an overview of the available knowledge on aquatic animal health and its contribution to ensuring global food security. Recommendations from this conference are presented as an appendix to this publication.

I trust that the information provided will be very useful in assisting Member Countries, on the basis of the recommendations adopted, as well as that of the OIE standards and guidelines, to strengthen aquatic animal health programmes that improve the productivity, safety and sustainability of aquaculture and alleviate poverty globally.

Dr Bernard Vallat
Director General of the OIE
Keynote address

Objectives and expectations for the conference

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Summary

Food security has become a major concern today right across the globe. Aquaculture is one of the world's fastest growing industries, and food derived from aquatic animals is an important source of high-quality animal protein for the growing global human population. A key objective of the conference is to highlight the important contribution of aquatic animal health programmes to improving aquaculture productivity and sustainability and thereby contributing to food security and poverty alleviation.

Given the rapid emergence and re-emergence of diseases, programmes for aquatic animal health are more important than ever. Efficient aquatic animal health programmes can make aquaculture products safe and affordable, enabling countries to increase production in an environmentally sustainable way and to facilitate safe trade in aquaculture products in a continually growing world market.

It is my expectation that the conference will demonstrate the need for aquatic animal health programmes to be consistent with the OIE international standards, and the need for good governance of Veterinary Services and Aquatic Animal Health Services (AAHS) to support efficient and sustainable aquaculture production.

Aquatic Animal Health Services face particular governance challenges. These services include both governmental and private sector activities. The governmental authority retains the overall responsibility for key activities, such as disease detection and reporting, management of disease outbreaks, use of veterinary products and certification, as well as supporting the development of appropriate alliances between the public and private sector. The conference will highlight high responsibilities of governmental authorities to establish the regulatory frameworks for the production of aquaculture products that are safe for human consumption, avoid unwanted impacts on aquatic animal health and the environment, and are appropriately certified to meet international trade requirements. Presentations will cover the key infrastructure elements such as good governance, modern and appropriate legislation, professional education and public–private partnerships, which are the building blocks of an efficient framework.

Participants will also be informed about the current aquatic animal health situation at the global and regional level and future trends.

The conference will also provide a better understanding of the scientific and technical requirements for effective aquatic animal health programmes covering matters under the OIE mandate: disease diagnosis, surveillance and notification; disease prevention and control; sanitary measures and health certification of aquatic animals and their products; food safety; control of veterinary products; farmed fish welfare; and the role and education of veterinarians and aquatic animal health professionals in the aquaculture sector.

Presentations will be made on the roles and responsibilities of OIE National Delegates and Focal Points in aquatic animal health management, and information provided on OIE initiatives to support Members wishing to improve the performance of AAHS and Veterinary Services using the OIE Performance of Veterinary Services (PVS) Pathway for good governance.
To strengthen the global capacity for aquatic disease prevention, detection and control, the OIE has established a global network of Reference Laboratories and Collaborating Centres for aquatic animal diseases and key topics in 13 countries. The OIE is taking steps to improve the world distribution of expertise through its laboratory twinning projects.

Finally, this conference will provide practical guidance and tools to help developing countries and those with ‘in-transition economies’ to attract donor support to develop and implement strategies to strengthen aquatic animal health programmes in line with OIE international standards. This is a prerequisite to improved aquatic animal health and food safety and sustainable aquaculture.

Keywords

Introduction

Food security has become a major concern today all around the globe. Aquaculture is one of the world’s fastest growing food-producing sectors, and food derived from aquatic animals is an important source of high-quality animal protein for the growing global human population. Worldwide, aquaculture production has grown at an average annual rate of 8.4% since 1970 and reached 65.8 million tonnes in 2008, with Asia, including the People's Republic of China, supplying 91% of global aquaculture production.

This conference will highlight the important contribution of aquatic animal health programmes to improving aquaculture productivity and sustainability and thereby contributing to food security and poverty alleviation.

The growing demand for food of animal origin is driven partly by population growth but mainly by rising living standards and prosperity in developing countries. Studies have shown clear benefits of aquaculture, in terms of ecological efficiency and environmental impact, over other systems for the production of protein of animal origin for human consumption. However, the drive to increase aquaculture production is unfortunately contributing to increased movement of aquatic animal pathogens and the rapid emergence and re-emergence of diseases, meaning that aquatic animal health programmes are more important than ever. Efficient health programmes and better aquatic animal health contribute to making aquaculture products safe and affordable. They enable countries to increase production in an environmentally sustainable way and to participate in safe international trade in aquaculture products in a continually growing world market.

I expect that this conference will demonstrate the need for aquatic animal health programmes to meet the OIE international standards, including good governance of the Veterinary Services and Aquatic Animal Health Services (AAHS), to support efficient and sustainable aquaculture production.

This conference will also contribute to our understanding of the scientific and technical requirements for effective aquatic animal health programmes. Speakers will address all matters under the OIE mandate:

- aquatic animal disease diagnosis
- surveillance and notification
- disease prevention and control
- sanitary measures and health certification of aquatic animals and their products
- animal production food safety
- the control of veterinary products
- the welfare of farmed fish
- the role and education of veterinarians and aquatic animal health professionals in the aquaculture sector.

Aquatic Animal Health Services, as defined by the OIE, include both public and private sector. Veterinarians and other health professionals play a key role in the establishment and implementation of aquatic animal health programmes, which are essential to meet the growing demand for aquaculture products, to help meet the needs of global food security.

Government authorities have authority and overall responsibility for key activities, such as disease detection and reporting to the OIE, management of disease outbreaks, standards for veterinary products and health certification, as well as supporting the development of appropriate alliances between the public and private sector. Government
Keynote address

authorities have a responsibility to establish appropriate regulatory frameworks for the production of aquaculture products that do not present risks to human health, animal health or the environment and are appropriately certified to meet international trade requirements.

Aquatic Animal Health Services face particular governance challenges. The OIE is helping AAHS in their work, notably through setting standards and disseminating information about disease events, as well as supporting AAHS to follow the OIE Performance of Veterinary Services (PVS) Pathway. It is equally important that governments and donors give priority to strengthening AAHS, especially in developing countries, so that aquatic animal diseases do not become a limiting factor for the production of safe aquaculture products.

Development of standards for safe aquaculture products

With specific reference to the World Trade Organization (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement), the OIE’s mission includes safeguarding world trade by publishing standards for international trade in animals and animal products. Implementation of the OIE standards (published in the Aquatic Animal Health Code and the Manual of Diagnostic Tests for Aquatic Animals) allows WTO Members to avoid the introduction of diseases and pathogens, without setting up unjustified sanitary barriers. Application of the OIE standards is the easiest way for WTO Members to meet their obligations under the SPS Agreement.

Speakers at this conference will inform participants about current OIE standards and future trends in setting standards.

Great progress has been made by the OIE Aquatic Animal Health Standards Commission in developing standards for aquatic animals and their products. Recent developments include the adoption by OIE Members of chapters on the prudent use of antimicrobial agents in aquatic animals, criteria for the safety of aquatic animal commodities, the control of hazards in aquatic animal feed, and the listing of two diseases of amphibians – an important topic in the context of ecological health. The OIE has also adopted standards for the welfare of farmed fish during transport and stunning and killing.

I am pleased to note that an increasing number of Members are engaging in the standard development process by submitting comments on new text and chapters proposed by the Aquatic Animal Health Standards Commission. The creation of National OIE Aquatic Animal Focal Points, under the overall authority of the National Delegate, will help to further increase this engagement. It is particularly important that members provide input on standards and priorities for future standard setting. The OIE provides advice and encouragement to Members on the implementation of standards, and other activities to strengthen AAHS.

Bearing in mind the need to coordinate the development and adoption of global standards for aquatic animals and their products, the OIE has maintained close collaboration with the Codex Alimentarius Commission, which, like the OIE, is a reference standard-setting organisation recognised under the WTO SPS Agreement. Codex takes primary responsibility for food safety and the OIE for animal health including zoonoses. The OIE and Codex collaborate closely in the development of standards relevant to the food production chain and the bridge between live aquatic animals and products.

Disease reporting

Disease reporting is a fundamental duty of OIE members, as highlighted in the recent OIE paper on the global legal basis of disease notification (www.oie.int/eng/PDF/notification-EN.pdf).

Each Member Country undertakes to report the animal diseases that it detects on its territory. The OIE then disseminates the information to other countries, which can take the necessary preventive action. The World Animal Health Information System (WAHIS), an internet-based computer system, enables OIE Members to process data on animal diseases and inform the international community of relevant epidemiological events and developments for more than 100 listed animal diseases, including 26 aquatic animal diseases. The information generated is available to all interested parties via the World Animal Health Information Database Interface (WAHID).
There is a trend of increasing notification of aquatic animal diseases by Member Countries to the OIE since the launch of WAHIS. For example, for reports received for 2009, 170 countries provided an annual health report on OIE-listed diseases, 68% of which were for terrestrial and aquatic animal diseases.

Since 2004, the OIE has developed the WAHIS Regional Core Strategy, to help OIE Members meet their regional requirements and their obligations to notify diseases to the OIE, while avoiding duplication. For aquatic animal diseases, the Network of Aquaculture Centres in Asia–Pacific (NACA), the OIE Regional Representation for Asia and the Pacific and the OIE Headquarters have embarked on developing a Regional Core to enable OIE/NACA Members to provide and share information additional to the OIE-listed diseases, especially aquatic animal diseases of regional importance. This will further improve transparency, knowledge and efficient data collection on aquatic animal diseases in the region and improve knowledge of the aquatic animal health situation worldwide.

Global partnerships

The OIE has developed cooperation agreements with a number of intergovernmental organisations (Food and Agriculture Organization of the United Nations [FAO], WTO) and other international non-governmental organisations to strengthen collaborative activities, including international organisations with a focus on aquatic animals, such as the Southeast Asian Fisheries Development Center (SEAFDEC) and the Organismo Internacional Regional de Sanidad Agropecuaria (Regional International Organization for Plant Protection and Animal Health – OIRSA). The OIE recognises the need to continue developing and strengthening models of collaboration at the international and regional level for the aquatic sector in a similar manner as those developed in the terrestrial sector.

The OIE’s strengths are leveraged through effective, dynamic and diverse global partnerships to address the complex global development of diseases such as avian influenza. For example the Global Early Warning System for Animal Disease including Zoonoses (GLEWS) is a joint OIE/FAO/WHO (World Health Organization) initiative that builds synergies in the alert and response mechanisms of the three partners. The OIE continues to work on strengthening collaboration at the international and regional level in the aquatic sector, in the knowledge that much more can be achieved by working collaboratively.

Reference Laboratories and Collaborating Centres

To strengthen global capacities for aquatic disease prevention, detection and control, the OIE has established a global network of Reference Laboratories and Collaborating Centres, with institutes in 13 countries specialising in aquatic animal diseases and key topics. The OIE is taking steps to improve the world distribution of expertise through its initiative to create laboratory-twinning projects.

The OIE laboratory-twinning programme aims to establish necessary scientific expertise in developing countries and those with ‘in-transition’ economies to improve their ability to comply with OIE standards and to detect and respond to outbreaks of disease.

As with all initiatives in the OIE PVS Pathway, the ultimate goal of twinning is to help alleviate poverty by improving food security. The objective is that the recipient twinning laboratory or institution will be able to provide technical support to other countries in its region by eventually becoming an OIE Reference Laboratory or Collaborating Centre. By improving the global distribution of capacity for disease detection and control and by creating truly global disease surveillance networks, the achievements of twinning will strengthen global security against animal diseases, zoonotic diseases and new and emerging diseases.

Institutes specialised in aquatic animals are under-represented in the OIE laboratory-twinning programme. Despite the urgent need to develop diagnostic capacity for aquatic animal diseases in South America, South Asia, and parts of Africa, as of June 2011 only 1 of the 30 currently active twinning projects addresses an aquatic animal disease. OIE laboratory twinning provides a real opportunity to strengthen and expand a network of OIE Reference Laboratories and Collaborating Centres for aquatic animal diseases. I urge Members to identify possible partner laboratories and consider participation in the OIE twinning programme.
**PVS Pathway for Aquatic Animal Health Services**

To meet the worldwide demand for aquatic animal protein, production must be intensified, which will bring increased risks to health and the environment that cannot be effectively controlled without regulatory programmes supported by good governance. Aquatic Animal Health Services, whether or not they are part of Veterinary Services, need the resources to develop and implement appropriate disease prevention and control programmes and the authority, including the legal framework, to enforce them. The awareness of farmers and operators throughout the food chain must be improved, notably with respect to the benefits of effective aquatic animal health programmes, so that they are motivated to comply with governmental programmes.

In many countries, AAHS are less developed and resourced than the Veterinary Services for terrestrial animals. Therefore, there is an important need for capacity-building approaches, such as the OIE PVS Pathway, for strengthening veterinary and aquatic animal health services by using the OIE Tool for the Evaluation of Performance of Veterinary Services (OIE PVS Tool), and related activities, including missions for strengthening veterinary legislation.

To date the OIE has evaluated Veterinary Services in more than 100 Member Countries. The OIE PVS Pathway is thus a proven tool to help Members wishing to strengthen their Veterinary Services. The OIE is now turning attention to the evaluation of AAHS, using the modified PVS Tool for the evaluation of AAHS. Most of the competencies of Veterinary Services were included, but some competencies that specifically relate to veterinary governance and training (such as the role of the veterinary statutory body) were modified to address the professional framework of aquatic health. The performance indicators are generally the same as those for Veterinary Services, with some important modifications.

The OIE is undertaking some evaluations of AAHS, but I am keen to receive more requests. I encourage OIE Members to apply for evaluation using the PVS Tool, as the OIE PVS Pathway has proven very helpful to Members wishing to strengthen Veterinary Services and is well accepted by major donors.

**Focal Points**

As of June 2011, 147 Members had nominated a National Aquatic Animal Focal Point, under the authority of the National Delegate, to assist in disease reporting and providing comments on the OIE’s standard-setting work. I encourage all Delegates that have not already nominated an Aquatic Animal Focal Point, as well as other OIE Focal Points, to do so.

**OIE initiative for veterinary education**

Veterinarians are under-represented in the aquatic animal sector, and there is also a need for training models for professionals working with aquatic animals in this sector. In order to increase the number of veterinarians working in the aquaculture sector, and to ensure that they are competent to deal with the specific challenges of aquatic animal health programmes, there is an urgent need to improve the education delivered to veterinarians and aquatic health professionals, particularly in developing countries.

The OIE recognises the critical role of veterinarians in protecting animal health and welfare, animal production food safety and environmental health as a global public good. The OIE is therefore undertaking a global veterinary education initiative, based on the specification of basic core curricula for initial and continuing veterinary education, which meets the current and future needs of society.

The OIE Ad hoc Group on Veterinary Education has developed recommendations for minimum competencies expected of ‘Day 1’ veterinary graduates to assure delivery of national Veterinary Services. The ad hoc Group focused its initial efforts on overall competencies rather than competencies for particular animal species.

The coverage of aquatic animals in veterinary undergraduate courses varies according to the importance of the aquatic sector in countries and regions, and in many parts of the world aquatic animal health and medicine is regarded as a postgraduate specialisation. The OIE is now considering the development of recommendations on aquatic animals in the undergraduate veterinary curriculum, as veterinarians will always be in the front line in all matters relating to the control of animal diseases, including zoonoses, in primary production.
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The contribution of aquatic animal professionals in the aquaculture sector is acknowledged, but it is important that the qualifications of such professionals be standardised and controlled. It is also critical that more veterinarians become involved in this area, especially to address the key issues of veterinary products and food safety.

Legislation – essential infrastructure for health programmes

Legislation and good governance are part of the essential infrastructure for aquatic animal health programmes. Laws and subordinate regulations should be appropriately flexible to provide appropriate health safeguards and efficient responses to changing situations. Legislation is needed to underpin the responsibilities and structure of the authorities responsible for the control and tracing of aquatic animal movements, aquatic animal disease control and reporting systems, and epidemiological surveillance and reporting.

Veterinary legislation of many OIE Members needs to be modernised to address new and emerging threats and modern societal expectations. As part of the follow-up to a PVS evaluation under the OIE PVS Pathway, the OIE undertakes missions to help Members update their national veterinary legislation, including entering into agreements for ongoing support of Members over a one- or two-year duration.

Fifth OIE Strategic Plan (2011–2015)

The Fifth OIE Strategic Plan provides a broader remit for the Aquatic Animal Health Standard Commission (AAHSC). In addition to its ongoing activities and initiatives, the Commission has started to address issues relevant to animal production food safety and will soon be addressing the effect of climate and environmental changes and issues relevant to invasive alien aquatic species.

Research needs

Applied research is needed in many key areas of aquatic animal production, including the identification of measures to reduce environmental impacts and innovations in techniques and management to reduce dependency on fishmeal and fish oil as a feed source.

Conclusions

I expect that this conference will provide a forum for OIE Members to exchange experiences and ideas, with the goal of improving aquatic animal health worldwide and, thereby, helping to alleviate poverty and hunger and improve human welfare. The OIE continues to advocate strongly on behalf of public and private components of Veterinary Services and AAHS. They are a global public good and they need and deserve significant investment by governments and the international community.

On behalf of OIE Members, I would like to thank the OIE’s partners and donors that helped the OIE to organise this conference, and all those who contributed to its success. Thanks go to the staff at OIE headquarters in Paris, the OIE Regional Representative for the Americas in Buenos Aires and the Sub-Regional Representative for Central America in Panama City. My thanks go to the European Commission (Directorate General for Health and Consumers), the OIRSA and the Central American Fishing and Aquaculture Sector Organisation for their generous support. Finally, my sincere thanks go to the Government of the Republic of Panama, notably the Ministry of Agriculture Development, the Ministry of Health, the Panama Food Safety Authority and the Authority for Aquatic Resources, for its agreement to hold the conference in Panama City.

I have a particular message for National Delegates, Focal Points and all other participants – please convey the important messages that will be discussed at this conference to your governments and encourage them to take all necessary steps to strengthen aquatic animal health programmes in your country and the efficiency of the AAHS.
Session 1

The current state of play: aquatic animal health programmes globally and regionally

Objectives: to describe aquatic animal health programmes and issues globally and regionally
Contribution of aquaculture to food security globally

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Summary

Fish, considered as ‘rich food for poor people’, is an excellent source of affordable, high-quality protein. More than 1 billion people get at least 20% and 3 billion people get 15% of their animal protein from fish. Aquaculture has played a significant role in global food production and is the fastest growing food-producing sector, with an annual growth of over 8% in the last three decades. The sector has contributed to food, nutritional and livelihood security and alleviation of poverty in developing countries. Aquaculture production accounts for nearly half of the food fish supply globally. The contribution of aquaculture to per capita consumption of fish increased from 14% in 1986 to 30% in 1996 and 47% in 2006. The contribution of fish to the total protein intake of people in poor households is relatively high.

Developing countries account for 90% of the aquaculture production, providing a livelihood directly and indirectly to millions of people in rural areas. The global trade in aquaculture products is becoming increasingly important. It is the main source of foreign exchange earning for some developing countries, financing other food imports, and has significant impact on food security. Wealth generated by households and small enterprises through aquaculture makes a significant contribution to rural development. Studies have shown that aquaculture is an ideal enterprise for the empowerment of rural women.

It is estimated that the world will need an additional 20–30 million tonnes of food fish by 2020 to meet the increasing demand. With capture fisheries having plateaued, aquaculture is expected to play a major role in bridging the gap between supply and demand.

This paper discusses the issues that need to be addressed to increase the contribution of aquaculture to food security.

Keywords

Introduction

The greatest disease of all humankind is ‘hunger’. We are passing through an era of increasing population, food shortages and food and nutritional insecurity. The global population has grown from 1.5 billion in 1900 to 7 billion now and is expected to pass 9 billion by 2050. Nearly a billion people are undernourished, with nearly 87% of them in Asia and sub-Saharan Africa. Micronutrient deficiencies or ‘hidden hunger’ affects over 2 billion people. Two hundred and fifty million children are at risk of vitamin A deficiency and an equal number suffer from deficiency of minerals such as iron, zinc, calcium, etc.

The Millennium Development Goal has set a target of reducing the number of undernourished people by half by 2015. While some progress has been made in terms of reducing the proportion of the hungry, the absolute number of the hungry is on the increase and has reached nearly 1 billion. Spiralling prices, as witnessed in the past few years, will make more people subject to food insecurity. Asia–Pacific accounts for 62% of the food insecure in the world, and sub-Saharan Africa accounts for 32%. The proportion of undernourished people is highest in sub-Saharan Africa at 30%.
Poverty and food insecurity

There is hunger and undernourishment even in countries where there is enough food to meet the needs of its population. Economic access to food happens only when households generate sufficient income to produce or purchase food. Hence, food security is linked with poverty and it, in turn, with rural development. In this context, aquaculture can be a starting point for alleviation of poverty in rural and peri-urban areas.

Contribution of fish to nutrition and livelihood security

Fish is the cheapest animal protein available in most developing countries and is considered as ‘rich food for the poor’. Fish provides over 20% of animal protein to 2.6 billion people globally: while on average it is around 13% in developed countries, it is about 30% in developing countries (4). Fish is the major source of animal protein in regions in which animal protein in diets is below the world average. Fish provides at least half of the animal protein intake for 400 million poor people in South Asia and Africa.

It has been shown that the proportion of animal protein intake increases with income: there is higher consumption of animal protein in developed countries with higher incomes compared with lower consumption in developing countries. However, consumption of fish protein as a percentage of total animal protein consumed is high among developing countries in Asia and Africa, as compared with developed countries in which the intake of terrestrial animal protein is high, indicating the importance of fish in the nutritional security of the poor in developing countries.

Besides being the cheapest source of protein, fish are also a rich source of essential fatty acids, vitamins and minerals. Studies have revealed that some of the farmed fish species are also high in iron and vitamin A. For example, some small fish occurring naturally in fish ponds in Bangladesh and the surrounding region, such as mola (Amblypharyngodon mola) and chanda (Parambassis ranga), are very high in vitamin A (8). It has been estimated that the vitamin A requirement of 2 million children could be met if each of the 1.3 million ponds in Bangladesh produced 10 kg/pond of A. mola (10). In Cambodia, a small fish, Esomus danricus, which is high in iron and when eaten with rice can supply 45% of the daily requirement of iron to women and 42% of the daily requirement to children (9), is being promoted by many agencies.

Contribution of fish to livelihoods and its economic importance

In addition to contributing to nutritional security, fish contribute to livelihood security. Globally, 540 million people, or 8% of the total population, are involved in fisheries and aquaculture (5). Growth in employment in the sector is more than population growth and also more than growth in employment in traditional agriculture. Eighty to one hundred per cent of rural aquaculture products are sold, generating cash income for low-income rural families. Furthermore, aquaculture brings foreign exchange earnings to many countries (e.g. Bangladesh, People’s Republic of China, India, Thailand and Vietnam).

From the point of view of economic importance, fish is the most internationally traded commodity. About 40% of global production enters the international market, compared with 10% of terrestrial-based meat production, and nearly 50% of aquatic products exported are from developing countries (5). The value of the global trade in fish in 2008 is estimated at US$102 billion (5). In many developing countries, foreign exchange earned through the export of aquatic products is used for the import of other food items.

Future demand for fish

Studies undertaken by the International Food Policy Research Institute (IFPRI), the Food and Agriculture Organization of the United Nations (FAO) and the WorldFish Center have indicated that by 2020 an additional 20–30 million tonnes will be needed to maintain the present level of consumption (4). Future demand estimates based on present per capita consumption may be underestimates, as per capita consumption of fish has been on the increase from 11.5 kg per capita in 1970 to 12.5 kg in 1980 to 14.4 kg in 1990 and 17.0 kg in 2008 and is likely to increase further in the future due to urbanisation and increased wealth. The middle class population is estimated to increase six-fold in the next 20 years in Asia and Africa (7) where poverty and undernourishment
are high, putting more pressure on the food/fish basket. Delgado et al. (3) suggested that urbanisation, leading to changes in food preferences, has in the past accounted for an extra 5.7–9.3 kg per capita per annum consumption of fish and meat.

**Global fish production**

Global production of fish in 2009 stood at 145 million tonnes, of which 118 million tonnes constituted food fish. Capture fisheries, which used to contribute the major portion of food fish production, have more or less stagnated in the last decade and stood at around 90 million tonnes in 2009, while aquaculture contributed 55 million tonnes (5). Due to overexploitation of stocks, it is likely that no major increase in capture fisheries can be expected and hence future demand will have to be met from increased aquaculture production.

**Aquaculture scenario**

Aquaculture is the fastest growing food commodity, with an annual growth of over 6% in the last two decades (5). Statistics from the FAO show that production has increased from less than a million tonnes in 1950 to 55 million tonnes in 2009. Eighty per cent of this production comes from some 20 million smallholder farms (< 2 ha) in developing countries. This increase in aquaculture production can be attributed to breakthroughs in research and development – domestication and development of culture technologies for more species (72 species in 1950 to 336 species in 2006) – increasing demand, both domestic and export, and an improvement in policies and governance.

Asia–Pacific dominates in global aquaculture production, contributing over 90% of total production, of which 61.5% is from China and 29.5% from the rest of Asia. Europe contributes 3.6% of global aquaculture production, of which 80% is from coastal aquaculture. South America contributes 2.2% of global production, with Ecuador, Brazil, Mexico and Chile spearheading development in the region.

Africa contributes only 1.4% to global aquaculture production, mostly from small-scale farms, but in recent years some export-oriented commercial aquaculture has started. This is a region with great potential in view of its low starting base, and in recent years there has been growing interest in aquaculture both from the public and private sectors.

Over 60% of global aquaculture production comes from fresh water, followed by 32% from the marine environment and 8% from brackish waters. Aquaculture systems, especially freshwater aquaculture, have moved from low-input subsistence farming in backyard ponds using agricultural by-products, with outputs of 1–5 tonnes/ha per year, to intensive systems using formulated feeds. This has led to outputs increasing to 200–400 tonnes/ha per crop, as demonstrated by catfish farmers in Vietnam – the highest production for any primary food production sector. In addition to ponds, intensive fish culture is being undertaken in cages installed in reservoirs and other open waters, recirculating systems, etc.

Compared with freshwater aquaculture, which has a long history, mariculture is has been gaining in importance in recent times, with domestication of a number of high-value species. Recent success achieved in breeding in captivity species such as bluefin tuna, yellowfin tuna, Atlantic bonito, etc. will not only lead to increased production but also allow conservation of wild stocks of these species, which are under threat of extinction due to overexploitation. However, the contribution of mariculture to food security will not be as great as that of freshwater and brackish water aquaculture, as mariculture is capital intensive with high operational costs and involves the farming of high-value species. This level of investment will be beyond the capacity of small-scale farmers, and also the outputs will not be able to contribute to the food basket of the poor in developing countries due to the high value, and therefore high cost, of the species farmed. Hence, much of the future increases in fish production will have to come from freshwater and brackish water aquaculture.

In addition to traditional aquaculture systems, excellent opportunities exist for farming in cages and pens installed in common property resources such as lakes, reservoirs, ox-bow lakes, etc., opening up opportunities for the involvement of landless people. This has been shown not only to increase production from these waters but also to create livelihoods for people living in the area.
Aquaculture vs terrestrial animal production

Aquaculture is one of the most environmentally efficient ways of producing animal source food. Aquaculture is a better converter of feed to body biomass, estimated at 30%, compared with 18% in poultry and 13% in pigs (6). Also, it has been estimated that the grain needed (as feed) to obtain 1 kg of fish protein is much less at 13 kg compared with 38 kg for pork and 61 kg for beef (6). Besides this, aquaculture is more environmentally friendly and has a small carbon footprint.

The future contribution of aquaculture

Various studies under different scenarios have predicted aquaculture production trends to 2020 and 2030 (2, 4, 12). Hall et al. (6) examining various projections, and assuming that there would be neither a catastrophic collapse or an exponential growth in capture fisheries, predicted an aquaculture production of 65–85 million tonnes by 2020 and 79–110 million tonnes by 2030, compared with 55 million tonnes in 2009.

Challenges for meeting the demand

If we are to meet these projected demands and achieve projected production potential, a number of issues, such as the impact of declining water and land resources, the impact of climate change, the intensification and spatial concentration of farms, increased aquatic animal health concerns, cost-effective production of feed, etc., need to be addressed.

As nearly 80% of aquaculture production comes from smallholder-operated farms and provides a livelihood option for the rural poor, issues that concern these small-scale farmers, such as access to resources – both natural and financial – lack of skills, and vulnerability and aversion to risk, need to be addressed and opportunities for enterprise development need to be provided.

Disease outbreaks in the past have crippled aquaculture operations, incurring losses amounting to billions of dollars (1, 11). With the expected expansion and intensification of aquaculture to meet the global demand and the increased transboundary movement of aquatic animals, fish health management is going to be a critical area in which efforts need to be concentrated in terms of developing diagnostic skills and kits and development of disease-resistant strains of fish.

Great strides have been made in improving production of crops and livestock through genetic enhancement and modification. However, in the case of fish, although there is thousands of years of history of aquaculture, very few cultured species have been domesticated and most of the cultured tropical fish are inferior to their wild counterparts due to years of inbreeding. Genetic enhancement of farmed species needs to be undertaken and access to these improved strains by small farmers needs to be ensured.

All the planned aquaculture developments should follow an ecosystem approach. Farmers need to be trained in best management practices that have been developed for many farmed species. Recent experience from India has shown that cluster formations of small-scale shrimp farmers resulted in improvements in their access to knowledge and bargaining power for inputs and outputs, resulting in higher production, less impact on the environment and higher profits.

With increasing product standards in terms of food safety, quality, traceability, certification and ecolabelling, small farmers need to be informed and trained to comply with international food safety standards, and small-scale aquaculture needs to be integrated into the globalised market economy.

Changes in the physicochemical environment as a result of climate change will impact on the ecosystem structure and functions. Research needs to address these issues and come up with species that can tolerate potential fluctuations in salinity and temperature.
Conclusion

Aquaculture has been resilient to the various economic crises witnessed in the past decade and is on an upward growth curve. The benefits of fish farming, relative to other animal production systems, are much higher, and an increase in the production of fish in relation to terrestrial meat production is likely to make more efficient use of available resources and meet the demand of a growing urban population. Based on the developmental trends, and given the commitment of governments to good governance, the sector will be able to meet the growing global demand for fish and contribute to food and livelihood security.

References

Aquatic animal health and international trade

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Summary

The World Trade Organization (WTO) is the intergovernmental organisation with the legal power to encourage adherence to international standards and mediate trade disputes. The WTO, with the signing of the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement), recognises the OIE as the reference standard-setting organisation for animal health and zoonoses. To assist with the implementation of the SPS Agreement and facilitate trade, the WTO has created the SPS Committee. In addition, the Standards and Trade Development Facility (STDF), founded by the OIE, the WTO, the Food and Agriculture Organization of the United Nations (FAO), the World Bank and the World Health Organization, provides a mechanism for donors to coordinate support of projects aimed at improving Members’ capacity to meet the obligations of WTO membership.

Good governance and the credibility of national Veterinary Services are essential components in safe trade, and are ultimately demonstrated when importing countries accept official health certification provided by exporting countries. The responsibility for aquatic animal health may rest fully or partially with Veterinary Services, or other governmental agencies may have this role. Regardless of the involvement of veterinarians in Aquatic Animal Health Services (AAHS), it is clear that OIE standards can be implemented effectively and health certification accepted internationally only if AAHS can demonstrate their effectiveness and credibility in a transparent manner. This is the global good offered to countries entering the OIE Performance of Veterinary Services (PVS) Pathway, i.e. a transparent means of demonstrating the steps taken towards sustainable improvement of a country’s compliance with the OIE standards on the quality of the Veterinary Services or the AAHS. Ultimately, the biggest challenge for the international community is to create the incentives and generate the political will for strengthening Veterinary Services and AAHS and providing for the universal recognition and application of the established international sanitary standards and, through this, fair and safe trade.

Keywords

Introduction

Aquatic animals and their products are of ever-growing importance in international trade. The rapid growth of aquaculture and trade increases the risk of disease spread. The most effective way to manage these risks is through the application of the OIE health standards (i.e. the recommendations set out in the OIE Aquatic Animal Health Code [Aquatic Code] and the OIE Manual of Diagnostic Tests for Aquatic Animals [Aquatic Manual]) along with transparency in reporting listed diseases to the OIE. In addition to official standards, trade requirements in the form of ‘private standards’ established by individual companies or associations are increasingly relevant to international trade. OIE Members have expressed concerns about private standards, which are not subject to the principles of the World Trade Organization (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement). OIE Members are encouraged to follow the Performance of Veterinary Services (PVS) Pathway as a means of strengthening governance and the capacity of AAHS to implement aquatic animal health programmes in line with the quality standards of the OIE.
The WTO legal framework for international trade

The WTO is the intergovernmental organisation that establishes, through a number of formal agreements, the legal framework within which international trade is conducted, including mechanisms for resolving disagreements between trading partners. In 1995, the SPS Agreement (6) came into effect. It establishes the rights and obligations of WTO Members with respect to measures to protect health and safety, i.e. sanitary and phytosanitary measures. To assist with the implementation of the SPS Agreement and to further the goal of facilitating safe trade, the WTO created the SPS Committee. The Committee holds three meetings each year, at which it monitors the state of play of international trade in animals, plants and their products, including differences between trading partners.

According to the WTO SPS Agreement, sanitary and phytosanitary measures may be taken to protect:

- human or animal health from risks arising from additives, contaminants, toxins or disease organisms in food, drink or feedstuffs
- human life from plant- or animal-borne diseases
- animal or plant life from pests, diseases or disease-causing organisms
- a country from other damage caused by entry, establishment or spread of pests.

Article 2.2 of the Agreement states that Members shall ensure that any sanitary and phytosanitary measure is:

- based on scientific principles applied only to the extent necessary to protect human, animal or plant life or health (least trade restrictive) and
- not maintained without sufficient scientific evidence, except as provided for in Article 5.7 (in cases in which relevant scientific evidence is insufficient).

Key principles in the SPS Agreement include those of transparency and non-discrimination between Members where identical or similar conditions prevail. Members are encouraged to harmonise sanitary and phytosanitary measures, the simplest approach being to base measures on international standards, guidelines or recommendations where they exist. If they decide not to apply existing international standards, Members should conduct a science-based risk assessment, using techniques developed by the relevant international organisations.

Another key provision concerns the equivalence of sanitary and phytosanitary measures. Although Members may have different sanitary and phytosanitary measures, this does not preclude the achievement of the required level of protection. Equivalence is an effective way of facilitating international trade, and procedures for this purpose have been adopted by the international standard-setting organisations and WTO Members. However, few formal agreements on equivalence have been achieved, perhaps reflecting the technical complexity of this approach.

The recognition of pest- and disease-free zones or regions (regionalisation) is another key principle of the SPS Agreement, which can be used to provide a basis for safe trade, even in situations in which countries are not able to eradicate diseases and pests of concern.

As part of the transparency provisions of the SPS Agreement, Members should inform other WTO Members about the SPS measures they plan to introduce, and provide an opportunity for comment (specific provisions exist for emergency situations). Control, inspection and approval procedures must be consistent with the provisions of the Agreement.

Support to developing country Members is an important consideration under WTO rules. The SPS Agreement contains provisions to assist developing countries in complying with the trade measures adopted by other WTO Members. In addition, the WTO Standards and Trade Development Facility (STDF) (5), founded by the OIE, the WTO, the Food and Agriculture Organization of the United Nations (FAO), the World Bank and the World Health Organization, provides a mechanism for coordination between countries and donors in the implementation of projects aimed at improving Member’s capacity to meet their obligations under the SPS Agreement.

The role of the international standard-setting organisations

The SPS Agreement establishes three reference standard-setting organisations, sometimes referred to as the ‘three sisters’. These are: the OIE in the field of animal diseases (including zoonoses), the Codex Alimentarius Commission (CAC) in the field of food safety and labelling, and the International Phytosanitary Commission in the field of plant diseases and pests. The ‘three sisters’ attend meetings of the SPS Committee as ‘observer
organisations’ and provide advice, at the request of the SPS Committee Chair or the SPS Secretariat, in relation to matters within their competence.

Given that food safety hazards may arise at the level of the animal/farm, where OIE standards are relevant, or after the ‘farm gate’, where CAC standards apply, it is clearly very important that OIE and CAC have good mechanisms for collaboration to ensure complete coverage of risks by standards – and to prevent overlap or duplication of standards. For the OIE, this is coordinated through the OIE Working Group on Animal Production Food Safety. At its annual meetings, the Working Group provides a forum for discussion among the OIE and CAC Secretariats and internationally recognised experts on topics relevant to the standard-setting mandates of the two organisations.

The ‘three sisters’ all establish ‘horizontal’ standards (e.g. on risk assessment and judgement of equivalence) and ‘vertical’ or specific standards (e.g. on the management of risks relating to specific diseases and pests). Reflecting the interest of the SPS Committee, the ‘three sisters’ have taken steps to improve consistency in their approaches to the establishment of standards, as appropriate, while recognising that there are some fundamental differences in approach that reflect the differing nature of risk and scientific/technical considerations relevant to risk management in the specific domains.

The key OIE standards for trade in aquatic animals and their products are the Aquatic Code (2) and the Aquatic Manual (3). The OIE also publishes a variety of other guidelines and recommendations relevant to the management of health risks associated with trade. The standards and many other publications, including information on the reporting of OIE-listed diseases by OIE Members, are available online. Publications may also be purchased from the OIE bookshop.

The Aquatic Code contains standards for OIE-listed diseases. An important ‘trade-facilitating’ aspect is provided by the definition of ‘safe commodities’, for which the definition or treatment of the commodity is sufficient to assure safety, without the application of additional sanitary measures. Where commodities cannot be considered as ‘safe’ in this context (e.g. live aquatic animals), the OIE establishes the measures and health certification provisions to prevent the spread of disease agents via trade. The relevance of ‘horizontal standards’ should not be overlooked. These standards have general, overarching application. They cover, for example, the management of risks associated with aquatic animal feed and requirements for disease surveillance and certification and recognition of equivalence. The Aquatic Manual contains important information relevant to the diagnosis of OIE-listed diseases and other relevant scientific information.

Clearly, food safety is a critically important issue in the trade of aquatic animal products for human consumption. Fortunately, most OIE-listed disease agents (viruses, bacteria) do not cause disease in humans. The food safety risks associated with parasitic diseases of aquatic animals can generally be managed by treatment (e.g. freezing or cooking) of the product.

In a complimentary manner, the food safety hazards associated with aquatic animals are covered in CAC standards (1). Key topics addressed by the CAC and not addressed by the OIE, as they are outside the OIE mandate, include water quality (especially important to molluscs) and standards for veterinary drug and chemical residues in products. The CAC Code of Practice for Fish and Fishery Products (CAC/RCP 52-2003) and the Code of Practice on General Principles of Food Hygiene (CAC/RCP 1-1969) cover food safety in relation to aquatic animals.

While animal welfare is not specifically addressed under the SPS Agreement, it is considered to be covered under the WTO Agreement on Technical Barriers to Trade (7). Since 2002 the OIE has been addressing a standard-setting programme on animal welfare, based on the fact that animal health makes a major contribution to animal welfare. For farmed fish, as for terrestrial livestock, the priority in the development of animal welfare-related standards was on animal transport and slaughter, as well as killing for disease control purposes. As of 2011, the OIE has adopted standards for the welfare of farmed fish during transport and slaughter and a standard on killing for disease control is under development.

**Trade and standards**

No matter how carefully standards are developed and applied, it is generally true that increasing trade increases the risk of disease spread. In aquatic animals and their products, activities considered to have been associated with the spread of pathogens include the introduction of non-native species into new environments; the importation of brood stock for aquaculture development; uncontrolled entry of aquatic animals into the aquatic environment (e.g. via ship ballast water); and the importation of feed comprising live aquatic animals or their products. The
OIE constantly reminds its Members that the application of the standards in the OIE Aquatic Code and Aquatic Manual, combined with transparency in reporting listed diseases to the OIE, are the most effective ways of managing disease risks. The capacity of the Aquatic Animal Health Services (AAHS) to provide reliable and credible certification on the application of the OIE standards is also the subject of an OIE standard. Members may take steps to improve the compliance of their AAHS with the OIE standards by entering the OIE Performance of Veterinary Services (PVS) Pathway, commencing with a mission using the OIE PVS Tool (Tool for the Evaluation of Performance of Veterinary Services) (4).

In addition to the health and safety standards outlined above, new trade requirements continue to arise. These are, increasingly, the subject of ‘private standards’, which are introduced through the actions of private companies, national retailers’ associations and international organisations.

Some private standard-setting organisations are global in scope (e.g. GlobalGAP and the Global Food Safety Initiative), and the private standards have an important bearing on participation in international trade. Private standards may address health and safety, frequently through ‘good agricultural practice’ requirements, but they are frequently far broader, covering topics such as labour laws, environmental impact and sustainable practices. These topics may be grouped as ‘corporate social responsibility’ (CSR) – the role of an official standard-setting organisation is not defined as it is for the ‘three sisters’ in relation to health and safety. Sometimes animal welfare is included as part of CSR.

In 2011 the International Organization for Standardization (ISO) adopted a new standard – ISO 26000 on Social Responsibility – which may be accessed on the ISO website (www.iso.org). This standard covers seven core subjects: organisation; human rights; labour; the environment; fair operating practices; consumer issues; and community involvement and development.

For several years the SPS Committee has been considering the issue of private standards in light of the concerns of Members, particularly developing countries, about their implications for market access and development. Some countries have identified potential positive effects of private standards. Nonetheless, concerns reflect the fundamental point that private standards are not subject to the principles set out in the WTO SPS Agreement and that their proliferation might erode the gains made through the operation of this Agreement. Fears have been expressed that private standards may be set higher than the related official requirements, while lacking an appropriate scientific basis, leading to higher costs of market access and uncertain (if any) gains in food safety. Another concern is that there are many different private standard-setting schemes and little harmonisation among them, potentially leading to higher certification costs. Some WTO Members have asked whether there is legal recourse under the SPS Agreement to address these concerns.

The OIE continues to work with private standard-setting organisations to encourage them to take steps to avoid the establishment of standards that conflict with official standards – with a focus on animal health, zoonotic diseases and animal welfare – which could create confusion and increase costs for exporters, especially those in developing countries.

Avoiding and resolving trade differences

Technical assistance

As mentioned previously, the SPS Agreement contains the principle of technical assistance to developing country Members. This is on the basis that helping less developed countries to comply with their obligations under the SPS Agreement can help to improve access to markets and avoid trade differences. The SPS Agreement Article 9 deals with the issue of technical assistance. According to this, WTO Members agree to facilitate the provision of technical assistance to help countries comply with sanitary and phytosanitary measures; such assistance may be in the areas of processing technologies, research andinfrastructures and may take the form of advice, credits, donations, grants (including seeking technical expertise), and providing training and equipment to help countries maintain and expand market access.
The ‘three sisters’ actively collaborate with the WTO in the provision of technical assistance. Relevant training activities include:

- e-training courses on the SPS Agreement – see https://etraining.wto.org/
- national SPS seminars – see G/SPS/GEN/997
- thematic SPS workshops, e.g. the workshop on national coordination, 17–21 October 2011, Geneva

In addition, the OIE actively provides specific capacity building to help countries comply with the obligations of OIE membership. The most important global initiative is the OIE PVS Pathway for strengthening good governance of Veterinary Services and Aquatic Animal Health Services. The PVS Pathway focuses on the elements required for credibility of Veterinary Services/AAHS in terms of issuing certification for animals and products. In many developing countries, certification programmes are not considered to be effective or credible. Problems may arise due to lack of technical capacity, shortages of adequately trained professional staff or failures of governance generally. In many developing countries, the capacity to strengthen programmes for disease diagnosis and reporting in aquatic animals needs to be strengthened, to underpin sustainable development and certification of aquatic animals and their products for trade.

As part of its capacity-building activities, the OIE provides training for Delegates and for Focal Points appointed under the authority of Delegates. At least once every two years, OIE Focal Point seminars are held in each region for each of the seven Focal Point topics (disease reporting; animal welfare; aquatic animals; animal production food safety; wildlife; veterinary products; and communications). Additionally, the OIE provides twinning mechanisms for improving the capacities of diagnostic laboratories and collaborating centres. Based on a similar mechanism, the OIE is developing a mechanism for twinning between veterinary educational establishments in developed and developing countries. The OIE strongly believes that strengthening governance and the capacities of veterinary and aquatic animal health professionals are critical to improving compliance with the SPS Agreement and giving developing countries the opportunity to participate in international trade.

**Resolving trade differences**

The WTO framework provides formal, legally binding mechanisms for resolving trade, based on the formation of a legal panel to hear arguments on the application or non-application by Members of the principles in the SPS Agreement. However, prior to this step, WTO Members have informal mechanisms for raising differences. There is a standing agenda item on bilateral concerns at the SPS Committee meetings, and the Offices of the Chair may be used as an informal approach to the resolution of trade differences.

The OIE has developed a voluntary mediation procedure as a basis for resolving differences between Members. This employs a scientific and technical evaluation, based on the OIE standards. It does not involve formal legal arguments and is less costly. However, the report may be considered confidential to the two parties, unless there is agreement to the contrary, and the outcomes of the procedure are not binding unless the parties formally agree to this.

**Future developments**

The productivity and sustainability of the aquaculture sector is challenged by the emergence of new diseases/syndromes and the need to establish suitable culture conditions, especially for new species. Applied scientific research is needed for this purpose. To access international markets, AAHS must be able to provide credible health certification. In addition to the need to prevent the global spread of aquatic pathogens, certification of the quality and safety of products for human consumption is critical to maintain markets. Loss of consumer confidence, even in the short term, can cause major trade losses – and lost markets can be difficult to regain.

The OIE will continue to implement its standard-setting programme, with a focus on the standards and recommendations needed to underpin safe trade. The OIE and CAC are committed to ongoing collaboration on standards relevant to the entire food production continuum.
The OIE is also taking steps to refine the OIE PVS Pathway to address the specific needs of AAHS where these are not part of Veterinary Services. Definition of the capabilities and educational requirements of aquatic animal health professionals will be an important part of this work.

The OIE will continue to provide input to the SPS Committee as it addresses the issue of private standards. Where appropriate, the OIE will enter into formal arrangements for collaboration with private standard-setting organisations having a global scope, with the objective of preventing the adoption of private standards for health and safety that conflict with the official standards of the OIE and CAC.

While not the subject of OIE standards to date, guidelines on risk management in the context of ‘invasive alien species’ will in future be considered by the OIE in collaboration with the Secretariat of the Convention on Biological Diversity.

Conclusions

The WTO SPS system and the reference standards of the OIE and CAC provide a clear framework for safe international trade in aquatic animals and their products. Application by WTO Members of the official standards set by the ‘three sisters’ is the best way to facilitate trade while managing risks associated with the transmission of animal diseases and foodborne illness.

While the current rapid growth of aquatic animal production is mainly a result of aquaculture development in developing countries, it is an unwelcome fact that these countries often lack the infrastructure and resources needed to meet the official standards applied by developed countries – and they have difficulty therefore in accessing higher value international markets. In many developing countries, the capacity to implement efficient aquatic animal health programmes also needs to be strengthened. The OIE launched the PVS Pathway to help strengthen good governance of Veterinary Services and AAHS, with a particular focus on the control of diseases, transparency and credibility in the issuing of health certification. Support for good governance can be achieved through collaboration among the WTO, the reference standard-setting organisations, such as the OIE, and its international partners (e.g. FAO) and donors. The involvement of regional organisations should also be further developed.

Some of the threats to sustainable expansion of aquaculture must be addressed by applied scientific research, for which the support of governments and donors is needed. Collaboration between the public and private sector is also critical to gaining and maintaining market access.

It is incumbent upon the WTO, the standard-setting organisations, donors and developed countries to provide support to developing countries in meeting the obligations of the SPS Agreement. Not only does this provide a basis for sustainable participation in regional and international markets but it can also help to improve the domestic supply of safe, affordable food, leading to improved food security.

References

The OIE aquatic animal health standards

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Summary
Aquatic animal health is of increasing importance, not least because of expanding worldwide farming of aquatic animals for essential food supply at the local level and for export trade. Disease outbreaks are causing significant losses in aquaculture production throughout the world and are having a major detrimental impact in some countries and regions. Because of this rapid growth in aquaculture worldwide and the disease risks associated with the increasingly globalised trade in live aquatic animals and their products, World Organisation for Animal Health (OIE) activities in the field of aquatic animal health are of relevance to all regions of the world. The OIE prepares standards to help countries prevent, detect and manage outbreaks of listed diseases and to facilitate safe trade in aquatic animals (amphibians, crustaceans, fish and molluscs) and their products. These standards are published in the Aquatic Animal Health Code (Aquatic Code) and the Manual of Diagnostic Tests for Aquatic Animals (Aquatic Manual). The Aquatic Code details health measures to be used by competent authorities of importing and exporting countries to avoid the transfer of agents pathogenic for aquatic animals or humans, while avoiding unjustified sanitary barriers. Criteria to assess ‘safe’ aquatic animal products are provided and each specific disease chapter provides recommendations to prevent the disease in question being introduced into an importing country. The Aquatic Code also provides, among other things, standards for notification of diseases and epidemiological information, handling, disposal and treatment of aquatic animal waste, aquatic animal production food safety, prudent use of antimicrobial agents in veterinary medicine and welfare of farmed fish. The Aquatic Manual provides a uniform approach to the diagnosis of, and surveillance for, the diseases listed in the Aquatic Code, so that disease notification obligations and the requirements for health certification in connection with international trade in aquatic animals and their products can be met. The adoption of the standards in the Aquatic Code and the Aquatic Manual follow the established, democratic procedures of the OIE, involving formal approval by National Delegates of the 178 OIE Members.

Keywords

Introduction
Aquatic animal health is of increasing importance, not least because of expanding worldwide farming of aquatic animals (aquaculture) for essential food supply at the local level and for export trade. Global aquaculture has been experiencing a boom since the mid-1970s, sustaining an average annual growth rate of almost 9% until a recent slight fall-back. Today it continues to expand in almost all regions of the world; it is the fastest growing food animal production sector globally, and there is substantial and increasing international trade in live aquatic animals and their products. However, infectious diseases are causing major production losses in aquaculture in many countries, even having a significant negative impact on some national economies. In some countries, the increase in aquaculture output has been based on species diversification, which has led to an increase in the demand for introduction and transfers of live non-indigenous aquatic animals, some of which have introduced new diseases with them. Evidence, or the belief, that serious diseases of aquatic animals have been, or could be, introduced into their territory from abroad has led some countries to impose strict controls on imports of live aquatic animals and their products. Although national quarantine and health certification requirements for imports are certainly a valid part of national biosecurity measures to prevent introduction of exotic diseases, they must be developed within the context of agreed international standards and should not be used as an unjustified barrier to competitive trade from other countries.
Developing the OIE standards for aquatic animal health

The World Organisation for Animal Health (OIE) provides recommendations for preventing the international spread of animal diseases, and these are the only standards recognised under the Sanitary and Phytosanitary (SPS) Agreement of the World Trade Organization (WTO) for animal health conditions applying to international trade in animals and animal products. The main aim of OIE is to ensure the sanitary safety of international trade in live animals and their products. This includes developing standards and guidelines for health measures to be used by the Aquatic Animal Health Services of importing and exporting countries to prevent the transfer of agents pathogenic for aquatic animals (amphibians, crustaceans, fish and molluscs) while avoiding unjustified trade barriers. These standards are presented in the OIE Aquatic Animal Health Code (Aquatic Code) (1) and the OIE Manual of Diagnostic Tests for Aquatic Animals (Aquatic Manual) (3).

Development of the OIE standards for aquatic animals is a major part of the ongoing work of the Aquatic Animal Health Standards Commission (AAHSC). In 1960, the OIE established the Fish Diseases Commission because of the increasing awareness of the importance of spread of infectious diseases of fish through increasing international trade in fish. In 1988, the scope of the Commission was extended to include diseases and pathogens of molluscs and crustaceans, and in 2003 the Commission was renamed as the Aquatic Animal Health Standards Commission. It is one of the four specialist commissions of OIE formed to study specific problems relating to the epidemiology and control of certain diseases or groups of diseases. Since the first editions of the Aquatic Code and the Aquatic Manual, published in 1995, the Commission has been continuously developing the standards to better meet the need for preventing the spread of aquatic animal diseases through international trade and to increase knowledge and awareness of their occurrence and distribution. Taking account of advances in scientific knowledge, the Commission prepares draft texts for new chapters, or revises existing chapters of the Aquatic Code and the Aquatic Manual with the input of internationally renowned independent experts, OIE ad hoc groups, and the expertise available at the many OIE Reference Laboratories for aquatic animal diseases. In addition, the AAHSC collaborates closely with the OIE Terrestrial Animal Health Standards Commission, on issues needing a harmonised approach in the Terrestrial Code and the Aquatic Code, and with the OIE Biological Standards Commission and the OIE Scientific Commission to ensure consistency of scientific standards in the two Diagnostic Manuals. Drafts of texts to be proposed for adoption are further refined with input from OIE member countries before being presented to, and adopted by, the National Delegates of the 178 OIE Member Countries and Territories (OIE Members) during the meeting of the World Assembly of National Delegates at the OIE General Session in May each year. The adopted text of new and revised Aquatic Code and Aquatic Manual chapters are made publicly available as soon as possible on the OIE website. The updated Aquatic Code is published in book form each year in the three official OIE languages (English, French and Spanish) and also made available electronically on the OIE website under ‘International Standard Setting’. The Aquatic Manual is printed every three years with an annually updated web version also being made available on the OIE website.

Aquatic Animal Health Code

A key objective of the Aquatic Code is to ensure the sanitary safety of international trade in aquatic animals (amphibians, crustaceans, fish and molluscs) and their products. This is achieved through the detailing of health measures to be used by competent authorities of importing and exporting countries to avoid the transfer of OIE-listed diseases of aquatic animals.

The diseases listed by the OIE have all been assessed to meet the Aquatic Code criteria for listing an aquatic animal disease (Article 1.2.1.) or criteria for listing an emerging aquatic animal disease (Article 1.2.2.). The disease list is reviewed annually by the AAHSC, and recommendations for deletions and additions are proposed to OIE Members for adoption. Modifications of this list of aquatic animal diseases are adopted by the OIE General Session in May and the new list comes into force on 1 January of the following year. Currently (2011), there are 26 aquatic animal diseases listed by OIE:

- two diseases of amphibians
- eight diseases of crustaceans
- nine diseases of fish
- seven diseases of molluscs.
Notification and reporting requirements apply to all listed diseases and any new emerging diseases of potential significance to OIE Members. For the purposes of the Aquatic Code, an emerging disease means a newly recognised infection resulting from the evolution or change of an existing pathogenic agent, a known infection spreading to a new geographical area or population, or a previously unrecognised pathogenic agent or disease diagnosed for the first time which has a significant impact on aquatic animal populations or public health.

A key purpose of listing a disease in the Aquatic Code is to ensure transparency of aquatic animal health status worldwide, by obliging Members to report its occurrence to OIE according to the rules stipulated in Section 1 of the Aquatic Code. In this context, it is important to understand that the circumstances for regular as well as immediate notification of aquatic animal diseases do not require the presence of clinical disease or mortality. The Aquatic Code clarifies, in Article 1.1.2.4, that the presence of an infectious agent, even in the absence of clinical disease, should be reported to OIE. The OIE collates and disseminates all the information received in alerts and reports on the status of those listed diseases in Member Countries.

OIE standards for import requirements are given in Section 5 of the Aquatic Code. These include standards for trade measures, importation/exportation procedures and health certification, specifically in chapters dealing with:

- general obligations related to certification
- certification procedures
- criteria to assess the safety of aquatic animal commodities
- control of aquatic animal health risks associated with transport of aquatic animals
- aquatic animal health measures applicable before and at departure
- aquatic animal health measures applicable during transit from the place of departure in the exporting country to the place of arrival in the importing country
- frontier posts in the importing country
- aquatic animal health measures applicable on arrival
- measures concerning international transport of aquatic animal pathogens and pathological material
- model health certificates for international trade in live aquatic animals and products of aquatic animal origin.

The standards and guidelines in the Aquatic Code are not only for live aquatic animals but are also for products derived from aquatic animals. Recently, criteria have been developed for assessing the safety, from an aquatic animal health perspective, of aquatic animal commodities in international trade. These criteria provide a means for assessing the safety of aquatic animal commodities irrespective of the country’s aquatic animal disease status. One set of criteria deal with the safety of aquatic animal commodities based either on the absence of the aquatic animal disease agent in the traded commodity or on the inactivation of the agent by processing the product. A second set of criteria deal with the safety of aquatic animal products destined for human consumption and are based on the expected volume of waste and absence of the pathogen in the waste tissue, as discarded (waste) tissues are an important pathway for exposure of susceptible aquatic animals to pathogens, if such are present in the imported aquatic animal product. These criteria are applied by the AAHSC for providing guidance for each of the listed diseases in the Aquatic Code as to which, if any, commodities of aquatic animals can be considered as safe for import without health guarantees for a particular disease in the country of origin. It is recommended that other imported commodities should be subject to the OIE health certification standards.

There is also a risk that disease may be introduced to a country or other epidemiological unit as a result of the accidental release of aquatic animal pathogens during or after international transport of packaged materials. Such pathogens may have been imported deliberately or inadvertently. It is therefore necessary to have in place measures to prevent their accidental release. These measures may be applied at national borders by prohibiting or controlling the importation of specified aquatic animal pathogens or pathological material, which may contain them. The Aquatic Code provides detailed guidelines on how such material should be handled, packaged and transported to prevent accidental release.

Each specific disease chapter in the Aquatic Code includes recommendations to prevent the disease being introduced into the importing country through importation of aquatic animals or their products and provides the following key information and guidance:

- definition of the pathogen/disease
- list of susceptible aquatic animal species
- what are ‘safe’ commodities (irrespective of disease status of the source country)
- how to determine the status of a country, zone or compartment
conditions to apply to importations of aquatic animals and products from a country, zone or compartment declared free, or not declared free, of the disease.

The Aquatic Code also provides standards for handling, disposal and treatment of aquatic animal waste, control of hazards in aquatic animal feeds, prudent use of antimicrobial agents in veterinary medicine and the welfare of farmed fish during transport, stunning and killing. Guidance is provided for notification of diseases and epidemiological information, aquatic animal health surveillance, import risk analysis and the quality of aquatic animal health services. General recommendations are provided for disease prevention and control, including zoning and compartmentalisation, disinfection, falling of aquaculture units, contingency planning and import risk analysis.

A major value of the Aquatic Code (and the Aquatic Manual) is that the standards and recommendations published in them are the result of wide consultation and eventual consensus among the competent authorities of OIE Members.

Manual of Diagnostic Tests for Aquatic Animals

The Aquatic Manual provides a uniform approach to the diagnosis of, and surveillance for, the diseases listed in the Aquatic Code, so that disease notification obligations and the requirements for health certification in connection with international trade in aquatic animals and aquatic animal products can be met. The Aquatic Manual describes diagnostic laboratory methods that are suitable for the detection of disease as part of a national aquatic animal health surveillance/control programme to determine the health status for a country, zone or compartment for a specified disease, or as part of a programme to underpin claims of freedom from a specific disease. Although many publications exist on the detection and identification of the pathogenic agents of aquatic animal diseases, the Aquatic Manual is unique in describing the methods that can be applied to the OIE-listed diseases in aquatic animal health laboratories throughout the world, thereby increasing the credibility of diagnostic test results and increasing confidence in disease surveillance findings. All the chapters are prepared by invited experts and subjected to external peer review by recognised international experts for the disease(s) in question prior to consultation with all OIE Members in the process leading to adoption. The current printed edition was published in September 2009 (3) and the next printed edition will be in 2012. Between the printed editions, amendments are made on an annual basis to the web version on the OIE website, which is therefore always the most up-to-date version of the Aquatic Manual, currently the 2011 edition. The ultimate objective of the Aquatic Manual is to facilitate international trade in aquatic animals and their products by ensuring harmonisation of diagnostic testing, avoiding differences in the interpretation of results, ensuring the quality of diagnostic tests and improving aquatic animal health worldwide.

Introductory chapters are provided on quality management in veterinary testing laboratories, principles and methods of validation of diagnostic assays for infectious diseases, and methods for disinfection of aquaculture establishments. These are followed by chapters providing general information on sampling, the reagents for isolation and identification of the pathogens and key references for further reading. Disease-specific chapters provide an up-to-date review of the key characteristics of the disease and its aetiological agent and detailed descriptions of the recommended methods applicable to each of the listed diseases of amphibians, crustaceans, fish and molluscs. Information is given on agent factors, host factors, the disease pattern and methods for control and prevention. Recommendations on sampling include selection of individual specimens, preservation of samples for submission, pooling of samples, test organs or tissues and samples/tissues that are not suitable for testing.

Descriptions are given of the recommended field diagnostic methods, clinical methods and agent detection and identification methods.

In each disease-specific chapter, there is also a rating of tests against purpose of use. This information is used to determine which test is appropriate for what purpose, e.g. a particular method may be highly suitable for diagnosing clinical cases of disease in individual animals of a certain age group, but the same method may be unsuitable for assessing the infection status of large numbers of clinically healthy animals. Each specific disease chapter includes a table comparing different methods for targeted surveillance and diagnosis of the disease as an assessment of a test’s ‘fitness for purpose’. The rating of the different diagnostic methods is somewhat subjective as suitability involves issues of reliability, sensitivity, specificity and utility. Although not all of the tests listed as category a (the recommended method) or category b (a standard method) have undergone formal standardisation and validation, their routine nature and the fact that they have been used widely without dubious results, makes them acceptable.
An explanation is given of the test(s) recommended for targeted surveillance to declare freedom from the disease in question as outlined in the Aquatic Code, based on the information provided in the disease-specific chapter and the tests assessed for ‘fitness of purpose’. Corroborative diagnostic criteria provide a definition of ‘suspect case’ and a definition of ‘confirmed case’. For example, a certain level of mortality at the right time of the year in susceptible animals, together with matching clinical signs, tissue lesions and histopathology, could be sufficient for suspicion of the disease. A confirmed case could be defined whereby, in addition to the above, the agent has been detected. However, detection of viable agents without any clinical signs could also constitute a confirmed case. This information is required for the purpose of disease investigations, especially in cases in which ‘disease-free’ status is threatened, and when surveillance of healthy populations yields controversial results, e.g. positive PCR (polymerase chain reaction) signals in the absence of any other evidence of infection.

The OIE standards for aquatic animal health surveillance are described in Chapter 1.4 of the Aquatic Code, and are supplemented by the OIE Guide for Aquatic Animal Health Surveillance (2), which provides detailed guidance on surveillance principles and practice, with full scientific explanation.

**Concluding remarks**

Due to the rapid global growth in aquaculture and the disease risks associated with the burgeoning international trade in live aquatic animals and their products, OIE activities in the field of aquatic animal health are of increasing importance. There are clear risks of the emergence and spread of aquatic animal diseases through this international trade, not least because some of the trade is insufficiently regulated by trading countries in terms of health safeguards. The OIE standards and guidelines in the Aquatic Code and Aquatic Manual provide a sound, and internationally agreed, base for the development of national measures for ensuring that importation or exportation of live amphibians, crustaceans, fish and molluscs, and their products, do not present an unacceptable risk of disease incursion into a country or other epidemiological unit. A major strength of the Aquatic Code and Aquatic Manual is that the standards, guidance and recommendations published in them are the outcome of wide consultation and eventual consensus among the competent authorities of OIE Members. All that is needed to mitigate the risk of disease introduction and major epizootics is for national governments, international regulators and traders to apply them effectively.

**References**

Heath standards: commodity-based approach

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Summary
Globally there is an increasing production of and trade in aquatic animal products. The volume of trade in aquatic animal products is significantly larger than that in live aquatic animals. The OIE Ad hoc Group on Safety of Products Derived from Aquatic Animals (AHG) has developed recommendations for the inclusion of two categories of products in disease-specific chapters of the Aquatic Animal Health Code: (i) products that can be traded irrespective of country disease status; and (ii) products destined for human consumption. The AHG developed criteria for assessing the safety of products, based on the absence of the disease agent in the traded commodity or inactivation of the disease agent by processing. A second set of criteria was developed to assess the safety of aquatic animal products destined for human consumption, based on the expected volume of waste and absence of the pathogenic agent in the waste tissue. Assessments were performed on products known to be internationally traded. There is a wide diversity in the types of aquatic animal products and species they are derived from. While the OIE definition for commodities includes live animals of all life forms, assessments focused on non-viable products derived from aquatic animals. Assessments were performed on available scientific information, using, in several instances, proxies to assess how safe the product might be. The assumptions used in the two sets of criteria are provided. It is of particular importance to stress that provisions relevant to ‘safe commodities’ are no ‘carte blanche’ for irresponsible trade: they must apply in the full context of the OIE Aquatic Code.

Keywords

Introduction

The global trade in aquatic animals and aquatic animal products has significantly increased over the past two decades, and they have become the world’s most traded food commodities (5). The volume of trade in aquatic animal products is significantly larger than that in live aquatic animals.

 Movements of live aquatic animals are usually considered to carry a high likelihood of pathogenic agent spread. Similarly, trade in animal products is also a recognised risk for the spread of aquatic animal pathogens. For example, pilchard herpesvirus is thought to have been introduced to Australia through the import of frozen pilchards for tuna feed (2); similarly, white spot syndrome virus is likely to have reached the USA in frozen shrimp (3).

A number of risk assessments have been undertaken for aquatic animal pathogens (4). However, import risk assessment can be expensive and time consuming and the required expertise may not be available in the importing country. Recognising the global importance of trade in aquatic animal products, especially to developing countries, the OIE established an Ad hoc Group on Safety of Products Derived from Aquatic Animals (AHG) with the objective of refining existing standards and developing new standards that facilitate safe trade in products derived from aquatic animals. Recommendations of the AHG called for the inclusion of two categories of products in disease-specific chapters of the Aquatic Animal Health Code (Aquatic Code):

1. products that can be traded irrespective of country disease status
2. products destined for human consumption.
Materials and methods

The AHG developed criteria for assessing the safety of aquatic animal products, based on the absence of the pathogenic agent in the traded commodity or inactivation of the pathogenic agent by processing. The criteria recognised that some internationally traded commodities may not contain any viable pathogen agent due to the type of processing the product was subjected to in the exporting country. (A good example of this is heat sterilised, hermetically sealed products, such as canned products, in which the temperatures applied during processing are considered sufficient to inactivate all known aquatic animal pathogens). Additionally, where the tissue tropism of the pathogen is restricted and well documented, it is possible to identify products that are produced from the tissues that are unaffected by the pathogenic agent.

A second set of criteria was developed to assess the safety of aquatic animal products destined for human consumption, based on the expected volume of waste and absence of the pathogen in the waste tissue. These criteria reflected the fact that products imported for the retail trade for human consumption are less likely to be re-processed in the importing country (especially if packed in consumer-ready packages), leading to a decreased likelihood that the product would be diverted in use. However, such products were not considered to carry a negligible risk per se. The level of risk was considered to depend on the amount of waste that may be generated and whether the pathogen may be present in such waste. Where little or no waste is generated, a product could be considered to carry a negligible level of risk, even if the tissues of the traded product did contain the pathogen.

These considerations were developed into a new chapter in the OIE Aquatic Code, Chapter 5.3 ‘Criteria to assess the safety of aquatic animal commodities’.

Assessments were performed by the AHG of products known to be internationally traded.

Results and discussion

The AHG developed clear criteria for assessing the inclusion of aquatic animal products in the lists of commodities in the Aquatic Code that do not require any disease-related measures by importing countries and assessed commonly traded commodities against these criteria.

While the OIE definition for commodities includes live animals of all life forms, assessments focused on non-viable products derived from aquatic animals: for human consumption, for aquatic animal feed and for other purposes (e.g. leather produced from fish skin).

There is a wide diversity in the types of aquatic animal products traded and the species they are derived from. The assessment of commodities was limited to the assessment of aquatic animals and aquatic animal products: (i) for any purpose; and (ii) prepared and packaged for retail trade for human consumption, from a country, zone or compartment not declared free from disease X. Internationally traded commodities are used for a wide range of purposes and it could be envisaged that criteria for the assessment of the safety of commodities for other purposes could be developed.

One of the difficulties encountered was the lack of available published industry standards for the processing of many aquatic animal products. Processes for industry standards (perhaps as minimum standards) would be useful for the purpose of import risk assessment, in particular heat treatments, such as cooking and pasteurisation. The duration of a given temperature treatment is in most cases relevant to the effect on the given pathogenic agent. To overcome this problem, the temperature treatment considered was specified in the commodity definition.

Assessments were performed using available scientific information. In several instances, proxy was used to assess the safety of the product. In many cases, a clear rationale for safety was lacking, suggesting areas for further research.

The AHG included assumptions in the two sets of criteria, assumed to be fulfilled prior to assessing products. Those assumptions also apply to the relevant articles in the Aquatic Code.

In this exercise, consideration was restricted to diseases listed by the OIE, as the Aquatic Code details measures only for the listed diseases. In any situation in which a novel pathogen has not previously been recognised, there is the potential for international spread.

It is believed that this approach to assessing risk from a commodity-based perspective, producing a list of products regarded as safe to trade, will provide increased trading opportunities for OIE Members, in particular developing
countries. Of particular importance, provisions in the two relevant articles are no ‘carte blanche’ for irresponsible trade. They must apply in the full context of the OIE Aquatic Code.

Acknowledgements

The author wishes to acknowledge the members of the OIE Ad hoc Group on Safety of Products Derived from Aquatic Animals, B. Oidtmann, C. Johnston, K. Klotins, G. Mylrea, P.T. Van, S. Cabot, P.R. Martin and L. Ababouch, for their contributions to this work.

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Aquatic animal disease reporting: ensuring transparency

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Summary

The World Animal Health Information System (WAHIS), an Internet-based computer system, enables OIE Members to process data on animal diseases and inform the international community of relevant epidemiological events and developments for over 100 animal diseases, including 26 aquatic animal diseases. The information generated is available through the World Animal Health Information Database (WAHID) Interface.

For diseases reported present during a given 6-month period, countries can provide quantitative data on number of outbreaks, mortality and morbidity rates and/or number of affected animals. For diseases that are present and notifiable within a country, the OIE recommends that the country provide quantitative data by month and by first administrative division, which is the most detailed quantitative data that the system can process. Before the launch of the OIE notification system in 2005, information on aquatic animal diseases was only collected annually. The forthcoming new version of WAHIS will separate the 6-monthly report for aquatic animal diseases from terrestrial animal diseases. In 2009, 114 countries reported aquatic animal diseases and even more are expected to do so as a result of these improvements.

The OIE’s tracking procedure for non-official animal disease information has also improved transparency, with an average of two additional immediate notifications of aquatic animal diseases being received each year. In 2010, six countries agreed to correct their historical data on aquatic animal diseases thanks to this tracking activity.

Since 2004, the OIE has developed the WAHIS Regional Core Strategy, to help OIE Members meet their regional requirements and their obligations to notify diseases to the OIE, while avoiding duplication. For aquatic animal diseases, the Network of Aquaculture Centres in Asia–Pacific (NACA), the OIE Regional Representation for Asia and the Pacific and the OIE Headquarters have embarked on developing a Regional Core to enable OIE/NACA Members to provide and share more information than that required by the OIE for OIE-listed diseases, especially data on aquatic animal diseases of regional importance. This will further improve transparency and knowledge and the efficiency of data collection on aquatic animal diseases in the region and improve knowledge of the aquatic animal health situation worldwide.

Keywords

The World Animal Health Information System (WAHIS)

The World Animal Health Information System is an Internet-based computer system, launched in 2005, that enables OIE Members to process data on animal diseases and enables system administrators to inform the international community, via alert messages, of relevant epidemiological events in OIE Member Countries and changes in the animal health situation relating to more than 100 animal diseases, including 26 aquatic animal diseases. Information generated by the system is available through the World Animal Health Information Database (WAHID) Interface.

Access to this secure site is available only to authorised users, namely OIE Delegates and their authorised representatives, who are generally in charge of epidemiological units and use WAHIS to notify the OIE, under the Delegate’s authority, of any relevant animal disease information. Whenever an important epidemiological event is confirmed, the Member Country concerned must inform the OIE within the following 24 hours by providing an immediate notification report, stating the reason for the notification, the name of the disease, the species affected, the geographical area, the control measures applied and any laboratory tests carried out or in progress.
To improve the scope and efficiency of the OIE’s early warning system, Members should immediately notify to OIE Headquarters any of the following events of epidemiological significance, including those relating to aquatic animals:

- the first occurrence or the reoccurrence of an OIE-listed disease in a country or zone/compartment of the country previously considered to be free of the disease
- any occurrence of an OIE-listed disease in a new host species
- any occurrence of an OIE-listed disease caused by a new strain of the pathogen or in a new disease manifestation
- any occurrence of an OIE-listed disease, if the disease has newly recognised zoonotic potential
- any occurrence of an emerging disease or pathogenic agent if the event is of epidemiological significance to other countries.

As soon as immediate notifications have been received, verified and validated by the OIE, they are published in the OIE’s three official working languages (English, French and Spanish) and are electronically distributed to OIE Delegates and to the subscribers to ‘OIE-Info’, the OIE open distribution list. Members that have informed the OIE of a significant epidemiological event using an immediate notification report must then provide follow-up reports on a weekly basis so that the event can be monitored as it evolves. In all cases, the country must submit a final report indicating either that the event has been resolved or that the disease has become endemic. In the latter case, the country will continue to submit information in its 6-monthly reports if the disease is an OIE-listed disease.

Six-monthly reports provide information on the presence or absence of OIE-listed diseases and the prevention and control measures currently applied or those that would be applied if the disease were to occur in the country. For diseases reported to have been present during a given 6-month period, countries must provide quantitative data on the number of outbreaks, the mortality and morbidity rates and/or the number of affected animals. The number of susceptible animals, cases, deaths, animals destroyed and animals vaccinated can be given in kilograms, tonnes or number of animals. For diseases that are present and are notifiable within a given country, the OIE recommends that the country provide quantitative data by month and by first administrative division, which is the most detailed quantitative data the system can collect. Before the launch of the new OIE notification system in 2005, aquatic animal diseases were included on the former list B of diseases and only annual information was collected. Since 2009, WAHIS has included the possibility of differentiating between disease events in domestic and wild species, both by using different occurrence codes and through disease maps that use different icons for domestic and wildlife outbreaks.

As a complement to WAHIS, the data and information provided by Members are accessible via the Web interface WAHID and can be accessed by the public through the OIE website (www.oie.int/wahid). This unique application improves the transparency, efficacy and rapidity of the dissemination of animal health information throughout the world by giving everyone access to all the available information on terrestrial and aquatic animal diseases, including zoonoses, presented by country/territory, by region, by month, by 6-month period or by year. This interface gives access to a range of other information, including data on animal populations at a national or regional level, epidemiological maps of significant disease events, world distribution maps of animal diseases and disease control methods.

A second version of WAHIS will be launched soon, incorporating significant improvements in the field of disease notification. In this new version, the 6-monthly report for aquatic animal diseases will be completely separate from the 6-monthly report for terrestrial animal diseases. This means that Members will no longer have to wait for missing data on terrestrial animal diseases before submitting their report on aquatic animal diseases, and vice versa, and for the same reason will help to avoid the submission of incomplete reports.

These improvements will increase still further the already increasing number of Members providing information on aquatic animal diseases. There has been an increase in the number of animal health annual reports since the launch of WAHIS. In 2009, 170 countries provided an annual health report on OIE-listed diseases and 116 (68.2%) of these reports covered both terrestrial and aquatic animal diseases (see Fig. 1). In 2010, up to 23 June 2011, 150 Members provided an annual health report and 118 (78.7%) of these covered both terrestrial and aquatic animal diseases.

To increase the efficiency of WAHIS and improve our knowledge of the world animal health situation, including that in aquatic animals, in 2002 the OIE introduced an active search procedure with the aim of tracking non-official information and rumours on animal health, including zoonotic diseases in humans. Information obtained from various sources is evaluated in the context of the animal health situation in the country or region concerned and, if
On average, two immediate notifications relating to aquatic animal diseases are obtained each year, thanks to this tracking procedure. In addition, the procedure has brought to light a number of discrepancies between information published in scientific papers and the historical data reported to the OIE. In 2010, for instance, six countries agreed to correct their historical data on aquatic animal diseases, thanks to information obtained via the tracking activity.

**OIE strategy for regional information systems to improve transparency and efficiency: the example of the OIE/NACA Regional Core**

The OIE has developed a strategy to enable OIE Members to meet their regional requirements and at the same time fulfill their obligation to notify diseases to the OIE, while avoiding unnecessary duplication. For aquatic animal diseases, the Network of Aquaculture Centres in Asia–Pacific (NACA), the OIE Regional Representation for Asia and the Pacific and the OIE Headquarters have embarked on the creation of the OIE/NACA WAHIS Regional Core to enable OIE/NACA Members to provide and share information additional to that required by the OIE (on OIE-listed aquatic animal diseases) by also including data on diseases of special interest to the region. The collected data will be available for analysis at the regional level, and information will be available on the websites of the OIE Regional Representation for Asia and the Pacific and NACA.

The establishment of the OIE/NACA Regional Core will further improve the transparency and efficiency of data collection on aquatic animal health in the Asia–Pacific region, a region known for its substantial contribution to world aquatic animal production, and it will certainly enhance our knowledge of the health situation in aquatic animals worldwide.

**Conclusions**

There has been increasing interest in aquatic diseases on the part of the OIE. The establishment by the OIE in 2005 of a single list of diseases has been beneficial for aquatic animal disease reporting, as specific forms were designed for the immediate notification and follow-up reports. Since 2005, monthly information on animal diseases...
has been provided, compared with annual information without geographical location before 2005. There is better worldwide coverage of aquatic animal diseases/health globally, as shown by the immediate notifications and annual animal health reports on OIE-listed aquatic animal diseases. The establishment of the OIE/NACA Regional Core will avoid duplication of data processing by participating Members and improve the quality of animal health information provided by Members in the Asia–Pacific region, which will contribute to better worldwide coverage of aquatic animal diseases in WAHID.
Aquaculture and issues of sustainability

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Summary

Aquaculture sustainability is defined in terms of both ‘strong’ and ‘weak’ approaches, and the relevance of this dichotomy is explained with regard to sustainable market opportunities and global food security. Identifying useful boundaries for assessing sustainability is a challenge. Global value chains link production and consumption of farmed seafood across continents, and a growing international trade increasingly substitutes for diminishing and inconsistent supplies from wild stocks. Several factors challenge the sustainability of aquaculture in tandem with its rapid rise to importance in supporting aquatic food security.

Modern commercial aquaculture systems remain relatively open to their immediate environments and, as they are resource intensive, are increasingly dependent on distant sources of feed and other inputs. The openness or porosity of production systems raises issues of both exclusion of pathogen and impacts on biodiversity. A key issue is the level to which isolation from the ‘environment’ is possible or desirable. Strategies to manage interactions to achieve a balance among the needs of the production system, the species farmed and the integrity of the environments that support them are presented and discussed. Pressures on water and land resources are both forcing intensification and stimulating integration, although these may be contradictory approaches.

Tracing sustained seafood supplies to the availability of basic nutrients and energy suggest the vulnerability of emerging aquatic food production systems. The challenges of meeting energy and nutrient needs in the coming decades will stimulate the emergence of ever more efficient systems, but competitiveness with other sectors of food production will be critical.

The EC FP7 research project SEAT (Sustaining Ethical Aquaculture Trade) uses life cycle analysis as a core tool to assess the broader impacts of aquaculture on the global environment, allied to detailed modelling of local environmental impacts. In addition, aspects of particular importance, such as water use and social and economic impacts, require assessment both local to production and along the value chain. The ethical dimensions and contradictions of Asian production systems based on trade with Europe are considered.

Keywords
The role of OIE aquatic animal health programmes in promoting food security in Africa

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Summary
In Africa, nearly 10 million people depend on fishing, fish farming, fish processing and trading fish. Fishing produces 7.3 million tonnes of fish per year, more than 90% of it caught by small-scale fishermen. Fish provides the main source of protein for the majority of Africans, and yet fish consumption per capita in sub-Saharan Africa is the lowest in the world. This may be associated with population growth, to over 1 billion, and increased demand from an expanding affluent urban population and rural communities. Fish also provides exports worth some US$2.7 billion annually.

In recent years a decline in marine fisheries and a steady increase in aquaculture production have been noted. Despite its enormous potential, the sub-Saharan region remains a minor player in the field of aquaculture. There are encouraging signs in the continent from Nigeria, which is the leader in terms of catfish aquaculture production, tilapia and other freshwater fishes, black tiger shrimp in Madagascar, production of niche species such as abalone in South Africa, and tilapia production in Egypt, Uganda and Kenya. Most fisheries and aquaculture in Africa is based on its lakes, rivers and inland waters, hence the burden of OIE-listed diseases is not enormous. However, the region has witnessed damaging outbreaks of epizootic ulcerative syndrome in the Zambezi river basin and koi herpesvirus in South Africa.

The aquatic animal health programmes, including disease diagnosis, surveillance, notification and certification of aquatic animals and their products have given impetus to enhanced trade in aquatic commodities, leading to a dramatic increase in people employed in the fish production and processing sectors and to increased revenue to developing countries in Africa.

Keywords

Introduction
The contribution of aquaculture to global supplies of fish, crustaceans, molluscs and other aquatic animals continues to grow, increasing from 3.9% of total production by weight in 1970 to over 25.7% in 2000 and 37.1% in 2009. Aquaculture continues to grow more rapidly than all other animal food-producing sectors. Worldwide, the sector has grown at an average rate of 8.1% per year since 1970 compared with only 0.9% for capture fisheries and 2.7% for terrestrial farmed meat production systems over the same period (1).

The sub-Saharan region continues to be a minor player in aquaculture production despite its natural potential. Even aquaculture of tilapia, which is native to the continent, has not developed significantly. This has been associated with a number of factors, including a lack of appropriate technologies, policies to stimulate production and investment in the sector by national governments (1).

Fish consumption has undergone major changes in the past four decades. Globally, fish consumption per person per year has been increasing steadily from an average of 9.9 kg in the 1960s to 17.0 kg in 2007. Fish and seafood consumption varies greatly between different regions of the world, with local averages ranging from 1 kg to more than 100 kg per person per year. Consumption figures in Africa remain the lowest (8.3 million tonnes, with 8.5 kg per capita) compared with other regions (1).
Importance of aquaculture in Africa

The contribution of sub-Saharan Africa to global aquaculture production remains very small but is increasing significantly. Between 1998 and 2008 there was a five-fold increase in production from 42,587 to 238,877 tonnes. The average percentage rate (APR) was 18.8% for the period. This was due to the emergence and intensification of private sector-led small- and medium-sized enterprises and the expansion of large commercial ventures, stimulated in some cases by growing public support and the inflow of foreign capital and expertise (3).

Agriculture in the broad sense plays a dominant role in most African economies as an important source of livelihood. The role of aquaculture as a major contributor to livelihood in all but few countries, e.g. Egypt, Nigeria, Uganda, Madagascar and Mozambique, is still very small. There is great potential for aquaculture to play a significant role in food and nutrition security, employment and wealth generation for both small- and large-scale producers in both rural and peri-urban localities, as has been exemplified in few countries. There is therefore need to increase production if the population of Africa is to be fed.

Africa’s population exceeded 1 billion in mid-2009, and, growing by 24 million per year, it is expected to double by 2050. This is true despite the ravages of disease, conflict and malnutrition, which claim many lives per year. The population of Northern Africa is estimated to be 205 million, Western Africa 297 million, Eastern Africa 313 million, Central Africa 125 million and Southern Africa 58 million (UN-DESA 2009). Over 15% of the continent’s population is in Nigeria, the eighth most populous nation in the world, which has an average growth rate of 2.3%.

Important developments regarding aquaculture

The new Partnership for African Development (NEPAD) has created new awareness through the Fish for All conference in Abuja. At this meeting African heads of state meeting in Abuja, Nigeria, in 2005 agreed to promote and protect fisheries and aquaculture as strategic commodities alongside rice, maize and other strategic products and committed themselves towards attaining continental self-reliance on fish by 2015.

Dynamic producer organisations have formed in various areas, and regional networks have been set up, e.g. Aquaculture Network for Africa (ANAF) and Sustainable Aquaculture Research Networks in Sub-Saharan Africa (SARNISA), and these contribute to the flow of information and better exchanges of experience and catalyse aquaculture development. Several governments are adopting such networks, not specific to aquaculture but still having spill-over effects on the sector. This is reflected in growing public support for aquaculture in regions and countries such as East Africa–Uganda, Madagascar and Mozambique. Specifically, Uganda has gazetted areas within the country to promote aquaculture.

The Food and Agriculture Organization of the United Nations (FAO) has come up with a special programme for aquaculture development in Africa: Special Programme for Aquaculture Development in Africa (SPADA), which along with NEPAD’S Action Plan for the Development of African Fisheries and Aquaculture is expected to contribute to the foreseen expansion of the sector in the next decade. The World Fish Centre has increased its presence on the continent in terms of staff numbers and disciplines as well as geographical coverage. These initiatives will benefit Africans if they are owned by African politicians and governments.

Farming systems and production

Excluding Egypt, 93.4 % of fishery production in Africa is derived predominantly from freshwater fish, and in particular indigenous and ubiquitous species of tilapias and African catfishes (Table I). Brackish water aquaculture and marine fish culture, as well as the culture of crustaceans and molluscs, date back no more than 20–30 years, and production is concentrated in a few countries, while the culture of marine algae is a recent innovation.
Food safety and aquatic animal health

This is an area that has not received wide attention in the African region. However, several countries have in place standard sanitary operations processes (SSOP) and hazard and critical control point (HACCP) programmes, developed in a framework of capture fisheries, but very few countries have aquaculture-specific facilities. Some countries are working to meet European Union (EU) guidelines and regulations on safety and quality control, which are essential for their emerging export market. Major exporting countries (Mozambique, Madagascar, South Africa), as well as a number of other countries, are also aware that biosecurity and aquaculture animal health management are critical and essential requirements for the sustainability of the industry. They are taking steps to address the issue. Interest in risk analysis and biosecurity has increased in several countries.

**Epizootic ulcerative syndrome**

Epizootic ulcerative syndrome (EUS) is a seasonal epizootic condition of great importance in wild and farmed fresh and brackish water fish. It is now considered to be indistinguishable from red spot disease, which was first observed in eastern Australia in 1972, and from mycotic granulomatosis, which was first reported in Japan in 1971 (Epizootic Ulcerative Syndrome [EUS], World Organisation for Animal Health (OIE) Manual of Diagnostic Tests for Aquatic Animals). Epizootic ulcerative syndrome has now extended its range through Papua New Guinea into South East Asia and South Asia and Pakistan. More recently, it has been reported in several African countries in the Zambezi river basin and in South Africa.

The causative agent of EUS is the fungus *Apharomyces invaderis*, which causes severe liquifactive necrosis of muscle tissue as it invades the body, and sometimes the hyphae extend into visceral organs. Infected fish usually suffer from severe bacterial septicaemia involving a range of opportunistic pathogens. The fungus, by itself, cannot normally invade fish, and it is postulated that some cofactor, such as epidermal damage, severe environmental stress or viral infection, is required to initiate this complex and exceedingly important condition.

The initial sign of the disease is usually mass mortality associated with distinct dermal lesions, including ulcers. Surviving fish typically have lesions of varying severity. These may appear as red spots, blackish burn-like marks or deeper ulcers with red centres and white rims. In some fish that survive for a long time, the ulcers may erode so deeply as to expose the vertebrae, brain and viscera. Histological occurrences include necrotising, granulomatous dermatitis and myositis associated with invasive, non-septate fungal hyphae, 10–20 mm in diameter.

### Table I: Top 10 aquaculture producers of food fish in Africa: quantity and growth rate, 2009

<table>
<thead>
<tr>
<th>Country</th>
<th>Production (tonnes), 2009</th>
<th>Average annual rate of growth (%) 2007–2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egypt</td>
<td>705,500</td>
<td>5.4</td>
</tr>
<tr>
<td>Nigeria</td>
<td>152,796</td>
<td>34.0</td>
</tr>
<tr>
<td>Uganda</td>
<td>76,654</td>
<td>22.5</td>
</tr>
<tr>
<td>Zambia</td>
<td>8,505</td>
<td>20.3</td>
</tr>
<tr>
<td>Ghana</td>
<td>7,154</td>
<td>36.9</td>
</tr>
<tr>
<td>Madagascar</td>
<td>6,096</td>
<td>−26.5</td>
</tr>
<tr>
<td>Kenya</td>
<td>4,895</td>
<td>7.5</td>
</tr>
<tr>
<td>Tunisia</td>
<td>4,214</td>
<td>11.9</td>
</tr>
<tr>
<td>South Africa</td>
<td>3,433</td>
<td>13.4</td>
</tr>
<tr>
<td>Democratic Republic of the Congo</td>
<td>2,970</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Source: FAO FishStat+ database

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The current state of play: aquatic animal health programmes globally and regionally  

Session 1  

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OIE Global Conference on Aquatic Animal Health
The disease is generally diagnosed based on clinical signs and histopathology. In the laboratory, the fungus has also been shown to be pathogenic to a wide range of fish, inducing similar pathology and mortality under various predisposing experimental conditions.

Epizootic ulcerative syndrome is an OIE-listed disease with important implications for international trade, and countries in which it occurs are required to notify the OIE of its presence. The disease first began to appear in the Chobe and Upper Zambezi rivers in 2006–2007 (Fig. 1). This was its first appearance in Africa. Later the disease was reported in Zambia, Botswana and Namibia, and in 2011 it was reported from western Cape Province of South Africa.

In July 2009, the FAO warned about the spread of this disease up- and downstream in the Zambezi river. The disease threatens the livelihoods of more than 32 million people in seven countries of Angola, Botswana, Malawi, Mozambique, Namibia, Zambia and Zimbabwe and threatens more than 200 species of fish in the Zambezi river basin.

**The role of OIE**

The main role of the OIE is to ensure the sanitary safety of the international trade in live aquatic animals and their products. This is achieved by providing guidelines on the health measures to be used by the competent authorities of importing and exporting countries to prevent the transfer of agents pathogenic for aquatic animals, while avoiding unjustified trade barriers.

The guidelines provided by the OIE include:

- notification of disease outbreaks and epidemiological information
- obligations and ethics in international trade
- risk analysis
- import and export procedures
- specific disease information
- aquatic animal health surveillance
- certification procedures
- aquatic welfare issues
- disease diagnosis.

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**Fig. 1** Zambezi–Chobe river basin: an area where there has been a recent outbreak of epizootic ulcerative syndrome. Adapted from FAO Regional Review on Aquaculture in Africa (2), courtesy of Melba Reantaso.
These guidelines have been applied in Africa in various forms. Of particular importance are disease diagnosis, surveillance and biosecurity.

With regard to Africa and EUS in particular, the capacity to diagnose the disease has been developed at the Veterinary School in Zambia. This is through yet another programme run by the OIE called twinning, whereby a laboratory in a developing country is twinned with a Reference Laboratory for a particular disease to train personnel in the developing country. Through this arrangement, capacity is being developed by twinning with the EUS Reference Laboratory in Bangkok, Thailand.

Through joint training efforts with FAO, biosecurity measures to contain the disease have been put in place. Surveillance along the Zambezi river is ongoing, and data are being collected about the status of the disease. The OIE has been involved in training Aquatic Animal Focal Points. These are individuals working in the fisheries sector who are generally responsible for day-to-day management of fisheries issues in their countries. The concept of Focal Points/persons was born out of the realisation that, in many countries, the responsibility for aquatic animals does not lie within the mandate of the Veterinary Authority.

**Producing for the market**

There is an expanding intra- and inter-regional trade. Processed catfish from Uganda is exported to Congo, Kenya and Sudan, as well as to the EU. The EU makes sure that standards are met before it will import these commodities. The value of marine products exported comprises 95% of the total maritime revenue of the target countries (Madagascar, Mozambique, South Africa and Tanzania) and 33% of the total aquaculture products of the region. There is increased interest in catfish aquaculture for both local consumption and export.

Tunisia, Morocco and Libya are involved in fish export to the EU, and Namibia is reported to export oysters, of which 700 tonnes were exported in 2007, and seaweed.

**Conclusion**

African countries should zone aquaculture areas and encourage the clustering of producers, as well as promoting the creation of viable organisations for the key aspects of the industry.

Countries wishing to be involved in export trade should endeavour to develop appropriate strategies in relation to globalisation in parallel with the technical development of the sector.

Through appropriate policies African countries should facilitate efforts to improve biosecurity and aquatic animal health management, as this could be critical and constitute an important requirement for the development and sustainability of the sector. This is particularly important for the countries surrounding the Zambezi river basin where EUS has been reported as it threatens the livelihood of millions of people in the region.

**References**

Aquaculture and aquatic animal health management issues in the Asia–Pacific region

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Summary
Aquaculture is the fastest growing food production sector in the world. In 2008, about 53 million tonnes of farmed fish and shellfish was produced globally. More than 90% of this was produced in Asia. Global trade in seafood in 2008 was US$102 billion. The epidemic spread and devastating impacts of aquatic animal diseases in the Asia–Pacific Region have clearly demonstrated the risks associated with international trade and the vulnerability of aquaculture systems to disease emergencies. Implementation of effective national/regional biosecurity strategies is essential to address health issues effectively, support sustainable aquaculture development and comply with international standards (e.g. the World Organisation for Animal Health [OIE] Aquatic Animal Health Code).

Development and adoption of the Food and Agriculture Organization of the United Nations (FAO)/NACA ‘Asia Regional Technical Guidelines for Responsible Movement of Live Aquatic Animals’ by 21 Asia–Pacific countries was a major advance facilitated by NACA during 1999–2001. Considerable progress has been made in the areas of disease diagnosis, aquatic animal health certification and quarantine, disease surveillance and reporting and farm level health management. The quarterly aquatic animal disease (QAAD) reporting system in the Asia–Pacific region, a joint activity among NACA, FAO and OIE Regional Representation (Tokyo) carried out since the second quarter of 1998, is testimony to this progress. The QAAD disease list includes all diseases listed by OIE in the latest edition of the OIE Aquatic Animal Health Code, plus other diseases of concern to the Asia–Pacific region. Over the coming two to three years, the regional QAAD reporting system will be gradually transformed to the OIE–NACA World Animal Health Information System (WAHIS) Regional Core to support online reporting. NACA works closely with the OIE and FAO to promote the role of the region in contributing to the international standard-setting process through the work of the Asia regional advisory group on aquatic animal health.

The Asia–Pacific region is now in a much better state of preparedness to deal with aquatic animal disease emergencies and meet international standards. Continued national commitment must be ensured for effective implementation of biosecurity governance and to improve compliance with international standards so as to promote sustainable aquaculture and responsible international trade.

Keywords
Disease diagnosis and reporting for aquatic animals in OIE Member Countries in the Americas

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Summary
One of the most important challenges facing the Americas is the development of the capacity to accurately diagnose and report diseases in aquatic animals. The objectives of this study were to review the capacity of countries within the Americas to diagnose and report selected OIE-listed diseases of aquatic animals and to determine the potential effects of human resources and aquaculture production levels on the performance of individual countries.

Data from two OIE databases, Handistatus II and the World Animal Health Information Database (WAHID), were analysed for the period from 1996 to 2010. The number of years that each country in the Americas had diagnosed and reported (where applicable) the incidence of Perkinsus marinus in oysters and clams, white spot disease in crustaceans or spring viraemia of carp in carps was recorded. Redundancy analyses were performed using the software CANOCO.

Performance in diagnosing and reporting each of these three OIE-listed diseases was significantly associated with the amount of aquaculture production and the number of non-private veterinarians in the country. Three groups of countries were determined. The first group included countries with extensive aquaculture production that had maintained their diagnostic capacities for 7–15 years (e.g. Brazil, Chile and the USA). The second group included countries with less than 200,000 tonnes of aquaculture production per year that had maintained their diagnostic capacities for 10–15 years (e.g. Canada, Colombia and México). The third group included countries that had been unable to maintain consistent diagnostic reporting for more than five years (73% of the analysed countries). Countries in the third group are unprotected against the potential introduction of OIE-listed diseases and face problems associated with the export of aquaculture products. The present study emphasised the potential consequences for biosecurity and trade and the options available to the OIE to build diagnostic capacity in these countries.

Keywords

Introduction
For developing countries, aquaculture is an important means of producing affordable, high-quality food that is a good source of protein. Aquaculture has grown rapidly in the last 10 years, both worldwide (8%) and in the Americas (21%) (1, 2). More than 60 aquatic species are cultivated in the Americas, with an emphasis on salmonids, shrimp and tilapia (1). Interestingly, the majority of aquaculture production has been conducted in rural rather than urban areas. Chile is the primary supplier of fish (mainly salmonids) in the Americas, grossing US$3.1 billion and producing 698,000 tonnes of fish in 2005 (52% of the total fish production of the Americas). Brazil and Mexico lead the Americas in tilapia production, with each country yielding a net of 100,000 tonnes in 2006 (1). Aquaculture in the Americas appears to be a promising tool to address issues of poverty and malnutrition in rural areas. One of the greatest limitations of aquaculture in the Americas, however, is the low level of training of aquaculture workers, who have been noted to have limited knowledge of disease management in aquatic organisms (7).
The implementation of international regulations for trade in aquaculture products is critical to preventing disease propagation among OIE Member Countries. In addition, the determination of each country’s capacity to diagnose and report diseases in aquatic animals is critical to the safety of commercial aquaculture activity in the Americas. Therefore, I examined the OIE databases to determine the status of disease diagnosis and reporting in the Americas. These databases contain all of the information reported by OIE Member Countries concerning their capacity to diagnose and report diseases of aquatic animals. In addition, the databases contain information regarding the number of years that each country has been able to maintain its disease-reporting capacity and human resources. It is important to determine whether human resources, such as the number of veterinarians or other professionals involved in disease diagnosis, or aquaculture production levels affect the diagnostic performance of Member Countries. Thus, the objectives of this study were to review the capacity of countries within the Americas to diagnose and report OIE-listed diseases of aquatic animals and to determine the potential effects of human resources and aquaculture production levels on the performance of individual countries.

Materials and methods

The data for the present study were obtained from the Handistatus II database and the World Animal Health Information Database (WAHID), both of which are available on the OIE website (www.oie.int/es/), for the period from 1996 to 2010. Although 26 aquatic animal diseases are currently listed by the OIE (www.oie.int/es/), this study focused on three diseases that were representative of those acquired by aquatic animals in the Americas. Thus, data on Perkinsus marinus in oysters and clams, white spot disease (WSD) in crustaceans and spring viraemia of carp (SVC) were used in this study. The reason for selecting these diseases was that they have never been removed from the OIE list of diseases of aquatic animals since they were first included. The primary outcomes measured for this study were the number of years for which a given country continuously diagnosed each disease and the number of reports that country has produced on that disease (if applicable). Although the diagnosis of a given disease could be positive or negative, the generation of such reports is indicative of the country’s continued diagnostic capacity.

Redundancy analysis (RDA) was performed using the software CANOCO (Microcomputer Power, Ithaca, NY, USA) (6). This method was used to evaluate potential associations between the number of years for which a country has had the capacity to diagnose a given disease and the number of reports of that disease (if present) as the dependent variables (collectively termed the ‘diagnostic performance’ herein) and the available human resources (i.e. the number of non-private veterinarians, academic veterinarians, private veterinarians and veterinary technicians) and aquaculture production per year as the independent variables. Using a detrended correspondence analysis, the length of the ordination axes’ scale (gradient) for the dependent variable data was found to be less than three standard deviation units, thereby suggesting that linear models, such as redundancy analysis, should be used (3). To avoid temporal autocorrelation, permutations were restricted to the cyclic shifts within the time series of each country. Monte Carlo tests were used to determine the significance of each canonical axis. It is also important to acknowledge that in the field of aquatic animal health, the veterinarian category includes biologists, fisheries engineers and other professionals associated with aquatic animal health (8). All data were obtained from the OIE databases, with the exception of data on aquaculture production, which were obtained from the Food and Agriculture Organization of the United Nations (FAO) website (www.fao.org/countryprofiles).

Results

General trends

Data on the diagnosis and reporting of the selected diseases (P. marinus, WSD and SVC) for each of 41 countries in the Americas are presented in Table I. The redundancy analysis, which included the number of continuous years in which diagnoses were made for the three selected diseases for each OIE Member Country in the Americas, the number of years in which reports for these selected diseases were made by an OIE Member Country, and all of the independent variables in Table I, showed a significant correlation. The percentage of variance explained by this linear model was 30.80% (F-ratio = 37.49; P-value = 0.0008; 4,999 randomisations for all canonical axis). The analysis was restricted to the number of non-private veterinarians and the amount of aquaculture production per year because there were no significant differences when the other four independent variables were removed.
Thus, the most important independent variables in this analysis were the number of non-private veterinarians (Gover in Table I) and aquaculture production (ProA). For example, when both variables were considered as independent variables, the diagnostic performance remained highly significant (explained variance = 25.60%; $F$-ratio = 102.78; $P$-value = 0.0008; 4,999 randomisations). Thus, after obtaining the results of the redundancy analysis for each selected disease, a more descriptive approach was used to assess the association between the number of years for which each disease was diagnosed and the amount of aquaculture production per year (Fig. 1).

**Perkinsus marinus**

The redundancy analysis of the diagnostic capacity of countries in the Americas for *P. marinus* with respect to the number of non-private veterinarians and aquaculture production per year was significant for all canonical axes (explained variance = 36.50%; $F$-ratio = 48.54; $P$-value = 0.0008; 4,999 randomisations). As shown in Fig. 1(a), three groups of countries were evident. The first group included countries with high aquaculture production that had maintained their diagnostic capacities for 8–15 years (Brazil, Chile and the USA; Table I). The second group included countries with less than 200,000 tonnes of aquaculture production per year that had maintained consistent diagnostic capacities for 12–15 years (e.g. Canada and Colombia). Cuba was an exceptional case because, although its aquaculture production is less than 40,000 tonnes per year, its diagnostic capacity for *P. marinus* has remained constant for the last 12 years. Countries that had maintained consistent reporting for 6–9 years, such as Costa Rica and Guatemala, were also included in the second group. The third group included countries that had been unable to maintain consistent diagnostic reporting between 1996 and 2010. Most Caribbean and Central American countries, as well as Mexico, were categorised in the third group (Table I).

**White spot disease**

The diagnostic capacity for WSD as a function of the number of non-private veterinarians and aquaculture production was significant (explained variance = 26.80%; $F$-ratio = 30.95; $P$-value = 0.002; 4,999 randomisations). The diagnostic capacity of countries in the Americas for WSD as a function of aquaculture production is presented in Fig. 1(b). The analysis of this disease also resulted in three groups of countries. The first group included countries with high aquaculture production that had been able to continuously maintain their diagnostic capacities for 8–12 years (Brazil, Chile and the USA). The second group included countries with less than 200,000 tonnes of aquaculture production per year that had consistently maintained their diagnostic capacities for 10–12 years (Canada, Costa Rica and Mexico). Again, Cuba was an exceptional case because, although its aquaculture production has been less than 40,000 tonnes per year for the last 11 years, its diagnostic capacity for WSD has remained constant. Countries that had maintained consistent reporting for the last six years, such as Belize, Guatemala and Nicaragua, were also included in this group. The third group included countries that had been unable to maintain consistent diagnostic capacities between 1996 and 2010. Ecuador, Honduras and most Caribbean countries were included in this group.

**Spring viraemia of carp**

The number of years for which each country maintained a diagnostic capacity for SVC as a function of the number of non-private veterinarians and aquaculture production was significant (explained variance = 26.90%; $F$-ratio = 31.05; $P$-value = 0.005; 4,999 randomisations). The diagnostic capacity of countries in the Americas for SVC as a function of aquaculture production is presented in Fig. 1(c). Three groups of countries were evident, based on the analysis of diagnostic capacity for SVC. The first group included countries with high levels of aquaculture production (Chile and the USA). These countries had continuously maintained their diagnostic capacities for 10–15 years (Table I). The second group included countries with less than 200,000 tonnes of aquaculture production per year that had consistently maintained their diagnostic capacities for 12–13 years, such as Canada. Once again, Cuba, even with a low aquaculture production, has maintained its diagnostic capacity for SVC for the last 11 years. Countries that had maintained consistent diagnostic performances for the last 5–11 years, such as Colombia, Costa Rica, Belize, Guatemala and Brazil, were also included in the second group (Table I). The third group included countries that had been unable to maintain consistent diagnostic capacities between 1996 and 2010. Ecuador, México and most Caribbean countries were included in this group.
Table I The number of continuous years for which each country in the Americas has maintained its capacity to diagnose Perkinsus marinus (Pm), white spot disease (WSD) and spring viraemia of carp (SVC) (first three columns)
The number of years in which there was a positive diagnosis for a specific disease is shown to the right of the slash. The remaining columns list the independent variables used as predictors in the redundancy analysis. Data were obtained from the Handistatus II and WAHID databases for the period from 1996 to 2010

<table>
<thead>
<tr>
<th>Region/Country</th>
<th>Pm</th>
<th>WSD</th>
<th>SVC</th>
<th>Gover</th>
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Note: MeVet: mean number of veterinarians (including all categories from Gov to Techni); Prom: mean number of non-private veterinarians; ProA, aquaculture production (tonnes × 1,000); SD, standard deviation.
The most notable finding of the present study was the statistical correlation between individual countries’ diagnostic performance for three OIE-listed diseases and their level of aquaculture production, as well as the number of non-private veterinarians per country. It is important to bear in mind that the meaning of these statistical associations is that countries in the first and second groups have the capacity to diagnose the given diseases. The countries that have had a positive diagnosis for at least one of the selected diseases are presented in Table I. Because

**Discussion**

The most notable finding of the present study was the statistical correlation between individual countries’ diagnostic performance for three OIE-listed diseases and their level of aquaculture production, as well as the number of non-private veterinarians per country. It is important to bear in mind that the meaning of these statistical associations is that countries in the first and second groups have the capacity to diagnose the given diseases. The countries that have had a positive diagnosis for at least one of the selected diseases are presented in Table I. Because
the countries were consistently divided into three groups, it seems reasonable to infer that similar groupings would be observed for most OIE-listed diseases of aquatic organisms in the Americas (i.e. the observed groups reflect the overall diagnostic capacities of the analysed countries). However, the redundancy analysis explained a relatively small extent of the variance in the data (25.6–36.5%), even when the trends were significant. Other than aquaculture production and the number of non-private veterinarians, the independent variables considered in Table I (e.g. the numbers of non-private veterinarians, academic veterinarians, private veterinarians and veterinary technicians) apparently made no significant contribution to the predicted diagnostic performance.

The relevance of aquaculture production as an independent predictor was not surprising because it is the focus of the diagnostic performance in question. Without aquaculture production, disease diagnostics would not exist. Therefore, it seems reasonable to suggest that diagnostic performance in the Americas will improve with increased aquaculture production. It is also important to acknowledge the significant contribution of non-private and academic veterinarians. Veterinarians are responsible for promoting and overseeing the regulation of aquatic health in the analysed countries. However, the other groups of professionals listed in Table I apparently did not significantly affect the diagnostic performances of individual countries. This lack of a significant association probably does not reflect the true situation, especially with respect to academic personnel. The diagnostic techniques for OIE-listed diseases of aquatic animals are mostly developed and standardised in academic institutions in the Americas (see, for example, the list of OIE reference laboratories at www.oie.int/es/). The contribution of academic personnel may not be adequately reflected by the number of individuals working on aquatic animal health, as compiled in the OIE databases. The lack of a significant impact of private veterinarians and veterinary technicians on the diagnostic performance for the selected diseases may indicate an insufficient number of individuals available to undertake tasks related to the diagnosis of OIE-listed diseases. To address this problem, the OIE has developed the ‘Performance of Veterinary Services’ (PVS) Tool. Following a request from a Member Country, the OIE can initiate a mission to assess the performance of its Veterinary Services and to design strategies for improvement. The OIE, together with the Welfare Fund, can provide financial support for this process. The OIE has applied the PVS Tool for terrestrial animals on more than 100 evaluation missions. The most recent application of PVS for aquatic animals occurred in Vietnam (www.oie.int/en/support-to-oie-members/pvs-pathway/).

For each of the selected diseases, the Americas show a clear division into three groups of countries (Table I; Fig. 1). The first group includes countries with high aquaculture production that have maintained their diagnostic performance over time; this pattern is unlikely to change in the near future. Cuba is a special case because it is the only Caribbean country that reported 11–12 years of continuous diagnosis of the three selected diseases, despite relatively low aquaculture production.

The consistency of diagnostic performance in the second group appears to be related to the value of the aquaculture products in each country. For example, shrimp farming is a profitable business for wealthy farmers and private companies in Belize, Mexico and Nicaragua (7). This profitability most likely explains why these countries have been able to maintain their diagnostic performance. In Mexico, at least nine academic institutions have the capacity to perform WSD testing (4), and eight of these institutions are located on the Pacific coast, where shrimp farms are located.

The third group includes countries that have been unable to maintain diagnostic performance for more than five years. This group includes 73% of the countries in the Americas (30 of the 41 countries in Table I). These countries are considered the most vulnerable because they are unprotected from potential introductions of OIE-listed diseases and because they face problems related to the export of their aquaculture products. Thus, there is an urgent need to improve the capacity of these countries, and the OIE has implemented several tools to address this problem. First, a country can request that the OIE apply the PVS Tool, which can provide financial support to establish diagnostic capacity. A second option to improve the level of expertise of a country’s human resources is to initiate an OIE twinning project (see the OIE website for further information). These suggestions are consistent with the strategies proposed by the World Bank (7) to diminish the risk of the translocation of diseases of aquatic organisms in developing countries.

Diseases of aquatic organisms are undoubtedly an important constraint on the development of aquaculture in the Americas, especially for 30 of the 41 countries included in this analysis that have not shown consistent diagnostic and reporting capacities. In 1997, the World Bank estimated that global losses from aquaculture diseases amounted to approximately US$3 billion per year (5). Thus, the further development of aquaculture in the Americas requires solid capacity-building strategies for the diagnosis of OIE-listed diseases of aquatic organisms in these countries, especially in rural areas.
References

Aquatic animal feeds: challenges and opportunities

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Summary

Global demand for seafood is increasing, and can only be met through aquaculture. However, concerns have been expressed regarding the sustainability of aquatic animal farming, as traditionally marine raw materials such as fish meal and fish oil are major components of aquaculture feeds. Reduction fisheries, which provide the raw materials for fish meal and oil production, although increasingly well managed, rely on wild fish stocks, which are limited resources. Significant efforts have therefore been devoted by the feed industry towards reducing reliance on marine ingredients. Raw material characterisation, identification of novel feed ingredients and an improved understanding of critical nutrients that limit our ability to replace fish meal and fish oil all need to be addressed. Research on the possible effects of innovative feed formulations on fish health and welfare has demonstrated that properly balanced formulations do not negatively affect animal health. The feed industry acknowledges the importance of the international standards of the World Organisation for Animal Health (OIE) and the Codex Alimentarius in formulating feed for the production of safe food products. New research findings allow the industry to formulate feed more efficiently and to reduce the input of marine raw materials, so that fish farmers can become ‘net fish protein producers’ and thereby ensure a sustainable supply of high-quality protein based on healthy seafood for a growing world population.

Keywords

The European Feed Manufacturers’ Federation (FEFAC) established a dedicated Fish Feed Committee in 2003, in response to growing attention from consumers and regulators towards food safety and sustainability issues in aquaculture. Today, the FEFAC Fish Feed Committee includes 20 members and fish feed experts from different European countries, including Norway, and has as its main task ensuring a common approach to identify and solve issues related to European Union (EU) feed legislation. Aquaculture in the EU is in fact today regulated by some 150 different regulations and directives, often based on land animals. A coordinated and simplified framework is needed, whereby the specific needs and conditions of the aquatic animal feed sector are taken into account.

Food security is a major challenge on a global level. The world population is predicted to reach 9 billion by 2050. At the same time, demand for animal proteins is set to increase towards Western standards which, according to the United States Department of Agriculture, corresponds to yearly per capita consumption levels around 92 kg of meat, 7 kg of fish, 272 kg of dairy products and 254 eggs. It has been calculated that, with our present technological abilities, and taking into account such issues as biodiversity, sustainability and climate change, we would need four planets Earth to meet this demand. To meet the needs of future generations we need to design sustainable production systems, and aquaculture is well placed to ensure an efficient, long-term animal protein supply. Sustainable growth in aquaculture can only be based upon formulated feeds, which are instrumental for stable farmed fish production with high food safety standards. To fully exploit this potential, however, several challenges need to be addressed.

Some of these challenges have been identified, from an European perspective, by the European Aquaculture Technology and Innovation Platform (EATIP), an international non-profit association dedicated to developing, supporting and promoting aquaculture and, especially and specifically, technology and innovation in aquaculture in Europe so as to:

− establish a strong relationship between aquaculture and the consumer
− ensure a sustainable aquaculture industry
− consolidate the role of aquaculture in society.
The EATiP approach is to identify, in a concerted effort involving different stakeholders along the aquaculture value chain, challenges that need to be addressed in order to ensure sustainable development of the EU aquaculture industry. Within the area of aquatic animal feeds, the following key goals have been identified:

- base the formulation of future fish feeds on solid knowledge of fish nutritional requirements, and expand the number of well-characterised and sustainable raw materials that can be used
- use advanced novel feed technologies to produce cost-effective feeds with improved quality
- understand and minimise the negative effects of alternative diets on fish health and welfare
- adapt and utilise advanced methods to understand and model nutritional responses
- resolve strategic research problems in fish nutrition.

The availability of well-characterised and sustainable raw materials that can be used in formulations is a major issue to be addressed (8). Aquatic animal feeds traditionally include high levels of marine ingredients such as fish meal and fish oil, which are limited resources (14), and it is widely recognised that responsible methods need to be designed and put into practice to ensure the sustainable exploitation of wild fish stocks by the fish meal and oil processing industry (6). According to the food and Agriculture Organization of the United Nations (5), catches for reduction purposes have been declining continuously in recent years, due to an increasing share being allocated to direct human consumption and to improved fisheries management and regulations. Although fish meal production has remained stable as more fish meal is produced from offal derived from the fish-processing industry, the fact that more than 50% of fish meal and 90% of fish oil globally available are used in aquatic animal feed formulations while aquaculture continues to be the fastest growing animal food-producing sector (with an average annual growth rate of 6.6%) clearly indicates that further growth of the aquatic animal farming industry has to be based on fish meal and oil replacement.

Plant protein concentrates and land animal by-products/processed animal proteins are good substitutes for fish meal (7, 13). The drive for plant oils (biodiesel and human food) creates huge quantities of cheap plant protein (soybean, rapeseed, etc.) that can be upgraded, while bioenergy developments lead to increased production of wheat and corn gluten (being the starch used for bioethanol production). Plant protein concentrates have been shown to be good fish meal replacers, but their price competitiveness and market availability remain issues limiting their use in compound feeds. Land animal by-products and processed animal proteins are good fish meal replacers as well, widely used throughout the world, with the notable exception of the EU, where Regulation CE 1234/2003 allows only non-ruminant blood products, collagen proteins and hydrolysed feather meal to be included in fish feed formulations. Although the EU regulatory framework is under revision, processed animal proteins (such as poultry meal) are not yet allowed. Their potential availability in Europe is estimated at 1.3–1.5 million tonnes per year, representing protein wasted or underutilised.

Fish oil substitution must take into account the need to maintain the good nutritional value of farmed fish as far as fatty acid composition is concerned (11). On the other hand, it has been estimated that, taking into account global fisheries availability and the recommended intake of long-chain ω3 fatty acids such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) for human health, alternative sources of these fatty acids, other than fish, need to be identified in order to fulfil global demand (Table I). Several fish oil replacers have been demonstrated to be excellent raw materials for aquatic animal feeds (15), but algae and genetically modified (GM) plants offer the most interesting potential to fill the above-mentioned gap. Algae are the actual source of long-chain ω3 fatty acids in the marine food web and are therefore an obvious candidate for increasing the supply of these essential nutrients along the aquaculture chain. Concerning GM plants, political and market obstruction still limits their use for aquatic animal formulations in Europe (see Regulations EC 1829/2003 and 1830/2003), notwithstanding the lack of scientific evidence about the possible negative impact of foreign DNA on fish health and welfare or on the safety of fish products (12, 17). On the other hand, the availability of GM plant-derived plant oils rich in ω3 highly unsaturated fatty acids (stearidonic acid-enriched soybean oil, for instance) may indeed not only reduce reliance on marine oils but even actually increase the global supply of essential nutrients with a positive impact on human health.

The issue of fish meal and oil replacement in aquatic animal feeds has been addressed in recent years by significant research efforts. Although further advancement has to be sought, it must be recognised that our state-of-the-art knowledge on aquatic animal nutrition and feeding already allows such efficient use of resources as to provide for the farming of carnivorous fish and for becoming a net producer of fish protein and lipids (Table II) without any negative impact on fish health and welfare as long as a proper nutritional balance is ensured (10).
Table I  Global balance of EPA and DHA availability versus world population requirements (S.J. Kaushik, unpublished data)

<table>
<thead>
<tr>
<th>EPA and DHA requirement</th>
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<tr>
<td>Recommended daily intake (according to ISSFAL)</td>
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<tr>
<td>Daily world population requirement (6 billion)</td>
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<td>Yearly world population requirement</td>
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<table>
<thead>
<tr>
<th>EPA and DHA availability (yearly)</th>
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</thead>
<tbody>
<tr>
<td>Global availability from fish</td>
</tr>
<tr>
<td>Edible (estimated 50%)</td>
</tr>
<tr>
<td>Fish oil (average 5% fat)</td>
</tr>
<tr>
<td>EPA and DHA (average 15% in fish oil)</td>
</tr>
<tr>
<td>DEFICTT (yearly)</td>
</tr>
</tbody>
</table>

DHA, docosahexaenoic acid; EPA, eicosapentaenoic acid

(a) International Society for the Study of Fatty Acids and Lipids (www.issfal.org)

Table II  Estimated dependency ratios of farmed salmon on capture fisheries or marine nutrients (3, 14)

<table>
<thead>
<tr>
<th>Ratio</th>
<th>Data from ref. 14</th>
<th>Data from ref. 3</th>
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<tbody>
<tr>
<td></td>
<td>1997 usage</td>
<td>2007 usage</td>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calculated from ref. 14</td>
<td>7.5</td>
<td>4.0</td>
</tr>
<tr>
<td>MPDR&lt;sup&gt;(a)&lt;/sup&gt;</td>
<td>2.57</td>
<td>1.20</td>
</tr>
<tr>
<td>MODR&lt;sup&gt;(b)&lt;/sup&gt;</td>
<td>2.15</td>
<td>1.13</td>
</tr>
</tbody>
</table>

(a) Marine protein dependency ratio = (Marine protein in feed as percentage × Protein concentration in marine protein sources used × Feed given in kg)/[(Salmon final weight × Final protein concentration in salmon) – (Salmon initial weight × Initial protein concentration in salmon)]

(b) Marine Oil Dependency Ratio = [Marine oil in feed as percentage + (Marine protein in feed as percentage × Oil concentration in marine protein sources used)] × Feed given in kg)/[(Salmon final weight × Final oil concentration in salmon) – (Salmon initial weight × Initial oil concentration in salmon)]

A regulatory framework that takes into account the specificity of the aquatic animal farming sector is instrumental in allowing application of the available technical and scientific knowledge. Some regulatory issues challenging the sustainable development of the European aquaculture industry have already been mentioned, such as the availability of alternative raw materials (land animal by-products, processed animal proteins, GM plants). The fact that EU legislation on feed additives and undesirable substances in raw materials and feed is based on land animal production is a further limitation for a sustainable development of aquaculture. Registration of feed additives according to Regulation EC 1831/2003 is too heavy a burden, given the limited size of the aquaculture sector, in which the expected revenue from a new additive for a fish species does not allow the high investment needed for the registration procedure. As a consequence, very little effort is invested in innovation in feed additives in Europe, as is evident from the fact that, while more than 100 enzymes are approved for animal feeds, only one (phytase) is available for fish feeds, and actually limited to salmonids. It should be noted, to take this example, that an increased level of vegetable ingredients in fish feed formulations may limit phosphorus availability. Phytase, on the other hand, increases the availability of phosphorus from vegetable sources, leading to increased efficiency in the use of resources and reduced environmental impact. Legislation on undesirable substances in raw materials and compound feeds is a further bottleneck with regard to the sustainable development of aquaculture. Indeed, the revision of Directive EC 2002/32 (the reference EU regulatory framework for undesirable substances) is progressively adapting the limits for key contaminants in raw materials and fish feeds to make them more specific.
to the aquaculture chain. To actively endorse the ongoing revision process, the FEFAC Fish Feed Committee established a dedicated Task Force on Contaminants to provide the European Food Safety Agency and the EU Standing Committee of the Food Chain with a scientific/technical interface. Although progress is evident, as maximum limits traditionally have been based on studies on land animals further adjustments are needed, e.g. in relation to endosulfan, which is always present in soybean oil. Maximum allowable limits for this chemical are based on the toxicity of waterborne endosulfan for aquatic animals: recent scientific evidence demonstrates that fish can tolerate much higher levels of dietary endosulfan and that carryover from feed to fish is very limited (1, 9). The current extremely low limit established by the EU legislation is therefore a major bottleneck, allowing only limited use of soybean oil as a replacer for fish oil, and is not justified in the light of new scientific evidence. More generally, the accumulation of maximum allowable limits for so many substances (39 such limits are set under EU legislation) will make sourcing of alternative raw materials extremely complex and challenging. It has been estimated that EU legislation on undesirable substances adds approximately 8% in extra costs to EU producers, who are not on a level playing field with third country competitors that do not have to meet these requirements.

Within this context, international standards such as the OIE Aquatic Animal Health Code (18) and the Codex Alimentarius Code of Practice on Good Animal Feeding (2) play a major role in establishing a global and coordinated framework to reduce unfair competition while ensuring feed, and therefore food, safety. The industry has recognised the importance of such standards and is also playing its role in supporting the establishment of measures ensuring feed quality and safety: FEFAC members have implemented the European Feed Manufacturers’ Guide (EFMC), assessed by EC DG SANCO (the European Commission’s Directorate General for Health and Consumers), in order to ensure the application of hazard analysis and critical control point-based risk assessment for feed production (4).

Conclusions

Aquaculture has the potential to play a major role in ensuring food security at a global level, and formulated feeds are instrumental in supporting the sustainable growth of aquaculture and a high level of feed and food safety. The industry is well aware of the challenges to be addressed. Actions taken to increase the sustainability of aquatic animal farming demonstrate the industry’s commitment while delivering significant results (16). Safe, healthy and sustainable seafood from aquaculture will therefore contribute to feeding a growing world population.

References


Diagnostic methods for aquatic animal diseases: global issues and trends

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Summary

The aims of this paper are: (i) to illustrate the importance of diseases of aquatic animals (fish, crustaceans, molluscs and amphibians) in general and specifically infectious salmon anaemia (ISA) globally and regionally; and (ii) to provide an overview of current trends in laboratory diagnosis and pathogen surveillance and identify challenges faced by diagnostic laboratories for aquatic animal diseases.

Aquaculture is the world’s fastest growing sector producing food of animal origin. The emergence and spread of serious diseases is a major threat to aquaculture, and robust methods for laboratory diagnosis and pathogen surveillance are needed to reduce the risks. This is facilitated by the work of World Organisation for Animal Health (OIE) Reference Laboratories and the use of rapid and sensitive diagnostic methods such as real-time reverse transcription polymerase chain reaction (RT-PCR)/PCR testing for early detection of infection before clinical signs develop. The 2007–2011 spread of ISA in the Atlantic salmon industry in Chile is a powerful example of a major disease outbreak being diagnosed and managed through the use of real-time RT-PCR testing.

Keywords


Introduction

Aquaculture, the water farming of fish and shellfish, is the world’s fastest growing animal food-producing sector, sustaining an annual growth rate of 8.4% since 1970 and sparing the wild fishery from overexploitation (8). Aquaculture now accounts for almost half of the total food fish supply (9), including 90% of all carps, 73% of all salmon and 50% of tilapia (Oreochromis niloticus), catfish (Ictalurus punctatus), molluscs, crabs and lobsters (13). However, the intensification of aquaculture and increased densities involves substantial aquatic animal stress which facilitates diseases (36), particularly from the environmental reservoir of infected wild aquatic animals (6, 7, 39). Infectious disease occurs in native populations of wild aquatic animals but is often not sufficient to sustain the natural transmission cycle (40), which is readily facilitated by aquaculture. Increased aquaculture production is accompanied by increased disease risk. This can occur through translocation of successfully cultured live animals to new destinations, particularly animals with a low prevalence of clinical disease or subclinical infections or asymptomatic carrier hosts (10, 33), or by the shipment of infected eggs (25, 30). Increased risk for new diseases occurs with the expanding range of ‘new’ farmed aquatic animal species, such as Atlantic halibut (Hippoglossus hippoglossus), Arctic char (Salvelinus alpinus), sablefish (Anoplopoma fimbria), Atlantic cod (Gadus morhua), crustaceans and molluscs, with the new production approaches such as integrated multitrophic aquaculture (26), and with the expanding global trade in aquatic animals and their products (33); for this, improved diagnostic and surveillance efforts are necessary, which are inevitably accompanied by the discovery of new and emerging diseases (1, 14, 25, 29, 31, 39). We are therefore most likely to see more aquatic animal diseases in the future. On the other hand, there is also growing concern about the potential effects of pathogens spreading to wild
fish that come into close proximity to marine pens and fish escaping from them (12, 18). As a result of globally expanding aquaculture, there is a requirement for development of an ever-increasing arsenal of pathogen detection techniques, vaccines and therapeutic agents that will allow early detection, prevention, and treatment of infectious diseases (see also corresponding review by Kibenge et al. [21]).

**Surveillance and diagnostic methods for aquatic animal diseases**

Effective disease surveillance, which needs robust laboratory diagnosis and pathogen surveillance, is key to implementing and improving disease prevention and control programmes. This in essence requires the involvement of the World Organisation for Animal Health (OIE), which provides international standards and guidelines for safe trade in animals and their products (4, 28), and has a worldwide network of OIE Reference Centres, the OIE Reference Laboratories and Collaborating Centres (42). In 2011, there were 225 Reference Laboratories, of which 36 laboratories with 27 experts covered 37 aquatic animal disease topics (42). Of the 36 aquatic pathogens, 20 were viruses, four bacteria, three fungi, eight protozoa and one a flatworm (Table I). The OIE Reference Laboratories carry out confirmatory diagnostic tests of the OIE-listed diseases, thereby providing science-based standards and diagnosis of terrestrial and aquatic animal diseases, including zoonoses (4). When results are confirmed positive, the Reference Laboratory immediately informs the OIE Delegate of the Member Country from which the samples originated, as well as the OIE Central Bureau.

**OIE-listed aquatic animal diseases**

The 2011 OIE list of notifiable aquatic animal diseases (those with a risk of spread through trade in aquatic animals and their products) includes nine fish diseases, seven molluscs diseases, eight crustacean diseases and two amphibian diseases (43). Since 2006, the global status of these diseases has been reported through the OIE’s online World Animal Health Information System (WAHIS). This transparency of disease reporting (immediate, periodic) in the global animal disease situation allows neighbouring countries to take interactive action to minimise disease entering their respective countries. However, there are several existing and emerging diseases that are not on the OIE list. In any case, OIE Member Countries have an obligation to report diseases of epidemiological significance, in addition to notifiable diseases. On the other hand, some endemic diseases remain a challenge for aquaculture. For example, salmonid rickettsial septicaemia (SRS due to *Piscirickettsia salmonis*) in Chile remains one of the most important causes of mortality in rainbow trout (*Oncorhynchus mykiss*), Coho salmon (*Oncorhynchus kisutch*) and Atlantic salmon (*Salmo salar*) in sea water, and it is the main cause of antibiotic use in Chile. Other examples such as pancreas disease in Norway, and sea lice in Norway, Chile, Scotland and Canada are huge sanitary problems.

**Current trends in laboratory diagnosis and pathogen surveillance**

Current trends in laboratory diagnosis and pathogen surveillance involve automation, miniaturisation, multiplex polymerase chain reaction (PCR), Luminex assays, microarrays and deep sequencing. The main driver for changes in diagnostic tests for aquatic animal diseases is to shorten turnaround time on large sample submissions, i.e. increase throughput. However, the overarching need is to be able to detect the pathogen early on in the infection and to track the movement of aquatic pathogens in the marine environment, both of which are only possible using nucleic acid-based assays. While these methods show great promise, most, if not all, are not currently listed in the OIE Manual of Diagnostic Tests for Aquatic Animals and thus cannot be used to provide a confirmatory diagnosis for regulatory purposes.

Pathogen detection using nucleic acid-based assays is a cornerstone of any modern animal disease (veterinary) diagnostic laboratory. Many viral, bacterial, fungal, and parasitic nucleic acid-based tests utilise conventional PCR, a rapid procedure for the *in vitro* enzymatic amplification of a specific segment of DNA (34). A single copy of the pathogen nucleic acid, if present in the clinical material, is amplified by more than a million-fold and can be readily detected by agarose gel electrophoresis and staining with fluorescent dyes. For detection of pathogen transcripts or of viruses with an RNA genome (RNA viruses), amplification by PCR requires that the RNA first be copied by reverse transcriptase enzyme to cDNA (complementary DNA) and then used in PCR; this technique is referred
<table>
<thead>
<tr>
<th>Test</th>
<th>Nature of aquatic animal pathogen(^{(b)})</th>
<th>Percentage of tests(^{(c)})</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Binocular microscopy</td>
<td>1</td>
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<td>Electron microscopy</td>
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<td>2</td>
<td>1</td>
</tr>
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<td>1</td>
<td>2</td>
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<tr>
<td>Immunohistochemistry</td>
<td>3</td>
<td>2</td>
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<tr>
<td>Culture</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>IFAT</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Western blot</td>
<td>1</td>
<td>2</td>
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<tr>
<td>Antigen ELISA</td>
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<tr>
<td>Yeast two-hybrid assay</td>
<td>1</td>
<td>2</td>
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2-DE, two-dimensional gel electrophoresis; ELISA, enzyme-linked immunosorbent assay; IFAT, indirect fluorescent antibody test; RAPD, random amplification of polymorphic DNA; RFLP, restriction fragment length polymorphism

(a) Data from *Annual Report of Activities in 2009 to OIE* (42)
(b) Number in brackets denotes number of pathogens (36 in total; four of these were newly adopted and did not feature in the 2009 Annual Report)
(c) Tests available but not used in 2009 are not included. A particular test is counted only once if it is used in more than one laboratory for the same disease or used in the same laboratory for more than one pathogen (there are 110 different tests in total)
to as reverse transcription PCR (RT-PCR). There is now a growing and necessary trend among animal disease diagnostic laboratories to complement, and in some cases replace, the classic PCR assays with ‘real-time’ or quantitative (q) PCR and RT-qPCR because of the very high sensitivity and rapid turnaround time of the test. Moreover, because qPCR assays use a closed-tube format, there is reduced risk of cross-contamination. These nucleic acid platforms rely only on in vitro amplification of the pathogen transcripts and can be performed in readily available Biosafety Level (BSL) 2 facilities, even for highly pathogenic agents. Such technologies offer great potential for improved specificity, sensitivity and speed of pathogen detection and, therefore, great effort should be focused on optimising these technologies for routine use. Most aquatic diagnostic laboratories worldwide now use qPCR and RT-qPCR. For example, in Puerto Montt in Región X in Chile, there are more real-time PCR machines dedicated to aquatic animal diagnostics than there are to human and terrestrial animal diagnostics combined (F. Kibenge, personal communication).

In qPCR and RT-qPCR, the accumulation of PCR product (amplicon) is monitored by measuring the fluorescence signal of a reporter using various chemistries (22) during the amplification reaction, thus enabling identification of the cycles during which near-logarithmic PCR product generation occurs. This allows the assay to reliably quantify the DNA or RNA content in a given sample. A TaqMan probe is usually 25–35 nucleotides long and contains a fluorescent reporter dye (e.g. 6-FAM) at the 5′-end and a quencher dye (e.g. TAMRA) at the 3′-end. Probes shorter than 20 nucleotides long are designed as Minor Groove Binder (MGB)™ probes. The proximity of the quencher dye to the reporter allows the quencher to suppress, or ‘quench’ the fluorescence signal of the reporter dye through fluorescence or (Fürster) resonance energy transfer (FRET). If the targeted pathogen nucleic acid is present in the sample, the pathogen gene probe specifically anneals between the forward and reverse primer sites. During the reaction, the 5′ to 3′ nucleolytic activity of Taq polymerase cleaves the probe between the reporter and the quencher only if the probe hybridises to the target. Upon degradation, FRET is interrupted, increasing the fluorescence of the reporter (and decreasing the fluorescence of the quencher). Accumulation of the RT-PCR products is detected directly by monitoring the increase in fluorescence of the reporter dye. Because the increase in fluorescence signal is detected only if the target sequence is complementary to the probe, non-specific amplification is not detected. A further step in the evolution of TaqMan chemistry is the use of probes that consist of Locked Nucleic Acid (LNA) oligonucleotides, 7–15 mers in length, to provide superior hybridisation characteristics and enhanced biostability compared with conventional DNA oligonucleotides (37). Moreover, some commonly used quenchers such as DABCYL and TAMRA suffer from a number of drawbacks, including poor spectral overlap between the fluorescent dye and quencher molecule (DABCYL) or inherent fluorescence of the quencher (TAMRA) – resulting in a relatively poor signal-to-noise ratio. Black Hole Quencher (BHQ) molecules have been developed to overcome these drawbacks. TaqMan assays are specific, highly reliable and applicable to a wide range of diagnostic technology, including multiplex PCR and array technology that allow development of assays to detect multiple pathogens or pathogen subtypes in a single sample (by allowing for amplification of various targets in the same real-time PCR machine), and are highly amenable to quality assurance/quality control, a key requirement for diagnostic laboratories. MIQE (minimum information for publication of quantitative real-time PCR experiments) and MIQE précis standards (5) have been described for ‘best practice’ of fluorescence-based qPCR, which facilitate the design of de novo assays and assure reproducibility of the results.

Luminex assays are based on xMAP technology (multi-analyte profiling beads) enabling the detection and quantification of multiple RNA or protein targets simultaneously. The xMAP system combines a flow cytometer, fluorescent-dyed microspheres (beads), lasers and digital signal processing to effectively allow multiplexing of up to 100 unique assays within a single sample (23).

With the application of both robotic technology and miniaturised technology to routine molecular biology techniques, future trends indicate further development into pathogen (genomic pattern) high-density qPCR arrays (19) such as the OpenArray platform (3), nucleic acid microarrays (2) and microfluidics digital PCR (dPCR) arrays (35). The OpenArray real-time qPCR, which combines the parallelism of microarrays with the quantification capabilities, sensitivity and specificity of qPCR, can run 3,000 PCR tests on one sample or as few as 64 PCR tests against 48 samples. It is therefore possible to test for multiple pathogens simultaneously, making the array techniques ideal for aquatic animal disease diagnosis and surveillance. In dPCR, the sample is diluted to achieve approximately 0 or ≥ 1 copy of target nucleic acid per reaction chamber prior to PCR (38). This not only dilutes out background signal, increasing the signal-to-noise ratio of low-abundance targets, but also provides accurate absolute quantification of the target nucleic acid present at low levels (35) without depending on the number of amplification cycles, and the technique is routinely used for clonal amplification of samples for deep sequencing (41). dPCR can be performed in standard 96- or 384-well plates, but this is labour intensive and prone to pipetting errors. Alternative approaches to the multi-well plate method include the microfluidic dPCR.
array chip. The unit uses a microfluidics sample handling system to split one sample into hundreds of individual reaction chambers which reside on an ‘integrated fluidic circuit’ or chip, which allows performance of close to 10,000 PCRs per chip (35).

**Early versus unbiased aquatic animal pathogen detection**

The rational diagnosis of infectious aquatic animal diseases requires the identification of pathogens in clinical specimens and subsequent correlation between presence of the pathogen and the clinical syndrome. Any delays in obtaining a confirmatory diagnosis or identification of the pathogen may allow infected animals to go undetected and facilitate disease spread. In aquatic animal disease diagnosis, where clinically affected animals are available for clinical observation and post-mortem examination and the disease is associated with a particular pathogen, confirmation of an aetiological diagnosis is relatively straightforward. Historically, laboratory diagnosis has relied on in vitro culture of the pathogen and/or measurement of antibodies in sera. Early detection of infection has relied on a number of different methods including the indirect fluorescent antibody test (IFAT) and RT-PCR/PCR testing. However, in pathogen surveillance either in aquaculture or in wild fisheries, which is normally done in the absence of clinically affected aquatic animals, in situations where many different pathogens could be present and in complex aquaculture situations where vaccines and/or therapeutics are used or where no pathogen has been identified, the limitations of even the best current methodologies become readily apparent. For example, some viral pathogens are completely refractory to virus culture, or in the case of some fish viruses and most shellfish viruses, there is a lack of permissive cell lines and good-quality antibody reagents. For invertebrate aquatic animals, which lack adaptive immune responses, measurement of antibodies in body fluids is not an option. Furthermore, the complexity of the aquatic animal viral flora itself presents several problems. Viruses such as infectious salmon anaemia (ISA) virus (ISAV) HPR0 that may be carried by apparently normal fish are inherently refractory to in vitro culture (20). The existence of a large number of constantly evolving viral serotypes can render IFAT nearly impossible, and where vaccination is practised against ISA, antibody detection tests are unable to differentiate between infection and vaccination responses by fish. Shrimp, for example, can be infected simultaneously or sequentially with multiple viruses (8) or even different strains of the same virus (15), presenting significant challenges for diagnostic pathogen detection. Moreover, singleplex RT-PCR testing, unlike isolation and in vitro culture, is inherently biased, requiring assumptions that ultimately restrict the possible outcome to the selected candidate pathogen. Furthermore, clinical signs in the early stages of many infectious diseases are not sufficiently distinctive, making it challenging to make a differential diagnosis, which therefore limits the utility of single agent diagnostic assays such as singleplex PCR/RT-PCR. Thus, for aquatic animal disease laboratories, there is a need for assays that can allow unbiased analysis of pathogens in a sample, as differential diagnosis is difficult in early infection before the appearance of clinical signs.

Early detection of infection before the appearance of clinical signs and identification of the pathogen in clinical samples is essential for effective control of any disease and especially reportable and/or emerging diseases. These require rapid and sensitive diagnostic methods. Real-time (quantitative) RT-PCR/PCR technology is one of the most powerful and sensitive methods used to date to indicate the presence of a pathogen by detecting the organism's nucleic acid material in the clinical sample in real time. The sensitivity, specificity, speed and number of samples that can be examined using this advanced diagnostic tool make it the gold standard for molecular diagnostic testing in both terrestrial and aquatic animal disease diagnostic laboratories. The emerging technique of microfluidic dPCR offers a unique approach to qPCR/RT-qPCR for measuring nucleic acids that may be present at very low levels (35), such as early in infection before the appearance of clinical signs. Judging from previous trends in biotechnology, we expect nucleic acid-based technologies to become more widely applied in animal disease diagnosis as the equipment and reagents become less expensive. However, it is also recognised that the development of molecular diagnostics for infectious diseases is a never-ending process; a perfect method does not exist. In 2009, the five most commonly used diagnostic tests in OIE Reference Laboratories for aquatic animal diseases or topics, in rank order, were:

1. classic PCR/RT-PCR
2. culture
3. qPCR/RT-qPCR
4. histopathology/histology
5. IFAT.
qPCR/RT-qPCR represented approximately 12% of the 110 different tests used in these labs (Table I). The unprecedented 2007–2011 spread of ISA in the Atlantic salmon industry in Chile (11, 20) and its severe economic impact, to the extent that the recovery of the industry is not expected before 2013, is a powerful example of disease-related catastrophes in aquaculture managed entirely by RT-qPCR testing. However, in this case and in others, single agent diagnostic assays such as singleplex PCR/RT-PCR are severely limited. It was shown through phylogenetic analysis that the original ISAV responsible for this outbreak arrived in Chile around 1996 and was widely disseminated in the Atlantic salmon industry in Chile around 2005, but was not detected until June 2007 in a clinical sample using a singleplex RT-PCR assay (11, 20). Implementation of effective biosecurity and biocontainment measures could have averted this epidemic had the appropriate aetiological diagnosis been established at an earlier time point.

In aquatic animals, as in terrestrial animals, there are clinical and subclinical conditions for which infectious agents have not yet been detected. It is estimated that, if there are 50,000 vertebrate species each harbouring 20 endogenous viruses, this would predict the presence of 1 million different viruses, more than 99.9% of them currently unknown (24). Failure to demonstrate the presence of an infectious agent could be due to a myriad of reasons (39), including taking the wrong samples (wrong tissue or wrong time due to unknown or subtle pathogenesis, poor storage), a lack of susceptible cell lines and a lack of the right technology. Newer technologies such as 454 pyrosequencing, when coupled with fast computers and bioinformatics tools, are providing robust methods for discovering new pathogens (24, 31). Unlike PCR or array methods in which investigators are limited by known sequence information, high-throughput sequencing is unbiased and allows an opportunity to consider the entire tree of life: bacteria, viruses, fungi and parasites. Thus, a staged strategy for pathogen detection is advocated (32): singleplex PCR/RT-PCR testing is good in a characteristic disease outbreak or in situations suggestive of infection with one known pathogen but is not ideal in the absence of clinical signs; multiplex PCR testing alleviates the problem by reducing bias and allowing simultaneous detection of a wide range of candidate viral and bacterial pathogens that may act alone or in concert and is good where the differential diagnosis list contains fewer than 30 agents and/or clinical signs are not pathognomonic of infection; microarrays are good where multiplex PCR testing has failed or cannot be set up for some reason, and they are well suited to pathogen detection in animal populations likely to have large numbers of samples and pathogens; and deep sequencing is useful where other methods have failed and is completely unbiased and therefore ideal for pathogen discovery (Fig. 1). The utility of deep sequencing for aquatic animal pathogen discovery was recently illustrated with the identification of a novel piscine reovirus associated with heart and skeletal muscle inflammation (HSMI) (31), an Atlantic salmon disease condition that has been known since 1999.
Challenges facing diagnostic laboratories for aquatic animal diseases

The challenges faced by diagnostic laboratories for aquatic animal diseases may be divided into general and specific challenges. The general challenges include: (i) the requirement for large numbers of aquatic animals for statistically relevant disease surveillance and monitoring. Therefore, reliable detection of the pathogen is difficult if clinically sick aquatic animals are not available or only a low percentage of aquatic animals is infected. There is therefore a constant need to increase throughput (through automation, miniaturisation, etc.) in order to reduce turnaround time and handle larger numbers of samples. Moreover, effective monitoring requires quantitative methods that inform on pathogen load in aquatic animals or the environment. Other general challenges are: (ii) the need for cost-effective, fast, highly sensitive and specific methods that allow unbiased pathogen detection; (iii) he never-ending assay development activities in the absence of a perfect diagnostic method; (iv) the fact that the prevalences of aquatic animal diseases change depending on the time of year, water temperature, success in disease management, etc., which forces the laboratories to be highly flexible in order to remain relevant; and (v) the fact that ring tests (proficiency testing), which are an effective way for establishing national/international cut-offs of (highly sensitive) nucleic acid-based assays, are not readily available without government support.

Some of the specific diagnostic challenges include:

1. limited knowledge about aquatic animal pathogens (39)
2. long turnaround time of diagnostic laboratories
3. long distances from the farm site to the diagnostic laboratory
4. poor quality of clinical samples
5. the fact that mixed infections are common and present a diagnostic dilemma.

For example, a single case in Norway may involve HSMI, pancreatic disease, cardiomyopathy syndrome and sea lice, or in Chile it may involve SRS, bacterial kidney disease, Caligus spp. and ISAV HPR0. Consider also shrimp diseases (8, 16). The other specific diagnostic challenge is: (vi) standardisation of diagnostic tests is a challenge because positive control reagents are expensive and not easy to obtain, the determination of cut-offs of diagnostic tests is complicated (the criteria are not clearly defined – could be related to the ability to culture the pathogen or to the clinical situation of the aquatic animal or farm, etc.) and the case definition may be different for different countries.

Conclusions

Aquaculture is important now and will continue in the future as a principal source of animal protein for human consumption. Aquatic animal disease is part and parcel of aquaculture. Intensification of aquaculture is accompanied by increased stress, resulting in a significant proportion of stock becoming infected. Unbiased pathogen detection from carrier aquatic animals is essential for effective disease control in the global aquaculture industry. Improved diagnostic and surveillance efforts will result in the discovery of new and emerging aquatic animal diseases. Nucleic acid-based assays, particularly multiplex assays such as microarrays, are well suited for pathogen detection, typing and discovery in aquatic animal populations. Diagnostic laboratories for aquatic animal diseases face challenges inherent in the nature of the aquaculture industry and require the involvement of the OIE.

References


Session 2

The current state of play: international and national challenges and opportunities

Objectives: to present international and national perspectives and experiences (positive and negative) on the implementation of OIE standards for aquatic animal health
Analysis of the global fish health situation: challenges and opportunities

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Summary

Outbreaks of disease in fish are increasing alongside the growing international trade in and intensification of aquaculture production. Although local pathogens combined with other factors, such as poor husbandry and inadequate water quality, are the most common causes of disease outbreaks in fish farming, the introduction of “exotic” pathogens through international trade in live aquatic animals and their products continues to be associated with new epizootics. Some examples of the international spread of important fish pathogens will be discussed in the presentation.

Without effective implementation of biosecurity measures, transboundary spread of diseases in fish will continue to have serious economic impact. Fish diseases, whether infectious, non-infectious or opportunistic, may present subclinical or clinical effects, accompanied by a net decrease in production. Serious fish diseases may first be seen as massive mortalities and are often associated with reduced efficiency in the production process. Some relevant data will be presented.

One of the OIE’s main objectives is to ensure the sanitary safety of international trade in live (aquatic) animals and their products. The OIE standards address the detection and early notification of listed diseases and new epidemiological events, as well as standards for disease prevention and management, including contingency planning. By implementing the OIE standards, Members can prevent the dissemination of transboundary diseases of fish and facilitate safe and sustainable aquaculture production. The OIE Aquatic Animal Health Standards Commission plays a key role in assuring the development of appropriate standards for implementation by OIE Members.

Keywords

Global fish production trends

To start this analysis it is first necessary to review the trends in global fish farming up to the year 2010, considering the three relevant species of fish in culture and worldwide production figures, average prices and the main countries involved.

Several species of tilapia (Oreochromis spp.) have shown worldwide sustained growth since 1990, with annual rates averaging 12%, achieving production of 3 million metric tonnes by 2010 at prices of US$4/kg. The trend is for production to reach 3.35 million tonnes by 2012. Asia and Latin America are the two major producing regions, and producing countries in order of importance are the People’s Republic of China, Indonesia, Egypt, Thailand, the Philippines, Brazil and Bangladesh. The largest increases in production are expected in China, Indonesia and Brazil (2).

Next in importance are the salmonids, specifically Atlantic salmon (Salmo salar), then rainbow trout (Oncorhynchus mykiss) and coho salmon (Oncorhynchus kisutch), which have shown sustained growth over the past decade, achieving a combined production of about 2 million tonnes by 2008 and 1.85 million tonnes by 2010. The decrease from 2008 to 2010 was due to the loss of about 200,000 tonnes of Chilean Atlantic salmon as a result
of infection with the infectious salmon anaemia (ISA) virus. This decline in global supply caused an increase in the price of value-added salmon products from US$4.6/kg in 2008 to US$6.9/kg by 2010. Atlantic salmon is the major species in this group, with Norway as the main producer, followed by Chile; the UK and Canada also feature. The worldwide demand for salmon products will continue to grow steadily, even though supply could increase by about 15%, which will have an impact on projected prices.

Pangasius catfish (*Pangasius hypophthalmus*) production in Vietnam has undergone explosive growth since 2006 at average annual rates of 104%, with production in 2010 reaching around 1.4 million tonnes at an average price of US$2.3/kg. The trend is for production to reach 1.7 million tonnes in 2012 (1, 2). Other producers are Thailand, Cambodia, Laos, Myanmar, Bangladesh and China.

**Challenges**

The trend is for total global fish farming production to reach 7.5 million tonnes of farmed fish by 2012, according to figures from the Global Outlook for Aquaculture Leadership (2), highlighting the importance of ensuring that aquaculture is conducted in a sustainable way in order to reduce the undesirable side effects of intensive fish production.

Maintaining these production levels is the challenge we must face in the worldwide production of fish. The most important challenges to overcome are global climate change, global economic changes that will affect trade in the products of aquaculture, the provision of fresh water, the effects of pollution and contamination of the aquatic ecosystem, and infectious diseases.

The manifestation of disease in fish is multifactorial, whereby host factors, pathogen factors and the aquatic ecosystem interact to develop the disease. Currently, the human factor is included as a fourth component, as it can have a direct influence on the interactions of the triad.

Infectious diseases of fish primarily cause mortality, which is often the first thing the producer will note, but other important effects include: a decline in the efficiency of production; environmental impacts associated with control measures; the implications associated with the use of antimicrobial agents; dissemination of pathogens at the regional, national and international level; a reduction in the quality of the product; residues in products for consumption; the loss of markets and the social impacts resulting from loss of work.

**OIE-listed fish diseases**

The OIE has developed a set of guidelines and tools aimed at reducing the spreading of diseases and their impact. Thus, the *Aquatic Animal Health Code* (3), includes fish diseases that meet certain criteria in Article 1.2.1. The following diseases of fish are listed by the OIE:

- epizootic haematopoietic necrosis virus (EHNV)
- infectious haematopoietic necrosis virus (IHNV)
- spring viraemia of carp (SVC)
- viral haemorrhagic septicaemia (VHS)
- infectious salmon anaemia (ISA)
- epizootic ulcerative syndrome (EUS)
- infection with *Gyrodactylus salaris* (*gyrodactylosis*)
- red sea bream iridoviral disease (RSIVD)
- koi herpesvirus disease (KHVD).

Table I shows which countries in 2010 had notified presence or known presence and/or occurrence limited to certain zones of diseases of fish listed by the OIE (4). Two OIE-listed diseases of fish, VHS and KHVD, were the major worldwide diseases in 2010.

Outbreaks of fish diseases are increasing alongside the growing international trade in and intensification of fish production. Although local pathogens combined with other factors, such as poor husbandry and inadequate water quality, are the most common causes of disease outbreaks in fish farming, the introduction of ‘exotic’
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Pathogens through international trade in live aquatic animals and their products continues to be associated with new epizootics. Some examples of the international spread of important fish diseases are given below.

- EHNV introduced to Finland from Germany via imports of live catfish (*Silurus glanis*)
- first cases of SVC in Switzerland, the USA and Denmark associated with imported koi carp
- *G. salaris* introduced to Norway from Sweden via juvenile salmon for stocking
- cases of VHS in UK trout associated with importation of trout fillets
- outbreak of EUS in fish from the Zambezi–Chobe river system
- KHVD dispersed to Canada, Costa Rica, Slovenia, India, Guatemala and Taiwan.

The main published standards for aquatic animals are the *Aquatic Animal Health Code* and the *Manual of Diagnostic Tests for Aquatic Animals*. The aim of these standards is to ensure the sanitary safety of the international trade in aquatic animals and their products. Listing by the OIE gives diseases global recognition, especially in relation to trade in fish commodities. However, there are also other diseases that are not listed by OIE that are important regionally, and in some cases globally, to the fish farming industry.

### Important diseases of tilapia not listed by OIE

The clinically significant tilapia pathogens fall into the general categories of viruses, bacteria and protozoa. Mycotic (fungal) diseases are significant only if tilapia are under constant stress. In certain systems, metazoan ectoparasites and endoparasites cause problems, but they do not have a significant impact on the tilapia industry. One of the most significant diseases in tilapia culture worldwide, and particularly in indoor systems, is caused by *Streptococcus* spp. The primary streptococcus infecting aquaculture facilities is *Streptococcus iniae*. Another bacterial disease that has significantly impacted production on some farms is the disease aeromonad septicaemia (MAS, motile aeromonas septicaemia) caused by *Aeromonas hydrophila*. Other bacterial agents are *Flavobacterium columnare*, *Francisella* spp., and the parasite *Trichodina* spp. Currently, the only significant viral pathogen that we are aware
of is an irido-like virus that has been traced to fish from a single producer in the USA. Of the different pathogens found, Streptococcus spp. is the most common, widespread and pathogenic, while Francisella spp. is an emerging pathogen. F. columnare infection is a common pathogen of juvenile fish.

**Important diseases of pangasius catfish not listed by OIE**

Despite large tonnages being produced at extremely high densities, large-scale disease outbreaks and mortality of pangasius catfish seldom occur. The following diseases, however, have been recorded: bacillary necrosis of pangasius (BNP), caused by Edwardsiella ictaluri; and MAS, caused mainly by A. hydrophila, Aeromonas sobria and Aeromonas caviae. Infection with Saprolegnia spp. (mycosis) and parasite infections including Ichthyophthirius and Trichodina can occur at the fingerling stage.

**Important diseases of salmon and trout not listed by OIE**

The largest disease-related losses during salmon production cycles were registered following outbreaks of pancreas disease (PD) and cardiomypathy syndrome (CMS) of Atlantic salmon. Another condition, heart and skeletal muscle inflammation (HSMI), appears to be not pathogenic but with a broad distribution. Following transfer to the sea, significant losses to IPN continue to be registered in salmonids. Infectious pancreatic necrosis virus (IPNV) in salmon and Flavobacterium psychrophilum in rainbow trout continue to account for losses during the freshwater phase of their culture. Other important pathogens are Piscirickettsia salmonis, causing a serious disease affecting salmonids, and the salmon lice, Caligus spp. and Lepeophtheirus salmonis, which have an increasing effect on both farmed and wild fish.

However, it is not just of infectious diseases that farmed fish die. For example, after the outbreak of ISAV in Chile, only one-third of the losses of fish in 2010 were attributable to infectious pathogens. In smolt stragglers, losses were up to 23%; 8% of losses were attributed to quality control, 7% to predators, 4% to environmental causes, 3% to deformities and 2% to mechanical damage, among other causes.

**Opportunities**

As always, after outbreaks of disease with high economic and social impacts, the public and private sectors in the countries affected reorganise to establish measures to prevent outbreaks of disease by implementing the recommendations of the Aquatic Code and Aquatic Manual, with the implementation of contingency plans, zoning, biosecurity measures, management of mortality, risk analysis, and better communication and transparency in information management, including prevention and control.

Without effective implementation of biosecurity measures, transboundary spread of diseases of fish will continue to have a serious economic impact. Fish diseases, whether infectious, non-infectious or opportunistic, may present subclinical or clinical effects, accompanied by a net decrease in production. Serious fish diseases may first be seen as massive mortality and are often associated with a reduction in the efficiency of the production process.

The case of the outbreak of ISAV in Atlantic salmon in Chile is an example of an OIE-listed disease of fish farmed under intensive conditions. The intensity of salmon production has seen steady growth as a result of the increase in production: 25% average growth in production of Atlantic salmon in Chile between 2003 and 2007. After the ISAV outbreaks 15,000 jobs were lost, and unemployment in the Puerto Montt region increased from 4.8% to 8.3%. Regional economic activity decreased by 27% compared with 2008. The average monthly mortality of Atlantic salmon of 3.06% increased to 15.02% as a result of ISA and the average weight at harvest decreased from 3.26 kg to 2.66 kg due to early harvest. Following the implementation of measures for prevention and control, the monthly mortality rate in Atlantic salmon fell to 0.61%. The subsequent recovery resulting from restocking at lower culture densities and a following period, as described in the Aquatic Code, not only retrieved the former average harvest weight but actually increased it to 5.22 kg.

The outbreak of EUS in fish from the Zambezi–Chobe river system is an example of an OIE-listed disease of fish under extensive-wild conditions. The disease had swept across Japan, Australia, the USA and many Asian
countries. In 2006, the disease was documented in Southern Africa in the Zambezi–Chobe river system. This was the first confirmed outbreak on the African continent, affecting Botswana, Namibia and Zambia. In Botswana and Zambia, the disease was prevalent in wild fish, whereas in Namibia cases were also reported from fish farms. Thus far, about 25 species of fish are documented as having been infected by EUS. Control of EUS in natural waters is probably impossible. *Aphanomices invadans* is an opportunistic agent and a non-fish-specific species, therefore it affects many species, and it is difficult to measure the magnitude of its impact in the ecosystem. However, the social impact is huge for the people living by the Zambezi–Chobe river system as there is now a lack of this protein-rich food source.

One of the OIE’s main objectives is to ensure the sanitary safety of international trade in live aquatic animals and their products. The OIE standards address the detection and early notification of listed diseases and new epidemiological events, as well as standards for disease prevention and management, including contingency planning. By implementing the OIE standards, Members can prevent the dissemination of transboundary diseases of fish and facilitate safe and sustainable aquaculture production. The *Aquatic Code* defines ‘basic biosecurity’ as a set of conditions applying to a particular disease, and a particular zone or country, required to ensure adequate disease security, such that a disease, including suspicion of the disease, is compulsorily notifiable to the Competent Authority, an early detection system is in place within the zone or country, and import requirements to prevent the introduction of disease into the zone or country, as outlined in the *Aquatic Code*, are in place. Guidelines are provided on the methodology for surveillance to confirm the absence of a disease, thus justifying protection, or to determine its distribution in an infected zone or country for disease control purposes. The OIE Aquatic Animal Health Standards Commission plays a key role in assuring the development of appropriate standards for implementation by OIE Members.

In conclusion, the dissemination of fish diseases listed by OIE and the growing impact of diseases not listed will continue beyond 2010. This makes the efforts of the Competent Authorities of the OIE Members to prevent and control diseases of fish using the guidelines and recommendations described in the *Aquatic Code* and *Aquatic Manual* all the more important. It should be remembered when applying these guidelines that non-infectious diseases of farmed fish are also important. Finally, as aquaculture is growing worldwide and there has been a tendency for it to become more intensive, it is essential that future production is conducted in a sustainable manner.

**References**


The global health issues: crustaceans, with an emphasis on penaeid shrimp

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Summary

A discussion of the global status of shrimp diseases might best begin with a review of the diseases currently listed by the World Organisation for Animal Health (OIE), those diseases that were recently removed from the list and those recently considered for listing. The OIE has, among its many responsibilities, the listing of diseases (terrestrial and aquatic) that may pose risks of being transferred to new regions or countries as a consequence of global trade. Because of their economic importance and their potential for transfer with live or dead crustacean commodities, the OIE has eight crustacean diseases listed in the 13th edition (2010) of the Aquatic Animal Health Code (Aquatic Code). Of the eight listed crustacean diseases, six are diseases of penaeid shrimp (one bacterial disease and five diseases of viral aetiology), the seventh is a viral disease of the freshwater prawn, Macrobrachium rosenbergii, and the eighth disease is caused by infection with a phycocyanetous fungus in freshwater crayfish. Two diseases were listed by the OIE as ‘under study’ in the 12th edition (2009) of the OIE Aquatic Code. One of the two, necrotising hepatopancreatitis (NHP), was listed in 2010, while the other, a disease of farmed spiny lobsters (Panulirus spp.), due to infection with a rickettsial-like bacterium, was removed from ‘under study’ status and not listed. OIE listing gives diseases global recognition, especially in relation to trade in crustacean commodities (i.e. live crustaceans or commodity products made from hosts infected with listed disease agents). However, there are also emerging diseases that are not listed by OIE that are important regionally, and in some cases globally, to the shrimp farming industry. Included in this review are the current OIE-listed diseases of crustacea, especially of the penaeid shrimp, and several examples of emerging diseases that are of potential importance globally.

Keywords

Introduction

In less than 40 years the global shrimp farming industry grew from being largely experimental to producing approximately 360 million metric tonnes in 2008, which accounted for 52% of the world’s shrimp market. The leading producers of farmed raised shrimp were primarily located in South East Asia, with the People’s Republic of China, Thailand, Vietnam, Indonesia and India being the largest producers. In the Americas, Ecuador, Mexico and Brazil were the largest producers in 2008 (20, 21, 24).

The global shrimp farming industry has largely recovered from the major viral pandemics, and production has begun a new phase of rapid growth (20). The adoption of new shrimp farming technologies and the abandonment of practices that posed high disease risks have contributed to the industry’s recovery and current expansion (19). Among the most notable changes in culture practices has been the shift of the industry away from using wild stocks for seed production to the use of domesticated stocks (20, 32, 33, 34, 37, 50). This has been a consequence of the ever-increasing incidence of diseases (e.g. due to infection by white spot syndrome virus [WSSV] and infectious hypodermal and haematopoietic necrosis virus [IHHNV]) in wild shrimp stocks, which has made the collection of wild postlarvae (PLs) and adult broodstock, for the production of PLs for use as seed stock, a risky practice (17, 34, 37, 74). With the declining dependence of the industry on wild stocks in Asia and in the Americas, the use of domesticated lines of specific pathogen-free (SPF) Penaeus vannamei (the Pacific white shrimp; taxonomy used in this review is according to Holthuis [26]) recently surpassed Penaeus monodon (the giant black tiger shrimp) as the dominant farmed shrimp species in Asia (20). This paradigm switch in the species being farmed occurred within the five years after SPF P. vannamei stocks were introduced in quantity to Asia in
the late 1990s. Because these stocks gave predictable culture performance, they soon displaced the farming of other penaeid species (e.g. $P$. monodon and Indian and Chinese white shrimp, $P$. indicus and $P$. chinensis, respectively) in regions once dominated by these species. The Food and Agriculture Organization of the United Nations (FAO) (20) credits the development and export of SPF stocks of $P$. vannamei from the USA to the major shrimp farming countries of Latin America and South East Asia as being the main contributor to the industry’s recovery and subsequent expansion following the viral pandemics of the early 1990s.

The most important diseases of cultured penaeid shrimp, in terms of economic impact, in the Americas (and in Asia) have infectious agents as their cause (16, 17, 18, 31, 79, 80). Among the infectious diseases of cultured shrimp, certain virus-caused diseases stand out as the most significant, and many of these are listed by the World Organisation for Animal Health (OIE – l’Office International des Epizooties) (Table I). Some of the most important diseases (and their etiological agents) were once limited in distribution to either the Western or the Eastern Hemisphere (18, 29, 30, 32, 33, 79). However, the international movement of live (for aquaculture) and dead (commodity shrimp for reprocessing, direct retail commerce and use as bait by sport fishermen) have been implicated or suspected as being responsible for the transfer and establishment of certain pathogens from Asia to the Americas (2, 14, 25, 30, 74). While frozen commodity shrimp have been implicated as the route by which WSSV was moved from Asia to the Americas, Taura syndrome virus (TSV) was moved in the opposite direction with infected live broodstock from Central America (14, 54, 65, 69, 82).

Table I OIE-listed penaeid shrimp diseases as of 2010 (80)

<table>
<thead>
<tr>
<th>Disease name</th>
<th>Pathogen type</th>
<th>Pathogen name and acronym</th>
<th>Principal host group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taura syndrome</td>
<td>ssRNA virus</td>
<td>Taura syndrome virus (TSV)</td>
<td>Penaeid shrimp</td>
</tr>
<tr>
<td>White spot disease</td>
<td>dsDNA virus</td>
<td>White spot syndrome virus (WSSV)</td>
<td>Penaeid shrimp</td>
</tr>
<tr>
<td>Yellow head disease</td>
<td>ssRNA virus</td>
<td>Yellow head virus (YHV) and gill-associated virus (GAV)</td>
<td>Penaeid shrimp</td>
</tr>
<tr>
<td>Infectious hypodermal and hematopoietic necrosis</td>
<td>ssDNA virus</td>
<td>Infectious hypodermal and hematopoietic necrosis virus (IHNNV)</td>
<td>Penaeid shrimp</td>
</tr>
<tr>
<td>Infectious myonecrosis</td>
<td>dsRNA virus</td>
<td>Infectious myonecrosis virus (IMNV)</td>
<td>Penaeid shrimp</td>
</tr>
<tr>
<td>Necrotising hepatopancreatitis</td>
<td>Rickettsia-like bacteria</td>
<td><em>Hepatobacterium penaei</em></td>
<td>Penaeid shrimp</td>
</tr>
</tbody>
</table>

As a consequence of the rapid growth and development of the penaeid aquaculture industry, many of the most significant shrimp pathogens were moved from the regions where they initially appeared to new regions, even before the ‘new’ pathogen had been recognised, named and proven to cause the ‘new’ disease, and before reliable diagnostic methods were developed. The diseases due to the shrimp viruses IHNNV, TSV and WSSV were all transferred with live shrimp stocks from country to country and from one continent to another well before their aetiology was understood and diagnostic methods were available. With some diseases, the introduced pathogen encountered totally naive hosts with little or no innate resistance. The pandemics due to the penaeid viruses WSSV and TSV, and to a lesser extent to IHNNV, infectious myonecrosis virus (IMNV) and yellow head virus (YHV), have collectively cost the penaeid shrimp industry billions of dollars in lost crops, jobs and export revenue (Table II). The social and economic impacts of the pandemics caused by these pathogens have been profound in countries in which shrimp farming constitutes a significant industry. This paper reviews the current status of the currently OIE-listed penaeid shrimp diseases in terms of their biology, distribution, production impacts and methods used for their diagnosis/detection.
**OIE-listed diseases of penaeid shrimp**

**White spot disease (WSD)**

**Biology of the agent**

The causative agent of WSD is WSSV (Table I, Fig. 1). White spot syndrome virus is a very large, enveloped, double-stranded DNA (dsDNA) virus. It was assigned by the International Committee on Taxonomy of Viruses (ICTV) to its own new genus, Whispovirus, and family, Nimaviridae (46, 47). Virions are large (80–120 × 250–380 nm), rod shaped to elliptical and with a trilaminar envelope (13, 73). Negatively stained virions purified from shrimp

![Fig. 1 Schematic of the major viruses of penaeid shrimp. The virions are drawn to scale; scale divisions are 20 nm (see text for definitions of the acronym for each virus)](image-url)
haemolymph show unique, tail-like appendages (Fig. 1) (13, 62, 73). The virions are generated in hypertrophied nuclei of infected cells without the production of occlusion bodies. In initial reports, WSSV was described as a non-occluded baculovirus, but WSSV DNA sequence analysis has shown that it is not related to the baculoviruses (70, 81). The size of the WSSV genome has been differently reported for different isolates but it is around 305 kbp.

Distribution of WSD
Disease due to WSSV has been reported from most shrimp farming countries in Asia, the Middle East and North, South and Central America (35, 62, 74, 79). Only Australia, parts of Africa and some specific zones or compartments can be considered free of WSD according to the guidelines laid out in the OIE Aquatic Animal Health Code (Aquatic Code) (80).

Production impacts
White spot disease remains the most significant disease in penaeid shrimp aquaculture. The approximate cumulative losses due to WSD listed in Table II may be far less than the actual impact of the disease, which was recently estimated to have approached $10 billion since 1993 (1).

Diagnosis/detection
The OIE-recommended method for diagnosis of WSD is by the use of a nested polymerase chain reaction (PCR) method (40, 79). A recent modification has been proposed to the OIE-recommended method; the modified version is a single step-method and has equal sensitivity and specificity to the OIE-recommended method (52).

**Taura syndrome (TS)**

**Biology of the agent**
Taura syndrome virus is a small, simple RNA virus. The virion is a 32 nm diameter, non-enveloped icosahedron (Table I, Fig. 1). The genome of TSV consists of a linear, positive-sense single-stranded RNA of 10 205 nucleotides, and it contains two large open reading frames (ORFs). ORF 1 contains the sequence motifs for non-structural proteins, such as helicase, protease and RNA-dependent RNA polymerase. ORF 2 contains the sequences for TSV structural proteins, including the three major capsid proteins VP1, VP2 and VP3 (55, 40, and 24 kDa, respectively) (5, 44, 45, 60). The virus replicates in the cytoplasm of host cells. Based on its characteristics, TSV has been assigned by the ICTV to the newly created genus *Cripavirus* in new family *Dicistroviridae* (in the ‘superfamily’ of picornaviruses) (46, 47).

Physicochemical and more recent molecular studies of TSV suggest that a single strain of the virus was present in the initial TSV pandemic in the Americas, but that new strains are emerging that differ in host range and virulence (51, 65, 75). Comparison of the complementary DNA (cDNA) sequence of TSV CP2 from approximately 50 TSV isolates in the author’s collection shows that there are currently four distinct strains (or genetic variants) of the virus (65, 75).

**Distribution of TS**
Disease due to TSV has been reported from most shrimp farming countries in Asia, the Middle East and North, South and Central America (35, 74, 79). Only Australia, Africa and some specific zones or compartments can be considered free of TS according to the guidelines laid out in the OIE Aquatic Code (80).

**Production impacts**
After WSD, TS is the second most costly disease to the global shrimp farming industry in terms of lost production (35, 74, 79). The development and global distribution of domesticated, TSV-resistant lines of *P. vannamei* SPF (free of all OIE-listed shrimp diseases) are among the reasons why this species has become the dominant shrimp species famed globally (20, 35, 37).

**Diagnosis/detection**
The OIE-recommended method for diagnosis of TS is by the use of a one-step reverse transcription (RT)-PCR method (79).
**Yellow head disease (YHD)**

**Biology of the agent**
The causative agent of YHD is YHV, gill-associated virus (GAV) and other closely related strains of the same virus (Table I) (79). Yellow head virus is an enveloped, rod-shaped, single-stranded RNA virus in the family Roniviridae in the order Nidovirales. Gill-associated virus, the Australian strain of YHV, has been recognised by the ICTV as the type species for the new virus genus Okavirus in the new family Roniviridae (46, 47, 80). Transmission electron microscopy (TEM) of YHV-infected tissues shows enveloped bacilliform virions, ranging from approximately 150 nm to 200 nm in length and from 40 nm to 50 nm in diameter. They are located within vesicles in the cytoplasm of infected cells and in intercellular spaces. The virions arise from longer, filamentous nucleocapsids (approximately 15 nm × 130–800 nm), which accumulate in the cytoplasm and obtain an envelope by budding through the endoplasmic reticulum into intracellular vesicles. Negatively stained YHV virions show regular arrays of short spikes on the viral envelope (Fig. 1) (6, 9, 35, 74).

**Distribution of YHD**
Disease due to YHV has largely been limited to South East Asia and India (79). At least six genetic variants of YHV are known, and of these only YHV has caused major disease losses. Australian GAV has been linked to disease outbreaks, but none have been as significant as those due to YHV. Other low-virulence genetic variants of YHV have been reported in wild and farmed penaeid shrimp (7, 8, 11, 61, 79). Most of the Americas, East Africa and some specific zones or compartments in East and South East Asia can be considered free of YHD according to the guidelines laid out in the OIE Aquatic Code (80).

**Production impacts**
When YHD emerged in Thailand in 1991 (39), losses were severe and the disease soon became listed by the OIE. The disease remains enzootic in South East Asia, but severe losses due to YHV are infrequently reported (35, 74, 79).

**Diagnosis/detection**
The OIE-recommended method for diagnosis of YHD is by the use of a one-step RT-PCR method (79). Specific methods to distinguish GAV and other non-pathogenic variants of YHV are also provided in the Manual of Diagnostic Tests for Aquatic Animals (79).

**Infectious hypodermal and haematopoietic necrosis (IHHN)**

**Biology of the agent**
Infectious hypodermal and haematopoietic necrosis virus is the smallest of the known penaeid shrimp viruses. The virion is a 22-nm diameter, non-enveloped icosahedron (Table I, Fig. 1). Its genome is linear single-stranded DNA of 3.9 kb in length. Because of its characteristics, IHHNV has been classified as a member of the Parvoviridae and a probable member of the genus Brevidensovirus (4, 5, 35, 43, 55, 63).

**Distribution of IHHN**
After its initial discovery in cultured shrimp in Hawaii in 1981, IHHNV was subsequently found to be widely distributed in cultured shrimp in the Americas and in wild shrimp collected along the Pacific coast from Peru to Mexico (29, 35). As of 2006, the only country in the Americas that can claim to have IHHNV-free zones or compartments (80) is the USA. This was achieved with the development and use of SPF shrimp stocks (59).

Infectious hypodermal and haematopoietic necrosis virus has been found to be widely distributed in wild and cultured *P. monodon* in East and South East Asia where it does not seem to cause production losses (10, 16, 17, 58, 68, 77). Molecular studies have shown considerable variation among Asian isolates of the virus (28, 66, 68), while little variation was found in isolates from the Americas (64). All isolates of IHHNV from the Americas are nearly identical with IHHNV from the Philippines. This finding, along with other aspects of the history and epidemiology of IHHN in the Americas, suggests that IHHNV was introduced from the Philippines with live *P. monodon* that were imported in the mid-1970s as a candidate aquaculture species during the very early development of shrimp farming in the Americas (30, 64, 68).
For the purposes of this review, the IHNV genotype from the Americas/Philippines genotype will be designated as IHNV-I; the variant from South East Asia will be designated IHNV-II; and the IHNV variant from East Africa, Madagascar and Mauritius and from Australia will be referred to as IHNV-III. The first two genotypes (IHNV-I and IHNV-II) are infectious to the representative penaeids, P. vannamei and P. monodon, while the latter genetic variant has been demonstrated to be not infectious to these species (28, 66, 68). The apparent reason for the lack of infectivity of the IHNV-III genotype was recently explained by the discovery that the DNA fragment represented by IHNV-III is incorporated into the genome of some genetically distinct populations of P. monodon in the Indo-Pacific region (12, 66).

Production impacts
Infection with IHNV is most severe in the American penaeids, Penaeus stylirostris and P. vannamei. The disease is especially severe in P. stylirostris, in which the disease may result in very high mortality. In P. vannamei, infection with IHNV causes runt and deformities (RDS disease), resulting in significantly reduced crop value. P. monodon rarely shows signs of IHNN or RDS (29, 35).

Diagnosis/detection
The OIE-recommended method for diagnosis of IHNN is by the use of a one-step PCR method (79). Specific methods to distinguish the integrated form of IHNV in the genome of P. monodon are available (67) and provided in the Aquatic Manual (67, 79).

Infectious myonecrosis (IMN)

Biology of the agent
Infectious myonecrosis virus particles are icosahedral in shape and 40 nm in diameter (Fig. 1). The genome consists of a single, dsRNA molecule of 7560 bp. Sequencing of the viral genome reveals two non-overlapping ORFs. ORF 1 encodes a RNA-binding protein and a capsid protein. The coding region of the RNA-binding protein is located in the first half of ORF 1 and contains a dsRNA-binding motif. The second half of ORF 1 encodes a capsid protein with a molecular mass of 106 kDa. ORF 2 encodes a RNA-dependent RNA polymerase (RdRp). Based on these characteristics, IMNV is most similar to members of the Totiviridae (57).

Distribution of IMN
The disease was first described in cultured P. vannamei in north-east Brazil (32). IMN causes significant disease and mortalities in juvenile and subadult pond-reared stocks of P. vannamei. Although IMN seemed to be confined to the north-east of Brazil, the disease spread to South East Asia and was reported from Indonesia in May 2006 (76). Because of the ever-increasing importance of P. vannamei in the Asia–Pacific and the large-scale transboundary movement and culture of the species, IMNV was considered important for the region and it was added in January 2006 to the Network of Aquaculture Centres in Asia–Pacific (NACA)/FAO/OIE (Asian Region) Quarterly Aquatic Animal Disease Report list for the purpose of surveillance and reporting. Infectious myonecrosis was listed by the OIE in 2005 (78).

Production impacts
Estimates for losses from IMN from 2002 to 2006 in Brazil exceed $100 million (35, unpublished data from the Brazilian Shrimp Farmers Association). Losses in Indonesia have been very significant and may exceed $1 billion by 2010 (Table II).

Diagnosis/detection
The OIE-recommended method for diagnosis of IMN is by the use of a nested RT-PCR method (56, 79).

Necrotising hepatopancreatitis (NHP)

Biology of the agent
The bacterial agent of NHP is an unclassified alpha-proteobacterium based on sequence analysis of its 16S rRNA (41, 72). Phylogenetic analyses also indicate that this bacterium is closely related to bacterial endosymbionts of protozoa Caedibacter caryophilus and Holospora obtusa. The NHP bacterium is a gram-negative, dimorphic,
intracellular rickettsia-like organism that occurs free within the cytoplasm of infected hepatopancreatic cells. The predominant form is a rod-shaped rickettsia-like organism (0.25 × 0.9 nm), whereas the helical form (0.25 × 2–3.5 nm) possesses eight flagella at the basal apex (38). The target tissue is the hepatopancreas, with NHP infection reported in all hepatopancreatic cell types. Elevated temperature (29–35°C) and salinity (20–40 parts per thousand [p.p.t.]) are associated with overt clinical disease (29, 48, 49). The bacterial agent of NHP has not been cultured. Hence, laboratory infections using live shrimp are necessary for research applications (23, 72). Recently, additional information on the genome sequence has become available, and the name *Hepatobacterium penaei* has been proposed for the bacterial agent of NHP.

**Distribution of NHP**

In the Americas, NHP occurs in most shrimp farming regions. The disease typically occurs when water temperatures and salinity are elevated (22, 72). The major shrimp-producing countries of South East Asia have remained free of NHP despite numerous, careless introductions of potentially infected stocks of *P. vannamei*. While NHP has apparently not been introduced and become established in South East Asia, the reason may be due to the nature of the disease and its requirement for high water temperatures and high salinity (from a prolonged dry season). Necrotising hepatopancreatitis (and TSV) were introduced to an arid, hot location in north-east Africa with a careless introduction of *P. vannamei* and it became temporarily established in the shrimp stocks reared at the importing location. Eradication of the disease required depopulation and fallowing (75). Other regions of south central Asia (e.g. India, East Africa and the Middle East have extended dry seasons with high water temperatures and they are beginning to import *P. vannamei*, which may result in the introduction of NHP into these regions.

**Production impacts**

After WSD, TS and vibriosis, NHP is perhaps the most significant disease in the Americas in terms of production losses and its cost of management (29). Where NHP occurs it causes significant production losses in shrimp farms, which may approach 100% if not correctly diagnosed and treated. The occurrence of NHP seems to be dependent upon a combination of high temperature and high salinity, with the disease most often tending to occur in regions where it is enzootic during the dry season when water temperatures and salinity are near to or greater than 30ºC and 30 p.p.t., respectively (27, 48, 49). In some epizootics of NHP, entire shrimp-farming regions are severely impacted with significant crop losses (27, 29, 36). While NHP can be treated with medicated feeds containing certain antibiotics to which the causative bacterium is sensitive, cultured stocks with developing infections of NHP are often not diagnosed before going off feed and becoming difficult or impossible to treat (29).

Because of its adverse effects on the shrimp-farming industry of the Americas, the trend towards reduced antibiotic use in shrimp farming and the likely transfer of NHP to semi-arid and arid regions in Asia, the Middle East and Africa, the disease was listed by the OIE in 2010 (80).

**Diagnosis/detection**

The method of diagnosis is PCR using the published methods described in Loy *et al.* (41, 42), Vincent and Lotz (71) and Nunan *et al.* (53).

**Conclusion**

Despite the huge negative impact of disease on the global shrimp-farming industry, it has continued to grow and mature into a more sustainable industry. In marked contrast to 30 years ago when PLs produced from wild adults and wild PLs were used to stock farms in the Americas, the industry now relies on domesticated lines of broodstock that have undergone selection for desirable characteristics including disease resistance (37, 50). The listing of the most important disease of farmed penaeid shrimp has helped elevate awareness of these diseases by governments and the global industry.
Acknowledgements

Grant support for the author of this review was provided by the United States Marine Shrimp Farming Consortium under Grant No. 2010-38808-21115 from the National Institute of Food and Agriculture of the United States Department of Agriculture, and a grant from the National Fisheries Institute.

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Contemporary issues in molluscan health: challenges and opportunities

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Summary

This presentation aims to provide perspective on contemporary challenges and opportunities in the management of molluscan health.

While challenges remain from pathogens such as Bonamia spp. and Perkinsus spp., the list of critical contemporary issues begins and ends with emerging herpes viral diseases. A viral ganglioneuritis, listed by the World Organisation for Animal Health (OIE) as infection with abalone herpes-like virus, continues to plague abalone populations in Taiwan and Australia, but more troublesome has been the emergence of the molluscan herpes viral strain ‘OsHV-1 μvar’ in populations of the Pacific oyster, Crassostrea gigas, a key global aquaculture species. This virus has been associated with high oyster mortality in Europe, Australia and New Zealand. These outbreaks have raised basic questions about viral diversity and evolution, especially with respect to virulence, and about mechanisms of transmission. They have also raised questions about our ability to detect and manage viral diseases of molluscs, particularly against a backdrop of international trade. The OsHV-1 μvar story is hardly one of a successful response to a serious emerging disease, but we can learn lessons from it.

Although infection with Ostreid herpesvirus-1 has not been listed as an emerging disease because it does not meet the OIE criteria for listing (Aquatic Code, Article 1.2.2.), the Aquatic Animal Health Standards Commission has recommended that a chapter be developed on this infection for the Aquatic Manual to provide guidance for Members on this disease.

As human impacts on marine environments deepen, we are increasingly aware that environmental stressors may interact with pathogens and affect disease processes, though not always predictably. Some anthropogenic inputs may exacerbate diseases. It has been suggested, for example, that immunosuppression in the oyster Saccostrea glomerata in Australia caused by agricultural run-off has heightened susceptibility to disease caused by Martelia sydneyi. Conversely, a recent study found that dinoflagellate Prorocentrum minimum may adversely affect the protistan pathogen Perkinsus olseni, raising the possibility that an external stressor such as a harmful algal bloom may actually help to mitigate molluscan diseases. Our understanding of marine molluscan diseases and identification of optimal strategies for their management will benefit from an understanding of these complex interactions. This promises to be a dynamic area of future research.

Keywords

Introduction

Since Malpeque disease first devastated eastern oysters (Crassostrea virginica) cultured in Prince Edward Island, Canada, in 1915 (25), epizootic diseases have been recognised as significant threats to mollusc production in different parts of the world. While the etiological agent of Malpeque disease remains unknown, most important molluscan diseases are better understood, and most are caused by protistan parasites such as: the Perkinsus spp. parasites responsible for the diseases known as perkinsosis in bivalves and gastropods; Martelia refringens and Martelia sydneyi, agents of martelliosis in bivalves; Mikrocytos mackini, the cause of mikrocytosis in oysters; haplosporidian parasites Bonamia ostreae and Bonamia exitiosa, which cause bonamiosis in oysters; and the various spore-forming haplosporidians that infect a number of invertebrate phyla, including Mollusca. Several
of these diseases, including infection with *Perkinsus marinus*, *Perkinsus olseni*, *B. ostreae*, *B. exitiosa*, and *M. refringens*, are diseases notifiable to the World Organisation for Animal Health (OIE-listed diseases). Other OIE-listed mollusc diseases affecting abalone are infection with *Xenohaliotis californiensis*, a bacterial disease, and infection with abalone herpes-like virus.

While remaining knowledge gaps concerning many of these pathogens hamper our ability to control them – the life cycles of *Martelia* spp., for example, are largely unresolved (3), and those of haplosporidians such as *Haplosporidium nelsoni* are not resolved at all – they have long been the focus of aquatic animal health programmes, and significant new developments with respect to the distribution and impact of the major protistan pathogens of molluscs have occurred only occasionally. Nonetheless, the situation with respect to these pathogens remains fluid, and numerous challenges in molluscan health management remain. In this paper four contemporary challenges will be highlighted. Two of these are chronic (preventing pathogen range expansions, and understanding the taxonomic identity and distribution of pathogens), and a third we are only beginning to appreciate (the impact of multiple stressors on molluscan health). The fourth, the emergence of the molluscan herpesviruses, is the most significant challenge that we presently face. To close two opportunities that arise from the herpesviral challenge will be highlighted.

**Challenges**

**Preventing range expansions**

The distributions of the major protistan pathogens of marine molluscs, for the most part, have been established for decades. The catastrophic introductions of *H. nelsoni* from Asia to eastern North America before 1957 (5), and of *B. ostreae* from western North America to Europe in the 1970s (14), continue to recede into the past, and the likelihood of major new translocations decreases as international commerce in molluscs becomes more secure and controlled. Nonetheless, we are reminded that the threat of disease introduction remains if we are not vigilant about prevention. The introduction of *P. marinus* (Fig. 1) to the Pacific coast of Mexico, presumably via direct seafood industry transfers of infected *C. virginica* from Mexico’s Gulf coast (7) into the Pacific, is an important recent example. The parasite found a susceptible host in Pacific waters in the oyster *Crassostrea cortesiensis*, a native species sister to type host *C. virginica*, and *P. marinus* now complicates efforts to expand production of *C. cortesiensis* and diversify Mexican oyster production beyond Pacific oyster *Crassostrea gigas*. *P. olseni* has been detected in ornamental *Tridacna* clams imported to the USA (33) highlighting both the potential for translocation of this pathogen and the risk posed by the ornamental industry, which is not everywhere as tightly controlled as the seafood industry, and which may place dangerous pathogens in the hands of individuals uneducated as to the risks that may be associated with the release of unwanted ornamental animals to local waters.

*Fig. 1* *Perkinsus marinus* infecting the oyster *Crassostrea virginica*, a case presenting the gut epithelial destruction typical of advanced *P. marinus* infection. Scale bar = 10 µm
Pathogen species with simple, direct life cycles are more likely to be successfully introduced to new systems than are species whose complex life cycles need to be constructed anew. Those with wide actual and potential host ranges are more likely to find a susceptible host in a recipient system. This, at least in part, explains why Bonamia spp. have a greater demonstrated record of introduction than Marteilia spp., for example, and why P. olseni, among the major protistan pathogens, may be the greatest introduction threat of all.

**Understanding the taxonomic identity and distribution of pathogens**

Increased sampling of new potential molluscan hosts in new locations, and the continuing development and expanded application of molecular methods, has produced a more nuanced view of pathogen distributions. The recognised geographic and host distributions of P. olseni (Fig. 2) expand continually. Nevertheless, numerous investigators have found that presumptive P. olseni infections have actually been caused by phylogenetically distinct parasites, such as Perkinsus honshuensis in Venerupis philippinarum in Japan (13) and Perkinsus beihaiensis in Crassostrea hongkongensis and Crassostrea ariakensis in the People’s Republic of China (27). Additional observations in Brazil may represent P. beihaiensis, or alternatively may be a distinct parasite species (30). Only P. olseni among these is a notifiable pathogen (OIE listed), however, so distinguishing this parasite from others is critical to optimise management regimes for P. olseni: they should provide control of, and protection from, P. olseni, while not unnecessarily constraining commerce by being applied to superficially similar but less consequential pathogens.

The issue of pathogen identities and distributions has more prominently (and controversially) arisen in the case of B. exitiosa (Fig. 3). Described originally from New Zealand, reports in recent years have placed this parasite in Australia, infecting Ostrea angasi (9), and in Spain, infecting Ostrea edulis (1). In 2010, B. exitiosa was discovered in England. This, like the observation in Spain, was viewed as an invasion by an exotic pathogen. The story is complicated, however, by the presence in widely varying locations of other Bonamia parasites that, in terms of appearance and DNA sequences, are indistinguishable from B. exitiosa: in Ostrea puechiana in Argentina (24); in C. ariakensis and Ostrea equestris in the south-eastern USA (4, 6); and in Ostrea stentina in Tunisian and Italian waters of the Mediterranean (22, 28). Bonamia roughleyi (16) is also indistinguishable from this group of parasites, which prevented the identification of the parasites from Argentina, the south-eastern USA and the Mediterranean as either B. exitiosa or B. roughleyi (22). Hill et al. (22) argued that there is no basis for discriminating any among this group, and suggested that these parasites, including B. exitiosa and B. roughleyi, ‘may belong to a single species’. Rather than dispersing recently as an inadvertent result of human activities, and requiring a management response appropriate to a pathogen invasion, this protist, if indeed one species, may actually be panzootic in numerous host species and simply went unrecognised as such, before sufficiently wide application of molecular techniques made its detection possible.

**Fig. 2** Perkinsus olseni infecting abalone Haliotis laevigata. Scale bar = 10 µm
Multiple stressors and molluscan health

Disease, of course, reflects the interaction of host, pathogen and environmental factors (34). A contribution of external factors in determining disease dynamics is assumed, even where it has not been empirically determined. Here I will consider harmful algal blooms as an important external influence. In many parts of the world, anthropogenic eutrophication of coastal systems has produced harmful algal blooms (HABs) that are increasing in frequency and intensity (2). Hypoxia produced by the sinking and decomposition of these blooms can be stressful to marine organisms, and the blooms themselves may be toxic, but recent evidence suggests that the HAB species may also interact with host–pathogen dynamics in unexpected ways.

The effects of HABs on molluscan health can be direct and species specific (17). They are typically adverse, compromising nutrition and reproduction (18), causing pathology to digestive glands, stomach and intestinal epithelia, and gills (20, 29), and sometimes resulting in death of exposed individuals (19). Indirect effects are less clear but warrant consideration. Galimany et al. (17) observed elevated bacterial levels in Prorocentrum minimum-challenged mussels, Mytilus edulis, suggesting that this HAB organism, P. minimum, present in the mussel gut by virtue of its ingestion during feeding, may reduce the mussel’s ability to manage its microbial flora. The implication was that this could increase susceptibility to bacterial infection. Hégaret et al. (20) made similar observations of elevated gut bacteria levels in P. minimum-challenged clams, Ruditapes philippinarum. These observations may be the product of host defences compromised by HAB exposure, reducing the molluscs’ ability to control gut bacteria populations. Conversely, they may reflect enhancement of bacterial growth promoted by the algal cells or their products. Either way, they suggest that interactions between molluscs and potential pathogens may be altered by HAB exposure. This begs the question: how might HAB exposure affect interactions with the major protistan pathogens of molluscs?

Conceivably, HABs may place stress on hosts that compounds the negative effects of established infections. Hégaret et al. (20), for example, found the effects of P. Olseni to be greater on P. minimum-challenged clams (R. philippinarum) than on control clams. The compounding effects of HABs and pathogens such as Perkinsus spp. may not reflect the reality of complex interactions among host, pathogen and bloom organisms, however. While both pathogens and HAB organisms interact with hosts, they may also interact with each other. Significant algal toxicity on P. Olseni has been documented for both Karenia spp. and P. minimum (11, 20, 21), raising the possibility that some HABs may mitigate, rather than exacerbate, parasite effects. The potential HAB impact on the C. virginica-P. marinus interaction is particularly intriguing: the parasite and HAB organisms may interact not only in the environment, but also in the medium of the oyster gut, an apparent portal of entry for P. marinus (Fig. 4). As with the HAB–clam systems above, we must envision three-way interactions among molluscan hosts, pathogens and each locally relevant HAB species, with the entire system influenced by environmental factors.
Emerging viral diseases

Herpesviruses have long been associated with disease in molluscs, such as the Pacific oyster, C. gigas, ‘summer mortality’, to which a herpesvirus contributes in Europe and western North America. More dramatic effects, however, have recently been apparent in abalone and oyster systems. Beginning in January 2003, a mass mortality of cultured abalone Haliotis diversicolor became apparent in Taiwan (8), and similar effects were observed in Haliotis rubra and Haliotis laevigata farmed in Australia in December 2005 and January 2006 (23). In both cases, the outbreaks were due to a novel herpesvirus distantly related (10, 31) to the ‘Ostreid herpesvirus’ previously known from C. gigas, R. philippinarum and other species. The new virus caused a viral ganglioneuritis in the abalone. More troublesome, because of the unique significance of its host in global aquaculture production, has been the emergence of the OsHV-1 μvar infecting C. gigas. This virus, a new variant of the herpesvirus (OsHV-1) established in Europe and elsewhere, appeared suddenly in France in 2008 and caused markedly higher seed oyster mortality, sometimes approaching 100%, than had been previously caused by the established OsHV-1 (32). In subsequent years transfers of infected seed spread the OsHV-1 μvar to growing areas throughout France and from Ireland and the UK to the Netherlands, Spain and Italy (15). Only Italy has thus far been spared significant resulting mortality (12). In the austral summer of 2010–2011, New Zealand and Australia reported significant mortality in some of their C. gigas-growing areas, with OsHV-1 μvar again associated with the mortality. While this concurrent yet remote OsHV-1 μvar emergence has not been explained, it raised the prospect of panzootic disease in a species critically important to global aquaculture industries.

The imposition of biosecurity measures to combat the OsHV-1 μvar outbreak has been slow, reflecting two significant challenges made apparent by this viral outbreak. The first is the obvious difficulty of imposing new regulation on a global industry of such great economic significance. The reluctance by many to accept the central role of OsHV-1 μvar in the epizootic, despite compelling scientific support (26, 32), has been related to this. The second challenge is the recognition and designation of pathogen strains of relevance to international animal health management. OsHV-1 is so widespread among C. gigas-growing areas that listing as an OIE-notifiable pathogen, for example, would be difficult to justify. Yet the OsHV-1 μvar strain, genetically distinct based on the current science (32) and distinctly more pathogenic than the OsHV-1 reference strain, is much more restricted in its apparent distribution and would fit criteria for OIE listing. The criteria for designating specific pathogen strains, however, are not resolved for the herpesviruses or any other pathogens of concern to the molluscan health community, a problem that clearly requires attention.
Opportunities

As devastating as the OsHV-1 μvar epizootic has been to affected countries, we may learn lessons from it that will be useful as global molluscan aquaculture industries continue to grow. While two of these lessons have been framed as ‘challenges’ in the preceding section, two others are more optimistically expressed as opportunities as we look to the future.

To consider more ‘artisanal’ industry structures

Most Pacific oyster production in Europe derives from a handful of large hatcheries and a couple of wild spat collection areas, all located in France. This represents a significant commercial bottleneck, to which the spread of the OsHV-1 μvar throughout European C. gigas-growing areas can probably be attributed, as noted above (15). Already there is interest in the establishment of more varied seed sources, which would likely take the form of smaller, more widely distributed hatcheries. This is a positive development that deserves support. Vertically integrating seed production, nursery and grow-out on smaller spatial scales would reduce the large-scale animal translocation from relatively few sources that is conducive to the rapid spread of emerging disease. It would also be harmonious with ‘varietal diversification’ to cultured stocks locally adapted to the environments and pathogen profiles (including pathogen strains, about which little is presently known) of specific regions. Nascent industries in developing countries should consider the merits of such commercial structures.

To reconsider which species we produce

In the light of the OsHV-1 μvar epizootic, it is clear that international dependence to such a significant degree on a small number of cultured species – the Pacific oyster, C. gigas, the Manila clam, R. philippinarum – is not without risk. With respect to oysters, in particular, the domestication of C. gigas is far ahead of other species, but consideration should be given to developing or expanding the culture of other species in the genera Crassostrea, Saccostrea, and Ostrea to provide a more diverse foundation for regional molluscan aquaculture industries. Expanding the culture of other molluscan orders and classes (clams, gastropods) would serve the same worthy purpose. While animal health may be somewhat beside the point, this strategy relates directly to the larger issue of food security, and so human communities dependent on molluscan aquaculture industries would do well to give aquaculture species diversity new consideration.

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Amphibian pathogens and global trade: an overview

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Summary
The global trade in amphibians for food and the ornamental animal industry entails the transport of tens of millions of live animals each year. In addition to the impact that harvesting wild animals can have on the long-term sustainability of anuran populations, there is mounting evidence that the emerging pathogens Batrachochytrium dendrobatidis (chytridiomycosis) and ranaviruses, are spread through this trade. The link between these pathogens and amphibian population decline and, for some species, extinction, suggests that the epidemiological impact of the trade is significant, and may negatively affect conservation and trade economics. This presentation provides a brief assessment of the volume of the global trade in live amphibians and the risk of individuals harbouring infection, and provides information on the recent listing by the World Organisation for Animal Health (OIE) of two diseases of amphibians, i.e. infection with B. dendrobatidis and infection with ranavirus, in the OIE Aquatic Animal Health Code, making them notifiable diseases.

Keywords

The global amphibian crisis
The Global Amphibian Assessment (GAA) of 2004 estimated that 43% of all amphibian populations worldwide were in decline and 32% (1,856 amphibian species/5,743 described species of amphibians) were threatened with extinction (51). At the time the assessment was conducted, nine extinctions of amphibian species had been recorded since 1980; an additional 113 amphibian species were thought to be extinct (based on records obtained from the International Union for Conservation of Nature and Natural Resources (IUCN) Red List) (42). Smith et al. (49) analysed the patterns of amphibian decline in tropical American species. The data indicated that those species most likely to decline to the brink of extinction were those with a low occupancy (number of amphibians at a given site) and a high degree of endemism. Thus, it appears that many of the most rare and unique amphibian species are being lost, resulting in homogenisation of other amphibian species across a range of sites and thereby reducing biodiversity at regional and global levels.

Recent research has identified two diseases that have been implicated in a global increase in amphibian mortality: chytridiomycosis, an emerging fungal disease, is caused by the pathogen Batrachochytrium dendrobatidis (Bd); and ranaviral disease (family Iridoviridae), is an emerging viral disease caused by ranaviruses (4, 11, 26). A series of papers has discussed the likely origin of these pathogens and the causes of their emergence; many outputs implicate the international trade in amphibians for food, companion animals, ornamental garden animals, scientific research, introduced or released animals and zoo animals as the reasons (10, 11, 14, 16, 36). However, debates continue on the relative importance of trade and other drivers in amphibian disease emergence (27).

Batrachochytrium dendrobatidis
Batrachochytrium dendrobatidis is a lethal, pathogenic fungus of amphibians (4). It has a global distribution and infects a wide range of amphibian hosts (15). Batrachochytrium dendrobatidis feeds on keratin in the epidermal skin layer, contributing to the onset of a disease known as chytridiomycosis (4). Clinical signs of heavy infection include hyperkeratosis, skin sloughing, erosions of the epidermis and occasional ulcerations (5, 37). Excessive shedding of the skin may be visible 12–15 days after exposure to fungal zoospores and can result in death within one to four weeks (37). Lethal infections appear to disrupt the transport of electrolytes (i.e. plasma sodium and
potassium) across the epidermis resulting in asystolic cardiac arrest and death (54). Chytridiomycosis is known to cause high mortality rates in adult anurans and Bd is considered among the world's worst invasive, alien species (4, 30).

In the wet tropics of Queensland, Australia, the prevalence of Bd infections in stream-dwelling frogs were found to be highest during the cool, dry months and at higher elevations (600–800 m above sea level), suggesting regulation by climatic conditions, such as temperature and precipitation (59). Temperate amphibian fauna appear to be more susceptible to lethal infections at low elevations than are tropical frogs (25). Kriger et al. (25) also found that the prevalence and intensity of infections appeared to be greatest at locales with high rainfall and cool temperatures. Further data have also provided evidence that the amount of direct contact with other infectious animals, water or substrates (as above) could be a predictor of individual or species survival (43).

It is still unclear why certain species are more susceptible to chytridiomycosis than others, but it appears that a number of environmental factors may be at play. For example, while experimental infections of Bd can be lethal in White's tree frog (Litoria caerulea) in captivity, infected populations of this species in the wild appear to be stable (10). Furthermore, while Bd is capable of causing death and disease in the laboratory and in the wild in a number of amphibian species, others appear to be resistant to the adverse effects of infection, such as the North American bullfrog (Lithobates catesbiana) (11).

The composition of biota found on a frog's skin has been implicated in influencing survival or mortality. Experimental studies have found an increased survival rate, for instance, in amphibians with a high concentration of violacein on their skin, an antifungal metabolite produced by the betaproteobacterium Janthinobacterium lividum, a normal inhabitant on the skin of a number of amphibian species (1). Amphibians are also known to secrete a variety of antimicrobial peptides as an innate immune defence, some of which are more effective at inhibiting the growth of Bd than others (41, 59).

**Ranaviral disease**

First isolated from Lithobates pipiens (Northern leopard frog) in the mid-1960s (19), ranaviruses are members of the family Iridoviridae and are known to infect amphibian, fish, insect and reptilian hosts (2, 31, 33, 52). Reported signs of ranaviral disease include loss of appetite, lethargy, swollen areas on the head and limbs, skin ulcerations, haemorrhaging (of the liver, kidneys and intestines), subcutaneous and intramuscular oedema, pale coloration, impaired mobility, and distended intestines (17, 35).

Transmission of ranaviruses has been reported to occur through contact with contaminated water and tissue, and the handling of healthy individuals by persons who had recently handled infectious animals (23). Ranaviruses are known to cause disease in adult and juvenile amphibians globally (8, 23, 40, 48). Large die-offs are often observed (9); however, the capacity of ranaviral infections to cause sustained declines is unknown (11). A study investigating differential mortality rates failed to identify predictable outcomes, concluding that virulence varies with host species and viral strain (48). Ranaviral infections in wild populations can lead to recurring die-offs from one year to the next. Evidence supports intraspecific transmission through chronic, sublethal infections of recent metamorphs (i.e. having undergone metamorphosis from tadpole to adult frog) returning to seasonal breeding sites, thus infecting the following year’s young and facilitating cyclic epidemics (6).

**Wildlife trade and the spread of amphibian pathogens**

Identifying reservoir hosts is critical to understanding the emergence and spread of infectious diseases. In the case of globally dispersed, recently emerged pathogens, the probability that such hosts are among those being dispersed internationally through the live animal trade is highly probable. Amphibians are transported internationally on a grand scale (on average 5.1 million per annum, 2000–2005 inclusive) (47). For years, authors have alluded to the potential for the international live animal trade to contribute to the global spread of amphibian pathogens (16). Scientific investigations set out to test the validity of this premise have provided evidence supporting the transport of Bd and ranaviruses on amphibian hosts (39, 46, 47).

Researchers have proposed Lithobates catesbeianus (North American bullfrog) and Xenopus laevis (African clawed frog) as prime suspects for the global dispersal of amphibian pathogens through trade routes (14, 16, 35). In
order to assess current trends and quantify the threats, data on the importation of amphibians into the USA were analysed for three major ports of entry (Los Angeles [LA], New York [NY] and San Francisco [SF]) (47). In excess of 28 million live individuals were imported into these ports over a 6-year period. *L. catesbeianus* were imported in far greater numbers than *X. laevis*, suggesting it as a high-risk species for the current, international transport of amphibian pathogens. Therefore, samples were collected from freshly imported market *L. catesbeianus* sold for human consumption in LA, NY and SF, and infection with both pathogens was found in all three cities and all seasons (47). Overall infection prevalence was calculated at 62% and 8.5% for *Bd* and ranaviruses respectively by polymerase chain reaction (PCR) testing (47). These results definitively identify the presence of two important pathogens in recently imported live market frogs in the USA.

Large-scale production of *L. catesbeianus* for human consumption has been ongoing since the early part of the 20th Century, particularly in Brazil, a pioneer in bullfrog farming, following its introduction in the 1930s. A previous study documented *Bd* infections in farmed *L. catesbeianus* in Uruguay (34). The author noted that the stocks for the farm's start-up originated in Brazil (34). In order to determine if *L. catesbeianus* introduced to Brazil and farmed for the food trade serve as reservoirs for amphibian disease, individuals located in the Brazilian states of São Paulo and Pará were tested to determine the prevalence of *Bd* infections (46). Results confirmed *Bd* infection on five farms (78.5% infection prevalence overall) by PCR testing. Isolates were obtained from three of the five farms and genotyped at 17 loci using multilocus sequence typing. Five isolates from the Brazilian farms were genotypically similar to each other as well as to isolates from Central and South America. Isolates from farmed bullfrogs were more similar to isolates from introduced populations in Venezuela than to those from the native range of the bullfrog in eastern North America. These results could have important implications for the origin and spread of *Bd* in Brazil and its neighbouring regions, as well as the conservation of native amphibian fauna. They may also suggest a potential for prior recombination within *Bd* in *L. catesbeianus*, which may have implications for the recent emergence of this pathogen.

Some have put forth the argument that, given the presence of *Bd* on a worldwide scale, what threat does the possible spread of the pathogen through the trade actually pose? In sequencing a global data set of *Bd* isolates, Farrer et al. (13) detected the presence of two lineages of *Bd* that are genetically divergent from the pandemic strain associated with global amphibian declines. One of these novel strains was isolated from the island of Mallorca (Spain), and its introduction appears to be the result of the intentional release of infected animals through a sanctioned reintroduction programme. The observed presence of distinct lineages of *Bd*, and their apparent spread into new regions through human-mediated pathways, could play a role in the mixing of pathogen genotypes. The pandemic lineage of *Bd* is lethal to a wide range of amphibian species, but there are still many that are only mildly susceptible to infection. The mixing of *Bd* genotypes could have far-reaching implications should a more virulent strain emerge, spread rapidly through trade routes and cause a secondary wave of extinction.

It has become increasingly evident that the international live animal trade can have damaging effects on the health and persistence of amphibian populations worldwide. Given the threatened status of many amphibian species and the apparent risks associated with the international transport of live animals, national and international organisations are taking steps to foster awareness and minimise the hazards associated with the international trafficking of amphibians and their pathogens. In 2008, the World Organisation for Animal Health (OIE) made chytridiomycosis and ranavirus internationally notifiable by listing them in the OIE’s *Aquatic Animal Health Code* (45). The addition of these pathogens to the OIE list of diseases came in response to their significant impact on animal health and to accumulating evidence that the live animal trade is contributing to the global spread of the pathogens. This was a momentous achievement for amphibian conservation, made only ten years after the discovery of chytridiomycosis, and notable for addition of the first, and only, amphibian pathogens to the OIE list of notifiable diseases.

**References**


Food safety and aquatic animals

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Summary

While the supply of fish from wild capture fisheries has stagnated over the years, the demand for fish and fish products continues to rise. Consumption has more than doubled since 1973. This increasing demand has been steadily met by a robust increase in aquaculture production, estimated at an average 8.3% yearly growth over the period 1970–2008. This trend is projected to continue, with the contribution of aquaculture to fish food supply estimated to reach 60% by 2020, if not before.

Likewise, fish and seafood are the most traded food commodity. Around 32–40% of the fish harvested globally have entered international trade over the last 40 years, increasing the total export value from a mere US$8 billion in 1976 to an estimated US$102 billion in 2008. Aquaculture production contributes significantly to this trade in fish. Developing countries contribute almost 50% of the value of world fish exports. On the other hand, three main import markets, the European Union, Japan and the USA, represented in total 70% of the import value in 2008. These markets dominate international fish trade in terms of price and market access requirements, especially the requirements for the safety and quality of fish.

Consumer protection has been and will remain a major concern for many countries. The recurring food and feed scares of the last decades (bovine spongiform encephalopathy, dioxins, avian flu, severe acute respiratory syndrome, melamine) exacerbate this concern and frequently make headlines in the media. Likewise, the increased globalisation of the fish trade has highlighted the risk of cross-border transmission of hazardous agents, and the rapid development of aquaculture has been accompanied by the emergence of food safety concerns such as microbial food infections and residues of veterinary drugs.

Many countries have responded by the enactment of a range of public regulatory frameworks for food safety and quality and for the protection of the environment from the negative impacts of aquaculture. Official standards published by the World Organisation for Animal Health (OIE) and the FAO/WHO (World Health Organization) Codex Alimentarius Commission are the technical references for health and safety measures affecting international trade that are adopted by Members of the World Trade Organization. In addition, a range of related standards have been introduced by the private sector (processors, retailers) or non-governmental organisations.

This presentation will review the safety and quality issues related to aquaculture production and the appropriate systems to manage these risks, as well as highlighting the need for well-designed practices to manage aquatic animal health and provide the basis for the application of good aquaculture practices and hazard and critical control point (HACCP) analysis in aquaculture.

Keywords


* The views expressed in this publication are those of the author and do not necessarily reflect the views of the Food and Agriculture Organization of the United Nations. Also the designations employed and the presentation of material in this information product do not imply the expression of opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Content and errors are exclusively the responsibility of the author.
**Introduction**

From very ancient times, fisheries have been an important source of food and also a provider of livelihoods and economic benefits for those engaged in harvesting, culturing, processing and trading of fish.

Likewise, fish and seafood are commodities that have been preserved and traded since the Bronze Age. According to the FAO (3), around 32–40% of the fish harvested globally has entered international trade over the last 40 years, increasing in total export value from a mere US$8 billion in 1976 to an estimated US$102 billion in 2008. Developing countries contribute almost 50% of the value of world exports of fish and fishery products, and their net receipts of foreign exchange (i.e. deducting imports from the value of exports) increased from US$1.8 billion in 1976 to US$27.2 billion in 2008 (3).

This increased globalisation of the fish trade has highlighted the risk of cross-border transmission of hazardous food agents, and the rapid development of aquaculture has been accompanied by the emergence of food safety and quality concerns. For example, the European Union (EU) alert system for food and feed has indicated that fish and fishery products were often responsible for a large proportion, and sometimes the largest proportion (up to 25%), of food safety and quality alerts during the period 2000–2005. Of these, aquaculture products were involved in 28–63% of alert cases, mainly because of the presence of high residues of veterinary drugs, unauthorised chemicals and bacterial pathogens. For example in 2005, 177 alert cases were due to aquaculture products that contained bacterial pathogens (37%), nitrofurans (27%), malachite green (20%), excess residues of sulphites (13%) and unacceptable residues of veterinary drugs (3%). Similar food safety problems have been reported by the control authorities of other major fish-importing countries (1).

As a result, a wide range of public regulatory frameworks for food safety and quality and for the protection of the environment from the potential negative impacts of fisheries and aquaculture have been implemented. In addition, a range of related standards have been introduced by the private sector (e.g. processors, retailers) or by non-governmental organisations (NGOs).

This paper reviews developments in aquatic food safety and quality and their implications for aquaculture development and the fish trade, with specific consideration given to developing countries.

**Fish production and trade**

World production from capture fisheries and aquaculture remains very significant for global food security and food trade, providing an apparent per capita supply of 17.2 kg live weight equivalent (LWE) in 2009. It averaged 138.2 million tonnes per year during the period 2000–2009, with a record high of 145.1 million tonnes in 2009 (Table I).

While fish production from capture fisheries has stagnated at around 90–92 million tonnes per year over the years, the demand for fish and fishery products has continued to rise. Consumption has more than doubled since 1973. The increasing demand has been steadily met by a robust increase in aquaculture production (Fig. 1), estimated at an average 8.3% yearly growth over the period 1970–2008, while the world population grew at an average of 1.6% per year. As a result, the average annual per capita supply of fish from aquaculture for human consumption has increased 10-fold, from 0.7 kg in 1970 to 7.8 kg in 2008, at an average growth rate of 6.6% per year. This

![Fig. 1 Global fisheries and aquaculture production, 1950–2008 (1)](image-url)
Table I World fisheries and aquaculture production and utilisation, 2004–2009 (3)

<table>
<thead>
<tr>
<th></th>
<th>Year</th>
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<tbody>
<tr>
<td></td>
<td>2004</td>
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<tr>
<td>Production (million tonnes/year)</td>
<td></td>
</tr>
<tr>
<td>Inland</td>
<td></td>
</tr>
<tr>
<td>Capture</td>
<td>8.6</td>
</tr>
<tr>
<td>Aquaculture</td>
<td>25.2</td>
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<tr>
<td>Total inland</td>
<td>33.8</td>
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<tr>
<td>Marine</td>
<td></td>
</tr>
<tr>
<td>Capture</td>
<td>83.8</td>
</tr>
<tr>
<td>Aquaculture</td>
<td>16.7</td>
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<tr>
<td>Total marine</td>
<td>100.5</td>
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<tr>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>Capture</td>
<td>92.4</td>
</tr>
<tr>
<td>Aquaculture</td>
<td>41.9</td>
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<tr>
<td>World fisheries</td>
<td>134.3</td>
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<tr>
<td>Utilisation (million tonnes/year)</td>
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</tr>
<tr>
<td>Human consumption</td>
<td>104.4</td>
</tr>
<tr>
<td>Non-food uses</td>
<td>29.8</td>
</tr>
<tr>
<td>Population (billion)</td>
<td>6.4</td>
</tr>
<tr>
<td>Per capita food fish supply (kg)</td>
<td>16.2</td>
</tr>
</tbody>
</table>

Note: Excluding aquatic plants

trend is projected to continue, with the contribution of aquaculture to fish food supply estimated to reach 60% by 2020, if not before (4).

A brief history of developments in food safety and quality

Evidence from early historical writings, dating back to ancient Assyrian, Egyptian, Greek and Roman times, indicates that governing authorities were already concerned with food control and consumer protection. For example, the Romans had a well-organised state food control system to protect consumers from frauds and bad produce (2). A major change took place following the industrial revolution in the 19th Century. The associated demographic changes resulting from urban development created a massive demand for food that could be processed and stored. This was the start of the modern food-processing industry.

In the latter part of the nineteenth and early twentieth centuries important developments in food safety and quality were achieved. These were mainly stimulated by the discovery of microbiology and major developments in food chemistry. Several discoveries linked specific agents to epidemics of diseases and documented routes by which these agents could be transmitted to humans, including through food and water (5). This enabled major advances in public health to significantly reduce the burden of a number of devastating epidemic diseases.

These achievements were consolidated further during the second part of the 20th Century to accompany the rapid developments and progress in food production, preservation and distribution in many developed countries.
Since 1980 food production and distribution have become more globalised and complex and market choices even wider, and other food scares have emerged globally (see Annex 1) and the media and consumers have developed a greater interest in food safety, ethical practices, and the environmental and social impacts of food production and distribution. Expansion of the food industry and food distribution systems across borders and continents has required the development of quality assurance systems to support business to business (B2B) contractual agreements and verification of conformity of food suppliers with buyers’ specifications. At the same time, the development of bilateral, regional and multilateral trade agreements has brought about changes in national and supra-national food control systems to harmonise requirements and procedures. A major breakthrough came about with the creation of the World Trade Organization (WTO) and the enactment of two international agreements on the sanitary and phytosanitary (SPS) measures and on the technical barriers to trade. These two agreements established the need to develop SPS measures based on science, in particular the assessment of risk, and to promote international harmonisation and equivalence of food standards and control systems to facilitate food trade.

**The international regulatory framework for aquatic food safety and quality**

**The World Trade Organization**

The WTO was established in 1995 as the successor to the 1947 General Agreement on Tariffs and Trade (GATT) as the final act of the Uruguay Round of negotiations, which began in Punta del Este, Uruguay, in September 1986 and concluded in Marrakech, Morocco, in April 1994. The Uruguay Round was the first to deal with the liberalisation of trade in agricultural products, an area excluded from previous rounds of negotiations.


The purpose of the SPS Agreement is to ensure that measures established by governments to protect human, animal and plant life and health in the agricultural sector, including fisheries and aquaculture, are consistent with obligations prohibiting arbitrary or unjustifiable discrimination in terms of trade between countries where the same conditions prevail – and are not disguised restrictions on international trade. It requires that, with regard to food safety and animal health measures, WTO members base their national measures on international standards, guidelines and other recommendations adopted by the Codex Alimentarius Commission (CAC) or the World organisation for Animal Health (OIE), where they exist (Fig. 2). This does not prevent a member country from adopting stricter measures if there is a scientific justification for doing so, or if the level of protection afforded by the Codex or OIE standards is inconsistent with the level of protection generally applied and deemed appropriate by the country concerned.

The SPS Agreement states that measures taken that conform to international Codex or OIE standards, guidelines or recommendations are deemed to be appropriate and necessary and not discriminatory. Furthermore, the SPS Agreement calls for a programme of harmonisation based on international standards. This work is guided by the WTO Committee on SPS measures. Membership includes representatives of the CAC, OIE and the International Plant Protection Convention (IPPC).

![Fig. 2 Sanitary and Phytosanitary (SPS) and Technical Barriers to Trade (TBT) Agreements, Codex Alimentarius and national food safety regulations](image-url)
The Agreement on TBT is a revision of the agreement of the same name, first developed under the Tokyo Round of negotiations (1973–1979). The objective of the TBT Agreement is to prevent the use of national or regional technical regulations and standards as unjustified technical barriers to trade. The agreement covers standards relating to all types of industrial products, including foods (except requirements related to SPS measures). It includes numerous measures designed to protect the consumer against deception and economic fraud.

The TBT Agreement basically provides that standards and technical regulations must have a legitimate purpose and that the impact or the cost of implementing the standard must be proportional to the purpose of the standard. It also states that, if there are two or more ways of achieving the same objective, the least trade restrictive alternative should be followed. The agreement places emphasis on international standards, with WTO members being encouraged to use international standards or parts of them except where the international standard would be ineffective or inappropriate in the national context.

The aspects of food standards that TBT requirements specifically cover are quality provisions, nutritional requirements, labelling, packaging and product content regulations, and methods of analysis. Unlike the SPS Agreement, the TBT Agreement does not specifically name international standard-setting bodies, the standards of which are to be used as benchmarks for judging compliance with the provisions of the Agreement.

**The Codex Alimentarius Commission**

Since 1962, CAC has been responsible for implementing the Joint FAO/WHO Food Standards Programme (see ftp://ftp.fao.org/codex/Publications/understanding/Understanding_EN.pdf). The Commission’s primary objectives are the protection of the health of consumers, the assurance of fair practices in food trade and the coordination of the work on food standards.

The CAC is an intergovernmental body with a membership of 176 countries and one regional economic integration organisation (as of 1 December 2008). In addition, observers from international intergovernmental organisations (e.g. OIE, WTO, International Atomic Energy Agency) and international non-governmental organisations (e.g. scientific organisations, food industry, food trade and consumer associations) may attend sessions of the CAC and of its subsidiary bodies. An Executive Committee, six Regional Coordinating Committees and a Secretariat assist the CAC in administering its work programme and other related activities (2).

The work of the Codex Alimentarius is divided among three basic types of committees:

- 10 general (also called horizontal) subject committees that deal with general principles, hygiene, veterinary drugs, pesticides, food additives, contaminants, labelling, methods of analysis and sampling, nutrition and foods for special dietary uses and import/export inspection and certification systems
- 11 commodity (or vertical) committees that deal with a specific type of food class or group, such as dairy and dairy products, fats and oils, or fish and fishery products
- ad hoc intergovernmental task forces (the number of which is variable) that are established to deal with specific issues within a limited time frame (usually five years).

The work of the committees on food hygiene, contaminants, fish and fishery products, veterinary drugs and import/export inspection and certification systems is of paramount interest to the safety and quality of aquatic products (2).

**Implementation**

Translation of the binding provisions of the SPS/TBT into national food laws and control systems, especially the need to align nationally with the standards developed by Codex Alimentarius and OIE for the safety of aquatic food has led to the development over the years of an integrated, multidisciplinary approach to safety and quality, considering the entire aquatic food chain. The food chain approach is recognition that the responsibility for the supply of food that is safe, healthy and nutritious is shared along the entire food chain – by all involved with the production, processing, trade and consumption of food (6).

In fisheries and aquaculture, there are five broadly defined needs, on which a strategy in support of the food chain approach to food safety should be based:

- Fish safety and quality from a food chain perspective should incorporate the three fundamental components of risk analysis – assessment, management and communication – and, within this analysis process, there
should be an *institutional separation* of science-based risk assessment from risk management – which is the regulation and control of risk.

- **Tracing techniques** (*traceability*) from the primary producer (including animal feed and medicines used during production), through post-harvest treatment, processing and distribution to the consumer must be improved.

- **Harmonisation of fish quality and safety standards**, implying increased development and wider use of internationally agreed, scientifically based standards, is necessary.

- **Equivalence in food safety systems** – achieving similar levels of protection against fish-borne hazards and quality defects whatever means of control are used – must be further developed.

- Increased emphasis on risk avoidance or prevention at source within the whole food chain – from farm or sea to plate – including development and dissemination of good aquaculture practices (GAP), good manufacturing practices and safety and quality assurance systems (i.e. hazard and critical control point [HACCP] analysis), are necessary to complement the traditional approach to fish safety and quality management based on regulation and control.

The implementation of the food chain approach requires an enabling policy and regulatory environment for the development of robust standards and codes of practice, establishment of appropriate food control systems and programmes at national and local levels, and provision of appropriate training and capacity building.

Adoption and implementation of GAP, good hygienic practices (GHP) and HACCP analysis are required in the food chain step(s). Government institutions should develop an enabling policy and a regulatory framework, organise the control services, train personnel, upgrade the control facilities and laboratories and develop national surveillance programmes for relevant hazards (e.g. chemical contaminants, biotoxins in bivalves). The industry should upgrade facilities, train personnel and implement GAP, GHP and HACCP. The support institutions (academia, trade associations, private sector, etc.) should also train personnel involved in the food chain, conduct research on quality, safety and risk assessments, and provide technical support to stakeholders. Finally, consumers and consumer advocacy groups have a counterbalancing role to ensure that safety and quality are not undermined by political or economic considerations solely when drafting legislation or implementing safety and quality policies. They also have a major role in educating and informing the consumer about aquatic food safety.

**Private standards and certification**

Driven by globalisation, the food industry has adopted food quality management systems that should in theory provide for better integration, coordination and traceability along the supply chain. Such schemes are voluntary and based on the generic quality schemes that have been developed under the aegis of the International Organization for Standardization (ISO) for industrial products (e.g. total quality management, ISO 9000:2000, ISO 22000). They will not be discussed here; the interested reader should consult the relevant documentation.

Concerns about the safety of aquatic products, following the major food scares of the 1990s (Annex 1), have spurred the development of additional private standards and certification schemes to be used in B2B transactions between suppliers and buyers.

Because of the increasing influence of civil society, these concerns have expanded to other areas of social and environmental issues of fisheries and aquaculture. By so doing, the food industry hopes to address the legal requirements to demonstrate ‘due diligence’ and to attend to the growing need for corporate social responsibility and to minimise reputational risks. A detailed description of the types of private standards of relevance to fisheries and aquaculture has been provided by Washington and Ababouch (7).

Unfortunately, there has been a great proliferation of private standards, which has created confusion for many stakeholders: producers and processors trying to decide which certification scheme will bring the most market returns, buyers trying to decide which standards have most credence in the market and will offer returns to reputation and risk management, and governments trying to decide where private standards fit into their food safety, animal health management and resource management strategies. It also raises questions about which certification programmes best serve consumer protection, the environment, the public and the producers. As a consequence, FAO was requested to develop international guidelines for certification in fisheries and aquaculture.

These guidelines were adopted in 2011 after a robust and wide stakeholder consultative process that was initiated in 2006 (4). They provide guidance for the development, organisation and implementation of credible aquaculture certification schemes.
They address the following four areas:

1. animal health and welfare
2. food safety
3. environmental integrity
4. socioeconomic aspects associated with aquaculture production.

The guidelines define the minimum substantive criteria for these four areas. They further cover requirements for:
   (i) standard-setting processes required to develop and review certification standards; (ii) accreditation systems needed to provide formal recognition to a certification body; and (iii) certification bodies required to verify compliance with certification standards. The normative role of the OIE and the CAC for animal health and food safety standards, respectively, is clearly identified in the guidelines.

Implications for aquatic food safety and trade

Public vs private standards

Aquatic products are the most traded food commodity. Over 1,000 species are exploited commercially. Nowadays, it is not unusual to have a fish harvested in one country, processed in another and consumed in a third. This globalisation of fish production, processing and trade has led to the development of a wide array of public and private standards claiming to provide for consumer and environmental protection. Consumer protection and animal health have been and remain the responsibility of government inspection and control authorities all over the world. In this context, it is legitimate to question why private standards and certification systems are needed and what value they add in ensuring consumer and environmental protection, in particular in aquaculture.

Indeed, private standards pose key questions for governments: do they duplicate, complement or undermine public regulatory frameworks for food safety assurance and sustainable aquaculture? Private safety/quality standards are typically based on mandatory regulation and therefore are not likely to conflict with public food safety regulation. Duplication is more likely to be an issue, if not in relation to the content of the requirements, then in methods of compliance and verification (including multilevel documentation). There is little evidence to suggest that compliance with private standards facilitates the implementation of public standards. Rather, compliance with public standards provides a baseline, and is therefore essential for meeting the additional requirements included in private standards schemes. Operators who achieve certification to a private standard are mainly those that already run effective mandatory food safety management systems.

Are private standards an efficient mechanism for achieving public policy goals of aquatic food safety assurance and sustainable aquaculture? If they are compensating for perceived shortfalls in public governance, then they might be simply treating the symptoms when a more effective solution would be to invest in strategies to improve those public systems. Governments need to determine, both individually and collectively, how private market mechanisms fit into public policy frameworks for aquaculture and how they will engage with them.

Implications for developing countries

Fish and seafood are important income earners for many developing countries. Developing countries are crucial for ensuring current and future global supplies of fish and seafood products. In general, certified aquaculture operators from developing countries tend to be those that are large-scale and involved in more integrated supply chains with direct links to developed country markets (through equity or direct supply relationships).

Evidence suggests that meeting and maintaining equivalence to the mandatory public standards of developed country markets continues to be the major challenge, rather than the requirements to meet private standards. For developing countries to take advantage of the opportunities presented by private standards they must first be able to meet the requirements of the regulatory requirements in importing countries. This would create the foundations for future responses to private standards. Any technical cooperation in developing countries would be best focused on getting the public systems right.

Some organisations and countries have argued that private standards go beyond relevant international public standards and have no particular scientific rationale and are therefore inconsistent with SPS obligations (8).
Some countries fear that private standards could allow importers to impose their domestic policy frameworks and/or other standards (e.g. labour, human rights), offering grounds for discrimination against developing country products. Further analysis is required to determine the consistency of private standards with the international standards and obligations of the SPS and TBT agreements.

Conclusion

The globalisation and further liberalisation of the world fish trade, while offering many benefits and opportunities, also presents new safety and quality challenges. The influence of civil society on producers, processors, retailers and governments to improve aquatic food safety management is increasing.

Assurance of the safety of aquatic products in the new millennium will require enhanced levels of international cooperation in promoting harmonisation, equivalence schemes and standards-setting mechanisms based on science. The SPS/TBT agreements of the WTO and the benchmarking role of the Codex Alimentarius and OIE provide an international platform in this respect.

References

Annex 1
Major food scares (7)

Introduction
Salmonella, Listeria, Escherichia coli, ‘mad cow disease’, dioxin, foot and mouth disease, avian influenza, beef, fish, shrimp, peanut butter, tomato, spinach ... Every few months, there is a new food-borne threat to worry about or a grocery favourite to avoid or being recalled from the supermarket shelves. In a world as technologically advanced and heavily regulated, food should not be so complicated. But, even as consumers have become better versed in home food safety techniques, the globalisation of food production, processing and supply has increased the risk of food-borne illnesses and the mass hysteria that follows their spread across borders and countries. So, a century after the idea of food poisoning first entered the public consciousness, we are still fighting some of the same mysterious food safety battles. It is estimated that food safety problems in the USA alone account for roughly 76 million illnesses, 325,000 hospitalisations and 5,000 deaths annually.

The term ‘food scares’ is generally associated with spiralling public anxiety over food safety incidents and the escalating government and media attention that supplements such events. Food scares can be categorised into microbiological-, contaminant- or animal disease-related outbreaks. The following are selected examples of major food scares that have occurred during the last 30 years.

Microbiology-related scares
Many food-borne illnesses are caused by bacteria, such as Salmonella, E. coli, Listeria and Campylobacter, or viruses (e.g. hepatitis A virus) that enter the food supply. The infected people develop symptoms that vary in severity. Although rare, some food-borne illnesses can be fatal. Botulism is a very rare food-borne illness caused by the consumption of food (meat, fish, vegetables) containing the botulinum toxin. The toxin accumulates in food as a result of bacterial growth due to malpractices during handling, processing or distribution. The disease can vary from a mild illness to a serious disease, which may be fatal within 24 hours. In severe cases, patients develop neurological symptoms such as visual impairment (blurred or double vision), loss of normal mouth and throat function (difficulty in speaking and swallowing, dry mouth), lack of muscle coordination and respiratory impairment, which is usually the immediate cause of death.

In 1982, an outbreak of botulism caused the death of one person in Belgium, following the consumption of canned salmon that was traced back to an Alaskan cannery. This led to the examination of the entire 1980 and 1981 production records of the Alaskan salmon-canning industry and a series of recalls involving over 50 million cans of salmon worldwide. An earlier outbreak of botulism had caused the death of two Detroit women in 1963, following the consumption of canned tuna. Tuna sales fell 35% nationwide, forcing the industry to set up a tuna emergency committee and launch a US$10 million campaign to revive confidence in tuna products. Also, this case led the USA food control authorities and the canning industry to embrace the Code of Good Manufacturing Practice and HACCP analysis as early as 1973.

Contamination-related scares
The last three decades have seen great concern worldwide over the presence in food of unacceptable levels of antibiotics (e.g. nitrofurans in shrimp), hormones (growth hormones in beef), pesticides (nitrofen in poultry and eggs) and other contaminants such as dioxins, polychlorinated biphenyls (PCBs) or polycyclic aromatic hydrocarbons (PAHs) in edible oils. The carcinogenicity of the chemical contaminants creates great anxiety, whereas the increasing resistance of many bacteria to most strains of antibiotics, which in turn are becoming less efficient at treating human microbial infections has stirred concern over antibiotic residues.

Whereas the discovery of contaminants in food and drink creates major public outrage, media hype and impressive product recalls, the most spectacular scare remains the 1999 dioxin food scare, when a PCB- and dioxin-contaminated batch of transformer oil entered the food chain via an animal feed mill in Belgium. This was then fed to broilers and subsequently recycled into pig feed, thus affecting poultry, eggs, pork and bacon products throughout Europe, with the export of poultry and pork being halted from Belgium, the Netherlands, France and Germany. Dutch and Belgian pig and poultry farms were again placed under quarantine due to another dioxin scare in January 2006, when restrictions were placed on a total of 582 farms. More recently (2008), high levels of melamine were found in infant formula, milk powder and pet foods in the People’s Republic of China, following
its deliberate and illegal addition to increase the protein content of these products, causing the death of many babies and children and hundreds of thousands to become very seriously ill. Several other countries were highly concerned and discovered alarming levels of melamine in various food products tested.

**Animal disease-related scares**

The main animal disease-related food scare worldwide remains bovine spongiform encephalopathy (BSE), or mad cow disease, which first appeared in the UK in 1986. Other epizootic-related incidents such as foot and mouth disease (FMD) or avian influenza have recently caused public concern and outrage.

Bovine spongiform encephalopathy is a condition that causes nervous system degeneration in cows and can lead to a new variant of Creutzfeldt–Jakob disease (vCJD), a similar illness in humans. Since 1986, nearly 200 people have died from vCJD around the world. Over 168,000 cases of BSE in cattle were confirmed between 1986 and 1996 in the UK alone, affecting over 35,000 farms. Although the USA has seen no more than a handful of the bovine or human forms, even the remote possibility that the disease might have migrated into the food supply can cause severe panic. In April 2008, the United States Department of Agriculture asked for a recall of school lunch meat in 26 states. No evidence of contamination was found, but the distributor recalled 143 million pounds of ground beef, making the incident the largest beef recall in the history of the USA.
The Panamanian aquaculture industry: development and future

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Summary

The Republic of Panama is located in Central America and has the advantage of having coasts bordering the Pacific Ocean and the Caribbean Sea, which offers privileged access to the enormous wealth offered by these two seas.

The most important aquaculture product exported from Panama is shrimp, from both wild and culture fisheries. The volume of production allows for significant export to international markets, the main importing countries being the USA, Europe and Japan. The Panamanian fishing industry operates in three modes: industrial, artisanal and aquaculture.

It is noteworthy that the aquaculture industry provides great benefits to the country, as the value of production is more than US$70 million a year and it generates about 40,000 jobs and makes a significant direct and indirect contribution to reducing the rate of unemployment and increasing the quality of life of those involved.

Application of the World Organisation for Animal Health (OIE) standards for aquatic animal heath, monitoring and disease reporting is important to maintain the confidence of trading partners in the health and quality of Panamanian aquaculture products.

In Panama the Competent Authorities for aquatic health and aquaculture are found in several public sector institutions, principally the Ministry of Agricultural Development, National Directorate of Animal Health (MIDA/DINASA), the Ministry of Health (MINSA), the Panamanian Food Safety Authority (AUPSA), and the Aquatic Resources Authority of Panama (ARAP).

Within the Department of Epidemiology, in DINASA, the National Aquatic Animal Health Programme is responsible for surveillance, control and monitoring of aquatic organisms and their diseases in the country and drawing up the parameters to establish import requirements, as well as control and checks on the use and mobilisation of wild stocks.

The main health mechanisms adopted to prevent and control diseases of aquatic organisms in Panama are as follows: selection of animals for reproduction after polymerase chain reaction (PCR) testing for disease; control of host animals and their movement; disease control and monitoring on farms, with the involvement of laboratories; and inspection, training and disease simulation exercises. Notably, in 2007, Panama was the first country to perform a simulation exercise for diseases that would have economic impact on the cultivation of marine shrimp.

Panama has the potential to increase shrimp exports to a figure of US$180 million annually, to promote and encourage export of high-quality tilapia, trout and cobia, and to open up new export markets. This depends on maintaining aquatic animal health status and improving surveillance and control to prevent the entry of diseases that may affect the health of shrimp and other aquatic production systems. Maintaining the approval of export markets by strengthening implementation of the OIE standards for aquatic disease control and reporting is important to ensure maintenance and expansion of export markets for the future.

Keywords
A five-year strategy for aquatic animal health management in Vietnam

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Summary

Vietnam is endowed with an abundant supply of water resources that are ideal for fisheries and aquaculture. It has 3,260 km of coastline, 112 estuaries, 1 million km² of Exclusive Economic Zone (EEZ) and more than 4,000 islands, which form many bays, straits and lagoons. Aquaculture production has been increasing over the last three decades largely due to the production of black tiger shrimp, white shrimp and pangasius catfish. Other important cultured species include molluscs, cobia, grouper, sweet snail, tilapia, snake-head and seaweed. Total export earnings from the fisheries and aquaculture sector in 2010 was more than US$4 billion, a large increase from US$1 billion in 1999. The aquaculture and fisheries industries are estimated to employ more than 5 million people.

The Vietnamese government is strongly aware that aquaculture is a key industry to provide food security and alleviate poverty, as well as providing foreign currency return. Species diversification and intensification have resulted in increased production, but disease outbreaks and water pollution have caused great production losses. The government of Vietnam has, therefore, recognised the urgent need to implement comprehensive health management strategies and policies in order to sustain the rapidly developing aquaculture sector.

Vietnam’s Aquatic Animal Health Services (AAHS) were formerly run by the National Fisheries Quality Assurance and Veterinary Directorate (NAFIQAVED). Since January 2008, when the Ministry of Fisheries (MoFi) and the Ministry of Agriculture and Rural Development (MARD) merged, they has become the responsibility of the Department of Animal Health (DAH). However, some responsibilities are held by two other departments under MARD, the National Agro Forestry and Fisheries Quality Assurance Department (NAFIQAD) and the Aquaculture Directorate (DAQ). This presentation will describe the current situation with regard to aquatic animal diseases and the AAHS in Vietnam.

Furthermore, in 2010, DAH supported a World Organisation for Animal Health (OIE) expert team to conduct a PVS (Performance of Veterinary Services) evaluation of AAHS in Vietnam. The results have been valuable in assisting in the development of a national strategy for 2011–2015, which will focus on the following objectives/ issues:

1. to build human capacity, i.e. for professional and technical staff working in aquatic animal health
2. to improve technical authority and capability in laboratory diagnosis, risk analysis, quarantine and inspection, epidemiology, control and early warning
3. to strengthen cooperation between DAH and other national institutions/organisations such as NAFIQAD and DAQ on aquatic animal health management
4. to strengthen international cooperation and private sector involvement in response to new/emerging diseases and trade issues. The details of the strategy will be described in this presentation.

Keywords
Public sector perspectives and experiences in France relating to the implementation of OIE standards on aquatic animal health

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Summary
The author begins by summarising the OIE Aquatic Animal Health Code provisions for the governance of health inspection services in the aquaculture sector and for technical rules relating to the surveillance and management of aquatic animal diseases. He then explains how these rules are taken into account in the European Union (EU).

Firstly, in accordance with the relevant Treaties, a new legislative text was added to the existing EU secondary legislation in 2006, namely Council Directive 2006/88/EC of 24 October 2006 on animal health requirements for aquaculture animals and products thereof, and on the prevention and control of certain diseases in aquatic animals. Then, in accordance with Articles 61 and 62 of the Directive, the European Commission proposed measures to implement the Directive, which were duly adopted under the committee procedure.

Secondly, the EU’s institutional system ensures proper implementation of this body of legislation by Member States, through inspections by the Competent Authorities, both central and local (Veterinary Services). These inspections are carried out by a specialist body of the European Commission, the institution responsible for compliance with treaties and secondary EU legislation: the Food and Veterinary Office (FVO). Located in Ireland, the FVO organises and carries out inspections of sanitary services responsible for implementing European Community legislation in Member States and third countries.

Lastly, the author deals with the particularities of the governance system of services responsible for sanitary inspection of animal production in France, with particular reference to the aquaculture sector. At the central level, a single Ministry is responsible for agriculture, food and fisheries, thereby embracing all animal production sectors ‘from the farm to the fork’. At the local level, all sanitary inspectors, covering the entire livestock and agri-food sector, are under the authority of a single state representative – the Prefect – who has a direct chain of command in each of the country’s main territorial divisions.

The presentation ends with a general description of how European rules are implemented in France, illustrated with current examples in the French fish farming and shellfish farming sectors.

Keywords
Mozambique’s public sector perspectives and experiences in the implementation of the OIE aquatic animal health standards

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Summary

This paper presents Mozambique’s perspectives and experiences (positive and negative) on the implementation of the World Organisation for Animal Health (OIE) standards for aquatic animal health.

Mozambique has been a member of the OIE since 1949. According to the OIE standards for animal health in general and for aquatic animals in particular, the country has to adhere to the objectives of the organisation, by complying with the regulations on disease communication and transparency.

In Mozambique the Veterinary Authority is under the Ministry of Agriculture, and the Competent Authority for aquatic animal health is under the Ministry of Fisheries. In addition, within this Ministry there are different institutions dealing with specific subjects relating to aquatic animals. Although this arrangement may bring some benefits due to specialisation on specific matters, some challenges arise in terms of the relationships and coordination between veterinary and fisheries authorities.

The demand for improved coordination is even higher for Mozambique as an exporter of aquatic animal products, as reporting on some diseases is a requirement to access markets with strict sanitary regulations such as the European Union.

To fulfil market requirements, since the introduction by the OIE of the Focal Point for Aquatic Animals, some improvements have been observed as there has been clarification of the role of each stakeholder involved in disease communication procedures. As an example, capacity building for the Aquatic Animal Focal Points was delivered on the use of the OIE World Animal Health Information System in the Southern African Region. Newly approved legislation in Mozambique covers animal welfare and includes aquatic animals under the regulation for aquatic animals inspection and compulsory disease reporting to the Competent Authorities.

One critical issue for capacity building is strengthening capabilities for identification of aquatic animal diseases and monitoring and control to prevent their dissemination, as well as improvement of the basic laboratory infrastructure. This is important to ensure good administrative organisation and financial capacity of the Competent Authority. With the objective of strengthening capacity, Mozambique recently applied for an Evaluation of Aquatic Health Services using the OIE Performance of Veterinary Services (PVS) Tool.

Keywords


Introduction

Mozambique is located in the south-eastern region of Africa (Fig. 1) and has an area of 799,380 km² and 20,530,714 inhabitants. The administrative division includes 11 provinces and 128 districts (Fig. 2). It has a coastline of more than 2,700 km, which makes sea fishing an important economic activity.

Available estimates indicate that up to 40% of the national population relies on fishery activities for its subsistence. The worldwide trend of decreasing marine fish stocks represents a great challenge for sustainable revenues in
the fishery industry and for the population living along the cost, whose subsistence and source of protein comes mainly from seafood. The recent discovery of the potential for aquaculture in Mozambique has brought hopes for resolving challenges regarding sustainable fisheries and poverty alleviation. The main commercial shrimp species produced in the country are from the family Penaeidae, namely *Penaeus monodon* and *Penaeus indicus*.

At present, the development and expansion of inland fish aquaculture and shrimp marine aquaculture constitutes the government’s top priority due to the high commercial value and opportunity for the improvement of per capita consumption of fishery products.

Currently, the fishery sector contributes about 2% of the national gross domestic product. On the other hand, fish production, including marine and inland waters fishing and aquaculture, exceeds 145,000 tons of fish per year. This represents an average contribution to the economy of US$375 million from fisheries. Fishery production consists of: artisanal fishing, 85%; industrial and semi-industrial, 14%, and aquaculture, 1%. In terms of the trade balance, it accounts for US$75.5 million in annual exports (1).
The main export product is shrimp, which accounts for US$43.7 million (60% of the total). From this amount US$3 million comes from aquaculture. The only way to increase the export potential and the earnings from this economically important product is through aquaculture, as capture fisheries is considered fully exploited.

The potential of marine aquaculture in Mozambique is 77,592 ha in ponds, 32,124 ha in cages and 10,591 ha allocated to marine algae. From the above potential areas, commercial marine shrimp production exploits an area of 2,500 ha in a semi-intensive system and produces around 1,000 tons of shrimp per year. Meanwhile, there is inland fish production estimated at 100 tons per annum (1).

The Fisheries Master Plan (PDP II) designates a crucial role to aquaculture in the development of the fisheries sector, particularly in the large-scale semi-intensive production of shrimp.

With regard to aquaculture of inland species, the whole country currently has about 8,000 ponds. Furthermore, estimates indicate that a total of 258,000 ha are suitable for inland small-scale aquaculture, which indicates that there is more room for growth in this sector, an initiative supported by the government’s strategy to increase inland fish production (PDP II).

This represents an opportunity for the improvement of per capita consumption of fishery products, which is presently 7.8 kg and falls below the consumption recommended by the Food and Agriculture Organization of the United Nations (FAO) of 18 kg. The recently approved Fisheries Master Plan established that, in the year 2019, per capita consumption should reach 11.11 kg and defined aquaculture as the only way to attain the goal of producing 80,000 tons of fish per annum by 2019.

However, this development may pose new challenges from the stand point of aquatic animal diseases, as it is well known that a lack of good management practices in such activities increases the risk of emergence and dissemination of diseases in addition to environmental contamination. The prevention of such disasters requires the adoption of sound policies as well as adequate legislation to support the work of the Competent Authority in controlling and monitoring aquaculture activities in the country.

Considering that Mozambique has been a member of the OIE since 1949, there is a responsibility for Mozambique to adhere to, through its OIE Delegate, the objectives of the organisation by complying with its regulations on disease reporting, communication and transparency.

Organisation of aquatic animal health institutions

In Mozambique, as in many countries, the Veterinary Services (VS) do not have responsibility for Aquatic Animal Health Services (AAHS). Despite this arrangement there are benefits due to specialisation on specific matters, though at the same time it poses some challenges on the relationships and coordination of activities between the Competent Authority for terrestrial animals and those responsible for aquatic animals.

The need for better institutional relationships and coordination will increase as the country requires sustainable market access for its exports of aquatic animal products. This is also a key issue for enabling a real time provision to the OIE and its members with updated information on the occurrence of OIE listed diseases.

In Mozambique, the AAHS do not reside in the VS, but in the Competent Authority for aquatic animals, which creates challenges for the OIE Delegate, who has responsibility for the notification of aquatic animal diseases, including those of aquatic animals.

Looking at the organisation of the Veterinary Services in Mozambique it is possible to note that the Veterinary Authority is under the Ministry of Agriculture whilst the Competent Authority for AAHS reports to the Ministry of Fisheries. Also within the Ministry of Fisheries there are the Institute for Development of Aquaculture (INAQUA) and the Fisheries Research Institute (IIP) with both play specific roles in aquaculture matters.

However, the Competent Authority for AAHS is the Instituto Nacional de Inspeção do Pescado (National Institute for Fish Inspection – INIP) that falls under the Ministry of Fisheries, which is the OIE Focal Point for aquatic animal health issues. This type of structure demands good coordination between INIP, INAQUA, IIP and the National Directorate of Veterinary Services (DNSV) which is not an easy task.
The role of each of the aforementioned institutions with regard to aquatic animal health issues is as follows:

**The National Directorate of Veterinary Services**

The National Directorate of Veterinary Services (DNSV) is under the Ministry of Agriculture. This directorate, apart from animal health issues, includes in its institutional framework responsibility for animal production. The following is the mandate of DNSV:

- Definition and implementation of animal disease programmes, including: disease prevention and control, epidemi surveillance and epidemic vigilance, import and export control, veterinary public health and control of zoonoses and wildlife veterinary control.
- Under animal production: definition and implementation of programmes for the support of animal production, the management of animal genetic resources and improvement, restocking programmes and livestock marketing.
- Regional and international coordination and disease notification and communication.

**The National Institute for Aquaculture Development (INAQUA)**

This institution was created in 2009 and has among its responsibilities the objective of promoting aquaculture development, monitoring the activities related to aquaculture and assuring sustainable exploitation of the available aquatic species and aquatic areas suitable for the development of aquaculture activities.

**The National Fisheries Research Institute**

Research undertaken by the National Fisheries Research Institute (IIP) includes the following:

- develop activities related to research on selection, genetic selection and adaptation of species that can be raised under aquaculture
- undertake genetic studies of selected species for aquaculture
- develop and recommend technologies for cultivated species
- undertake studies on pathology in aquatic animals under captivity or in the wild.

**The National Institute for Fish Inspection**

The National Institute for Fish Inspection (INIP) is responsible for the control of the sanitary condition of aquatic products for both domestic consumption and exports. It is responsible for declaration of the country’s disease status and freedom from specific diseases.

**The National Institute for Agrarian Research**

The National Institute for Agrarian Research (IIAM) is within the Ministry of Agriculture and includes the Central Veterinary Laboratory, which performs some diagnostic tests. The laboratory has the capacity to perform histopathology and diagnosis of shrimp diseases. The polymerase chain reaction (PCR) test for aquatic animals is performed at the Veterinary Faculty of Eduardo Mondlane University. A need for capacity building in the area of aquatic animal disease diagnosis, in particular the training of personnel to be able to perform both histopathology and PCR testing of fish diseases, has been identified as important.

**Implementation of OIE standards**

Since the OIE introduced the National Focal Points for several topics, including aquatic animals, improvements have been observed within the Mozambique government, as a result of training seminars and clarification of the role of each Focal Point. For example, training of Aquatic Animal Focal Points on the use of the OIE World Animal Health Information System (WAHIS) for the Southern African Region (SADC), as well as regional seminars and workshops on other aquatics topics, have been conducted.
The nomination by the OIE Delegate of the National Aquatic Animal Focal Point was an important step in Mozambique towards improvements in compliance with OIE standards. OIE activities are coordinated between the DNSV and the INIP, and since 2007 the Mozambique delegation to the OIE General Session has included one or two aquatic animal health specialists, representing the Competent Authority for aquatic animals.

 Newly approved legislation in Mozambique states that the welfare issues of aquatic animals should be clearly regulated and that it is compulsory for aquaculture farmers to report to the Competent Authority any disease occurrence, so that it can evaluate the need for specific control measures or notification.

 The creation in 2009 of INAQUA, an institute specially dedicated to the development of aquaculture, is also a positive step to improve the management and monitoring of aquaculture activities.

 Regarding capacity building, three Mozambique technicians attended a training course on the recognition and control of epizootic ulcerative syndrome (EUS) in Zambia. Following this training course, a survey was conducted in the Zambezi River that concluded that EUS was not present in Mozambique.

 The Aquatic Animal Focal Point attended the training course on WAHIS in Malawi, which improved her capacity to report aquatic animal diseases directly into WAHIS.

 Mozambique has requested a Performance of Veterinary Services (PVS) evaluation of its Aquatic Animal Health Services. This request has been approved by the OIE Director General and a mission of PVS experts is scheduled to undertake the evaluation in September 2011.

 Challenges

 Mozambique’s recently approved legislation guiding the Competent Authority (2) states the following objectives:

 - fulfilment of the market requirements, better consumer protection and human health, regarding whenever adequate the health protection and welfare of animals and of the environment
 - verification of compliance with the standards defined for undertaking official controls to allow preventing, eliminating or reducing to an acceptable level the health risks for human beings and animals.

 These are clear indications of the commitment of the Government of Mozambique in relation to animal health issues that need to be materialised in specific actions, and it will require coordination among all stakeholders to achieve the above-mentioned objectives.

 From our point of view, the challenge to get the appropriate approach involving all stakeholders does not lie in having all capacities and skills concentrated under one single institution but is actually a matter of adequate coordination, cooperation and collaboration between different interested institutions and stakeholders.

 Another critical issue lies in the capacity of these institutions regarding aquatic animal health issues. This includes skills regarding technical aspects such as identification of aquatic animal diseases, monitoring and control to prevent their dissemination and adequate laboratory infrastructures. From the administrative side, capacity building includes the organisation of the Competent Authority itself to deal with aquatic animal issues through the provision of human and financial resources.

 Regarding the OIE as the organisation recognised by the World Trade Organization as an international standard-setting body for the development of normative standards to facilitate safe trade in animals and animal products, the Government of Mozambique requests that the OIE continue to support Member Countries on issues of capacity building to ensure that they can implement the OIE standards.

 Perspectives

 Mozambique expects to address the above mentioned challenges in the following ways:

 - to benefit from an OIE PVS evaluation and subsequent PVS Pathway activities, which will enable the Competent Authority for aquatic animals to improve its capacity to implement OIE standards
 - to have the national legislation harmonised with OIE standards, and guidelines approved and implemented in Mozambique
 - to have established in the country the capacity for the detection and diagnosis of major aquatic animal diseases.
Conclusion

There is a need to continue to strengthen the existing coordination and collaboration between the DNSV and INIP, the Competent Authority for Aquatic Animal Health Services. The establishment of an institutional framework that ensures an improvement in aquatic animal health will also ensure improvement in the adoption of and compliance with OIE standards. In this regard, the expectations of the Competent Authority from the OIE PVS evaluation and related missions and the ensuing implementation of the results are:

- compliance of national legislation with international standards and requirements regarding aquatic animals
- improved coordination among the stakeholders dealing with aquatic animal issues
- implementation of adequate controls for the safe trade of aquatic animals, including quarantine among others
- increased capacity regarding identification of OIE-listed diseases of aquatic animals
- easy access to reference laboratories for the diagnosis of aquatic animal diseases.

References

Application of the OIE PVS Tool to Aquatic Animal Health Services

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Summary
Aquatic animal production based on aquaculture is growing exponentially, and has during the last 5–10 years already surpassed catch fisheries, measured in volume production, in many of the major seafood-producing countries worldwide. Aquaculture production represents today an essential asset to the income of developing and in-transition countries, and is an important alternative protein source to terrestrial animal production, assuring food security in a world in which protein sources are under continuous pressure. The potential of aquaculture production to expand and support the growing protein needs of the developing and in-transition countries is dependent on good governance.

Intensive production systems and large volumes in limited geographical water systems are putting pressure on animal health, animal welfare and food safety. Aquaculture is expanding, and new species are continually being introduced into farming. Aquatic animal health is a relatively new veterinary field, and new and emerging diseases are being discovered at a very rapid rate.

Following the first World Organisation for Animal Health (OIE) Global Aquatic Animal Health Conference held in Norway in 2006, the OIE followed up on the recommendations to support good governance of aquatic animal health services by expanding the OIE Performance of Veterinary Services (PVS) Tool to include good governance of aquatic animal health services.

The OIE PVS evaluation should become an important asset for countries intending to build good aquatic animal health governance. It is also important that there is collaboration among the OIE, the Food and Agriculture Organization of the United Nations, the World Bank and donors to ensure that there are good incentives to request an OIE PVS aquatic evaluation and to ensure that financial support is based on sound considerations of an individual country’s structure and needs.

Keywords

Introduction
The World Organisation for Animal Health (OIE) has had responsibility for aquatic animal health standards for more than 50 years. The OIE Performance of Veterinary Services (PVS) Pathway has been developed in later years to support OIE Members in building their capacity to respond to OIE standards in a legitimate and comprehensive fashion. Although many OIE PVS evaluations have been performed during the past five years, these have been focused on the Terrestrial Animal Health Code, and Terrestrial Veterinary Services. A need to use the same tool for Aquatic Animal Health Services (AAHS) has been identified, but there have been certain limitations to the tool that have required adaptation before it could be presented to Member Countries requesting an aquatic OIE PVS evaluation.

At the first OIE Global Aquatic Animal Health Conference held in Norway in 2006, it was recommended that the OIE support good governance of AAHS by expanding the OIE PVS Tool to include good governance of AAHS (4). The Tool needed some adaptations to support this expansion. Some of the main adaptations required focused on the fact that AAHS in many relevant countries are not necessarily directly connected to the Veterinary Services. Veterinary competence is not always the most relevant competence to assess, and statutory bodies do not exist for aquatic animal health professionals. Surveillance and control in aquaculture in an open aquatic environment is also quite different from that in most terrestrial systems.
Session 3

Solutions and tools to improve aquatic animal health

Following the adaptation of the tool, the OIE performed a pilot OIE PVS aquatic evaluation in South East Asia, and after this evaluation the Tool was adjusted once again, incorporating the feedback from the evaluation team. The OIE has also focused on training relevant aquatic animal health professionals so that they are ready to perform more evaluations.

Why do we need to include AAHS in the OIE PVS activities?

Aquatic animal production based on aquaculture is growing exponentially, and has during the last 5–10 years already surpassed catch fisheries, measured in volume production, in some of the major seafood-producing countries worldwide. Aquaculture production represents today an essential asset to the income of developing and in-transition countries, and is an important alternative protein source to terrestrial animal production, assuring food security in a world in which protein sources are under continuous pressure (2). The potential of aquaculture production to expand further and support the growing protein needs of the developing and in-transition countries is, however, dependent on building structures that support good governance of AAHS.

Intensive production systems and large volumes in limited geographical water systems are putting pressure on animal health, animal welfare and food safety. Aquaculture is expanding and new species are being introduced into a farming environment. Aquatic animal health is also a relatively new field within veterinary science, and new and emerging diseases are being discovered at a very rapid rate (3). There is an expectation that the OIE and OIE Members take their share of the responsibility to ensure sustainable and ethical production in the coming years.

The OIE has produced standards for aquatic animal health for more than 50 years, and since 1995 it has published the Aquatic Animal Health Code and Manual of Diagnostic Tests for Aquatic Animals, separate from the Terrestrial Animal Health Code and Manual of Diagnostic Tests for Terrestrial Animals. The latest editions of the Aquatic Code and Aquatic Manual are available online: www.oie.int (5, 6). They represent the accepted international standards and diagnostic procedures for trade in aquatic animals and their products. Chapter 3.1 of the Aquatic Code refers to the quality of AAHS. The aquatic OIE PVS Tool is part of the effort to help member countries fulfil their international obligations, as described in the Aquatic Code and Aquatic Manual.

Unique issues for good aquatic animal health governance

As the OIE PVS Tool was originally developed to accommodate traditional, terrestrial Veterinary Services, it has been necessary to look at some of the unique issues for good AAHS. Issues that require special attention when comparing AAHS and traditional terrestrial animal health services are related to the need to consider the qualifications of personnel, education systems that include relevant information and science, and surveillance and control systems that are adapted to the special environment of aquatic farming.

Aquatic animal health has in many countries not been part of the veterinary curriculum, and other professionals with university-level education have in many instances filled a void as production has grown. When considering the qualifications of personnel in the services it is therefore not always a good criterion to consider exclusively the number of veterinarians, though these should not be excluded from the equation.

An even more difficult issue is that there is no internationally calibrated standard for aquatic animal health education, either within the veterinary curriculum or as a separate curriculum. One may argue that the veterinary curriculum as such is still not calibrated in an international context, but there has been a growing focus on this issue, as the veterinary degree is in most countries a restricted degree. Therefore, there has also been a strong focus in the OIE PVS Tool on the mandate and activity of the Veterinary Statutory Body. This mandate and activity does not necessarily reflect on a country’s ability to govern aquatic animal health professionals, and one might want to consider if there should be some alternative recognition of an aquatic animal health professional, or if this should be part of the ‘Day 1’ competencies of a veterinarian. As yet, there is no such structure or standard, and this complicates the picture.

Another unique issue for aquatic animal health is that the government structures often have been built around the traditional fishery authorities, and the focus has been primarily oriented towards increasing production and quality from a technological and innovation point of view, often in competition with the traditional fishery sector. Only in later years has one understood the importance of considering regulating farming systems to support
disease control and environmentally sustainable production, and the necessity to bring on board personnel with relevant qualifications and competence.

Aquatic animal health is institutionally often the responsibility of the fisheries ministries, rather than the Veterinary Authority, in which one traditionally has found the Delegate to the OIE. One has often therefore a need to bridge the knowledge gaps regarding OIE international standards and obligations at a national level. Many countries do not have a common disease reporting system that covers aquatic animal diseases and lack also routine contact between agencies when the standards are being developed. One important step taken by the OIE was to encourage National Delegates to nominate Aquatic Animal Focal Points, to help the country participate in the work of standard setting. These Focal Points may be located within the Veterinary Services or in another government agency but, in all cases, they are under the authority of the national OIE Delegate. By August 2011, 149 of the total 178 OIE Members had nominated Aquatic Animal Focal Points, with Asia, the Far East and the Oceania region having the highest response rate of all OIE regions (OIE secretariat, personal communication) (see Table I).

**Table I** Nomination of Aquatic Animal Focal Points by OIE Member Countries, August 2011

<table>
<thead>
<tr>
<th>OIE region</th>
<th>Number of OIE Members</th>
<th>Nominated Focal Points</th>
<th>As % of OIE Members</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>52</td>
<td>43</td>
<td>83</td>
</tr>
<tr>
<td>Americas</td>
<td>29</td>
<td>25</td>
<td>86</td>
</tr>
<tr>
<td>Asia, Far East and Oceania</td>
<td>31</td>
<td>29</td>
<td>93</td>
</tr>
<tr>
<td>Europe</td>
<td>52</td>
<td>41</td>
<td>65</td>
</tr>
<tr>
<td>Middle East</td>
<td>14</td>
<td>11</td>
<td>79</td>
</tr>
<tr>
<td>Total</td>
<td>178</td>
<td>149</td>
<td>84</td>
</tr>
</tbody>
</table>

A further significant challenge to the governance of AAHS concerns the availability of scientific expertise, specifically in relation to diagnostic laboratories for aquatic animal diseases, epidemiology and associated scientific research. National diagnostic and epidemiological services play a very important role in supporting aquatic animal health programmes. However, limited financial support for capacity building of basic services tends to reflect the historical importance of industries, and governments today are less inclined to make significant new investments in such services. Many AAHS face a challenge in securing adequate scientific support to the aquatic animal sector.

Finally the issue of disease management in the aquatic environment often requires new and different tools from the traditional terrestrial surveillance and control programmes. Understanding the possibilities and limitations in the field requires specialised expertise both at the planning level and when advising producers. Some aquaculture industries are well established and farming is effectively ‘industrialised’, with resulting efficiencies of scale and an internationally competitive market presence. Others are typically carried out by small-scale, often poor, producers. Furthermore, the rapid up-scaling, and intensification of aquaculture, particularly in developing countries, is often based on the introduction of new species for farming, sometimes under non-optimal environmental conditions (1).

The continuing trends of rapid expansion and innovation in the field of aquaculture production present particular challenges to AAHS. The positive contribution that can be made to aquatic animal health programmes by a relatively wealthy and well-organised industry cannot be expected from poorer and less organised industries. The knowledge base of poor producers, e.g. with respect to good farming practices, prudent use of antimicrobials, and hygienic food processing, is quite different.

Finally for many countries there is also the issue of lack of basic legislative framework to support their work in building sustainable and ethical production and fulfilling international standards. This is not unique to aquatic animal health, but it is often a clear limitation for good aquatic animal health governance.
**Consequences for an aquatic evaluation**

The OIE has recognised that the evaluation teams must have some basic understanding of the issues that are unique to aquatic animal health. Evaluators with relevant qualifications have been trained to use the OIE PVS Tool. Furthermore, the Tool itself has been modified to better suit an evaluation of AAHS. Terms and definitions have been brought in from the *Aquatic Code* and *Aquatic Manual*.

More specifically, the following competencies have been modified:

I-1 Staffing: a professional level of staff must be considered without exclusive reference to veterinarians (though not excluding these).

I-2 Competencies: competence of aquatic animal health professionals must be described, but we have yet to define a ‘global standard’ for an aquatic animal health professional.

II-2 Veterinary laboratories: aquatic animal health laboratories are not necessarily part of the veterinary laboratory, and must be considered separately where these exist in parallel to the veterinary laboratories.

III-5 Veterinary Statutory Body (VSB): in a country where the veterinarians are not the aquatic animal health professionals, the VSB is less relevant, but as yet there is no alternative body or authorisation system for aquatic animal health professionals.

**Conclusions**

Good aquatic animal health governance is a major building block for the future growth of sustainable and ethical aquatic animal production. An important lesson that many pioneer countries have learnt the hard way is that it is better to prepare for worst-case scenarios than to repair the damage. Disease prevention is in itself an important asset for sustainable growth and food security.

One of the most important short-term challenges for the OIE and Member Countries is to identify incentives to use the ‘OIE PVS Pathway’ as an essential support for good governance of AAHS. There is a need for closer collaboration to ensure that the activities and investments of the OIE, the Food and Agriculture Organization of the United Nations, the World Bank, donors and national governments are all pulling in the same direction. This is even more pertinent for the aquatic animal sector as compared with the better known and accepted terrestrial animal sector.

As a starting point, the approval of external funding and capacity-building projects in the AAHS should be dependent on the conduct of an OIE PVS aquatic evaluation, as is now generally accepted in relation to capacity building for Veterinary Services. The next steps should include the development of an OIE Gap Analysis and also a review of framework legislation for AAHS.

**References**

Australia's experience of the use of the OIE PVS Tool to improve aquatic animal health

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Summary

Australia takes a conservative approach to quarantine to protect its favourable disease status and enhance its access to international aquatic animal markets. To maintain our disease status we use World Organisation for Animal Health (OIE) standards including the Aquatic Code and Performance of Veterinary Services (PVS) Tool in conjunction with a process of structured evaluation and assessment of competent authorities with respect to their market access requests.

Over the past five years we have engaged with competent authorities in several countries to evaluate their capacity to provide aquatic animal health certification and sustain animal health controls and systems. We typically engage in evaluation of the disease freedom of countries, zones and compartments.

Australia’s system of evaluation is underpinned by the OIE standards and comprehensively covers a wide range of competencies including legislation, infrastructure, investment, training, resourcing, administration and quality management, laboratory services, animal health controls, health management planning and policy, zoning, surveillance, processing and import/export controls – to name a few. This system of evaluation provides us with the means to facilitate trade in healthy aquatic animals and their products without compromising Australia’s biosecurity. This approach also provides opportunities for further cooperative relationships with our trading partners through developing innovative real-time responsive risk management models that have the capacity to give good-quality evidence-based feedback to our trading partners for the continual improvement of sustainable aquatic animal health controls across the entire pre-border, border and post-border biosecurity continuum.

Keywords

Introduction

Australia’s risk-based approach to quarantine protects its favourable pest and disease status and enhances access to international markets for its aquatic animals and their products. The Australian Government Department of Agriculture, Fisheries and Forestry (DAFF) maintains this favourable status by ensuring that imports of aquatic animals and animal products meet Australia’s quarantine requirements. This is achieved using World Organisation for Animal Health (OIE) standards and guidelines such as the Aquatic Animal Health Code (2) and the OIE Performance of Veterinary Services (PVS) Tool, Application to Aquatic Animal Health Services (PVS Tool) (3), in a process of structured evaluation of our trading partners’ Aquatic Animal Health Services (AAHS) as they relate to market access requests.

Australia has seen an increase in market access requests from trading partners over recent years. To facilitate this trade we have engaged with several countries’ AAHS to evaluate their capacity to provide aquatic animal health certification that complies with international standards and also meets Australia’s import requirements. These evaluations include assessment of exporting countries’ ability to attest to disease-free exports on a disease-free country, zone or compartment basis. Similarly, Australia has also been subject to evaluation of its ability to provide health certification for aquatic animal exports.
Australia’s method of evaluation of the AAHS or other competent authority is underpinned by the OIE standards and PVS Tool and involves assessment of a wide range of competencies. These include legislation, infrastructure, training, resourcing, administration and quality management systems (QMS), laboratory services, animal health controls, health management planning and policy, zoning, surveillance, processing and import/export certification, inspection and controls. Although our method of evaluation allows us to facilitate safe trade in aquatic animal commodities (that are associated with a wide range of end uses) without compromising Australia’s biosecurity, it also provides opportunities for fostering cooperative relationships with our trading partners. We do this through developing innovative real-time, responsive risk management models that have the capacity for sharing good-quality evidence-based information. This aids in the continual improvement of sustainable aquatic animal health controls across the biosecurity continuum—pre-border, border and post-border.

**What do we evaluate?**

One of the primary aims of an evaluation is to recognise a country’s self-declaration of freedom from aquatic animal diseases of concern to Australia. As part of the evaluation, the capacity of the country’s AAHS to maintain a disease-free status and provide reliable health certification is assessed and verified. The declaration must be made and assessed according to international standards and be for a country, a zone, a zone with internal biosecure compartments, a vertically integrated or partially integrated compartment or a single compartment. We have found that evaluating the disease-free status of an entire country is the least complicated process, most likely due to the evaluation having fewer layers of complexity with more uniform national controls and legislative framework when compared with evaluating the status of a zone or compartment. Zone and compartment disease freedom involve more stakeholders, and there are more complex issues with regards to integrated health management systems and environmental, political, economic and social concerns. A typical evaluation for a zone or compartment may take over a year to complete.

The lines that demarcate zones and compartments are not always clear-cut, especially at the production level. For example, a well-resourced hatchery or processor operating to a quality-managed biosecurity system and strictly adhering to the requirements of a regulating authority’s health management controls and licence or permit conditions can be accommodated into an evaluation for recognition as a biosecure compartment within a disease-free zone. Including compartments in this way offers the flexibility to quarantine areas of concern within a zone, and safe trade in healthy aquatic animals can continue from the disease-free compartments in the event that the health status of the zone is compromised. Vertically integrated systems are best evaluated from a compartment perspective as their quality-managed biosecurity plans, in general, allow for compartmentalising within a zone and alignment with the animal health control programmes and auditing requirements of their AAHS. In the event of a disease outbreak somewhere within the zone, compartmentalisation operating strictly to a good biosecurity plan offers the capacity to take responsive action (early diagnosis, quarantine, decontamination, disposal, tracing, etc.) so that continued trading can occur from the protected, uncontaminated and still operational components of the compartment. Quality-managed traceability is particularly important in this case to ensure that product integrity is maintained, as the origin of products in transit can be determined and costly re-export avoided.

An evaluating country can have added confidence that industries working according to their auditable QMS and approved biosecurity plans are in turn being regulated and audited by their AAHS. For example, by evaluating a third-party processor as a partially integrated compartment within a zone, in the event of a disease outbreak occurring at a farm level, the processor can take immediate action to demonstrate disease freedom in processed commodities. If they can prevent contamination of the compartment from the breached sector of the zone, they may be able to continue to trade existing uncontaminated stock, and continue processing produce from unaffected zones or compartments.

**The first hurdle: first contact and making a submission to an importing country to show that you can meet its sanitary requirements for market access**

It is important to understand the reasons why a submission is being made. Is it due to lobbying pressure from a small sector of industry? Will market access benefit all industry and affiliated downstream industries? Is it
worthwhile resourcing the surveillance, testing and auditing needed to make a declaration of disease freedom for the projected amount of trade? Is it on the agenda as a trade or industry expansion priority of the government making the declaration?

The reason (or reasons) will directly influence the quality of the initial submission to the trading partner, and a submission’s quality can reflect the current status and direction of a country’s trading policies and strategies, the standard of its aquatic animal health controls, and its familiarity with the international standards. The submission ultimately provides an indication of the commitment, relationships and leadership in the relevant public and private sectors. Both parties initially need to engage in principled negotiations (in good faith) to express their level of resourcing and commitment to the project so that priorities can be agreed and resources allocated to expedite an outcome. A poorly resourced submission and low level of commitment will not build a healthy relationship between the parties and typically slows the process, with no guarantee of a successful outcome.

Once policy and strategic direction are mutually understood, priorities are agreed and resources, roles, and responsibilities established, it is then prudent to schedule the evaluation process with enough flexibility to adjust milestones and account for unforeseen issues such as introducing new legislation or implementing or changing domestic animal health controls.

**The evaluation**

Although each evaluation is different, we use the same set of tools to plan and build each one on a case-by-case basis. Australia’s evaluation tool is an amalgamation of legislative requirements, international standards and guidelines and audit processes built from the assessment categories of an internationally recognised guiding platform—the OIE’s standards and PVS Tool (Fig. 1).

The resulting audit process used to evaluate an AAHS is comprehensive but not complicated. Evaluation staff undergo training in quality management and auditing and the audit tables used for each evaluation closely follow the method described in the PVS Tool (3). The first document in the evaluation process is a questionnaire asking for detailed information covering all categories in the audit table. The completed questionnaire must be received by a specified date, at which point we enter the desk assessment phase. This is an iterative process in which apparent deficiencies or gaps in the systems may be identified and communicated, follow-up activities are identified and resources are committed. Once all the information has been examined an invitation is sought for an on-site in-country verification visit. Following the on-site visit, a draft evaluation report, including recommendations to address any AAHS shortcomings that are identified, is presented to the AAHS for review and comment on factual errors. After the evaluation report is finalised, the AAHS establishes an action plan against any recommendations. This is also an iterative process—the action plan, including revised animal health controls and health certification, needs to be agreed between the trading partners. Once recommendations have been implemented, health certification is finalised, sanitary measures (e.g. if necessary for ongoing compliance) are agreed, import permit conditions are developed and issued, and an ongoing management system is formally structured, market access for disease-free animals and their products can commence.
On-site in-country verification visit – bringing it all together

Critical to understanding the competency of the AAHS is understanding the ways in which its animal health systems function and work together to achieve a purpose. Although things may appear satisfactory during the desk assessment phase, in practice these systems may be disparate, uncommunicative, and dysfunctional. One tool that may be used during an in-country verification visit is a simple traceability trial, which is essentially an on-site performance assessment. Figure 2 represents a scenario to test the function and purpose of integrated and coordinated systems. For example, by tracing where and how reporting to OIE on disease status is carried out we can verify the functional integrity of a system under the control of the AAHS. The OIE Focal Point for disease reporting (under the authority of the National Delegate) can quickly lead the on-site auditor to documentation on QMSs, surveillance systems, state-run or accredited reporting laboratories, involvement in proficiency testing, resources and training of aquatic animal health specialists, legislation and legal responsibility, and involvement in simulation exercises. The OIE Focal Point is a good example of a ‘connector’ who can assist audits by providing a means to reveal the functionality, performance and integration of animal health controls with a clear chain of command (cf. PVS Tool, Section I-6 Coordination Capability of the Aquatic Animal Health Services [3]). The reason that OIE Focal Points, quality managers in processing facilities, AAHS-operated simulation exercises, and domestic and international transporters are excellent connectors is due to their requirement to have multiple contacts in other systems to perform their own tasks (1).

Limiting factors – time, resources and legislation

There is an unspoken expectation in both industry and government that an evaluation for market access is (a) an easy and quick process and (b) going to result in market access. Although negotiations held in good faith and an effective communication strategy can mostly account for these expectations, in reality the commitment of the AAHS to provide the required detailed information for the initial desk assessment will have a large impact on the time taken. Even when a well-resourced commitment is made, the process is often significantly influenced by limiting factors such as translation difficulties and the level of understanding and experience in complying with international standards. Even so, all attempts should be made by both parties to run an evaluation according to a strict schedule, taking into account varying degrees of commitment and resourcing. As countries come to understand better and take up the PVS Tool (Application to Aquatic Animal Health Services) as an internationally accepted tool, the process should become less problematic and delays should be reduced. We envisage that once AAHS have been through the process of an extensive evaluation any future evaluations could leverage off the documentation from the initial finalised submission (i.e. the process could be expedited by reviewing and updating the generic evaluation categories).

Fig. 2 Connectors perform a specific purpose to assist audit tracing by providing a pathway that reveals the functionality and integration of animal health controls

Control of aquaculture and aquatic animal health

Resources, responsibilities and training

Research and development

Laboratory and diagnostic

Emergency preparedness

Legislation Policy and certification

Passive and targeted surveillance

Connector: OIE Reporting Focal Point

Evaluation

Resources,
responsibilities
and training

Research and
development

Laboratory
and diagnostic

Emergency
preparedness

Legislation Policy and
certification

Passive and
targeted surveillance

Connector: OIE Reporting Focal Point

Evaluation

Fig. 2 Connectors perform a specific purpose to assist audit tracing by providing a pathway that reveals the functionality and integration of animal health controls

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There is an unspoken expectation in both industry and government that an evaluation for market access is (a) an easy and quick process and (b) going to result in market access. Although negotiations held in good faith and an effective communication strategy can mostly account for these expectations, in reality the commitment of the AAHS to provide the required detailed information for the initial desk assessment will have a large impact on the time taken. Even when a well-resourced commitment is made, the process is often significantly influenced by limiting factors such as translation difficulties and the level of understanding and experience in complying with international standards. Even so, all attempts should be made by both parties to run an evaluation according to a strict schedule, taking into account varying degrees of commitment and resourcing. As countries come to understand better and take up the PVS Tool (Application to Aquatic Animal Health Services) as an internationally accepted tool, the process should become less problematic and delays should be reduced. We envisage that once AAHS have been through the process of an extensive evaluation any future evaluations could leverage off the documentation from the initial finalised submission (i.e. the process could be expedited by reviewing and updating the generic evaluation categories).
The importance of a quality management system

Once the evaluation is complete and if market access is established, an ongoing reporting and re-evaluation schedule is implemented to align with the level of risk accepted. The most effective way to ensure compliance and maintain disease freedom is through a dedicated QMS. A QMS provides sustained proof of performance and continual improvement. A QMS integrates the health management systems and ensures that they systematically perform at required levels, it offers full traceability and product integrity, it is auditable, it applies self-check principles to identify deficiencies in or deviation from the criteria, it enables prompt corrective action, it can define roles and responsibilities, and it provides good-quality feedback for continual improvement. By far the best connector is the quality manager – there is no substitute for an accredited QMS that is well resourced and run by competent specialists to provide the assurances required by an evaluating trading partner. When a QMS attains the level of competency required, there is ample justification to switch from a highly active evaluation and audit schedule to a lower passive level of compliance based on QMS reporting (e.g. for an evaluating country to reduce the level of intervention at the border for consignments from specific countries based on their transparent reporting and provable compliance). We regard a QMS as a critical competency, especially for integrated health control systems that function to deliver a specific health service such as the management of a disease-free zone or compartmentalising third-party processing. Further benefit would be attained through the harmonisation of QMSs between animal health services and the existing human health service QMS programmes (i.e. a ‘One Health’ approach). Similar application of an accredited QMS to AAHS would ensure that health controls and systems would deliver an integrated and functional service that is regularly audited and improved to facilitate trade in healthy aquatic animals and their products.

Multiple government authorities

In some cases it is not evident which government agency is the competent authority responsible for the specific commodity. It is usually thought to be the agency that issues the health certificate, but this is not always the case – legislation can traverse commodities and/or regulatory responsibilities, and the hierarchical status of the certification component may not be apparent. This becomes a practical problem when issues arise that would threaten, or result in, loss of market access. Reporting an AAHS assessment in these circumstances needs to ensure that there is a clear understanding of the importing country’s expectations of each of the exporting country’s agencies, and which of them will be held accountable if critical non-compliance with importation requirements occurs. Thus, if the Veterinary Services (VS) insist on retaining certification rights or cannot easily change legislation to delegate responsibility to the agency that controls a country’s aquatic animal health systems (e.g. its fisheries/aquaculture authority), then market access cannot be considered until a decision is reached on which authority to evaluate. In some instances, to expedite market access, agreement may be made to commence an evaluation of the AAHS of a controlling authority (e.g. fisheries authority) while acknowledging that work will progress towards resolving delegation issues. If work has already commenced, the risk of wasting resources increases greatly due to reluctance to commit to delegating authority or very slow progress resulting in the potential for a complete second evaluation of the VS. This second assessment is less likely to succeed until the VS show that they can either take full responsibility for, or replicate, the fisheries department’s existing animal health control operations.

For example, in a recent evaluation, a compartment-type health system hinged on the legal ability of the aquatic animal health specialist in the fisheries and aquaculture agency to sign a health certificate. The fisheries department had full legislative responsibility for the system being evaluated, but no legal basis for signing the animal health certificate, a critical sanitary requirement for gaining market access. In this instance, a separate government authority had control of the VS and the legislative responsibility for signing all animal and animal product health certificates. Aquatic Animal Health Services can be more legally complicated than terrestrial animal VS and this simple example demonstrates a common problem encountered when undertaking evaluations for aquatic animal commodities. One simple solution to solve this problem is the establishment of a Memorandum of Understanding (MoU) between the relevant agencies. Fortunately, most acts of law allow for MoUs to delegate authority for signing health certificates to an aquatic animal health specialist and negate the need for evaluating multiple authorities. Note that, although the MoU may not confer legal delegation, it may be an acceptable, officially endorsed solution.
A government-to-government process?
Although market access evaluations and agreements must remain a government-to-government process, the relationships between aquaculture, fisheries, processors, transporters and other peripheral industries are becoming central to the success of trading outcomes due to the joint responsibilities required to operate effective biosecurity systems, especially for the operation of disease-free zones and compartments. As evaluations move from broad assessments such as country disease freedom to more complex assessment such as compartmentalisation, the bonds and responsibilities between government and industry become more complicated. Hence our evaluation teams pay particular attention to the relationships and leadership qualities of industry partners during on-site verification visits and request to be notified of any changes in industry leaders or their roles. The importance of public sector leadership is noted in the PVS Tool (cf. Leadership on the part of the public sector is a fundamental and critical determinant of success (see ‘Using the results’ [3]).

Chain of custody, also known as product integrity
A critical control point in an effective biosecurity system that is often overlooked in an evaluation based solely on the PVS Tool is the chain of custody, or product integrity, across the biosecurity continuum. With increasing opportunities in the global trade of aquatic animals and their products comes an increased opportunity for third-party processing and value adding. For example, whole raw prawns and Atlantic salmon are two potentially high-risk commodities that are consolidated for transport and processed in third-party countries into a multitude of value-added product types. Third-party processing of aquatic animals imported from many countries with different disease status has been shown to increase the risk of, for example, substitution occurring en route to the destination country. By incorporating chain-of-custody biosecurity or product integrity into our evaluations we find third-party processing to be a common industry practice. As a result, we require that export control systems are in place to prevent redirection to third-party processors; otherwise, we require the processing authority to be evaluated as a disease-free transport and processing compartment.

When something goes wrong
An outbreak or report of disease will most likely result in the implementation of compliance procedures and an immediate adverse effect on trade. However, having evaluated animal health control systems in place provides a good foundation on which to rebuild trade in healthy aquatic animals and their products – and provides a measure of the success of the initial evaluation and ongoing management. It is during this time that emergency preparedness can be assessed and reviews conducted to identify shortcomings and provide direction and leadership to rebuild effective biosecurity systems. In the event of a disease outbreak, we follow the recommendations in the Aquatic Code (Articles 4.1.1. and 4.2.7.). However, if a trading partner is satisfied with, for example, the emergency response, eradication, level of testing, rebuilding efforts and improvements, there is no reason that disease freedom cannot be recognised earlier than the time frames specified in the international standards, in order to allow for recommencement of trade in healthy animals. This would be particularly relevant in closed and semi-closed aquaculture zones or compartments where there are shorter production cycles and greater control and application of effective health management is possible.

Conclusions
Using the OIE PVS Tool, Application to Aquatic Animal Health Services (3), for determining disease freedom and equivalence in aquatic animal health controls represents a new era in comprehensive, harmonised and improved aquatic animal health management worldwide. In applying the PVS Tool, OIE Member Countries have a firm foundation from which to improve their aquatic animal health controls to facilitate safe trade in aquatic animals and their products.

Application of the PVS Tool to AAHS is at an early stage. However, repeated application will provide a means for improving the PVS Tool itself over time and for exploring new applications of the tool. Although the OIE PVS Tool, Application to Aquatic Animal Health Services – First Edition, 2010 (3), is a successful and important document for
Members, it is critical that it is able to be amended quickly to be responsive to the rapidly changing and dynamic aquatic animal industries. Following our experience with the PVS Tool, we would recommend that:

− In future iterations of the PVS Tool, more consideration be given to the importance of QMS in the critical competencies, especially for integrated health control systems that function to deliver a specific health service such as the management of a disease-free zone or compartmentalising third-party processing.
− Evaluation of the biosecurity of the chain of custody (product integrity) of aquatic animals and their products be more thoroughly considered in the critical competencies of the PVS Tool.
− Countries develop a framework for the consistent and systematic evaluation of their trading partners’ animal health controls. This fosters confidence in the continuity and timeliness of the process and could be included in the PVS Tool in the future.
− Member Countries note that legislative arrangements for government control of aquatic animal industries and health are often complicated and may restrict market access until legal arrangements between the controlling authorities are secured.

Acknowledgements
DAFF wishes to acknowledge the partnership contributions of all the countries involved with Australia in the two-way assessment process, without which none of us can improve the international standards for the safe trade of aquatic animals and their products.

References
Professional education and aquatic animal health: 
a focus on aquatic veterinarians and veterinary 
para-professionals

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Summary
The rapid growth of global aquaculture has resulted in challenges typically seen in any new developing 
agricultural industry, including an increase in disease outbreaks among aquatic animal species. Ensuring an 
adequate number of well-trained and skilled aquatic veterinarians and veterinary para-professionals, together 
with the national, regional and global infrastructure to prevent, control and possibly eradicate aquatic animal 
diseases is, therefore, an imperative. The current challenge in the burgeoning aquaculture field is to determine 
the diverse veterinary and paraveterinary skills and services needed in an aquatic veterinary workforce, the 
education necessary to ensure these skills, what educational and training programmes currently exist and 
what education refinements are needed to expand the workforce and produce deliverable veterinary services. 
Several programmes to evaluate and address these needs have either recently been established or are in 
development in multiple countries around the globe. These include: the World Organisation for Animal Health 
(OIE) Performance of Veterinary Services (PVS) processes, including Gap Analysis, to evaluate a country’s 
veterinary infrastructure; the efforts of the OIE Ad hoc Group on Veterinary Education (AHG) to examine 
minimum veterinary educational needs; and the development of academic and extra-academic educational 
opportunities and credentialing programmes for aquatic veterinarians and veterinary para-professionals.

Keywords
Aquatic veterinary and paraveterinary education – Continuing veterinary education and professional 

Introduction
With the continued growth of aquaculture (40) and a concomitant increase in the number of devastating aquatic 
animal disease outbreaks around the world (93), there is an urgent need globally for a well-educated and clinically 
competent aquatic veterinary workforce (63).** The incentives for countries to give attention to preparing such a 
workforce are strong, and countries that lag behind are likely to suffer severe consequences.

The driving forces behind the expansion of aquaculture are multiple. The global human population is anticipated 
to reach 9 billion by 2050 (69, 70) and will alter global demographics and societal demands for food. In countries 
that are unable to increase their aquaculture production it is likely to lead to an increased dependence on 
international trade of terrestrial and aquatic animals and their products (51). Additionally, countries around the 
world are becoming more reliant on seafood production for self-sustenance and generating income from exports. 
Globally, farmed fisheries or aquaculture production (primarily finfish, mollusc and crustacean) has grown over 
the last 30 or more years to be roughly equivalent to that of harvest fisheries production (41). Currently, global 
aquaculture production appears to exceed or rival production from many terrestrial livestock and poultry industries

** The authors view a veterinary workforce as made up of veterinarians and non-veterinarians (para-professionals) who collectively provide 
the services needed to ensure the health and welfare of animals, and implement optimal measures for the prevention, control and 
eradication of animal diseases. In most countries individuals lacking a recognised veterinary degree are prohibited from being licensed 
or registered to legally practice veterinary medicine; however, these para-professional, including veterinary technicians or nurses, 
fisheries biologists, academicians and other research scientists, provide important and vital laboratory and other supportive services 
required by veterinarians.
Furthermore, some anticipate that the continued growth of aquaculture production (estimated at 9–14% per annum over the last 30–40 years), despite a steady decline in harvest fishery production, might result in seafood dominating the global production of animal protein for human consumption by 2030 or 2050 (39). Indeed, awareness of this growth has changed the attitudes of many who now recognise that aquaculture has the potential to positively affect the world by increasing productivity of subsistence farming, alleviating hunger in lesser developed nations and improving national economies. As suggested by Dr Barry O’Neil, the 2009 President of the World Organisation for Animal health (OIE) (55) during the 77th OIE General Session: ‘While the world is producing more than 1,000 million tonnes of meat, fish and dairy products every year, [there has been] a trend over the last 25 years [for] … meat and dairy products traded … [to have] fallen by one-third. Interestingly, over this same time the percentage of aquaculture products traded has risen to over 100% and some studies have predicted that by 2050 half the animal protein consumed by people will come from aquaculture.’

Non-food-producing aquaculture (e.g. home and public aquaria, wild fisheries replenishment) has seen similar growth (56), and these industries will require attention to animal health and disease control, similar to that in seafood-producing aquaculture (83).

Because of the large number of aquatic species and the diversity in production systems for both the food and non-food aquatic markets, there is an urgent need globally for the establishment and expansion of a well-educated and clinically competent aquatic veterinary workforce. Such a viable workforce will support national infrastructure and governance (21) that allow implementation of aquatic animal disease prevention, control and eradication (biosecurity) measures in accord with the OIE standards (45). In addition, this workforce will contribute to future food security of many countries (23) and meet the terms of the sanitary and phytosanitary (SPS) requirements (94) for safe international trade of animals and their products (58).

The OIE and other international standards-setting bodies have developed several assessment tools to assist a country in fulfilling SPS requirements (65). Perhaps the most relevant is the OIE PVS Pathway, based on the Tool for the Evaluation of Performance of Veterinary Services (PVS Tool [88]) and PVS Gap Analysis. Although well utilised to evaluate the veterinary infrastructure and workforce focusing on terrestrial animal disease capabilities, little attention has been given to the evaluation of the aquatic veterinary infrastructure and workforce. Many countries may find utility in the PVS Pathway (88) for defining needs and improving aquatic veterinary resources, and providing assurance that an exporting country has the capabilities to respond to animal disease outbreaks and provide disease-free products that meet SPS requirements.
**OIE education initiatives**

A first step in building the infrastructure needed to address the global challenges facing the aquaculture industries is to assure the availability of high-quality veterinary and veterinary para-professional educational programmes that address not only general veterinary medical principles but also issues related specifically to aquatic animal health and disease management. Several national and international initiatives are under way to assess the needs and requirements of veterinary medical education and curricula in today’s changing world. For example, one recent study in Europe (37) and two in North America (13, 53) examined veterinary and non-veterinary academic programmes and curricula with a focus on meeting demographic changes and societal needs. These national initiatives will no doubt contribute to the advancement of core and advanced skills needed for a viable aquatic veterinary workforce in those regions.

On an international level, the OIE Ad hoc Group on Veterinary Education (AHG) was formed following the October 2009 OIE Global Conference on Veterinary Education and charged with addressing certain recommendations from that conference. The focus of the AHG was to outline minimum competencies for the entry-level veterinary graduate relevant to the delivery of National Veterinary Services (NVS). Under this remit, these services are those provided under the legislative framework and the auspices of the governmental authority of a given country to implement animal health programmes and ensure the health and well-being of animals, people and ecosystems.

Within the OIE Terrestrial Animal Health Code, the term “Veterinary Services” (92) includes both public and private components of the veterinary profession involved in animal and public health, as well as in animal welfare. Within the Aquatic Animal Health Code (85) equivalent ‘Aquatic Animal Health Services’ may be delegated to a government authority other than the veterinary authority, or a non-governmental organisation in a country (the ‘Competent Authority’), to implement animal health and welfare measures and other standards and recommendations in the Aquatic Code. Similarly, private sector veterinarians, or veterinary para-professionals who are normally accredited or approved by the Competent Authority to deliver the delegated functions, provide these services in some countries.

The AHG focused its initial efforts on overall competencies rather than competencies for particular animal species. This decision was made, in part, because of the paucity of existing information singling out specific competencies for one species over another; for example, aquatic vs terrestrial species. In addition, the AHG did not dictate specific academic courses that should be taught or how many credit hours of educational contact were necessary. Indeed, many of the competencies outlined by the AHG probably cross course boundaries and can be integrated across the curriculum in multiple courses.

The AHG also utilised stakeholder input and information gleaned from documents regarding the scope of NVS as defined by the OIE, veterinary school curricula, educational accreditation standards and private practice accreditation programmes. Aquatic animal species are not specifically singled out either in educational accreditation or in recognition standards within the USA (11), the UK (60) or the European Union (EU [33]), nor in the Day 1 competencies of the UK (59) or the EU (34). This does not mean that education in aquatic animal health is not occurring, nor that competencies singling out aquatic animal species should not be included in minimum competencies expected for delivery of NVS. Indeed, the AHG recognised the existence of several aquatic veterinary and veterinary para-professional education, training and specialty certification programmes throughout the world, some of which will be outlined in subsequent sections of this paper. However, defining species-specific competencies was beyond the scope of the AHG terms of reference.

The report of the AHG was presented to the OIE Terrestrial Animal Health Standards Commission in early 2011 (90) and transmitted in the report from that Commission to the World Assembly of Delegates at the OIE 79th General Session in May 2011. The competencies outlined in that report are those that the AHG believe will prepare the average entry-level (i.e. new graduate) veterinarian to promote global veterinary public health and provide an excellent base for advanced training and education for those veterinarians wishing to pursue a career in NVS – whether that service be focused on terrestrial or aquatic species. At the 79th General Session, the OIE World Assembly of Delegates subsequently approved Resolution 34, which called, in part, for the OIE to ‘present a framework and recommendations to the World Assembly of Delegates on the Day 1 minimum competencies required by veterinarians for countries to meet the OIE quality standards for Veterinary Services (both public and private components), taking into account existing input prepared by the Ad hoc Group on Veterinary Education and relevant Specialist Commission’ (91).
Aquatic veterinary and veterinary para-professional educational programmes

As in other animal agriculture industries, an aquatic veterinary workforce will require the involvement and integration of aquatic veterinarians and paraveterinary support professionals, collectively having a wide variety of skills and experience in numerous and diverse disciplines. This diversity is required to support all infrastructure levels including: implementing international standards and government regulations; providing diagnostic research, laboratory and other support services; and interpreting these research and diagnostic test results and delivering veterinary services to producers and other stakeholders.

The education and experience of aquatic veterinarians and veterinary para-professionals are driven by different needs and has resulted in different skill sets. However, both segments will ultimately make significant contributions to an effective aquatic animal health workforce. Non-veterinary education at institutions of higher education (e.g. fisheries biology and natural sciences) typically provides skills suitable for careers in higher academics, basic and applied research and natural resource conservation. Over many years, a large number of these professionals have contributed to a wealth of basic and applied information and technology (49) that is now used to support delivery of services by practising veterinarians. In contrast, veterinarians, many of whom are clinical practitioners, are specifically educated and trained to utilise medical principles in applying research findings and technology to provide veterinary services to clients.

As aquaculture developed as a new agricultural industry, the primary early contribution of veterinary and non-veterinary professionals has been in basic research involving general animal biology and physiology, pathobiology of infectious agents, development of vaccines and therapeutic agents, and laboratory diagnostic tests and protocols (48). This information has been pivotal for the development of aquaculture and its support industries. In addition, the early research on which today’s aquaculture is based has resulted in a large pool of non-veterinarian professionals primarily employed in public and private research institutions and government fish hatcheries that support wild fisheries recovery programmes. Despite the efforts focused on non-commercial aquaculture, disease pathobiology and diagnostic protocols generated from this research has been influential in establishing laboratory protocols that are useful for aquatic veterinary diagnostic laboratory services.

Utilisation of non-veterinarian research scientists, academicians, laboratory personnel or government employees to provide veterinary medical services is complicated by employment obligations and conflicts of interest of publicly employed service providers competing with those in private practice, as well as other factors such as legal liability for any substandard veterinary practices. Indeed, in many countries, in large part because of the unique professional education and clinical training provided to veterinary students, delivery of animal health services is restricted to licensed or registered veterinarians. A requirement for licensure or registration is graduation from an accredited, approved or recognised veterinary degree-awarding programme. Without veterinary skills for translating academic research results into applied veterinary services, there are examples (50) of producers being encouraged to adopt animal health and disease management practices that have resulted in limited or ineffectual control of disease spread. Thus, interpreting and transferring academic research findings into deliverable veterinary services to meet burgeoning aquaculture needs requires a workforce that includes experienced and knowledgeable aquatic veterinarians.

A number of established programmes support the educational and training needs of both aquatic veterinarians and veterinary para-professionals (2, 42, 44, 49, 67, 82). Some of these programmes are incorporated into veterinary school curricula, whereas others are found within pre-baccalaureate general biology, fisheries or wildlife biology programmes. Occasionally a university may offer post-graduate academic veterinary programmes, (sometimes associated with veterinary internships and residencies), or non-veterinary research-oriented programmes for advanced degrees. However, the majority of current educational opportunities in aquatic animal health areas are extra-curricular continuing education and professional development (CEPD) programmes. Several of these programmes in North America, Europe and Australasia, discussed below, may serve as examples to stimulate additional programme development.

Academic and extra-curricular educational opportunities

It is important to be aware that recognised academic institutions of higher education that award a veterinary degree require graduates to gain a basic understanding of the anatomy, physiology and other biological functional of all animal types, including aquatic species.

Because veterinary school curricula cover a multitude of species, some (47) believe this uniquely qualifies veterinarians to be the experts in delivery of aquatic animal health. However, others (64) believe that veterinary
Schools must incorporate aquatic-specific courses into core curricula in order to provide the core or Day 1 skills and competencies necessary to practise aquatic veterinary medicine. In reality, as in most species-oriented veterinary practice, refinements of aquatic veterinary skills are obtained through post-graduate and on-the-job clinical experience and CEPD. Indeed, as discussed elsewhere in this paper, concern for ensuring veterinarians have the core or Day 1 skills in many species-oriented practices has led to re-examination of the educational requirements of veterinary credentialing.

Because many veterinary curricula do not yet include aquatic specific courses, extra-curricular CEPD programmes are frequently the primary source of specific aquatic animal veterinary medical education (43). However, post-graduate degree programmes and specialty certification focusing on advanced aquatic animal health studies and skills are available (66). Although adding courses that specifically address the unique needs of aquatic animals to a veterinary school’s core curriculum has some merit, curricula at most veterinary schools are already extremely full. In addition, advanced degrees or specialty certification programmes may exceed the education and skill sets needed to be able to practise general aquatic veterinary medicine. A more viable approach, then, to develop a global cadre of qualified entry-level aquatic veterinarians might be to ensure that current veterinary courses adequately address unique aspects of major aquatic species. Alternatively, veterinary schools in regions with a particular emphasis on aquaculture could create species-specific courses and allow students from other veterinary schools to attend and receive credit towards their veterinary degrees. It is already increasingly more common for North American veterinary students to select aquatic veterinary externships at outside institutions during their final scholastic year in order to gain additional aquatic clinical experience. Finally, veterinary schools may also need to rely on CEPD programmes to supplement any perceived deficiencies in aquatic animal-specific information.

Exposure to aquatic veterinary medicine in veterinary curricula may be greater than what is immediately evident. While it is generally accepted that much of a veterinary curriculum will apply equally to both terrestrial and aquatic animals, it is difficult to ascertain precisely how much is devoted specifically to aquatic veterinary issues. Frequently, when aquatic animal medicine is included in the curriculum, it is identified as ’exotic’ or ’zoological’ veterinary medicine (66). However, results of surveys of North American veterinary schools conducted in 1993 (57) and 1997 (1) suggest that, in 84% of these schools, a relatively high number of required semester credit hours (on average 147 over a four-year curriculum) are directly relevant to aquatic veterinary issues. In Europe, 58% of the veterinary schools in 19 countries provide some education in aquatic animal veterinary issues (82). Although the number of credit hours addressing aquatic animals varies a great deal (Fig. 2) among European schools, credit hours were reported from both basic and clinical subjects and include topics such as regulatory aspects of aquaculture, industry practices and public health.

Fig. 2 The number of educational credits in European veterinary education institutions, dedicated to aquaculture and fish health in European veterinary institutions and transferable between veterinary schools. Adapted from Weber et al., 2009 (78)

AT, Austria; BA, Bosnia-Herzegovina; DE, Germany; DK, Denmark; EE, Estonia; ES, Spain; FR, France; GR, Greece; IE, Ireland; IT, Italy; NL, Netherlands; NO, Norway; PT, Portugal
There are several notable examples of academic and CEPD programmes throughout the world that cater to both non-veterinarians and veterinarians seeking additional knowledge and skills in aquatic species medicine. As examples, these include degrees, courses and other programmes offered at Stirling University (UK [81]), the University of Florida (USA [79]), through the NOVA University Network – a network of Nordic Forestry, Veterinary and Agricultural Universities (54) – AQUAVET I and II programmes (80) run by the University of Pennsylvania and Cornell University (USA), and the University of Arizona’s (USA) Shrimp Aquaculture Pathology course (78).

Currently, extra-curricular aquatic veterinary CEPD programmes are organised by veterinary, and occasionally, non-veterinary entities. Veterinary organisations and most veterinary schools provide CEPD primarily focused on improving clinical skills or introducing new clinical findings or techniques that are useful in delivering improved veterinary services to clients. In many counties, annual CEPD is a statutory requirement (codified in government regulations) for re-licensure or re-registration to allow veterinarians to continue to legally practice veterinary medicine. Increasingly, local, regional, national and international veterinary organisations have one or more days of CEPD sessions annually devoted entirely to aquatic veterinary medicine. Examples include, since 1998, up to four days of aquatic veterinary sessions at the Annual Convention of the American Veterinary Medical Association and three days of similar sessions at the World Veterinary Congress since 2006.

Many aquatic veterinary organisations devote entire multi-day CEPD programmes to aquatic veterinary medicine. Examples include: those of the American Association of Zoo Veterinarians (USA [4]); the Association Française des Vétérinaires Aquacoles (France [14]); the Association of Reptilian and Amphibian Veterinarians (USA [15]); the Australian College of Veterinary Sciences – Aquatic Animal Health Chapter (16); the Eastern Aquaculture Veterinary Association (USA/Canada [32]); the Fish Veterinary Society (UK [38]); and, the World Aquatic Veterinary Medical Association (84).

Several non-veterinary organisations involved with aquatic animal health also provide CEPD sessions as part of their regular meetings. These programmes primarily focus on new research results and laboratory techniques useful for veterinary para-professionals working in diagnostic laboratories and state and federal fish hatcheries. Examples include those organised by the European Association of Fish Pathologists (35), the American Fisheries Society – Fish Health Section (7), the Asian Fisheries Society – Fish Health Section (12), the Network of Aquaculture Centres in Asia–Pacific (52) and the European Aqua-TT programme involving the University Enterprise Training Partnership for the European aquaculture industry and linked to the EU Lifelong Learning Programme (31).

To attract more veterinarians to its CEPD programmes, the American Fisheries Society – Fish Health Section (FHS) recently applied for, and received, approval as a RACE (Registry of Approved Continuing Education) programme provider. The Registry of Approved Continuing Education is a programme (3) administered by the American Association of Veterinary State Boards (AAVSB) that certifies continuing education for veterinarians that meets certain standards as established by the AAVSB. Many US states and some countries accept RACE-approved CEPD programmes, as well as many other programmes, to fulfil continuing education requirements for veterinary re-licensure. Although gaining RACE approval is intended to attract veterinarians to the Eastern Fish Health Workshop and the Western Fish Disease Workshop (both are held annually in collaboration with the American Fisheries Society, as well as the US Geological Survey and the US Fish and Wildlife Service) it is unknown whether other non-veterinary organisations will utilise a similar approach.

**Advanced training and aquatic animal health competency**

Although a veterinary degree from an accredited veterinary school and licensure or registration to practise veterinary medicine affords recognition of entry-level veterinary medical competency, there are also systems in place to recognise advanced competencies. These systems typically recognise specialisation or primary focus with a species type or a specific veterinary discipline. As in human medicine, dentistry and other medical fields, the term ‘specialist’ in veterinary medicine is typically reserved for ‘Board Certified’ veterinarians that have highly advanced education, experience and skills in one or more veterinary disciplines (e.g. pathology, internal medicine, surgery), and who have successfully completed a rigorous certification examination assessing these advanced knowledge and skills. Certification of such specialists is administered through specialty colleges, boards or other entities, and veterinarians who earn certification are then entitled to carry an advanced title (e.g. Diplomate, American College of Veterinary Internal Medicine) (5). In some regions, it is considered unethical for a veterinarian to claim to be a specialist unless board certification or a similar title has been specifically awarded by a recognised certification organisation (10).
Several programmes outside those certification programmes administered through veterinary speciality organisations currently exist to recognise veterinarians with aquatic specialisation. These include the Royal College of Veterinary Surgeons’ Diploma in Fish Health and Production (61) and the Fellowship in Aquatic Animal Health within the Australian and New Zealand College of Veterinary Scientists (19). All recognised veterinary speciality programmes require extensive study and clinical experience and examination well beyond the knowledge and skills of Day 1 competencies needed to practise general veterinary medicine.

As in all disciplines of medicine, general veterinary practitioners often refer complex medical or surgical cases to those specialists who demand considerably higher fees for their services. In many cases, these specialists are employed in academic programmes of higher education. Because of the cost and time required to acquire advanced specialty certification, often these specialists are not available to economically depressed aquaculture industries. In addition, low demand for veterinarians with advanced specialty certification in aquatic animal health and production has historically been a strong disincentive for more general veterinary practitioners to acquire such specialisation. Often this level of specialisation is not required of a veterinary workforce to assist NVS in ensuring aquatic animal health and optimal response to diseases.

Although not recognised as a veterinary specialty certification programme that is equivalent to a Diplomate of a College of Veterinary Pathologists (6, 36), a similar programme exists for veterinary para-professionals who primarily provide support services for aquatic disease laboratory diagnostics. This programme provides the opportunity for American Fisheries Society – Fish Health Section members to offer its members the opportunity to become Certified Fish Pathologists (9). This programme is utilised by the US Fish and Wildlife Services and state governmental agencies that support wild fisheries hatcheries and natural resource replenishment. Although many of the diagnostic laboratory services available through these government programmes are not available to veterinarians serving commercial aquaculture industries, they have been important in establishing new standardised laboratory diagnostic tests and procedures for aquatic animal diseases (8).

**Certification of core aquatic veterinary competency**

Recognising the need for a programme that recognises those veterinarians that have acquired the core education, skills and competency to practise aquatic veterinary medicine, the World Aquatic Veterinary Medical Association (WAVMA) is implementing a new Certified Aquatic Veterinary Practitioner (Cert-AqVP) programme. The objective is to credential graduate veterinarians who have acquired sufficient core or Day 1 knowledge, skills and experience (KSE) to be competent to practise aquatic veterinary medicine with a wide variety of aquatic species (e.g. aquatic mammals, reptiles, amphibians, finfish, crustaceans and molluscs). While still being refined before full implementation, the Cert-AqVP programme will require demonstrated competency through knowledge and skills assessments (KSA) in eight core KSE areas (Table I).

The Cert-AqVP programme is specifically structured to supplement education that may not be available during a veterinary degree programme and will not duplicate or conflict with veterinary specialist programmes that exist or may be developed in the future. As envisaged, veterinarians may obtain these KSEs through a variety of academic, CEPD or self-study programmes and clinical experience, from any existing or future source. To establish a baseline of available aquatic veterinary education opportunities worldwide, the WAVMA is in the process of evaluating existing programmes to ensure that they meet the specific KSE objectives. Additionally, the WAVMA will be developing specific education modules to supplement deficient KSE areas. Once existing educational opportunities are identified or specific modules developed, a veterinarian wishing to be awarded a Cert-AqVP will be required to document completion of all eight KSE subject areas through KSA. Awardees will also be required to fulfil additional CEPD requirements on a regular basis to maintain their certified status.

Relevant to this discussion, the WAVMA Cert-AqVP programme will have KSE/KSA requirements addressing appropriate legislation and regulations relative to aquatic veterinary medicine on a national, regional and international level. In particular this module will also require a good working knowledge of international aquatic animal health standards, including the OIE Aquatic Animal Health Code and Manual of Diagnostic Tests for Aquatic Animals (85, 87). Once in place, this module will be available internationally and may assist in addressing the challenges in engaging OIE Member Countries in aquatic activities, which have been identified elsewhere (22).
Several countries have initiated education and training programmes focusing on aquatic animal health-related
issues that will directly contribute to the effectiveness of NVS, or other government departments, ministries or
agencies that have statutory authority over aquatic animal health and diseases.

Veterinary authorities and other competent governmental authorities in many countries lack adequate resources
to employ a large number of veterinarians and veterinary para-professionals to perform all official work related
to animal health and disease. To address this concern, several countries have developed public–private partnerships
in which the veterinary authority utilises private veterinary practitioners to perform some official regulatory activities
on the government’s behalf. Under this model, the governmental authority retains overall authority and responsibility
for ensuring adequate delivery of the delegated function. Many are referred to as National Veterinary Accreditation
Programmes (NVAPs), including those in Australia (20), Canada (27) and the USA (73). Within the EU, Official
Veterinarians perform regulatory functions roughly equivalent to those of veterinarians accredited through other
NVAPs. Countries that utilise an NVAP require veterinarians to complete specific education and training before
being assigned the regulatory responsibility for inspecting, monitoring, reporting and certifying the health or
disease status of animals. These responsibilities are usually codified in regulations, and accredited veterinarians
are held accountable for correctly fulfilling these official duties and risk losing their accreditation (and potentially
their licence to practise veterinary medicine) if they are negligent in fulfilling their official duties (72).

While NVAPs have been in existence for many decades (e.g. the NVAP administered in the USA was codified in
1921), it is only quite recently that those in Canada and the USA are undergoing revision to specifically include
aquatic veterinary education to support NVS activities. These and other NVAP revisions were initiated in 2002
(68) and have now been full codified in the US (68) and Canadian regulations (24) and are being implemented.
In the USA, approximately 55,000 accredited veterinarians have registered for the new NVAP. Although most
veterinarians are expected to continue to service traditional livestock, poultry and companion animal industries, it
is estimated that 2,000–3,000 accredited veterinarians will be available to service the US aquatic animal industries
within a few years.

Within the aquatic components of the US and Canadian NVAP, veterinarians are required to complete an initial
core aquatic veterinary education module and undertake additional annual CEPD courses. The core NVAP aquatic
veterinary education modules (Table I) are designed to support the implementation of National Aquatic Animal

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<tr>
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<tr>
<td>Anatomy and physiology of aquatic animals</td>
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<td>Environmental evaluation (water quality) that affects the health of aquatic animals</td>
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<td>Industry structure and function, including commercial aquaculture (farmed seafood and ornamental fisheries), natural resource (wild) aquaculture and ornamental (pet) and public aquaria</td>
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<tr>
<td>Pathobiology and epidemiology of important aquatic animal diseases</td>
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<tr>
<td>Veterinary clinical diagnostic techniques and technologies for assessing important aquatic animal diseases</td>
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<tr>
<td>The availability and appropriate use of therapeutic and biological agents (drugs, vaccines and bacterins) for preventing, controlling and treating important aquatic animal diseases</td>
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<tr>
<td>Public health, zoonotic diseases and seafood safety aspects relevant to aquatic veterinary medicine</td>
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<tr>
<td>International, federal, state/provincial and local legislation, regulations and standards affecting the practice of aquatic veterinary medicine</td>
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<tr>
<td>Principles of aquatic animal welfare and well-being</td>
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<tr>
<th>Table I  World Aquatic Veterinary Medical Association (WAVMA) Certified Aquatic Veterinary Practitioner (Cert-AqVP) programme core subject matter areas</th>
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Education programmes supporting National Veterinary Services

Several countries have initiated education and training programmes focusing on aquatic animal health-related
issues that will directly contribute to the effectiveness of NVS, or other government departments, ministries or
agencies that have statutory authority over aquatic animal health and diseases.
Table II Aquatic veterinary education modules in development incorporated into the National Veterinary Accreditation Programmes to support implementation of National Aquatic Animal Health programmes in Canada (a) and the USA (b)

When fully implemented in 2011–2012, educational materials and web-based modules and other programme materials will be accessible to other countries

<table>
<thead>
<tr>
<th>Education module subject matter</th>
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<tbody>
<tr>
<td>Introduction to the National Aquatic Animal Health Program (NAAHP) Delivery (a)</td>
</tr>
<tr>
<td>Disease Prevention and Biosecurity in Aquaculture (b)</td>
</tr>
<tr>
<td>Regulations and Health Certifications for Aquaculture (b)</td>
</tr>
<tr>
<td>Aquatic Animal Diseases and Related Regulatory Activities (b)</td>
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<tr>
<td>Export Certification Program and Delivery (a)</td>
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<tr>
<td>Aquatic Animal Health Import Program (a)</td>
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<td>On Site Practical Procedures (a)</td>
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<tr>
<td>Compartmentalisation (a)</td>
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<tr>
<td>Aquatic Premises Identification (AquaPiq) and Aquatic Animal Knowledge (a)</td>
</tr>
<tr>
<td>Receiving Mandatory Notifications and Completion of the Aquatic Premises (a)</td>
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Health Programmes (26, 46). This training will be available through in-person meetings, and will be accessible on the Internet (J. Constantine & T. Behre, personal communication). As yet, Australia has not incorporated aquatics in their NVAP (I. Ernst, personal communication) in order to support implementation of the AQUAPLAN and AQUAVETPLAN (17, 18). However, several training programmes and educational materials developed since 2001 (Table III) would strongly support this action. In the EU, utilising Official Veterinarians to implement many of the aquatic animal health requirements outlined in the European Council Directive EC2006/88 (28) has not received attention. As both US and Canadian web-based education modules and other NVAP materials will be publicly available, they may be useful for other countries considering similar programmes and educational needs.

Locating aquatic veterinarians and veterinary para-professionals

Currently, from informal examination of numerous veterinary organisation membership databases and other sources, it is estimated that 7,000–10,000 veterinarians throughout the world deal with a variety of aquatic veterinary issues. To help refine this information, the American Veterinary Medical Association developed a global online resource (www.AquaVetMed.info) comprising a Directory of Aquatic Veterinarians and a Directory of Aquatic Diagnostic Laboratories (62). Veterinarians and laboratories can register to include their interests and services on this site at no cost. As an incentive to register, registrants can also subscribe to AquaVetMed e-News, a free electronic newsletter that distributes information on numerous issues of interest to aquatic animal health professionals. Currently the veterinary directory contains more than 3,500 individuals, and, based on website usage, these directories are being accessed extensively by clients, government agencies, veterinarians and other stakeholders seeking aquatic veterinarians.

Discussion and conclusions

Numerous educational opportunities in aquatic animal health are currently available. However, organised approaches in academic and non-academic programmes are needed to focus on the specific needs of an expanding and increasingly global aquatic veterinary workforce that, by necessity, will include aquatic veterinarians and veterinary para-professionals. The resources and the infrastructure to support a diverse and well-skilled workforce able to meet the needs of aquaculture industries are reasonably well developed in several countries, but seriously lacking in others. Most importantly, over the past 5–10 years there has been a dramatic increase in the need and demand for professionals who are able to utilise, interpret and convert research and diagnostic laboratory findings into
deliverable veterinary services. A large body of aquatic animal health and disease information generated from early scientific discovery has assisted burgeoning aquaculture industries worldwide, and makes a shift in emphasis to developing veterinary responses and services more feasible. This change has also opened up opportunities, and it is one of the most important factors encouraging students and graduate veterinarians to seek additional education and experience in order to be fully involved with aquatic veterinary medicine.

Veterinary schools around the world face an ever-growing challenge for adding more courses to an already full veterinary curriculum. Further, the relatively low profit margin in many aquaculture industries has been a disincentive for encouraging veterinarians to seek supplemental education and skill training in aquatic animal species – a challenge also being faced by terrestrial livestock industries in attracting and maintaining a sufficient number of well-educated and experienced veterinarians (30).

Complicating the ability of many countries to advance a well-educated and clinically competent aquatic veterinary workforce is the fact that the government authority with oversight of aquatic animal health is different from the government authority with oversight of terrestrial animal health and other veterinary issues. In many cases, the

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**Table III** Examples of targeted training and capacity-building projects initiated by the Australian Fisheries Research and Development Corporation, Aquatic Animal Health Subprogramme, to support the implementation of AQUAPLAN and AQUAVETPLAN

In most cases projects were completed in two to four years (29). Project reports are available at: www.frdc.com.au/research/Animal-Health

<table>
<thead>
<tr>
<th>Year initiated/project number</th>
<th>Project title</th>
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<tbody>
<tr>
<td>2001/093</td>
<td>Strategic planning, project management and adoption</td>
</tr>
<tr>
<td>2002/645</td>
<td>Aquatic animal health exotic diseases training manual</td>
</tr>
<tr>
<td>2002/654</td>
<td>Development of a training course on exotic diseases of aquatic animals</td>
</tr>
<tr>
<td>2002/655</td>
<td>Design and organisation of a multi-state disease emergency simulation exercise</td>
</tr>
<tr>
<td>2002/660</td>
<td>Enhancement of emergency disease management through the education and training of the Consultative Committee on Emergency Animal Disease (CCEAD) participants on the CCEAD process</td>
</tr>
<tr>
<td>2002/664</td>
<td>Aquatic animal health emergency management training and incident simulation</td>
</tr>
<tr>
<td>2002/666</td>
<td>Training course on exotic diseases of aquatic animals</td>
</tr>
<tr>
<td>2003/642</td>
<td>Revision and expansion of the Australian Aquatic Animal Disease Identification Field Guide for publishing on CD-ROM</td>
</tr>
<tr>
<td>2003/645</td>
<td>The development of media tools to increase the awareness of aquatic animal diseases</td>
</tr>
<tr>
<td>2003/646</td>
<td>Database of diseases and pathogens of Australian aquatic animals</td>
</tr>
<tr>
<td>2003/647</td>
<td>Development of a database for Australian laboratory diagnostic expertise for diseases of aquatic organisms</td>
</tr>
<tr>
<td>2003/669</td>
<td>Conduct of a multi-jurisdictional simulation exercise focused on health management in Australian aquaculture</td>
</tr>
<tr>
<td>2004/079</td>
<td>Strategic planning, project management and adoption</td>
</tr>
<tr>
<td>2005/621</td>
<td>Establishment of a national aquatic animal health diagnostic network</td>
</tr>
<tr>
<td>2005/641</td>
<td>Current and future needs for aquatic animal health training and for systems for merit-based accreditation and competency assessments</td>
</tr>
<tr>
<td>2008/039</td>
<td>Strategic planning, project management and adoption</td>
</tr>
<tr>
<td>2009/315</td>
<td>People development programme: Aquatic Animal Health Training Scheme</td>
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</tbody>
</table>
government authority with oversight of aquatic animal health is the same authority with oversight of harvest fisheries or wildlife and may not be familiar with the needs of an aquatic veterinary workforce. Often these officials lack sufficient training in aquatic animal health and have little to no collaboration with the veterinary authority. Indeed, as Shariff suggests (64): ‘the situation is pathetic when fisheries officers who have undergone a Bachelor’s [degree] programme and have done a mini project on bacteria or parasites of fish, without any formal courses in biomedical subjects such as pathology, virology, epidemiology, pharmacology, are entrusted to work as “fish health experts.” Since many of the fisheries departments are embarking on their own aquatic animal health management programmes without input from the Veterinary Department, progress has been very slow.’ Some countries have already rectified the challenge presented by multiple government agency involvement in aquatic animal health, through legislation, regulations or memoranda of understanding (25, 71) that delegate different responsibilities concerning aquatic animal health to the veterinary authority or other government authorities.

The first step towards improving aquatic animal health infrastructure on a global basis is to encourage a well-educated and clinically competent aquatic veterinary workforce that includes well-trained aquatic veterinarians and veterinary para-professionals. In accord with many of the recommendations that emerged from the 2011 OIE Global Conference on Aquatic Animal Health Programmes (Table IV) (87), the following suggestions for future action are provided:

- Where feasible, veterinary schools should consider:
  - For veterinary students: including core aquatic animal courses in veterinary curricula and providing credit for such courses and externships taken at other veterinary institutions.
  - For graduate veterinarians: expanding veterinary CEPD and internship and residency programmes focusing on aquatic veterinary medicine.
- The WAVMA should be encouraged to rapidly implement the Certified Aquatic Veterinary Practitioner Programme for recognising proficiency in aquatic veterinary medicine at an entry level.
- Veterinary and non-veterinary organisations should expand and focus conference, symposia and workshops on core skills needed to enhance the aquatic veterinary workforce.
- The OIE should encourage partnerships and twinning programmes between member countries for educational programmes that cater to expanding a well-educated and clinically competent aquatic veterinary workforce.

**Table IV** Recommendations of the ‘Panama Declaration’ affecting the development of a well-trained and educated aquatic veterinary and paraveterinary professional workforce, made during the OIE Global Conference on Aquatic Animal Health, 28–30 June 2011 (87)

<table>
<thead>
<tr>
<th>Recommendations for OIE action</th>
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<tbody>
<tr>
<td><strong>22</strong> The OIE should cooperate with governments and with relevant international and regional organisations to increase awareness of the need for aquatic animal health programmes, improve disease reporting and foster cooperation between veterinary and other relevant authorities at the national and international level</td>
</tr>
<tr>
<td><strong>23</strong> The OIE should strengthen collaboration with donors and with regional and international organisations, such as FAO (the Food and Agriculture Organization of the United Nations), to advocate for the key role of veterinarians and aquatic animal health professionals in the prevention and control of disease and to encourage governments and donors to invest in Veterinary Services and Aquatic Animal Health Services (AAHS) as a global public good</td>
</tr>
<tr>
<td><strong>24</strong> The OIE should continue taking steps to make the PVS Pathway, appropriately adapted to national aquatic animal health systems, more accessible to governments that wish to strengthen AAHS, including through the conduct of pilot evaluations of AAHS at the request of OIE Members</td>
</tr>
<tr>
<td><strong>25</strong> The OIE should continue providing capacity-building support to National Delegates to help them to comply with their rights and obligations and to Aquatic Animal Focal Points under the authority of National Delegates, to strengthen the capacities of OIE Members, particularly developing countries, to participate in the standard-setting process</td>
</tr>
<tr>
<td><strong>26</strong> The OIE should continue encouraging governments, relevant regional and international organisations and donors to provide sufficient resources for aquatic animal health governance and programmes, and for applied research relevant to these programmes, including into aquatic animal feed, welfare, therapeutics and vaccines</td>
</tr>
</tbody>
</table>
### Acknowledgements

We greatly appreciate updated information, concerning several programmes mentioned in this contribution, from Kay Watson (European School of Veterinary Postgraduate Studies), Dr Ingo Ernst (Department of Agriculture, Fisheries and Forestry, Australia), Dr Joanne Constantine (Canadian Food Inspection Agency), Dr Todd Behre (United States Department of Agriculture, Animal and Plant Health Inspection Service, Veterinary Services) and Dr Janet Whaley (United States Department of Agriculture, Animal and Plant Health Inspection Service, Veterinary Services). Dr Scott Weber (University of California) kindly provided Fig. 2 for use in this publication. Dr Elizabeth Sabin (American Veterinary Medical Association) reviewed and offered important suggestions to this contribution.

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<table>
<thead>
<tr>
<th>Number</th>
<th>Recommendation</th>
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<tbody>
<tr>
<td>27</td>
<td>The OIE should promote twinning projects that can strengthen early diagnosis; reporting, prevention and management of aquatic animal diseases; and other appropriate elements of capacity building.</td>
</tr>
<tr>
<td>28</td>
<td>The OIE should address the particular needs of veterinarians working with aquatic animals as part of its recommendations on the Day 1 competencies of graduating veterinarians, including by asking the Aquatic Animal Health Standards Commission to prepare recommendations on the content of the curriculum for Day 1 and Specialist Veterinarians.</td>
</tr>
<tr>
<td>29</td>
<td>The OIE should convince governments and donors to assist African countries under threat from epizootic ulcerative syndrome.</td>
</tr>
<tr>
<td>30</td>
<td>Countries where aquaculture is an important or growing sector should consider requesting an OIE PVS evaluation of their AAHS, with the objective of improving competencies and general compliance with OIE standards and guidelines.</td>
</tr>
<tr>
<td>31</td>
<td>Independent of entering the PVS Pathway, Members should take steps to improve compliance with OIE standards and guidelines, notably on the diagnosis and reporting to the OIE of aquatic animal diseases, on the use of therapeutic tools, such as antimicrobials, and on the formation of public–private partnerships.</td>
</tr>
<tr>
<td>32</td>
<td>Those Members who have not yet done so should nominate national Focal Points for Aquatic Animals under the authority of the OIE Delegate and support participation of nominated Focal Points in OIE regional capacity-building seminars and other relevant activities.</td>
</tr>
<tr>
<td>33</td>
<td>The OIE National Delegate should take steps to ensure that the OIE standards and recommendations on the prudent use of antimicrobial agents are respected in his/her country.</td>
</tr>
<tr>
<td>34</td>
<td>OIE Reference Centres should, as part of their mandate, continue to comply with and promote the application of OIE standards, and provide services to OIE Members.</td>
</tr>
<tr>
<td>35</td>
<td>Members with an OIE Reference Centre for aquatic animal diseases should provide sufficient resources to enable the Centre to adequately fulfil its mandate and duties.</td>
</tr>
<tr>
<td>36</td>
<td>OIE Members, especially those with OIE Reference Centres, should give favourable consideration to participating in the OIE Twinning Programme.</td>
</tr>
<tr>
<td>37</td>
<td>Governments should support and encourage applied research on key questions related to aquatic animal health programmes, including those on relevant aspects of feed for use in aquaculture, aquatic animal welfare, and ecologically sustainable tools for the prevention and control of important aquatic animal diseases.</td>
</tr>
<tr>
<td>38</td>
<td>Governments should, as appropriate, comply with their WTO (World Trade Organization) SPS obligations with respect to aquatic animal health certification for international trade.</td>
</tr>
</tbody>
</table>
References


35. European Association of Fish Pathologists. Available at: eafp.org (accessed 26 August 2011).


54. NOVA University Network, a network of Nordic Forestry, Veterinary and Agricultural Universities educational programmes. Available at: www.nova-university.org (accessed 26 August 2011).


Veterinary products and aquatic animals: towards the responsible and prudent use of antibiotics

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Summary
The use of antimicrobial agents in aquaculture raises some unique and important issues. Bacteria possess a remarkable ability to become resistant to antimicrobial agents. The overuse or misuse of these agents automatically leads to a reduction in their therapeutic value with serious consequences for animal health and welfare and the economics of aquaculture. The use of antimicrobial agents in aquaculture may also present risks for human health. For these reasons, it is essential that the use of these agents be regulated to ensure that it is both prudent and rational. The World Organisation for Animal Health (OIE) initiated the development of standards on this topic in January 2010. This paper will discuss current thinking on the administrative procedures and structures, involving both regulation and monitoring, that will be required to achieve these goals.

The main objective of regulation is to ensure that only those agents that can be demonstrated to be both safe and efficacious are used. This should be achieved by a process of evidence-based licensing. There is, in many jurisdictions, a dramatic shortage of licensed products, and it will be argued that increasing the number of licensed products is a prerequisite for the efficient management of antimicrobial agent usage.

As the emergence of resistant bacteria is a major negative consequence of antimicrobial use, administrative structures are needed to provide a framework for the monitoring and surveillance of these phenomena. However, the protocols and interpretive criteria required to quantify resistance in aquatic bacteria have not yet been fully developed. It will be argued that these methods are a prerequisite for monitoring and surveillance programmes. Therefore, competent authorities and other relevant regulatory bodies need, as a matter of some urgency, to engage with the current international research aimed at harmonising and validating the required antimicrobial susceptibility testing methods.

Keywords

Introduction
The use of antimicrobial agents in aquaculture raises some unique and important issues. This paper will, therefore, concentrate on the management of this group of veterinary products. Since 2010 an ad hoc expert group on the responsible use of antimicrobial agents in aquatic animals has been meeting within the World Organisation for Animal Health (OIE) to draft new chapters for the Aquatic Animal Health Code. This paper provides an introduction to the issues that have informed the debate within the ad hoc group. However, the ideas presented in this paper are the personal opinions of the chairman of the ad hoc group and should not be taken as representing the position of the group or of any section of OIE itself.

A definition of antibiotics
In this paper antibiotics will be defined as substances that, at in vivo concentrations, kill or inhibit the growth of microorganisms. It should be noted that, defined in this way, the term antibiotic includes products derived from plants.
**The need for antibiotics in aquaculture**

The most effective way of reducing losses to infectious disease in aquaculture is to apply appropriate husbandry to the rearing of farmed animals. This would include rearing them in optimal environmental conditions, stocking at densities appropriate to those conditions, providing optimal nutrition and using appropriate vaccines (9). It is, however, unrealistic to expect these measures to completely eliminate infectious disease epizootics in farmed aquatic animals. When epizootics do occur, consideration of animal welfare and the economics of the farm require application of an appropriate therapy. When bacterial infections play a major role in the aetiology of these epizootics, antibiotics have been shown to be the most effective class of therapeutic agents.

Experience has shown that disease epizootics will be more common when new species are being farmed, when aquatic animal species are being farmed in new areas or environments and when they are being reared by farmers with limited experience. Given the rapid global expansion of aquaculture these conditions can be expected to occur regularly.

These considerations suggest that, although antibiotic therapy should be seen as a last resort, it will remain for the foreseeable future an essential component of the farming of aquatic animals.

**The need for prudence in the use of antibiotics in aquaculture**

The use of antibiotics in aquaculture necessarily involves the introduction of chemicals that are biologically active at low concentrations into the environment and the food chain. The presence of antibiotics in any environment exerts a selective pressure for the emergence of bacteria resistant to their action.

There are a wealth of data demonstrating that the more antibiotics are used (not only misused) for therapeutic purposes the more frequently clinically significant resistant variants of the bacteria that are the target of those therapies are encountered (11). Thus, antibiotic use is under an inevitable negative feedback control. The more they are used the less use they are. The only way that the impact of the emergence of antibiotic resistance in bacterial species that infect aquatic animals can be limited is to exercise extreme prudence in the use of these agents.

There is a risk that antibiotic resistance selected within aquaculture may transfer to bacteria capable of infecting land-based animals including humans. Therefore, there is a possibility that use in aquaculture may compromise the therapy of human diseases and result in increased human morbidity and mortality. At present, it has not proved possible to quantify the size of this risk (12). However, the existence of some risk of adverse effects on human health again requires that antibiotics are used in aquaculture with responsibility and prudence.

**The current status of regulation and monitoring of antibiotic use**

There is huge variety in the extent and the style of regulation and monitoring/surveillance of antibiotic use in aquaculture. Some authorities have very sophisticated procedures but the majority, including many responsible for large production volumes, have not. For those authorities that have well-developed regulations, these have centred round the idea that use should be confined to only those antibiotic products that have been licensed by the granting of marketing authorisations. However, the current situation is that globally very few antibiotics are licensed for aquaculture. Many authorities have licensed no antibiotics and others have licensed only a few (2, 3, 4, 5). Some large industries (shrimp) have no licensed antibiotics.

With respect to the monitoring of antibiotic use in aquaculture, the situation is equally underdeveloped. We have, with the exception of data for a limited number of national industries (7), no accurate estimates of the amount of antibiotics used in aquaculture. With respect to the consequences of antibiotic use (target bacteria resistance) we have little information. The absence of harmonised methods for resistance determination means that what data sets we have cannot be compared, and the lack of validated methods results in much of the information we do have being suspect (10).
**The way forward**

The considerations above demonstrate the need to develop science-based guidelines for the development of regulations governing the use of antibiotics in aquaculture and for the regular and systematic monitoring and surveillance of their use.

**Prudent and responsible use**

Licensing the use of antibiotics in aquaculture, via the granting of marketing authorisations, is seen as the key element in attempts to regulate their prudent and responsible use (6). This aims to ensure that only those agents that are safe and efficacious are used and that all products are labelled as to their appropriate use. When a marketing authorisation is granted it becomes possible to formulate regulations that specify the responsibilities and duties of all stakeholders.

In placing marketing authorisations at the centre of attempts to regulate antibiotic use it must be admitted that so far very few such marketing authorisations have been granted. This has been partly a function of the cost and complexity of preparing the necessary documentation and partly one of the unregulated state of the antibiotic market in many jurisdictions. Further problems with the marketing authorisation-based approach relate to the relative specificity of the marketing authorisation.

The safety of antibiotic use involves consideration of the animals treated and those who handle the drug but most importantly those who consume the aquatic animal product. Two key parameters are involved in establishing that antibiotic use in aquatic animals is safe for human consumers. The first is the maximum residue level (MRL) that should be present in the product consumed. Values for antibiotic-specific MRLs can be set internationally (often by major importing countries) and can be applied to all aquaculture products (1). MRLs are, therefore, not specific. The second key parameter, the time after a standard treatment that it is safe to assume that the residues have fallen to below the MRL (the withdrawal time) is, however, specific. Its values are influenced by the species of animal treated and the environment (temperature and salinity) of the treatment. With respect to antibiotic efficacy, studies can establish only that a specified dose regimen delivered using a specified antibiotic-containing product will control losses resulting from a specified bacterial infection of a specified farmed species under specified environmental conditions.

These considerations demonstrate that marketing authorisations will always have to relate to the use of antibiotics under specified conditions. The wide spectrum of activities represented by aquaculture, however, is such that, in practice, the industry will always require access to antibiotic therapies in a diverse set of conditions. It is, therefore, inevitable that there will be a continuing need for ‘extra-label’ or ‘off-label’ use. Strict adherence to a marketing authorisation-only policy would not be practicable and would not be in the interests of animal welfare or farm economics or even scientifically justifiable.

Regulation of ‘extra-label’ or ‘off-label’ use is a major problem and one that must be addressed with some urgency.

**Monitoring resistance to antibiotics**

The emergence of resistance to antibiotics is the most important and significant adverse effect of the use (and misuse) of these agents. There is strong evidence that the group of bacteria most affected are those capable of infecting aquatic animals and the specific target of antibiotic therapies (11). There is, therefore, a clear need and obligation to collect information on the frequencies of resistance in these bacteria. Resistant bacteria and, even more importantly, bacterial resistance genes have been shown to be highly mobile and therefore resistance must be seen as a global, transnational issue. For this reason data on the frequencies of resistance are required on a regional, national and international basis. This underlies the need for them to be obtained using standardised, internationally harmonised and validated methods (8). At present the major problem with designing and performing resistance-monitoring programmes is the lack of such standard susceptibility test methods (10).

There have been, however, recent advances in the development of standardised susceptibility testing protocols for aquatic bacteria. Susceptibility testing involves the development of standard laboratory methods (test protocols) for generating a measure of the susceptibility of a bacterium and then developing criteria that allow the meaning (in terms of sensitivity or resistance) to be given to these susceptibility measures. It is generally accepted that
the approach of the Clinical and Laboratory Standards Institute (CLSI) should form the framework within which future development of such protocols should take place (2, 3, 4). The CLSI approach is a work in progress, and Table I presents a simplified illustration of the current state of its development. As can be seen, considerable progress has been made with the standardisation of test protocols. Conversely, little progress has been made with establishing species- or genus-specific interpretive criteria. There is an urgent requirement for studies that will facilitate the establishment of these criteria.

Table I  Summary of the current progress in susceptibility testing (2, 3, 4)

<table>
<thead>
<tr>
<th>Species</th>
<th>Test protocols</th>
<th>Interpretive criteria</th>
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<tbody>
<tr>
<td><em>Aeromonas salmonicida</em></td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td><em>Aeromonas</em> spp.</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td><em>Edwardsiella</em> spp.</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td><em>Flavobacterium</em> spp.</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td><em>Photobacterium</em> spp.</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td><em>Streptococcus</em> spp.</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td><em>Photobacterium</em> spp.</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td><em>Vibrio</em> spp.</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td><em>Piscirickettsia salmonis</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Vibrio salmonicida</em></td>
<td>?</td>
<td></td>
</tr>
<tr>
<td><em>Tenacibaculum maritimum</em></td>
<td>?</td>
<td></td>
</tr>
<tr>
<td><em>Francisella</em> spp.</td>
<td>?</td>
<td></td>
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</tbody>
</table>

+, indicates that the relevant protocols have been adopted
?, indicates that protocols have been proposed but not formally adopted

There are two factors that make this task less onerous than it might at first appear. The bacterial groups identified in Table I are those that have been agreed by CLSI and OIE to be of major significance for global aquaculture. However, most regulatory authorities will be able to identify a much shorter list of the bacterial species that are of importance to their local industries. The framework within which the CLSI guidelines are developed allow interpretive criteria to be developed on a species-by-species basis.

**Surveillance of the amounts of antibiotics used in aquaculture**

Data on how much antibiotics are being used in aquaculture is a fundamental requirement. It is recognised that the ease with which different competent authorities will be able to develop systems for collecting this data will vary depending on local conditions. These local conditions will also influence the sources that can most appropriately be used for collecting relevant data. However, these data are essential if we are to understand emerging patterns of resistance, to inform and monitor strategic planning and to perform risk analysis. Therefore, competent authorities should be moving towards a situation where they can collect and report the required information.

The core data that is required would be absolute amount (kilograms of active ingredient) used together with the species of animals treated (number, weight). Additional information on the rationale for each use (therapy/prophylaxis), the mode of administration (bath/oral), the type of husbandry and the environmental conditions would add significant value to the core data.
**Risk analysis**

The perception that antibiotic use in aquaculture may result in adverse effects on human health is having, and will have, significant impact on therapeutic practices in aquaculture. The number and range of antibiotics licensed for aquaculture is already very limited. Pressure from those primarily concerned with antibiotic resistance in bacteria that infect humans may lead to further limitations (13). It should, however, be noted that it has proved difficult to gain any quantitative, or even qualitative, assessment of the risk that antibiotic use in aquaculture presents for human health (12).

It is generally accepted that the risks associated with the presence in the market place of antibiotic-resistant bacteria capable of infecting humans is considerably lower for the products of aquaculture than it is for the products of land-based agriculture (12). It should not prove impossible to design, commission and perform the studies that would lead to a quantitative estimate of these risks. In doing so, however, it should always be borne in mind that such resistant bacteria may not be a consequence of antibiotic use in aquaculture. They may be present in aquaculture products as a result of contamination of rearing waters with land-based effluent or as a result of post-harvest contamination.

Possibly a more serious risk is that represented by transferable resistance genes selected as a result of the use of antibiotics in aquaculture. These genes may contribute to the postulated environmental reservoir of such genes that is maintained by natural processes and inputs derived from all therapeutic uses of antibiotics. To the extent that this reservoir is a significant source of resistance genes in bacteria infecting humans, antibiotic use in aquaculture may have an adverse impact on human health. Assessment of this risk will require studies of the relative contributions that aquaculture, agriculture and human medicine make to the postulated environmental reservoir and studies of the contribution of that reservoir to resistance in bacteria relevant to antibiotic therapy in humans. These studies will be complex and, as yet, no real start has been made.

**Conclusions**

This paper has discussed prudent and responsible use of antibiotics in aquaculture largely from a regulatory perspective. However, the actual users of antibiotics are farmers and their healthcare professionals who buy and use antibiotics because they think or hope that it will increase their profits. Anecdotal evidence suggests that, currently, much of that use is inappropriate and imprudent. It could be argued that the greatest gain in prudent use (and economic efficiency) could be achieved by providing farmers with good-quality advice (9). Education programmes to train farmers and their on-farm advisors in the correct use of antibiotics and the provision of adequate and local diagnostic and antibiotic susceptibility testing services may have as large a role to play in promoting prudence and responsibility as the formulation of appropriate regulatory frameworks.

**References**


Biotechnology and the diagnosis and surveillance of aquatic animal pathogens

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Summary
Over the past two decades, immunological and molecular reagents have made an increasing contribution to the development and improvement of diagnostic tests used for the detection and identification of pathogens of aquatic organisms. These tests are either based on the use of monoclonal/polyclonal antibodies directed against pathogen epitopes (e.g. enzyme-linked immunosorbent assay [ELISA], immunoblot, immunohistochemistry) or based on amplification/detection of nucleic acid sequence(s) specific to the target pathogens (e.g. polymerase chain reaction [PCR], real-time PCR, loop-mediated isothermal amplification [LAMP], in situ hybridisation, Luminex assay).

The laboratory methods that are considered to be international standards for the detection of aquatic animal diseases are described in the World Organisation for Animal Health (OIE) Manual of Diagnostic Tests for Aquatic Animals (Aquatic Manual).

Various assays have been developed in recent years for the major pathogens of finfish (e.g. infectious pancreatic necrosis virus, infectious haematopoietic necrosis virus, viral haemorrhagic septicaemia virus, infectious salmon anaemia virus, Piscirickettsia salmonis, Vibrio spp., Aeromonas spp., etc.), molluscs (Bonamia spp., Martelia spp., Mikrocytos mackini, Perkinsus spp., Ostreid herpesvirus 1, abalone herpes-like virus, etc.) and crustaceans (e.g. white spot syndrome virus, yellow head virus, infectious myonecrosis virus, etc.). Many of these tests have been implemented into routine practice in national and state government diagnostic laboratories and in private veterinary and pathology clinics, as well as in research laboratories around the world. Aquatic animal disease management plans, including health surveillance, export certification, and biosecurity measures, increasingly rely on the use of sensitive and specific biotechnology-based diagnostic tests. As a case study, this presentation describes the emerging abalone herpes-like virus occurring in Australia and the development of diagnostic tests for its detection, study and management.

Keywords

Introduction
Increasing demand for aquatic animal protein, depletion of wild fish stocks and emergence of international markets have, among other factors, contributed to an increase in the number of aquatic animal species farmed around the world. These developments have paralleled the emergence of novel pathogens and the geographical expansion of previously restricted disease agents. Outbreaks of virulent pathogens can result in mass mortalities among naïve aquatic species with devastating economic and social consequences. The introduction and emergence of pathogens on a regular basis worldwide has served to emphasise the importance for governmental agencies and private enterprises of monitoring the health status of their aquaculture animals and wild stocks. The need for diagnostic surveillance and preparedness for potential disease outbreaks has been the basis for the development and application of pathogen-specific tests for use in aquatic animals. This paper presents an overview of some methodologies/tests that are currently used to detect, identify, monitor and manage pathogens of aquaculture species.
**Immunoaassays/antibody-based diagnostic technologies**

These assays use antibodies that have been characterised for binding specificity as test reagents. These antibodies can be labelled (e.g. fluorochrome, dyes, beads, etc.) for direct or indirect detection of binding.

**Immunohistochemistry (IHC)**

The IHC technique is a widely used and valuable tool in the diagnosis of aquatic infectious disease agents. Diagnostic antibodies can be produced that bind specifically to antigens of a pathogen present in cells or tissues of an infected animal. Immunohistochemistry is particularly useful not only to detect the pathogen but also to locate its distribution (target tissues), to observe differential expression of its proteins and to understand its infectious cycle. Visualising the antibody–antigen interaction can be accomplished in many ways; however, the most common procedure involves the use of enzyme-conjugated antibodies to catalyse a colour-producing reaction. In order to potentiate a stronger signal, the preferred method employs indirect detection through a secondary antibody–enzyme conjugate that has anti-species antibodies binding to the primary antibody. The method involves a reaction between the infected tissue and antigen-specific primary antibodies (unlabelled) followed by a reaction with a secondary labelled antibody that binds with the primary antibody and thus amplifies the specific signal. The secondary antibody must be raised against the primary antibody and as such must be derived from a different species (22). Labelled secondary antibodies against most common animal species are therefore generic and are available commercially. It must be noted that IHC is not rapid as it requires several days to complete. It also requires experience in interpretation. Figure 1 shows IHC performed on salmon liver tissue infected with *Piscirickettsia salmonis*, an important pathogen of salmonids worldwide (7).

![Fig. 1 Immunohistochemistry assay performed on salmon liver tissue infected with *Piscirickettsia salmonis*](image)

**Lateral flow immunoassay**

The lateral flow assay involves the detection of a target antigen (e.g. white spot syndrome virus [WSSV]) in a test sample. The test sample (e.g. gill/pleopod tissue extract) is dropped into the well of a device (containing a nitrocellulose membrane) and reacts with polyclonal anti-WSSV antibodies labelled with colloidal gold particles. The antibody–antigen (virus) complex then flows, via capillary action, along the membrane and binds to another WSSV monoclonal antibody fixed on the test line, forming a line that is coloured red by the colloidal gold. The excess complex moves further along the substrate and binds to an anti-mouse antibody on the control line, causing a red colour to develop along the control line as well (Fig. 2). If the virus is absent from the sample, only gold-labelled antibodies flow along the substrate and do not bind to the test line (which is virus specific), which means that only the control line appears.

Lateral flow chromatography strips specific for detection of WSSV in prawn tissue are now commercially available. These tests are inexpensive, do not require highly skilled staff, as is the case for some molecular techniques, and provide rapid results with ease of use in the field. However, they are not very sensitive and are mostly suitable...
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for near-outbreak or outbreak confirmation (26). For early detection of WSSV, an assay combining polymerase chain reaction (PCR) and lateral flow chromatography strips has been developed and provides a much higher sensitivity than the lateral flow assay alone (27).

**Nucleic acid-based diagnostic technologies**

Nucleic acid-based diagnostic assays aim to detect specific genomic sequences of infecting agents through target amplification (e.g. PCR-based) or direct target probing with signal amplification (e.g. in situ hybridisation [ISH]).

**Conventional polymerase chain reaction**

Amplification of nucleic acid is now widely used in the diagnosis of aquatic animal diseases. A conventional PCR reaction utilises two oligonucleotide primers, each annealing (hybridising) to one strand of double-stranded DNA of the target (pathogen DNA present in the infected animal tissues). The RNA genomes can also be detected by PCR assays but must first undergo reverse transcription of their RNA into DNA using a reverse transcriptase prior to PCR amplification. A DNA polymerase extends the annealed primers by adding on deoxyribonucleotide triphosphates to generate double-stranded products. By raising and lowering the temperature of the reaction mixture using a thermocycler, the two strands of the DNA product are separated and serve as templates for the next round of annealing and extension. The process is repeated 35–40 times to provide millions of target DNA copies (19). The resulting amplified DNA product is then stained with a fluorescent dye, run on an agarose gel and visualised with a blue light transilluminator (Fig. 3). Further analysis of the DNA product, through restriction fragment length polymorphism or sequencing, can be performed to confirm the identity of the pathogen and discriminate between variants.

**Fig. 2 The principle of lateral flow chromatography**

**Fig. 3 Photograph of a stained agarose gel**

A PCR assay was performed on extracted tissue DNA from abalone herpesvirus-infected abalone (lane 1 and 2) and healthy abalone tissues (lanes 3 and 4). The 486 bp amplicons seen in lane 1 and 2 are virus specific. Lane 5 contains a 100 bp DNA ladder.
Over the past two decades, we have seen the introduction of PCR assays in the arena of disease diagnosis of aquaculture animals (finfish, crustaceans, molluscs) of economic importance, as most important pathogens can now be detected and identified through the use of PCR (30). The high sensitivity of PCR allows pathogen detection soon after infection, even before the onset of signs of disease. This feature is a key element in the management of cultures as it allows early harvesting thus avoiding total loss of production (e.g. WSSV in prawn cultures). A variation on the conventional PCR is the nested PCR, which uses two sets of primers in two successive PCR reactions. Although more sensitive than the conventional PCR, it has increased risks of cross-contamination between samples.

The PCR assay is sensitive, specific and allows molecular typing (differentiation at the genomic level) of microorganisms. It is also regularly used to confirm histopathology.

**Real-time PCR**

Real-time PCR is based on the same principle as the PCR method with the added feature that the amplified DNA is detected as the reaction progresses as opposed to conventional PCR in which the product of the reaction is detected at the end. An increase in DNA product during PCR leads to an increase in fluorescence intensity (see detection methods, below) and is measured at each amplification cycle, thus allowing DNA concentrations to be quantified (28) (Fig. 4).

There are two methods used for the detection of amplified target DNA in real-time PCR: the first one uses non-specific fluorescent dyes that label any double-stranded DNA (e.g. SYBR Green). The second method uses sequence-specific DNA probes consisting of oligonucleotides that are labelled with a fluorescent reporter which permits detection only after hybridisation of the probe with its complementary DNA target (e.g. TaqMan, Molecular Beacons, Scorpions). SYBR Green provides the simplest and most economical format; however, because the labelling is not specific to the pathogen DNA, multiplexing is not possible and labelling of primer dimers or other spurious DNA products can result in overestimation of target (pathogen) concentration. As for the second method, the DNA probes are designed to hybridise specifically to an internal region of the amplified pathogen DNA, thereby making this method more specific. In addition, the use of probes is preferred when multiplexing is required. Multiplexing an assay involves the designing of more than one probe, each one having a spectrally unique profile, permitting the detection of multiple targets in a single well/sample.

The development of real-time PCR has allowed true quantification of target nucleic acid, which is not only very valuable for the study of pathogens’ life cycles (e.g. gene expression) but also for diagnostic purposes (e.g. establishing the level of infection, pathogen persistence and potential carrier status of the animals). Quantification
of target nucleic acid can be performed by establishing a standard curve constructed from DNA of known concentration (e.g. plasmid); this curve is then used as a reference standard for extrapolating the abundance of a particular DNA sequence in a sample. The RNA genome viruses can also be quantified; however, an additional step is required – the reverse transcription of their RNA into DNA – for the amplification to be carried out. The advantages of real-time PCR as a diagnostic tool include high sensitivity and specificity, short turnaround time, the absence of a post-PCR detection procedure (no need to run a gel), little or no risk of carryover, and multiplexing capabilities (16). Disadvantages include the high cost of the initial equipment purchase, the cost of reagents and the high-level technical laboratory skills required. In recent years several real-time assays have been developed for aquatic animal disease agents, highlighting the usefulness of this technology for diagnostic and research applications (1, 3, 6, 21, 29, 31).

**Loop-mediated isothermal amplification (LAMP)**

The LAMP method is an innovative gene amplification technique emerging as a simple diagnostic tool for early detection and identification of microbial diseases. Loop-mediated isothermal amplification is one of several modern isothermal amplification techniques. It is highly specific, generally more sensitive than PCR, rapid (~1 hour), relatively low cost and can be applied for disease diagnosis in aquaculture settings that do not have sophisticated technical equipment or in the field itself. Therefore, LAMP makes an attractive diagnostic tool for lower income countries. This method employs a DNA polymerase and a set of four (up to six) specially designed primers that recognise a total of six distinct sequences on the target DNA (Fig. 5). The target DNA is amplified at a constant temperature (approximately 65°C) using either two or three sets of primers and a polymerase with high strand displacement activity in addition to replication activity. The different primers are used to identify six distinct regions on the target gene. The amount of DNA amplified in LAMP is considerable and, unlike conventional PCR, fragments encompass various lengths due to the formation of ‘concatemers’ so, when run on a gel, smears of DNA as well as discrete bands may appear. Amplified DNA can be detected by several methods (5), two of those being: by the release of magnesium pyrophosphate resulting in visible turbidity due to precipitation, which allows easy visualisation by the naked eye; or from a signal via fluorescent dyes that intercalate between nucleotides of the DNA or bind to its surface such as SYBR Green (32). Measurement of fluorescent DNA may be used to quantify the target, but in some cases, due to late non-specific DNA amplification, LAMP is not as reliable as the real-time PCR assay. Another limitation of LAMP is that, unlike real-time PCR, it cannot be multiplexed to detect more than one pathogen.

The excellent review by Savan et al. (24) on LAMP assays and fish and shellfish pathogens highlighted its wide use in detecting aquatic pathogens. In recent years, LAMP assays have been developed against several finfish, crustacean and mollusc pathogens including spring viraemia of carp virus (25), lymphocystis disease virus (14), WSSV (13) and the Ostreid herpesvirus 1 (23). In addition, these studies demonstrated that the LAMP assays involved less technical investment than conventional and real-time PCR and were 10–100 times more sensitive than their corresponding conventional single-step PCR assays. A recent study described the combination of LAMP and the fluorescence energy transfer-based probe technique to develop a new platform for the detection
of WSSV. This adapted version of LAMP, although requiring a more sophisticated methodology, was shown to be very specific, quantitative and of equal sensitivity to a nested PCR and to have a very low risk of carryover contamination (5).

**Suspension array technology (SAT)**

Suspension array technology is a high-throughput, large-scale and multiplexed screening platform used in molecular biology. It has wide application in biological fields including disease diagnosis. It uses microsphere beads (5.6 mm in diameter) that can be differentiated on unique optical properties (fluorescent colour-coded). An array is created by attaching DNA oligonucleotide probes (or antibodies or other proteins) to up to 100 different microsphere sets. Suspension array technology allows for the simultaneous testing and differentiation of multiple pathogens (or strains/isolates of a given pathogen). These sets of microspheres can be differentiated by flow cytometry as each set has a unique wavelength fingerprint (10).

One platform, the Luminex xTAG technology, uses a proprietary universal tag system that allows easy optimisation, development and expansion of molecular diagnostic assays. The methodology (Fig. 6) includes DNA extraction from the tissues of an infected animal, followed by a multiplex PCR specific for various pathogens (e.g. viruses) to generate target-specific amplicons of each of the viruses/strains potentially present in the sample. The following step involves target-specific primer extension reactions to detect viral targets present in the sample. During this step, each virus target is specifically hybridised to a target-specific primer (TSP) possessing a unique DNA tag. A DNA polymerase extends perfectly formed hybrid DNA complexes (TSP/virus target gene sequence) and simultaneously incorporates biotin–deoxycytidine triphosphate into the extension product (18). In the following step, the biotin-labelled TSP/virus hybrid DNA is mixed with the microspheres and coupled with the specific primer's anti-tag (unique to a specific virus tag). Biotinylated extension products hybridising on to the bead surface are detected with a fluorescent reporter molecule (typically streptavidin–phycoerythrin) by the flow cytometer and analysed by the Luminex software.

![Fig. 6 Workflow for the Luminex xTAG method](image-url)
Some benefits of SAT include excellent sensitivity and specificity, rapid data acquisition and multiplexed analysis capability. Multiplexing offers the advantage of simultaneous detection of multiple nucleic acid sequences in a single reaction vessel, which reduces time, labour and cost compared with single reaction-based detection methods (10). The main drawbacks of SAT are the cost of equipment and reagents, the lengthy method (one or two days compared with a few hours for the real-time PCR assay) and the difficulty in optimising the primers’ hybridisation parameters (e.g. temperature) associated with multiplexing. The author’s laboratory is currently developing a SAT for the detection of aquareoviruses and aquabirnaviruses, which are prevalent in Tasmanian fish. It is expected that other laboratories will also adopt this technology as a diagnostic and epidemiological tool for aquatic pathogens of significance.

In situ hybridisation

In situ hybridisation is a technique by which specific nucleotide sequences are identified in cells or tissue sections. As a diagnostic tool, ISH aims at hybridising (binding) a labelled complementary DNA or RNA oligonucleotide probe to a specific pathogen nucleic acid sequence in a fixed tissue section. The site of binding is then localised by histochemical or immunohistochemical methods (17). In situ hybridisation is a highly sensitive technique that allows detection and localisation of a given pathogen in its host. The steps involved in ISH are: probe preparation and labelling (the non-isotopic label digoxigenin is often used), tissue fixation, permeabilisation, hybridisation and signal detection. An excellent detailed description of all ISH steps is presented by Nouri-Aria (20). In situ hybridisation has proven very useful in improving our understanding of parasite life cycles, such as that of Marteilia within its host, and in observing early infections that are not easy to detect by routine histological observation (4, 12). It is also commonly used to detect viruses in molluscs, crustaceans and finfish (2, 8, 9, 15). It has also been adapted for use in conjunction with PCR; this approach has been shown to have higher sensitivity than ISH alone for WSSV (11). The advantages of ISH include its use on archival materials for retrospective examination (formalin-fixed paraffin embedded tissues) (2) and frozen tissues. In addition, ISH can detect more than one target when using different labelling methods (20). The disadvantages include the time consuming nature of the procedure and the high cost of reagents.

Conclusion

Globalisation of trade in live and frozen aquaculture animals has contributed to the transboundary spread of aquatic pathogens worldwide. Fundamental to the disease management strategies of aquaculture production is the development, validation and implementation of improved diagnostic tests. Of particular interest are the tests based on modern molecular technologies, which offer greater specificity and sensitivity and the means of investigating variations in emerging pathogens at the genomic level.

While it is relatively straightforward to establish a series of diagnostic tests for surveillance and exclusion testing of commonly occurring disease agents, it is much more challenging to respond to an emerging pathogen never encountered before due to delays in obtaining information and developing specific reagents. However, international laboratory networks can provide support through the sharing of expertise, reagents and training opportunities.

Acknowledgements

The author thanks Olivia Jackson-Corbeil and Abigail Jackson-Corbeil for their technical assistance in the preparation of the manuscript.

References


Preventing the risk of invasive species in aquaculture

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Summary
Aquaculture is one of the most important and fastest growing fisheries sectors, increasing at a rate of 7% per year since the 1970s and today accounting for greater than 50% of the total fisheries production destined for human consumption. It is an important economic activity in the coastal areas of many countries around the world, offering opportunities to alleviate poverty, boost employment, assist in community development, enhance food security, and reduce overexploitation of natural coastal resources. The importance of aquaculture as a vector for the introduction and spread of aquatic invasive species (AIS) – species that have been introduced to an area outside their natural range and cause harm – is also evident.

There are two classes of introductions that may result from aquaculture activities. First is the establishment and spread of invasive species that have been intentionally introduced for aquaculture purposes (i.e. the ‘target’ species). Second is the establishment and spread of species that are associated with farmed species or facilitated by aquaculture activities. These may include both ‘hitch-hiking’ species (animals and plants that grow in association with the cultured species) and disease-causing organisms that may impact target or other species.

The International Council for the Exploration of the Sea (ICES) Working Group on the Environmental Interactions of Aquaculture (WGEIM) has considered mechanisms to minimise the risks of invasive species in aquaculture using a risk assessment-based pest management framework. Identification of risk (based on relevant environmental, economic, social and cultural values) is used to limit the introduction of AIS. If AIS are present, then hazard analysis and critical control points (HACCP) principles are used to identify critical control points and potential control measures. A solid understanding of the biology/ecology of the species and ecosystems involved, including an appreciation of how these may change over time (e.g. with successive generations or global climate change), is essential.

Keywords
Session 4

Capacity building for aquatic animal health services

Objectives: to define needs for capacity building to support the strengthening of Aquatic Animal Health Services
The OIE Focal Point concept and capacity-building activities

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Summary

As established in its Fifth Strategic Plan, the World Organisation for Animal Health (OIE) will pursue capacity-building activities in order to meet the objectives of the organisation, such as providing expertise and encouraging international solidarity in the control of animal diseases and improving the legal framework and resources of national Veterinary Services (VS).

The OIE capacity-building activities aim to support the VS in their efforts to implement the OIE international standards. The OIE general capacity-building activities include conferences and workshops conducted at regional, global and sometimes national level.

The most important global capacity-building initiative of the OIE is the evaluation of the compliance of VS with the OIE quality standards, done through the OIE Performance of Veterinary Services (PVS) Pathway.

Among activities included within the work programme of the OIE Regional and Sub-regional Representations, capacity building of the OIE Delegates and their nominated Focal Points is a key element to help OIE Members to accomplish their obligations as Members, as well as to stimulate participation in the OIE standard-setting process and implement guidelines and standards developed by the OIE.

During the 76th General Session of the World Assembly of Delegates in May 2008, the importance of the Focal Point for information on animal diseases was reiterated and Delegates were also requested to nominate additional Focal Points for wildlife, veterinary products, animal production food safety, animal welfare and aquatic animals. In 2011, the Delegate will be invited to provide the OIE with a Focal Point for communication.

The OIE also recognises Reference Laboratories and Collaborating Centres. Among the different activities undertaken, these institutes play an important role in capacity building by providing technical advice and scientific training to OIE Members. The laboratory twinning initiative between Reference Laboratories or Collaborating Centres and candidate national laboratories provides another approach to capacity building by improving diagnostic capacity and expertise around the world.

The OIE constantly updates and improves its capacity-building activities. In the interest of undertaking an effective programme of capacity building, the OIE collaborates closely with other international organisations as well as with donors.

Keywords

Introduction

The Veterinary Services (VS) and the Aquatic Animal Health Services (AAHS) are the very core of national systems for the prevention and control of animal diseases, including those transmissible to humans, and play a major role in every country as guarantors of animal health and public health-associated issues. This mission presupposes the existence of appropriate governance and legislation.

Bringing the VS/AAHS into line with international standards has a significant beneficial impact on the countries and the international community as a whole. This will impact not only in the fields of agriculture, economy, public health (including food safety and the supply of animal protein) and access to international markets, but also in local and global prevention of emerging and re-emerging animal diseases (1, 2).
One particular strategic objective of the Fifth Strategic Plan (2011–2015) of the World Organisation for Animal Health (OIE) is to strengthen the capacity of Members’ VS/AAHS to achieve improvements in animal health, veterinary public health and animal welfare, including both their ability to participate in the development of international standards and guidelines and their ability to apply these standards and guidelines (3).

The OIE constantly updates and improves its capacity-building activities and, in the interest of undertaking an effective capacity-building programme, the OIE collaborates closely with other international organisations as well as with governments and donors. The ultimate aim of these activities is to bring the VS/AAHS in line with the international standards in the OIE Codes.

The National Delegate for the OIE, with the support of nominated National Focal Points, plays a key role in achieving improvements in animal health, veterinary public health and animal welfare by complying with obligations on animal disease notification and by ensuring that animal health legislation in his/her country is consistent with the relevant OIE standards and guidelines. For this reason, the main recipients of OIE capacity-building activities are National Delegates and nominated National Focal Points for the OIE.

**The National Focal Point concept**

The concept was originally designed to assist OIE Delegates in their obligation of collecting and submitting to the OIE information on animal diseases and to provide a contact point for the OIE Animal Health Information Department. The National Focal Point for Animal Disease Notification has existed for many years and has proved to be a successful model.

At the 76th OIE General Session in May 2008, the International Committee – now known as the World Assembly of Delegates – mandated the OIE to create the conditions for Delegates to appoint additional National Focal Points, addressing wildlife, veterinary products, animal production food safety, animal welfare and aquatic animals. In 2011 the National Focal Point for Communication was added, giving a total of seven National Focal Points.

The activities of National Focal Points are under the authority of the OIE Delegate, whether the individual official is under the jurisdiction of the Veterinary Authority or located in other departments or ministries outside the jurisdiction of the Veterinary Authority. According to the organic rules of the OIE, the National OIE Delegate is the unique official representative of the Member Country. The role of the National Focal Points for aquatic animals, animal welfare, animal production food safety, wildlife and veterinary products is to establish and communicate with a network of experts; to establish a dialogue and facilitate cooperation where responsibilities are shared with other Competent Authorities; to receive reports issued by OIE specialist commissions and ad hoc groups and conduct consultations with experts on those reports; and to prepare science-based comments for the Delegate on OIE draft standards.

The National Focal Points for aquatic animal diseases and wildlife also contribute to the collection and submission of disease information on aquatic animals and wildlife, respectively. However, the National Focal Point for Animal Disease Notification acts as the key point of contact for the OIE Animal Health Information Department and is responsible for notifying animal disease information to the OIE through the World Animal Health Information System (WAHIS).

The role of the National Focal Point for Communication is to facilitate communication among relevant stakeholders, specific target audiences and the media; to receive and disseminate information issued by the OIE concerning communication activities; and to prepare comments for the Delegate on draft OIE standards, guidelines and recommendations relating to communication.

**Capacity-building activities of the OIE**

One of the objectives of the OIE Fifth Strategic Plan (2011–2015) is to strengthen the capacity of Members’ VS/AAHS to achieve improvements in animal health, veterinary public health and animal welfare, including both the country’s ability to participate in the development of international standards and guidelines on these matters and its ability to apply the standards and guidelines.

The OIE capacity-building initiatives comprise: the OIE Performance of Veterinary Services (PVS) Pathway, the capacity-building programme for OIE National Delegates and nominated National Focal Points; the activities of
The OIE PVS Pathway

The main global capacity-building initiative of the OIE is the PVS Pathway, which has the objective of helping Members’ VS/AAHS to comply with the quality standards in the Terrestrial Animal Health Code (the Terrestrial Code) and the Aquatic Animal Health Code (the Aquatic Code).

This is an important foundation for improving animal and public health and enhancing compliance with the World Trade Organization Agreement on the Application of Sanitary and Phytosanitary Measures (WTO SPS Agreement), at national, regional and international levels (4).

To help ensure the effective performance of the VS/AAHS of Member Countries, the OIE has dedicated two chapters in the Terrestrial Code and one chapter in the Aquatic Code to the quality of VS/AAHS, respectively (5). These chapters provide the legal framework for the ‘OIE Tool for the Evaluation of Performance of Veterinary Services’ (the OIE PVS Tool), a specific methodology developed as the basis for evaluating performance against the international standards.

Based on the OIE PVS Tool, the OIE PVS Pathway comprises an initial OIE PVS evaluation, which may be followed by several steps, including a PVS Gap Analysis, PVS Pathway follow-up missions, the OIE Veterinary Legislation Support programme (VLSP) and other specific activities, projects and programmes.

The OIE PVS Evaluation is a qualitative assessment to determine the performance and the compliance of VS/AAHS with the OIE international standards on quality. The OIE considers this first step as the ‘diagnosis’. The PVS Gap Analysis is a quantitative assessment of a country’s needs and priorities based on the outcome of the country’s OIE PVS evaluation mission, taking into account the priorities fixed by the country, national factors and conditions. The aim of PVS Gap Analysis is to identify concrete actions to correct gaps, to prioritise activities and to quantify the needs and investments, allocating the indicative budget to address the compliance for priority critical competencies. The OIE defines this second step as the ‘prescription’, while other specialised supports, such as the OIE VLSP, are considered as the ‘treatment’ (Fig. 1).

Fig. 1 The OIE PVS Pathway
OIE PVS Pathway missions are conducted by independent, external, OIE-certified experts. As at June 2011, the OIE had received more than 200 requests for missions under the PVS Pathway and had conducted more than 160 missions. Details are provided in Table I.

**Table I  PVS Pathway Missions as at June 2011**

<table>
<thead>
<tr>
<th>OIE Region</th>
<th>No. Member Countries</th>
<th>OIE PVS Evaluations Requests</th>
<th>Missions</th>
<th>PVS Gap Analysis Requests</th>
<th>Missions</th>
<th>Legislation Requests</th>
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<td>2</td>
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<td>4</td>
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<td>67</td>
<td>38</td>
<td>33</td>
<td>21</td>
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</tbody>
</table>

The OIE PVS Tool has mainly been used in the terrestrial domain, but some requests to evaluate AAHS have been received. A pilot mission was completed in an Asian country and missions to countries in Africa and Asia will be conducted in 2011.

**Global programme of capacity building for new OIE Delegates and National Focal Points**

The OIE general capacity-building activities include conferences and workshops conducted at regional, global and sometimes national level. As one of the activities in the work programme of the OIE Regional and Sub-regional Representations, capacity building of OIE Delegates and National Focal Points is a key element to help OIE Members exercise their rights and meet their obligations as Members of the OIE.

The OIE encourages the National Delegate of each Member Country to nominate specific National Focal Points to support them in seven domains: aquatic animal diseases, wildlife, sanitary information systems, veterinary medicinal products, animal welfare, food safety, and communication. These Focal Points support the National OIE Delegate in his or her functions and in interaction with the OIE in relation to each specific domain and constitute a unique global network receiving permanent capacity building from the OIE.

On a 2-year cycle, the OIE organises regional seminars and workshops for each of the seven focal point domains and for newly appointed OIE Delegates, with the objective of facilitating consistency and harmonisation among OIE Members in assigning responsibilities to the nominated Focal Points, and to allow better use of their expertise in supporting the Delegate. This activity aims, among other things, to achieve better participation of Member countries in the OIE standard-setting process.

In line with the increasing importance of the role of the OIE focal points, this programme is continuing to expand, with 57 focal point training seminars organised to December 2010, and 24 scheduled for 2011.

**OIE Reference Laboratories and Collaborating Centres**

The OIE recognises official Reference Laboratories and Collaborating Centres in order to support the overall scientific and technical work related to diseases or relevant specific topics. OIE Reference Laboratories, mainly disease based, provide scientific and technical assistance and expert advice on topics linked to the diagnosis of diseases. The OIE Collaborating Centres, being competence based, provide expertise internationally with reference to their designated specialty, by providing advice and training and by developing new techniques and procedures.
In June 2011, the OIE had a global network of 225 Reference Laboratories, covering 111 diseases in 37 countries, and 40 Collaborating Centres covering 38 topics in 21 countries.

Reference Laboratories and Collaborating Centres, collectively referred to as Reference Centres, play an important role in capacity building by providing technical and scientific advice and training to OIE Members and by coordinating scientific and technical studies in collaboration with other laboratories or organisations.

**OIE Laboratory Twinning**

The OIE concept of ‘laboratory twinning’ aims to build expertise on the most important animal diseases and zoonoses in priority regions, in direct support of the OIE’s strategy to improve global capacity for disease prevention, detection and control through better veterinary governance. Through laboratory twinning, the OIE aims to improve the ‘north–south’ distribution of advanced expertise, allowing more countries to access high-quality diagnostic testing and technical knowledge within their own region, thus facilitating early disease detection and rapid control. A high level of scientific expertise is also essential to allow countries to formulate science-based animal health control strategies and maintain veterinary scientific communities to support the standard-setting function of the OIE (6).

Each twinning project links an existing OIE Reference Centre with a selected candidate institute. Knowledge and skills are exchanged through this link throughout an agreed project duration. Twinning projects provide mutual benefits for both parent and recipient institutes, including through the creation of joint research opportunities. The entire international community benefits from improved global networks for disease surveillance.

As at June 2011, three twinning projects had been completed, 29 approved or commenced and six approved and due to commence.

**Veterinary education**

The veterinary profession has a key role to play in society. Community expectations may vary from country to country, but in all cases veterinarians are expected to demonstrate high standards of professional ethics and competence. In order for the veterinary profession to meet these expectations, veterinarians must be highly competent and must respect professional codes of practice and rules. Education (both initial and continuing) must be of high quality and veterinarians should, at graduation, have mastery of key competencies relevant to societal demands. The Veterinary Statutory Body (VSB) as defined in the *Terrestrial Code* plays an important role in establishing and taking steps to ensure compliance with professional codes of conduct and rules.

High-quality veterinary education and effective VSBs are the cornerstones of good governance of VS. Quality and international harmonisation contribute to improving animal health and welfare globally. For this reason, the OIE has established standards and guidelines relating to veterinary education and the establishment and functioning of VSBs.

Unfortunately, the quality of veterinary education is not acceptable in many countries today. To address this concern, in October 2009 the OIE organised a first global conference on veterinary education. This was followed by a second conference in May 2011. Participants at these conferences, which included Veterinary Deans from all regions of the world, confirmed that veterinary education needs to be strengthened globally, notably with respect to: the establishment of minimum requirements (a ‘core curriculum’); the harmonisation of key curriculum elements, to facilitate international mobility of veterinarians; the establishment of quality control and recognition procedures for veterinary education establishments; and the regulation of the veterinary profession by the VSB at national level.

The OIE has continued to work on the implementation of these recommendations by: (i) defining the key competencies of veterinary graduates in order for VS to fulfil the OIE mandate; (ii) preparing recommendations for pilot twinning projects involving veterinary education establishments and VSBs; (iii) encouraging the creation of regional VSB associations; and (iv) within the framework of the PVS Pathway, by strengthening mechanisms for evaluating the quality of VS staff (7).
References


Capacity development in aquatic animal health: the roles and responsibilities of FAO

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Summary
Managing aquatic animal health in aquaculture is particularly challenging because of the great diversity of the sector in terms of species cultured, the range of culture environments, the nature of containment, the intensity of farming practices and the variety of systems used. Human and institutional capacity is one of the cornerstones essential for an effective aquatic animal health programme. It is at the heart of any development effort and one of the core values of FAO.

The capacity-building efforts of FAO are delivered through normative and field programmes. Several mechanisms, such as the Technical Cooperation Programme (TCP), Unilateral Trust Fund (UTF) projects and other bilateral and multilateral arrangements, provide various opportunities for FAO members to avail themselves of specialised training courses and participate in training workshops and expert consultations and desk studies, at various levels of representation, from policy and decision makers to field personnel and farmers.

The range of subjects include, for example, development of national strategies on aquatic animal health and biosecurity frameworks, design and implementation of surveillance programmes, emergency preparedness and contingency planning, disease outbreak investigation, application of risk analysis to aquaculture, and improving compliance with international trading standards published by the World Organisation for Animal Health (OIE) on aquatic animal health. Through these activities, FAO generates outputs in the form of documentation (e.g. technical guidelines in support of the FAO Code of Conduct for Responsible Fisheries, disease diagnostic guides, extension materials, workshop reports and proceedings, biosecurity factsheets, etc.) that provide further guidance.

This presentation will elaborate on recent past, ongoing and pipeline FAO capacity-building activities in cooperation with member governments and collaborating partners, such as OIE, in countries and regions that are at different levels of aquaculture development. The presentation emphasises the need to keep pace with the unprecedented level of aquaculture development in terms of species, systems and technology and the challenges in developing human and institutional capacities.

Keywords

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Donors' perspectives – EU: Better Training for Safer Food

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Summary

Better Training for Safer Food (BTSF) is a European Commission training initiative covering food and feed law and animal health and welfare and plant health rules. It trains national authority staff involved in official controls in European Union (EU) Member States, countries working towards accession with the EU and third countries. Better Training for Safer Food aims to keep participants up to date with all aspects of EU law in the areas specified above and ensure that controls are carried out in a uniform, objective, adequate and efficient manner. Efficient controls are an essential factor in maintaining high levels of consumer protection, animal health and plant health. Harmonisation of controls contributes furthermore to a level playing field for food businesses.

Participants from national authorities of third countries may under certain conditions attend the Member States’ training. Training is also organised specifically for representatives of third countries, particularly developing countries in their home countries.

The main objectives of the third country training are to help third countries better understand and more easily meet EU rules and thus reduce the number of consignments rejected at EU borders. This will in turn give EU consumers access to a more diverse range of safe products. A further objective is to enhance sanitary and phytosanitary (SPS) regulatory cooperation with and enhance food standards of third countries to benefit local consumers and ensure fair trade, particularly with developing countries.

Together with this, BTSF has also developed some additional programmes in third countries aiming at strengthening their capacity in animal and plant health; supporting food security through technical and policy advice on animal health and food safety and quality; helping third countries produce agro-food products compatible with international standards; contributing to reducing food-borne disease; supporting the competitiveness of the agro-food sector; and contributing to rural development and employment. The year 2009 saw the launch of the BTSF Africa programme, which includes regional workshops, sustained training missions and, based on a service contract with the World Organisation for Animal Health (OIE), the provision of assistance in the organisation of SPS capacity-building activities in Africa that covers regular training and information for OIE National Focal Points for aquatic animals.

Keywords


Introduction

Better Training for Safer Food (BTSF) is an initiative of the European Commission Directorate General for Health and Consumers, managed by the Executive Agency for Health and Consumers. It trains Member State and third country national authority staff involved in official controls in the areas of food and feed law, animal health and welfare rules and plant health rules (1).

Better Training for Safer Food aims to increase levels of competence and awareness of relevant European Union (EU) legislation among official control staff by giving them a better understanding of the checks they need to carry out. This should help to ensure more harmonised and efficient controls, leading to higher levels of consumer protection, animal health and plant health. Harmonised controls will allow businesses across the EU and beyond to compete on a level playing field and reap the benefits of increased trade in safe food.
**Training principles**

The training aims to complement national training in these areas of control authorities by promoting a common EU-level understanding. It should also spread knowledge as widely as possible among the target audience. For this reason, participants should be able to pass on knowledge acquired from BTSF training to their colleagues.

All workshops have an international selection of participants and tutors. This increases the value of the experience and knowledge exchanged during the training.

The training is mainly organised through the periodical launch of calls for tender related to individual programmes. Contracts are subsequently awarded to bodies who implement the programmes, some of which are EU-based and some of which take place in third countries. Places on some EU-based activities are open to third country participants.

**BTSF in figures 2006–2010**

Better Training for Safer Food started its activities in 2006. During 2006–2010, around 520 events of between 3 and 15 days’ duration were held on around 20 subjects. They were attended by more than 23,000 participants from around 180 countries. The overall budget was approximately €54 million. Roughly two-thirds of the training took place in the EU and one-third in third countries, not including BTSF Africa activities.

**Training on aquatic diseases**

Following requests from EU Member States and stakeholders and consultation with other countries, training on aquatic diseases was launched in 2010. It is aimed at promoting a common understanding of EU aquatic animal health legislation so as to equip Veterinary Services to protect the EU against such diseases.

The training takes the form of 3-day workshops. Some of these focus on mollusc and crustacean diseases and others on fish diseases.

The workshops give an overview of EU aquatic animal health legislation. Other subjects include pathogen and disease description, surveillance, inspection, sampling, outbreak measures and national and international disease notification obligations. Presentations are supported by study cases and workshops include at least a half-day’s practical training during field trips to mollusc, crustacean or fish farms.

**Third country training**

Many developing countries export agro-food products to the EU, but they need to increase their technical capacity to ensure that their products comply with EU and international sanitary and phytosanitary (SPS) standards. BTSF training helps developing countries to better understand these standards, thereby increasing their capacity to meet them.

This should ease access to the EU market for developing country products and reduce the number of rejections at EU borders. It will also drive up safety standards for consumers in developing countries and give EU consumers access to a more diverse range of products.

Training in third countries is organised via regional-level workshops and sustained missions carried out by individual experts who provide training and advise the authorities of the beneficiary country. Usually, the experts also meet industry representatives or farmers.

The missions are demand driven and flexible. They are often provided as a follow-up to the inspections conducted by the Food and Veterinary Office of the European Commission.
**BTSF Africa**

Better Training for Safer Food in Africa is managed by the European Commission in close consultation with the African Union Commission, and with the involvement of regional economic communities and specialised bodies within Africa. During 2009–2011 around 100 events were organised across seven activities for a budget of €10 million. These were attended by around 4,000 participants.

Better Training for Safer Food in Africa is aimed at strengthening the SPS capacity of national, regional and pan-African authorities in areas such as control, surveillance, legislation, management and inspection. This will help African countries to produce agro-food products compatible with international standards and contribute to reducing food-borne disease. A further aim is to support food security through technical and policy advice.

The European Commission is exploring the possibility of launching training similar to that provided under BTSF Africa in other regions of the world.

**References**

Defining needs in capacity building: a donor's perspective

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Summary

Preventing, detecting and identifying diseases of animal and public health concern can be a challenge for numerous countries. This is perhaps an even greater challenge with aquatic animal health than with terrestrial animal health, due to technical and other issues. In addition, developing strategies to address such challenges can be equally taxing and, in some cases, may require the support and engagement of several ministries of the national government, as well the private sector, in the transparent assessment of infrastructure and capacities (including human, financial and physical resources, legislative authority, etc.) in an effort to identify needs in capacity building and priorities for the donor community to support.

Use of the Performance of Veterinary Services (PVS) Pathway established by the World Organisation for Animal Health (OIE) to evaluate and identify needs for capacity building is a useful approach and could serve as the foundation for eliciting donor support through financial commitments to specific projects and/or transfer of knowledge through technical and cooperative arrangements such as laboratory twinning.

Donors participate in sanitary and phytosanitary capacity-building projects for numerous reasons: alignment with foreign aid and policy objectives, compliance with international standards for the protection of animals and animal products in a highly integrated global market place, and, increasingly, recognition of the security implications for food supplies from deliberate attack (indeed there is considerable untapped potential for collaboration between the animal health and security communities). Whatever the case may be, establishing a coherent path forwards, based on an objective analysis, assists in understanding needs and identifying key partnerships for addressing capacity challenges.

Keywords


Introduction

According to statistics and data collected in the annual publication, referred to as The State of World Fisheries and Aquaculture, the Food and Agriculture Organization of the United Nations (FAO) concludes that global markets for fish and fishery products are expanding and that fisheries and aquaculture are economic drivers for many developing countries (1).

In the context of the demand for fish and fish products and in improving economies there are and will continue to be significant challenges to aquatic animal health and socioeconomic health in terms of developing sustainable practices for inland and coastal aquaculture and developing and enforcing sustainable practices for capture fisheries that lead to positive impacts on the aquatic food chain and biodiversity. The disease and health impacts as a result of climate change and ecosystem degradation (2) also have the potential to confound efforts in developing and enforcing practices that will lead to sustainable and viable fish and aquaculture populations.

From a global perspective, these challenges affect us all. However, developing strategies to tackle such challenges can be equally taxing and, in some cases, may require the support and engagement of several ministries of the national government, as well the private sector, in the transparent assessment of infrastructure and capacities (including human, financial and physical resources, legislative authority, etc.) in an effort to identify needs in capacity building and priorities for the donor community to support.
International organisations such as the World Organisation for Animal Health (OIE), and the FAO, have developed standards for controlling and managing disease and/or programming for certification and protocols for sustainable aquaculture. With respect to OIE programmes, the OIE PVS Pathway, based on the use of the Tool for Evaluation of the Performance of Veterinary Services (PVS Tool), is designed to evaluate and identify needs for capacity building. This approach can serve as the foundation for eliciting donor support through financial commitments to specific projects and/or transfer of knowledge through technical and cooperative arrangements such as laboratory twinning.

In general, using a method such as the PVS Tool, which lends itself to objective analysis, ultimately assists in understanding the needs of countries and can be used in identifying key partnerships (such as with donors) and leverage expertise through technical or cooperative arrangements. The benefits of objective analysis include clear objectives that the donor community can use to identify and fund projects that align with their foreign aid and policy objectives. In this regard, donors have expectations that any projects should be auditable and have measurable performance indicators to maintain engagement and contributions (3).

Other positive benefits that stem from engaging in programmes such as the PVS Pathway have broader implications for enhancing aquatic animal health programmes with respect to management of and response to disease incursions, socioeconomic health of countries or regions, security of the global food supply, and, finally, opportunities to work with developers of private standards for certification schemes to ensure consistency across markets and in alignment with domestic and international standards.

In summary, donors participate in capacity-building projects for numerous reasons: alignment with foreign aid and policy objectives, compliance with international standards for the protection of animals and animal products in a highly integrated global market place, and, more increasingly, recognition of the security implications for food supplies from deliberate attack (indeed there is considerable untapped potential for collaboration between the animal health and security communities). Whatever the case may be, establishing a coherent path forwards based on an objective analysis assists in understanding needs and identifying key partnerships for addressing capacity challenges.

**Acknowledgements**

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**References**


Capacity building at the regional level: the work of SEAFDEC in South East Asia

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Summary

Fisheries are recognised as a very important sector that contributes to food security, livelihood, well-being, and economic development for people all over the world. During the past few decades, however, circumstances have changed in that most of the fishery resources have reached their maximum yield or are on the verge of overexploitation. The contribution and importance of the aquaculture subsector has become more prominent. In 2008, global aquaculture production reached 52.5 million tonnes, accounting for 36.9% of the total fishery production with several countries in the South East Asian region among the top 10 global aquaculture producers. To increase production from aquaculture, intensive culture technologies have been developed and widely practised, resulting in several negative consequences such as increased use of feeds including low-value fish, high organic discharge and increased pressure on the environment and impact on species diversity, as well as an increase in the occurrence of aquatic animal diseases. Such circumstances led to increasing use of chemicals and drugs as unnecessarily precautionary practices to prevent disease transmission and outbreaks. Accompanying the rapid and uncontrolled development of aquaculture, there are also emerging requirements to secure the quality and safety of aquaculture products for human consumption, as well as to ensure the health and welfare of aquatic animals.

In South East Asia, aquaculture activities are undertaken mostly by small-scale operators, with limited resources, capacity and knowledge, making it difficult to accommodate the emerging situations and requirements. Thus, appropriate capacity-building activities are crucial for countries in the region, specifically to build capabilities at the farm level to enable fish farmers to apply the necessary prevention and control measures.

This presentation provides an overview of the capacity-building activities of the Southeast Asian Fisheries Development Center (SEAFDEC), an intergovernmental organisation working towards the promotion of sustainable fishery development in the South East Asian region.

In summary, the priorities for capacity-building activities relevant to aquatic animal health and welfare in the region could include: (i) enhancing the capacity of fisheries and aquaculture-related authorities on aspects relevant to animal health and welfare, and the safety of aquaculture food products, with emphasis on promoting appropriate management and improving the aquaculture environment; (ii) development of tool kits that are relevant and applicable for small-scale farmers to enhance their capacity to respond to emerging requirements; (iii) strengthening the capacity of veterinary-related authorities on aquatic animal health and welfare as well as collaboration with fisheries and aquaculture-related agencies on relevant issues; and (iv) fostering collaboration among countries in the region, and with international and regional organisations, to exchange information, mobilise expertise and enhance national capacities to satisfy the animal health and welfare and food safety requirements of aquaculture products. It is anticipated that integrated efforts in the development of human resources will help to enhance the contribution of fisheries as an Association of Southeast Asian Nations (ASEAN) priority sector to economic development, with a view to the goals of ASEAN economic community building by the year 2015, as targeted by ASEAN and supported by SEAFDEC under the ASEAN–SEAFDEC Strategic Partnership cooperation framework.

Keywords


**Introduction**

Fisheries in the Association of Southeast Asian Nations (ASEAN) region are generally characterised as being small scale, but they have been playing a major role in accelerating economic development and generating livelihood opportunities, and contributing to the region's food security. Over the last decade, the total fishery production has increased steadily from 15,654,000 tonnes in 1998, valued at US$8,944 million, to 27,260,000 tonnes, valued at US$28,584 million in 2008 (Table I), at an annual rate of about 6% in terms of quantity and about 9% in terms of value. Although the 10-year production from marine capture fisheries has been slowly increasing, production from inland capture fisheries and from aquaculture during the same period showed a significant increase. In 2008, the region’s fishery production accounted for about 19% of the world's total fishery production of about 142 million tonnes (FAO, 2010). In terms of exports, data in 2007 showed that the world's total export of fishery commodities was 39,788,511 tonnes of which more than 15% was contributed by the South East Asian countries (6,061,416 tonnes). Thailand was the top exporting country of the region, contributing about 41% of the region's export of fishery commodities, with Vietnam second at 25% (FAO, 2010).

In order that such trends can be sustained and the contribution of fisheries to food security in the region be enhanced, SEAFDEC continues to strengthen its collaboration with the ASEAN countries through the ASEAN–SEAFDEC collaborative mechanism and gives due attention to addressing the problems and constraints of fishery management with the objective of reversing the current state of the region’s fishery resources, which have been observed to be on the brink of serious deterioration. Strengthening the fishery management sector would mean that the gap between supply and demand for fish and fishery products would be bridged while at the same time ensuring that the balance between conservation and exploitation of the fishery resources would be maintained.

**Table I Total and subsector fish production in South East Asia, 1998–2008 (000 tonnes)**

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Marine capture</td>
<td>1998</td>
<td>11,448.4</td>
<td>12,052.4</td>
<td>12,756.4</td>
<td>13,380.8</td>
<td>13,938.8</td>
<td>15,814.4</td>
</tr>
<tr>
<td>Inland capture</td>
<td>1998</td>
<td>947.8</td>
<td>1,330.1</td>
<td>1,516.7</td>
<td>1,429.2</td>
<td>2,107.1</td>
<td>2,381.7</td>
</tr>
<tr>
<td>Aquaculture</td>
<td>1998</td>
<td>3,258.1</td>
<td>3,860.2</td>
<td>5,027.6</td>
<td>6,243.7</td>
<td>8,348.2</td>
<td>11,064.0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1998</td>
<td>15,654.3</td>
<td>17,242.7</td>
<td>19,300.7</td>
<td>21,053.7</td>
<td>24,394.1</td>
<td>27,260.1</td>
</tr>
</tbody>
</table>


In the early stages of fishery development, the requirements focused on improving fishing technologies and practices in order to maximise production from marine capture fisheries. However, from the early 1990s, overexploitation of fishery resources was reported in the major fishing areas of the world. The associated deterioration of fishery resources resulted in the continuous decline of production from marine capture fisheries.

In the mid-1990s, various international fisheries instruments were adopted globally with the objective of promoting sustainable development of fisheries. The most relevant of the fisheries instruments included the United Nations Convention on the Law of the Sea (UNCLOS), the Food and Agriculture Organization of the United Nations (FAO) Code of Conduct for Responsible Fisheries (CCRF), the Kyoto Declaration on the Sustainable Contribution of Fisheries to Food Security, and the Rome Declaration on World Food Security. Such instruments called for concerted efforts towards the conservation and sustainable management of fishery resources, strengthening scientific research for the sustainable development of fisheries and aquaculture, adjusting capacity to be commensurate with long-term stock productivity, increasing the availability of fish and fishery products for human consumption, and eliminating unsustainable patterns of fish consumption and production.
Thus, the development of fisheries had moved towards maximising the utilisation of catches, enhancing the contribution from the aquaculture subsector, and ensuring sustainable utilisation of fishery resources. Moreover, the increasing preference of consumers for fish and fish products for health reasons also intensified the trade in fish and fishery products, which brought about improvements in many countries’ economies, especially in the South East Asian region. This development also came with the requirements by major importing markets for improved quality and safety of fish and fishery products from production to marketing.

In the South East Asian region, after going through very rapid development during the past decades, there is now an ever-increasing number of small-scale fishers. Being dependent on fishing for their livelihoods and with no other alternative sources of income because of limited know-how and insufficient financial resources, the small-scale fishers tend to saturate the absorbing capacity of the fishery sector. Having no way out, the fishers therefore continue to race for the diminishing fishery resources.

Meanwhile, outside the fishing communities and elsewhere around the world, the demand for more food derived from fish is on the rise. In an effort to supply the much-needed demand for food derived from fish, many fishers continue to maximise their exploitation of the remaining resources, to the extent of resorting to irresponsible means without looking ahead to the possible effects of their actions on the environment and the resources that have often already been degraded. The continued practice of irresponsible fishing operations, such as the use of dynamite and chemicals, as well as overfishing, is resulting in a food security crisis in areas in which degraded fishery resources are further squeezed to the last drop, trapping the fishery sector in resource degradation.

Moreover, the attempts by many countries in the region to boost foreign exchange earnings and improve their economies has diverted the low-value fish species, which were once a valuable source of cheap protein food for the fishing communities, to the fishmeal industry. This results in reduced availability of food derived from fish for many people and contributes to potential food insecurity, especially in fishing communities. Meanwhile, the expansion of the aquaculture sector to supply the foreign market with food derived from fish has led to a dramatic increase in the demand for aquafeeds. Thus, the exploitation of low-value fish species, and even the juveniles of commercially important fish, for utilisation as aquafeeds has added pressure to the already degraded fishery resources and exacerbated the conflict between the utilisation of fish products for aquafeeds and the use of the same resources for human consumption.

**Aquaculture issues/challenges in South East Asia**

Aquaculture has a great potential to fill the gap between supply and demand for fish and fish products. Despite the importance of the subsector, aquaculture in the South East Asian region is faced with a number of issues and challenges, which include: increased use of aquatic feed derived from low-value fish for aquaculture in order to enhance production; organic discharge to the environment resulting in environmental degradation; impact from aquaculture on the species/genetic diversity of the aquatic ecosystems; the occurrence/spread of aquatic animal diseases, and increasing use of chemicals and drugs as a result of the intensification of aquaculture; the requirements for better quality/safety of products, environmental integrity, and aquatic animal health and welfare, and the increasing number of certification schemes/requirements by countries importing aquaculture products; and the possible impacts and mitigation of impacts from climate change to aquaculture.

Taking into consideration the above issues and challenges, capacity-building activities are urgently required; specifically at the farm level to enable small-scale fish farmers to undertake practices that conform with emerging requirements, including those on aquatic animal health and welfare.

The priority areas for capacity-building activities relevant to aquatic animal health and welfare can be summarised as follows:

1. enhancing the capacity of fisheries and aquaculture-related authorities in aspects relevant to animal health and welfare and the food safety of aquaculture products, with emphasis on promoting appropriate management and improving the aquaculture environment
2. development of tool kits that are relevant and applicable for small-scale farmers to enhance their capacity to respond to emerging requirements
3. strengthening the capacity of veterinary-related authorities on aquatic animal health and welfare, as well as collaboration with fisheries and aquaculture-related agencies on relevant issues
4. fostering collaboration among countries and organisations for exchanging information, mobilising expertise, and enhancing national capacities to satisfy the animal health and welfare and food safety requirements of aquaculture products.
Relevant capacity-building activities undertaken by SEAFDEC

While moving towards global competitiveness, countries in the region have been confronted with challenges threatening the sustainable development of fisheries. In view of such challenges, the availability of human resources in the relevant fisheries disciplines is crucial for the countries to be able to address these challenges.

SEAFDEC had always recognised the importance of human resources in the sustainable development of fisheries; and through its technical departments, namely the Training Department (TD) in Thailand, the Marine Fisheries Research Department (MFRD) in Singapore, the Aquaculture Department (AQD) in the Philippines and the Marine Fishery Resources Development and Management Department (MFRDMD) in Malaysia, SEAFDEC conducts research and development activities and capacity building in the ASEAN countries using interdisciplinary approaches covering responsible fisheries and aquaculture technologies and practices, post-harvest technology and practices, fisheries management concepts and approaches, and policy and advisory services.

Activities relevant to promoting sustainable aquaculture

SEAFDEC and the AQD has been undertaking activities to support sustainable aquaculture development in the region, focusing on:

1. the development of responsible aquaculture technologies and practices
2. the responsible use of aquatic genetic resources for the purpose of aquaculture
3. the adoption of measures to avoid environmental degradation
4. the promotion of environmentally sound culture methods and commodities.

Strategies that are being implemented to promote and ensure sustainable aquaculture for countries in the region include: building the capacity of national personnel in fish health and management; an intensive information and communication campaign for good aquaculture practices (GAqP) for different species and aquaculture systems; implementation of hazard analysis and critical control point (HACCP) programmes at the farm level and other food safety programmes; full traceability systems for aquaculture production; registration and accreditation of hatcheries and farms; and the establishment of early warning systems for aquatic animal diseases. In addition, biotechnological innovations were also studied and applied, aimed at the development of genetically superior strains of fishes, feed that provide balanced and nutritious diets, vaccines and immunostimulants to improve disease resistance, and molecular tools for fast and accurate disease diagnosis. Efforts are also being made on genetic marker development and research on probiotics for disease prevention and control in aquaculture.

In addition, activities were also undertaken by SEAFDEC and MFRD to enhance the quality and safety of fish and fishery products for human consumption (both for export and domestic markets) through the application of HACCP programmes, as well as the development of standard operating procedures for good manufacturing practice for small- and medium-sized fish-processing establishments in the region.

Activities to address chemical and drug residues in aquaculture products

The use of antibiotics in food animals raises two main issues: risks to human health, and the development of antimicrobial resistance. The effects on human health of some of the main antibiotics used in cultured shrimps in many countries (chloramphenicol and nitrofurans) are believed to be associated with increased risks of cancer. In order to alleviate the issue, ASEAN Member Countries identified and adopted approaches to: promote the implementation of the ASEAN guidelines on good aquaculture practices on farms; closely regulate and monitor the use of antibiotics in aquaculture; develop a public awareness programme on the effects of using antibiotics; and develop ASEAN-SEAFDEC training programmes on the detection of residues of antibiotics.

Based on the approaches adopted, programmes were formulated and implemented by SEAFDEC and MFRD to support countries to conduct surveys on the presence of antibiotics and chemicals (i.e. chloramphenicol, nitrofurans, malachite green and leuco-malachite green) in aquaculture products in the South East Asian countries, and enhance the capacity of laboratories in these countries to analyse antibiotic and chemical residues. Activities were also undertaken (in collaboration with SEAFDEC and AQD) to study the appropriate withdrawal period for the use of antibiotics in aquaculture to ensure the safety of aquaculture products for human consumption.
Major outputs/outcomes from SEAFDEC activities

Development of fish disease inspection methodologies for artificially bred seeds
Through the implementation of activities by AQD, diagnostic methods for important viral diseases of aquatic animals in the ASEAN region were developed. Results from the research on the development of standardised diagnostic methods and husbandry methods for disease control have been disseminated. Specifically, diagnostic methods such as the polymerase chain reaction (PCR) methods were standardised for white spot syndrome virus (WSSV) of black tiger shrimp (Penaeus monodon), viral nervous necrosis (VNN) of marine fish, especially grouper, and monodon baculovirus (MBV) and hepatopancreatic parovirus (HPV), as well as other diseases. In addition, methods were also developed for the prevention and control of luminous vibrosis, a common bacterial disease that has heavily affected shrimp aquaculture in South East Asia, caused mainly by Vibrio harveyi.

The standard diagnostic methods have been disseminated throughout the region in manuals that reflect the findings from the research activities and the methods that have been developed. Training, a major component of the dissemination process, was conducted either formally at SEAFDEC and AQD or through AQD’s online training programme, whereby trainees can participate in training through specialised modules developed by AQD using the Internet.

Strengthening of the disease surveillance system for aquatic animals
SEAFDEC has strengthened the network of the region’s resources and facilities for fish health diagnosis, including the promotion of human capacity building. After the initial activity of the network was implemented by AQD, refinement of diagnostic methods and development of new preventative methods for aquatic animal diseases was carried out. A surveillance system for important viral diseases, specifically for shrimps in the region, was also instituted. The ASEAN region is proud of its regionally recognised reference laboratory for specific aquatic diseases.

With the strengthening of a disease surveillance system, including continued human and institutional capacity building in the region, the ASEAN countries have developed a well-coordinated network for the timely and efficient reporting of an outbreak of any aquatic disease.

Establishment of evaluation methods for residues in aquaculture products
Evaluation methods for chemicals in aquaculture products have also been established to ensure the safety of aquaculture products, and the use of antibiotics in the region’s aquaculture industry has also been closely monitored. A compilation of the methods for chloramphenicol and nitrofurane residue testing were prepared by SEAFDEC, MFRD and AQD and disseminated to the region’s fish disease laboratories.

The way forward
In order to ensure a sustainable contribution from fisheries to food security and the well-being of people in the South East Asian region, SEAFDEC, in collaboration with the Member Countries, has implemented activities that address a wide range of fishery-related concerns and issues. In 2001, ASEAN and SEAFDEC organised an ASEAN–SEAFDEC Conference on Sustainable Fisheries for Food Security for the New Millennium, ‘Fish for the People’, at which the Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region were adopted and used as guiding principles and priority actions in the achievement of sustainable fishery development. The Resolutions adopted in 2001 specified the need to: ‘Acknowledge the need for enhanced human resource capabilities at all levels and encourage greater involvement by stakeholders to facilitate consensus and compliance in achieving sustainable fisheries’ and ‘Mobilise regional technical cooperation to reduce disparities and promote solidarity among ASEAN Member Countries’. This was taken up by SEAFDEC and the Member Countries, which, over the past decade, undertook programmes of activities to enhance the capability of personnel in terms of achieving sustainable fishery development.

However, with a changing environment and challenges facing the fisheries sector, ASEAN and SEAFDEC in June 2011 organised a sequel Conference on Sustainable Fisheries for Food Security Towards 2020. Fish for the People 2020: Adaptation to a Changing Environment. At the 2011 conference, the ministers and senior officials responsible for fisheries of the ASEAN–SEAFDEC Member Countries also adopted the revised Resolution and Plan of Action on Sustainable Fisheries for Food Security for the ASEAN Region Towards 2020. These instruments will serve as a policy framework and guidelines for the adoption of priority actions towards ensuring the sustainability
of fisheries for food security and improving the livelihoods of people in the region during the next decade. The Resolution continues to address the need to ‘Promote cooperation among Member Countries and with international and regional organisations in encouraging responsible aquaculture practices through joint research, technology transfer and human resource development’ (Resolution 16).

For aquaculture development, the Resolution particularly addresses the need to ‘Mitigate the potential impacts of aquaculture on the environment and biodiversity including the spread of aquatic animal diseases caused by the uncontrolled introduction and transfer of exotic aquatic species and overdevelopment of aquaculture’ (Resolution 17). A Plan of Action, specifying priority areas that should be undertaken by countries in addressing issues related to aquatic animal diseases, was also developed and includes:

− Develop and implement ASEAN guidelines for environmentally friendly and responsible aquaculture and good aquaculture practices that cover: (i) the integration of quality and safety management systems for products with significant trade potential; (ii) the harmonisation for chemical use and food safety in aquaculture; (iii) the development of product traceability systems from farm to market; and (iv) harmonisation of the quarantine and inspection/sampling procedure and sanitary and phytosanitary (SPS) measures for aquaculture products to secure food safety (Plan of Action 40).

− Reduce the risk of negative environmental impacts, loss of biodiversity, and disease transmission by regulating the introduction and transfer of aquatic organisms in accordance with the Regional Guidelines on the Responsible Movement of Live Aquatic Animals and Plants (Plan of Action 49).

− Continue the national efforts to control serious disease outbreaks by providing government support to: (i) R&D to improve the ability to handle new and emerging diseases and surveillance of transmission of diseases to wild populations; and (ii) regional initiatives on harmonisation of regional disease control standards, disease reporting and implementation of contingency plans to handle new and emerging diseases (Plan of Action 50).

− Further enhance the capabilities in the diagnosis and control of fish diseases within the region through: (i) continued support in development of technology and techniques for disease identification; (ii) promotion of the widespread use of affordable, field-friendly, rapid and standardised diagnostic tests; and (iii) the establishment of regional and inter-regional referral systems, including the designation of reference laboratories and timely access to disease control experts within the region (Plan of Action 51).

− Develop regional warning systems on aquatic animal health and diseases to inform other Member Countries of relevant epidemiological events and to raise awareness of new diseases that may pose risks. Build emergency preparedness capacity through rapid and timely responses to reduce potential catastrophic consequences of diseases (Plan of Action 52).

Taking into account the above-mentioned Resolution and Plan of Action as policy frameworks and guiding principles, it is envisaged that the development of human resources in fisheries in the South East Asian region, specifically those that address the particular requirements for good aquaculture practices and aquatic animal health, would be further strengthened to ensure the sustainable development of aquaculture and the contribution from fisheries to food security and the well-being of people in the ASEAN region in the decade to come.

References


Challenges and tools needed to ensure good governance: the Philippines’ experience with the OIE PVS Pathway

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Summary

The aim of this presentation is to share the Philippines’ experiences of following the World Organisation for Animal Health (OIE) Performance of Veterinary Services (PVS) Pathway and the importance of good governance to support high-quality veterinary services.

In the last decade, globalisation of trade and the threat of emerging zoonotic diseases have highlighted the need for countries to strengthen mechanisms and systems to protect human and animal health as well as their national economies. Since 2006, the OIE has been developing a tool to assess the Performance of Veterinary Services (the OIE PVS Tool) of Member Countries with the goal of helping national Veterinary Services (VS) to meet the OIE quality standards for the prevention and control of animal diseases and facilitate safe trade in animals and animal products. The Philippines is presently undertaking a leap in development with the formulation of a national strategic plan, the blueprint for better VS. In 2008, the Philippines first undertook an evaluation of its VS by the OIE – the initial phase of activities along the OIE PVS Pathway – with the leadership and support of the Bureau of Animal Industry (BAI). The current state of the VS was assessed, weaknesses identified and recommendations made for improvements. As an important follow-up activity, consultations were held with stakeholders in the animal health industry to solicit their support and cooperation for the VS moving along the PVS Pathway. In the following year, a PVS Gap Analysis was conducted by the OIE, allowing the capture of more detail on the appropriate level of advancement to be achieved and the financial support needed to strengthen the VS. This is to further support the next activity in the PVS Pathway – the development of a strategic plan for the Philippine VS. Coincidentally, during this period, the BAI planned to restructure the VS through modernisation of veterinary legislation. A key step was the development of new draft veterinary legislation and the submission for approval of ‘An Act Strengthening the Animal Industry and Veterinary Services in the Philippines’. It is anticipated that the implementation of modernised legislation and other elements to improve governance will help the Philippine VS move towards achievement of the goals of the PVS Pathway and the realisation of high-quality VS in the Philippines.

Keywords

Introduction

In the last decade, globalisation of trade and the threat of emerging zoonotic diseases have highlighted the need for countries to strengthen mechanisms and systems to protect human and animal health as well as their national economies. Since 2006, the World Organisation for Animal Health (OIE) has been developing a tool to assess the Performance of Veterinary Services (the OIE PVS Tool) of Member Countries with the goal of helping national Veterinary Services (VS) to meet the OIE quality standards for the prevention and control of animal diseases and facilitate safe trade in animals and animal products. This paper shares the experiences of the Philippines on pursuing the OIE PVS Pathway and the importance of good governance to support high-quality veterinary services.
OIE PVS evaluation mission

In early 2008, the government of the Philippines, through its Chief Veterinary Officer (CVO), requested the OIE to undertake an evaluation of its VS – the initial phase of activities along the OIE PVS Pathway. To prepare for this, baseline documents were gathered and a PVS Task Force, within the Philippine VS, was organised so that the conduct of the OIE PVS evaluation mission would be smooth and orderly. Through the leadership and support of the Bureau of Animal Industry (BAI), of which the CVO is the Director, an itinerary was planned by the PVS Task Force for the evaluation mission. The country’s VS were evaluated via meetings and visits to government agencies, local government units (LGUs), field offices, diagnostic laboratories, universities with veterinary courses, ports of entry, slaughterhouses, markets, and research institutions in selected areas that represented the VS in the Philippines’ three island groups.

In May 2008, the PVS evaluation mission, comprising two OIE experts and one OIE observer, visited the Philippines. The OIE PVS Tool (2007 edition) was used as the reference document for the evaluation (3). The evaluation team assessed the national VS against the four fundamental components in the PVS Tool and their respective critical competencies to determine the country’s level of advancement.

Meetings were held at the BAI so that OIE experts could talk with officials from the Department of Agriculture (DA) as well as representatives from the Professional Regulation Commission – the Board of Veterinary Medicine members (the Philippines’ veterinary statutory body), the Philippine Veterinary Medical Association, veterinary officers from LGUs and the private sector, and committees such as the National Advisory Committee for Animal Disease Control and Emergency (NAC-ADCE) and the Committee on Animal Welfare (Fig. 1). Meetings were also held with the administrative staff of the BAI as well as staff from agencies within the Department of Health and the Department of Environment and Natural Resources. For out-of-town trips, the OIE PVS Evaluation mission team was split into two, one covering Northern Luzon and Western Visayas and the other Southern Luzon and Southern Mindanao, but they later rejoined to visit Central Visayas. There were visits to DA regional field units, regional animal disease diagnostic laboratories, provincial/city veterinary offices, public markets, state universities, seaports, airports, and research institutions, including a poultry-dressing plant and a swine abattoir. An exit meeting was held to present the initial findings of the PVS evaluation with the BAI and other concerned agencies. The CVO gave the draft report to the BAI for review and comments before the final evaluation report was drawn up in July 2009. The report included an assessment of the current state of the VS against the critical competencies, strengths and weaknesses identified, and recommendations for improvement (2).

Consultation meeting on the PVS evaluation report

An important follow-up activity after the PVS evaluation mission was a 1-day consultation meeting held with stakeholders in the animal industry to solicit their support and cooperation for the strengthening of the VS (Fig. 2). In December 2009, a consultation meeting on the PVS was conducted by the OIE Sub-regional Representative for South East Asia (OIE-SRR) and the Project Coordinator of the OIE/AusAID Programme for Strengthening Veterinary Services in South East Asia (PSVS). The objectives of the consultation meeting were:
Among the important agreements made during this meeting were the following (1):
- establishment of a PVS Working Group, chaired by a PVS coordinator from BAI, with representation from each of the sectors (government, academia, LGUs, and industry)
- initiating the development of a VS strategic plan by the PVS Working Group considering all the outputs of the meeting, including the findings and priorities of both the OIE PVS evaluation and all the VS stakeholder sectors.

In compliance with the first agreement, BAI Special Order No. 16, series of 2010, dated 21 May 2010, the ‘Creation of the PVS Working Group and Preparations’ was issued. The Order outlined duties and responsibilities of BAI officers and stakeholders as the following:
- review and study the PVS report
- develop a National Veterinary Services Strategic Plan (medium to long term) including priorities, goals, objectives, action plans and a timeline for activities to strengthen the VS in line with recommendations in the PVS report
- gather relevant information and necessary references that might assist in the strategic planning process;
- ensure the smooth and orderly conduct of the OIE PVS Gap Analysis mission by:
  - preparing, compiling and packaging the necessary information and documents required for Gap Analysis
  - planning, coordinating and facilitating the visit of PVS Gap Analysis experts
  - making comments and helping finalise the PVS Gap Analysis report
- harmonise the results of the PVS Gap Analysis into the strategic plan
- develop an implementation plan for the strategy, including mechanisms for its periodic review and refinement
- communicate with donors and relevant government authorities to ensure support for the implementation of the strategic plan.

**PVS Gap Analysis mission**

Following a request by the CVO, a PVS Gap Analysis mission, the second step in the PVS Pathway, was conducted by a team of three OIE experts in July 2010. More data on the VS were collected prior to the mission, including some economic data. The Gap Analysis mission aimed to: (1) strengthen in a sustainable manner the VS compliance
with OIE standards defined in the OIE Terrestrial Animal Health Code; and (2) determine precisely what activities and means were needed to bring the VS progressively and sustainably into line with OIE quality standards.

A series of meetings was scheduled with the Gap Analysis mission experts, which included:

- high-level DA officers
- officers for veterinary public health inspection, border security inspection, inspection of veterinary products and residues and veterinary and technical training, laboratories, the veterinary services field network and cross-cutting services.

Plenary working sessions were conducted with relevant officials, in which the national priorities and objectives of the VS were identified. Forty critical competency cards were also discussed in these sessions to determine the level of advancement needed to improve the VS as well as to map out the strategies and activities to achieve these levels (Fig. 3). Budgets were estimated and then formulated to come up with the necessary financial input needed to strengthen the VS.

OIE PVS strategic planning mission

To support the next phase in the PVS Pathway, an OIE PVS strategic planning mission was held in September 2010 (Fig. 4) and included four OIE experts. The PVS strategic planning mission assisted the Philippine VS in developing a strategic planning framework.
The outcome of this mission was the development of a vision, mission and goals for the VS as follows:

**Vision**
A Philippine Veterinary Services that is capable of integration globally, efficiently protecting human and animal health and welfare, instrumental in achieving security and livestock industry growth under a sustainable environment.

**Mission**
To deliver quality and affordable Veterinary Services through the application of modern veterinary technologies, effective implementation of animal production and health programs, with a strong legislation.

**Goals**

**On veterinary structure and function**
A well-coordinated and authoritative national Veterinary Service system that operates efficiently and effectively in the delivery of all its major livestock trade, animal health and veterinary public health functions.

**On trade**
Implement sanitary measures to facilitate growth of local and international trade of animal and animal products.

**On animal health**
Improve surveillance, diagnosis, reporting, controlling and eradication of diseases of national importance as well as foreign animal diseases.

**On veterinary public health**
Ensure the promotion and protection of public health through appropriate food safety control measures and zoonotic disease management.

The final PVS Gap Analysis report will be used to support the formulation of a strategic plan and to provide justification to advocate the strengthening of the Philippine VS.

**Tools for good governance**

**Modern legislation**
Coincidentally during 2010, the BAI was in the process of restructuring the VS to modernise its veterinary legislation. A key step was the development of proposed legislation entitled ‘An Act Strengthening the Animal Industry and Veterinary Services in the Philippines’. Veterinary colleagues had been trying to work on this for some years. Much attention had been given to finishing this work because of the need to clearly define and expand the scope of the VS to be more relevant for current times.

The objectives of this proposed Act are to:

- protect human and environmental health from hazards caused by animal diseases and zoonoses
- establish a modern and responsive VS
- formulate, promote, enforce and implement rules, policies and programmes for the promotion of animal health, animal welfare and environmentally friendly animal production processes
- institutionalise inter-agency, multi-sectoral and local government cooperation on animal health and veterinary service programmes
- ensure animal food production safety and food security in support of poverty alleviation
- guarantee compliance with and harmonisation of sanitary and phytosanitary (SPS) measures and other veterinary protocols with international standards;
- promote an environment of global livestock trade competitiveness
establish nucleus and multiplier livestock breeder and production farms in support of the government’s modernisation programmes in agriculture.

This proposed Act was submitted for approval by the Senate and Congress.

**Strong alliance with stakeholders**

To support the VS along the PVS Pathway, a strong alliance with stakeholders is important. The OIE PVS evaluation assessed this to be a strength of the Philippine VS. Aside from other government agencies, the VS has good partnerships with the following industries and their representations:

- Industry – pork producers, pig farmers, cattle raisers, broiler raisers/integrators, meat importers, meat processors, feed millers and drug companies.
- Professional associations – Philippine Veterinary Medical Association, Philippine College of Poultry Practitioners, Philippine College of Swine Practitioners, Philippine College of Veterinary Public Health.
- LGUs – Provincial, City and Municipal Veterinarians League of the Philippines (PCMVLP).
- Non-governmental organisations – animal welfare groups.
- Academe – state universities.

In the Philippines, there are many forums for interaction with stakeholders. These are possible through meetings and gatherings with the VS in:

- NAC-ADCE
- National Agricultural and Fishery Council (NAFC) – Committee on Poultry, Livestock and Feed Crops
- Philippine Inter-agency Committee on Zoonoses (PhilCZ)
- technical working groups
- consultation meetings
- trade fairs, summits and conferences.

**Challenges**

One of the challenges that we face is developing and implementing the National Veterinary Services Strategic Plan (NVSSP). This is not an easy task and involves organising a dedicated technical writing group to draft and finalise the plan, which might take some time because of competing demands on government personnel. Implementing this alongside the present rationalisation plan (streamlining) of the government will also be a challenge given the reduction in the number of positions. The NVSSP should focus on aligning with the priorities and banner programmes of the current administration to gain its acceptance.

Another challenge is the sourcing of funds to modernise the VS because of constraints in government bureaucracy and finances. It is important to work diligently within the system and regularly submit budget proposals and justifications. Income from regulatory activities and services can be utilised for the development and modernisation of government facilities and enhancing the proficiency of services. Use of funds such as these should be put into legislation with checks and balances to assure that these are being wisely used. Finding the right venue and responsible people to manage these funds is essential. Additional funding could also be obtained via external assistance through international donor funding. Foreign-assisted projects and programmes should be coordinated phase by phase towards the modernisation of the VS. The challenge is to ensure that government personnel consult and coordinate activities that lead towards the common desired goals in the NVSSP.

Current international trends and issues pose challenges towards the development of the VS. There are always the lingering threats of transboundary diseases (e.g. foot and mouth disease, classical swine fever, Newcastle disease), and effective disease management through prevention, control and eradication programmes takes time to be established and implemented by the VS. During the last 20 years, there has been an upsurge of emerging diseases, especially zoonoses. Animal disease mortalities and morbidities challenge the VS in terms of the socioeconomic impact that these entail. Countries also have to comply with international standards and guidelines. Technology developments, protocols and country agreements have to be coordinated in order to reach quality standards for animal health. Coping too with the effects of global climate change, the forces of nature and the rational use of drugs and biologicals in animals are also areas that challenge the governance of the VS.
In conclusion, it is anticipated that the implementation of modernised legislation, strong alliance with stakeholders and other elements to improve governance will help the Philippine VS move towards achievement of the goals of the PVS Pathway and the realisation of a high-quality VS in the Philippines.

References

Appendix: Recommendations
OIE Global Conference on
Aquatic Animal Health

Panama Declaration

Considering that:

1. The first OIE Global Conference on Aquatic Animal Health was held in Bergen, Norway, in 2006, and recognised the urgent need for Members to develop national aquatic animal health strategies;
2. There is a need for greater efficiency in the production of animal protein to meet the demands of the growing world population, especially in developing countries;
3. Aquaculture is one of the world's fastest growing food-producing sectors, and food derived from aquatic animals is an important source of high-quality animal protein; aquaculture represents now close to 50% of aquatic animal global consumption;
4. Aquatic animal diseases represent a major limitation to efficient aquaculture production and a constraint on international trade;
5. An increasing number of aquatic species are farmed worldwide but few, if any, are truly domesticated, leading to important gaps in knowledge, including on the nutritional requirements, welfare and disease control of many farmed species;
6. Countries need effective aquatic animal health programmes to increase production of safe products in an environmentally sustainable way and to participate in international trade;
7. Veterinarians and other aquatic animal health professionals play a key role in the establishment and implementation of aquatic animal health programmes;
8. Aquatic Animal Health Services, whether part of the Veterinary Services or not, frequently lack human and financial resources and infrastructure, including legislation, to implement efficient aquatic animal health programmes;
9. The mandate of the World Organisation for Animal Health (OIE), as an intergovernmental organisation with 178 Members, is to improve terrestrial and aquatic animal health and welfare worldwide and to promote safe trade;
10. The need for all OIE Members to support the application of the OIE standards to improve animal health and welfare globally and to promote safe international trade in animals and animal products worldwide, notably through meeting the obligations of World Trade Organization (WTO) membership (as appropriate), including those for health certification;
11. Government authorities are responsible for establishing appropriate regulatory frameworks for aquaculture products to mitigate risks to human health, animal health and the environment, and to ensure that these products are safe and appropriately certified to meet international trade requirements;
12. Good governance is of critical importance in enabling Veterinary Services and Aquatic Animal Health Services, in coordination with stakeholders, to fulfill the basic missions recommended by the international community and the OIE in order to improve animal health and welfare worldwide;
13. There is a need to increase the capacity of all countries worldwide to create or maintain national animal health and veterinary public health systems that cover all national territories, with the necessary infrastructure to provide for the prevention, surveillance, early detection and rapid response to outbreaks of aquatic animal diseases, including zoonoses, whether these arise through natural, accidental or intentional events and for the safety of aquatic animal products for human consumption;
14. The OIE is working to support Member Countries, including through the ongoing conduct of capacity-building seminars that aim to raise awareness and improve capacities of national Focal Points for Aquatic Animals, under the overall authority of the National OIE Delegate;
15. At the 79th OIE General Session (2011), the OIE adopted a resolution calling for the provision of recommendations on veterinary education, based on recommended minimum competencies required of Day 1 veterinary graduates, to enable all countries to meet the OIE standards for efficient Veterinary Services (comprising both the public and the private sector);
16. In many countries, aquatic animal health and medicine are regarded as a post-graduate specialisation and are not taught to veterinary undergraduates;

17. OIE Reference Centres are of critical importance to help the OIE to fulfil its mandate relevant to diagnostic capacities and the setting of science-based standards, guidelines and recommendations on animal health and welfare;

18. The OIE Twinning Programme, launched in 2006, creates opportunities for developing and in-transition countries, including implementing laboratory diagnostic methods based on the OIE standards, with the eventual aim of creating more OIE Reference Centres in geographic areas that are currently under-represented and reinforcing the veterinary scientific community in developing countries;

19. Scientific knowledge on tools for disease prevention and therapy is less advanced for aquatic animals than for terrestrial animals, notably in relation to the use and availability of veterinary medicines, including antimicrobial agents;

20. The risks presented by the use of antimicrobial agents;

21. Epizootic ulcerative syndrome (EUS) presents important threats to fish health, livelihoods and food security in Africa; and

The conference makes the following recommendations:

For the OIE:

22. The OIE should cooperate with governments and with relevant international and regional organisations to increase awareness of the need for aquatic animal health programmes, improve disease reporting and foster cooperation between veterinary and other relevant authorities at the national and international level;

23. The OIE should strengthen collaboration with donors and with regional and international organisations, such as FAO, to advocate for the key role of veterinarians and aquatic animal health professionals in the prevention and control of disease and to encourage governments and donors to invest in Veterinary Services and Aquatic Animal Health Services as a Global Public Good;

24. The OIE should continue taking steps to make the PVS Pathway, appropriately adapted to national aquatic animal health systems, more accessible to governments that wish to strengthen Aquatic Animal Health Services (AAHS), including through the conduct of pilot evaluations of AAHS at the request of OIE Members;

25. The OIE should continue providing capacity-building support to National Delegates to help them to comply with their rights and obligations, and to Aquatic Animal Focal Points under the authority of National Delegates, to strengthen the capacities of OIE Members, particularly developing countries, to participate in the standard-setting process;

26. The OIE should continue encouraging governments, relevant regional and international organisations and donors, to provide sufficient resources for aquatic animal health governance and programmes, and for applied research relevant to these programmes, including into aquatic animal feed, welfare, therapeutics and vaccines;

27. The OIE should promote twinning projects that can strengthen early diagnosis; reporting, prevention and management of aquatic animal diseases; and other appropriate elements of capacity building;

28. The OIE should address the particular needs of veterinarians working with aquatic animals as part of its recommendations on the Day 1 competencies of graduating veterinarians, including by asking the Aquatic Animal Health Standards Commission to prepare recommendations on the content of the curriculum for Day 1 and Specialist Veterinarians; and

29. The OIE should convince governments and donors to assist African countries under threat from epizootic ulcerative syndrome (EUS).

For OIE members:

30. Countries where aquaculture is an important or growing sector should consider requesting an OIE PVS evaluation of their Aquatic Animal Health Services, with the objective of improving competencies and general compliance with OIE standards and guidelines;

31. Independent of entering the PVS Pathway, Members should take steps to improve compliance with OIE standards and guidelines, notably on the diagnosis and reporting to the OIE of aquatic animal diseases, on the use of therapeutic tools, such as antimicrobials, and on the formation of public–private partnerships;
32. Those Members who have not yet done so should nominate national Focal Points for Aquatic Animals under the authority of the OIE Delegate and support participation of nominated Focal Points in OIE regional capacity-building seminars and other relevant activities;
33. The OIE National Delegate should take steps to ensure that the OIE standards and recommendations on the prudent use of antimicrobial agents are respected in his/her country;
34. OIE Reference Centres should, as part of their mandate, continue to comply with and promote the application of OIE standards and provide services to OIE Members;
35. Members with an OIE Reference Centre for aquatic animal diseases should provide sufficient resources to enable the Centre to adequately fulfil its mandate and duties;
36. OIE Members, especially those with OIE Reference Centres, should give favourable consideration to participating in the OIE Twinning Programme;
37. Governments should support and encourage applied research on key questions related to aquatic animal health programmes, including on: relevant aspects of feed for use in aquaculture; aquatic animal welfare; and ecologically sustainable tools for the prevention and control of important aquatic animal diseases; and
38. Governments should, as appropriate, comply with their WTO SPS obligations with respect to aquatic animal health certification for international trade.