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Report of the

ROUND-TABLE DISCUSSION: MOVING FORWARD THROUGH LESSONS LEARNED ON RESPONSE ACTIONS TO AQUATIC ANIMAL DISEASE EMERGENCIES

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PREPARATION OF THIS DOCUMENT

This document presents the *Report of the round-table discussion: moving forward through lessons learned on response actions to aquatic animal disease emergencies***,** which was held in FAO headquarters, Rome, from 16 to 18 December 2019. The report was prepared by Drs J. Richard Arthur (FAO Consultant, Canada), Melba B. Reantaso and Bin Hao (FAO, Rome). It is intended that this document will be circulated to interested stakeholders (i.e. competent authorities and other relevant government agencies, aquaculture producers and academia, including relevant fora) to provide information, raise awareness and build consensus on the need for emergency response and contingency planning for dealing with mass mortalities of cultured and wild populations of aquatic animals.

ABSTRACT

This report presents the results of a Round-table discussion: moving forward through lessons learned on response actions to aquatic animal disease emergencies organized by the Food and Agriculture Organization of the United Nations (FAO) in collaboration with the Norwegian Agency for Development Cooperation (NORAD) under the auspices of the project GCP/GLO/979/NOR: "Improving Biosecurity Governance and Legal Framework for Efficient and Sustainable Aquaculture Production" that was held from 16–18 December 2019 at the FAO headquarters in Rome, Italy. The meeting was attended by 43 experts from 22 countries, representing governance authorities, intergovernmental organizations, academia, research institutions and the private sector. Twenty presentations were delivered, namely: (1) National competent authority: role and experiences (China, Ghana, Indonesia, Saudi Arabia, Norway, The Philippines, Thailand, Viet Nam, and the United States of America); (2) Inter-governmental organization: role and activities/experiences related to investigating specific mass mortalities of aquatic animals (Network of Aquaculture Centres in Asia-Pacific, World Organisation for Animal Health and FAO); (3) Producer and research/academic sectors: role and activities/experiences related to investigating specific mass mortalities of aquatic animals (MSD Animal Health/Belgium; Instituto Zooprofilattico Sperimenal delle Venezia/Italy; Wageningen Bioveterinary Research/Netherlands; Centre for Environment, Fisheries and Aquaculture Science/United Kingdom; Mississippi State University/United States of America; and (4) Global Burden of Animal Diseases (GBAD)/University of Liverpool/United Kingdom.

The meeting successfully achieved its objective of taking stock and sharing experiences and lessons learned on response actions to aquatic animal disease emergencies as basis for generating recommendations for the further development and improvement of the draft FAO *Decision-tree for dealing with aquatic animal mortality events* and supporting guidance.

The meeting generated an annotated table of contents for the above decision-tree document consisting of the following major sections, namely: Introduction; Phases in an Emergency; Elements of an Emergency Response (Preparedness Phase, Response Phase, Recovery Phase); Decision-tree for Mass Mortality Events; Conducting Field Investigation; Tools and Guidance; and Case Study Examples. It is expected that this document will be made available in 2021.

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ANNEXES

ACKNOWLEDGEMENTS

The Food and Agriculture Organization of the United Nations (FAO) gratefully acknowledges the active participation of the 43 experts who participated in this round-table discussion. The participants, who came from 22 countries and represented intergovernmental organizations, academe, research institutions and the private sector are thanked for their self-funded participation, active contributions to a successful meeting and for their expressions of interest to participate in future activities related to emergency preparedness for mass mortalities of cultured and wild aquatic animals..

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ABBREVIATIONS AND ACRONYMS

AAHRDD	Aquatic Animal Health Research and Development Division (Thailand)
AHPND	Acute hepatopancreatic necrosis disease
ALs	Associate laboratories
ANAAHC	ASEAN Network on Aquatic Animal Health Centres
ASEAN	Association of Southeast Asian Nations
BoNT/E	Botulinum neurotoxin E
BFAR	Bureau of Fisheries and Aquatic Resources (Philippines)
CCEAAD	Collaborating Centre for Emerging Aquatic Animal Diseases (OIE)
CCRF	Code of conduct for responsible fisheries (of the FAO)
CDC	Centers for Disease Control and Prevention
Cefas	Centre for Environment, Fisheries and Aquaculture Science (United Kingdom)
CEV	Carp edema virus
CVO	Chief veterinary officer
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CyHV-2	Cyprinid herpesvirus 2
DIV1	Decapod iridescent virus 1
DoF	Department of Fisheries (Thailand)
EAAD	Emerging aquatic animal diseases
ECTAD	Emergency Centre for Transboundary Diseases
EHC-AH	Emergency Management Centre for Animal Health
EHP	*Enterocytozoon hepatopenaei*
ELISA	Enzyme-linked immunosorbent assay
EMS	Early mortality syndrome
ESC	Enteric septicemia of catfish
EUS	Epizootic ulcerative syndrome
FAO	Food and Agriculture Organization of the United Nations
FBC	Fisheries Biotechnology Center (Philippines)
FHI	Fish Health Inspectorate (for England and Wales)
FIAA	Aquaculture Branch (of the FAO)
GAPS	Good aquaculture practices
GBAD	Global burden of animal diseases
GEMP	Good emergency management practices
GIEWS	Global information and early warning system (of the FAO)
HPLC	High performance liquid chromatography
IHHNV	Infectious hypodermal and hematopoietic necrosis virus
IHNV	Infectious hematopoietic necrosis virus
iiPCR	Insulated isothermal polymerase chain reaction
II.ZZ.SS.	Istituti Zooprofilattici Sperimentali
IMN	Infectious myonecrosis
IMNV	Infectious myonecrosis virus
ISKNV	Infectious spleen and kidney necrosis virus
IZSVe	Istituto Zooprofilattico Sperimentale delle Venezie
JFRC	Jeddah Fisheries Research Center
KHD	Koi herpes disease
KHV	Koi herpesvirus
MARA	Ministry of Agriculture and Rural Affairs (China)
MARD	Ministry of Agriculture and Rural Development (Viet Nam)

MERS	Middle East respiratory syndrome
MEWA	Ministry of Environment, Water and Agriculture (Saudi Arabia)
MME	Mass mortality event
MOFA	Ministry of Food and Agriculture (Ghana)
MOFAD	Ministry of Fisheries and Aquaculture Development (Ghana)
MSU-CVM ADL	Mississippi State University College of Veterinary Medicine Aquatic Diagnostic Laboratory
NACA	Network of Aquaculture Centres in Asia-Pacific
NAQUA	National Aquaculture Company (Saudi Arabia)
NF	Fisheries Division (of the FAO)
NFTEC	National Fisheries Technology Extension Center (of MARA)
Norad	Norwegian Agency for Development Cooperation
NRIA	National Research Institute of Aquaculture (Japan)
NVWA	Nederlandse Voedsel - en Warenautoriteit
OIE	World Organisation for Animal Health (formerly Office International des Épizooties)
PCR	Polymerase chain reaction
PMP/AB	Progressive Management Pathway for Aquaculture Biosecurity
POSIKANDU	Pos Kesehatan Ikan Terpadu
PPP	Public-private partnership
PRFRI	Pearl River Fisheries Research Institute
PVS	Performance of Veterinary Services
QAAD	Quarterly Aquatic Animal Disease (Report)
R&D	Research and development
ROI	Return on investment
RRC	Regional resource centres
RRE	Regional resource experts
RRL	Regional reference laboratories
RT-PCR	Reverse transcription polymerase chain reaction
SADC	Southern African Development Community
SAS	Saudi Aquaculture Society
SDGs	Sustainable development goals
SEAFDEC	Southeast Asian Fisheries Development Center
SHIV	Shrimp hemocyte iridescent virus
SOPs	Standard operating procedures
SPF	Specific-pathogen-free
TCP	Technical Cooperation Programme (of the FAO)
TiLV	Tilapia lake virus
TiLVD	Tilapia lake virus disease
TIU-DGA	Technical Implementing Unit – Directorate General of Aquaculture (Indonesia)
TOC	Table of contents
TS	Taura syndrome
USDA	United States Department of Agriculture
VHSV	Viral hemorrhagic septicemia virus
VTC	Visceral toxicosis of catfish
WBVR	Wageningen Bioveterinary Research
WG	Working group
WRI-CSIR	Council for Scientific and Industrial Research’s Water Research Institute (Ghana)

WSD	White spot disease
WSSV	White spot syndrome virus
WTD	White tail disease
YHD	Yellow head disease
YHV	Yellow head virus
YSFRI	Yellow Sea Fisheries Research Institute

1. Background

1.1 Introduction

1. During the last three decades, the aquaculture sector and its governance (state and non-state actors) have been challenged by serious aquatic animal disease incursions and, in some cases, the sector was caught off-guard by the emergence of new diseases. For example, since 2009, we have seen the emergence of acute hepatopancreatic necrosis disease (AHPND), tilapia lake virus (TiLV), *Enterocytozoon hepatopenaei* (EHP), shrimp hemocyte iridescent virus (SHIV) and more recently, infectious spleen and kidney necrosis virus (ISKNV). Some known diseases have re-emerged to cause mass mortalities in new geographical localities, for example, white spot disease (WSD) in the Saudi Arabia and Australia, koi herpesvirus (KHV) in Iraq, epizootic ulcerative syndrome (EUS) in the Democratic Republic of Congo and infectious myonecrosis virus (IMNV) in India. Additionally, large-scale mass mortality events (MMEs) due to environmental causes appear to be affecting both cultured and wild populations of aquatic animals with increased frequency and severity. These include losses due to such events as algal blooms, temperature extremes, oxygen depletion, point-source pollution (chemical and oil spills) and pesticide runoff from agricultural activities.

2. Due to various factors, government agencies and the private sector often have difficulty in responding rapidly and effectively to MMEs. Such factors include a lack of planning for emergency response, absence of readily accessible funds, lack or appropriate organizational structure, and a lack of appropriate training and expertise. The effectiveness of responses to mass mortalities of aquatic organisms varies from country to country, depending on the cause and the state of national emergency preparedness. Often there is a lack of follow up to a mortality event, in order to determine where improvements can be made. A systematic assessment of the economic and social impacts of a mass mortality of aquatic organisms is often lacking, as, in general, standardized procedures for assessing such impacts are not available. In view of the clear need to improve the response of national government agencies and the private sector to mass mortalities of cultured and wild populations of aquatic organisms, an expert meeting, the *Round-table discussion: moving forward through lessons learned on response actions to aquatic animal disease emergencies* (the round-table discussion) was organized by the Food and Agriculture Organization of the United Nations (FAO) in collaboration with the Norwegian Agency for Development Cooperation (Norad).

1.2 Purpose

3. The objectives of the round-table discussion were to:

- take stock, share experiences and lessons learned on response actions to aquatic animal disease emergencies;
- review and make recommendations for development and improvement of the draft FAO *Decision-tree for dealing with aquatic animal mortality events*;
- make recommendations towards the development of a framework for a systematic assessment of the financial, socio-economic and other impacts of aquatic animal diseases; and
- identify key elements for a project proposal to improve response actions to aquatic animal disease emergencies.

1.3 Participants

4. The Round-table Discussion was held in the German Room, FAO headquarters, Rome, Italy from 16–18 December 2019. Some 43 representatives of national government agencies, international and

regional organizations, non-governmental agencies, aquaculture producers and academia coming from 22 countries participated in this event. The list of participants is given as Annex 1.

1.4 Process

5. The draft programme for the Round-Table discussion is given as Annex 2. There were four technical sessions , each with an associated Working Group activity, namely:

- Session 1: Response actions to aquatic animal disease emergencies.
- Session 2: Decision-tree for dealing with aquatic animal mortality events.
- Session 3: Framework for systematic impact assessment of aquatic animal diseases.
- Session 4: Key elements for improving response actions to aquatic animal disease emergencies.

Day 1: Session 1
During Session 1, presentations were delivered by resource expert speakers, representatives of international and regional organizations, country representatives, academia and the private sector on experiences regarding response actions to aquatic animal disease emergencies. The scope of the presentations included the following:

- brief background to the central problem/issue examined;
- response actions taken and findings;
- implications and lessons learned from (2) in terms of cost, effectiveness, and improvements;
- discussions.

Day 2: Sessions 1 and 2
Session 1: Continuation of Session 1.
Session 2: Review the FAO document on *Decision-tree for dealing with aquatic animal mortality events*, incorporating lessons learned from Day 1.

Day 3: Sessions 3, 4 and 5
Session 3: Discuss considerations for developing a framework for systematic impact assessment of aquatic animal diseases.
Session 4: Identify key elements for a project proposal to improve response actions to aquatic animal disease emergencies.
Session 5: Moving Forward and Closing.

6. Prior to the meeting, the following set of questions, to be answered in the content of the presentations, was provided by Dr Reantaso (FAO headquarters, Rome) to all presenters:

- What is the role/mandate of your institution and relevant structure in place for dealing with aquatic mass mortality events (MMEs)?
- Example of an MME that you have been involved. Describe the specific MME scenario (the central issue/problem investigated/examined).
- Describe the response actions taken and the outcomes/findings/conclusions/ any follow-up work.
- Describe the implications of (3) in terms of effectiveness, cost.
- Describe lessons learned and improvements.
- In your opinion, what are the 5 minimum emergency preparedness response requirements that need to be in place?

1.5 Products

7. The outcomes of the meeting include:

- summaries of experiences and lessons learned on response actions to aquatic animal disease emergencies;
- recommendations for further development of the FAO *Decision-tree for dealing with aquatic animal mortality events* and supporting guidance;
- considerations on a framework for the systematic impact assessment of aquatic animal diseases and an associated guidance manual;
- recommendations for the development of a project for improving national government and private-sector response actions to aquatic animal disease emergencies; and
- a meeting report (this document), including summaries of all presentations and results and recommendations arising from the Working Group activities and plenary discussions.

2. Welcoming remarks and introduction to objectives, mechanics and expectations

8. The participants were welcomed by Dr Melba Reantaso on behalf of the FAO, who stressed the informal nature of the meeting, thanked them for their participation and wished them a pleasant stay in Rome.

9. Dr Arni Mathiesen, Assistant Director-General of FAO's Department of Fisheries and Aquaculture[1], then gave the Welcoming Address. Dr Mathiesen highlighted the importance of the round-table discussion, citing the clear need to improve the response of national authorities and the private sector to mass mortalities of cultured and wild aquatic animal populations. He noted that FAO and partners are promoting the Progressive Management Pathway for Improving Aquaculture Biosecurity or PMP/AB and highlighted that the 10th session of FAO's Committee on Fisheries Sub-Committee on Aquaculture held in Trondheim last August has endorsed and supported PMP/AB and the development of a long-term, multidonor assisted partnership programme on aquaculture biosecurity. He expressed FAO's deep appreciation to the participants for their kind support to FAO initiatives and the hope that a more strengthened partnership will lead to a collectively shared responsibility to assist the aquaculture sector in reducing mass mortality events. The full text of Dr Mathiesen's Welcome can be found as Annex 3.

10. Dr Reantaso then briefly presented the background, objectives and expected outcomes of the meeting. These are as outlined in Sections 1.2 to 1.5 of this report. She highlighted the timelapse between initial disease emergence and the timeline of observation, diagnosis, management guidance, and adoption into the World Organisation for Animal Health's (OIE) *Aquatic Animal Health Code.* She noted that many meetings have been held to identify the factors, drivers and pathways of disease emergence, and highlighted the varying capacities of the aquaculture sector and the relevant Competent Authorities to deal with aquatic animal health emergencies.

11. Following the conclusion of Dr Reantaso's introductory presentation, the participants nominated and elected Drs Rohana P. Subasinghe and David Hurchermeyer to serve as Chairman and Vice-chairman, respectively, for the round-table discussions to follow.

3. Session 1: response actions to aquatic animal disease emergencies

12. To provide background information and set the tone for the discussions to follow, 19 technical presentations then followed during Session 1 on Days 1 and 2. These included 10 country

[1] As of the date of the publication, the Department of Fisheries has been renamed to Fisheries Division (NF).

presentations given by representatives of national Competent Authorities, 4 presentations given by participants from international organizations, and 5 presentations given by attendees from universities, government research laboratories and the private sector. Summaries of these presentations are given below.

3.1 National competent authority: roles and experiences

3.1.1 China: Response actions to aquatic animal disease emergencies in China (Dr Qing Li)

13. In China, the aquatic animal disease prevention and control systems, with the lead of the Ministry of Agriculture and Rural Affairs (MARA) play key role in dealing with aquatic mass mortality events (MMEs). The Bureau of Fisheries at MARA has the main responsibilities related to prevention of disease epizootics and the quarantine of aquatic animals. The MARA's National Fisheries Technology Extension Center (NFTEC), as a National Aquatic Animal Disease Prevention & Control Agency, mainly undertakes the organization and implementation of each project on aquatic animal health. Fisheries authorities at the provincial, city and country levels take charge of the prevention and control of animal diseases within their jurisdictions. Local aquatic animal disease prevention and control agencies take charge of animal disease monitoring, surveillance and treatment, as well as having other technical responsibilities related to animal disease prevention and control.

14. Once a mass mortality of aquatic animals occurs, the emergency should be immediately reported to a superior administrative authority. An example is a MME in rainbow trout that happened in November 2009 at a farm in Gansu Province that used a flowing-water production system. Immediately after the message reached the NFTEC, on-site investigations were conducted by an expert team organized by NFTEC. Through disease diagnostics performed by designated laboratories, the cause of the mass mortality was identified to be infectious hypodermal and hematopoietic necrosis virus (IHNV). This was the first case of IHN emerging and causing a disease outbreak in China. The report of new emerging IHN was made to MARA in timely manner. Contingency treatments, including stamping out, biosafety treatment and disposal of affected aquatic animals, were implemented promptly with the financial support of MARA. Disease alerts were promptly issued to the major areas of rainbow trout aquaculture nationwide, and the movement of fingerlings of rainbow trout from the infected zone was prohibited. Through the implementation of these emergency response actions, the risk of the pathogen spreading to new areas was effectively eliminated, and unnecessary economic losses avoided. Approximately 1 million RMB was invested by the Chinese Government for funding and aiding the biosafety treatment and disposal of affected animals.

15. Lessons learned from this case revealed that government grants for the prompt start-up of contingency plan at the national level are critical to ensuring the implementation of an emergency response action. However, due to insufficient emergency preparedness at the farm level, the limited diagnostic capability of local agencies, and imprudent use of drugs, the emergency response action could not be fully implemented. Furthermore, the risk of aquatic animal disease spreading within the water circulation system in the same zone would still be high.

16. The emergency response can be improved by increasing the generalized publicity, and promoting emergency preparedness by disease reporting at the farm level in timely manner. The improvement of diagnostic ability and the capability of laboratories of the aquatic animal disease prevention and control agencies at all levels is also very important.

17. The five minimum emergency preparedness response requirements that need to be in place are: (i) to establish a contingency plan at the national level; (ii) to improve the diagnostic capability of local aquatic disease prevention and control agencies; (iii) to strengthen awareness of the need for disease reporting at the farm level; (iv) for the government to subsidize the relevant institutions; and (v) to set norms to guide the implementation of stamping out, biosafety treatment and disposal.

3.1.2 Ghana: Mass mortality events in Ghana (Peter A. Ziddah)

18. In Ghana, the Veterinary Services of the Ministry of Food and Agriculture (MOFA) is responsible for animal welfare and the prevention, control and treatment of both terrestrial and aquatic animal diseases, while The Fisheries Commission of the Ministry of Fisheries and Aquaculture Development (MOFAD) is responsible for fish production and other aspects of both capture fisheries and aquaculture.

19. Recently, some mass mortality events have occurred in Ghana. In 2014, a mass mortality of fish occurred in Lake Volta due to *Streptococcus agalactiae* 1b. An outbreak of *S. agalactiae* 1a occurred at a Chinese farm near the Kpong Dam in 2017, and in 2018, an outbreak of infectious spleen and kidney necrosis virus (ISKNV) was diagnosed in the same area.

20. To deal with these disease outbreaks, actions were initiated by the Environmental Protection Agency, WRI-CSIR/Vet services and foreign partners (Icthopharma, France; Ridgeways and Cefas, United Kingdom; the Norwegian Veterinary Institute; and MSD) to look at aquaculture activities. Pathogen identification was done by foreign partners and water analysis was accomplished by the Council for Scientific and Industrial Research's Water Research Institute (WRI-CSIR).

21. Disease containment was slow due to the reluctance of farmers to report diseases quickly and a poor response by regulators due to a lack of necessary skills. In Ghana, there are no veterinarians specialized in aquatic animal services, government fish health services are inadequate, and there is weak legal support for enforcement of control measures. Ghana is currently trying to establish a specialized laboratory for fish health; however, there is minimal funding.

22. The measures instituted to deal with disease outbreaks included the temporary closure of some farms, the implementation of sanitary measures, and the banning of movements of live and dead fish within the country. Farmers and the general public have also been sensitized to the need to recognize and report fish diseases, and border officials have been reminded on issues related to fish importations.

23. As a result of these disease outbreaks, the government has now seen the need to provide funding for emergency preparedness. The Fisheries Commission is hiring four veterinarians and recognizes the need to train additional staff. Laboratory infrastructure is also being improved. However, institutional cooperation between stakeholders is very weak and needs to improve; diseases would not have spread so widely if the relevant institutions worked together instead of acting independently.

3.1.3 Indonesia: Indonesia government policy to overcome the situation on mass mortality of aquatic animals (Dr Dyah Setyowati)

24. Indonesia is the largest archipelago country in the world and consists of 17 504 islands with an area of 6.6 million km^2. The competent authority for fish health is the Directorate of Aquaculture Region Development and Fish Health. The legal basis for controlling fish diseases in Indonesia is the Ministry of Marine Affairs and Fisheries Regulation No. 13 of 2019.

25. In 1994, Indonesian vannamei shrimp were attacked by white spot syndrome virus (WSSV) with mortality up to 100 percent. In May 2006, the first outbreak of infectious myonecrosis virus (IMNV) occurred in Situbondo, East Java, with a mortality of 60 percent. In 2007, infectious myonecrosis (IMN) entered Lampung and spread very quickly to shrimp cultivation centers, with 80 percent mortality.

26. Problems with handling aquatic animal mass mortality in Indonesia include: the absence of an effective aquatic animal mass mortality management system; the limited capacity of the testing laboratory; the low ability of field workers; the limited information available regarding the causes of mass death of fish; and the limited ability of farmers to handle fish diseases and their low knowledge in managing aquatic animal health and the environment. The estimated economic losses due to WSD and IMN are IDR 2.5 billion and IDR 1.25 billion, respectively.

27. In addressing the mass mortality events (MMEs) of fish due to disease, it is necessary to develop a national strategy for fish health and the environment funded by the FAO. Implemented in 2013–2015, the FAO project TCP/INS/3402 on “Development of preventive aquatic animal health protection plans and enhancing emergency response capacities to shrimp disease outbreaks in Indonesia” conducted surveillance for disease outbreaks caused by IMNV and WSSV in three provinces and three districts, namely Banten Province (Tangerang District), Lampung Province (South Lampung District) and East Java Province (Banyuwangi District).

28. Effective handling of an aquatic animal MME is done through the implementation of emergency response which includes: contingency plan, early warning, early detection and early response. The implementation of the emergency response involved the District Fisheries Service, Provincial Fisheries Service, the Technical Implementing Unit – Directorate General of Aquaculture (TIU-DGA), fish and environmental health laboratories (central and regional) and farmers. Pos Kesehatan Ikan Terpadu (POSIKANDU) is a fish and environmental health service. There are 51 POSIKANDU units spread across Indonesia (i.e. in Sumatra, Java, Kalimantan, Sulawesi, Bali and Nusa Tenggara). The role of POSIKANDU is expected to be as a "one stop service" in anticipation of controlling fish and environmental health problems.

29. The action response to the handling of aquatic animal MMEs is expected to produce a decrease in aquatic animal mortalities due to disease (decreased prevalence) and the number of floating net cages in accordance with the carrying capacity of the reservoir. The the implementation of the action response has been hindered by the unavailability of standard operating procedures (SOPs) for handling aquatic animal MMEs, the low capacity of field officers and laboratories in the regions in handling samples, the low awareness of farmers on the application of biosecurity measures (which are considered expensive and inefficient), and the limited budget available for handling diseases.

30. The handling of aquatic animal MMEs can be done effectively if it is supported by SOPs, adequate laboratory and field staff capacity and the awareness of farmers in the need to conduct good aquaculture practices (GAPs) and the availability of sufficient budget.

3.1.4 Saudi Arabia: Emergency response in aquaculture, the Saudi Arabia experience (Faris M. Alghamdi and Dr Victoria Alday-Sanz)

31. Saudi Arabia has a recently new, developed industry with a few players focusing mostly on whiteleg shrimp (*Penaeus vannamei*), barramundi, gilt-head bream, silver seabream and tilapia. There are no freshwater bodies in the kingdom, and after a severe crisis faced by the shrimp industry between 2011 and 2013, a new proactive biosecurity strategy was implemented that has been effective in controlling mass mortalities in aquatic animals.

32. Fisheries and aquaculture health is the responsibility of the Ministry of Environment, Water and Agriculture (MEWA), which has established a public-private partnership (PPP) with the Saudi Aquaculture Society (SAS) to implement part of the biosecurity measures, such as the collection of samples of the national surveillance programme, biosecurity audits, pre-approval for stocking and emergency response assessment. The National Reference Laboratory is located at the Jeddah Fisheries Research Center (JFRC), where all samples are analyzed.

33. Saudi Arabia’s aquaculture and wild fish have an exceptional health status, so the pathogens listed for disease control include most of the known pathogens described for the susceptible species cultured in the kingdom. The monthly national surveillance programme includes all these pathogens and allows early detection, and triggers emergency response and contingency plan.

34. While mass mortalities of aquatic animals are not common in the kingdom, we still have two types of sanitary emergencies: those related to the detection of pathogens that are under a control programme and those related to sanitary trade barriers of aquaculture products. In the first case, white spot syndrome virus (WSSV) is the main concern in the kingdom, while in the second case, two emergencies have occurred during 2019. The first one was the report by Chinese customs of yellow head virus type 1 (YHV) in exported product which led to the ban of importation into China. YHV had never been detected in the kingdom before, not through the National Surveillance Program nor through emergency samples. Polymerase chain reaction (PCR) methods were reviewed and on return of the product to the kingdom, samples were sent to the OIE Reference Laboratory for YHV (Commonwealth Scientific and Industrial Research Organisation, (CSIRO). The second case was the imposition of quarantine for aquatic products imported into China due to the presence of Middle East respiratory syndrome (MERS) in the kingdom. In this situation, the country is assessing shrimp exporting companies’ staff health status regarding MERS and confirming the absence of MERS carriers (camels) in the farming areas in order to declare it a compartment free of MERS. These types of sanitary emergencies also have a significant economic impact for the industry.

3.1.5 **The Norwegian Veterinary Institute** (Dr Edgar Brun)

35. In Norway, the Ministry of Trade, Industry and Fisheries deals with fish disease issues at the political level, while the Maritime Authority and the Food Safety Authority are the executive bodies within the system. Below them, and at the scientific advisory level are the Norwegian Veterinary Institute (NVI) and the Marine Institute. The NVI conducts research in the areas of animal health, fish health and food safety. Its primary responsibilities include diagnostics/analyses, scientific advisory support to authorities and industry, risk assessments, disease surveillance and preparedness, research, documentation of the national health situation, and welfare. The Marine Institute also deals with welfare but more with infrastructure.

36. The Food Safety Authority has released a new contingency plan that is freely available on the Internet. Industry should have a system to handle diseases and mass mortalities related to infection but also to handle removal, treatment and proper transport. There is onus on the industry to handle its own problems. Transparency of health status in the industry is very important, while welfare has become more important.

37. For health monitoring, one visit every second month for farms and a monthly visit for hatcheries is recommended. Several private laboratories are taking part in this activity, with the NVI

confirming diagnoses. There is an open publication system on diseases, with information placed on the Web, including maps indicating the sites. Companies are required to report any incidences of disease, which can be in collaboration with fish health services; however, in the end it is the farmers who are responsible for reporting. The Food Safety Authority can place strong restrictions on any farm where there is an "impact on society".

38. Norway has not seen many mass mortality events (MMEs), just instances of high mortality. Although not related to infectious disease, algal bloom due to *Chrysochromulina leadbeateri* caused losses in May 2019. Two similar events also occurred in 1991 and 2008. In the northern fjords and fresh waters of Norway, in May there is almost 24 hours of sunlight and a very calm sea. The MME happened on a holiday when nobody works. This is important because emergency events, including this one, require quick response. In Norway, many farms feed by joystick with lots of screens and cameras etc. Fish started to die within hours. Because the MME happened so quickly, people thought there was a new algal bloom. It was a large challenge to get well boats. However, collaboration allowed a quick response. There was limited capacity due to the large numbers of fish, with tanks of large dead fish occurring within one week. In total, nine companies were affected, more than 8 million salmon died (14 400 tonnes), and losses of 40–50 million Euros were estimated.

39. The lessons learned include that a better knowledge of potential threats to aquaculture from "the ocean" is needed, not just of infectious diseases. Easily available knowledge gained from previous MMEs is important, and public-private collaboration is essential. Governmental bodies also have to work on high-speed responses, especially during an MME, and need to know the regulations well enough to be flexible and find solutions.

40. The requirements for an adequate response to an MME include: well-implemented and updated contingency plans at the farm, regional and national levels; a reporting and communication plan; the capacity to handle not only regular daily volumes of dead fish but also a truly large amount of dead fish from a farm or even an entire region; adequate early detection systems, and the ability to make causal investigation, tracing and prediction. In the MME due to algae, there was also the need to investigate fish to make sure there was not an underlying infectious disease.

3.1.6 Philippines: Response to aquatic animal disease emergencies (Dr Joselito R. Somga)

41. In the Philippines, the Bureau of Fisheries and Aquatic Resources (BFAR) under the Department of Agriculture is the main government agency that deals with aquatic animal mass mortality events (MMEs). The BFAR Central Office and its 16 Regional Field Offices have Fish Health Units and designated Fish Health Officers. The Fish Health Laboratories in the Central and Regional Field Offices have different levels of diagnostic capability based on the existing aquaculture and fisheries activities in the respective regions. The BFAR Fish Health Unit provides aquatic animal health services in the country including responding to aquatic MMEs. Other government agencies involved in aquatic MMEs are the Department of Environment and Natural Resources under the Department of Interior, and the Local Government Units.

42. In June 2018, BFAR responded to a reported mortality of tilapia in a nursery pond. Based on history, unexplained significant mortality was observed by the operator during the first month of stocking of tilapia in the nursery pond. Some fish had bulging eyes and distended abdomens. Analysis of samples sent to the Fisheries Biotechnology Center (FBC), Department of Agriculture showed no external parasites and low level of *Aeromonas* bacteria. With these results and in light of the Disease Advisory and Alert on Tilapia Lake Virus (TiLV) by the Network of Aquaculture Centres in Asia-

Pacific (NACA) and the Food and Agriculture Organization of the United Nations (FAO), the operator requested the FBC to test the samples for TiLV. The results of semi-nested reverse transcription polymerase chain reaction (RT-PCR) conducted by FBC on June 18 and 24, 2018 showed positive for TiLV. The FBC and operator thus informed BFAR on the detection of TiLV in tilapia. After a meeting on June 27, 2018 with the FBC on detection of TiLV, BFAR conducted an on-site investigation on June 28, 2018. Based on gross physical examination, some fish manifested bulging eyes. Results of analysis of the tilapia samples examined at the BFAR Central Office Fish Health Laboratory showed a a low number of gill flukes by microscopy. Bacteria isolated from the liver and spleen were identified as *Streptococcus agalactiae* and *Aeromonas sobria*. Results of insulated isothermal polymerase chain reaction (iiPCR) and seminested RT-PCR for the samples tested showed positive for TiLV.

43. With the detection of TiLV, the movement of fingerlings from the affected nursery pond was restricted, and BFAR conducted regular monitoring and collection of samples for TiLV testing. BFAR also conducted training of BFAR Central and Regional Fish Health Laboratory staff on Laboratory Detection Test for TiLV, while FBC and the Southeast Asian Fisheries Development Center (SEAFDEC) conducted surveillance for TiLV in other tilapia-producing areas in the country and issued a Memorandum Order for Mandatory Screening for TiLV and issuance of Health Certificate for transboundary movement of tilapia for aquaculture certifying that the tilapia were tested and free from TiLV. The detection of TiLV in the Philippines was also reported to the World Organisation for Animal Health (OIE) in November 2018 through immediate notification.

44. The awareness of the tilapia operator/farmer on TiLV, an emerging disease of tilapia, through the disease advisory and alert on TiLV provided by NACA and FAO and his cooperation to report the unexplained fish mortality events to the competent authority was instrumental in the immediate detection of TiLV in the Philippines. Further, other requirements for emergency preparedness response include: a) a disease emergency protocol that will serve as guidelines and identify key agencies and personnel that shall be involved, procedures to be undertaken, and response actions such as diagnosis, chemical treatment, disinfection, destruction/killing and disposal of dead aquatic animals; b) legal basis for conducting emergency disease response; c) government extension workers trained on disease recognition at the farm level; d) resources to provide diagnostic services and technical expertise in disease control; and e) available funds or budget.

3.1.7 Thailand: Lessons learned in response to aquatic animal disease emergencies in Thailand (Dr Puttharat Baoprasertkul)

45. The rearing of freshwater and marine species are two major categories of aquaculture in Thailand. A statistical survey in 2017 by the Department of Fisheries (DoF) revealed that 509 059 farms covering an area of 880 530 rai were used for freshwater aquaculture, while the total number of farms culturing marine shrimp was 21 561, covering approximately 294 683 rai countrywide. More than 50 percent of freshwater production was tilapia, while *Penaeus vannamei* accounted for 94 percent of the shrimp cultured. The DoF is assigned to be the competent authority for aquatic animals in Thailand. Under DoF, a central division called the Aquatic Animal Health Research and Development Division (AAHRDD) together with other six divisions and one provincial office are responsible for mass mortality events (MMEs) in aquatic animals. The role of AAHRDD during MMEs includes epidemiological investigation, disease diagnosis, public awareness, movement control, treatment guidance, disease eradication, disease reporting and surveillance programme.

46. Since the first report of an emerging disease, epizootic ulcerative syndrome (EUS) occurred in Thailand, many serious diseases have subsequently appeared and contributed to significant production and economic losses in Thai aquaculture. These include yellow head disease (YHD), white spot disease (WSD), Taura syndrome (TS), koi herpes disease (KHD), white tail disease (WTD), acute hepatopancreatic necrosis disease (AHPND) and tilapia lake virus disease (TiLVD). We have gradually learned and improved our response system against aquatic animal diseases.

47. AHPND, which occurred in 2012, is selected for my current presentation. AHPND outbreak in aquaculture was first detected in 2010. Although the outbreak information was globally reported, it took about four years to eventually establish a case definition and confirm the causative agent, and another year to achieve a diagnostic technique. Several response actions, such as public awareness, a war room committee and mitigation measures were implemented by DoF Thailand; however confusion about disease information reduced the effectiveness of efforts to control infections.

48. DoF has learned some lessons from the AHPND outbreak. First, when an aquatic animal disease outbreak appears, disease control cannot be accomplished by any single country, but only by the whole world through the approach “One Health, One World”. Confusion due to inappropriate information delays disease control efficacy. Collaboration among aquatic animal health agencies efficiently strengthens emergency responses against aquatic animal diseases. Finally, the responsible movement of live aquatic animals and the implementation of biosecurity practices are essential, and must be recognized as priorities for aquaculture.

49. Presently, several up-to-date laws and regulations related to disease control are in place in Thailand, and these act to improve the emergency response system. Aquatic animal health collaboration in the region is actively promoted through the Association of Southeast Asian Nations (ASEAN) Network on Aquatic Animal Health Centres (ANAAHC). Disease diagnosis is also developed to ensure emergency preparedness in Thailand. To fight against emerging diseases, communication and collaboration, capacity building for aquatic animal health personnel, rapid and accurate disease detection, appropriate legislation, and the allocation of emergency budget are key requirements for emergency preparedness response in aquaculture.

3.1.8 United States of America: Aquatic animal disease emergencies - lessons learned (Dr Kathleen Hartman)

50. In 2019, the United States of America had its first detection of tilapia lake virus (TiLV), which was linked to imported tilapia fingerlings. The fingerlings were brought into the United States of America for further grow-out, export and domestic movement. The importer noted higher than usual morbidity and mortality rates in imported fish and submitted live animals for diagnostic evaluation. Before the detection of TiLV was confirmed by the United States Department of Agriculture (USDA), the competent authority, fingerlings had already been moved to other farms. Upon confirmation, the USDA coordinated with state and industry for local response efforts including epidemiological investigation, additional sample collection, and facility cleaning and disinfection. Epidemiological investigation revealed positive traces to two additional facilities in the United States of America. The complete investigation and release of all facilities from state-mandated quarantine or hold-orders took approximately six months and cost USDA about USD 100 000 in emergency response funding. This money funded laboratory testing and field activities, such as travel and time for collection of samples, epidemiological questionnaire completion and cleaning and disinfection. Challenges to this response were the disparate authorities for aquaculture at the local level, under-trained field personnel, lack of standards for response to an emerging pathogen, and length of time for pathogen confirmation and a national-level response. Recommended elements of an effective emergency response infrastructure include: abilities for early disease detection by ensuring laboratory capability and high through-put,

validated diagnostic assays, existing surveillance strategies that are robust and powerful enough for pathogen detection, and also, the experience and competency to accurately interpret test results. Further, there must be clearly defined authority to respond at both the local and national levels to contain, eradicate and ultimately prevent additional pathogen introduction, as well as, to support the recovery of the farm, region and country. Most importantly, the success of any emergency disease response depends on the communication and cooperation of all parties involved. Trust, competency and preparedness must be established in peacetime such that these remain resilient when emergencies occur.

3.1.9 Viet Nam: Response actions to aquatic animal disease emergencies: Early Mortality Syndrome (EMS) in Viet Nam (Dr Phan Thi Van)

51. By the end of 2010, farmers in the Mekong Delta culturing giant tiger prawn (*Penaeus monodon*) and whiteleg shrimp (*P. vannamei*) experienced a mass mortality event (MME) which was not similar to any previous shrimp disease outbreak in Viet Nam. It was later officially reported in Soctrang Province in April 2011. Affected shrimp showed discoloured hepatopancreas which were either shrunken or swollen. It was subsequently called early mortality syndrome (EMS) and then AHPND. At that time, the total infected area, based on the clinical signs shown by shrimp samples, was forty-six thousand ninety-three ha (forty-five point seven percent) of the total shrimp culture area.

52. Recognizing the severity of EMS, the Ministry of Agriculture and Rural Development (MARD) gave full support to the study of the causative agent and the development of prevention strategies to mitigate the disease. A National Task Force for Shrimp Disease was then established with the mandate to identify the causative agent and minimize the problem caused by EMS. Because the cause of the EMS was, at that time, not known (whether pathogen or environment), the approach applied in this massive study included screening for all possible causes, including possible pathogen and environmental factors as well as careful observation at any farms inside the EMS zone that were not affected, to initiate prevention ideas.

53. Led by MARD, the following actions were taken in order to respond to EMS: a) establishing the National Task Force for shrimp disease; b) performing an intensive epidemiological survey; c) carrying out screening for shrimp pathogens to narrow down the suspected causative agents of EMS; d) carrying out diagnostic investigations on both pathogen and environmental factors; e) distributing water disinfectants to EMS-affected provinces; f) providing funds for emergency research to be done by national institutions and universities; and i) seeking assistance from regional and international organizations.

54. Viet Nam sent a request for technical assistance to the Food and Agriculture Organization of the United Nations (FAO), and as soon as we sent the request, a Rapid Deployment Team fielded by FAO visited the Mekong Delta provinces in July 2011 to conduct a quick assessment of the then unknown disease. Viet Nam then received support from FAO through project TCP/VIE/3304(E) "Emergency assistance to control the spread of an unknown disease affecting shrimps".

55. The definition of AHPND was developed, and then its causative agent was found, and at the same time different preventive measurements were developed and evaluated. The shrimp industry has now recovered from the problem and remains as one of the important contributors to the Vietnamese economy. Nowadays, research on more effective prevention approaches and measures is still funded by the Government of Viet Nam in order to minimize the risk of AHPND.

56. Fast communication, fast responses, working together and working hard are the keys to success in controlling the EMS situation in Viet Nam. To deal with future MMEs, five minimum emergency preparedness response requirements should to be in place: timely information on any

potential MME, smooth communication, consolidated working platform, adequate capacity (human and funding) and international support.

3.1.10 Zambia: Moving forward through lessons learned on response actions to aquatic animal disease emergencies in Zambia (Dr Bernard Mundenda Hang'ombe)

57. Aquaculture is one of the fastest-growing agri-industries in Zambia. The traditional source of fish products has been the natural water systems such as rivers, lakes and swamps. However, the commercial farmed fish subsector has rapidly expanded in the recent past, causing Zambia to become the sixth-largest producer of farmed fish in Africa and the biggest producer of tilapia in the Southern African Development Community (SADC). This growth has easily been possible because Zambia is home to some of the major waterbodies of Southern Africa. Efforts by policy-makers to support aquaculture development arise from the need to keep pace with population growth and demand for fish and consequently raise the per capita fish consumption in the country. With the growth of the aquaculture industry, there is the potential for disease emergencies through a number of factors that may include the introduction of diseases through importation of broodstock and other associated activities meant to improve the industry.

58. Zambia has reported some significant diseases that have led to mass mortality events (MMEs) of fish. The first event was documented in the capture fisheries in 2007, where massive fish mortalities were being recorded in the western part of Zambia along the Zambezi River. This was due to epizootic ulcerative syndrome (EUS). The disease has now spread throughout the country, causing massive losses in the new waterbodies where it is being documented. In the aquaculture industry, massive mortalities have been documented in some fish farms where streptococcosis/lactococcosis has been diagnosed. These mortalities are usually observed in fish above 150 g.

59. These events, especially the mortalities in capture fisheries, necessitated the government to come up with legislation that included provisions for the control of fish diseases. New laws were formulated on the movement of fish and the importation of fish products. The disease status of fish was recognized and enshrined in the law. As for the aquaculture industry, a lot still needs to be done, as the commercial players wield a lot of influence on how the industry should be regulated. As such, commercial interest supersedes the reality of disease on the farms. The fish farms that have reported MMEs have called upon the University of Zambia, School of Veterinary Medicine for assistance. This has resulted in the introduction of biosecurity measures and systems aimed at minimizing diseases and losses on those particular farms. Some of these farms have gone further and put up basic laboratories for fish disease diagnosis. Despite having such measures in place, capacity to run these facilities is lacking. Hence, the need for more action on aquatic disease preparedness. In general, the significant requirements for emergency disease preparedness may include: improved diagnostic capacity through the supply of required reagents, preparation of annual budgets for aquatic health implementation (funds should be readily available), materials and resources for fish disease surveillance and monitoring to be made available, development of legislation that allows extension staff to collect and ship fish samples for disease diagnosis (quarantine regulations, reaction time guide and formulation of sampling guidelines), and establishment of communication systems from the fishing zones or aquaculture establishments.

3.2 Intergovernmental Organizations: Role and activities/experiences related to investigating specific mass mortalities of aquatic animals

3.2.1 Network of Aquaculture Centres in Asia-Pacific: Response actions to aquatic animal diseases in Asia-Pacific (Dr Huang Jie)

60. The role of the Network of Aquaculture Centres in Asia-Pacific (NACA) in dealing with mass mortality events (MMEs) includes the following: (i) maintaining a close relationship on aquatic animal health with FAO, OIE and NACA member governments; (ii) establishing regional aquatic animal health forces, including the Advisory Group for Aquatic Animal Health; (iii) building regional capacity through activities such as the Australia/NACA regional proficiency testing programmes, via regional training courses and by designating Regional Reference Laboratories (RRL), Regional Resource Centres (RRC) and Regional Resource Experts (RRE); (iv) networking of regional aquatic animal health resources (e.g. developing regional subnetworks for specific subjects); (v) locating resources for response to aquatic animal disease emergencies; (vi) providing early warning for disease emergencies through through the NACA Website and newsletter; (vi) maintaining a regional reporting system through the regional aquatic animal disease list, which is updated annually; (vii) publishing the Quarterly Aquatic Animal Disease (QAAD) Report, regional technical guidance, Disease Cards for emerging diseases, and a regional FAO/NACA diagnostic manual; (xiii) sharing information on emerging diseases and information on diagnostic tests and prevention via the NACA Website; (ix) coordinating projects for aquatic MMEs such as the FAO/NACA/Indonesia Project on emergency response for KHV (TCP/INS/2905) (2002); and the ASEAN/SEAFDEC/DOF/ NACA/ANAAHC/JAIF: Aquatic Emergency Preparedness and Response Systems for Effective Management of Transboundary Disease Outbreaks in Southeast Asia; and (x) organizing regional consultations and workshops such as the Australia/NACA regional consultation workshop for AHPND (2013) and the NACA/China regional consultation workshop and training courses for tilapia lake virus (TiLV).

61. Examples of response actions to MMEs in Asia include the outbreaks of whitespot disease (WSD) in China and acute hepatopancreatic necrosis disease (AHPND) and decapod iridescent virus 1 (DIV1) in Asia.

62. Lessons learn by NACA and improvements needed include that a rapid response approach to MMEs should be established in aquatic animal health services. A coordinator (Disease Control Centre for Aquatic Animals) can enhance linkages among the competent authority, experts, veterinarians and farmers in response to an MME. Encouragement and support should be given to key contributors, who can immediately report MMEs, rapidly respond to the report, provide early identification of the causative agent, and recommend effective response measures. Decision-makers should respect the expertise that can identify the causative agent and provide support for practical actions. A hidden truth is often revealed by the discerning few: identification of the causative agent cannot be based on votes but only on scientific evidence. Decisions for response actions can be improved. Actions should be considered to reduce or eliminate the risk of disease spread. Preparedness scenarios for response actions can be developed under different biosecurity levels. Farmers' rights and benefits need to be taken into account. Recyclable and eco-friendly treatment of diseased aquatic animals can be improved.

63. There are five response requirements needed for a minimum level of emergency preparedness: (i) a responsible and ascendable decision-maker; (ii) a rapid response approach in aquatic animal health services, with a central coordinator (a Disease Control Centre for Aquatic Animals); (iii) a competent expertise resource or a network which can provide this resource; (iv) an encouraging policy for the key contributors responding to an MME; and (v) a set of preparedness guidelines for emergency response scenarios under different biosecurity risks.

3.2.2 World Organisation for Animal Health: The OIE's role and activities on aquatic animal health emergencies (Dr Stian Johnsen)

64. The World Organisation for Animal Health (OIE) is an intergovernmental organization responsible for improving animal health worldwide. The OIE is headquartered in Paris and currently has 182 member countries, 12 Regional and Subregional Representations, 301 Reference Centres and 72 Partner Organizations.

65. The OIE works with countries to tackle infectious disease emergencies. However, in the context of disease emergency response, the OIE does not focus on just MMEs but has a wider mandate. The OIE's 6th Strategic Plan (2016–2020) has three pillars, emphasizing transparency, risk management and veterinary services. OIE standards are adopted every year in May during the General Session.

66. The OIE "Toolbox" for member countries includes four components: (i) Prepare (operational readiness, which is costly but useful); (ii) Prevent (risk reduction, which is the key is to minimizing consequences); (iii) Detect (effective surveillance and transparency); and (iv) Respond (integrated response, the focus of this meeting).

67. The OIE works mainly with the national veterinary services. Through the Performance of Veterinary Services (PVS) pathway, the OIE sends teams out to assess national capacity and expertise. Many PVS have been done for the terrestrial animal sector, but only 13 for the aquatic sector. OIE is currently finalizing the second edition of the PVS.

68. The OIE sets international standards that are based on transparency. Disease reporting is mandatory, but is not great for aquatic diseases. This may be due to the fact that very often when a country notifies OIE about a disease presence, trade is affected. However, if countries want to do something about controlling disease spread, then reporting is vital.

69. A recent aquatics meeting has resulted in a shift in the OIE Aquatic Animal Health Strategy, which will be launched at the 88th General Session in May 2020. A key is element is stakeholder engagement. Producers large and small have short memories and think day to day. Thus it is necessary to explain why they need to invest in the future.

70. The Aquatic Animal Commission is developing a chapter on Biosecurity for Aquaculture Establishments in line with the PMP/AB that will be included in the next Aquatic Code. Work has also started on chapters on emerging disease preparedness and disease outbreak management. These were discussed for the first time in February and are currently being drafted.

71. The OIE assists member countries with the preparation of regional and country contingency plans; however, to date not many plans for aquatic disease emergencies have been developed. Many plans are disease specific; however, we need to be more open. There are more aquatic than terrestrial animal species, and lots of trade. For aquatics, you have to be prepared for unknown diseases while also being prepared for known enzootic diseases. OIE has a platform for sharing national contingency plans, but this is mainly terrestrial at present and needs to be expanded.

72. Collaboration is the key to improving global aquatic animal health. Collaboration and actions that yield common benefit need to be cultivated. Implementation of standards should be emphasized and investment in strengthening of aquatic animal health services increased. Important standards need to continue to be developed and refined (biosecurity, response, declaration of freedom) and new threats identified. The sharing of information on emerging diseases should be encouraged. There is a need to improve OIE-FAO coordination and cooperation. The agencies need to sit down and make long-term plans together, figure out how to best spend and allocate resources, and how to make use of these reference centers, as we both deal with biosecurity, emergency response, etc.

3.2.3 Food and Agriculture Organization of the United Nations: Emergency management centre for animal health (Dr Etienne Bonbon)

73. The Emergency Management Centre for Animal Health (EMC-AH) is a bridge between the technical and operational branches and works hand in hand with the Emergency Centre for Transboundary Diseases (ECTAD). This structure helps us look at animal health as not just diseases but at the problems on a more global scale.

74. The EMC-AH's Strategic Action Plan 2018–2022 defines the centre's Vision as "A world prepared to manage high impact animal health emergencies" and its Purpose as "To enhance country, regional and international capacity to be better prepared to respond to animal health emergencies."

75. The programme's four pillars are: (i) Preparedness (Support countries to enhance their readiness for the management of animal health emergencies); (ii) Response (Support countries at risk or affected to respond to animal health emergencies; (iii) Incident Coordination (Develop leadership and expertise and support national, regional and international coordination of animal health events); and (iv) Collaboration and Resource Mobilization (Develop strong collaborative networks and resource availability for a timely and effective management of animal health emergencies).

76. To address Preparedness, FAO's Good Emergency Management Practices (GEMP) provide guidelines (within the international legal framework), from the more general to the more specific, to organize and strengthen countries' ability and capacity to manage animal health emergencies. GEMP provides best management practices to address all animal health emergencies along the phases of the event: peacetime, alert, emergency and reconstruction. Emergency preparedness is an ongoing self-improving process whose emergency management actions aim at good preparedness, prevention, detection, response and recovery. The actions of Prepare, Prevent, Detect, Respond and Recover are timed to be implemented along the curve of a point-source epidemic. Since 2011, 41 GEMP Essentials Workshops have been offered to over 1 000 participants from 130 countries.

3.2.4 Food and Agriculture Organization of the United Nations: FIAA technical assistance to FAO member states re: response actions to aquatic disease emergencies (Dr Melba Reantaso)

77. The Food and Agriculture Organization of the United Nations (FAO) is a specialized agency that leads international efforts to defeat hunger. Our goal is to achieve food security for all and make sure that people have regular access to enough high-quality food to lead active, healthy lives. With over 194 member states, FAO works in over 130 countries worldwide.

78. FAO's Aquaculture Branch (FIAA) is one of six branches within the Department of Fisheries and Aquaculture. FIAA currently has a staff of 11, with one expert specialized in aquaculture biosecurity. FIAA's activities include providing technical assistance and capacity building, developing projects (via Technical Cooperation Programme (TCP) projects and extrabudgetary funds), and developing technical guidelines within the framework of the FAO Code of Conduct for Responsible Fisheries (CCRF). We are in process of developing an aquaculture biosecurity partnership programme.

79. Examples of past and recent MME disease emergencies that have been addressed through FAO assistance include: koi herpesvirus (KHV) in Indonesia, epizootic ulcerative syndrome (EUS)

in Botswana, acute hepatopancreatic necrosis disease (AHPND) in Viet Nam and in Ecuador, and tilapia lake virus (TiLV) in Angola.

80. In providing emergency assistance, FAO has learned a number of lessons. While task forces have made a difference in identifying the causative agents of MMEs, these are an ad-hoc action; a more institutionalized mechanism is needed. Local task forces are very important; thus skills and knowledge need to be passed on to locals who are in the frontline of any disease emergency. Detailed documentation and post-mortem evaluation after an outbreak are essential. Contingency plans and risk profiles for major aquaculture species are important. Enhancing awareness of emerging epizootics and improving diagnostic capacities both at the national and regional levels is needed. Proactive disease reporting is a mechanism for early warning. Emergency preparedness with advance financial planning is a core function of national authorities. Farmers should be empowered to manage disease and other risks. It is important to bring together government, producers and academe to look at the disease event from their respective lens. A strong national commitment and regional and international cooperation are essential. During an MME, a communication strategy is needed that does not create public panic. The stigma of reporting needs to be broken, and methods to deal with illegal trade need to be improved. Efforts of donors need to be sustained for longer periods.

81. FAO has a number of mechanisms in place to deal with aquatic animal disease emergencies. These include emergency TCP projects, disease forecasting, Crisis Management Centers, early warning bulletins and the FAO Global Information and Early Warning System (GIEWS) Special Alerts.

3.3 University, government laboratory and private-sector presentations

3.3.1 Centre for Environment, Fisheries and Aquaculture Science (Cefas): Preparing for, investigating and controlling aquatic animal disease emergencies. Introducing the OIE collaborating centre for emerging aquatic animal diseases (CCEAAD) (Dr David W. Verner-Jeffreys)

82. A major constraint in achieving the goal of doubling of production to meet global needs by 2050 are new and emerging aquatic animal diseases (EAAD) in aquaculture sectors globally. It is critical to achieve rapid detection and characterization of the causative agent(s), understand their epidemiology, and to disseminate the information efficiently to raise awareness and support efforts to develop diagnostic tests which are critical for disease control and ultimately listing, as appropriate. The Centre for Environment, Fisheries and Aquaculture (Cefas) Weymouth Laboratory has a long history and expertise in pathogen systematics, disease diagnosis and surveillance in aquatic animals and has strong relations with other expert centers and has developed a strong international reputation, linking an integrated scientific approach to disease investigation and management with both regulatory functions and research present in one location. New molecular and bioinformatic approaches, able to discern pathogen diversity in the environment and hosts, have also been developed.

93. At a national level, Cefas hosts the Fish Health Inspectorate (FHI) for England and Wales. The FHI is responsible for preventing the introduction and spread of serious diseases in fish, shellfish and Crustacea by: managing programmes that monitor the health of fish, shellfish and Crustacea; taking steps to treat and reduce the spread of diseases; assessing the outbreak, spread and impact of diseases; investigating unexplained deaths in fish and shellfish; and advising on ways to reduce the risk of spreading infectious diseases. Recognizing the increasing importance of emerging diseases in aquatic systems (particularly aquaculture) internationally, Cefas has been designated by the World Organisation for Animal Health (OIE) as the Collaborating Centre for Emerging Aquatic Animal

Diseases (CCEAAD). This expands on Cefas's previous designation as the OIE Collaborating Centre for "Information on Aquatic Animal Disease".

94. The CCEAAD consists of Cefas as the lead laboratory with "Associate Laboratories" (ALs) in key aquaculture producing regions around the world. It is planned that ALs use their expertise to identify potential emerging disease issues (both listed and especially those which may have "new" aetiologies) and alert Cefas to facilitate rapid diagnosis and characterization of possible agents.

95. A network of laboratories in major and developing aquaculture regions across the globe is envisaged, with the objective to harmonize and exchange information and expertise to improve emerging disease surveillance globally and to ensure international solidarity through the ability to offer expertise to some of the poorest countries where aquaculture provides a critical food source threatened by disease occurrence. Other activities will include promotion of veterinary services through provision of training courses and workshops, achieving reduction in the transmission of diseases through risk management based on prompt scientific investigations, and enhancing the capacity and sustainability of national veterinary services to tackle emerging diseases in aquatic animals. Since its formation in 2019, the CCEAAD is already engaged assisting the authorities in Ghana with outbreaks of infectious spleen and kidney necrosis virus (ISKNV) in tilapia farms on Lake Volta and characterizing a novel virus implicated in *Macrobranchium rosenbergii* hatchery mortalities in Bangladesh.

3.3.2 Istituto Zooprofilattico Sperimentale delle Venezie: Round-table on response actions to AAD emergencies (Drs Anna Toffan and Amedeo Manfri)

96. The Istituto Zooprofilattico Sperimentale delle Venezie (IZSVe) is a public veterinary institute and it is part of the Istituti Zooprofilattici Sperimentali (II.ZZ.SS.) network in Italy. IZSVe is located in Padova, in the northeast of Italy and hosts numerous national and international centers and in particular, the National Reference Centre for Fish, Mollusc and Crustacean Diseases and the OIE Reference Laboratory for Viral Encephalo-Retinopathy.

97. At a national level, II.ZZ.SS. are the public authorities deputed by the Ministry of Health to conduct prevention and control in the fields of animal health and food safety. IZSVE, as the reference laboratory for fish, molluscan and crustacean diseases, has been frequently involved in the identification of the causative agent of aquatic animal disease mortality events.

98. Data analysis of IZSVE past activities on aquatic animal mass mortality events (MMEs) showed that in Italy these kinds of events are frequent but, in general, low in scale and with no seasonality. In many cases, it was not possible to identify the causal agent of the mortality clearly, especially when wild aquatic animals were involved. Analysis of the causes revealed that late or improper sampling as well as lack of anamnestic information were the most common problems. Many different stakeholders are involved in detection of mortality events, and collaboration among different institutions was necessary but not always efficient.

99. In 2018, Iraqi authorities contacted our institute through the FAO to perform diagnosis on a huge MME in common carp along the Tigris and Euphrates rivers. This led to the first reports of koi herpesvirus (KHV) and carp edema virus (CEV) in the country (Toffan, *et al.,* 2019).

100. Among the minimum emergency preparedness response requirements that need to be in place, we suggest:

- Coordination between different entities. Coordination at the central level is advisable (especially in cases involving wild fish).

- Identification at the national level of a coordination/reference center on MMEs.
- Peculiarities of aquatic animals make diagnosis of their diseases more difficult than those of terrestrial animals (i.e. specific media for growing bacteria, specific temperatures, many uncultivable pathogens, emergence of new pathogens).
- Standard sampling protocols.
- Training of local veterinary services in identifying as soon as possible whether the MME is clearly pathogen related or environmentally related.
- Emergency funds must be available.

Reference

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3.3.3 Response actions to aquatic animal disease emergencies: Wageningen Bioveterinary Research, the Netherlands (Dr Olga Haenen)

101. Wageningen Bioveterinary Research (WBVR) (https://www.wur.nl/en/Research-Results/Research-Institutes/Bioveterinary-Research.htm) is the official, independent Dutch Government Veterinary Institute of the Ministry of Agriculture, Nature and Food Quality. For the government, research activities consist, among others, of statutory tasks related to animal health. The Ministry, Directorates, and the chief veterinary officer (CVO) set the tasks of Nederlandse Voedsel - en Warenautoriteit (NVWA), the official veterinary service (which does the field work, like registration of farms, notification of disease outbreaks, sampling and transport of samples to WBVR, and interventions). Mostly farms have a veterinarian. The National Reference Laboratory for Fish, Shellfish, and Crustacean Diseases of WBVR is (according to 2006/88/EC) in charge of aquatic diagnostics, disease notification, confirmation testing, research, and advice. In case of aquatic mass mortalities, the standard NVWA procedure applies: NVWA and the Ministry are informed, NVWA takes samples, brings them to WBVR, the fish farm is closed temporarily by NVWA, and waits a diagnosis. WBVR tests the fish by fast, validated tests and informs NVWA and the Ministry on findings. In the case of a notifiable disease, the CVO notifies the European Union and the OIE. Netherlands has no active surveillance for fish diseases, and no infectious hematopoietic necrosis virus (IHNV)- or viral hemorrhagic septicemia virus (VHSV)-free farms. All farms now have status “unknown” (Cat. III in 2006/88/EC).

102. Example 1: Infectious hematopoietic necrosis (IHN**)** is an European Union??- and OIE-notifiable disease of salmonid fish caused by IHN virus (IHNV), present in Western Europe since 1987. In the spring of 2008, IHNV was detected for the first time in the Netherlands in rainbow trout, *Oncorhynchus mykiss*, and another seven times, up to 2011. In 2016, a single new IHN case was reported. The Dutch trout branch is small, mainly put-and-take fisheries, stocked with imported ready-to-catch trout. The epidemiology and phylogeny of IHNV outbreaks in the Netherlands from 2008 to 2011 were analyzed. IHNV was most likely introduced from Germany, but phylogenetic results suggested earlier introduction than in 2008.

103. *Example 2: CyHV-2 in imported goldfish.* In global fish trade, yearly, > 1 billion ornamental fish is transported, with >3 000 deliveries of tropical ornamental fish into the Netherlands as an important import- and transfer port, from >40 countries worldwide, 50 percent from Southeast Asia. The NVWA sent 50 batches of imported freshwater ornamental fish (36 species/genera from 13 countries), mainly from Asia and South America, directly from Schiphol Airport to WBVR, for analysis. Among several other tests, goldfish were tested for cyprinid herpesvirus 2 (CyHV-2). At the

National Research Institute of Aquaculture (NRIA), Japan, in a collaborative study, 1/8 goldfish samples was found positive for CyHV-2. This isolate appeared highly virulent to the Ryukin goldfish (Ito, Kurita and Haenen, 2017). Moreover, CyHV-2 outbreaks occurred in mass mortalities in wild gibel carp (*Carassius gibelio*) in the Netherlands (an invasive fish species), but also in 2017 inf China in gibel carp as food fish (Lingbing Zeng via N.J. Olesen, pers.comm.). This non-notifiable viral disease may be devastating.

104. *Lessons learnt and improvements:* As diseases like IHN can be spread across borders, epidemiologists in Europe should actively cooperate to understand and prevent the spread of IHNV. Moreover, accurate notification is possible by fish farmers seeking financial compensation. Regarding CyHV-2, we should all be aware of the risk of disease via imports of (ornamental) fish and its subsequent transfer to wild fish, as seen in this case involving gibel carp populations. All involved persons, including fish importers should be aware of this, and appropriate prevention, hygiene, and waste-water treatment should be in place.

Reference

Ito,T., J. Kurita & O.L.M. Haenen. 2017. Importation of CyHV-2 infected goldfish into the Netherlands. *Dis. Aquat. Org.,* 126: 51–62. (available at\: https://doi.org/10.3354/dao03157).

3.3.4 MSD: Ghana tilapia ISKNV case study (Lee Yeng Sheng and Collard Arnaud)

105. MSD Animal Health is a commercial entity with interest in aquatic preventative solutions against diseases. In event of outbreaks, we provide technical support to help partners mitigate losses and aid in their operational recovery.

106. *Infectious Spleen and Kidney Necrosis Virus (ISKNV): Ghana 2018.* ISKNV has been known within MSD to be present in tilapia exclusively in Indonesia over the last 12 years. Due to this specificity, we only apply ISKNV test on samples originating from Indonesia. Samples collected from Ghana in September 2018 were only tested against tilapia lake virus (TiLV) and streptococcosis. The results showed only < 20 percent positive for TiLV, which did not match the outbreak impact observed. A second phase of investigation was performed in Q4 2018, when up to 90 percent mortalities and positive ISKNV tests from other laboratories were reported.

107. New samples were collected and tested to verify ISKNV’s presence. Results were: Positive > 70 percent ISKNV, Positive >85 percent *Streptococcus agalactiae* serotype Ib (co-infections), and Negative for TiLV.

108. *ISKNV risk mitigation strategy.* MSD provided a risk mitigating strategy based on internal technical knowledge of iridovirus pathogenicity, coupled with heat intervention process adapted from barramundi farming (acknowledgements to Alain Michel and Allegro-Aqua’s Jeffrey Teo).

- Volta Lake at high ISKNV levels: Sanitize water in ponds/tanks to reduce ISKNV load in hatchery culture. Hold juveniles to larger sizes (>10 g) on land before transfer into lake.

- ISKNV pathogenesis: Perform heat intervention above 36 °C, heating every 4 to 7 days to break viral incubation cycle. Elevated water temperature accelerates fish metabolism; enhance innate immunity to overcome early infections.

- Improve juvenile survivability in hatchery/nursery phase: Implement weekly cyclical heat intervention process to juveniles as part of routine operations. Heat every 4 to 7 days to disrupt viral infection/incubation to suppress mortalities.

- Vaccination against ISKNV: Deliver vaccine to populations 10 g and above. MSD's ISKNV vaccine can be combined with MSD's *Streptococcus* vaccine for delivery in a single shot.

- Long-term environmental and farm sustainability: Implement heating and vaccination programmes. Proper disposal of sick/dead fish. Collective measures adopted by all tilapia producers in a lake or management area will ensure environmental reduction of ISKNV pressure over time.

109. The strategic actions in place in Ghana and their applicability are:
- Water sanitization in hatchery to reduce viral pressure (limited application, cost factors; limited practice in early hatchery phase).
- Heat intervention widely adopted.
- Different protocols among farms, variable results:
  - Improvements up to 60 percent survival at 5 g reported.
  - Hold fry to larger size on land before stocking into lake (Not adopted; capacity limitations.)
  - Many perform heating on lake using specific processes.
  - Vaccination against ISKNV (Not adopted; cost factors).
- First trials planned to evaluate return on investment (ROI) and commercial benefit.

110. Key learnings from MSD:
- Diseases do not follow rules and geographical boundaries; learning point in excluding pathogens for testing such as ISKNV.
- Diagnosis: We need to maintain global surveillance of diseases and expand diagnostic access to farms as an early warning system. Such resources are limited and this requires global partnerships at the country, institutional and commercial levels. MSD can contribute as a resource center to support aquaculture sustainability.
- Emergency preparedness response requirements:
  - Timely access to fish health technical services in-country.
  - Identification of farm biosecurity gaps and improvements.
  - Understand disease pathogenicity and characteristics.
  - Routine farm or area disease surveillance.
  - Seek help with open mind without resistance to change.

3.3.5 Mississippi State University: Visceral toxicosis of catfish (Patricia S. Gaunt)

111. Visceral toxicosis of catfish (VTC) was only formally recognized as a syndrome in market and brooder-size catfish raised in earthen ponds in 1999. Farmers described the sudden death of larger catfish (market and brooder-size) when pond-water surface temperatures were between 18–22 ºC. Often entire ponds of market-ready fish were lost during epizootics, which created huge economic losses for farmers. Post-mortem lesions in affected fish include ascites (fluid in coelomic cavity), intussusceptions of intestinal tract, splenic congestion, and eversion of the stomach into the oral cavity. The term "visceral toxicosis" was coined because the characteristic clinical signs, such as abnormal swimming and schooling behaviour, were attributed to a neurotoxin. As part of the diagnostic work-up of these fish, bacterial and viral cultures from VTC-affected catfish submitted to the Mississippi State University College of Veterinary Medicine Aquatic Diagnostic Laboratory

(MSU-CVM ADL) at Stoneville, Mississippi were consistently negative. The characteristic clinical signs and lesions of VTC could be reproduced when serum from an affected fish was injected into a healthy catfish. When the serum was heated to 85 °C for 5 minutes prior to injection, clinical disease did not appear in the sentinel fish. The algal toxins anatoxin and microcystin were initially suspected as a cause of VTC, but high performance liquid chromatography (HPLC) assays for these toxins were negative in affected fish. Because of the multiple neurologic signs associated with VTC, we then investigated botulinum toxin.

112. Two mouse bioassays and a commercial enzyme-linked immunosorbent assay (ELISA) for detection of botulinum neurotoxin E (BoNT/E) in affected catfish sera were negative. Anaerobic cultures of intestinal contents for *Clostridium botulinum* were negative in VTC cases. Polymerase chain reaction (PCR) assays for the botulinum E toxin gene were negative in liver, intestinal contents, kidneys and spleen of affected fish. However, botulinum can be difficult to detect because some animals are extremely sensitive to the effects of toxin, and the conventional mouse bioassay may lack the sensitivity for its detection.

113. We designed a catfish serum neutralization assay based on the mouse bioassay system to detect BoNT in catfish. Sera from VTC-affected catfish were incubated with botulinum antitoxins and injected into sentinel fish to assess toxin neutralization. Sera were considered neutralized by a monospecific antitoxin if no signs or mortality were noted. Using this assay we demonstrated the presence of either BoNT/E and/or F in VTC-affected catfish. This was the first report indicating that catfish are more sensitive than mice for the detection of botulinum. The results of this catfish bioassay were confirmed by the endopep mass spectrometry assay at the Centers for Disease Control and Prevention (CDC) in Atlanta, Georgia, which positively identified BoNT/E (and not BoNT/F) in catfish sera.

114. The botulinum toxin molecule is composed of a heavy chain and a light chain linked with a disulfide bond. When the toxin is ingested, the heavy chain binds to proteins on the presynaptic vesicle and BoNT enters the neuron by endocytosis. The light chain has endopeptidase activity and cleaves BoNT-serotype specific proteins associated with docking and release of the acetylcholine vesicles. The end result of the endopeptidase action of BoNT is disruption of acetylcholine vesicle release at the neuromuscular junction, which results in flaccid paralysis. This is manifested in affected catfish as erratic swimming, loss of equilibrium, loss of motion, and, terminally, open mouths.

115. Although we did not think of the grain-fed catfish as carnivorous, one apparent method by which fish contract botulism is cannibalism of dead fish containing lethal concentrations of BoNT produced by germinating clostridia. Larger, more dominant catfish appear to be at risk for VTC, presumably because they are at the top of the feeding chain. Fish at risk forage on dead fish at cooler temperatures when food is less available in ponds.

116. The economic impact of botulism in aquaculture is well documented in salmonids ("bankruptcy disease"), and the significance of VTC as a disease of farm-raised catfish is revealed in several surveys. In a National Animal Health Monitoring Survey published in 2003, the United States Department of Agriculture (USDA) found that 14 percent of market-sized catfish operations (> 150 surface acres) experienced VTC outbreaks during the previous year. In that survey, VTC was ranked as the 6th most commonly occurring disease in market-sized fish operations. During previous years at MSU-CVM ADL, 1 to 5 percent of the annual diagnostic case accessions of catfish were confirmed as VTC cases (and many others were suspect cases). Ganesh Kumar, MSU (personal communication) estimated the cost to industry at USD 3.4 million annually.

117. In Europe, treatment for the fish botulinum consisted of draining ponds and liming to a pH of 11, which would kill the spores. This is cost prohibitive for 10 acre catfish ponds. The initial management approach that farmers took was to not overwinter large fish. If fish were on-flavour, they were sent for processing. Those that were not on-flavour remained in ponds and were fed at least 1 to 2 times a week during cool weather. Another initial management strategy involved the use of less temperature-sensitive live bait fish fed to brooder-sized fish. Instead of tilapia, which became weakened at 17 ºC and died at lower temperatures, farmers fed more hardy bait fish such as gizzard shad that could withstand cooler temperatures.

118. Beginning in 2006, new technologies were implemented in the catfish industry which indirectly impacted a sharp decline in VTC cases. The production of hybrid catfish which were a cross between female channel catfish (*Ictalurus punctatus*) and male blue catfish (*Ictalurus furcatus*) became very popular, in part, because they were found to grow faster (market size in 18 months) than traditional channel catfish (market size in 24 months). Because these fish spent less time in the pond being vulnerable to diseases than the channels, they were less likely to die and become contaminated with BoNT. The second technology involved a vaccine for the bacterial disease enteric septicemia of catfish (ESC). Because of the high efficacy of this vaccine, this reduced mortality of fish, leaving fewer carcasses in catfish ponds. Another technology in the catfish industry was the split pond system that allowed intensive rearing of catfish in 20 percent of the space of a typical catfish pond. Two of the acres of a traditional catfish pond were used for stocking and rearing the fish and the other eight acres were used for waste management and an oxygen generating system. The two areas were separated by screens to ensure fish containment in the two acres. A levy between the two areas contained two large paddlewheels which forced water from the fish rearing side to the waste side during the day. At night, intense aerators aerated the fish-rearing side, which allowed the dissolved oxygen to remain at >3 ppm. With intense aeration, there was less likelihood for an anaerobic sediment.

119. In recent years, there have only been isolated reports of VTC in the Mississippi Delta. There is not a cure or treatment for VTC, but farmers and fish health professionals can ameliorate its effects. Management of VTC outbreaks consist of removing carcasses from smaller ponds. At-risk food fish should be marketed if possible. Those remaining in ponds should be fed at least 1 to 2 times weekly. As temperatures cool, if farmers have fish showing neurologic signs, they should seek fish health professional help immediately. Fish from a VTC-affected pond can be seined and placed in spare ponds without fish. Intense aeration should be implemented in VTC-affected ponds.

3.4 Session 1 closing

120. Dr Rohana Subasinghe provided the closing remarks for Session 1. He noted that the meeting was moving further than the scope that had been set out in the morning, and that the we cannot hope to accomplish everything in three days. He emphasized that the primary topic of the meeting is mass mortalities in aquatic animals (MMEs): sudden emergencies of voluminous mortalities, and the issue is how can we develop a decision-tree that will assist the authorities to decide what to do and when to do it. He noted that tomorrow's discussions will focus on emergencies due to acute MMEs and deciding what criteria are needed for authorities to take a decision on action. He noted that there appear to be no such guidelines; however, there are many guidelines dealing with other items that the group has discussed.

121. Dr Richard Arthur then noted that the goal of tomorrow afternoon's exercise is to define a rather narrow document. There are many issues of emergencies in aquatic animal health but all of

them cannot be addressed in this document; our goal is to provide guidelines for responding to aquatic animal health MMEs and provide guidance to Competent Authorities as to when and how to proceed. The current situation is that there is continuously little or no preparation, and the cycle repeats itself: response is often slow, Competent Authorities often don't know what to do, and there are often long delays before an investigation team is in place. The guidelines should help the responsible agencies with preplanning, getting a team in place, and investigation of major MMEs so that they can respond more rapidly, have emergency funding in place, and hopefully also the necessary guidance. At present, there is only a draft table of contents that is completely open to discussion. The first thing is to discuss the definitions for MME terms and then decide on the scope for the work to be accomplished after this workshop is completed.

4. Session 2: Review of the draft decision-tree

122. In preparation for Session 2, before the meeting, the participants were provided, for their review and comment, with a draft annotated copy of the proposed table of contents (TOC) for a possible FAO guidance document on a decision-tree for dealing with aquatic animal mortality events. In plenary, the background and draft TOC were briefly presented to the group by Dr David Hurchermeyer, after which the participants were divided into two Working Groups (WGs) and each WG tasked with reviewing and modifying, as far as time allowed, the proposed TOC. The two WGs then presented their results to plenary. After the conclusion of the meeting, their suggestions were then reviewed by the FAO team and incorporated into a revised TOC, which is attached as Annex 5.

5. Session 3: Considerations for developing a framework for systematic impact assessment of aquatic animal diseases

123. To provide background for discussion, Session 3, began with a presentation given by Dr Benjamin Huntington on "Global Burden of Animal Diseases (GBAD)", a summary of which follows.

5.1 Presentation on GBAD: The Global Burden of Animal Disease (Dr Benjamin Huntington)

124. Livestock and aquaculture are critical for ensuring human health and maintaining livelihoods. Health and productivity are negatively impacted by the presence of endemic and emerging diseases, increasing the amount of resources needed to maintain these animals, which in turn increases competition for land, air and water. In response, hundreds of millions of dollars are invested globally on disease mitigation in order to improve livestock and aquatic health and productivity, yet a systematic process to determine the burden of animal disease on the health and wellbeing of people is not available. It is unknown how the burden is apportioned between smallholders and the commercial sector, by region and gender. Consequently, decision-makers lack the information to accurately assess whether their investments target the animal health issues that have the most significant impact on human wellbeing. The Global Burden of Animal Diseases (GBADs) is essential for evidence-based animal health decision-making. It will challenge the status quo whereby investments are made through: (1) cost-benefit analyses based on assumptions or weak data; (2) rules of thumb (heuristics) of whether a problem needs to be addressed; or, (3) reactions to outrage-generating crises. Current decision making based on incomplete scientific evidence has negative outcomes for producers and consumers of livestock and aquaculture products, and ultimately society as a whole. GBADs will add value, as well as inform and update heuristics that decision-makers rely upon to meet political, societal and global development demands. GBADs will build on the successful human Global Burden of Disease studies. It will create information on the economic burden of animal diseases in order to achieve evidence-based decision-making. GBADs data will be securely and

sensitively handled, and the information produced will be supported by material for data interpretation. This comprehensive approach will enable users to make judgements on their investments in terms of optimizing the economic efficiency of the livestock and aquaculture sectors and minimizing any adverse impacts on the environment and public health. The information generated will be categorized by the type of farmers affected with an emphasis on smallholders and also the gender balance of the burdens. GBADs will provide a societal mirror on the animal disease and health burden and indicate the individuals and communities which are the most impacted. It will describe the burden in economic terms and demonstrate how animal health is associated with and affects agricultural productivity, smallholder household income, the empowerment of women and the equitable provision of a safe, affordable, nutritious diet. GBADs will measure and improve societal outcomes from livestock and aquaculture and have a positive impact on the Sustainable Development Goals (SDGs) contributing to a world in which there is Zero Hunger (SDG2), Good Health and Well-being (SDG3), Gender Equality (SDG5); Decent Work and Economic Growth (SDG8); and Responsible Consumption and Production (SDG12).

6. Session 4: Identifying key elements for a project proposal to improve national response actions to aquatic animal disease emergencies

125. The key elements to be included in a project proposal to improve national response actions to aquatic animal disease emergencies should address the needs identified by the participants. The key recommendations provided by the representatives of the various countries and international organizations are listed below. The many commonalities that can be identified include: the need for improved contingency planning; capacity building (improved diagnostic capability, training of laboratory and field staff); preparation of guidance documents (e.g. SOPs, disease manuals, contingency plans); improved infrastructure (especially for disease diagnosis); legal aspects (revised or new laws and regulations to allow/improve enforcement to control disease outbreaks); improved communication, coordination and awareness (between competent authority, aquaculturists and the general public, and between agencies, both within country and internationally); improved disease reporting; increased funding for aquatic animal health activities; and designated funding for rapid emergency response.

126. *China*

1) Establish contingency plan at the national level.
2) Improve the diagnostic capability of local aquatic disease prevention and control agencies.
3) Strengthen the awareness of disease reporting at the farm level.
4) Increase government subsidies to institutions.
5) Set norms to guide the implementation of stamping out, biosafety treatment and disposal.

127. *Ghana*

1) Improve skills training in disease diagnosis and control for both field and laboratory staff.
2) Improve laboratory infrastructure in the country.
3) Provide adequate and emergency funding for fish health activities.
4) Provide legal backing for enforcement of laws and regulations related to control of disease outbreaks.
5) Institutionalize stakeholder coordination in the aquaculture industry.

128. *Indonesia*

1) Strengthen institutional capacity for emergency response.
2) Increase coordination between government and private sector.
3) Provide capacity building for field officers and fisheries counselors.

4) Prepare contingency plan documents.
5) Provide adequate budgets.
6) Improve record keeping and documentation at the farm level.

129. *Thailand*

1) Improve communication and collaboration though an active aquatic animal health network and with stakeholders.
2) Provide capacity building for aquatic animal health personnel in the region.
3) Provide rapid and accurate methods for disease detection.
4) Improve implementation and enforcement of laws and regulations.
5) Allocate a budget for emergency response.

130. *United States of America*

1) Facilitate early detection: improve laboratory capability and through-put, provide diagnostic assay Se/Sp, improve surveillance (sampling and testing), power and robustness; improve interpretation).
2) Improve authority to respond: local (premises quarantine, hold orders, depopulation, recovery) and national biosecurity (import controls), surveillance (zones, compartments), recovery).
3) Insure adequate resources to respond: funds, subject matter experts and trained personnel.
4) Improve communication: internal and external.
5) Improve cooperation: industry-state-federal partnership.

131. *Viet Nam*

1) Ensure timely information on any potential aquatic animal disease emergency.
2) Develop smooth communication.
3) Consolidate working platform.
4) Increase capacity (human and funding).
5) Seek international support.

132. *Zambia*

1) Support diagnostic capacity (availability of laboratory reagents).
2) Approve annual budgets for aquatic health implementation.
3) Increase availability of materials and resources for fish disease surveillance and monitoring.
4) Develop legislation that allows extension staff to collect and ship fish samples for disease diagnosis (quarantine regulations, reaction time guide and formulation of sampling guidelines).
5) Establish communication systems from the fishing zones or aquaculture establishments.

133. *World Organisation for Animal Health (OIE)*

1) Cultivate collaboration and actions that yield common benefit.
2) Emphasize implementation of standards.
3) Invest in strengthening of Aquatic Animal Health Services.
4) Continue to develop and refine important standards: biosecurity, response, declaration of freedom.
5) Identify new threats and encourage sharing of information on emerging diseases.

134. *MSD*

1) Facilitate timely access to fish health technical services in-country.
2) Identify farm biosecurity gaps and improvements.
3) Understand disease pathogenicity and characteristics.

4) Establish routine farm or area disease surveillance.
5) Seek help with an open mind without resistance to change.

135. Mississippi State University (MSU) (VTC specific)

1) Remove carcasses from ponds (easier in smaller ponds).
2) Monitor pond temperatures daily during late fall and early spring.
3) Increase aeration in ponds.
4) Seek fish health professional help immediately with fish showing neurologic signs.
5) Harvest of fish from VTC-affected ponds to spare ponds without fish.

136. *Wageningen Bioveterinary Research* (*WBVR)*

1) As diseases like IHN spread across borders, epidemiologists in Europe should actively cooperate to understand and prevent the spread of IHNV.
2) Promote accurate notification by fish farmers seeking financial compensation. IHNV must have been present earlier in the Netherlands, but was not notified, as farms were closed and farmers got no compensation.
3) Address the risk of aquatic animal disease being transferred from imports of (ornamental) fish to wild fish (e.g. as in the case of gibelo carp populations).
4) Ensure that all involved persons, including fish importers are aware of this, and appropriate preventive, hygienic and waste water treatment measures should be in place.

137. *Centre for Environment, Fisheries and Aquaculture Science* (*Cefas)*

1) Improve detection systems: field and laboratory (rapid/ accurate/ predictive?).
2) Ensure effective reporting systems (farm, national, international).
3) Develop rapid decision-making processes.
4) Develop control measures implementation plans.
5) Assure underpinning regulatory frameworks.
6) Ideally, response should be led at a country level by dedicated and appropriately resourced official services.

7. Summary and way forward

138. Dr Melba Reantaso presented the Conclusions and Way Forward. With regard to the stated purpose of the round-table discussion, she noted that taking stock and sharing experiences and lessons learned on response actions to aquatic animal disease emergencies had been achieved, while reviewing and making recommendations for development and improvement of the draft FAO *Decision-tree for dealing with aquatic animal mortality events* had been achieved through the WG activities.

139. Dr Reantaso then enumerated the lessons learned by the FAO Team. These included:

- While the use of an emergency Task Force by FAO made a difference in identifying the causative agent, it was an *ad-hoc* action. Thus a more institutionalized mechanism is needed.
- The involvement of a local task force is very important. Skills and knowledge need to be passed on to locals, as they are in the frontline of any disease emergency.
- Detailed documentation and a post-mortem evaluation after an outbreak is important.
- Preparation includes the development of contingency plans and risk profiling for major aquaculture species.

- Enhancing awareness of emerging epizootics and improving diagnostic capacities at both the national and regional levels is important.

140. Dr Reantaso then posed a number of difficult questions related to emergency response:
- How to break the stigma of reporting?
- How to deal with illegal trade?
- How to sustain the efforts of donors?
- How to deal with scientific publications preceding national competent authority recognition of disease event?
- How to deal with the scenario where the competent authority does not recognize a private-sector initiative to send samples for laboratory tests outside the country, just because of the fact that they are not official samples?
- How to prevent the spill over of pathogens from aquaculture to wild populations and vice-versa?

141. She then noted the products of the round-table discussion as being:
- Summaries of experiences and lessons learned on response actions to aquatic animal disease emergencies.
- Recommendations for further development of the FAO *Decision-tree for dealing with aquatic animal mortality events* and supporting guidance.
- Awareness on a framework for the systematic impact assessment of aquatic animal diseases (GBAD).
- Recommendations for the development of a project for improving national government and private-sector response actions to aquatic animal disease emergencies.
- A meeting report, including summaries of all presentations and results and recommendations arising from the Working Group activities and plenary discussions (this document).

8. Closing remarks

142. In closing the round-table meeting, Dr Melba Reantaso stated that the group had achieved the Purposes 1 and 2. For Purpose 3 related to GBADs, the group had heard about GBAD from Dr Ben Huntington; more information about this topic will be disseminated as soon as available. She noted that aquaculture health economics is one the five pillars of a planned umbrella programme on aquaculture biosecurity that was endorsed by FAO's Committee on Fisheries Sub-Committee on Aquaculture during its tenth session in August 2019.

143. Dr Reantaso expressed the deep appreciation of FAO first of all to Norad for the collaboration and support and to the experts for their many contributions to the round-table discussion, noting that many of the participants were self-funded. In this regard, she presented each of the experts with a Certificate of Appreciation, rather than a Certificate of Participation, which is typically given by FAO to meeting participants.

144. Finally, a number of the experts expressed their thanks to the FAO team for organizing the round-table discussion. They noted the importance of collaboration between international organizations, the new and interesting information presented, and the importance of countries sharing their experiences. They expressed their appreciation to Dr Melba Reantaso for the key role she has played in promoting aquatic animal heath globally.

ANNEX 1

Programme

Date	Activities
16 December, Monday	**DAY 1**
09.00–09.30	**Workshop Opening** (Moderator: Dr Melba Reantaso) ▪ Welcome remarks (Dr Arni Mathiesen, Assistant Director-General, Department of Fisheries and Aquaculture, FAO) **Self-introduction of participants**
09.30–09.50	Appointment of Chairperson and Vice-Chairperson (Dr Melba Reantaso) Background, objectives and expected outcomes of the meeting (Dr Melba Reantaso)
09.50–10.30	**Coffee break and group photo**
Session 1: Response actions to aquatic animal disease emergencies	
	National competent authority: role and experiences
10.30-10.45	China (Dr Qing Li)
10.45-11.00	Ghana (Dr Peter Ziddah)
11.00-11.15	Indonesia (Dr Dyah Setyowati)
11.15-11.30	Kingdom of Saudi Arabia (Dr Faris M. Alghamdi and Dr Victoria Alday Sanz)
11.30-11.45	Norway (Dr Edgar Brun)
11.45–12.15	Discussions
12.15–13.30	Lunch break
13.30-13.45	Philippines (Dr Joselito Somga)
13.45-14.00	Thailand (Dr Puttharat Baoprasertkul)
14.00-14.15	Viet Nam (Dr Phan Thi Van)
14.15-14.30	United States of America (Dr Kathleen Hartman)
14.30-14.45	Zambia (Dr Bernard Mudenda HangOmbe)
14.45–15.15	Discussions
15.15–15.30	Coffee break
	Intergovermental organization: role and activities/experiences related to investigating specific mass mortalities of aquatic animals
15.30–15.45	Network of Aquaculture Centres in Asia-Pacific (Dr Huang Jie)
15.45-16.00	World Organisation for Animal Health (Dr Stian Johnsen)
16.00-16.15	FAO: Emergency Management Center (Dr Etienne Bonbon)
16.15-16.30	FAO: Aquatic animal health (Dr Melba Reantaso)
16.30–17.00	Discussions
17.00–17.15	**Wrap up and Day 2 Tasks**

Date	Activities
17 December, Tuesday	**DAY 2**
Session 1: Response actions to aquatic animal disease emergencies (continued)	
	Producer and research/academic sectors: role and activities/experiences related to investigating specific mass mortalities of aquatic animals
08.30–08.45	MSD Animal Health (Belgium) (Dr Lee Yeng Shen and Dr Arnaud Collard)
08.45–09.00	Instituto Zooprofilattico Sperimenal delle Venezia (IZSV, Italy) (Dr Amedeo Manfrin)
09.00–09.15	Wageningen Bioveterinary Research (WBVR, Netherlands) (Dr Olga Haenen)
09.15–09.30	Centre for Environment, Fisheries and Aquaculture Science (United Kingdom) (Dr David Verner-Jeffreys)
09.30–09.45	Mississippi State University (MSU, United States of America) (Dr Patricia Gaunt)
09.45-10.15	Discussions
10.15–10.30	Coffee break
10.30–11.00	Discussion
11.00–12.30	**Working Group Activity** 1: Essential elements of an effective and timely response action to aquatic animal disease emergencies
12.30–13.45	Lunch break
13.45–15.00	WG presentations and discussions
15.00–15.15	Coffee break
Session 2: Review of the draft annotated contents outline FAO document on *Decision-tree for dealing with aquatic animal mortality events,* incorporating lessons learned from Day 1	
15.15–15.45	**Presentation:** Decision Tree and contents outline for the associated technical guidelines
15.45–16.45	**Working Group Activity 2:** Discussion and recommendations for development and revision
16.45–17.15	WG presentations and discussions
17.15–17.30	Wrap up and Day 3 Tasks
18 December, Wednesday	**DAY 3**
Session 3: Considerations for developing a framework for systematic impact assessment of aquatic animal diseases	
08.30–09.00	Presentation and discussions: Global Burden of Animal Diseases (GBAD) (Dr Benjamin Huntington)
09.00–10.00	**Working Group Activity 3:** Considerations for developing a framework for the systematic impact assessment of aquatic animal diseases
10.00–10.15	**Coffee Break**
10.15–12.00	**Working Group Activity 3:** continued and presentations Session 3 Summary and Recommendations
12.00–12.30	WG presentations and discussions
12.30–13.45	**Lunch Break**
Session 4: Identifying key elements for a project proposal to improve national response actions to aquatic animal disease emergencies	
13.45–15.00	Plenary discussions
15.00–15.15	Coffee break
Session 5: Moving Forward and Closing	
15.15–16.00	Presentation of Session Summaries and Conclusions
16.00–16.15	**Closing remarks**

ANNEX 2

List of participants and their profiles

#	Name	Profile
1	**Victoria ALDAY-SANZ** Director of Biosecurity and Breeding Programs National Aquaculture Company (NAQUA) Kingdom of Saudi Arabia www.naqua.com.sa	A veterinarian with an M.Sc. and Ph.D. from Stirling University, Dr Alday-Sanz has worked for over 25 years on diverse aspects of aquaculture biosecurity, covering diseases, diagnostics, sanitary legislation, health management, development of specific-pathogen-free (SPF) stocks and antimicrobial treatments. She has collaborated as an expert for International Organizations such as FAO, OIE, the European Union, the European Food Safety Authority and the World Bank, as well as with the private sector such as shrimp producers and aquaculture financial and insurance companies worldwide. She carries out research and development (R&D) activities for private companies and maintains links to the academic world through teaching at other institutions. She has published over 35 papers in peer-reviewed journals, over 50 articles in industry magazines, 5 book chapters, and is co-author of the CD-rom *Diagnosis of Shrimp Diseases* and editor of *The Shrimp Book*. Presently, she is the Director for Biosecurity and Breeding Programs for the National Aquaculture Company (NAQUA) and Director of National Aquaculture Biosecurity of Saudi Arabia.
2	**Faris Mohammad ALGHAMDI** Director General – Fisheries Health & Services Ministry of Environment, Water & Agriculture Riyadh Kingdom of Saudi Arabia www.mewa.gov.sa	Mr Alghamdi is responsible for health and safety measures for shrimp and fish production in the Kingdom of Saudi Arabia (KSA). He is leading the biosecurity programme for the aquaculture industry in the Kingdom. He is responsible for auditing of shrimp and fish farms intending to export from KSA, providing technical support regarding health certification of aquaculture products from KSA, approving health certificates according to the requirements of importing countries and the approval of foreign establishments intending to export to KSA. He is also responsible for the development and implementation of the Rapid Alert System for export consignments, managing all resources and technical staff at the National Reference Laboratory in Jeddah and Qatif Laboratory, and all matters regarding aquaculture imports/exports.

#	Name	Profile
3	**J. Richard ARTHUR** Aquatic Animal Health Consultant Box 1216 Barriere, British Columbia Canada V0E 1E0	Dr Arthur has 45 years' experience in aquatic animal health, both in Canada and internationally. He contributed to the development of aquatic animal health expertise in Asia in the 1980s as advisor to the International Development Research Centre's (Canada) Fish Health Project to the Government of the Philippines, and served as Network Coordinator for the Asian Fish Health Network. He also initiated the formation of the Fish Health Section of the Asian Fisheries Society. In 1989, he became head of aquatic parasitology at the Department of Fisheries and Oceans Canada's Maurice Lamontagne Institute and began an ongoing association as an advisor and consultant to the FAO's aquatic animal health programme. He assisted with development of the Progressive Management Pathway for Aquatic Biosecurity (PMP/AB) and participated in major FAO inter-regional projects on AHPND and IMNV. He is a member of FAO's Expert Committee on Antimicrobial Residues in Aquaculture. Dr Arthur is the author/editor of more than 100 scientific papers and edited volumes dealing with aquatic animal health and fisheries parasitology, and currently specializes in risk analysis for introductions of aquatic species for aquaculture, international aquatic animal health policy and the development of national aquatic animal health strategies.
4	**Puttharat BAOPRASERTKUL** Head of Aquatic Animal Health Certification Research and Development Group Aquatic Animal Health Research and Development Division (AAHRDD) Department of Fisheries Paholyothin Rd. Jatujak Bangkok, 10900 Thailand	Ms Baoprasertkul is a Fisheries Biologist at Senior Professional Level and Chief of the Aquatic Animal Health Certification Research and Development Group at Aquatic Animal Health Research and Development Division (AAHRDD), Department of Fisheries, Thailand. She has experience in diagnostic tests for aquatic animals, disease surveillance to certify aquaculture establishments and compartments for exportation, requirements for export of live aquatic animals into importing countries, and aquatic emergency preparedness and response systems for transboundary diseases. She has been involved in several inter-regional projects on aquatic animal health with international agencies, namely FAO, NACA, USAID-MARKET, Cefas and SEAFDEC/AQD. She was selected as a consultant for a training project on IMNV diagnosis and disease surveillance that was funded by FAO. She was also invited by OIE Tokyo to speak on "Antimicrobial resistance in Aquaculture". She is a National Focal Point for the ASEAN Network on Aquatic Animal Health Centres (ANAAHC), which recently developed the Regional Technical Guidelines on Early Warning System for Aquatic Animal Health Emergencies, in collaboration with SEAFDEC/AQD. Ms Baoprasertkul is the author of more than 50 scientific papers on immunogenetics in aquatic animals, disease diagnosis, disease surveillance, prudent use of veterinary medicines in aquatic food production and biosecurity in aquaculture.

#	Name	Profile
5	**Etienne Bonbon** Senior Veterinary Advisor EMC-AH/Animal Health Service Food and Agriculture Organization of the United Nations Viale delle Terme di Caracalla SN 00153 Rome Italy	Dr Etienne Bonbon has been Senior Veterinary Advisor to the FAO Animal Health Service, Emergency Management Centre for Animal Health since May 2017. He received his diploma in Veterinary Medicine in 1987, DVM in 1989, and Master's Degree in human and animal epidemiology in 1991. Primarily a private practitioner in rural areas, he has been a Veterinary Public Health Inspector in the French Ministry of Agriculture since 1991. From 1992 to 2017, he was successively: Deputy Director of Veterinary Services in continental France and Martinica; Head of the Export Unit at the General Directorate for Food in Paris; Regional Veterinary Attaché for the Near and Middle East in Beirut, and then for Northern Asia in Beijing; Seconded to the European Commission in the Directorate General Health and Consumers in Brussels; Head of the Communication Unit of the OIE and Advisor to the Director General of the OIE in Paris; and Seconded to the European Union Delegation to the OECD, UNESCO and OIE in Paris. He has been President of the OIE Terrestrial Code Commission since 2015, after having been Vice-President since 2009.
6	**Edgar BRUN** Director for the Department of Aquatic Animal Health and Welfare Norwegian Veterinary Institute (NVI) Ullevålsveien 68 P.O. Box 750 Sentrum 0106 Oslo Norway	Dr Brun is veterinarian and holder of a dr. scient degree from the Norwegian School of Veterinary Medicine. In 2000/2001, he completed a Master in Epidemiology at the London School of Hygiene and Tropical Medicine, Royal Veterinary College. He worked for eight years as a fish health field veterinarian and continued working at the Norwegian Veterinary Institute (NVI) where in 2006 he became head of the Epidemiology Section and in 2018, Director for the Department of Aquatic Animal Health and Welfare. In 2010, the institute was approved as an OIE collaborating centre for epidemiology and risk assessment for aquatic animal diseases, a centre that he co-directed together with the Atlantic Veterinary College until 2017. In 2015, he was one of the initiators of the first global conference in aquatic epidemiology (AquaEpi) and in 2019, he was elected vice president of the European Association of Fish Pathologists (EAFP). He has headed and participated in several research projects both nationally and through the European Union, and has been a member of OIE and European Food Safety Authority (EFSA) ad hoc groups. In 2018, he joined the first FAO meeting on PMP/AB in Washington, D.C. and has since been part of evolving the programme and its funding. He is now responsible for a Norwegian-funded programme aiming to develop competence in aquatic animal health management in Ghana.

#	Name	Profile
7	**Iona CAMPBELL** Marine ecologist Scottish Association for Marine Science (SAMS) Oban, Argyll, PA37 1QA United Kingdom	Dr Campbell has nine years of research experience in the seaweed industry and associated interactions with the aquatic environment. She is currently working on the Global Seaweed STAR project. Her research focuses on the development of biosecurity management tools and policy strategies, both for the global seaweed aquaculture industry and for national strategies in the Philippines, Malaysia, Tanzania and the United Kingdom. She has also conducted research on seaweed farms of the largest scale while living in China, in collaboration with the Yellow Sea Fisheries Research Institute. She has contributed to the European Union guidelines for sustainable aquaculture of seaweeds, and published peer-reviewed articles and book chapters on the topic of seaweed cultivation and the environment.
8	**Arnaud COLLARD** Leader Aquaculture Medium, Central Eastern Europe, Middle East, region MSD Animal Health sprl Clos du Lynx 5, 1200 Bruxelles Belgium	Dr Collard is fish veterinarian in the two largest fish farms in Africa (Ghana and Zimbabwe) where he has established vaccination protocols and developed monitoring programmes for emerging diseases. For more than a century, MSD Animal Health, a leading global biopharmaceutical company, has been inventing for life, bringing forward medicines and vaccines for many of the world's most challenging diseases. Through its commitment to the Science of Healthier Animals™, MSD Animal Health offers veterinarians, farmers, pet owners and governments one of the widest range of veterinary pharmaceuticals, vaccines and health management solutions and services. MSD Animal Health is dedicated to preserving and improving the health, well-being and performance of animals. It invests extensively in dynamic and comprehensive R&D resources and a modern, global supply chain.
9	**Xuan DONG** Aquatic Animal Health Specialist Yellow Sea Fisheries Research Institute (YSFRI) Chinese Academy of Fishery Sciences (CAFS) Ministry of Agriculture and Rural Affairs (MARA) Qingdao China http://www.ysfri.ac.cn/	Dr Dong currently works at the Yellow Sea Fisheries Research Institute (YSFRI), Chinese Academy of Fishery Sciences (CAFS). He is a member of the World Organisation for Animal Health's (OIE) Reference Laboratory for white spot disease (WSD) and infectious hypodermal and hematopoietic necrosis (IHHN). He has been engaged in epidemiology and biosecurity of crustaceans in China. He has hosted and participated in more than 15 research projects such as those of the National Natural Science Foundation of China and has published more than 50 papers and 6 books. He has experience in the identification of new pathogens and has engaged in the platform construction of new pathogen identification in aquatic animals. He has identified acute hepatopancreatic necrosis disease (AHPND)-causing *Vibrio campbellii* and published the whole genome of yellowhead virus 8 genotype (YHV-8). He is also a member of the Roniviridae Study Group for the International Committee on Taxonomy of Viruses (ICTV).

#	Name	Profile
10	**Jeannine FISCHER** Chargée de mission Standards Department (Aquatic Animal Health) World Organisation for Animal Health (OIE) Paris France http://www.oie.int	Dr Fischer joined the OIE in the Standards Department, working on aquatic animal health in August 2019. She works closely with the Aquatic Animal Health Standards Commission, including the drafting of chapters on emergency disease preparedness and emergency disease outbreak management to be included in the Aquatic Code. Dr Fischer is a trained marine biologist. For almost seven years, she managed and prepared for biosecurity responses for the Ministry for Primary Industries in New Zealand, including responses to aquatic animal diseases and aquatic pests. She also developed an Aquatic Readiness Programme and worked closely with New Zealand's aquaculture industry. For six months, she managed the Readiness Programmes Team, overseeing and contributing to preparedness programmes for responses.
11	**Patricia S. GAUNT** Professor College of Veterinary Medicine Mississippi State University (MSU) 127 Experiment Station Road P.O. Box 197 Stoneville, MS 38776 United States of America	A diplomate of the American Board of Veterinary Toxicology, and professor of aquatic animal health at Mississippi State University (MSU), College of Veterinary Medicine, Dr Gaunt has over 20 years' experience as a veterinarian diagnosing diseases and prescribing medication for catfish. She works in conjunction with the MSU Extension Service in assisting farmers with catfish production. Her research focus is in aquatic pharmacology and toxicology. She conducted the pivotal safety and efficacy studies for the approval of the antibiotic florfenicol by the United States Food and Drug Administration for control of mortality associated with the bacterial diseases of enteric septicemia of catfish and columnaris disease. She is a recognized authority on Veterinary Feed Directive (VFD) orders for fish, which manages the correct use of medicated feeds to treat food fish with bacterial diseases in the United States of America. She is a member of the American Veterinary Medical Association's (AVMA) Aquatic Animal Health Committee and Council on Antimicrobials, which promotes antimicrobial stewardship in animals to mitigate antimicrobial resistance. She is also a member of the Clinical and Laboratory Standards Institute Working Group on Aquatic Animals, which sets guidelines to establish antimicrobial susceptibility patterns for aquatic bacterial pathogens. She has served as associate editor for the *Journal of Aquatic Animal Health* and is currently co-editor-in-chief. She is the author of over 70 scientific papers.

#	Name	Profile
12	**Rosa Federica GRASSI** Specialist in Maritime Law and Economics Partner of L'Equipaggio Snc, Responsible for International Relations, Quality Control and HACCP Team Management	Ms Grassi has a Masters Degree in Maritime Law and Economics from the University of Pescara and is specialized in International Business Development Processes. Since 2006, she has been responsible for international trade and quality control of an import-export frozen seafood products company, directly overseeing quality and output of fish products in overseas operations in Europe, Peru, South Korea, China, Viet Nam, India and Australia. She is a member of the Technical-Scientific Committee of the Italian National Association of Seafood Companies (ASSOITTICA), advising the association on matters relating to the production, processing, packaging, marketing, labelling, quality, hygiene and safety of seafood and aquaculture products, as well as on European Union and national legislation. She has collaborated with the University of Pescara and the Chamber of Commerce, Industry, Crafts and Agriculture of Pescara (Italy) as a seminar tutor on the "Common Fisheries Policy in the European and global context". She is a consultant with NISEA Soc Coop arl, a research cooperative specialized in socio-economic studies and research initiatives on fisheries and aquaculture, examining fish processing companies and reporting on European Union regulations in the fishery sector, as well as on marine litter. She is currently working on a "fishing for litter" project named "Catch & Clean".
13	**Andrea GUSTINELLI** Department of Veterinary Medical Sciences *Alma Mater Studiorum* University of Bologna Via Tolara di Sopra 50 - 40064 Ozzano Emilia (BO) Italy	After graduating in 2002 in Veterinary Medicine, Dr Gustinelli obtained a Ph.D. in "epidemiology and control of zoonoses" in 2008 and specialized in "animal health and animal productions" in 2010 at the Faculty of Veterinary Medicine of the University of Bologna. Since 2018, he is a de facto Diploma holder of the European College of Aquatic Animal Health. He is currently a Senior Researcher at the Department of Veterinary Medical Sciences of the University of Bologna. He has taken many professional positions in national and international research projects relating to fish pathology and in particular, in fish parasitology. He has taught at several advanced training courses and specialization schools. He is co-author of over 200 scientific publications. Since 2002, he has conducted research on the pathology of aquatic animals and parasitic zoonoses, with particular attention to parasitic and bacterial pathogens of fish imported or produced in Italy, characterization of the parasitic fauna of aquatic animals resident (both wild and farmed) in Italian territory, the study of the pathogenic effects of parasites in farmed marine fish, veterinary and public health aspects linked to aquaculture in eastern Africa, and the epidemiology of fish-borne parasitic zoonoses (diphyllobothriasis, anisakiasis and opisthorchiasis).

#	Name	Profile
14	**Olga L.M. HAENEN** Head of the National Reference Laboratory for Fish, Shellfish and Crustacean Diseases Wageningen Bioveterinary Research P.O. Box 65, 8200 AB Lelystad, The Netherlands Street address: Houtribweg 39, 8221 RA Lelystad The Netherlands https://www.wur.nl/en/Research-Results/Research- Institutes/Bioveterinary-Research.htm	Dr Haenen has been Head of the National Reference Laboratory: for the Netherlands for Fish, Shellfish and Crustacean Diseases since 1985, and for Belgium: Shellfish and Crustacean Diseases. She has over 34 years' experience as an all-round fish diagnostician and researcher, especially related to eels, carps/koi, tilapia, catfish, ornamental fish and marine flatfish, and risks of contact zoonosis pathogen transfer via international trade of fish. She was a member of the Aquatic Animal Health Standards Commission of OIE from 2009 to 2012; a member of other national and international advice committees and publication boards on fish diseases, for the government, fish farmers, private pond owners, veterinarians and zoos, and European Community, OIE, EFSA and FAO, since 1987; a member of the FAO book expert team "Management of Bacterial Diseases in Aquaculture", 2016–2019; and chairperson of the ICES Working Group "Development of standardized and harmonized protocols for the estimation of eel quality" (WKPGMEQ), January 2015, Brussels. Dr Haenen is a professor on healthy and safe insect farming for food and feed and an Honorary Member of the European Association of Fish Pathologists. She has published more than 75 peer-reviewed scientific papers, 4 books, and given over 300 lectures on fish diseases.
15	**Bernard Mudenda HANG'OMBE** Microbiology Unit University of Zambia School of Veterinary Medicine Para-clinical Studies Lusaka Zambia	A microbiologist trained in Japan, Dr Hang'ombe underwent further training in diagnosis and management of fish diseases at the Aquatic Animal Health Research Institute, Bangkok, Thailand. He is involved in the investigation and diagnosis of fish diseases in Africa. Currently he is in charge of surveillance and monitoring of epizootic ulcerative syndrome in the Zambezi and Congo River basins. Furthermore, he works with commercial farms on Lake Kariba to control massive fish mortalities as a result of *Streptococcus/Lactococcus* infections in farmed tilapia. All these activities are being done in collaboration with the FAO and WorldFish. He has also been instrumental in the surveillance and monitoring of tilapia lake virus. He has also collaborated with government institutions in other countries on their aquatic disease status and has been a resource person in meetings of training veterinarians in Africa on fish diseases. On direct involvement in fish disease outbreaks, he has been involved in the control of EUS in the Zambezi and Congo River basins through preparation of extension materials and development of applicable biosecurity frameworks for aquatic diseases to suit local situations.

#	Name	Profile
16	**Kathleen H. HARTMAN** Aquaculture Program Leader USDA APHIS, Veterinary Services 1408 24th Street, SE UF Tropical Aquaculture Laboratory (http://tal.ifas.ufl.edu) Ruskin, FL 33570 United States of America	Dr Hartman is the Aquaculture Program Leader for the United States of America Department of Agriculture's Animal and Plant Health Inspection Service (USDA APHIS) Veterinary Services and has been with USDA APHIS VS for over 16 years – first as an Aquaculture Epidemiologist and then as the Aquaculture Coordinator in Import/Export Services. She received a Master's Degree from the University of Maryland (fish nutrition) and both a DVM and a Ph.D. (aquatic animal pharmacokinetics) from Virginia Tech. She has a courtesy Assistant Professor appointment at the University of Florida, in the Program of Fisheries and Aquatic Sciences. She is currently on the Technical Standards Committee of the American Fisheries Society's Fish Health Section (AFS FHS) and has also served on their Professional Standards Committee. She has been a certified AFS FHS Aquatic Animal Health Inspector since 2008. She is a current member and the Secretary on the board of the World Aquaculture Society and is a Past President of the U.S. Aquaculture Society.
17	**Jie HUANG** Director General Network of Aquaculture Centres in Asia-Pacific (NACA) Bangkok Thailand http://www.enaca.org	The Director General of the Network of Aquaculture Centres in Asia-Pacific (NACA), Dr Huang is an expert on aquaculture epidemiology and biosecurity. He served as a Senior Researcher in the Yellow Sea Fisheries Research Institute (YSFRI), Chinese Academy of Fishery Sciences (CAFS); as the Chief Scientist of CAFS on aquatic animal disease control; as the OIE Designated Expert of the OIE Reference Laboratories for WSD and IHHN; and as a Vice President of the Aquatic Animal Health Standards Commission of the OIE. He has conducted projects on diagnostics, epidemiology, molecular mechanisms of viral infection, and control technology for aquatic animal diseases for 29 years. He and the group in YSFRI have identified several new pathogens and reported emerging diseases in farmed shrimp in China, established a series of detection techniques for aquatic animal pathogens, identified the viral attachment protein and its cellular receptor of WSSV, developed and applied aquaculture microbiological control technologies, and actively promoted the concept of the biosecurity system for the aquaculture industry. He had more than 150 corresponding author papers of which 46 were published in international journals, has obtained 50 patents, published 30 national and industrial standards, won 13 national and provincial awards, and trained nearly 100 doctorate and masters students.

#	Name	Profile
18	**David HUCHZERMEYER** Aquatic Veterinary Specialist Sterkspruit Veterinary Clinic P.O. Box 951 Lydenburg 1120 Republic of South Africa Website: www.sterkspruitveterinaryclinic.co.za	Dr Huchzermeyer has been in mixed private veterinary practice in Lydenburg, South Africa since 1986 and is currently practice principal of Sterkspruit Veterinary Clinic, providing fish and crocodile consultations, diagnostics and pathology services. He is an honorary Research Associate in the Department of Ichthyology and Fisheries Science at Rhodes University, Grahamstown; an Extraordinary Lecturer in the Department of Paraclinical Sciences in the Faculty of Veterinary Science, University of Pretoria; and an Extraordinary Associate Professor in the Unit for Environmental Sciences and Management at the North West University. He has been co-presenter of training courses on biosecurity and aquatic animal diseases for veterinarians throughout Africa on behalf of OIE and FAO. He has been closely involved with the disease-free certification process required for export of trout ova and koi to the European Union and other world markets. Dr Huchzermeyer was part of the team from Rhodes University that first confirmed epizootic ulcerative syndrome as the cause of ulcerations in wild fish in the Chobe and upper Zambezi rivers in 2007. He has tracked the rapid spread of this exotic disease through Zambia and, as part of an FAO emergency disease investigation task force, to the northeast of the Democratic Republic of Congo.
19	**Benjamin HUNTINGTON** Honorary Research Fellow Institute of Infection and Global Health University of Liverpool United Kingdom	Dr Huntington cut his teeth working in clinical practice in the United Kingdom and Canada, specializing in cattle and poultry production. He then spent six years directly employed by United Kingdom poultry integrators in a general management and veterinary capacity. Here he specialized in policy design and implementation in health and welfare, biosecurity and food safety and worked across feedmills, breeding, hatching, growout, transport and processing plants. He has worked on animal health projects in partnership with government in the United Kingdom, overseas and with the FAO in Southeast Asia. During his time in industry, he was a member of a number of industry boards tackling issues such as *Campylobacter* and welfare, and was the Chair of the British Poultry Council Antimicrobial Stewardship Committee.

#	Name	Profile
20	**Anton IMMINK** Aquaculture Director Sustainable Fisheries Partnership (SFP) Stirling, Scotland United Kingdom http://www.sustainablefish.org	Mr Immink leads the development of aquaculture improvement projects (AIPs) addressing multiple risks across production areas, particularly in shrimp in Asia. He led the development of Fish Source aquaculture methodology (https://www.fishsource.org/), which provides public information on the risks and improvement needs in farmed seafood production areas; and the Sustainable Fisheries Partnership (SFP) Framework for Sustainable Aquaculture (https://www.sustainablefish.org/Programs/Aquaculture/Framework-for-Sustainably Managed-Aquaculture), which identifies coordinated health management as a core development need in aquaculture industries. He has partnered with major retailers and brands including Walmart, Sainsburys, Aldi and McDonalds to improve the environmental performance of their seafood supplies and has over 30 years' experience supporting aquaculture development in many countries across Asia and Africa.
21	**Mona Dverdal JANSEN** Researcher Department of Epidemiology Norwegian Veterinary Institute (NVI) Ullevålsveien 68, Pb 750 Sentrum N-0106 Oslo Norway	Dr Jansen is a veterinary epidemiologist working on surveillance and control of viral diseases in Norwegian salmonid aquaculture, with infectious salmon anaemia currently being the main area of responsibility. She is involved in multiple projects on non-salmonid species, including the Fish for Development project in Ghana (tilapia), the PMP/AB surveillance pilot testing in Indonesia (*Penaeus vannamei*) and a collaboration with WorldFish on the assessment of tilapia mortality and its economic impact in Bangladesh and Egypt. She is also a member of the OIE ad hoc group on tilapia lake virus.
22	**Stian JOHNSEN** Mission Manager Standards Department Management of aquatic animal health activities 12, rue de Prony 75017 Paris France	Dr Johnsen has been working for the OIE in the Standards Department since 2017 and is managing all aquatic animal health activities. This includes acting as the Secretariat for the Aquatic Animal Health Standards Commission, coordinating work between OIE departments and other international organizations, and training of veterinarians and aquatic animal health professionals in Member Countries, as well as the drafting of chapters on emergency disease preparedness and emergency disease outbreak management to be included in the Aquatic Code. He is an aquatic veterinarian who has been seconded from the Norwegian Food Safety Authority to the OIE for four years to work on aquatic animal health. Back home, he used to do scientific work before working for the authorities on development of aquatic animal legislation, biosecurity and contingency planning, coordination of international relations (including being the OIE Aquatic Focal Point), participating in expert groups in the European Union drafting revised and new legislation, as well as taking part in bilateral relations on aquatic animals. He has also worked as a national expert in the European Union.

#	Name	Profile
23	**Qing LI** Director Division of Aquatic Diseases Prevention and Control National Fisheries Technology Extension Center (China Society of Fisheries) (NFTEC) Ministry of Agriculture and Rural Affairs (MARA) Beijing, People's Republic of China http://www.nftec.agri.cn/	Dr Li is a professor, an aquatic animal health management specialist, and now the Director of the Division of Aquatic Diseases Prevention and Control, National Fisheries Technology Extension Center (NFTEC), Ministry of Agriculture and Rural Affairs (MARA). She is also the Secretary-General of MARA's Expert Committee on Aquaculture Diseases Prevention and Control, the Secretary-General of the China's Technical Standardization Committee on Aquatic Animal Epidemic Prevention, and the designated focal point in P.R. China for dealing with aquatic animal health issues related to the OIE. She also has eight years of visiting scholar and working experiences in Japan. Over the years, she has been engaged in the guidance and administrative management of aquaculture drug use, disease prevention and control, and has a thorough understanding of the situation, system, problems and relevant policies of aquatic animal diseases emergency response in P.R. China.
24	**Amedeo MANFRIN** Aquatic Animal Health and Welfare Specialist National Reference Laboratory for Fish, Mollusc and Crustacean Diseases – IZSVe Viale Università, 10 – 35020 Legnaro (Padova) Italy http://www.izsvenezie.it	Dr Manfrin is experienced in fish bacterial pathogens and vaccines production, above all, in salmonids and Mediterranean species. He is also involved in fishery and aquaculture products control and is a partner of several national and international projects on fish health, welfare, seafood safety and organic aquaculture. He is a lecturer at the University of Padova and has provided training courses preparing farmers and veterinarians for fish disease and zoonoses control. He has expertise on dealing with international (Standing Committee On Food Chain and Animal Health, OIE Aquatic Animal Diseases Working Group, Standing Committee on Animal Welfare, private expert of European Food Safety Authority, private expert of FVO – DG SANCO inspection teams on fishery products – Philippines and ornamental fish – Malaysia and Greece – Marine Aquaculture), national (Ministry of Health and Ministry of Agriculture) and local institutional authorities. Dr Manfrin has good experience in specific legislation on aquaculture and animal health conditions for minimum measures for the prevention, control and eradication of exotic and non-exotic diseases. He was a tutor in three Better Training for Safer Food (BTSF) organized in Italy and Spain in 2012, 2014 and 2015, with responsibility for the training dedicated to hygiene and official control of aquaculture products.
25	**Mohammed ODAIBI** General Secretary Saudi Aquaculture Society King Abdul Aziz Rd, Al Murabba, Riyadh 12628 Kingdom of Saudi Arabia	Mr Odaibi holds a Bachelor's Degree in marine biology. His job responsibilities include serving as a member of a high-level Biosecurity Committee and the Biosecurity Technical Committee; participation in national biosecurity workshops and events; and review the Biosecurity Monthly, Quarterly and Annual Reports before their submission to Ministry.

#	Name	Profile
26	**Magnus Sverre PETERSEN** Higher Executive Officer Section for Knowledge Programmes The Knowledge Bank Norwegian Agency for Development Cooperation Postal address: P.O. Box 8034 Dep, 0030 Oslo Norway Office address: Bygdøy allé 2, 0257 Oslo, Norway	Dr Petersen is an aquaculture biologist by training. Since 2018, he has worked in the Fish for Development Programme of the Norwegian Agency for Development Cooperation. In this position, he works mostly within Norway’s support for aquaculture in development cooperation. Part of his responsibilities within this programme is determining how to harness Norwegian institutional competence to the benefit of developing countries. This is often done bilaterally by providing technical assistance and capacity building to national authorities for managing fisheries and aquaculture sectors, but also multilaterally, such as through the United Nations system. His prior experience includes work with development cooperation at the Royal Norwegian Embassy in Kathmandu, and working as a journalist covering new technology in the Norwegian aquaculture sector.
27	**Rafael Miguel RAFAEL** Aquatic Animal Health Officer Head of Aquaculture Research Center National Fisheries Research Institute (IIP- Gaza) Mapapa, Gaza- Mozambique	Mr Rafael has 15 years experience in aquatic animal health in Mozambique. He contributed to creating a nucleus of aquatic animal health in the Ministry of Sea, Inland Waters and Fisheries, a body that advises government, especially the competent authority on all issues related to aquatic animal health. He participated in the epizootic ulcerative syndrome (EUS) project in the South Africa Development Community (SADC) region under FAO supervision. He is currently working on active surveillance of TiLV and other tilapia diseases in Mozambique.
28	**Yuriy RUD** Head of Laboratory of Biotechnology in Aquaculture Institute of Fisheries of the National Academy of Science (IF NAS) Kyiv Ukraine http://www.http://if.org.ua	Dr Rud has a Ph.D. in virology and has been a senior research associate in aquaculture since 2014. He is working in (i) molecular diagnostics of fish diseases and cell culture units (IF NAS), (ii) as national project coordinator for “Investigation of molecular and biological properties and phylogenetic characteristics of fish pathogens in Ukraine” (funded by the Ukrainian Government) (IF NAS), (iii) in the research department of the virology unit (KNUTS), and (iv) as deputy head of the Ukrainian Association of Fish Pathologists (UAFP) and Ukraine's Fishing industry Cluster of Innovations (UFICI). Other affiliation: Research Department ESC Institute of Biology and Medicine Taras Shevchenko National University of Kyiv (KNUTS) Kyiv, Ukraine http://https://biology.univ.kiev.ua

#	Name	Profile
29	**Dyah SETYOWATI** Head of Section of Fish Disease Control Directorate of Aquaculture Regional Development and Fish Health (DARDFH) Directorate General of Aquaculture (DGA) Ministry of Marine Affairs and Fisheries (MMAF) Jakarta Indonesia www.kkp.go.id	Ms Setyowati has 16 years experience in fish health in Indonesia. She participated in the 2013–2015 FAO project IMNV disease surveillance on Vannamei shrimp in South Lampung District, Tangerang District (Banten Province) and Banyuwangi District and is involved in the Biosecurity Pilot Project on Vannamei Shrimp Farms in South Lampung Regency. In 2019, she was involved in activities of the FAO "GCP/GLO/979/NOR: Improving Biosecurity Governance and Legal Framework for Efficient and Sustainable Aquaculture Production", which is a pilot project on surveillance of EHP disease in shrimp in Jembrana District (Bali Province). She participates as part of a team to investigate mass mortalities due to fish diseases and environmental causes, as well as on a task force to control TiLV and AHPND in Indonesia. She played an active role in the drafting of the regulations of the Ministry of Marine Affairs and Fisheries (MMAF) for the control of fish diseases, as well as the regulations of the MMAF concerning aquatic animal welfare, and also participated in the preparation of technical guidelines for dealing with AHPND and for controlling antimicrobial resistance.
30	**Aminah Al SHAIK** Supervisor Biosecurity Division Saudi Aquaculture Society Ministry of Environment, Water and Agriculture Kingdom of Saudi Arabia	Ms Al Shaik holds a Master’s Degree in Marine Biology and is responsible for organizing biosecurity surveillance activities in the Kingdom of Saudi Arabia. She provides technical guidance to aquaculture projects related to animal health and immediate response to disease outbreaks. She also participates in national biosecurity workshops and events, prepares monthly and annual surveillance activity reports and participates in polymerase chain reaction (PCR) laboratory activities.
31	**Joselito R. SOMGA** Veterinarian IV Fisheries Inspection and Quarantine Division Bureau of Fisheries and Aquatic Resources 860 Quezon Avenue, Quezon City, Philippines http://www.bfar.da.gov.ph	Dr Somga is the Chief, Fisheries Quarantine Section of the Bureau of Fisheries and Aquatic Resources (BFAR). He is a veterinarian with an M.Sc. in Tropical Fish Health. He joined BFAR in 1989 and has been working on aquatic animal health, including diagnostic activities for fish and shrimp diseases, response to disease emergencies and fish kill investigation, and sanitary and phytosanitary (SPS) measures on quarantine and health certification for trade or transboundary movement of live aquatic animals. He was actively involved in the establishment of the BFAR Regional Fish Health Laboratories and the BFAR Fish Health Network. He served as the country’s National Coordinator (2000 – 2002) for the FAO/NACA/OIE Project that led to the development of the *Asia Regional Technical Guidelines for the Responsible Movement of Live Aquatic Animals*. He was also the National Project Coordinator (2014–2016) to the FAO Inter-regional Technical Cooperation Program on Reducing and Managing the Risks of Acute Hepatopancreatic Necrosis Disease. Presently, he is the Focal Point for the ASEAN Network of Aquatic Animal Health Centers, and the OIE Focal Point for Aquatic Animals.

#	Name	Profile
32	**Mwansa SONGE** Head, Aquatic Animal Health Department of Veterinary Services Central Veterinary Research Institute Lusaka Zambia	Ms Songe is interested in planning for and/or launching response actions to aquatic animal disease emergencies, which are enhanced by the rate at which the aquaculture subsector is developing in Zambia. Growth is expected to further be stimulated in the next few years through support from the African Development Bank-funded project, the Zambia Aquaculture Enterprise Development Project (ZAEDP). This expansion could favour the spread of disease and creates the need for specialists to take a proactive approach towards aquatic animal health management. Zambia is going through the exciting phase of starting to formulate a National Strategy for Aquatic Animal Health (with the technical support from FAO). “Emergency Preparedness and Contingency Planning” will be one of the important elements of the strategy and therefore, this is the perfect time for her to interact with, learn from, and share notes with those that have experience in emergency response actions to aquatic animal disease emergencies.
33	**Rohana P. SUBASINGHE** Consultant Futurefish 16 I, Iconic Residencies 110 Parliament Road, Rajagiriya Sri Lanka	Dr Subasinghe has over 35 years of international experience in aquaculture development and aquatic animal health management. He developed, led and implemented the FAO's aquatic animal health programme for many years. He served as a Senior Fisheries Officer at FAO and spearheaded the FAO's aquaculture development programme until he retired at the end of 2015. He has continued his involvement with the FAO's aquatic animal health programme, and assisted the development of the Progressive Management Pathway for Aquatic Biosecurity (PMP/AB). Currently he is attached to WorldFish and leads an aquaculture development programme in Nigeria. Dr Subasinghe has authored many publications on aquaculture and aquatic animal health. He is a pioneering member and a past-chairman of the Fish Health Section of the Asian Fisheries Society. He is currently the president of the Asia-Pacific Chapter of the World Aquaculture Society (WAS), and is also a honorary life member of WAS.

#	Name	Profile
34	**Kathy (Feng-Jyu) TANG-NELSON** Aquatic Animal Health Specialist Arizona United States of America	Dr Tang-Nelson is an Aquatic Animal Health Specialist with specific interests in the role of diagnosis for rapidly responding to the emergence of aquaculture diseases. She is currently a research affiliate of the Yellow Sea Fisheries Research Institute in Qingdao, China and previously (1997 to 2017) was a member of the research faculty at the University of Arizona. She has authored over 70 peer-reviewed publications on diseases of aquatic species and developed molecular diagnostic protocols, such as quantitative PCR and in situ hybridization, for the detection of major shrimp pathogens. She was recognized as an expert by the OIE on a number of shrimp diseases, and participated in an OIE-twinning project between the United States of America and Indonesia, which trained Indonesian researchers in the diagnosis of shrimp diseases and aided them in setting up a functional diagnostic laboratory of high standards. Recently, she participated in the FAO-supported workshops focused on TiLV, providing training to researchers in Southeast Asia and Africa. Her latest work with the FAO includes publishing the *Shrimp infectious myonecrosis strategy manual*, which provides key information for national policy-makers, producers and other stakeholders with regard to the development of disease contingency plans.
35	**Anna TOFFAN** National Reference Laboratory for Fish Diseases Aquatic Animal Virology Unit OIE Reference Laboratory for Viral Encephalo-Retinopathy Istituto Zooprofilattico Sperimentale delle Venezie (IZSVE) Viale dell'Università 10, 35020 Legnaro (Padova) Italy www.izsvenezie.it	Dr Toffan is a veterinarian currently managing the Aquatic Animal Virology Unit hosted at the National Reference Centre for Fish, Molluscs and Crustacean Diseases. She graduated in Veterinary Medicine in 2002 and attended the doctoral school in Public Health and Comparative Pathology. In 2005, she also earned the specialization in "Breeding, hygiene, pathology of aquatic species and control of derived products." Since 2010, she has been working at the National Reference Centre for Fish, Molluscs and Crustacean Diseases at the Istituto Zooprofilattico Sperimentale delle Venezie (IZSVe) in the group led by Dr Giuseppe Bovo until 2011 and now by Dr Giuseppe Arcangeli, involved in research, diagnostic and capacity-building activities. In 2016, she was appointed OIE Expert for the OIE Reference Laboratory for Viral Encephalopathy and Retinopathy, located at the IZSVe. Dr Toffan's research interests are mainly focused on the diagnosis and control of viral diseases of freshwater and marine species, particularly the pathogenesis of viral diseases and the development of safe and efficacious vaccines in the above-mentioned species. She is also involved in several national and European-funded research projects having fish viruses as their main topic.

#	Name	Profile
36	**Phan Thi VAN** Director Research Institute for Aquaculture 1 Dinh Bang Tien Son, Bac Ninh, Hanoi Viet Nam	Dr Van is the Director of Research Institute for Aquaculture No. 1 and an Associate Professor of Vietnam National University of Agriculture under the Ministry of Agriculture and Rural Development. She has 25 years of work experience in aquaculture, with a focus on aquatic animal health, environment and good aquaculture practices. She has been used as an expert by FAO, UNDP, OIE and others, both inside and outside Viet Nam (Asia, Europe, Africa and the Caribbean). She was chairwoman of the Fish Health Section (2014–2017) of the Asian Fisheries Society and a member of the National Task Force for Shrimp Disease during the first occurrence of AHPND in Viet Nam. She has also led a number of national and international projects on aquatic animal diseases.
37	**Jing WANG** OIE Asia-Pacific Food Science Building 5F The University of Tokyo 1-1-1 Yayoi, Bunkyo-Ku Tokyo 113-8657 Japan	Dr Wang joined the OIE Regional Representation for Asia and the Pacific (RRAP) in May 2017 as a Regional Veterinary Officer. Her major responsibilities include organization of capacity-building training, and aquatic animal and AMR-related activities. She has been involved in aquatic animal activities since she joined OIE RRAP and helped to contribute to the implementation of the regional programme related to aquatic animal diseases. Prior to joining the OIE, she served at the China Animal Disease Control Center for several years as Assistant Professor, focusing on the laboratory diagnosis of animal diseases as well as laboratory quality management. From 2013–2015, she was seconded to the Veterinary Bureau, Ministry of Agriculture, P.R. China, where she gained knowledge on disease control and preparedness for emerging disease.
38	**Qing WANG** Director, Laboratory of Aquatic Disease Control and Prevention Pearl River Fisheries Research Institute (PRFRI) Chinese Academy of Fishery Sciences (CAFS) Ministry of Agriculture and Rural Affairs (MARA) Guangzhou China http//www. prfri.ac.cn	Dr Wang is an expert on aquatic viral disease control and Director of the Laboratory of Aquatic Disease Control and Prevention, Pearl River Fisheries Research Institute (PRFRI), Chinese Academy of Fishery Sciences (CAFS). In 2008, she graduated from Sun Yat-sen University and joined PRFRI. Since then, she has been working in the Laboratory of Aquatic Disease Control and Prevention for 11 years. From 2013–2015, she was invited to visit the OIE KHV Reference Laboratory in the Friedich-Loeffler-Institut for three months, communicating research experience on KHV diagnosis. Thereafter, she worked as a visiting scholar in the College of Veterinary Medicine, Oregon State University for one year on research on KHV latency infection. Her research focuses on epidemiological surveillance, risk assessment and vaccine development for freshwater fish viral diseases, especially grass carp reovirus, koi herpesvirus, iridovirus, and so on. Her team has established more than 20 fish cell lines for viral isolation, 10 diagnostic kits for viral detection and inactivated or oral vaccines against grass carp reovirus, published 81 papers and has had 13 invention patents authorized.

#	Name	Profile
39	**David VERNER-JEFFREYS** Principal Microbiologist Antimicrobial Resistance Programme Lead Centre for Environment, Fisheries and Aquaculture Science (Cefas) Weymouth Laboratory, Barrack Road Weymouth, DT4 8UB Dorset United Kingdom	Dr Verner-Jeffreys is an aquaculture health expert who has worked for the Centre for Environment, Fisheries and Aquaculture Science (Cefas), based at their Weymouth Laboratory, since 2003. He obtained his Ph.D. from the University of Glasgow in 2000. Before joining Cefas, he worked in Hawaii for the Oceanic Institute, helping the development of rearing programmes for tropical marine finfish and shrimp species. His main areas of expertise are in aquatic animal diseases, leading investigations into unexplained mortalities and, more fundamentally, the biology of the major bacterial pathogens of fish and shellfish. He has a strong interest in, and provides advice to industry and the Government of the United Kingdom, on the risks associated with antimicrobial resistance (AMR) in aquaculture pathogens and reservoirs of AMR in the aquatic environment. This includes leading the FAO International Reference Centre for AMR (United Kingdom).
40	**Hao ZENG** Director, Aquaculture Division Bureau of Fisheries Administration (BFA) Ministry of Agriculture and Rural Affairs (MARA) Beijing China http://www.moa.gov.cn/	Dr Zeng is an aquatic animal health management specialist and Director of the Aquaculture Division in the Bureau of Fisheries Administration (BFA), Ministry of Agriculture and Rural Affairs (MARA). He joined MARA in 2002, and in 2005, started his work in BFA on aquaculture and specifically aquatic animal health management. He has been engaged in administrative management and policy research for prevention and control of aquatic animal epidemics in P.R. China for many years, and has participated in the formulation and revision of relevant laws, regulations and standards for aquatic animal epidemic prevention, such as the animal epidemic prevention law, the administrative measures for animal quarantine, and the administrative measures for practicing veterinarians. He is mainly responsible for the formulation and implementation of the annual national aquatic animal epidemic monitoring plan, organizing and guiding the handling, prevention and control of emergent major aquatic animal epidemics, and reviewing the aquatic animal epidemic information reported by P.R. China to OIE. He is also responsible for the implementation of the quarantine system for aquatic fry production areas in P.R. China and participates in the compilation and approval of the bulletin on the health status of aquatic animals in China and other important documents on aquatic animal epidemic prevention.

#	Name	Profile
41	**Peter Akpe ZIDDAH** Aquatic Animal Health Specialist Fisheries Commission P. O. Box GP 630 Accra Ghana	Dr Ziddah received a DVM and M.Sc. in Veterinary Medicine from Kishinev Veterinary Institute (Moldova Agricultural University) in 1987; a Certificate in Tropical Veterinary Medicine from the same institute in 1990; and an M.Sc. in Aquatic Veterinary Sciences from the University of Stirling in 1997. He worked for the Veterinary Services of the Ministry of Food and Agriculture from 1987–1998. His work schedule including examination of animals and checking their health status, treating animals, conducting post-mortem examinations, educating animal owners on sanitary and nutritional measures, educating the public on zoonotic diseases etc. In 1998, he was seconded to the Fisheries Commission where he established the Fish Health Unit. He established the presence of various pathogens in the aquatic environment, which led the development of the Ghana Aquatic Animal Health Policy to guide development interventions in the aquaculture industry. In 2017, he provided information that enabled Ghana to ban the importation of ornamental fish to prevent the introduction of TiLV. In 2014, the industry experienced an incidence of *Streptococcus agalactiae* 1a and 1b, which was contained through the use of an autogenous vaccine. Currently, ISKNV has been found and measures are being adopted are improve biosecurity on farms and introduce immunization.
42	**Qingli ZHANG** Director, Division of Marine Aquaculture Animal Disease Control and Histopathology Yellow Sea Fisheries Research Institute (YSFRI) Chinese Academy of Fishery Sciences (CAFS) Ministry of Agriculture and Rural Affairs (MARA) 106 Nanjing Road, Qingdao 266071 China http://www.ysfri.ac.cn/	Dr Zhang is a professor and the Director of the Division of Marine Aquaculture Animal Disease Control and Histopathology, Yellow Sea Fisheries Research Institute (YSFRI), Chinese Academy of Fishery Sciences (CAFS). He received his Ph.D. in marine biology from the CAFS in 2007, and devoted himself to the investigation of emerging diseases of maricultured animals and the development of novel diagnostic techniques for mariculture pathogens. He identified two novel nodaviruses, covert mortality nodavirus (CMNV) and movement disorder nodavirus (MDNV) from farmed shrimp, and proved CMNV's prevalence in Asia and Latin America, as well as CMNV's cross-species transmission in marine fish, and revealed the patho-ecological characteristics of CMNV. He established the rapid and highly sensitive detection technology platform for aquaculture animal pathogens, developed on-site rapid and highly sensitive detection kits for more than 20 kinds of aquatic animal pathogens, and applied more than 10 000 kits in P.R. China. He organized the China-ASEAN Aquatic Animal Proficiency Testing Technology Training Course, the China-Southeast Shrimp Disease Diagnostic Technology Training Class in 2015–2016, and promoted on-site rapid detection technology and kits in North Africa and Southeast Asia.

#	Name	Profile
43	**Snjezana ZRNCIC** Croatian Veterinary Institute Laboratory for Fish and Molluscs diseases Savska 143, 10000 Zagreb Croatia	Dr Zrncic has more than 30 years experience in aquatic animal health, mostly in Croatia and neighbouring countries. After completing her Ph.D. at the Veterinary Institute in Zagreb, she established the Laboratory for Aquatic Animal Diseases at the Croatian Veterinary Institute, a national diagnostic institution. She has experience with diagnostics of European Union (EU)-listed diseases and cooperated closely with the Chief Veterinary Officer in managing the outbreaks of viral hemorrhagic septicaemia, infectious hematopoietic necrosis and koi herpesvirus disease. Along with listed diseases, she is an expert in the diagnostics and management of diseases of Mediterranean fish species. From 2013–2015, she worked as FAO expert for diagnostics in project TCP/RER/3402 Assistance to Western Balkan Countries for Improving Compliance to International Standards on Aquatic Animal Health, prepared the *West Balkan Regional Aquatic Animal Disease Diagnostic Manual* and participated in FAO activities on Strengthening capacities, policies and national action plans on prudent and responsible use of antimicrobials in fisheries (FMM/RAS/298). Currently, she is serving as the General Secretary of the European Association of Fish Pathologists. She has published about 100 papers and is currently participating in two EU-funded projects, H2020 MedAID and Interreg Italy-Croatia AdriAquaMed, both dealing with the improvement of health management of Mediterranean fish species.

FAO Secretariat

Dr Melba B. Reantaso Dr Bin Hao Mr Omar Elhassan	Ms Nathalie Perisse Ms Svetlana Velmeskina Ms Lisa Falcone

ANNEX 3

Welcome speech:
Assistant Director General Arni Mathiesen
(16 December, 09.00, German Room)

On behalf of the Director General of FAO, Dr Qu Dongyu, I am pleased to welcome you to this important round-table discussion on “Moving forward through lessons learned on response actions to aquatic animal disease emergencies”.

During the last three decades, the aquaculture sector and its governance (state and non-state actors) have been challenged by serious aquatic animal disease incursions; in some cases, the sector was caught off-guard by the emergence of new diseases

For example, since 2009, we have seen the emergence of acute hepatopancreatic necrosis disease (AHPND), tilapia lake virus (TiLV), *Enterocytozoon hepatopenaei* (EHP), shrimp hemocyte iridescent virus (SHIV) and more recently, infectious spleen and kidney necrosis virus (ISKNV).

Some known diseases have re-emerged to cause mass mortalities in new geographical localities, for example, white spot disease (WSD) in the Saudi Arabia and Australia, koi herpesvirus (KHV) in Iraq, epizootic ulcerative syndrome (EUS) in the Democratic Republic of Congo and infectious myonecrosis virus (IMNV) in India.

Additionally, large-scale mortality events due to environmental causes appear to be affecting both cultured and wild populations of aquatic animals with increased frequency and severity. These include losses due to such events as algal blooms, temperature extremes, oxygen depletion, point-source pollution (chemical and oil spills) and pesticide runoff from agricultural activities.

Due to various reasons, government agencies and the private sector often have difficulty in responding rapidly and effectively to mass mortality events. Such factors include a lack of planning for emergency response, absence of readily accessible funds, lack of appropriate organizational structure, and lack of adequate training, expertise and capacity. The effectiveness of responses to mass mortalities of aquatic animals varies from country to country, depending on the cause and the state of national emergency preparedness.

Often, there is a lack of follow up to a mortality event, in order to determine where improvements can be made. A systematic assessment of the economic and social impacts of a mass mortality of aquatic animals is often lacking, as, in general, standardized procedures for assessing such impacts are not available.

In view of the clear need to improve the response of national authorities and the private sector to mass mortalities of cultured and wild aquatic animal populations, this round-table discussion is being organized by the FAO in collaboration with the Norwegian Agency for Development Cooperation (Norad).

FAO is at the forefront of providing technical assistance and capacity building to our member states on aquaculture biosecurity and aquatic animal health. You will hear more about this in FAO presentations later today.

You may recall that FAO, in collaboration with NACA, organized the first Regional Workshop on Preparedness and Response to Aquatic Animal Health Emergencies that was hosted by the Government of Indonesia in September 2004, some 15 years ago. That meeting was triggered by diseases such as EUS, viral nervous necrosis (VNN), WSD and KHV. As earlier mentioned, they are still problems as of todate. That workshop also produced very detailed guidelines on the same subject that you will be discussing today. The main authors of that guidelines are here, Drs Richard Arthur and Rohana Subasinghe. I believe that these guidelines are technically rich in scope and are still valid.

Some of you may also be aware that FAO and partners are promoting the Progressive Management Pathway for Improving Aquaculture Biosecurity or PMP/AB. You may recall that we started discussions on this in April 2018 during the first consultation hosted by the World Bank in Washington DC and followed by a second consultation hosted by OIE in Paris last January and a third one here in Rome last March. I am pleased to inform that the 10th session of FAO's Committee on Fisheries Sub-Committee on Aquaculture held in Trondheim last August has endorsed and supported PMP/AB and the development of a long-term, multidonor assisted partnership programme on Aquaculture Biosecurity. The PMP/AB has four stages and in each of the stages, emergency response and preparedness is an important consideration; it is also one of the five pillars of the proposed umbrella programme on aquaculture biosecurity.

This meeting is really an important event. I urge you to carefully assess what are the major gaps why biosecurity seems to be the greatest challenge in aquaculture. A final objective of this meeting is the planned Decision-tree manual that will hopefully provide guidance to all relevant stakeholders (national Competent Authorities and private-sector aquaculturists) in dealing quickly, efficiently and effectively with mass mortality events affecting stocks of cultured and wild aquatic animals. They are the frontliners at the ground level, and the type and quality of response actions that they provide will determine the consequence of such emergency events. We have here many of the important players in this field and we have some of countries with very rich experiences in dealing with mass mortality events. I look forward to hearing the outcomes of this event and rest assured of FAO support to relevant follow up-actions that will be identified.

Before closing, I would like to express our deep appreciation to everyone for your kind support to FAO initiatives and together let us pursue more strengthened partnership so that we can collectively share the responsibility to assist the aquaculture sector in general in addressing and reducing mass mortality events.

Rome will be sunny the next three days, so please enjoy the time that you are here. My staff will be around to assist in any way we can to make your stay enjoyable and memorable.

All the best and good morning to everyone.

ANNEX 4

Group photographs

Photo collage

Photo collage: Forty three experts from governance authorities, intergovernmental organizations, academe/research institutions and production sector, actively participated in the Round-table discussion: moving forward through lessons learned on response actions to aquatic animal disease emergencies organized by the Food and Agriculture Organization of the United Nations (FAO) in collaboration with the Norwegian Agency for Development Cooperation (NORAD) under the auspices of the project GCP/GLO/979/NOR: "Improving Biosecurity Governance and Legal Framework for Efficient and Sustainable Aquaculture Production" that was held from 16–18 December 2019 at the FAO headquarters in Rome, Italy.

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Photo Collage: Forty three experts from governance authorities, intergovernmental organizations, academe/research institutions and production sector, actively participated in the Round-table discussion: moving forward through lessons learned on response actions to aquatic animal disease emergencies organized by the Food and Agriculture Organization of the United Nations (FAO) in collaboration with the Norwegian Agency for Development Cooperation (NORAD) under the auspices of the project GCP/GLO/979/NOR: "Improving Biosecurity Governance and Legal Framework for Efficient and Sustainable Aquaculture Production" that was held from 16–18 December 2019 at the FAO headquarters in Rome, Italy.

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Photo Collage: Experts receiving certificate of appreciation during the Closing ceremony of a Round-table discussion: moving forward through lessons learned on response actions to aquatic animal disease emergencies organized by the Food and Agriculture Organization of the United Nations (FAO) in collaboration with the Norwegian Agency for Development Cooperation (NORAD) under the auspices of the project GCP/GLO/979/NOR: "Improving Biosecurity Governance and Legal Framework for Efficient and Sustainable Aquaculture Production" that was held from 16–18 December 2019 at the FAO headquarters in Rome, Italy.

ANNEX 5

Decision-tree for dealing with aquatic animal Mass Mortality Events (MMEs) – Annotated table of contents

Chapters	Annotation	Comments/Available guidance documents
INTRODUCTION	• Why countries are often unable to react quickly and effectively when a mass mortality of cultured or wild aquatic animals occurs. • At the population level, MMEs are considered rare events. However, on a global scale, they are a common occurrence in both wild and cultured populations. • MMEs are due to both natural and human-related causes. Natural causes include both biotic (pathogens and disease, biotoxicity caused by algal blooms) and abiotic factors (e.g. environmental factors, such as climatic extremes (temperature fluctuation, flooding, drought), oxygen stress and starvation). Human causes include mortalities due to chemical spills and other types of pollution. In many MMEs, there are multiple stressors. • Invasive aquatic bivalves (and inter alia, perhaps exotic species introduced for aquaculture) appear to be more susceptible to MMEs, due to their being less well adapted to the local environment and its extremes than are native species (McDowell and Sousa, 2019).	Lack of preparedness and planning for emergency response to aquatic MMEs means countries continue to repeat the same disorganized sequence of events over and over each time a mass mortality occurs. Dealing successfully with MMEs requires detailed, careful preplanning by responsible authorities. Responsibilities of decision-makers include directing staff, logistics, selecting interventions, communicating to professionals and the public, planning future response needs, and establishing strategic and tactical priorities along with their funding requirements (Morgan, 2019). MMEs have recently been recognized as important events in controlling population size in wild aquatic animals (see McDowell and Sousa, 2019). Approximately 75% of MMEs have been reported from North America and Europe, indicating the events in other regions are highly under reported. The data for the study by Fey *et al.* (2015) were limited to MMEs in wild populations. Invasive aquatic species or introduced exotic species have occasionally been carriers of pathogens that have induced severe MMEs in local populations naive for those micro-organisms. There is the potential for impacts on trade, with sanitary measures having a severe economic impact on production.
Background	• An analysis of MMEs in wild populations from 1940 to 2012 found that such events have become more common for birds, fish and marine invertebrates, but have declined for amphibians and reptiles and not changed for mammals (Fey *et al*., 2015)	Information from country presentations, Internet and recent publications. In wild populations, MMEs can be staggering in their magnitude, killing over 90% of a population, resulting in the death of over a billion individuals, or producing 700 million tonnes of dead

Chapters	Annotation	Comments/Available guidance documents
	• MMEs appear to be occurring more frequently in time, and to be largely associated with disease and biotoxicity (Sielpielski *et al*., 2014) • Some recent examples of mass mortalities caused by environmental factors and biological pathogens. • Some estimates of socio-economic impacts of recent mass mortalities. • Requests to FAO for assistance have indicated that member countries are often weakly prepared and ill-equipped to deal with MMEs.	biomass in a single event. For example: Australasian pilchard mortalities (see Jones *et al.*, 1997). MMEs can cause proportionally similar losses in populations of cultured aquatic animals, leading to major socio-economic impacts on industries and the human populations that depend on them for food and/or income. For example, World Bank (2014) documents the socio-economic impacts of infectious salmon anaemia (ISA) in Chile, early mortality syndrome (EMS) in Viet Nam and white spot syndrome (WSS) in Mozambique. In non-aquatic populations, MMEs with the largest magnitudes were those that resulted from multiple stressors, starvation and disease (Fey *et al*., 2015). Countries may also lack laboratory facilities for disease diagnosis and professional services for a rapid diagnosis.
Objectives	• To provide a guidance document that will assist national Competent Authorities and private-sector aquaculturists to deal quickly, efficiently and effectively with MMEs affecting stocks of cultured and wild aquatic animals.	Strong emphasis must be placed on the essential need for governments to do adequate emergency response planning and management.
Scope	• A guide for users: Includes guidance for dealing with MMEs of aquatic animals (fish, crustaceans, molluscs, amphibians, etc.) whose causes may be biological pathogens, extreme abiotic conditions or of unknown cause.	Responsibility for various groups of aquatic organisms may be spread across several agencies, depending of the individual country. Co-ordination and communication are thus essential.
Intended audience	• National Competent Authorities and aquaculturists charged with front-line responsibility for investigating mass mortalities of aquatic animals. • Senior government policy-makers and other stakeholders responsible for aquaculture and aquatic biosecurity.	
Definition of a mass mortality event	• Abnormal mortality events (MMEs) are rapidly occurring catastrophic demographic events that punctuate background mortality levels (Fey *et al.*, 2015).	What is called mass mortality depends on the country- or animal species-dependent definition. In general, MMEs would be of a magnitude sufficient to cause substantial

Chapters	Annotation	Comments/Available guidance documents
	• As applied to aquaculture, the sudden death of cultured aquatic animals or plants in numbers sufficient to represent a serious economic loss. • As applied to natural waters, the sudden death of wild aquatic animals in numbers large enough to cause widespread notice and concern among fisherfolk and/or economic, health and environmental implications.	losses to aquaculture and/or attract widespread public notice and concern.
Definition of emergency in aquaculture	• Any of the following may constitute an emergency in aquaculture: o Occurrence of an abnormal mortality event in a population of cultured aquatic animals. o A country's first detection of an OIE- listed disease (infection with a certain pathogen) in a population of cultured aquatic animals. o A country's detection, outside of an existing zone of control, of a listed pathogen that is under specific control measures, and which is of national concern. o A country's first detection, outside of an existing zone of control, of an emerging disease (as defined by OIE) which is of national concern.	Note that the purpose of this document is to develop a TOC for a document providing guidance on MMEs. Thus some aquaculture emergencies will fall outside its scope. Note that the definition of an emergency in aquaculture is case dependent. An event that has serious socio-economic consequences and at the extreme it may affect the national economy. This could, for example, range from a single case of an infectious agent to an undefined MME.
PHASES IN AN EMERGENCY		
• **Preparedness phase**	• Having established the legal foundation to act with authority. • Having the required organizational structure, mandates, reporting mechanisms, expertise, equipment and financial resources in place to react immediately to a report of an MME. This includes creating awareness within the aquaculture industry of the need to report to the competent authority.	Criteria need to be established for initiating a response by the competent authority. For example, minor losses in a localized area would generally not cause mobilization of the response team.
• **Response phase**	• Actions to be taken during an MME event.	Ability to respond immediately should be established, thus a maximum acceptable response time should be established.

Chapters	Annotation	Comments/Available guidance documents
		For example, minor losses in a localized area would generally not cause mobilization of the response team. Initial reporting responsibilities lie with aquaculture industry, fisheries and the general public. Standard operating procedures (SOPs) should be followed for investigation.
• **Recovery phase**	• Analysis by the national competent authority of what worked and what could be improved (e.g. modification of response SOPs)	Terms of reference (TORs) for evaluation would need to be developed and then modified on a case-by-case basis. In some cases where performance was unsatisfactory, an independent review panel may be needed (drawn from the competent authority, academia and the private sector). Efforts should be made to restore business continuity
• **Review phase**	• Analysis by the national competent authority of what worked and what could be improved.	TORs for evaluation would need to be developed and then modified on a case-by-case basis. In some cases where performance was unsatisfactory, an independent review panel may be needed (drawn from the competent authority, academia and the private sector)
ELEMENTS OF AN EMERGENCY RESPONSE (Ideal situation)		
• **Early warning**	• National competent authority and aquaculturists have advance awareness of the possibility of unusual weather events occurring. • National competent authority and aquaculturists are aware of disease situation globally and regionally.	Surveillance system for detection of pathogens established based on risk analysis. Disease manuals (as part of contingency plan) should be prepared in advance. Communication networks are established and used by key staff. Awareness/interest created within the industry and other stakeholders of the need to report MMEs in natural environments.
• **Early detection**	• National competent authority receives notification of an MME while it is occurring, rather than after it has occurred.	Requires awareness of need for rapid reporting among aquaculturists, fishermen and the general public (all interested and concerned parties). Surveillance will help early detection.

Chapters	Annotation	Comments/Available guidance documents
		“Hotline” for reporting should be set up. Guidelines for information to be included when reporting may be useful.
• **Early response**	• Response team is activated and reaches mortality site within 24 hrs of initial notification.	Criteria for initiating a rapid response by field crew needs to be established. Not all reports will initiate a response. All requirements for rapid response have been addressed by good emergency response planning.
PREPAREDNESS PHASE		
Advance preparation and operational planning	• Information is available in documents. Details of planning, expertise needed, logistics, etc. will vary depending on country situation (aquaculture systems, species cultured, diseases of concern, etc.) • Designated emergency funds must be available for rapid access.	FAO will prepare an overall strategy manual; each country needs to prepare a formal emergency plan and other country-specific documents (e.g. disease manuals, disposal guidance, etc.) FAO disease manuals for AHPND and IMNV can serve as templates. Refer to guidance in Arthur *et al*. (2005).
RESPONSE PHASE:		
Initial Response		
Situational assessment	• Key focal point/senior officer in competent authority to assess “hotline” report to determine if the response team should be activated.	The investigation phase is the earliest part of a response, and may present great uncertainty in terms of understanding the epidemiology of an MME and may require a hypothesis to test these (Morgan, 2019). Criteria or checklist for response team activation should be developed.
Seeking internal assistance	• Involvement of key groups and individuals. This could be termed formation of 2nd level team. • Includes specialists in aquaculture, environment and disease diagnostics, as appropriate.	Depending on findings of the initial response team, assistance from specific experts or laboratories may be needed. Lists of available expertise and laboratories should be developed. MoAs with key individuals and laboratories should be in place to provide rapid access/participation.
Seeking regional and international assistance	• International assistance should be requested only in cases where the response team and internal assistance have been fully activated and are unable to provide a preliminary or confirmatory diagnosis.	OIE Reference Centers may provide confirmatory diagnosis or assist with identification/characterization of emerging diseases. However, this will require time, and local authorities must implement precautionary preventive

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	• Assistance from international agencies (e.g. FAO, OIE and others), research laboratories and experts can be sought. However, the lag time between receipt of request and mobilization of an expert team makes this a choice of last resort.	measures even if the cause of the MME has not been identified. A list of OIE and other reference laboratories and their areas of expertise, as well as a database of other expert and laboratory facilities should be made available.
Communication	• Internal communication and engagement with the general public, including early warning to farmers and other concerned parties, and then international reporting. • Communication strategies should be developed and implemented as part of preplanning.	competent authority spokesperson to media should be already designated and briefed. To avoid misinformation and confusion, only an officially designed spokesperson should provide information to media.
DECISION-TREE FOR DEALING WITH MASS MORTALITY EVENTS		
Initial Response	• Immediate actions to be taken by competent authority	Assess if the magnitude and nature of the event justifies a full response. If so: Send an expert to the site of mortality to record and evaluate the situation, including reading the history of the event (farm records of the last week, including weather records, power cuts, other). Make a preliminary diagnosis/suspicion, and inform the farmer, also on next steps. Communicate with relevant stakeholders, including potentially impacted communities. Take steps to contain the risk and reduce likelihood of spread, including correct disposal of mortalities, treatment of potentially infected water. Test for environmental causes, like poor water quality. Conduct on-site diagnostics and collection of sample specimens (both with and without signs of disease) for diagnostic testing. Epidemiological base needed here for choosing scenario, based on diagnostic experience and the rapid risk estimation. Criteria for the authorities to take action.

Chapters	Annotation	Comments/Available guidance documents
		• What to do? • When to do? Immediately. • How to do? • By whom? Assemble an investigation team or contact external experts as soon as possible.
Situational evaluation	• Is the mortality covering a whole waterbody (go to Scenario 1, 2 or 3), or is the mortality focal in only certain units of a connected site or open water (go to scenario 1 or 3)? • Field assessment by the response team determines whether the situation in hand is Scenario 1, 2 or 3	For each scenario the competent authority needs to use the decision-tree, to be sure to be in the right scenario. If the Scenario involves a pathogen or an unknown cause, immediately implement additional biosecurity measures.
Scenario 1	• MME is suspected to be pathogen related	Review initial recommendations and strengthen biosecurity as required. Immediate implementation of restrictions on movements of aquaculture organisms and visitors, quarantine of facilities and other containment measures is likely. SOPs for implementation of movement restriction and quarantine must be available Rapid action to identify the pathogen must be taken.

Scenario 2	• MME is suspected to be primarily environmentally caused, e.g.:
	  o Biotic: algal blooms
	  o Abiotic: climatic extremes (temperature fluctuation, flooding, drought), oxygen stress, starvation
	  o Human causes: chemical spills; other types of pollution
		Stop any water exchange. Consider aeration.
		
		Assessment of aquaculture practices may lead to recommendations to modify culture methods or use an alternate species so as to avoid repeat.
		
		Actions may be recommended for facilities that have not yet suffered major losses (e.g. increased aeration, emergency harvest, moving cages to unaffected area).
		
		SOPs for handling, collection, transport and disposal of mortalities, and for cleaning and disinfection of facilities.

Scenario 3	• MME is of unknown/uncertain cause	Assume a biological cause until proven otherwise. Implement restrictions on movement of animals and/or quarantine measures as appropriate.

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		Often, the cause of a MME may be difficult to assign to either pathogen or environment. The role and interaction of environmental stressors, opportunistic pathogens and co-infections needs to be recognized. In recent kills/mortalities in wild fish, the first, easily cultured or most obvious pathogen is often initially blamed, but further analyses show multiple opportunistic bacterial pathogens, sometimes viral infection and often high parasite loads, all of which can contribute to mortality. However, the underlying "cause" could be sublethal contaminant exposure or other environmental stressors. Sometimes these underlying causes (e.g. pesticide runoff, sewage) can be managed if recognized.
CONDUCTING FIELD INVESTIGATION		
Consultation with affected fish farmers	• Observations made during mortality occurrence may provide clues to cause.	Sheet/guidelines for interview of fishfarmers to be available for collection of field information.
Field sample collection	• Samples to be collected will be determined by Scenario and should be collected during the MME. • Sampling can include water and sediments, whole fish and/or selected tissues. • If the cause is clearly an environmental factor, sampling may not be necessary. Or only sampling of water and sediments to confirm.	Standardized guidelines for recording of field data. Standardized guidelines/procedures for sampling of water and sediments. Standardized guidelines/procedures for sampling of diseased/ moribund/ dead aquatic animals. Samples taken from decaying animals will have little/no value. Guidelines on proper preservation and shipping of samples to laboratory – requirements may vary depending on sample and type of examination.
Laboratory tests	• Testing of water and sediment samples and aquatic animals should be done as quickly as possible using a local laboratory. • If necessary, samples can be sent to regional or international reference laboratory for confirmation.	List of tests to be run. List of local/national laboratories. List of regional and international reference laboratories.
Surveillance	• If MME is due to a pathogen that has been introduced to the country (first finding) or a serious pathogen that is under a control programme, then a	Surveillance programme will need to be set up tailored to pathogen and country specifics.

Chapters	Annotation	Comments/Available guidance documents
	surveillance programme may need to be established. • For first reports, nearby farms and natural waters should be tested to determine the extent of pathogen distribution and options for preventing further spread or possibility of eradication.	Pathogen distribution will determine if eradication or containment is feasible. If pathogen is now enzootic in natural waters, eradication from individual aquaculture facilities by stock destruction, draining, disinfection, use of specific-pathogen-free (SPF) stocks, etc. accompanied by improved biosecurity measures may allow successful aquaculture production.
Risk communication	• Aquaculturists in uninfected areas of the country should be advised of the risk of infection (infected and resistant species, routes of infection) and biosecurity measures they can take to avoid their facilities becoming infected.	Where they exist, fish farmer associations or other professional associations can assist with this activity.
Immediate actions to be considered by competent authority	Define the extent of the MME and, if possible, identify epidemiological units (establishment, compartment and zone (refer to OIE terminology). • Implement, as needed: o Movement restrictions or ban o Effluent control o Quarantine of farm or farms o Blocking of outlet canal o Emergency harvest o Control and protection zone o Bans or trade restrictions o Notification of trading partners, OIE, NACA o Destruction of stock, sanitary disposal, disinfection of ponds and facilities o Address transboundary responsibilities on shared waterbodies	Re-establish movements through permitted process. Establish criteria to release from quarantine to allow continuity of business. Blocking of outlet canal, if possible. Address human component.
Actions following identification of cause of mortality events	• Competent authority should conduct a "post-mortem" analysis of the actions taken during each MME to determine areas of the emergency response plan that can be improved.	
Dealing with mortality events in wild populations	• Get information from experienced countries or agencies. • Provide information to to all stakeholders including fish farmers, other countries in case of shared waterbodies, etc.	Often little can be done. Consider possible adaptive management strategies (for instance, where a single fish species dominates due to trophic changes brought about by eutrophication, climate change, increasing fishing pressure may help to normalize abnormal biomass.)

Chapters	Annotation	Comments/Available guidance documents
		For pathogens, surveillance, disinfection (if confined to a small waterbody), bans on movement of live and fresh aquatic animals may slow spread to new areas. When new pathogens are detected in wild fish in a new geographic area, public outreach to anglers, boaters etc. may help slow the spread through providing information on disinfecting of boats and equipment, in addition to bans on fish movement.
Impacts of mortality events	• Socio-economic impacts of MME should be assessed by the national competent authority using a standardized assessment protocol. • Impacts include both direct and indirect losses. Direct losses are e.g. loss of stock, cost of stock destruction, disinfection and down time, while indirect losses include reduced potential for future aquaculture, losses to secondary industry (processing, feed sellers), loss of incomes to all players along the aquaculture value chain, impacts on local communities, impacts on domestic markets, impacts on international trade. • Expenditures include costs of diagnostics, research, communications, training, enhanced surveillance, enhanced biosecurity, vaccination, sanitary measures.	Impact assessment guidelines may need to be developed by FAO. Consider the direct costs as they apply to the establishment/compartment/ control zones/rest of country, and costs borne by the authorities. Consider the indirect costs to all of the above plus the wider economy. Consider the impacts on human livelihoods and food availability. Consider the cost on the environment. In general, Cost = losses + expenditures.
RECOVERY PHASE		
Post-mortem evaluation and improvement and follow-up actions	• Costs and impacts (both direct and indirect) of MME should be estimated. • Accurate estimates of losses suffered will provide stronger justification for support to emergency response. • Aquaculture managers will need to review aquaculture systems, biosecurity and management practices in order to resume production.	Guidelines/standardized procedures for assessing the costs and impacts of MMEs are needed.
What are the minimum preparedness and advance	• Crosscutting issues – training, capacity building, gender, etc.	To be developed. Possible to do this as a checklist?

Chapters	Annotation	Comments/Available guidance documents
preparedness requirements and actions needed?	• What are the minimum things any country should have in place? • For advanced countries?	Training is required at two levels: - Training of field team biologists to be able to analyse the situation on site and conduct proper sampling and sample preservation. - Training of laboratory staff for rapid proper diagnosis In less advanced countries, these two points have often been the reason for delay in setting up of contingency measures.
TOOLS, GUIDANCE, STANDARDS	• Guidance to aquaculturists and others for reporting a MME to the competent authority. • List of information to be collected on site • Standardized sampling procedures	Contingency planning guide SOPs – quarantine, etc. Disease manual for aquaculturists Up-to-date diagnostic manual for diagnostic laboratories Disease response manuals To be assembled as an Annex?
Emergency Response Tools	• Checklist of information to be gathered • Standardized sampling procedures • Emergency kit • List of country-level laboratories • Expertise on fish disease	Also as an Annex?
When to seek external (regional and international assistance) and information that need to be provided	Confirmation of causative agent	
Case study examples	China – selected diseases Ghana – ISKNV KSA – WSSV Norway - ISA Thailand – TiLV USA - VTC Zambia – EUS	To be requested from country presentors

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A Round-table discussion: moving forward through lessons learned on response actions to aquatic animal disease emergencies, organized by the Food and Agriculture Organization of the United Nations in collaboration with the Norwegian Agency for Development Cooperation was held from 16 to 18 December 2019 at the FAO headquarters in Rome, Italy. Forty four experts from 22 countries, representing intergovernmental organizations, academia, research institutions and the private sector participated in this event. The meeting was informed of experiences and lessons in dealing with aquatic animal disease emergencies from the lens of governance authorities, intergovernmental organizations and the producer and research/academic sectors. The 20 technical presentations delivered provided important and useful recommendations for the further development and improvement of the draft FAO Decision-tree for dealing with aquatic animal mortality events, and supporting guidance.

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