AMR in Aquaculture: Proposal

Contents

Abbreviations

AAH:	Aquatic animal health
AAHP:	Aquatic animal health professionals
AAHS:	Aquatic Animal Health Services
AAHSC:	Aquatic Animal Health Standards Commission
AHG:	*Ad hoc* Group
AMR:	Antimicrobial resistance
AMR & VP:	Antimicrobial Resistance and Veterinary Products
AMU:	Antimicrobial use
AST:	Antimicrobial susceptibility testing
CAHS:	Centre for Aquatic Health Services
CEFAS:	Centre for Environment, Fisheries and Aquaculture Sciences
CC:	Collaborating Centre(s)
FAO:	Food and Agriculture Organization of the United Nations
FP:	Focal Points
HQ:	Headquarters
LMIC:	Low- and middle- income countries[1]
NAP:	National Action Plan
NVI:	Norwegian Veterinary Institute
OIE:	World Organisation for Animal Health
PPP:	Public-Private Partnership
PVS:	Performance of Veterinary Services
RL:	Reference Laboratory(ies)
RR:	Regional Representation(s)
SRR:	Sub-Regional Representation(s)
VLSP:	Veterinary Legislation Support Programme
VS:	Veterinary Services
WHO:	World Health Organization
WG:	Working Group

[1] According to World Bank classification

List of Tables and Figures

List of Tables

List of Figures

Summary statement

Title	AMR in Aquaculture[2]: Proposal
Start date	2020
Duration	Five years
Country/Region	Global
Beneficiaries	OIE Members
Cost	1,371,259 EUR
Outcomes	- Awareness on AMR/AMU in aquaculture is raised globally - Responsible and prudent AMU and control of AMR in aquaculture is increased - Monitoring and surveillance of AMR/AMU in aquaculture is improved
Goal	Members effectively control AMR in aquaculture
Purpose	This proposal aims to enhance the OIE's tools and activities to effectively manage AMR in aquaculture, such as developing guidelines, harmonising standards, developing communication resources, updating publications, delivering training, connecting experts, and supporting existing programmes. Resources to address AMR/AMU to support Members to engage in responsible and prudent AMU and to build capacity to control AMR arising from AMU in aquaculture are required.

[2] Referred to the farming of aquatic animals with some sort of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc.

Goal statement

The goal of this proposal is to enhance the World Organisation for Animal Health (OIE)'s support to their Members in order to effectively control antimicrobial resistance (AMR) in aquaculture.

Purpose

This proposal addresses the goal by analysing existing OIE tools and activities, including guidelines, standards, and support programmes, that are used to assist Members. It proposes actions aiming to use or enhance those tools and activities relevant to effectively and efficiently controlling AMR arising from AMU in aquaculture.

In order to raise awareness of AMR and antimicrobial use (AMU) in aquaculture, this proposal expects to set up a coordinated network of experts on AMR in aquaculture, to produce OIE evidence delivered globally, and to broaden targeted communication resources. Likewise, in order to promote responsible and prudent AMU and increased control of AMR in aquaculture, this proposal is expected to result in a fine-tuned OIE *List of Antimicrobial Agents of Veterinary Importance*, training of National Focal Points (FP) on AMR/AMU in aquaculture, updated technical publications, further developed OIE international standards for AMR, and the use of the OIE Performance of Veterinary Science (PVS) pathway to build capacity in Members' Aquatic Animal Health Services (AAHS). Finally, to improve monitoring and surveillance on AMR/AMU in aquaculture, this proposal is expected to bring about a refinement of the OIE AMU global data collection for aquatic animals, and strengthened collaboration within the Tripartite to carry out programmes addressing AMR in aquaculture.

Context and need for intervention

The issue of AMR in aquaculture

The significance of aquaculture as a source of high-quality nutrients and in supporting the economies of millions of people globally is undeniable. In fact, aquaculture contributes to several of the United Nations Sustainable Development Goals for 2030, including goal two, Zero Hunger [1]. In recent decades, increased demand for food along with depleted wild fish stocks and intensification of husbandry techniques made aquaculture the fastest growing food production sector. Globally, total aquaculture production accounts for around 50% of overall seafood supply. In 2018, global aquaculture production reached 82.1 million tonnes of aquatic food producing animals valued at USD 250.1 billion [1]. However, the importance of aquaculture production growth is not only in boosting the economies of exporting countries, but also increasingly in contributing to the diets of their domestic populations, mostly low- and middle-income urban and rural consumers [2]. Unfortunately, the intensification of aquaculture together with its globalisation has caused more frequent and more detrimental disease outbreaks. Health issues commonly result from stressful conditions due to increased stocking densities and are often accompanied by reduced water quality. This is exacerbated when, due to movement of aquatic animals, pathogenic agents reach naive hosts in new geographical areas.

As with livestock farming, the use of antimicrobials in aquaculture increases when prophylactic alternatives (e.g. vaccines, probiotics, immunostimulants) are not available or not effective, or when health management practices are deficient. Given the remarkable growth of aquaculture worldwide, and signs of misuse or overuse of antimicrobials, there is reasonable concern about the contribution of aquaculture to AMR in the environment, and the consequences for environmental, animal, and

human health. Antibiotics in aquaculture are mainly administered through feed to an affected population. In semi-open aquaculture systems [3], undigested medicated food and fish faeces, containing unabsorbed antibiotics and excreted antimicrobial metabolites, end up in the waters and sediments surrounding fish farms, where they can remain active for several months [3]. In semi-closed aquaculture systems[4], eventual wastewater discharges release high loads of organic matter into the environment with bacteria exposed to antimicrobials during treatments. Subtherapeutic levels of antibiotics in the aquatic media exert selective pressure for antimicrobial resistant bacteria and favour horizontal transmission of AMR genes, which can persist in the environment for several years [4]. In fact, antimicrobial resistant bacteria and AMR genes to various antibiotics have been found in the proximity of aquaculture settings, to the point of being considered "genetic hotspots" [5,6].

The negative consequences of AMR arising in aquaculture settings are the selection of antimicrobial resistant bacterial pathogens of aquatic animals, terrestrial animals, and humans which may result in ineffective treatments and changes in the composition of environmental bacteria. AMR in animal and human bacterial pathogens could occur either by the direct selection of resistant variants or, indirectly, through the transmission of AMR genes within the aquatic environment, from the aquatic to the terrestrial environment, or vice versa. The risk of selecting antimicrobial resistant bacteria relevant to human health in the aquatic environment is limited, as the number of zoonotic bacteria that infect aquatic animals is restricted to a few species (e.g. *Vibrio vulnificus*). Thus, a higher risk is associated with the transmission of AMR genes crossing the aquatic-terrestrial interface. There is also potential risk to public health by direct infection with antimicrobial resistant enteric bacteria (e.g. *Salmonella* spp.) in aquaculture products. However, the occurrence of these bacteria would be the result of contamination from human or animal wastes that could have acquired resistance in the aquatic or terrestrial environment.

Most of the frequently isolated bacterial pathogens of aquatic animals have been found to be resistant, harboring various AMR genes. AMR pathogens of fish, such as *Aliivibrio salmonicida, Aeromonas hydrophila, A. salmonicida, Edwardsiella ictaluri, E. tarda, Flavobacterium psychrophilum, Lactococcus garvieae, Photobacterium damselae* subsp. *piscicida, Piscirickettsia salmonis, Pseudomonas* spp., *Streptococcus iniae, S. parauberis, V. anguillarum, Y. ruckeri*; and AMR pathogen of shrimps such as *Aeromonas* spp., *V. parahaemolyticus*, *Vibrio* spp., have been documented to harbour antimicrobial resistant genes [6,7].

The flow of antibiotics, antimicrobial resistant bacteria and AMR genes in common aquaculture systems associated with other activities and the environment is schematised in Figure 1.

[3] Refers to systems where it is not possible to have control over the water entering or exiting the system (mostly fish net-pens in natural waterways such as lakes, estuaries, and coastal marine regions). In these systems, some aquatic animals and vectors may also enter and exit.

[4] Refers to systems where there is some control over the water entering and exiting the system (mostly land-based production systems and enclosed floating pens). Aquatic animals and vectors may be prevented from entering and exiting the system, however there is limited control to prevent the entry or exit of pathogenic agents.

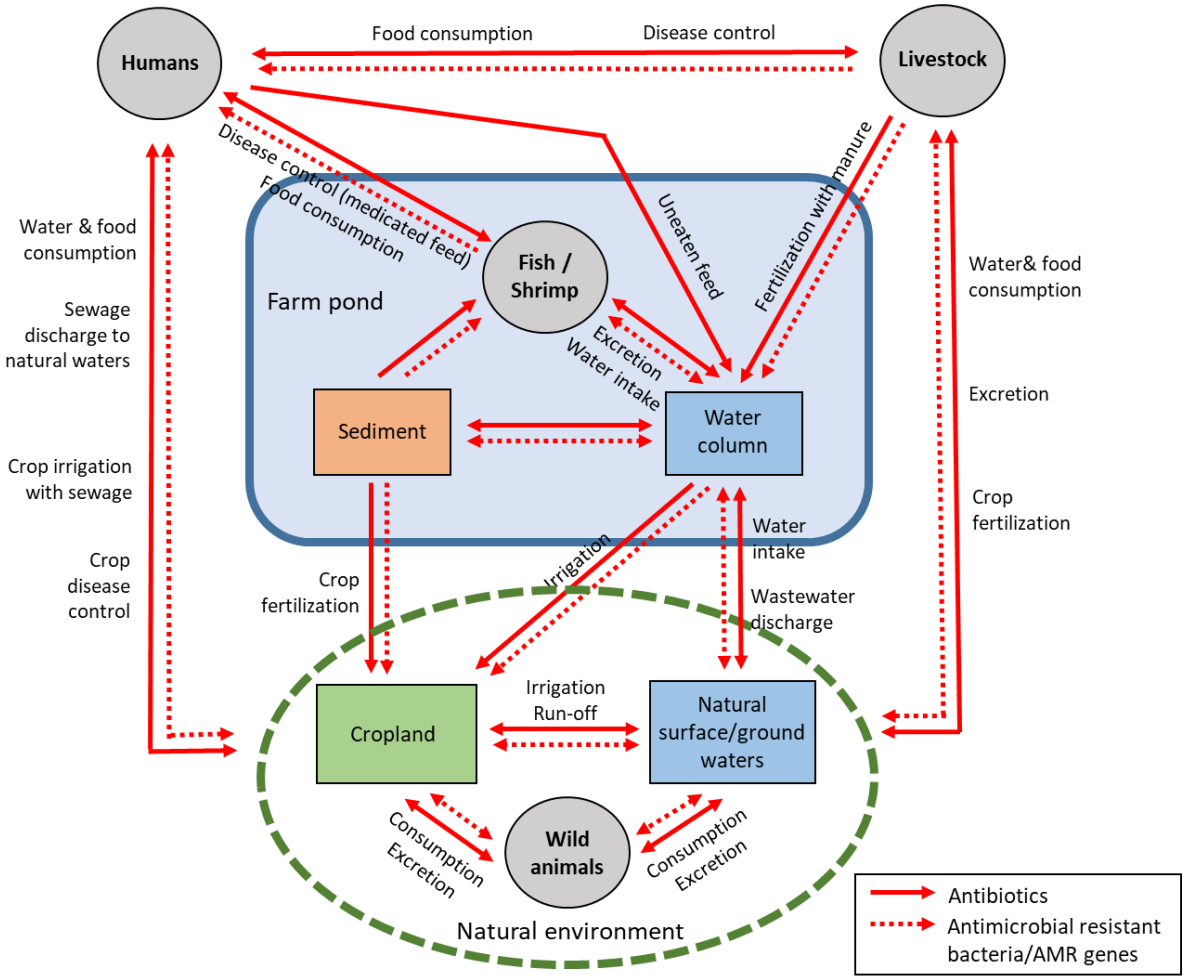

Figure 1: Flow of antibiotics and antimicrobial resistant bacteria and AMR genes related to common aquaculture systems associated with other activities and the natural environment (adapted from [8])

Background to the proposal

The OIE has had a mandate to address Aquatic Animal Health (AAH) since 1965. In 2010, Section 6 *Antimicrobial Use in Aquatic Animals* was added to the OIE *Aquatic Animal Health Code* (*Aquatic Code*), but resources to create awareness on AMR and promote responsible and prudent AMU in aquaculture have been limited.

Given the increasing importance of aquaculture for food security, and in ensuring employment and preserving economies globally, the OIE is progressively assuming the commitment to actively and effectively respond to Member countries' needs in this sector. Following a One Health approach, the OIE is becoming involved in activities to support control of AMR in aquaculture. This was documented in the recommendations of the 4th OIE Global Conference on Aquatic Animal Health: Collaboration, sustainability – our future (Chile, 2019) to which this proposal responds:

- Recommendation 5, "Assist Member Countries in strengthening their Veterinary Services or Aquatic Animal Health Services to promote good governance practices including national legislation and regulatory frameworks, with specific emphasis on the prevention of aquatic animal diseases and prudent use of antimicrobial agents in aquatic animals";
- Recommendation 7, "Continue to encourage governments, relevant regional and international organisations and donors to provide resources for applied research in vaccines,

alternative therapeutics and other management approaches to reduce the need for use of antimicrobial agents in aquatic animals, including consideration of the regulatory processes to efficiently authorise commercial use of these alternatives";

- Recommendation 11, "Encourage governments and donors to invest in Aquatic Animal Health Services, and to strengthen their work on prevention, control and eradication programmes for aquatic animal diseases and more fully comply with the OIE international standards, including through making full use of the OIE PVS Pathway".

This proposal also addresses the earlier recommendations of the 2nd OIE Global Conference on Antimicrobial Resistance and Prudent Use of Antimicrobial Agents (Morocco, 2018),

- Recommendation 1, "To continue updating OIE standards in the OIE Terrestrial and Aquatic Codes relevant to AMR and needed capacities of Member Countries and to complete standards in the OIE Terrestrial and Aquatic Manuals";
- Recommendation 3, "To continue to develop the OIE List of Antimicrobial Agents of Veterinary Importance, considering… b) the sub-division of the List in the different animal species…".

In order to address AMR in the aquaculture sector, the OIE was funded by the Norwegian Agency for Development Cooperation to recruit an expert to develop a detailed work proposal related to AMR in aquaculture (present document).

Engagement with existing activities and scope

The outcomes that this proposal is expected to achieve are aligned with the workplans established for achieving the four objectives of the OIE *Strategy of Antimicrobial Resistance and the Prudent Use of Antimicrobials* released in 2016. They also contribute to the Objective 3: *Solidarity* (Activity 3.4 *Practical AMR guidance*[5]) of the new OIE *Aquatic Animal Health Strategy* that will be launched by 2021.

The scope of this proposal is the focusing and enhancing various OIE tools and activities to respond to Members' needs to control AMR arising from AMU in aquaculture. The interventions are projected to achieve ten outputs in a five-year timeline. However, to achieve the expected results, inputs from and collaboration with various Departments of the OIE Headquarters (HQ), Regional Representations (RR) and Sub-Regional Representations (SRR), Working Groups (WG) and *Ad-hoc* Groups (AHG), Aquatic Animal Health Standards Commission (AAHSC), partners and experts relevant to AMR in aquaculture will be required as well as resources to fund these activities.

Evidence

The need for intervention to control AMR in aquaculture is evidenced by the abundant scientific literature that reveals high levels of AMR in aquaculture environments and the associated risks to human, animal, and environmental health, especially in low- and middle- income countries (LMIC). Moreover, as the pressure on food security and climate change intensifies, AMR in aquaculture would continue increasing affecting mostly countries with higher temperatures [9].

Indiscriminate use of antimicrobials is common in many countries, including various top aquaculture

[5] "This activity will identify how the OIE can support Members to better address the prudent and responsible use of antimicrobial agents, while improving access to appropriate and effective veterinary medicinal products to better control antimicrobial resistance in aquaculture. This Activity, which will be complementary to the OIE AMR Strategy, will build on existing OIE initiatives and enable the OIE to develop tools that support Members to manage the threats of AMR in the aquatic sector."

producers. An average use of 15 antibiotics per country, have been found in the top 15 aquaculture producing countries [4]. An essential measure to minimise the risk of AMR in aquaculture is to monitor and control AMU at a national, regional, and global level, involving farmers, veterinarians/aquatic animal health professionals (AAHP) and Veterinary Services (VS)/Aquatic Animal Health Services (AAHS). However, in aquaculture, monitoring AMU is a complicated task due to the great diversity of species and culture systems, the unconsolidated nature of production in many regions, and the commonly unregulated use of antimicrobials. Over 90% of the world aquaculture production is carried out in in LMIC where regulation and enforcement, as well as practices and resources in aquaculture are limited [5], and the use of falsified antimicrobials is not uncommon [10]. In addition, the diversity in AMU in aquaculture in several LMIC is significant, which mostly reflects the number of species cultivated. Furthermore, often antimicrobial treatments are administered without professional consultation or uninformed by any susceptibility testing. Due to the high costs of developing new antibiotic molecules, antibiotic agents used in aquaculture are also used in human or veterinary medicine. Six common classes of antibiotics (aminoglycosides, macrolides, penicillins, quinolones, sulfonamides, and tetracyclines) regularly used in aquaculture (and in livestock) are listed by the World Health Organization (WHO) as critically or highly important antimicrobials [11,12]. The approval of antibiotics in LMIC have commonly been based on food safety hazards and national standards or international export quality standards, with enforcement programs limited to exported products, likely leaving domestic products untested [13].

The use of vaccines to control aquatic animal diseases has proven successful in decreasing AMU in some countries producing highly valuable fish (i.e. salmon), yet the low profitability of markets of low-intensity systems in many regions discourage pharmaceutical companies from developing vaccines for lower-value fish [14] . The lack of acquired immunity in crustaceans, on the other hand, often leads to a greater dependence on antibiotics in the shrimp farming sector. Use of probiotics as pathogen inhibitors may present an alternative for reducing the need for antibiotics. However, probiotic bacteria are not exempt from acquiring resistance through horizontal gene transmission [5].

External sources of AMR such as livestock and human wastewaters that affect aquaculture environments should not be overlooked. In LMIC, combining livestock and aquaculture in integrated farming systems presents an option for increased productivity, yet the potential exchange of antimicrobial resistant bacteria and their genes from livestock wastes increases the risk of AMR in those systems [3]. The fact that multi-antibiotic resistance indices found globally from aquaculture-related bacteria (Figure 2) correlate with multi-antibiotic resistance indices from human clinical bacteria [9] also makes evident the need to embrace a One Health approach to tackle AMR.

Country and regional programs for the surveillance and monitoring of AMR in bacteria isolated from aquatic animals are necessary, as described in the OIE *Aquatic Code*. These programs should follow standardised laboratory methods and harmonised interpretative criteria [7,15]. Similarly, it is essential to reinforce AMU global and country databases for aquatic animals to determine the species and the geographical areas that require their practices to be improved [13]. Emphasis on good management practices are essential as well as promotion of alternatives to the use of antimicrobials. The development and use of vaccines are considered an important strategy to avoid the need for antibiotics in fish aquaculture [16,17]. All these measures require farmer education, laboratory capacity, access to AAHP or veterinarians, sound domestic policies and regulations with the capacity for enforcing them, and fluid coordination between AAHS with other relevant authorities.

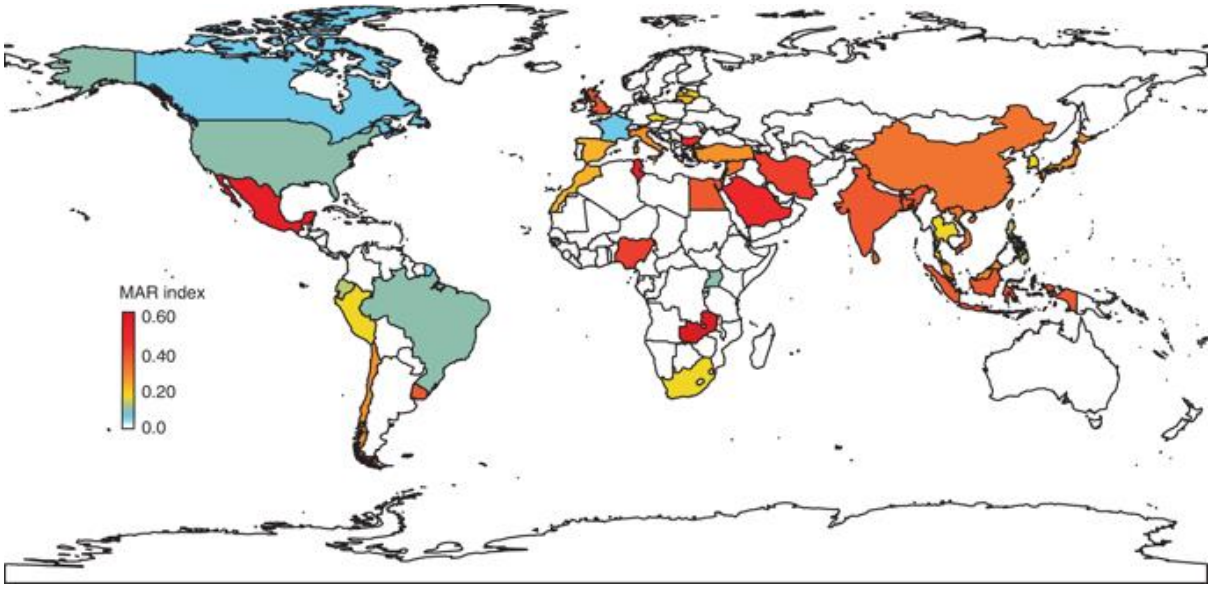

Figure 2: Global multi-antibiotic resistance index calculated from aquaculture-derived bacteria. No index was calculated from countries in white [9].

Result chain and Theory of Change

Results chain

A results chain for this proposal has been prepared (Table 1). It is based on assumptions of how the proposed strategy for interventions (See Expected outcomes, outputs, and suggested activities section) will contribute to the OIE's support to its Members to effectively control AMR arising from AMU in aquaculture. It is expected that the results will be reflected in informed decisions in the aquaculture sector related to control of AMR and responsible and prudent AMU. This in turn will lead to a decrease in AMR and, eventually, to a reduced impact of infectious diseases on aquatic animal health and welfare, food security, and economic development.

Table 1: Implementation of the Proposal on AMR in Aquaculture

Inputs	Activities	Outputs	Outcomes	Impact goals
- OIE's staff time	A1: Establish a network of professionals working on AMR in aquaculture	O1: Coordinated network of experts on AMR in aquaculture established	1. Awareness of AMR/AMU in aquaculture is raised globally	- Informed decisions in
	A2: Participate in relevant fora and global conferences to highlight OIE's role	O2: OIE's evidence on AMR/AMU in aquaculture disseminated at global events of aquaculture and AAH		
	A3: Develop additional communication and behaviour change resources to create awareness of	O3: Communication resources broadened to address AMR/AMU in aquaculture		

- Partners' engagement - Economic resources - OIE expertise (HQ & RR/SRR staff, WG, AHG, CC, RL) - Members' engagement	AMR/AMU in aquaculture			aquaculture sector related to AMR/AMU - Decrease of AMR arising from AMU in aquaculture - Reduced impact of infectious diseases on AAH & welfare, food security, food safety, and economic development
	A4: Develop an annex for aquatic animals in the OIE *List of antimicrobial agents of veterinary importance*	O4: OIE *List of Antimicrobial Agents of Veterinary Importance* fine-tuned	2. Responsible and prudent AMU and control of AMR in aquaculture is increased	
	A5: (a) Incorporate presentations on AMR/AMU in aquaculture in seminar programmes for relevant OIE National FP (b) Development of e-modules related to AMR in aquaculture	O5: Relevant National FP trained on AMR/AMU in aquaculture through on-site and virtual formats		
	A6: OIE standards on AMR in aquaculture harmonised with their terrestrial counterpart	O6: OIE international standards on AMR/AMU further developed and updated		
	A7: Publish new OIE technical articles addressing AMR/AMU in aquaculture	07: OIE technical publications on AMR/AMU in aquaculture updated		
	A8: (a) Analyse existing PVS evaluation reports on aquatic animals (b) Participate in review of draft of legal assessment tool (c) Promote PVS Pathway programmes	O8: AMR in aquaculture addressed in the OIE PVS Pathway to build capacity in Member's AAHS		
	A9: (a) Prepare a detailed OIE Template for AMU database of aquatic animals; (b) Conduct a pilot project for AMU data collection in aquatic animals at field/farm level	O9: OIE AMU global data collection for aquatic animals refined	3. Monitoring and surveillance of AMR/AMU in aquaculture is improved	
	A10: Strengthen coordination with FAO for supporting programmes on AMR surveillance in aquaculture	O10: Tripartite efforts addressing AMR in aquaculture strengthened		

Assumptions or conditions for success

The achievement of individual outputs and their respective activities are mostly independent of each other and would mainly depend on internal processes, e.g. coordination with other Departments, formation of expert groups and their availabilities, or coordination with OIE RR/SRR, affiliated centres or external organisations. The implementation of the proposed activities will depend on resources and partners availability. A description of the results chain based on the expected outcomes is presented below.

Outcome 1: Awareness on AMR/AMU in aquaculture raised globally

This outcome is expected to be achieved through the accomplishment of three outputs.

The establishment of a coordinated network of experts on AMR in aquaculture (Output 1: Coordinated network of experts on AMR in aquaculture establishedoutput 1), to be managed by the OIE, consisting of internal and external experts, and operating indefinitely, is envisioned. This network is meant to capitalise on the expertise within and external to the OIE for the coordinated assistance of Members' needs. This network would provide support on the dissemination of relevant technical information and would promote potential cooperation on the development and implementation of various projects, including organising and/or participating in other activities suggested in this proposal. In order to achieve this output, it will be necessary to connect with experts dealing with AMR in aquaculture within the OIE (HQ and RR/SRR), Collaborating Centres (CC), and other organisations and institutions (activity 1). This activity will require the establishment of regular meetings and the secretariat role of the Antimicrobial Resistance and Veterinary Products (AMR & VP) Department. The success of the proposed output will depend on the cooperation from relevant OIE staff, Specialist Commissions, Working Groups, and external partners that see in this network a means of synergistic efforts for common goals.

The delivery of OIE's evidence on AMU in aquaculture in the most influential conferences in aquaculture and AAH (output 2) will convey a message based on the OIE international standards on health and welfare for aquatic animals to the industry and academic audiences (in addition to the governments). These audiences are influential stakeholders, and having their activities aligned with OIE's view on AMR/AMU would contribute to a unified effort towards similar goals. To achieve this output participation at global and regional conferences and relevant fora to highlight the OIE's role is recommended (activity 2). The development of this activity will depend exclusively on internal decisions and resources.

Broadening communication resources to address AMR in aquaculture (output 3) will directly impact outcome 1. The development of additional communication resources to create awareness of AMR/AMU in aquaculture and behaviour change (activity 3) will impact various stakeholders in the aquaculture sector. This activity will be performed by the AMR & VP Department and the Communication Department, possibly in coordination with the Standards Department, and it may also require the support of relevant external experts.

Outcome 2: Responsible and prudent AMU and control of AMR in aquaculture increased

This outcome is expected to be achieved through the accomplishment of five outputs.

Fine-tuning the OIE *List of antimicrobial agents of veterinary importance* (output 4) would result in a more accurate categorisation of the antimicrobial agents used in aquaculture. By offering improved information on the antimicrobial classes available for different pathogens of aquatic animals, the fine-tuned list would provide additional and appropriate options to Member on antimicrobial treatment for aquatic animals. To achieve this output, experts will develop an annex for aquatic animals in the

OIE *List of Antimicrobial Agents of Veterinary Importance* (activity 4), and verify the existing antimicrobial agents listed, determine essential antimicrobial agents for aquaculture, and review of the main bacterial diseases of aquatic animals and their treatments. This activity will require supervision of the WG on AMR, the formation of an AHG on AMR in aquatic animals and the secretariat role of the AMR & VP Department. The OIE List would be an important document for consultation for the Members' AAHS.

Training for relevant National FP on AMR in aquaculture through on-site and virtual formats (output 5) will offer guidance to Members on various subjects of particular importance in AMR/AMU in aquaculture and build capacity in this sector. Cycles of training for FP for Veterinary Products and Aquatic Animals are on-going. These cycles could address AMR/AMU in aquaculture with systematic training by incorporating presentations on related topics through the implementation of on-site and virtual sessions (activity 5a). In addition, e-modules could be developed to reinforce subjects related to AMR in aquaculture offered in these training cycles (activity 5b). Interest by Members in this activity is assumed, especially in those regions where aquaculture is economically important. Participation of members of the network on AMR in aquaculture (output 1) and relevant CC will be important in organising and implementing this activity. The achievement of this outcome will depend on coordination between the AMR & VP Department and the Standards Department, the Secretariat of the OIE Platform for the training of VS, the engagement of Members and the contribution of relevant experts.

To further develop and update the OIE international standards for AMR/AMU in aquaculture (output 6), harmonisation of the standards on AMR/AMU in aquaculture with their terrestrial counterparts (activity 6) is required. This will allow Members to have up-to-date standards in this area. An assumption is that AAHS will actively use the OIE standards as guidance for policies and regulations directed to control AMR in aquaculture. This activity will require the approval of the AAHSC through the secretariat role of the Standards Department and will contribute to capacity building of Members' AAHS.

Updated OIE technical publications on AMR/AMU in aquaculture (output 7) will provide current information that will be helpful to Members' AAHS and academia globally on understanding AMR in aquaculture. This will also demonstrate the OIE's reinforced interest on AMR in aquaculture to the OIE community. Experts on these topics will be asked for support in publishing new articles on AMR in aquaculture in order to update the OIE technical publications in this area (activity 7). This activity will require coordination with the Publication Unit and input from the proposed AMR in aquaculture network and the CC, and will depend on the cooperation of multiple experts willing to contribute to these publications.

Addressing AMR in aquaculture through the OIE PVS Pathway is important for building capacity in Members' AAHS (output 8). This output would be achieved by analysing existing PVS evaluation reports on aquatic animals (activity 8a), participating in the review of the draft of the *One Health AMR Legal Assessment Tool* (activity 8b), and the promotion of PVS pathway programmes (activity 8c). Coordination with the Capacity Building Department will be necessary. When drafting the *One Health AMR Legal Assessment Tool*, the participation of the other members of the Tripartite will be necessary for the development of an aquatic AMR component.

Outcome 3: Monitoring and surveillance programmes in selected countries according to international standards

This outcome is expected to be achieved through the accomplishment of two outputs.

The refinement of the OIE AMU global data collection (output 9) will directly impact outcome 3. This outcome is expected to be achieved through two sub-activities: the development of a detailed OIE

Template for AMU database of aquatic animals (activity 9a) and by conducting a pilot project for AMU data collection at field/farm level (activity 9b). Through the first sub-activity it will be possible to pinpoint and monitor "hot species/groups" within the aquaculture sector (particularly fish and crustaceans) that deserve more attention, for instance, in terms of Members' regulatory processes and enforcement. The latter sub-activity will attempt to obtain a more accurate information of AMU. These activities will require the input of the RR/SRR, the WG on AMR, and the secretariat role of the AMR & VP Department. Delivery of the output will depend on the availability of resources for OIE WAHIS for incorporating the proposed sub-categorisation in their system, and on the availability of the required group of experts. For the pilot project, collaborations with partners that have similar interests, would be necessary.

Strengthening of Tripartite efforts to address AMR in aquaculture (output 10) could be achieved through coordination with the Food and Agriculture Organization of the United Nations (FAO) to increase synergistic efforts for common goals such as supporting programmes on AMR surveillance in aquaculture (activity 10). Achievement of this outcome will require a high-level commitment by the organisations involved and Members having the willingness and necessary resources to participate in a pilot project.

Impact Goals

All the outcomes described above lead to three impact goals. It is important to note that the processes external to this proposal could also contribute to the achievement of the impact goals. The first expected impact goal is to promote informed decisions in the aquaculture sector related to AMR/AMU. It is estimated that by raising awareness of AMR/AMU globally, the stakeholders in the aquaculture sector will enhance their practices and contribute from different angles to reduce AMR. An enhanced guidance role from the OIE on responsible and prudent AMU, and improved control of AMR arising from AMU in aquaculture, is expected to assist Member's AAHS in making decisions that will effectively benefit their aquaculture sector. Similarly, improving monitoring and surveillance on AMU and AMR in aquaculture will provide Member's AAHS with the information required to establish appropriate measures to control AMR. Informed decisions will lead to a second impact goal which is the decrease of AMR arising from AMU in aquaculture, and eventually towards a third goal which is a reduced impact of infectious diseases on the health and welfare of aquatic animals, food security, and economic development. With lower levels of AMR pathogens, the detrimental effect of bacterial disease outbreaks is expected to be diminished by potentially less ineffective treatments. Since diseases are known to be the primary constraint for aquaculture development, more manageable bacterial disease outbreaks would be reflected in a more prosperous and sustainable food-production sector that effectively contributes to food security globally.

Theory of Change

In order to plan and evaluate the long-term goals of the proposal a Theory of Change, with intended outputs, outcomes, and impact, has been designed and is presented in Figure 3. This will allow future interventions, when necessary, to achieve the results in the proposed pathway.

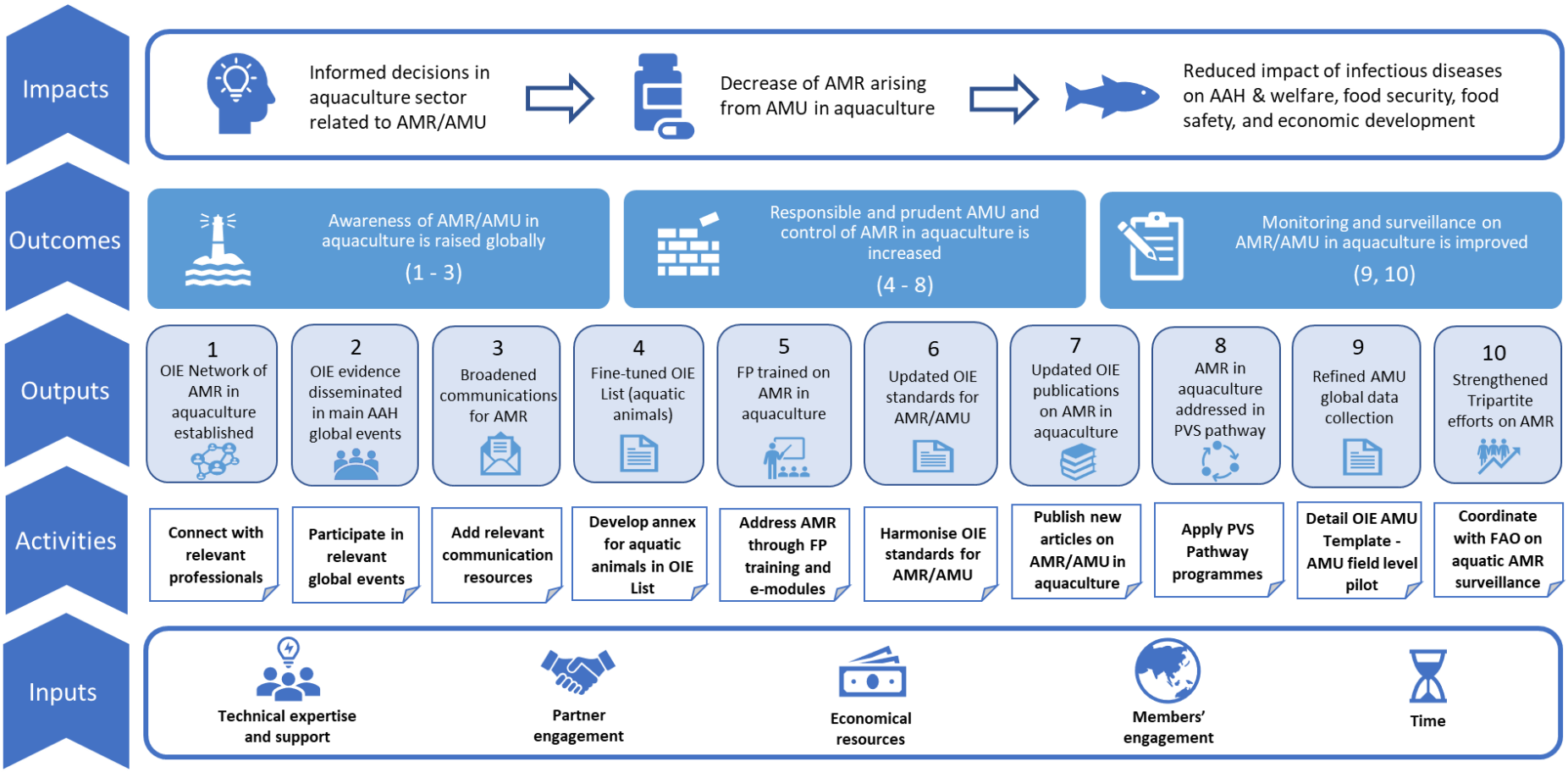

Figure 3: Theory of Change for the AMR in Aquaculture's Proposal

Delivery mechanisms and implementation

The delivery mechanisms and implementation of the suggested activities in this proposal are outlined in Table 2.

Table 2: Proposal on AMR in Aquaculture

Action to be taken	Output	Timeframe
Establish a network on AMR in aquaculture	1	
- OIE HQ assumption of secretariat role - Contacting AMR dedicated officers in RR/SRR to explain the initiative - Invitation of CC experts to join the network - Contacting representatives of relevant regional organisations - Setting of periodical meetings (bimonthly, initially video conferences) - Sharing activities internally with the OIE AMR Network		Oct 2020-Sep 2022
Develop an annex for aquatic animals in OIE *List of Antimicrobial Agents of Veterinary Importance*	4	
- Supervision by the WG on AMR (following methodology used for the *Poultry List*). - Formation of an AHG on AMR in Aquatic Animals (AHG requires 5 in-person/on-line meetings) o Verification of current antimicrobial agents on the OIE List to determine those that are essential o Gathering of information on antimicrobial agents used in aquaculture and on main bacterial diseases/pathogens for representative groups of aquatic animals		Nov 2020-Oct 2022
Refine the OIE AMU global data collection	9	
- Coordination with the AMU database team - Propose adjustments to the WG on AMR - Adjustment of the OIE AMU Template adding proposed sub-groups - Coordination with WAHIAD for subcategorization of aquatic animal production accordingly - Sharing information with Members about the adjustment of the OIE AMU Template	9a	Dec 2020-Sep 2022
- Coordination with Mott MacDonald on the incorporation of aquatic animal missions on AMU field/farm data collection pilot project	9b	Jan 2023-Dec 2023
Deliver OIE's evidence at global events	2	
- Searching and selecting the most relevant events on AAH and aquaculture to participate according to their programmes - Delivering OIE's evidence on AMR in aquaculture (HQ and RR staff)		Jan 2021-Mar 2025
Develop additional communication and behaviour change resources	3	
- Coordination with the Communication Department for drafting communication and behaviour change tools - Hiring of the services of a communication agency (for developing infographics) - Dissemination of new tools to FP and aquaculture sector		Jan 2022 – Dec 2022

Action to be taken	Output	Timeframe
Training of National FP through on-site and virtual formats	5	
- Coordination between the AMR & VP Department and the Standards Department to address FP for Veterinary Products and Aquatic Animals - Develop survey on needs related to AMR in aquaculture when training FP for VP and FP for AA - Pilot FP training in Asia Pacific Region (with RRAP) - Delivering FP training in other regions	5a	Jan 2022-Jul 2024
- Development of virtual training formats on the OIE Platform for the Training of Veterinary Services through coordination with the Secretariat of the OIE Platform for training of VS - Contacting CC and relevant experts	5b	Jan 2024-Mar 2025
Address AMR in aquaculture in PVS Pathway	8	
- Reviewing of the PVS evaluation reports on aquatic animals	8a	Sep 2022-Apr 2023
- Reviewing of the aquatic AMR component in the One Health AMR Legal Assessment Tool draft	8b	Oct 2021-Dec 2022
- Coordination with the Capacity Building Department for the adaptation (if necessary) and promotion of other programmes related to education, VPP, PPP, and lab twining	8c	Jan 2024-Jul 2025
Harmonise OIE Standards related to AMR in aquatic animals	6	
- Coordination with the AAHSC through the Standard Department on the recommendations for standards harmonisation - Schedule discussion in the AAHSC meetings' agenda		Sep 2022-May 2025
Publish new technical articles	7	
- Coordination with the Publication Unit, Director General and Deputy Director General to discuss potential publications - Invitation to potential authors - Translations of articles - Publication of various technical articles		Jan 2023-Dec 2024
Strengthen Tripartite effort addressing AMR in aquaculture	10	
- Coordination with FAO on common programmes and propose support for a pilot programme on AMR surveillance in aquaculture		Jan 2024-Jul 2025

Management and monitoring

Sustainability

This proposal is expected to be sustainable over time as it engages with the all the objectives of the OIE Strategy on Antimicrobial Resistance and the Prudent Use of Antimicrobials. It will also contribute to the implementation of Activity 3.4 *Practical AMR guidance* referred to Objective 3: *Solidarity* of the new OIE *Aquatic Animal Health Strategy*. Additionally, it addresses the recommendations of the 4th OIE Global Conference on Aquatic Animal Health: Collaboration, sustainability – our future (Chile, 2019), and of the 2nd OIE Global Conference on Antimicrobial Resistance and Prudent Use of Antimicrobial Agents (Morocco, 2018).

The outcomes of the proposal are focused on long-term changes, such as raising global awareness of AMR/AMU in aquaculture, increasing responsible and prudent AMU and control of AMR in aquaculture, and improving monitoring and surveillance of AMR/AMU in aquaculture. These

outcomes involve sustainable capacity building, which should remain after the proposal has been completed.

Although some outcomes are at country/regional level, most activities are operational from HQ level. This indicates that as far as OIE HQ supports these activities and funding is secured, they should be able to continue.

Risks

A list of risks based on the most important assumptions underlying the causal pathway between outputs and outcomes in the Theory of Change (Figure 3) are presented in Table 3: Risk Matrix for Proposal on AMR in Aquaculture, along with potential mitigation measures.

Table 3: Risk Matrix for Proposal on AMR in Aquaculture

Risk	Likelihood	Impact	Mitigation measures	Residual Impact
Experts on AMR in aquaculture do not work cohesively in a network	Low	Medium	Maintenance of regular communication, definition of clear objectives of the network to focus goals	Low
OIE views are not reflected in global events' recommendations	Low	Medium	Contact relevant organisations to share the benefits of following OIE standards and guidelines	Low
Communications resources do not reach targeted audience	Low	High	Send material directly to Delegates and FP for Veterinary Product and FP for Aquatic Animals. Distribute material in conferences and technical events	Low
Members' administration systems prevent improvements to their lists of antimicrobial agents	Medium	High	Work closely with Members to understand the challenges of legislation of veterinary products and how these can be addressed	Medium
Logistical or situational difficulties for on-site training	Medium	High	Reinforce implementation of virtual training and use of e-modules	Low
FP do not implement or share information on the training received on AMR in aquaculture in their country	Medium	High	Actively disseminate and seek feedback from FP after training seminars to improve the presentation material according to their needs. Maintain working group sessions alongside presentations to actively engage FP, and encourage sharing of country experiences	Medium
Difficulties in coordination between relevant stakeholders within a member country	Medium-High	High	Develop messages targeting aquaculture to promote a One Health approach	Medium
Amendments of OIE standards not considered a priority by the AAHSC	Medium	High	Coordinate with AAHSC on which specific chapters could be prioritised	Medium
OIE standard amendments on AMR in aquaculture are not followed by some Members	High	High	Work closely with Members to explain and advocate for the benefits of following these OIE standards	Medium

Risk	Likelihood	Impact	Mitigation measures	Residual Impact
Not enough experts from CC able to contribute to publications on AMR in aquaculture	Medium	High	Reach experts working in diverse organisations, research institutions, and academia well in advance	Low
Developing legislation on AMR in aquaculture is not a priority for some Members	Medium-High	High	Awareness raising activities on the importance of One Health concept to address AMR in aquaculture	Medium
Members are not able to collect meaningful and specific data on AMU in aquatic animals	High-Medium	High	Work closely with Members to understand the challenges to collecting aquaculture AMU data and how these can be addressed Strengthen effort for pilot project of AMU collection at field level	Medium
Difficulties in coordinating within the Tripartite	Medium	High	Provide timely information on meetings, definition of clear objectives of the network to focus goals	Medium

Logical Framework (Logframe)

The logframe presented in Table 4 gives a preliminary indication of the planned proposal – it will need to be reviewed and revised as the proposal progresses. Performance indicators, along with baselines, targets, and potential data sources for these indicators, are provided for the proposal outcomes and outputs. Given that those indicators for which reliable and meaningful data could be collected are prioritised, there are no indicators provided for the impact goals. Some targets are set as "increase over five-year period" as it is difficult to have an estimate. These targets will be reviewed once the proposal is underway, to set more specific appropriate targets for these indicators.

Table 4: Logical Framework for the Work Proposal on AMR in Aquaculture

	Result chain	Performance indicator(s)	Data sources	Baseline	Target
Outputs	Coordinated network of experts on AMR in aquaculture established	Number of experts joining the Network	OIE AMR&VP Department	N/A	At least nine members in the first year; increase over the following years
	OIE evidence on AMR/AMU in aquaculture delivered at global events of aquaculture and AAH	Number of global events where the OIE has participation	Conference & Fora Proceedings (website)	N/A	One on the first year; increase over the following years
	Communication resources broadened to address AMR/AMU in aquaculture	Number of new communication resources oriented to AMR in aquaculture	OIE Communications Department	A section in a brochure, and in an OIE Fact Sheet; some visuals	Increase by the end of the second year

	List for antimicrobial agents used in aquaculture fine-tuned	List annex for aquatic animals is prepared	OIE AMR&VP Department	N/A	First year
	Relevant FP trained on AMR/AMU in aquaculture through on-site and virtual formats	Number of presentations or training sessions on topics related to AMR in aquaculture; number of e-modules developed	OIE National FP Training Seminars	0-1 presentation on AMR in aquaculture per cycle/region	Two or more per year from the second to the fifth year
	OIE standards on AMR in aquatic animals further developed and updated	Number of new or amended chapters in the OIE *Aquatic Code* and *Manual*	OIE Standards Department	N/A	Fifth year
	OIE technical publications on AMR/AMU in aquaculture updated	Number of articles published which make reference to OIE technical publications	OIE Publication Unit	6 in last 20 years	Increase by the end of the third year
	AMR in aquaculture addressed in the OIE PVS Pathway to build capacity in Members' AAHS	Number of PVS evaluation reports analysed	OIE PVS Pathway	N/A	Fourth year
		Development of an aquatic AMR component in the *One Health AMR Legal Assessment Tool*			
		Number of Members interested in PVS pathway programmes			
	OIE AMU global data collection for aquatic animals refined	Fine-tuned OIE AMU Template for fish and crustaceans	OIE AMR&VP Department	N/A	Second year
		Operational pilot project for AMU at field/farm level			
	Tripartite efforts addressing AMR in aquaculture strengthened	A common programme is developed (e.g. surveillance on AMR in aquaculture)	OIE AMR&VP Department/ FAO	N/A	Fourth and fifth year

	Result chain	Performance indicator(s)	Data sources	Baseline	Target
Outcomes	Awareness on AMR/AMU in aquaculture raised globally	Number of interactions between Members and HQ regarding AMR in aquaculture	AMR&VP Department	N/A	Increase over five-year period
	Responsible and prudent AMU and control of AMR in aquaculture increased	Number of Members' legal (e.g. policies) and technical documents (e.g. risk analysis) produced to address AMR in aquaculture	FP Training Seminars	N/A	Fifth year
	Monitoring and surveillance of AMR/AMU in aquaculture improved	Number of countries providing detailed AMU for aquatic animals	AMR&VP Department	N/A	Fourth and fifth year
		Number of collaborative projects in joint programmes addressing AMR in aquaculture (OIE & FAO)	AMR&VP Department	N/A	Fifth year

	Result chain	Performance indicator(s)	Data sources	Baseline	Target
Impact Goals	Informed decisions in aquaculture sector related to AMR/AMU	N/A	N/A	N/A	N/A
	Decrease of AMR arising from AMU in aquaculture	N/A	N/A	N/A	N/A
	Reduced impact of infectious diseases on health & welfare of aquatic animals, food security, and economic development	N/A	N/A	N/A	N/A

Budget

The budget below represents the estimated cost to implement the AMR in Aquaculture: Proposal over the 5-year implementation period. It includes funding for dedicated project staff to manage and implement the planned activities as well as funding for specific activities that will require dedicated resources.

This work plan is a component of the larger OIE *Aquatic Animal Health Strategy*, to be launched in 2021. The work plan and this strategy are synergistic and will be implemented in parallel.

Additional resource mobilisation efforts will be undertaken to ensure that the OIE *Aquatic Animal Health Strategy* has sufficient resourcing.

World Organisation for Animal Health (OIE) AMR in Aquaculture: Proposal			
	Category	**Detailed Description**	**Budget EUR**
Outcome 1: Awareness on AMR/AMU on aquaculture is raised globally			
	Staff/personnel	AMR/Aquatics project officer to provide support to Outputs 1-3 over 5 years	165,000
	Travel	1 OIE staff attendance at 1 global event per year (scientific conferences on aquatic animals or other awareness-raising events related to AMR and aquatics) 5 flights @ 1,500 = 7,500 Per diem @ 150 * 3 days * 5 events = 2,250	9,750
	Communications	Development of infographics, fact sheets, posters, and other awareness raising/advocacy material, and adaptation of existing materials, to promote knowledge and awareness of AMR in aquatics	90,000
	Total Outcome 1		264,750
Outcome 2: Responsible and prudent AMU and control of AMR in aquaculture is increased			
	Staff/personnel	AMR/Aquatics project officer to provide support to Outputs 4-8 over 5 years	165,000
	Meetings	Face-to-face meetings to support fine-turning of OIE list of Anti-microbial agents and to develop 2 Chapters and revise 1 Chapter of Aquatic Animal Code/Manual (4 meetings @ 15,000/meeting)	60,000
	Travel	Participation of OIE staff members (1HQ + 1 RR/CC) to Focal Point Trainings to deliver presentations on AMR/Aquatic Flight @ 1500 * 2 training = 3,000 * 2 staff = 6,000 Per diem @ 150 * 2 training * 3 days * 2 staff = 1,800	7,800
	Training	Development of e-modules on AMR and aquatics, 2 modules @ 20,000 per module	40,000
	Publications	Articles in technical series, OIE Bulletin, or other scientific publications	15,000
	PVS Aquatic Missions	6 missions @ 35,000 per mission	210,000
	Lab Twinning Projects	4 twinnings @ 80,000 per twinning	320,000
	Total Outcome 2		817,800
Outcome 3: Monitoring and surveillance of AMR/AMU in aquaculture is improved			
	Staff support	AMR/Aquatics project officer to provide support to Outputs 9-10 over 5 years	165,000
	Travel	1-2 field missions for AMU field/farm data collection pilot project 2 flights @ 1500 = 3,000 Per diem @ 150 * 5 days * 2 missions = 1,500 Coordination with FAO on common programmes and support for a pilot programme on AMR surveillance in aquaculture 2 flights @ 1500 = 3,000 Per diem @ 150 * 5 days * 2 missions = 1,500	9,000
	IT support	Integration of aquatic animal AMU data into OIE-WAHIS, including fish sub-categories	25,000
	Total Outcome 3		199,000
	Sub-Total		**1,281,550**
	OIE overheads 7%		89,709
	Grand total		**1,371,259**

Expected outcomes, outputs, and suggested activities

Outcome 1: Awareness on AMR/AMU on aquaculture is raised globally

Output 1: Coordinated network of experts on AMR in aquaculture established

Current status of networking

Developing and maintaining networks is crucial for mutual support and coordinated efforts to control AMR. Synergistic joint efforts targeting common goals are essential, within and outside the OIE. Currently, two Departments at the OIE HQ are working on AMR in aquaculture:

- Antimicrobial Resistance and Veterinary Products Department
- Standards Department

The AMR & VP Department has been primarily concentrated on AMR issues related to terrestrial animals. The Standards Department functions as a Secretariat for the AAHSC who oversee standards development in the OIE *Aquatic Code* and the OIE *Manual for Diagnostic Tests for Aquatic Animals (Aquatic Manual)*. In 2019, the OIE appointed an expert to work specifically on issues related to AMR in aquaculture, within the AMR & VP Department, in response to the demand of the global OIE community.

Within the OIE RR/SRR, there are dedicated AMR officers with experience in aquaculture. The OIE has also an internal AMR Network that meets monthly with all interested Departments at the HQ and representatives of the RR or SRR.

In addition, the OIE has multiple CC, providing scientific expertise and support to the OIE and its Members on a wide range of topics, and promote international collaboration on animal health and welfare. There are five CC focused on veterinary products and three CC whose foci are aquatic animal related topics. The OIE also counts on multiple Reference Laboratories (RL) for scientific and technical assistance and expert advice on topics linked to diagnosis and disease control. For details on CC and RL, please see Appendix Ia.

Challenges

The OIE does not have many technical staff dedicated to working on AAH related issues. At the HQ, interest in this area is mainly concentrated in the Standards Department and, recently, in the AMR & VP Department. The new OIE Aquatic Animal Health Strategy, which will also cover the AMR issue, is expected to broaden the approach of the OIE. It will consolidate the commitment of the Organisation to the health and welfare of aquatic animals and acknowledge the importance of aquaculture for the economies and food security of many Members. At the RR and SRR, the AMR officers work collaboratively, although not under a formal network, to address AMR related problems in aquaculture. The absence of an established network to link relevant actors in the OIE HQ and RR/SRR precludes establishment of effective collaborations for the control of AMR in aquaculture, an area that has been neglected.

The OIE has a robust network of CC and RL, but no structure specifically designated to focus on AMR in aquaculture. The CC with focus on veterinary medical products have different levels of expertise and engagement supporting the OIE on topics specifically related to the control of AMR in aquatic animals (e.g. National Veterinary Assay Laboratory NVAL, Agence Nationale du Médicament Vétérinaire, within the French Agency for Food, Environmental and Occupational Health & Safety ANSES, Center of Veterinary Medicine, Food and Drug Administration, CVM-FDA) is not particularly oriented to aquatic animals. The CC related to aquatic animals are designated as focused on emerging diseases (i.e. Centre for Environment, Fisheries and Aquaculture Sciences, CEFAS) and epidemiology of aquatic animal diseases (i.e. Norwegian Veterinary Institute, NVI, and Centre for Aquatic Health

Services, CAHS). However, it should be noted that these centres do also have expertise on AMR in aquaculture. In fact, CEFAS is also a FAO reference centre for aquatic AMR, and the NVI is both a national reference laboratory and responsible for national monitoring on AMR in animals, food and feeding stuffs. CAHS is currently expanding its expertise on epidemiology of AMR into aquaculture.

Proposed activity

To secure collaborative efforts and a coordinated approach, within and outside the OIE, to control AMR arisen from AMU in aquaculture, it is recommended:

A1: To connect with relevant actors involved directly, or indirectly, in AMR in aquaculture to establish an OIE Network of Experts on AMR in aquaculture. This network would include dedicated staff of OIE HQ and OIE RRs and SRR, relevant OIE Commissions and WGs, and external partners. Representatives of the OIE CC and RL with expertise in AMR in aquaculture would also be contacted to strengthen the proposed network. In addition, representatives of National and Regional organisations/laboratories with interest, in aquaculture or AMR (e.g. Association of South East Asian Nations, Network of Aquaculture Centres in Asia-Pacific, Southeast Asian Fisheries Development Center, World Fish, Global Aquaculture Alliance) could be invited as guest members.

- The Secretariat role will be provided by the OIE HQ (expert on aquaculture). Regular meetings will be held bimonthly. These meeting will be via teleconference.
- Activities from this Expert Network would be shared on a regular basis with the OIE HQ relevant Departments, RR and SRR through the existing internal OIE AMR Network to ensure mutual information sharing.

Output 2: OIE's evidence on AMR/AMU in aquaculture disseminated in global events on aquaculture and aquatic animal health

Current status of relevant global events

Global conferences on AMR in the veterinary field and on AAH, that include AMR sessions, are periodically organised by the OIE to disseminate up-to-date technical and scientific information. These conferences are:

- OIE Global Conference on Antimicrobial Resistance and Prudent Use of Antimicrobial Agents
- OIE Global Conference on Aquatic Animal Health

There are various other global conferences, fora, symposia and meetings organised by prestigious international organisations such as the Fish Health Section of the American Fisheries Society, the European Association of Fish Pathologists, the World Aquaculture Society, the Global Aquaculture Alliance, among others. These events usually cover subjects related to AMR and AMU.

Challenges

Aside from the successful organisation of the OIE global conferences on AMR and AAH, there is no regular participation by the OIE in various other global conferences and fora linked to AMR in aquaculture. The absence of the OIE in these events precludes from expanding its networks in this area and prevents participants (i.e. academia and industry) of such events from being familiar with the OIE international standards and guidelines. In addition, this void left by the OIE prompts other international organisations to take leadership.

Proposed activity

In order to increase visibility of the OIE's role in the control of AMR arising from AMU in aquaculture, and to create opportunities to expand networks and build partnerships with academia and the private sector to achieve alignment with the OIE standards, it is recommended:

A2: To participate in the most important global and regional events on AAH and aquaculture. The choice of event would depend on the event programmes. Suggested events are:

- International Symposium on Aquatic Animal Health, a symposium organised every four years by the Fish Health Section of the American Fisheries Society. In the 8th (Charlottetown, 2018), a parallel conference of the World Aquatic Veterinary Medical Association covered practices in aquatic veterinary medicine including the use of drugs and anaesthetics.
- International Conference on Diseases of Fish and Shellfish, a conference organised every two years by the European Association of Fish Pathologists. In the 19th conference (Porto, 2019), there was a session dedicated to AMR in aquaculture and a workshop on Antimicrobial Susceptibility Testing (AST) method development for *Vibrio* spp.
- World Aquaculture, an annual meeting organised by the World Aquaculture Society. In the upcoming meeting (Singapore, 2020), the technical programme covers Drugs and Chemotherapeutics.
- Global Outlook Aquaculture Leadership (GOAL), an annual conference organised by the Global Aquaculture Alliance. In the conference GOAL 2019 (Chennai, India) the topics included antibiotic use in aquaculture and AMR. Moreover, a keynote speaker addressed antibiotic use in aquaculture and AMR in humans.
- Various fora organised by regional organisations involved or with interest in aquaculture or AMR (e.g. Association of South East Asian Nations, Network of Aquaculture Centres in Asia-Pacific, Southeast Asian Fisheries Development Center, Sustainable Aquaculture Research Networks in Sub Saharan Africa, The Aquaculture Association of Southern Africa, World Fish, Global Aquaculture Alliance).

Output 3: Communication resources broadened to address AMR/AMU in aquaculture

Current Status on communication resources

Effective communication targeting different audiences is essential to the OIE for dissemination of technical information relevant to AAH and welfare. To promote awareness on AMR and to encourage the use of the OIE international standards and guidelines on responsible and prudent AMU and control of AMR, communication multimedia tools are produced, and targeted campaigns are launched. Among the informative documents and communication resources produced, there are website portals, various factsheets, memory aids, infographics, briefs, press releases, news broadcasting, posters, and short videos on AMR. The communication resources specifically dedicated to AMU and AMR related to aquaculture are the following:

- The OIE website maintains a portal dedicated to *Aquatic Animals* with a section on *Responsible and prudent use of antimicrobials* that refers to the OIE *Aquatic Code* chapters on AMR and AMU in aquatic animals, the OIE AMU global database, the OIE *List of Antimicrobial Agents of Veterinary Importance*, and the "We need you" campaign, that encourage the participation of all stakeholders in controlling AMR in the veterinary field
- Among the OIE Multimedia resources for Aquatic Animals, a brochure *Benefits of aquatics animals are infinite. Keep them healthy* includes a section on *Preserving the efficacy of*

antimicrobial agents that promotes the OIE standards and the *List of Antimicrobial Agents of Veterinary Importance*

- Among the OIE Fact Sheets, one addressing *Aquatic Animals* has a succinct section on *Use of antimicrobial agents* which also promotes the OIE standards and the *List of Antimicrobial Agents of Veterinary Importance*
- As part of the "World Antimicrobial Awareness week", the OIE has created posters titled *Fighting Antibiotic Resistance* addressed to national authorities, veterinarians, breeders and animal owners, as well as covers and banners for social media, that show aquatic animals among the available visuals.
- The "We Need You" campaign involves, among various tools, short videos, leaflets, and posters portraying cartooned animals, including fish.

Challenges

The OIE has produced various communication multimedia resources and targeted campaigns that include AMR in aquaculture. However, an approach targeting responsible and prudent AMU and control of AMR for different aquaculture species and aquaculture systems have not yet been developed. This is important because the differences within the aquaculture sector (species, systems, environments, etc.) present specific challenges on AMR. On the other hand, the current communication tools addressing aquatic animals are mainly oriented to AAH. Stressing more specific information on AMR, beyond sharing OIE standards and guidelines, such as pointing out the drivers of AMR, pathways of AMR dissemination in the environment and the consequences for animal and public health, in a simplified way, is desirable.

Proposed activity

In order to promote enhanced awareness of AMR in aquaculture it is recommended:

A3: To develop additional informative documents and resources specifically oriented to aquaculture. The production of factsheets, memory aids, infographics, briefs, news broadcasting and short videos should include specific issues related to AMR in aquaculture and synoptically describe guidelines to control it. Suggested communication resources are:

- Infographic on the One Health approach for AMR explicitly including aquaculture and indicating the main drivers and pathways of AMR in aquaculture using representative species/systems
- Factsheet exclusively on the OIE standards, AMU data collection, *List of Antimicrobial Agent of Veterinary Importance* and the various programmes of the OIE PVS Pathway that could be applied in the aquaculture sector in terms of AMR/AMU
- The visual for aquatic animals of the posters, covers and banners for social media, produced for the "World Antimicrobial Awareness week" could be modified by replacing the pictures. The current pictures of seafood products might be conveying the idea that the recommendations are addressed to seafood processing plants rather than farming facilities. Using pictures of live aquatic animals is suggested.

Outcome 2: Responsible and prudent AMU and control of AMR in aquaculture is increased

Output 4: OIE *List of Antimicrobial Agents of Veterinary Importance* fine-tuned

Current status on the OIE *List of Antimicrobial Agents of Veterinary Importance*

The OIE has developed a *List of Antimicrobial Agents of Veterinary Importance* (OIE *List*) that contains antimicrobial agents authorised by various Members in food-producing animals, including antimicrobial agents used in aquaculture. The OIE *List* categorises antimicrobial agents as "critically

important", "highly important" and "important" in veterinary medicine, based on their extensive use and importance for treating important animal diseases. The list includes 32 antimicrobial agents used in aquatic animals from which 25 are classified as critically important, five as highly important, and two as important.

Challenges

The OIE *List* was developed to address the antimicrobial agents used for therapeutic purposes in food-producing animals, covering various terrestrial animal groups and aquatic animals. Therefore, the categorisation criterium does not fully represent the specific use of antimicrobial agents against unique pathogens of aquatic animals present in aquaculture environments. In addition, the OIE *List* might need to be updated given that new updates are usually done every two to three years. The last update was in 2018 (endorsed by the Scientific Commission in February 2019) and was focused on the terminology used for antimicrobial classification.

Proposed activity

For the proposed activity it is recommended:

> **A4**: To develop an annex to the OIE *List* dedicated exclusively to aquatic animals. This would include antimicrobial agents used in aquaculture for the main diseases of fish, crustaceans, molluscs and amphibians and include those that might be missing. Complementarily:
>
> - To verify in the current OIE *List* if the antimicrobial classes/subclasses indicated for aquatic animals are appropriate and reflect those currently used in aquaculture
> - To determine those antimicrobial agents that are essential in aquaculture
>
> Following the methodology for the *Poultry List* annex, the suggested activity will be under the supervision of the WG on AMR. This activity will require the formation of an AHG on AMR in aquatic animals.

Output 5: Relevant National Focal Points systematically trained on AMR in aquaculture through on-site and virtual formats

Current status on training

In order to provide VS/AAS with good governance concepts, the OIE National FP Training is delivered to individuals designated by the OIE Delegate of each Member to assist them on eight key topics[6]. Regional training seminars are offered in every second-year cycles for each of the key topics, including Aquatic Animals and Veterinary Products. Occasionally, presentations specifically in subjects related to AMR/AMU in aquaculture or on alternatives to antibiotics in aquaculture have been offered.

Challenges

So far, only a small portion of OIE National FP Trainings have been dedicated to addressing issues related to AMR in aquaculture. Some of the training events offered to FP on Aquatic Animals and/or Veterinary Products have included a few presentations in this area but, given the commitment of the OIE to address this issue more actively, a more intense training programme is necessary.

In addition, reaching the appropriate FP (knowledgeable about aquaculture and AMR), is challenging with the current approach.

[6] Eight key topics: animal disease notification, wildlife, veterinary products, animal production food safety, animal welfare, aquatic animals, communication, and laboratories

Proposed activity

To systematically address AMR in aquaculture in the FP training, the proposed activity is recommended:

A5(a): To incorporate presentations on AMR in aquaculture in the seminar programmes regularly delivered for FP for Veterinary Products and FP for Aquatic Animals. These presentations could be in-person and/or through the use of virtual training formats through digital systems such as webinars.

- Examples of topics (their rationale is indicated in Appendix Ib) are:
  - Drivers, pathways, and consequences of AMR in aquaculture
  - Use of alternatives to antimicrobial agents in aquaculture
  - Veterinary products including medicated feed for aquatic animals
  - Quality of veterinary products used in aquaculture
  - Estimation of AMU in aquaculture
  - Risk analysis for AMR in aquaculture
  - Antimicrobial susceptibility testing relevant to aquaculture
  - Threats of AMR in zoonotic bacteria from aquatic environments
  - Scoping the new annex for aquatic animals in the OIE *List of Antimicrobial Agents of Veterinary Importance*
  - Aquaculture in the implementation of National Action Plan (NAP) on AMR
  - Legislation relating to AMR/AMU in aquaculture

A5(b): To develop e-modules for e-learning of training material related to AMR in aquaculture emphasising relevant OIE standards and guidelines and other technical topics.

Output 6: OIE Standards for AMR/AMU in aquatic animals further developed and updated

Current status of OIE standards

The OIE *Aquatic Code* provides standards for the improvement of aquatic animal health worldwide. It also includes standards for the welfare of farmed fish and use of antimicrobial agents in aquatic animals. The sanitary measures in the OIE *Aquatic Code* should be used by the Competent Authorities of importing and exporting countries for the prevention, early detection, reporting and control of pathogenic agents in aquatic animals and to prevent their spread via international trade in aquatic animals and their products, while avoiding unjustified sanitary barriers to trade. Standards on AMU in aquatic animals are covered in **Section 6: *Antimicrobial Use in Aquatic Animals*** of the OIE *Aquatic Code* and contains five chapters:

- *6.1. Introduction to the recommendations for controlling antimicrobial resistance*
- *6.2. Principles for responsible and prudent use of antimicrobial agents in aquatic animals*
- *6.3. Monitoring of the quantities and usage patterns of antimicrobial agents used in aquatic animals*
- *6.4. Development and harmonisation of national antimicrobial resistance surveillance and monitoring programmes for aquatic animals*
- *6.5. Risk analysis for antimicrobial resistance arising from the use of antimicrobial agents in aquatic animals*

The OIE *Aquatic Manual* provides methods for the detection of OIE-listed diseases, general provisions of laboratory testing capability required to provide effective laboratory testing for pathogenic agents of aquatic animals and principles of validation of diagnostic assays.

Challenges

Chapter 6.4 *Development and Harmonisation of National AMR Surveillance and Monitoring Programmes for Aquatic Animals,* of the OIE *Aquatic Code*, includes information on sampling protocols, however various details or different scenarios are missing. In addition, the recommended bacterial species for surveillance and monitoring programs only include zoonotic bacterial species of aquatic food products, and there are no specific suggestions for the main pathogens of aquatic animals to target. Although AMR monitoring programs are useful for minimising risk to public health, monitoring AMR in important bacterial pathogens of aquatic animals is essential to control diseases that could affect their health and welfare and, often, cause significant economic losses in aquaculture.

The OIE *Aquatic Manual* does not include a chapter on standardised methodologies for AST for pathogens in aquatic organisms or a chapter dedicated to the production of vaccines for fish. Guidance on AST for bacteria in aquaculture settings is essential because implementing AST facilitates appropriate antimicrobial treatments during disease outbreaks. It is also needed to establish programs of surveillance, based on standardised methodology and interpretation. Likewise, proper standards and production controls for vaccines are essential to ensure the availability of consistent, high quality products for use in AAH programmes. As stated above (see Evidence section), the development and use of vaccines is considered an important strategy to decrease AMU in fish aquaculture.

Proposed activity

A6: To harmonise the OIE international standards on AMR/AMU in aquatic animals with the standards for terrestrial animals.

The following amendments in the OIE *Aquatic Code* are recommended for consideration of the AAHSC:

- To include more detailed information on sampling protocols in Chapter 6.4 *Development and Harmonisation of National AMR Surveillance and Monitoring Programmes for Aquatic Animals*, to better harmonise the chapter with the equivalent chapter in the OIE *Terrestrial Animal Health Code*, Chapter 6.8 *Harmonisation of National AMR Surveillance and Monitoring Programs*.

The following amendments in the OIE *Aquatic Manual* are recommended for consideration of the AAHSC:

- A new draft chapter on AST similar to Section 2.1.1 *Laboratory methodologies for bacterial antimicrobial susceptibility testing* in the OIE *Manual of Diagnostic Tests and Vaccines for Terrestrial Animals*.
- A new draft chapter on vaccine production similar to Chapter 1.1.8 *Principles of veterinary vaccine production* in the OIE *Terrestrial Manual*.

Output 7: OIE technical publications on AMR/AMU in aquaculture updated

Current status of technical publications

The OIE publishes a series of scientific and technical documents for dissemination in the international veterinary community across a wide range of animal health issues. These publications include the *Scientific and Technical Review*, the OIE Bulletin, and non-periodicals such as technical series and thematic publications, proceedings and compendiums.

Some publications have been focused on therapeutic agents, AMU, and AMR in aquaculture. In the last 20 years, 4 review articles have been published in the *Scientific and Technical Review*:

- 2019 - *The future of therapeutic agents in aquaculture* (K. Gravningen, H. Sørum, T.E. Horsberg)
- 2013 - *Monitoring and surveillance of antimicrobial resistance in microorganisms associated with aquatic animals* (P. Smith, V. Alday-Sanz, J. Matysczak, G. Moulin, C.R. Lavilla-Pitogo, D. Prater)
- 2012 - *Use of antimicrobial agents in aquaculture* (Y.H. Park, S.Y. Hwang, M.K. Hong, K.H. Kwon)
- 2008 - *Antimicrobial resistance in aquaculture* (P. Smith)

Also, two articles in the OIE Bulletin:

- 2012-2 - *Expected benefit of aquaculture and the challenge of antimicrobial use – Part I* (D. Prater)
- *2012-4 - Expected benefit of aquaculture and the challenge of antimicrobial use – Part II* (D. Prater)

More complete references of these and other articles referring to AMR in veterinary medicine published by the OIE are found in the Appendix Ic.

Challenges

Although there is a very recent review paper on therapeutic agents used in aquaculture published in the OIE *Scientific and Technical Review*, there are other earlier articles dedicated to the issue of AMR and AMU in aquaculture in the OIE Bulletin that might require an update. With the continued growth and intensification of aquaculture and the issues related to AMU and AMR in this sector, recent developments should be accounted for and published.

It should be highlighted that there are no publications on AMR or AMU in aquaculture in the OIE Technical Series or in the Thematic and Joint Publications which are important means to disseminate knowledge on AMR and AMU in aquaculture.

Proposed activity

In order to produce more publications addressing AMR in aquaculture it is recommended to invite experts to undertake one of the following options:

> **A7**: To develop a publication on AMR in aquaculture in the OIE Technical Series or in the OIE Bulletin. Articles in this issue could cover AMU in aquaculture, including issues of quality of antimicrobial agents, AMR drivers and pathways of dissemination, AMR in aquaculture and public health, aquaculture food products and AMR, alternatives to antimicrobial agents (e.g. vaccination, probiotics, immunostimulants) in aquaculture, assessing risk for AMR in aquaculture. These articles could address these issues in the whole aquaculture sector or be focused on fish, crustacean, molluscs or amphibians. It would be important to have at least a review article on AMU and AMR in amphibians as information for these species is scarce.

Output 8: AMR in aquaculture addressed in the OIE Performance of Veterinary Services Pathway to build capacity in Members' AAHS

Current status on the OIE PVS Pathway

Building capacity is crucial for developing and maintaining adequate AAHS. The OIE has developed the OIE PVS Pathway to build capacity in Members' VS and AAHS. This programme involves evaluation missions such as the PVS Evaluation of AAHS based on assessing critical competences described in the OIE *Tool for the Evaluation of Performance of Aquatic Animal Health Services* (OIE PVS Tool-Aquatic). These critical competences include the capability to regulate veterinary medicines for aquatic animals and to undertake residue testing, including for antimicrobial agents. To date, 13 countries have

received PVS Evaluation (Aquatic) missions, and there has been one pilot PVS Gap Analysis (Aquatic) mission and one PVS Evaluation Follow Up (Aquatic) mission. A further seven countries have expressed interest in receiving a PVS Evaluation (Aquatic) demonstrating uptake by countries and the growing importance of the aquaculture sector to national economies. The 2nd edition (under preparation) of the OIE PVS Tool-Aquatic will add a new critical competence for assessing the capability to manage AMU and AMR using a One Health approach through NAP. Such NAP would need to include monitoring AMU and controlling AMR in aquaculture through relevant regulation, awareness campaigns and surveillance of AMR in aquatic animal and food-borne pathogens.

In addition, the PVS Pathway offers targeted support in prioritised areas. Among the targeted support options are OIE National Focal Points Training (see Activity 5), and the following additional programmes:

- **Veterinary Legislation Support Programme (VLSP)**, for improving legislation related to the veterinary field. No VLSP on AMR for aquatic animals has been performed to date, as the VLSP tools (for standard VLSP missions as well as for pilot AMR specific legislation assessments) have been developed so far only for terrestrial animals.
- **Veterinary and Veterinary Paraprofessional Education**, for providing veterinary education establishments and veterinary paraprofessional training institutions with guidelines and support. The scope of the guidance is to identify Day 1 competencies and developing curricula to deliver those competencies to strengthen the veterinary workforce and the performance of the national VS. Competency and curricula guidelines include issues related to the use of veterinary products and AMR and are adaptable to address education on aquatic animals.
- **Public-Private Partnership (PPP)**, for promoting partnership between public and private sectors to provide services or other outputs in the veterinary domain. There have been successful precedents of Public-Private Partnerships related to AAH but not yet specifically on activities related to controlling AMR in aquaculture.
- **OIE Laboratory Twinning Programme**, for assisting building of laboratory capacity and scientific expertise in collaboration with the OIE network of RL and CC. This programme has been used previously to improve laboratory capacity to fight fish and crustacean diseases, but not to control AMR through, for instance, AST in aquatic bacteria.

Challenges

Many of the programmes have the potential to be of great benefit for Members to improve their AAHS and aquaculture sectors in terms of controlling AMR and promoting responsible and prudent AMU. It is probable that either the issue of AMR in aquaculture is perceived as emerging or as a low priority in some countries, or that the benefits of the OIE PVS Pathway are not reaching those authorities directly related to aquaculture.

No VLSP on AMR for aquatic animals has been performed due to a lack of clear legislation standards for AAH. Nevertheless, in the coming months it is expected that the Tripartite will merge their respective methodologies into a single *One Health AMR Legal Assessment Tool*, and the VSLP may cease to conduct AMR missions independently from the FAO and WHO.

Proposed activities

In order address AMR in aquaculture through the PVS pathway to build capacity in this area, it is recommended:

> **A8(a)**: To review and analyse existing PVS evaluation reports on aquatic animals in various Members to continue identifying challenges related to structures, availability of professional advice and veterinary products.

A8(b): To participate in the review of the development of an aquatic AMR component when drafting the *One Health AMR Legal Assessment Tool* to ensure future Tripartite missions include an assessment of the legislation relevant for AMR in the aquaculture sector.

A8(c): To promote various PVS programmes:

- The PVS Evaluation (Aquatic) missions to build capacity at the AAHS, taking advantage that the new edition of the OIE PVS Tool-Aquatic will have a new critical competence on AMU/AMR.
- The Veterinary and Veterinary Paraprofessional[7] Education guidelines in countries with an important aquaculture sector, stressing the Veterinary Products competency and including the particularities of drug administration and AMR in aquaculture.
- PPP to control AMR (and to promote responsible and prudent AMU) in aquaculture. To explore creating this as a specific topic of PPP, as a tool to benefit private small to large scale aquaculture enterprises and at the same time preserve aquatic animal and public health.
- The OIE Laboratory Twinning Programme among Members to improve their laboratory capacities and scientific expertise, for example, in AST, to support AMR surveillance programmes oriented towards aquaculture.

Output 3: Monitoring and surveillance of AMR/AMU in aquaculture is improved

Output 9: OIE AMU global data collection for aquatic animals refined

Current status of AMU

Antimicrobial overuse and misuse are key drivers of AMR. In order to establish global trends, the OIE monitors global AMU in food-producing and companion animals through the:

- *OIE Global database on antimicrobial agents intended for use in animals*

Since 2016, every year a new round of data collection for Member's AMU is launched. The information, requested in an OIE Template, includes data of AMU in aquatic animals raised in aquaculture settings such as Fish, Crustaceans, Molluscs and Amphibians[8]. The collected AMU data is annually published in the:

- *OIE Annual report on antimicrobial agents intended for use in animals*

In this report, AMU data for types of use, animal groups, routes of administration, antimicrobial classes, and overall antimicrobial quantities is shown by OIE region. In addition, sources and barriers to obtain information are described. The information of AMU is adjusted by aquatic animal production data obtained from the World Animal Health Information System to determine AMU in relation to the weight of aquaculture production of each country (for terrestrial animals the FAO Statistical Database is mainly used to obtain animal biomass). In these reports the number of countries reporting AMU in aquatic food-producing animals, the antimicrobial class used and the number of countries reporting quantities of antimicrobial agents used in overall aquatic food-producing animals are described.

[7] In the aquaculture sector of many countries the role of veterinarians and veterinary paraprofessionals is usually assumed by AAH professionals

[8] In addition to amphibians, some reptiles could also be considered under aquaculture production, i.e. crocodilians and aquatic turtles, but in the OIE AMU report, reptiles are considered a separate category

Challenges

The current AMU global data collection does not allow discrimination of data by economically important aquatic food-producing animal groups. Such information would be useful to identify subsets of the aquaculture sector which may have problems of overuse or misuse of antimicrobial agents and could help to establish trends for the different aquatic animal groups. This is especially important in an industry that accounts for around 35 dominating cultured species (from a total of more than 600) [18]. In addition, these species are cultured in different production systems (open, semi-open, semi-closed, closed), and at different water temperatures (tropical, temperate, cold) and salinities (freshwater, brackish water, seawater), each with unique characteristics for certain pathogens to thrive. In addition, the AMU data adjusted for animal biomass shown as a total of all animals (terrestrial and aquatic food-producing animals) does not allow comparison between animal groups and geographical regions.

Furthermore, the AMU data collected from Members is mostly based on sales rather than actual use. Given than many antimicrobial agents are indicated for several species it is difficult to estimate the actual use for each animal species, including aquatic animals.

Proposed activities

To refine the AMU global data collection, it is recommended:

A9(a): To refine the OIE AMU data collection Template by breaking down AMU information for aquatic animals in the OIE annual data collection. The proposed subdivision would involve adding subgroups of economic importance within fish and crustaceans in the Baseline Information worksheet. Thus, in question 25 of the OIE AMU data collection Template: *"Food-producing animal species covered by the information on antimicrobial quantities"*, the group "*Fish – aquaculture production*" would include 6 subgroups from which to choose: *Carps (Cyprinids), Salmon/Trout (Salmonids), Tilapia (Cichlids), Catfishes (Siluriformes), Marine fish*, and *Others*. Likewise, the group "*Crustaceans – aquaculture production*" would include 2 subgroups to choose from: *Marine shrimps/prawns (Penaeids)* and *Others*. In question 27 "*Companion animal species covered by antimicrobial quantities, if any*" would include the group: *Ornamental fish*. This would allow Members to specify (by checking in the respective boxes) which of these subgroups are covered whenever they report AMU data for food-producing fish and/or crustaceans, and for ornamental animals. This additional information would further help in understanding potential antimicrobial overuse or misuse within specific sectors of aquaculture. In addition, it is also recommended:

- To consider estimating data adjusted for animal production of aquatic food-producing animals (mg of antimicrobial agent/kg of aquatic animal produced). AMU data adjusted for the weight of aquatic animal would be more accurate to compare over time and across geographical areas.
- To consider for the future creating a Reporting Option 4 that would offer the option of reporting quantitative amounts of antimicrobial agents per aquatic animal "species": fish, crustaceans, molluscs, and amphibians separately. Although logistically reporting this information is very challenging, it would give a much more accurate picture of AMU within the aquaculture sector.

A9(b): To consider starting a pilot project, with a few selected countries, to obtain AMU data at a farm/field level, which would reflect real use data.

Output 10: Tripartite efforts addressing AMR in aquaculture strengthened

Current status of collaborative work with the Tripartite

The OIE carries out activities in collaboration with FAO and the WHO, to address AMR. In 2006, the FAO, OIE and WHO organised a consultation group to discuss scientific findings and to reach scientific consensus on issues regarding the public health aspects of AMR and AMU in aquaculture. As a result, the following report was released:

- *Antimicrobial Use in Aquaculture and Antimicrobial Resistance Report of a Joint FAO/OIE/WHO Expert Consultation on Antimicrobial Use in Aquaculture and Antimicrobial Resistance*

In this report, evaluation of AMU patterns, public health impact and development of strategies to minimise the risk were presented. Since 2010, WHO, FAO and OIE (the Tripartite), addressed the threat of AMR as one of their main priorities using a "One Health" approach. The Tripartite has produced three key documents on AMR:

- The *Global Action Plan (GAP) on Antimicrobial Resistance*, adopted in 2015, requests among its strategic objectives to optimise the use of antimicrobial medicines in human and animal health and acknowledges the OIE's efforts in the animal AMU database.
- The *Monitoring and Evaluation (M&E) Framework*, was developed to monitor and evaluate the global GAP indicators based on the performance of national and international partners.
- *Antimicrobial resistance. A manual for developing national action plans*, offers guidance to countries in preparing their NAP to be aligned with the GAP.

The Tripartite has also established:

- The *AMR Multi-Partner Trust Fund (AMR MPTF): Combatting Antimicrobial Resistance through a One Health approach* to support One Health NAPs. The AMR MPTF has been set up for an initial five-year period (2019-2024).
- The *Tripartite Integrated Surveillance System for AMR/AMU (TISSA)*, is an initiative to provide a platform for publication of data relating to AMR and AMU from different sectors by global and regional surveillance systems.

Each of the members of the Tripartite has their own activities to control AMR according to their mandate. For instance, FAO is currently conducting two projects related to AMR in aquaculture and recently published various documents related to AST, AMU, and risk of AMR (see Appendix Id).

Challenges

The members of the Tripartite have focused their efforts to fight against AMR based on a One Health approach. Given that AMR affects both animal health and productivity, there is a need for better coordination between OIE and FAO to control AMR in aquaculture. Communication between the two organisations is established but coordination across global and regional projects faces some challenges. The current number of independent projects and recently published documents related to AMR in aquaculture indicates the potential to increase collaboration.

Proposed activity

In order to prevent overlapping efforts, it is recommended to establish fluid communication with FAO and coordinate an agenda with activities of common interest. Suggested collaborative activities are:

A10: To strengthen relationship at a regional/sub-regional level through coordination with FAO and WHO on AMR in aquaculture and the environment. Examples of collaborative projects are:

- To support FAO in the establishment and harmonisation of susceptibility data for epidemiological cut-off values for bacterial pathogens relevant to aquaculture using selected pathogens of economically important species.
- To support FAO in the development/implementation, in a selected group of countries and with participation of RR/SRR, of a programme of surveillance of AMR in aquaculture according to the methods established in *The Performance of Antimicrobial Susceptibility Testing Programmes Relevant to Aquaculture and Aquaculture Products* (FAO, 2019).
- To ensure, through the AMR MPTF, that the NAP under their programme cover needs related to AMR in aquaculture.

Appendix

Ia. OIE Reference Centres (Collaborating Centres and Reference Laboratories)

CC focused on veterinary products:

- Diagnosis and Control of Animal Diseases and Related Veterinary Product Assessment in Asia:
  - National Institute of Animal Health, NIAH (Japan)
  - National Veterinary Assay Laboratory, NVAL (Japan)
- Training of official veterinarians, diagnosis of infectious animal diseases and zoonoses, and control of veterinary drugs in West and Central Africa: Ecole Inter-Etats des Sciences et Médecine Vétérinaires (Senegal)
- Veterinary Drug Regulatory Programmes: Center for Veterinary Medicine, Food and Drug Administration, CVM-FDA (USA)
- Veterinary Medicinal Products: Agence Nationale du Médicament Vétérinaire, ANMV - French Agency for Food, Environmental and Occupational Health & Safety, ANSES (France)

CC focused on aquatic animals:

- Emerging Aquatic Animal Diseases: Centre for Environment, Fisheries and Aquaculture Sciences - CEFAS (United Kingdom)
- Epidemiology and Risk Assessment of Aquatic Animal Diseases (Americas): Centre for Aquatic Health Science - CAHS, Atlantic Veterinary College, University of Prince Edward Island (Canada)
- Epidemiology and Risk Assessment of Aquatic Animal Diseases (Europe): Norwegian Veterinary Institute - NVI (Norway)

RL within AMR topic:

- Antimicrobial Resistance: Animal and Plant Health Agency (United Kingdom)

Ib. Rationale of Topics Proposed on the OIE National Focal Point Training for addressing AMR in aquaculture

The following topics are proposed for inclusion in OIE National Focal Point Training to address AMR in aquaculture. A brief rationale is provided:

- **Drivers, pathways, and consequences of AMR in aquaculture**. The drivers of AMR in aquaculture settings are not always clear which impedes proper control of the problem. At the same time, the consequences of AMR (both in aquatic animal pathogens and in human pathogens that emerge from aquaculture) should be understood. This would allow to establish appropriate surveillance programmes and supportive policies to protect veterinary and public health.
- **Use of alternatives to antimicrobial agents in aquaculture**. Immunoprophylactic control of aquatic animal diseases is necessary to minimise dependency on therapeutic drugs. Fish vaccination has been successfully used in various countries. There are also many reports on the beneficial use of probiotics for shellfish. These and other means of disease control (prebiotics use, bacteriophage therapy, selective breeding, etc.) could help prevent AMR in aquaculture in addition to improved management.
- **Veterinary products including medicated feed for aquatic animals**. Information on the availability and use of antimicrobial agents for fish (Carps, Salmon/Trout, Tilapia, Catfishes, marine fish, ornamental fish), crustaceans and molluscs is necessary to facilitate efficient treatment for ensuring the health and welfare of aquatic animals. This is important to prevent major loses in the aquaculture sector and reduce AMR emergence.

- **Quality of veterinary products used in aquaculture**. The production and commercialisation of falsified or substandard antimicrobial agents also occurs in the aquaculture sector, especially in LMIC with poor regulations or weak enforcement capacity. Stressing the importance of good quality veterinary products is critical not only to ensure health and welfare of aquatic animals but also to prevent AMR.
- **Estimation of AMU in aquaculture**. The OIE Annual report on antimicrobial agents intended for use in animals reveals a need to increase the number of countries reporting quantitative data of antimicrobial consumption in aquaculture. In the last annual report (4th, focused on 2016 data) the number of countries reporting quantities of antimicrobial agents used in aquatic food-producing animals was 9 out of 60 countries that reported AMU for this group.
- **Risk analysis for AMR in aquaculture**. Risk analysis is an important tool to make decisions. Understanding basic concepts of hazard identification, qualitative and quantitative risk assessment, risk management and risk communication of AMR in aquaculture settings and the implications for aquatic animal and public health is critical. Addressing specific cases with key pathogens would enhance the understanding of the risks involved in AMR in aquaculture in a practical way. Chapter 6.5. *Risk analysis for antimicrobial resistance arising from the use of antimicrobial agents in aquatic animals* of the OIE *Aquatic Code* and the experience from the workshop "AMR in Aquaculture" (Durban, RSA, 2019), organised by the SRR of Southern Africa, would be used as references.
- **Antimicrobial susceptibility testing relevant to aquaculture**. AST for clinical treatment or surveillance programmes are of paramount importance in aquaculture. The use-specific and standardised methods of AST for bacteria from aquatic animals is required. Recently FAO published *The Performance of Antimicrobial Susceptibility Testing Programmes Relevant to Aquaculture and Aquaculture Products* (see Appendix 1d) that offers guidance in this matter.
- **Threats of AMR in zoonotic bacteria from aquatic environments**. Bacterial species of aquatic origin considered zoonotic represent a risk for public health. Topical infections represent a risk especially to farmers and other workers in the productive chain, and foodborne infections (caused by contaminated seafood) represent a risk to consumers. Resistance in zoonotic pathogens would lead to unsuccessful therapies that could be avoided with prudent and responsible AMU and understanding zoonoses in the aquatic environment.
- **New annex for aquatic animals in *OIE List of Antimicrobial Agents of Veterinary Importance***. Exchanges with Members on the annex to discuss the advantages of having a list dedicated exclusively to antimicrobial agents used in aquatic animals. Discussion of possibilities for adjusting the number of authorized antimicrobial agents in aquaculture would be useful.
- **Aquaculture in the implementation of NAP on AMR**. Aquaculture needs to control AMR should be represented in NAPs on AMR. To ensure this happens, Members need guidance on treatment and prevention of aquatic animal diseases with prudently used, accessible, effective and quality-assured antimicrobial agents. This training would be addressed to selected countries.
- **Legislation related to AMR/AMU in aquaculture**. Legislation specific to aquatic animals is important to guide AMU and to control AMR (as detailed in activity A8b).

Ic. Detailed references of articles referred to AMR published by the OIE

The following list of articles published in the *Scientific and Technical Review*, the OIE Bulletin and Conferences Proceedings and Compendiums in the last 20 years related to AMR including those referred to aquatic animals:

Scientific and Technical Review

- *The role of aquatic animal health in food security*. Rev. Sci. Tech. Off. Int. Epi. 38 (2) (I. Ernst & E. Peeler; Ed. 2019):
  - *The future of therapeutic agents in aquaculture* (K. Gravningen, H. Sørum & T.E. Horsberg) p 641-651.
- *Coordinating surveillance policies in animal health and food safety 'from farm to fork'*. Rev. Sci. Tech. Off. Int. Epiz. 32 (2) (S. Slorach; Ed.: 2013):
  - *Integrating animal health surveillance and food safety: the issue of antimicrobial resistance* (J. Acar & G. Moulin) p 383-392.
  - *Bacterial infections from aquatic species: potential for and prevention of contact zoonoses* (O. Haenen, J. Evans & F. Berthe) p 497-507.
  - *Monitoring and surveillance of antimicrobial resistance in microorganisms associated with aquatic animals* (P. Smith, V. Alday-Sanz, J. Matysczak, G. Moulin, C.R. Lavilla-Pitogo & D. Prater) p 583-593.
- *Antimicrobial resistance in animal and public health* Scientific and Technical Review 31 (1) (J. Acar & G. Moulin; Ed.: 2012):
  - *Use of antimicrobial agents in aquaculture* (Y.H. Park, S.Y. Hwang, M.K. Hong & K.H. Kwon) p 189-197.
- *Changing trends in managing aquatic animal disease emergencies* Scientific and Technical Review 27 (1) (E.-M. Bernoth; Ed.: 2008):
  - *Antimicrobial resistance in aquaculture* (P. Smith) p 243-264.
  - *Biotechnology and DNA vaccines for aquatic animals* (G. Kurath) p 175-196.
- *Plurithematic issue* Scientific and Technical Review 20 (3) (OIE; Ed.: 2001):
  - *Antimicrobial resistance: an overview* (J. Acar & B. Röstel) p 797-810.
  - *Antimicrobial resistance: risk analysis methodology for the potential impact on public health of antimicrobial resistant bacteria of animal origin* (D. Vose et al.) p 811-827.
  - *Antimicrobial resistance: responsible and prudent use of antimicrobial agents in veterinary medicine* (F. Anthony et al.) p 829-839.
  - *Antimicrobial resistance: monitoring the quantities of antimicrobials used in animal husbandry* (T. Nicholls et al.) p 841-847.
  - *Antimicrobial resistance: standardisation and harmonisation of laboratory methodologies for the detection and quantification of antimicrobial resistance* (D.G. White et al.) p 849-858.
  - *Antimicrobial resistance: harmonisation of national antimicrobial resistance monitoring and surveillance programmes in animals and in animal-derived food* (A. Franklin et al.) p 859-870.

OIE Bulletin

- *Fighting Antimicrobial Resistance, a long-term commitment*. Bulletin No. 2016-3:
  - *Fighting antimicrobial resistance, a long-term commitment* (editorial, M. Éloit) p 1-2.
  - *OIE launches its Strategy on Antimicrobial Resistance and the Prudent Use of Antimicrobials* (M. Éloit) p 3-7.
- Bulletin No. 2012-4:
  - *Expected benefit of aquaculture and the challenge of antimicrobial use – Part II* (D. Prater) p 9-14.
- *Health of aquatic animals*. Bulletin No. 2012-2:
  - *Expected benefit of aquaculture and the challenge of antimicrobial use – Part I* (D. Prater) p 3-9.
- *Veterinary medicinal products*. Bulletin No. 2010-1:

- *Veterinary medicinal products and vaccines: indispensable tools for any effective animal health and welfare policy* (editorial, B. Vallat) p 1-2.
- *The necessity for veterinary medicines* (P. Jones) p 3-5.

Proceedings

- *Aquatic Animal Health: 'Riding the Wave to the Future'*. Proceedings of the Third OIE Global Conference on Aquatic Animal Health, Ho Chi Minh City, Vietnam (OIE; Ed. 2016):
  - *The use of antimicrobial agents in aquaculture: addressing the challenges* (D. Prater)
- *Aquatic Animal Health Programmes: their benefits for global food security*. Proceedings of the OIE Global Conference on Aquatic Animal Health, Panama City, Panama (OIE; Ed.: 2012):
  - *Veterinary products and aquatic animals: towards the responsible and prudent use of antibiotics*

Ad hoc joint publication

- Technical Brief on Water, Sanitation, Hygiene and Wastewater Management to Prevent Infections and Reduce the Spread of Antimicrobial Resistance (FAO, OIE, WHO, 2020)

Compendium

- *Responsible and Prudent Use of Antimicrobial Agents for Animals*. Compendium Booklet (OIE Global Conference; Ed. 2014)

Other publications

- *OIE Standards, Guidelines and Resolution on antimicrobial resistance and the use of antimicrobial agents* (OIE, 2nd Ed. 2019).

Technical Items

- Importance of the prescription of antimicrobial agents and control of their distribution (with a possible e-tracking system) by the Veterinary Services for a proper implementation of the antimicrobial resistance strategy (Y. Kosenko) 28th Conference of the OIE Regional Commission for Europe, 2018
- Global action to alleviate the threat of antimicrobial resistance: progress and opportunities for future activities under the 'One Health' initiative (K. I. S. Yahia) 85th General Session OIE, 2017
- Combatting antimicrobial resistance through a One Health approach: actions and OIE strategy (J-P Orand, G. Moulin & E. Erlacher Vindel) 84th General Session OIE, 2016
- Harmonisation of the registration and control of veterinary medicinal products in Africa the model of the West African economic and monetary union (WAEMU) (I. Dare) 17th Conference of the OIE Regional Commission for Africa, 2007

Id. FAO's current projects and latest documents related to AMR in aquaculture

FAO's current three projects related to AMR in aquaculture:

- *Addressing Antimicrobial Usage in Asia's Livestock*
- *Aquaculture and Crop Production Systems*
- *Containment of Antimicrobial Resistance in terrestrial and aquatic food production systems, under the One Health approach in Latin America*)

FAO's other recent documents tackling the issue of AMR and AMU in aquaculture:

- FAO Fisheries and Aquaculture Report No. 1268. Rome; Smith, P. 2019. *The performance of antimicrobial susceptibility testing programmes relevant to aquaculture and aquaculture products*. FAO Fisheries and Aquaculture Circular No. 1191. Rome, FAO

- FAO 2019. *Aquaculture development. 8. Recommendations for prudent and responsible use of veterinary medicines in aquaculture*. FAO Technical Guidelines for Responsible Fisheries. No. 5. Suppl. 8. Rome
- FAO 2020. *Report of the FAO Expert Working Group Meeting "Scoping Exercise to Increase the Understanding of Risks of Antimicrobial Resistance (AMR) in Aquaculture"*, Palermo, Italy, 26–29 November 2018

References

[1] FAO 2020. The State of World Fisheries and Aquaculture 2020 – Sustainability in action. Rome. https://doi.org/10.4060/ca9229en

[2] B Belton, SR Bush, DC Little 2018. Not just for the wealthy: rethinking farmed fish consumption in the Global South. Glob Food Sec 16, 85–92.

[3] FC Cabello, HP Godfrey, AH Buschmann, HJ Dölz 2016. Aquaculture as yet another environmental gateway to the development and globalisation of antimicrobial resistance. Lancet Infect Dis 16: e127–33

[4] R Lulijwa, EJ Rupia, AC Alfaro 2020. Antibiotic use in aquaculture, policies and regulation, health and environmental risks: a review of the top 15 major producers. Rev Aquacult 12, 640–663.

[5] JEM Watts, HJ Schreier, L Lanska, MS Hale 2017. The Rising Tide of Antimicrobial Resistance in Aquaculture: Sources, Sinks and Solutions. Mar Drugs 15, 158

[6] K Thornber, D Verner-Jeffreys, S Hinchliffe, MM Rahman, D Bass, CR Tyler 2019. Evaluating antimicrobial resistance in the global shrimp industry. Rev Aquacul 1-21.

[7] RA Miller, H Harbottle 2017. Antimicrobial drug resistance in fish pathogens. Microbiol Spectrum 6(1):ARBA-0017-2017

[8] WY Mo, Z Chen, HM Leung, AOW Leung 2017. Application of veterinary antibiotics in China's aquaculture industry and their potential human health risks. Environ Sci Pollut Res 24: 8978–8989.

[9] M Reverter, S Sarter, D Caruso, J-C Avarre, M Combe, E Pepey, L Pouyaud, S Vega-Heredía, H de Verdal, RE Gozlan 2020. Aquaculture at the crossroads of global warming and antimicrobial resistance. Nat Commun 11:1870

[10] RM Zellweger, J Carrique-Mas, D Limmathurotsakul, NPJ Day, GE Thwaites, S Baker on behalf of the Southeast Asia Antimicrobial Resistance Network. 2017. A current perspective on antimicrobial resistance in Southeast Asia. J Antimicrob Chemother 72: 2963–2972.

[11] HY Done, AK Venkatesan, RU Halden 2015. Does the recent growth of aquaculture create antibiotic resistance threats different from those associated with land animal production in agriculture? The AAPS Journal 17, 3

[12] WHO 2019. Critically Important Antimicrobials for Human Medicine. 6th Revision 2018. Geneva.

[13] PJG Henriksson, A Rico, M Troell, DH Klinger, AH Buschmann, S Saksida, MV Chadag, W Zhang 2018. Unpacking factors influencing antimicrobial use in global aquaculture and their implication for management: a review from a systems perspective. Sustain Sci 13: 1105–1120.

[14] K Gravningen, H Sørum, TE Horsberg 2019. The future of therapeutic agents in aquaculture. Rev Sci Tech Off Int Epiz, 2019, 38 (2), 641-651.

[15] P Smith, V Alday-Sanz, J Matysczak, G Moulin, CR Lavilla-Pitogo, D Prater 2013. Monitoring and surveillance of antimicrobial resistance in microorganisms associated with aquatic animals. Rev sci tech Off int Epiz 32 (2), 583-593

[16] NMHCS 2015. Norwegian Government's National Strategy against Antimicrobial Resistance 2015–2020; Norwegian Ministry of Health and Care Services; Publication number: I-1164 E.

[17] JFA 2014. FY2013 Trends in Fisheries. White Paper on Fisheries: Summary, Japan Fisheries Agency

[18] M Troell, RL Naylor, M Metian, M Beveridge, PH Tyedmers, C Folke, KJ Arrow, S Barrett, A-S Crépin, PR Ehrlich, Å Gren, N Kautsky, SA Levin, K Nyborg, H Österblom, S Polasky, M Scheffer, BH Walker, T Xepapadeas, A de Zeeuw 2014. Does aquaculture add resilience to the global food system? PNAS 111: 13257-13263