Pathway to aquaculture biosecurity: Mitigating risks, managing progressively and engaging the value chain

PMP/AB Technical Working Group

FAO Fisheries and Aquaculture Division, Rome, Italy

Management of aquatic organism health by national, regional, international and multistakeholder cooperation is necessary to sustain the growth that has been achieved" – a resolute appeal for global action made at the turn of the Third Millennium, barely 25 years since aquaculture was recognised as an industry sector. To ensure they were not ignored, "Management of Aquatic Animal Health" was enshrined in the Strategy for Aquaculture Development beyond 2000 adopted by the Conference on Aquaculture in the Third Millennium in 2000 (FAO, NACA, 2000) and reinforced in the two global aquaculture conferences that followed (Phuket 2010 and Shanghai 2020) (FAO/NACA, 2012; FAO, NACA, 2021).

As health management gained relevance and urgency, two essential pillars were introduced by FAO, WOAH, NACA, and industry and academic partners: risk management and aquatic biosecurity. These and the other components of aquatic organism health strategy have now converged into the novel initiative "Progressive Management Pathway for Aquaculture Biosecurity" (PMP/AB).

Rising output and the rise and spread of disease

World aquaculture output, from the first estimate of six million tonnes a year in 1975, had reached 126 million tonnes (worth USD 296.5 billion) by 2021 (FAO, 2023). By the 1990s, however, the emergence and spread of new and other persistent diseases began to cause concern to farmers, traders, governments, scientists, international technical organisations, and assistance agencies that these diseases were slowing the growth of the sector. Concerns focused on three issues:

1. *Increasing numbers, frequency, spread, severity and persistence of diseases.* Important cultured and wild aquatic species are affected.

2. *Increasing costs to the industry.* As damage became widespread from production loss, vanished value addition, lost employment opportunities, and the cost of disease control, measures soared. By the second decade of the millennium, it was reported that industry- wide losses caused by diseases of aquatic organisms exceeded USD six billion a year.

3. *Time lag from detection of an outbreak to development and deployment of control measures.* The damage to the industry accrues and the costs pile up during this time. Three or more years can pass between the disease being detected and the placement of control measures. For example, Acute hepatopancreatic necrosis disease

Good husbandry and biosecurity practices can produce healthy and resilient farmed aquatic species. Photo credits (clockwise): David Huchzermeyer, Melba Reantaso, Shuaib T Muhammad , Melba Reantaso.

inflicted a loss in shrimp production of USD 12 billion from outbreak to implementation of a control (Shinn et al., 2018).

Magnifying these concerns is the overriding need to sustain the livelihoods of millions working along the aquaculture value chain and to ensure the food security and nutrition of over eight billion people.

Disease emergence drivers, factors and pathways

The fundamental strategy of the PMP/AB is prevention, enabled by risk management. This makes it imperative to understand the drivers, factors and pathways to aquatic disease emergence.

The following is an overview of the analysis of three important factors made by experts prior to the development of the PMP/AB.

Aquaculture biosecurity

The analysis reflects the barriers and complex challenges to carrying out the mandate from the Millennial conferences. Surmounting them depends on the sector arming itself with one basic capacity: aquaculture biosecurity. In the context of the PMP/AB, aquaculture biosecurity is the cost-effective management of risks posed by infectious agents to aquaculture through a strategic approach at enterprise, national and international levels with shared public-private responsibilities. Its key elements are risk management, a multi-level geographical coverage and value chain approach, and multi-stakeholder collaboration and collective responsibility.

Drivers, factors and pathways that contribute to aquatic disease emergence
Aquatic health management and disease control: multiple institutions involved; inadequate or poorly implemented biosecurity measures and low capacity for emergencies; perceived low incentive to report on known and emergent diseases; weak regulatory framework and lack of an effective public-private sector partnership (PPP).
Trade of aquatic organisms: highly traded commodity (70% exposed to international trade); live animals (larvae, fry, adults) and their products (live, fresh, frozen) globally traded; invasive animals are traded and pathogens carried by the primary host.
Knowledge of pathogens and their hosts: unique aquatic medium; for unknown and even known diseases, there remained significant knowledge gaps regarding transmission, immunity and genetics; diagnostics focused on known/listed diseases; breeding strategies not in place for many species; not easy for farmers to obtain efficacious and affordable vaccines.
Ecosystem change: physico-chemical conditions in aquaculture are often sub-optimal for host; aquatic hosts are cold-blooded, thus highly vulnerable to stressors; the aquatic medium is pathogen-rich, diversity changes with environment conditions; pathogens evolve and spill-over and spill-back relative to wild populations.

The special challenge

Compounding the institutional shortcomings in aquaculture biosecurity is the difficult technical/environmental challenge posed by the culture medium. Monitoring growth and keeping optimal water parameters are difficult enough. Preventing the introduction and monitoring the presence of pathogens in the surrounding and culture waters, avoiding water contamination, and reducing susceptibility to infection by mitigating stress-related impacts on the culture environment make aquaculture biosecurity much more complicated.

PMP/AB: a new way to handle the challenges

The PMP/AB aims to enhance aquaculture biosecurity capacity at the regional, national, local sector and enterprise levels. To do so, it builds on:

- Existing institutional and legal frameworks, capacity and appropriate tools, using risk-based approaches and PPP.
- Resilience to the biosecurity vulnerabilities.

Developed in two multi-stakeholder consultations and several Technical Working Group meetings (FAO, 2020), and endorsed by FAO's Committee on Fisheries Sub- Committee on Aquaculture (Tenth, Eleventh and Twelfth sessions), the PMP/AB is expected to sustain:

Diversity of aquaculture systems and environment produce diverse aquatic protein foods. Photo credits (counter-clockwise): Melba Reantaso, Paulo Padre, Dukhyun Yoon, Yngve Torgensen, Melba Reantaso.

- A reduction in disease burden.
- An improvement of health at farm and national levels.
- A minimisation of global spread of diseases.
- An optimisation of the socio-economic benefits from aquaculture.
- An attraction of investment opportunities into aquaculture.
- An achievement of the One Health goals – health of the ecosystem, people, and cultured organisms.

The PMP/AB will, therefore, contribute to SDG2, “Zero Hunger”; SDG 3, “Good health and well-being”; SDG 6, “Clean water and sanitation”; and SDG 14, “Life below water”.

How to join, practice and progress along the Pathway

A comprehensive guide to entry and execution is provided by the Progressive Management Pathway for Aquaculture Biosecurity (PMP/AB): guidelines for application (guidelines) (FAO, forthcoming). The guidelines illustrate (see figures below) and explain the pathway’s four stages:

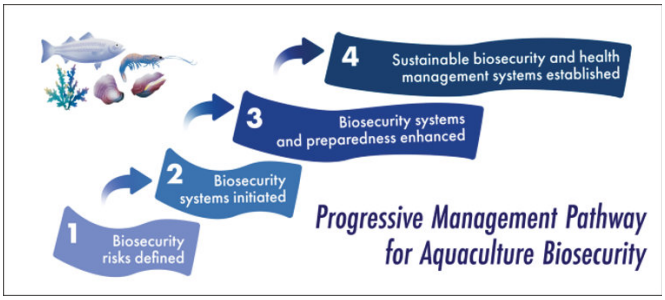
1. Biosecurity risks defined.
2. Biosecurity systems initiated.
3. Biosecurity systems and preparedness enhanced.
4. Sustainable biosecurity and heath management systems established.

Three principles guide every stage:

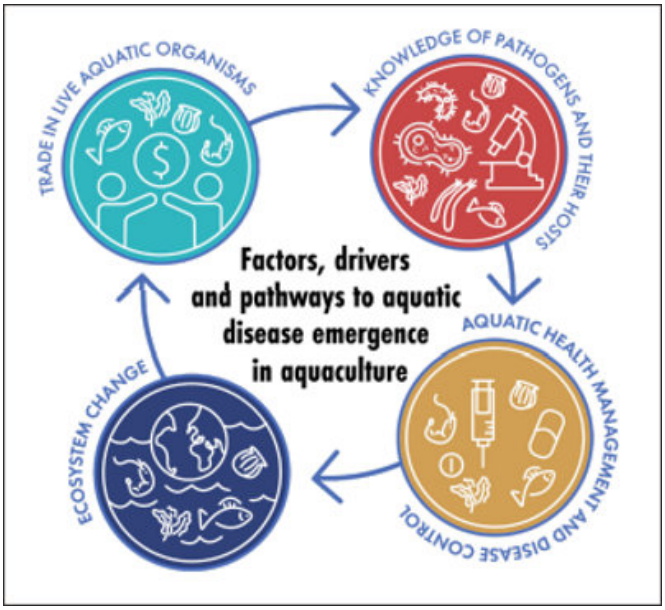
1. Risk-based.
2. Collaborative.
3. Progressive, with a good understanding of the epidemiological triad.

The triad portrays the relationship between a pathogen and susceptible aquatic population in a suitable environment that allows transmission of the pathogen and development of disease in the population. Understanding the relationship between host, pathogen and environment affected by human actions is key to the implementation of the PMP/AB.

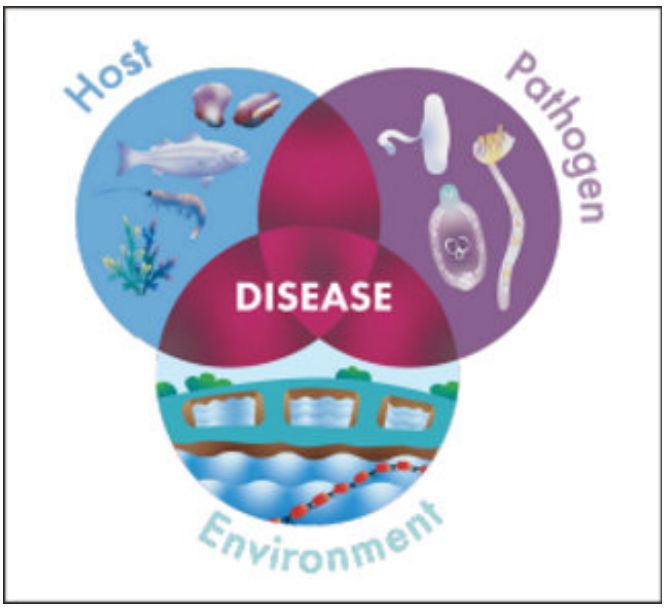
Risk assessment and emergency preparedness are carried out in every stage. Each stage has key indicators and activities. The five objectives of each stage are attained through five outcomes, whose satisfactory achievement allows the country to progress to the next stage. The four stages including the overall objectives and key outcomes to complete each stage; the details of each outcome; the recommended activities to produce each outcome; and a flowchart of the process and activities to complete Stages 1, 2 and 3 are described in the guidelines.



Four stages of the PMP/AB. Figure credits: Paulo Padre.



Factors, drivers and pathways to aquatic disease emergence in aquaculture.



Snieszko circle showing the relationship between host, pathogen and environment in disease development.

Practical guidance can also be drawn from three ongoing applications in three sectors: Seaweed, which covers all cultured seaweed species (Cottier-Cook, et al., 2022); Shrimp, which can be applied by the country, sector or an enterprise (Bondad-Reantaso, et al., 2022); and Tilapia, which

adopts a value chain approach (MacKinnon et al., 2023). More guides and tools to get started and progress through the pathway are cited in the guidelines.

Benefits

The mutually reinforcing benefits accrue to a country, the industry, the farms and the enterprises along the PMP/AB. Briefly these are:

- **Better governance:** It offers countries the opportunity to harness aquaculture production that is responsive to environmental and human-induced challenges and requires enabling policies.
- **Partnership, shared ownership and responsibilities:** It provides a solid platform for public-private partnerships, through the formulation of strategic and implementation plans that are jointly developed by industry stakeholders, governance authorities and academe. This ensures buy-in and best-fit for each country.
- **Tangible benefits to stakeholders at every stage:** This encourages long-term commitment. Co-management principles ensure that problems are well defined and management solutions are identified.
- **Commitment to risk management:** It establishes risk ownership and promotes active engagement and long-term commitment to risk management.
- **Sustainability:** All the above, which can be boiled down to collaboration among the major stakeholders marked by coordinated efforts of various institutions and experts; pooling resources, sharing knowledge, expertise and experiences; cooperation and goodwill; and the sustainability of the biosecurity component of aquaculture management and the global aquaculture industry.

Way forward

The PMP/AB, which now includes aquatic plants, hence the use of the term aquatic organisms covering both plants and animals, is a paradigm shift in the way disease challenges are handled. It is infused with the principle embodied in the timeless adage – “An ounce of prevention is worth a pound of cure.” Proactive and preventive biosecurity measures are less expensive than solution- based, reactive responses to outbreaks. Reducing the time taken to respond to an outbreak is crucial.

The desired outcome is healthy and safe aquatic foods, with reduced disease burden and the achievement of One Health goals, to enhance the food and nutrition security of a growing world population. The broader outcomes are increased investment in the sector; sustained economic benefits for primary stakeholders; and social, economic and environmental benefits for everyone else. To bring these about, aquaculture stakeholders need and are encouraged to take an active role in the PMP/AB, exploring the opportunities for cooperation, partnership and co-ownership – reaping the co-benefits that it offers.

One of the clearest signs of a maturing industry is when the focus is on disease prevention supported by effective governance and innovation.

Countries and aquaculture value chain stakeholders are, therefore, encouraged to embrace PMP/AB and establish biosecurity in parallel with any aquaculture development.

These specific benefits include: better risk management, cost-effective mobilisation and application of scientific, technical and physical resources, and public confidence on the safety of the products and goodwill engendered by social and environmental responsibility.

References

Bondad-Reantaso, M.G., Mackinnon, B., Hao B., McLaws, M., and Huang J. 2022. The progressive management pathway for improving aquaculture biosecurity (PMP/AB): relevance and potential application to the shrimp aquaculture sector. In V. Alday-Sanz, ed. The Shrimp Book II. 5m Books Ltd

Cottier-Cook, E.J., Cabarubias, J.P., Brakel, J. et al. 2022. A new Progressive Management Pathway for improving seaweed biosecurity. Nature Communications 13. Article 7401. 6 pp. (also available at www.doi. org/10.1038/s41467-022-34783-8)

FAO. 2020. Progress towards development of the progressive management pathway for improving aquaculture biosecurity (PMP/AB): Highlights of 2019 activities. FAO Fisheries and Aquaculture Circular No. 1211. Rome, FAO. 42 pp. (also available at www.fao.org/documents/card/en/c/cb0560en)

FAO. 2023. Fishery and Aquaculture Statistics. Global aquaculture production 1950–2021 (FishStatJ). In: FAO Fisheries and Aquaculture Division [online]. Rome. Updated 2023. (also available at www.fao.org/fishery/en/fishstat)

FAO. forthcoming. The Progressive Management Pathway for Aquaculture Biosecurity: guidelines for application. Fisheries and Aquaculture Technical Paper No. 689. Rome

FAO, NACA. 2000. Aquaculture Development Beyond 2000: the Bangkok Declaration and Strategy. Conference on Aquaculture in the Third Millennium, 20–25 February 2000, Bangkok, Thailand. NACA, Bangkok and FAO, Rome. pp. 27. (also available at www.fao.org/fishery/en/ publication/20045)

FAO/NACA. 2012. Farming the Waters for People and Food. R.P. Subasinghe, J.R. Arthur, D.M. Bartley, S.S. De Silva, M. Halwart,

N. Hishamunda, C.V. Mohan & P. Sorgeloos, (Eds.) Proceedings of the Global Conference on Aquaculture 2010, Phuket, Thailand. 22–25 September 2010. FAO, Rome and NACA, Bangkok. 896 pp. (also available at www.fao. org/documents/ card/en/c/f086204d-0bb9-5132-8ba7-9b10044a75b1/)

FAO, NACA. 2021. Shanghai Declaration: Aquaculture for food and sustainable development. 2020 Global Conference on Aquaculture. 22 pp. (also available at www.fao.org/3/cb8517en/ cb8517en.pdf)

MacKinnon, B., Debnath, P.P., Bondad-Reantaso, M.G., Fridman, S., Bin, H., & Nekouei, O. 2023. Improving tilapia biosecurity through a value chain approach. Reviews in Aquaculture, Vol.

15, Issue S1. pp. 57–91. (also available at www.onlinelibrary. wiley.com/doi/ full/10.1111/raq.12776)

Shinn, A.P., Pratoomyo, J., Griffiths, D., Trong, T.Q., Vu, N.T., Jiravanichpaisal, P., and Briggs, M. 2018. Asian shrimp production and the economic costs of disease. Asian Fisheries Science 31S: 29–58. (also available at www. asianfisheriessociety.org/publi- cation/downloadfile.php?id=1223&file=Y0dS bUx6QTJOekUy- TURVd01ERTFORGMzTWpVek5EZ3VjR1Jt)