

## Biosecurity and Disease Management in Shrimp Aquaculture: From Pathogen Exclusion to Resilient Production Systems

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Shrimp aquaculture is one of the fastest-growing food production sectors and a major export earner for many tropical and subtropical countries. Its growth has been accompanied by high-density culture and, in many regions, environmental degradation, both of which have increased the incidence of infectious disease in farmed shrimp [2]. Since disease outbreaks emerged in the 1980s, control has relied mainly on on-farm biosecurity, probiotics, and the development of SPF and SPR stocks, primarily against bacterial and viral infections [2]. Because infected shrimp ponds cannot easily be treated, the central objective of shrimp health management is to exclude pathogens and limit their spread [2,3]. This article reviews the scientific and practical basis for that approach. It is organised as follows: Section 2 describes the main pathogens, Section 3 the economic burden, Section 4 the drivers of outbreaks, Sections 5 and 6 biosecurity and genetic strategies, Section 7 diagnostics and international standards, Section 8 health economics, and Sections 9 and 10 country examples, challenges and research needs.

### Major pathogens affecting farmed shrimp

Shrimp diseases are caused by viruses, bacteria, fungi and microsporidian parasites. The table below summarises widely recognised diseases and the main features that matter for management. Descriptions of the agents are general background knowledge from the shrimp pathology literature, and readers should consult primary sources, such as the WOAHA Aquatic Manual, for case definitions.

**Table 1. Selected shrimp diseases and their management relevance (author's summary; economic figures from [1]).**

| Disease (abbreviation)                                    | Causative agent                                                                       | Management relevance                                                                                                |
|-----------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| White spot disease (WSSV)                                 | DNA virus (white spot syndrome virus)                                                 | Can cause rapid, high mortality in ponds; infects many crustaceans, so wild hosts and carriers complicate exclusion |
| Acute hepatopancreatic necrosis disease (AHPND)           | Bacterium ( <i>Vibrio</i> parahaemolyticus strains carrying a toxin-encoding plasmid) | Affects early grow-out; linked to pond water and sediment quality; has caused major regional losses [1]             |
| Infectious myonecrosis (IMNV)                             | RNA virus                                                                             | Estimated to have caused large losses in affected regions between 2002 and 2012 [1]                                 |
| Infectious hypodermal and haematopoietic necrosis (IHHNV) | DNA virus                                                                             | Subject of WOAHA reference-laboratory review in 2026 [5]; associated with growth problems and stock quality         |
| Hepatopancreatic microsporidiosis (EHP)                   | Microsporidian parasite                                                               | Mainly causes growth retardation instead of acute mortality, so it can go unnoticed without testing                 |

## Economic burden of disease

Estimates of disease losses show how costly outbreaks can be. A historical review compiled by Subasinghe lists about USD 3.0 billion in losses from several pathogens in 1987–1994, about USD 1 billion for infectious myonecrosis virus in 2002–2012, about USD 12 billion for AHPND in 2010–2018, and about USD 1.6 billion from several pathogens in 2017 [1]. These numbers come from different studies with different methods and time frames, so they are not directly comparable and are best read as indicators of scale. They also reflect lost production and not wider costs, such as lost employment and reduced export revenue.

**Table 2. Estimated economic losses from shrimp disease, as compiled in [1].**

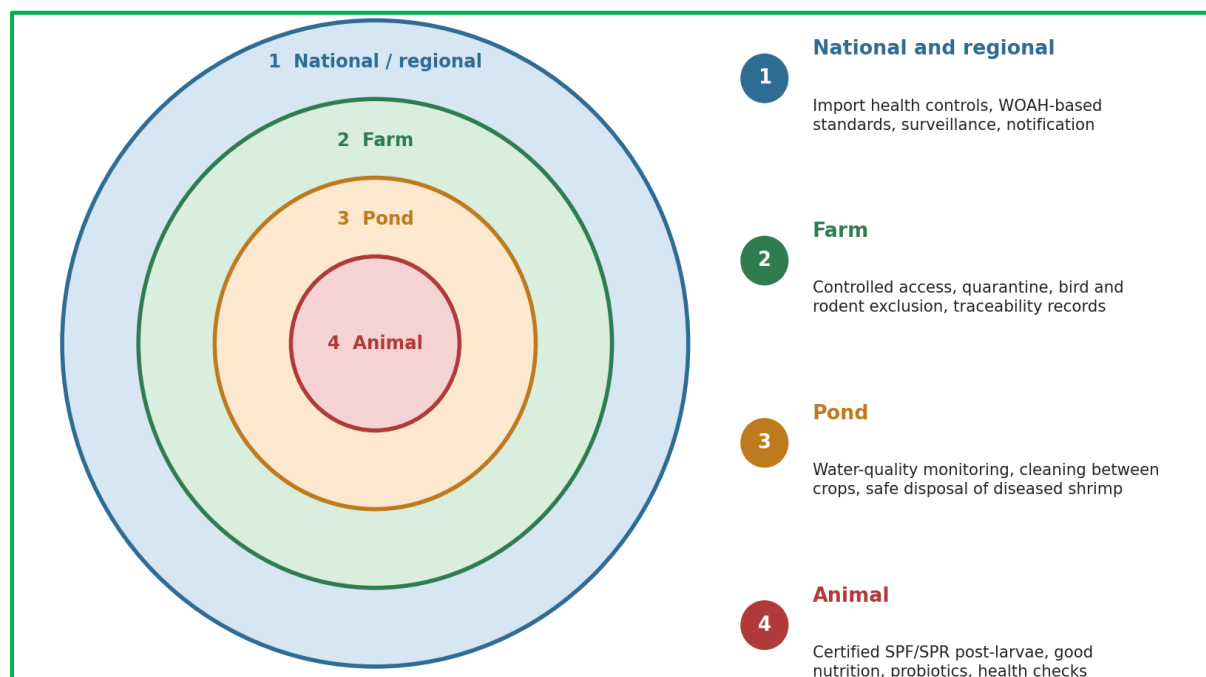
| Period    | Disease or cause             | Estimated loss (USD) |
|-----------|------------------------------|----------------------|
| 1987–1994 | Several pathogens            | ~3.0 billion         |
| 2002–2012 | Infectious myonecrosis virus | ~1 billion           |
| 2010–2018 | AHPND                        | ~12 billion          |
| 2017      | Several pathogens            | ~1.6 billion         |

## Drivers of outbreaks

Outbreaks rarely have a single cause. Disease is typically the outcome of an interaction between the pathogen, the host and the environment. Reviews of resilient shrimp farming point to poor management practices as important contributors, including a lack of water-quality monitoring, gaps in biosecurity and inadequate nutrition [3]. Improper cleaning between crops can allow disease to carry over to the next cycle, and improper disposal of diseased shrimp can spread infection between farms and spill over into natural aquatic ecosystems [3]. High stocking density, poor pond preparation, and stress from fluctuating temperature, salinity or oxygen are generally recognised risk factors in shrimp pathology, although their relative importance varies by system. Because these factors are modifiable, they provide the basis for preventive health management.

## Biosecurity: a layered framework

Biosecurity can be defined as the set of measures that prevent pathogens from entering a population and limit their spread within and between populations. In aquaculture it is applied at several levels (Figure 1). WOAHP guidance stresses that biosecurity at production-site level is necessary for preventing the entry and spread of aquatic animal diseases and is an important part of health management [8].



**Figure 1. Nested layers of biosecurity, from national policy (outer ring) to the individual animal (centre); protection builds inward and no single layer is sufficient (schematic prepared for this article, based on [3,4,8]).**

**Exclusion and insulation measures**

Practical measures described in the literature include controlled access to farms, use of more disease-resistant strains, sourcing post-larvae with health certification, use of prebiotics, installing nets over ponds to keep out wild birds and rodents, and disinfection practices such as foot dipping to prevent spread between ponds and farms [3]. Each measure targets a specific pathway of introduction, and none is sufficient alone. The value of a biosecurity programme lies in the combined reduction of risk across all pathways.

**Detection and traceability**

Shrimp pathogens can be tracked along supply chains by traceability systems that record health and origin data at each stage of production, processing, retail and consumption [3]. Such systems help to identify the source of an outbreak and support decisions on movement restrictions. They depend on reliable record keeping and consistent identification, which can be difficult in sectors dominated by many small producers.

**Prevention, preparedness and response**

A conceptual framework linking organism health and economics describes biosecurity actions as spanning prevention, preparedness and response. It gives examples such as producing SPF or SPR larvae to reduce infection risk at grow-out stage, applying various biosecurity measures to reduce the occurrence of white spot syndrome virus on a farm, and mounting an emergency biosecurity response to an outbreak of tilapia lake virus [4]. The framework also stresses that an accurate case definition is essential, because preparedness and response both depend on knowing exactly what is being detected [4].

**Genetic and stock-based strategies**

SPF stocks are produced from broodstock that have been tested and shown to be free of listed pathogens, whereas SPR stocks have been bred for resistance or tolerance to specific pathogens. Both approaches are part of the standard set of control measures, together with farm-level biosecurity and probiotics [2]. The review by Subasinghe also notes that SPF production combined with certification by the competent authority for two years or more may not, on its own, be enough for a zone to be accepted as free of certain diseases [1], which indicates that stock health status and area health status are different things. In practice, SPF seed lowers the risk of introducing pathogens but does not protect against infection from the environment after stocking.

**Diagnostics, surveillance and international standards****Role of WOA**

WOAH sets international standards for aquatic animal health through the Aquatic Animal Health Code and the Aquatic Manual. Under its listing criteria, a disease may be considered for listing where it has caused significant production losses nationally or internationally, or is likely to harm wild aquatic populations, or is a public-health concern, and where its infectious cause is established (or strongly associated) and there is a likelihood of international spread through live animals, products or fomites [8]. Listing triggers notification obligations, which supports early warning and trade decisions.

**Current standard-setting work**

The February 2026 report of the WOA Aquatic Animal Health Standards Commission describes work on chapters for aquatic animal disease surveillance, emergency disease preparedness and disease outbreak management, with some items proposed for adoption at the 93rd General Session in May 2026 [5]. It also describes a new chapter on validating diagnostic assays for infectious diseases of aquatic animals, and consultation with WOA reference-laboratory experts for IHNV [5]. Validation matters because a test that performs differently between laboratories can lead to false confidence or unnecessary trade restrictions.

**Health economics of prevention**

The decision to invest in biosecurity is partly an economic one. The conceptual framework in [4] argues that biosecurity should be part of an integrated strategy that manages disease,

business, and environmental and social risks at the same time. For a farmer, the relevant comparison is between the certain cost of preventive measures and the uncertain but potentially severe cost of an outbreak. For a government, the comparison includes spillover effects on neighbouring farms and wild populations, which individual farmers do not pay for. This difference between private and public costs is a standard reason for public support of surveillance and shared biosecurity infrastructure.

## Country examples

### Ecuador

The Fish Site reports that Ecuador's shrimp industry has recovered from severe disease-related losses to become one of the world's leading producers, a subject examined at the Global Shrimp Forum 2026 [6]. The recovery shows that disease can be managed at industry scale, but the sources reviewed here do not identify which specific measures were responsible, so conclusions about cause should be drawn only from detailed epidemiological studies.

### India

A recent book chapter reviews biosecurity and disease management in Indian aquaculture and stresses the importance of WOAHA aquatic standards for international health requirements [7]. For Indian shrimp farmers, where farms are often small and numerous, the practical issues are access to certified seed, laboratory diagnostics, and farmer training. These points are an inference from the sector structure and should be checked against national data before use.

## Challenges and research needs

- Affordability: develop low-cost biosecurity packages that small farms can adopt, and test them in field trials.
- Diagnostics: expand access to validated, rapid tests that can be used near the farm.
- Traceability: implement data systems that link seed source, farm health records and processing.
- Wild reservoirs: improve understanding of carrier species and environmental persistence of pathogens.
- Economics: quantify the cost-effectiveness of biosecurity measures at farm and national level.

## Conclusion

Shrimp disease has repeatedly caused large losses, and the main lesson from the literature is that prevention is more effective than treatment. Effective programmes combine layers of protection, from national standards and surveillance to farm hygiene and certified seed, and rely on accurate diagnosis. The main challenges are to make these measures affordable and verifiable for small producers, and to keep international standards and national practice aligned.

## References

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