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SUSTAINABLE SHRIMP AQUACULTURE MANAGEMENT: BIO - FLOC AND SECURITY

Edited by

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MADRAS CHRISTIAN COLLEGE, EAST TAMBARAM, CHENNAI - 600 059 & NATIONAL INSTITUTE OF AGRICULTURAL EXTENSION MANAGEMENT, HYDERABAD

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MESSAGE

National Institute of Agricultural Extension Management (MANAGE), Hyderabad is an autonomous organization under the Ministry of Agriculture & Farmers Welfare, Government of India. The policies of liberalization and globalization of the economy and the level of agricultural technology becoming more sophisticated and complex, calls for major initiatives towards reorientation and modernization of the agricultural extension system. Effective ways of managing the extension system needed to be evolved and extension organizations enabled to transform the existing set up through professional guidance and training of critical manpower. MANAGE is the response to this imperative need. Agricultural extension to be effective, demands sound technological knowledge to the extension functionaries and therefore MANAGE has focused on training program on technological aspect in collaboration with ICAR institutions and state agriculture/veterinary universities, having expertise and facilities to organize technical training program for extension functionaries of state department.

The nation's fisheries and aquaculture sector has developed from a traditional source of income into a business sector that is heavily reliant on technology. Fisheries and aquaculture is witnessing a changed scenario from its traditional role as a supplementary subsistence activity in most of the States to viable and sustainable economic activity. The sector is now gaining importance as an attractive investment destination and a lucrative business activity. With the changing consumption pattern, emerging market forces and recent technological developments, the sector has assumed increased importance with farmers and other stakeholders in the country. Fish consumption has recently increased worldwide with high demands in the developing countries. Fish contains protein source because it is less expensive than other meats including bush meat, hog, chicken, and cattle. Fish is anticipated to be the most major source of protein in the human diet on a global scale, and it is believed that more than 30% of all fish consumed by humans comes from aquaculture.

It is a pleasure to note that, Madaras Christian College, Chennai & MANAGE, Hyderabad is organizing a collaborative training program on "*Sustainable Shrimp Aquaculture Management: Biofloc and Bio Security*" from 25-27 March, 2024 and coming up with a joint publication as e-book on "*Sustainable Shrimp Aquaculture Management: Biofloc and Bio Security*" as immediate outcome of the training program.

I wish the program be very purposeful and meaningful to the participants and also the e-book will be useful for stakeholders across the country. I extend my best wishes for success of the program and also Madaras Christian College, Chennai & MANAGE, Hyderabad, many more glorious years in service of Indian agriculture and allied sector ultimately benefitting the farmers. I would like to compliment the efforts of Dr. Shahaji Phand, Centre Head-EAAS, MANAGE, Hyderabad Dr. C. Joyce Priyakumari for this valuable publication.

Dr. P. Chandra Shekara

Director General, MANAGE

MESSAGE

MCC Pulicat Estuarine Biological Research Centre (MCC PEBRC) formerly known as Estuarine Biological Laboratory (EBL), an Off-Campus Facility of the Department of Zoology, Madras Christian College, Chennai was established at Pulicat (Pazhaverkadu), Thiruvallur district in 1968. Pulicat Lake is a biodiversity hotspot in Southern India. This Centre has been working on the environmental and fisheries aspects of the lake and the livelihood of fisher men folk of the number of coastal villages juxtapose to the lake and generated a lot of data apart from publishing many research reports and articles. By the virtue of the long period of experience of the faculty and the scholars on the Pulicat lake and its fisheries, a number of fisheries and aquaculture opportunities were identified and technologies and entrepreneurial skills have been developed for the benefit of stakeholders. This Centre has been availing a number of R & D schemes from the funding agencies viz. DBT, DST, UGC, etc. The Centre has now upgraded its facilities to focus also on the applied research and technology development in areas such as aquaculture, aquaponics, Lake- ranching, Coral rocks, etc. focusing on biodiversity richness of the Pulicat Lake.

It is a pleasure to collaborate with MANAGE, Hyderabad in organizing a collaborative training program on "*Sustainable Shrimp Aquaculture Management: Bio-floc and Bio Security*" from 25-27 March, 2024. I whole heartedly wish the program to be a grand success.

C. Joyce Priyakumari

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PREFACE

In India population increasing every day with increase in the demand for the food. Aquaculture is the main source of food, income and employment. Even though aquaculture is rapidly growing profitable industry, the diseases caused by various pathogens, feed cost, water availability and suitable culture methods are the main problems faced by the aqua farmers. Owing to the great diversity of aquaculture operations, the description of types of aquaculture systems may be complex and sometimes confusing. Broadly, aquaculture structures include ponds, tanks, raceways, cages and pens. Economics of the different culture systems and its applicability in the small and medium scale fish production is required for existing as well as new entrepreneur in the sector. The use of these culture systems and its economics in the installation and maintenance has to be nurtured to the sustainable shrimp aquaculture for formulating their budget and adopting the right systems for the right species. This book was made possible by the sincere efforts of the contributing authors.

This e-book is an outcome of collaborative online training program on "*Sustainable Shrimp Aquaculture Management: Bio-floc and Bio Security*" conducted from 25–27 March, 2024. This book will be highly useful to the young aquapreneurs and field workers who are working at the ground level. Various important topics on different culture systems which are practised in aquaculture have been covered for the benefit of the readers.

The editors express sincere thanks to Dr. P. Wilson, Principal, Madras Christian College, Chennai for the encouragement in publishing this e-book. The financial aid provided by MANAGE, Hyderabad for this training program is duly acknowledged. We hope and believe that the suggestions made in this e-book will help to improve the knowledge on the different culture systems in upcoming aquapreneurs.

Editors

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Chapter 1

Biosecurity systems in shrimp aquaculture

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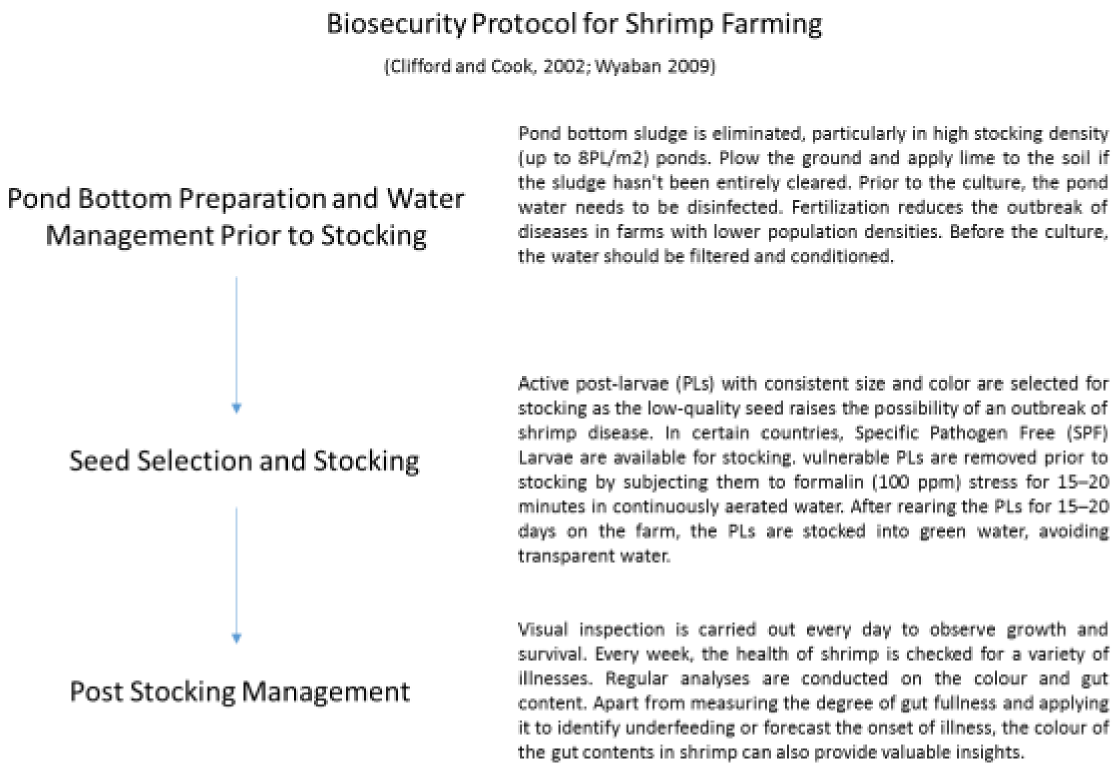
The process of excluding particular diseases from cultured aquatic stocks in broodstock facilities, hatcheries, and farms, as well as from entire regions or countries, with the aim of preventing disease, is known as biosecurity as it relates to prawn aquaculture (Lightner 2003). He talked about methods for limiting the import of live and frozen prawns and eliminating pathogens from stock (i.e., post larvae and broodstock), particularly by using quarantine and specific pathogen-free (SPF) certified stocks. The recommended approaches for removing pathogens from hatcheries and farms included removing vectors and external sources of contamination as well as avoiding internal cross-infection. Within the poultry sector, biosecurity is characterised as a crucial set of instruments for the avoidance, management, and eradication of economically significant infectious illnesses. Incoming water is frequently treated with ozonization and chlorine, while equipment, clothes, and other potential vectors are treated with iodine and chlorine. The use of SPF prawns, which are widely accessible commercially, is one biological measure. The shrimp industry's second line of defence is the application of certain pathogen-resistant prawns, which are not only free of disease but also resistant to particular illnesses. Since shrimp lack a distinct immune response, common immunostimulants such lipopolysaccharides, peptidoglycans, and β-1-3 glucan are employed to increase the shrimp's capacity to fend against infection. According to FAO (2003) and Tang *et al*. (2003), the viruses WSSV and IHHNV are thought to have been brought into the Americas from Asia via frozen or live contaminated commodity prawns. In wild penaeid prawns from the Americas (Motte *et al*. 2003) and Asia (Fegan), both WSSV and IHHNV have been shown. Shrimp farming has evolved as a result of the introduction of these and other viruses into wild shrimp stocks in the Americas. The days of collecting broodstock and post larvae from the wild without worrying about them possibly transmitting disease are long gone.

The days when prawn farms could be planned and run without a biosecurity programme are long gone, with the exception of the most remote areas. With the adequate biosecurity protocols should stop the illness from spreading to other ponds and causing the entire crop to fail. A strategy for eradicating infections at the stock level and partially disinfecting the facility level was suggested by Lightner (2003). In order to eradicate infections in affected ponds and tanks should be cleaned, depopulated, and replenished with SPF prawns after larvae and broodstock have been removed. However, if partial disinfection (with lime, chlorine, or drying) is unsuccessful, it could be required to depopulate the entire stock and follow the entire facility. Improved environmental and biological conditions for the sick population could boost its resistance to illnesses, according to Horowitz and Horowitz (2003).

The use of captive or domesticated stocks that have been submitted to an intensive disease surveillance and control programme and are cultivated under controlled conditions is the single most important principle of biosecurity (Lightner 2003). In aquaculture none of the techniques developed were able to offer much protection against crop losses in farms that use seed stock derived from wild stock sources. Instead, they should be integrated into the operational design and management of shrimp farms that have previously been impacted by TSV and WSSV in order to eradicate them and ensure that they are not back. One way to reduce this risk is to use only domesticated prawn stocks that have a documented history of being free of viruses of concern. But an SPF Stock control, which is the most crucial biosecurity principle, can be summed up as using domesticated or captive stocks that have been actively involved in disease surveillance and control programmes and are cultivated under controlled conditions (Lightner 2003).

Diseases of shrimps

Numerous pathogenic agents, such as bacteria, viruses, fungus, and protozoa, can infect farmed prawns. The primary focus of this analysis is on bacterial and viral illnesses that have significantly impacted the prawn farming sector. Shrimp can contract several viruses, but not all of them can lead to life-threatening illnesses. The majority of prawn species that are farmed for commercial purposes have been found to harbour the infectious hypodermal and hematopoietic necrosis virus (IHHNV). In certain species, like the Asian tiger shrimp *Penaeus monodon*, it seems innocuous, but in others, it causes death and stunted growth. Other viruses that harm the hepatopancreatic cells and cause the damage include the Baculovirus penaei (BP), Hepatopancreatic parvo-like virus (HPV), and Monodon baculovirus (MBV). It is thought that these viruses infect people and lower their growth rates. As previously mentioned, white spot syndrome virus (WSSV), yellow head virus, and other viruses are the three that cause acutely deadly infections in prawn aquaculture. Taura syndrome virus (TSV) and Yellow head virus (YHV). Within a few days after the onset of the disease symptoms, all three viruses have the potential to cause significant death. A viral disease usually becomes less severe two years after it first manifests. This seems to show some kind of adaptive reaction to the pathogen. The viruses are never totally eradicated, though. They occasionally reappear to cause widespread fatalities, especially during stressful periods. Moreover, growth retardation frequently follows viral infections which causes economic losses.



Role of biosecurity in shrimp aquaculture

Biosecurity plays a crucial role in shrimp aquaculture due to its significance in maintaining the health and productivity of shrimp farms. Biosecurity refers to a set of preventive measures and management practices aimed at minimizing the introduction and spread of diseases, pests, and other pathogens in aquaculture systems. Here are some key reasons highlighting the importance of biosecurity in shrimp aquaculture:

a. **Disease Prevention**: Shrimp farms are vulnerable to various diseases caused by bacteria, viruses, fungi, and parasites. These diseases can lead to massive economic losses through reduced production, increased mortality, and decreased quality of shrimp. Biosecurity measures such as strict control of water quality, screening of broodstock, regular health monitoring, and isolation or quarantine of new stock help prevent the introduction and spread of pathogens, reducing the risk of disease outbreaks.

b. **Minimizing Economic losses**: Disease outbreaks in shrimp aquaculture can result in significant economic losses for farmers. The costs associated with mortality, decreased growth rates, and decreased market value of infected shrimp can be substantial. By implementing biosecurity measures, farmers can reduce the likelihood of disease occurrence, minimize losses, and maintain a stable production system.

c. **Sustainability and Environmental protection**: Biosecurity practices in shrimp aquaculture contribute to the sustainability and environmental protection of aquatic ecosystems. Disease outbreaks in shrimp farms can lead to the release of pathogens and chemicals into the surrounding environment, potentially affecting wild shrimp populations and other aquatic organisms. Effective biosecurity measures help minimize the use of antibiotics, chemicals, and other treatments, reducing the environmental impact of shrimp farming.

d. **International Trade and Market access**: Biosecurity is critical for maintaining international trade relationships and market access for shrimp products. Many countries have strict regulations and standards to prevent the introduction of exotic diseases through imported shrimp. By implementing robust biosecurity protocols, shrimp farmers can demonstrate their commitment to producing healthy and disease-free shrimp, ensuring compliance with international trade requirements and facilitating market access.

e. **Long-term Sustainability of the Industry**: Shrimp aquaculture is a rapidly growing industry that contributes to global food security and economic development. To ensure the long-term sustainability of the industry, it is essential to maintain healthy and productive shrimp farming systems. Biosecurity measures are instrumental in preventing the emergence and spread of new diseases, as well as the development of antimicrobial resistance, which can threaten the viability of shrimp farming in the long run.

In conclusion, biosecurity is of utmost importance in shrimp aquaculture to prevent the introduction and spread of diseases, minimize economic losses, protect the environment, maintain market access, and ensure the long-term sustainability of the industry. Implementing robust biosecurity measures is crucial for the success and profitability of shrimp farms and contributes to the overall health and productivity of the global shrimp aquaculture sector. SPF Shrimp Feeds offers a range of shrimp larval diets, including Artemia cysts, microparticulated feeds, and black flake diets, in addition to live SPF Polychaetes, Artemia Vibrio treatment, and bio-remediation for shrimp farming.

Potential areas for research and development

Despite the encouraging results in the present aquaculture industry, important advances need to occur before this technology becomes commercially viable. Two critical areas of research include: 1) selective breeding of shrimp for rapid growth and high survival in biosecure production systems, and 2) the development of aquatic feeds appropriate for biosecure systems. With advanced biosecure technologies available, the shrimp farming industry will be able to expand into areas away from the coast with greater control against the spread of disease and without adversely affecting the environment.

References

Clifford, H.C., Cook, H.L. (2002). Disease Management in Shrimp Culture Ponds. Aquaculture Magazine: 28(4): 18-26

FAO (2003). Health management and biosecurity maintance in white shrimp (Penaeus vannamei) hatcheries in Latin America. FAO Fisheries Technical Paper 450. FAO, Rome. 62p.

Horowitz, A. Horowitz, S. (2003). Alleviation and prevention of disease in shrimp farms in Central and South America: A microbiological approach. p. 117-138 in C.-S. Lee and P.J. O'Bryen, editors. Biosecurity in Aquaculture Production Systems: Exclusion of Pathogens and Other Undesirables. The World Aquaculture Society, Baton Rouge, Louisiana, USA.

Lightner, D. V. (2003). Exclusion of specific pathogens for disease control in a penaeid shrimp biosecurity program. p. 81-116 in C. -S. Lee and P. J. O'Bryen, editors. Biosecurity in aquaculture production systems: Exclusion of pathogens and other undesirables. The World Aquaculture Society, Baton Rouge, Louisiana, USA.

Motte, E., E. Yagcha, J. Luzardo, F. Castro, G. Leclercq, J. Rodriguez, P. Miranda, 0. Borja, J. Serrano, M. Terrems, K. Montalvo, A. Namaez, N. Tenorio, V. Cedeno, E. Mialhe, Boulo, V. (2003). Prevention of IHHNV vertical transmission in the white shrimp Litopenaeus vannamei. Aquaculture, 219: 57-70.

Tang, K. F. J., B. T. Poulos, J. Wang, R. M. Redman, H. -H. Shih, Lightner, D. V. (2003). Geographic variations among infectious hypodermal and hematopoietic necrosis virus (IHHNV) isolates and characteristics of their infection. Diseases of Aquatic Organisms, 53:91-99.

Wyaban, J. (2009). World Shrimp Farming Revolution: Industry Impact of Domestication, Breeding and Widespread Use of Specific Pathogen Free *Penaeus vannamei*. Craig L. Browdy and Darryl E. Jory, editors. The Rising Tide, Proceedings of the Special Session on Sustainable Shrimp Farming, World Aquaculture 2009. The World Aquaculture Society, Baton Rouge Louisiana USA. 12-21p.

Chapter 2

From Policy to Practice: Implementing Biosecurity Strategies for a Sustainable Aquaculture Sector in India

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Introduction

Biosecurity is one of the most important aspects of today's aquaculture, particularly in countries like India, where the sector is the backbone of both the economy and food security (Yanong and Erlacher, 2012). Aquaculture, or the farming of aquatic organisms like fish, shellfish, and seaweeds, has become increasingly essential with the world's increasing appetite for seafood and diminishing wild fish stocks. Aquaculture contributes significantly towards national economic development in India, employs millions of people, contributes to rural development, and improves nutritional security by providing consistent supplies of high-quality protein. Moreover, substantial export revenues are generated while India improves its rank in the global seafood market.

According to the National Fisheries Development Board (NFDB), India is the second-largest producer of fish in the world, with aquaculture accounting for over 50% of the country's total fish production. Key species farmed in India include various types of fishes and shrimps, particularly *Penaeus vannamei* (Pacific white shrimp), which dominates the export market. Aquaculture has become a lifeline for rural communities, providing employment and supporting livelihoods for millions of farmers and workers in coastal and inland areas. The government initiatives actively promoted aquaculture through schemes which aims to double India's aquaculture production by 2025.

Despite its economic importance, the rapid growth of aquaculture in India brings with it a range of biosecurity challenges that must be addressed to ensure the sector's sustainability. Effective biosecurity measures are essential for preventing the exposure and spread of harmful pathogens leading to disease outbreaks, such as those caused by viruses, bacteria, and parasites, bringing in significant economic losses, undermine consumer confidence, and expose to risk of food security. Furthermore, maintaining the genetic integrity of aquaculture stocks can make farmed animals highly resistant to the effects of the disease and alterations in the environment. These could be critical areas that safeguards not only the health of aquatic species but also continue to keep stability and profit in the industry. Therefore, it is quite essential that comprehensive biosecurity protocols work in reducing risks, so that long-term sustainability of aquaculture in India can be assured.

1. Understanding Biosecurity in Aquaculture

Biosecurity in aquaculture comprehends a range of strategies aimed at preventing the entry and spread of diseases, pests, and invasive species. It is crucial to India for sustaining the health of aquatic species, preventing economic losses, and upholding natural balance. The concept entails erecting biological, chemical, and physical barriers to keep harmful agents away from farmed organisms. The need for biosecurity was further highlighted by disease outbreaks in the shrimp farming industry, particularly those brought on by the Early Mortality Syndrome (EMS) and White Spot Syndrome Virus (WSSV). These diseases destroyed shrimp farms across India, resulting in significant financial losses and raising awareness highlighting the vulnerability of aquaculture to pathogens.

Key biosecurity measures in aquaculture include (Bera et al., 2018):

Source Control: Ensuring that all inputs including seeds, feed, and water, are devoid of pathogens.

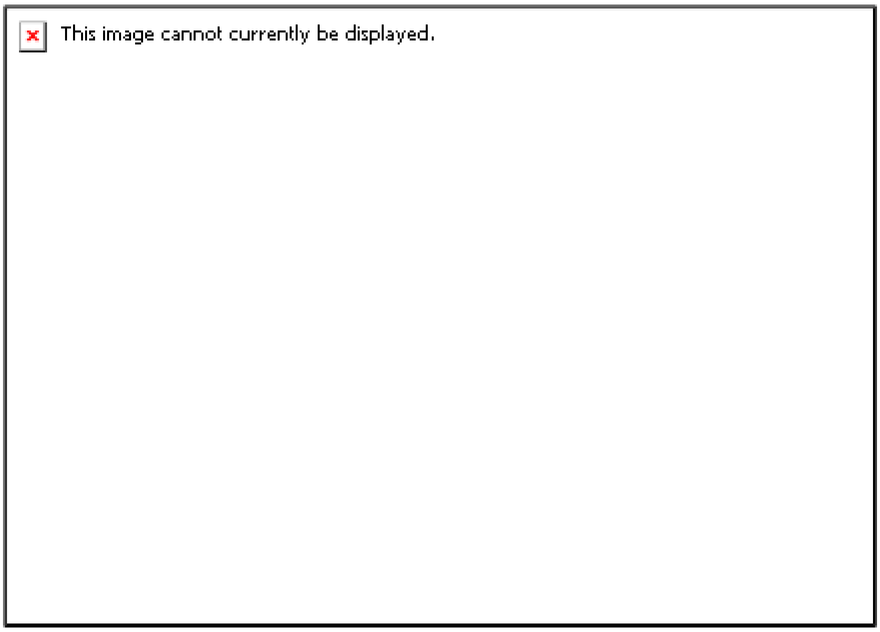
Hatchery Management: providing routine health screening and the use of pathogen-free broodstock.

Water Quality Management: Maintaining optimal water conditions to avert development of harmful organisms.

Farm Zoning: Assign specific areas to "isolate" different stages of production to prevent possible cross-contamination.

Quarantine and Monitoring: Monitor health regularly and quarantine new stock before bringing it into the farm.

Waste Management: Proper disposal of waste to stop infections from spreading across the surrounding area.



Source: **[RASTECH Magazine]**

2.Challenges facing Biosecurity in Indian Aquaculture

Despite the heightened knowledge in biosecurity, various issues associated with the integration of full-scale practices in the various aquaculture sectors across India.

2.1 Lack of knowledge and training

The scope of the biosecurity measures on most of the small and medium-sized farms are unrevealed, because these are usually in the rural settings where resources and training programs are usually limited. Such under-informed practices tend to overstock, engage in improper water quality management, and overuse chemicals, which will enhance disease risks.

2.2 Financial Constraints

This would be expensive, especially for the small-scale farmers who may lack the financial muscle to invest in modern facilities and equipment/technologies. Among such costs include monitoring and testing, water treatment, and quarantine facilities, among others which no small-scale farmer could afford.

2.3 Environmental Degradation

Intensification of aquaculture has been seen as an activity which generates environmental degradation mainly through water pollution and habitat destruction that is more pronounced with shrimp farm intensification. For example, untreated wastewater discharged directly into a natural water body affects the ecosystem receiving it but also contributes to the spread of disease.

2.4 Antibiotic Resistance

Misdosing of antibiotics in aquaculture has resulted in growth of antibiotic-resistant bacteria that threaten private public health. Even though part of the preventive and curative measures of fish and shrimp farming is antibiotics, their overuse results in residues in the environment and the food chain thereby lowering the effectiveness of treatment generating resistant strains of pathogens.

3. Technological Advancements in Biosecurity

The adoption of modern technologies is proving to be a game-changer in enhancing biosecurity within India’s aquaculture industry.

3.1 Recirculating Aquaculture Systems (RAS)

RAS is a technology designed for water reuse in closed systems, reducing the risk of disease transmission to minimum levels. Water quality is regulated and minor environmental exposure in fish and shrimp farming leads to a highly bio-secure environment (Holan *et al.*, 2020). These systems are increasingly being adopted, especially in resource-scarce regions.

3.2 Automated Health Monitoring Systems

Aquatic species status is being viewed live because of the new digital platforms. Sensors are placed to measure the key parameters such as water temperature, dissolved oxygen, and pH levels, while cameras with AI capture signs of early diseases, thus enabling swift intervention. (Chiu *et al.,* 2022).

3.3 Selective Breeding and Genetic Improvement

Genetic improvements in aquaculture species have led to the development of disease-resistant strains. This leads to minimal use of chemical treatments and antibiotics. Repeated selective breeding programs are helping to produce more resilient stocks with a general improvement in farm-level biosecurity (Gjedrem and Baranski, 2009).

4.Implementation of Biosecurity:

4.1 Hatchery Management

Biosecurity in aquaculture hatcheries is essential for preventing the entry, spread, and establishment of diseases and pests that adversely affect aquatic organisms in health. Implementation of biosecurity measures ensure production of healthy and high-quality seeds for sustainable operations. The approaches undertaken in hatcheries implementing biosecurity approaches include:

4.1.1. Risk Assessment

- Determine sources for infection risks (for example, new fish, water, feed or equipment).
- Determine the possible threats posed by pathogens, parasites, or pests.
- Identify measures to address the previously determined risks, depending on species-specific threats.

4.1.2. Site and Facilities Management

- Hatcheries shall be isolated from sources of external pollution.
- The access shall be limited to only authorized personnel.
- Apply foot baths and disinfection stations.
- Perform pathogen removal through treatment of water, such as filtering or UV sterilization.
- Maintain quarantine areas for newly introduced and infection suspect broodstock and larvae.
- Treat waste effluent water before discharge to prevent contamination of the environment.

4.1.3. Health Monitoring and Disease Surveillance

- The broodstocks and larvae must be checked for diseases through regular health checks.
- Suppliers for the broodstock must be pathogen-free certified.
- Maintenance of detailed records of health monitoring, treatment, and mortality rates.

4.1.4. Broodstock and Larvae Management

- Keep new broodstocks under quarantine for a while to watch out for any manifestations of diseases.
- Immunise with vaccines or other prophylaxis to the broodstock.
- Avoid intermingling of different age groups or species in order to minimize cross-contaminations.

4.1.5. Sanitary and Hygienic Practices

- The nets, tanks, and other equipment should regularly be cleaned and disinfected.
- Workers should follow strict hygiene rules, which include wearing protective gear.
- Dead larvae, bio-waste, and contaminated water must not be left out as they could trigger diseases.

4.1.6. Feeding and Nutritional Management

- Ensure the quality of feed given to the larvae.
- The feed should not harbour any contaminants.
- Keep the feed stored in a dry, protected place free from pests.
- Monitor the feeding, as over-feeding of larvae can lead to increased waste production and enhance the risk of water pollution as well.

4.1.7. Preventive Measures and Response Plans

- Where necessary, have vaccination programs against diseases that are enzootic in the cultured species.
- Planned isolation protocols should be ready to be implemented immediately, followed by treatment and report transmission.

- Keep contact with veterinary services and comply with appropriate regulations in control of diseases.

4.1.8. Biosecurity in Hatchery Design

- Separate clean and contaminated water to avoid re-circulation of potential pathogens.
- Tanks with smooth surfaces to hinder biofilm formation, which can harbour the potential pathogens.
- The separate the broodstock, larvae, and quarantine to minimize the potential cross-contamination.
- Implementing a comprehensive biosecurity plan requires consistent application of these measures and regular evaluation to adapt to emerging threats or changes in the hatchery environment.

A well-implemented biosecurity plan help to control disease outbreaks thereby survival rates and hatchery productivity will be improved.

4.2 AQUACULTURE LIVESTOCK MANAGEMENT

Biosecurity practices in livestock management form the basis of maintaining healthy and productive fish, shrimp, or other aquatic species in aquaculture. Biosecurity measures prevent disease entry, spread, and establishment in the aquaculture environment; consequently, mortality rates are minimized, and yields are maximized in the best quality.

The approaches in implementing biosecurity are:

4.2.1. Risk Assessment and Planning

- Evaluate potential sources of disease, such as introduction of new stock, feed, water supply, and anthropogenic intervention. Develop specific measures to address the risks identified, including disease-specific action plans (Peeler, 2005).
- Provide Standard Operating Procedure (SOP) that outline the biosecurity measures to be taken at every step of the production cycle.

4.2.2. Water Quality and Management

- The water sourced should be well filtered and treated of harmful pathogens. UV or ozone treatment should be applied when necessary.
- Regular monitoring of water parameters like, pH, salinity, temperature, dissolved oxygen, and ammonia levels to maintain adequate conditions for the livestock.
- The effluent water before releasing into natural water bodies must be treated to avoid contamination and the spread of diseases.

4.2.3. Stock Management and Quarantine

- All incoming livestock should be quarantined for a fixed time period of 2-4 weeks, to look for signs of disease before introducing it to the main production system.
- Acquire seed, fry, or fingerlings from certified disease-free suppliers to limit the risk of introduction of pathogens.
- Conduct periodic health checks on stock, looking for any signs of disease, abnormal behaviours, or mortalities.

4.2.4. Feed and Nutritional Management

- Use high-quality feed that is fresh and nutritionally balanced, and free from contaminants.
- Avoid over-feeding which can lead to water quality issues that creates stress on livestock and make them more vulnerable to diseases.
- Keep the feed stored in a cool, dry place to avoid spoilage or contamination by pests, mold, or bacteria.

4.2.5. Personnel Hygiene and Protocols

- Train workers on biosecurity protocols, hygiene standards, and disease recognition.
- Limit access to production areas to authorized personnel only. Use protective clothing including boots, gloves, and disinfectant footbaths.
- Ensure that personnel wash their hands and disinfect their equipment when they move from one production unit to another in order to prevent cross-contamination.

4.2.6. Facility and Equipment Sanitation

- Nets, tanks, and other equipment should be disinfected thoroughly after each use, especially when moving between different production units.

- Use chemical disinfectants like iodine or chlorine or heat sterilization to disinfect tools and equipment used in handling the livestock.
- Keep the facility clean by removing organic matter such as dead fish, excess feed and waste, and ensure cleaning of tanks or enclosure frequently to prevent the proliferation of harmful microbes.

4.2.7. Disease Surveillance and Health Management

- Perform daily health checks by observing the behaviour, feeding patterns changes, and physical condition of stock. Look for signs like lesions, discoloration, erratic swimming, or lethargy.
- Periodically test and diagnose samples of fish or shrimp for pathogens such as viruses, bacteria, or parasites.
- Remove and isolate any sick or dead animals without any delay to prevent the spread of disease.
- Vaccinate livestock against common diseases specific to the species being raised, if applicable.

4.2.8. Waste Management

- The dead animals are to be disposed of in a biosecure manner, be it incineration or deep burial to avoid contamination of the environment.
- Minimize organic waste by reducing overfeeding and collecting uneaten feed to avoid water contamination, which can lead to disease outbreaks.

4.2.9. Biosecurity in Livestock Housing and Design

- Keep different age groups or species in separate tanks or enclosure to reduce the risk of cross-contamination.
- Avoid overstocking, which can increase stress and susceptibility to disease. The stocking densities vary upon species and water quality conditions.
- Design facilities to prevent wild fish or pests from entering the system and employ screens, barriers, or nets to prevent the entering of birds, rodents, or insects from which pathogens can be introduced.

4.2.10. Emergency Response and Contingency Plans

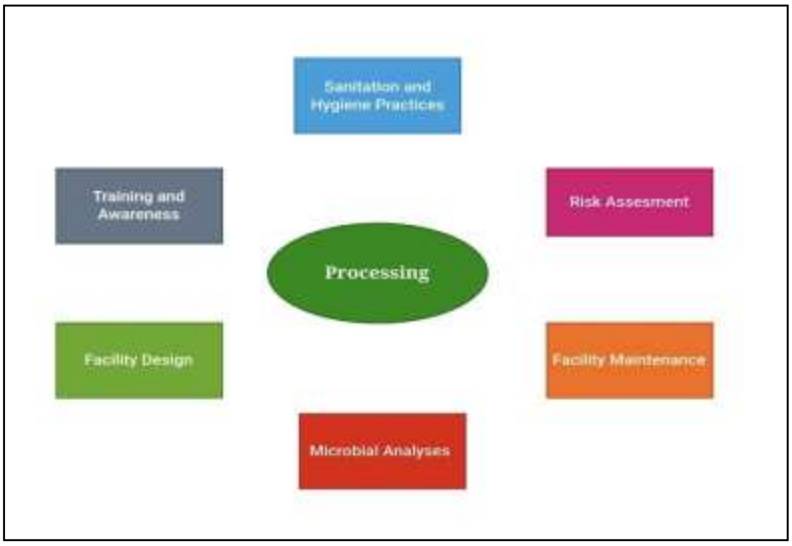
- Develop emergency plans to counter disease outbreaks, including isolation, treatment, and depopulation (if necessary).
- Consult aquatic veterinarians or specialists to develop treatment protocols, including the use of antibiotics, antifungals, or other medications as needed.

4.2.11. Collaboration with Authorities and Industry

- Ensure assent with national and international biosecurity regulations related to livestock management in aquaculture.
- Collaborate with aquatic health experts, veterinarians, and research institutions to stay updated on emerging diseases and biosecurity technologies.

By implementing these biosecurity measures in aquaculture livestock management, farmers can safeguard animal health, reduce mortality rates, and improve the overall sustainability and productivity of the aquaculture operation.

4.3 Processing



Implementing biosecurity in aquaculture processing is crucial for ensuring product safety.

4.3.1. Risk Assessment

- Identifying the potential hazards. Evaluate the risks associated with particular species, water source and feed.

4.3.2. Facility Design and Maintenance

- Establish a proper layout to cut-down cross-contamination by separating areas for receiving, processing, and packaging.
- Keep in clean and sanitary conditions, include regular cleaning and maintenance schedules.

4.3.3. Personnel Hygiene

- Implement hygiene practices for working personnels and train them on biosecurity measures.
- Mandate handwashing and personal protective equipment (PPE).

4.3.4. Microbial Analyses

- **Sampling:** Regularly collect samples from water, fish, equipment, and surfaces.
- **Microbial Testing:**

  - Total Plate Count (TPC): To assess microbial load.

  - Coliform Tests: To check for feces contamination.

  - Pathogen Detection: PCR or culture methods to identify specific pathogens presence like *Vibrio* sp., *Aeromonas* sp.

4.3.5. Training and Awareness

- Conduct regular training sessions for staff on biosecurity protocols and microbial risks.
- Promote awareness of the importance of biosecurity in maintaining product quality and safety, as it helps to ensure the health of aquaculture stocks and the safety of processed products.

By implementing these biosecurity measures, it helps to ensure the health of aquaculture stocks and the safety of processed products.

5. Government Initiatives and Regulatory Framework

The Indian government has taken measures to initiate various initiatives and create a more structured approach towards biosecurity for sustainable aquaculture practices.

5.1 Marine Products Export Development Authority (MPEDA)

The MPEDA plays a significant role in regulating and promoting aquaculture for export markets. It has further introduced certification systems for hatcheries and farms that comply with the basic principles of biosecurity protocols.

The **Rajiv Gandhi Centre for Aquaculture (RGCA)** plays a significant role in biosecurity within the aquaculture sector. As part of MPEDA, RGCA aims to develop sustainability and safety within aquaculture by their training programs and setting guidelines and protocols for biosecurity practices such as quarantining and screening of imported brooders all over India to control various risk factors.

MPEDA's **National Centre for Sustainable Aquaculture (NaCSA)** promotes responsible farming practices and assists farmers in adopting biosecurity measures. The NaCSA in India plays a crucial role in enhancing biosecurity within the aquaculture sector through various measures and initiatives by conducting research on disease prevention and comprehensive monitoring programs to detect and manage diseases early control by creating industry-specific biosecurity plans, strategies and technologies.

5.2 National Fisheries Development Board (NFDB)

The NFDB trains and funds aquaculture farmers for the effective and successful implementation of biosecurity measures. It focuses on modernizing hatcheries, improving disease diagnosis, and promotion of environmentally sustainable practices.

5.3 Pradhan Mantri Matsya Sampada Yojana (PMMSY)

Launched in 2020, the PMMSY aims in sustainable growth in fish production and improving the efficiency of aquaculture. A key component of the scheme is promoting biosecurity in fish and shrimp farms, by including the use of certified pathogen-free seeds and improved disease management protocols.

5.4 Food and Agriculture Organization (FAO)

The Food and Agriculture Organization (FAO) has developed comprehensive framework emphasizing sustainability of aquaculture by ensuring the health of aquatic species by reducing risks, and minimizing the effect of disease outbreaks on production and trade through strategies provided with guidelines adapted according to the specificity of the species, environment, and production system significantly providing health certification for aquaculture products ensuring that they are free of diseases, especially in international trade, by promoting the harmonization of health protocols among countries to ensure safe trade of aquatic products and reduction of risks of transboundary aquatic animal diseases.

5.5 Coastal Aquaculture Authority (CAA) of India

The **Coastal Aquaculture Authority (CAA) of India** plays a crucial role in promoting biosecurity measures within the aquaculture sector. The CAA sets up guidelines and regulations to prevent outbreak of disease in aquaculture farms, ensuring that proper biosecurity protocols are in order. By monitoring aquaculture activities frequently, the authority detects and manages diseases much earlier and minimize their impact on production. They organize training programs and workshops for farmers to introduce and educate them on biosecurity practices, such as hygiene, input management and disease management techniques. They also support research initiatives that are aimed at understanding disease dynamics and development of adaptable aquaculture practices. Through such initiatives, the CAA aims to promote and boost sustainable aquaculture while safeguarding the health of aquatic ecosystems.

6. Conclusion

With the ever-increasing growth in India's aquaculture sector, biosecurity has emerged as a very crucial factor that cannot be overstated. Disease outbreaks, environmental issues and risks to public health all demand the implementation of resilient biosecurity measures to ensure the sustainability of the industry. While the government, through various initiatives, has made significant progress in promoting biosecurity, but much more needs to be done in terms of awareness creation and training, particularly with regards to making financial support available to small-scale farmers.

Advancements include recirculating aquaculture systems and automated health monitoring, offer promising solutions for the future. However, successful implementation of biosecurity in Indian aquaculture would require a concerted efforts from all- government agencies, industry leaders, researchers, and farmers. By prioritizing biosecurity, India would be able to ensure it secured its aquaculture sector by ensuring its continued contribution to economic growth and food security while protecting the environment and public health sustainably.

References:

Bera, K. K., Karmakar, S., Jana, P., Das, S., Purkait, S., Pal, S., & Haque, R. (2018). Biosecurity in aquaculture: an overview. Aqua International, 18(12), 42-46.

Chiu, M., Yan, W., Bhat, S. A., & Huang, N. (2022). Development of smart aquaculture farm management system using IoT and AI-based surrogate models. Journal of Agriculture and Food Research, 9, 100357, 1-11.

Gjedrem, T., & Baranski, M. (2009). Selective Breeding in Aquaculture: An Introduction. In Reviews: methods and technologies in fish biology and fisheries, 87-103, 151-167.

Holan, A. B., Good, C., & Powell, M. D. (2020). Health management in recirculating aquaculture systems (RAS). In Aquaculture health management (pp. 281-318). Academic Press.

Peeler, E. D. M. U. N. D. (2005). The role of risk analysis and epidemiology in the development of biosecurity for aquaculture. Diseases in Asian Aquaculture V. Fish Health Section, Asian Fisheries Society, Manila, Philippines, Queensland, Australia, 35-46.

Yanong, R. P., & Erlacher-Reid, C. (2012). Biosecurity in aquaculture, Part 1: An overview, 1-15.

Chapter 3

STOCK MANAGEMENT PRACTICES IN SHRIMP AQUACULTURE

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Introduction

Fish stock assessment is an evaluation of the state of the stock as relating to change in the abundance or composition of the stock to changes in the amount of fishing. It involves the use of theories, laws, models, and methods propagated by various scientists. Fisheries tend to collapse because of fleet over-capacity, leading to harvesting the stocks of fish beyond their ability to recover. Fishery collapses have been very common, creating economic, social, and ecological problems of great complexity. One of the major aims of fisheries management is to avoid fleet overcapacity by directly controlling the fishing effort (input control) or by setting limits to the total catch per season/year and its biological characteristics (output control). On the other hand, fish stocks may also be under-utilized because of fleet under-capacity. This is particularly the case when fleets are artisanal, in initial stages of development, or have poor infrastructure facilities. When fish stocks are under-utilized because of fleet under capacity, there is a loss of economic diversification, revenue, employment, and food security. In this situation, the prices of seafood are usually higher because domestic supply may not meet the demand. Due to the reasons mentioned above, fisheries management must strike a balance between over-exploitation and under-exploitation (Restrepo *et al*., 1992). The risk of over-exploitation is the risk of management inaction, letting fishermen take too many fish from the sea thereby negatively impacting the sustainability of the stock and the fishing industry. The risk of under-exploitation is the risk of excessive management interference, setting too many obstacles to the fishermen to take fish. The fishery manager has to strike a balance by directly controlling the fishing capacity (input control) and/or by setting restrictions on the catch (output control).

Changing Role of Assessment in Fisheries Management

Commercial fisheries usually develop initially through a dynamic process that involves several distinct stages:

1. **Discovery of a valuable stock**: This is the predevelopment of the fishery.
2. **Rapid growth of fishing effort**: There is a period of rapid growth in fishing activity.
3. **Full development**: The fishery reaches full development, where yields are near or perhaps a little above a long-term sustainable level.
4. **Stock reduction and competition**: The rapid development results in fish stock reduction and more fishermen competing for the remaining fish.
5. **Overexploitation and collapse**: The fishery often enters an overexploitation stage, which is followed by a collapse. The stock may or may not recover on its own during this period.

Fisheries management should consider quantification of these different phases of fisheries for making informed decisions. The most important management and assessment question is determining the level of fishing pressure that should be permitted at an initial stage of fisheries development. On a sustainable basis, is the stock likely to support 10 boats, 100, or 1000. In the early development phase, even a rough estimate of assessment will be valuable, allowing for more precise estimates as the fishery develops.

A key role of stock assessment during fisheries development is to provide regular updates and feedback of population parameters and estimated potential into the decision-making process. Systematic and regular assessments will provide good early warnings of overfishing and help avoid overcapitalization. A simple method of assessment, as the fishery develops, is to monitor the relationship between fishing effort and catch and plot a graph. As the catch reaches the top of the curve and starts to drop, it shows that the MSY (Maximum Sustainable Yield) has been reached, and it is time to reduce the fishing effort.

When fish stocks are overexploited, the key role of stock assessment is to quantify the choices as precisely as possible. How to rebuild the stocks? Should it be through reducing fishing effort? If so, how much? How long will it take for the fisheries to rebuild? In this situation, it is important to predict how the stocks will respond to new management initiatives. Stock assessment can provide reasonable predictions about such circumstances based on available information.

Breadth of Stock Assessment

Stock assessment is sometimes viewed as a narrow biological discipline summarized as "the interpretation of commercial catch to estimate potential yields." However, stock assessment involves much more. It involves understanding the dynamics of fisheries, recognizing that fisheries are dynamic entities responding over time to management regulations and extrinsic factors.

Modern stock assessment is not just about making static predictions about sustainable yields. It also involves predicting how policies should be structured to address inevitable changes. Fisheries are much more than fish catch. Fishermen are a critical component, and stock assessment must account for their responses and predict factors important to them, such as catch per unit effort. Processing and marketing are also vital components of the fishery system.

Importance of Stock Assessment to Fisheries Management

Scientists strive to increase the types and amounts of data collected from fisheries and research projects to improve stock assessment accuracy. Fisheries managers consider the results of these assessments when taking management actions, which may affect stock abundance or productivity.

If a stock is overfished, actions need to be taken to reduce fishing pressure to allow the stock to rebuild to an acceptable level, promoting a healthy fishery for the future. Conversely, if a stock is healthy, managers ensure it is harvested at a sustainable level.

The results of stock assessments form the basis for long-term and short-term fishery management decisions. They provide:

1. **Status determinations**:
    - Determining whether underfishing or overfishing is occurring and defining the level that would produce maximum sustainable yield.
    - Comparing current reproductive potential (usually measured as spawning biomass) to a limit level, triggering a rebuilding plan if necessary.
2. **Forecasting**: Expected future catch and stock abundance associated with proposed harvest policies.

3. **Ecosystem input**: A time series of abundance, mortality, and productivity for ecosystem food web models.

Principles of Fisheries Management

The following key principles focus on effective fisheries management:

1. Fish resources are a common property resource.
2. Sustainability is paramount, and ecological impacts must be considered.
3. Decisions must be made based on the best available information, but uncertainty should not delay necessary actions.
4. A harvest level for each fishery should be determined.
5. The total harvest across all sectors must not exceed the allowable level.
6. Steps consistent with the impacts of each sector must be taken if overharvesting occurs.
7. Management decisions should aim to achieve optimal community benefits, considering economic, social, cultural, and environmental factors.

These principles overlap and interact, reflecting the challenges and complexity of fisheries management.

Different Types of Management

A review of fisheries management frameworks worldwide shows three primary approaches:

1. **Rights-based approach**: Involves setting biological reference points (BRPs) like MSY and catch quotas to maintain stock sustainability.
2. **Ecosystem approach**: Focuses on multiple regulatory measures and considers ecosystems and their services in management decisions.
3. **Precautionary approach**: Recognizes the importance of taking action even when complete scientific information is unavailable.

Definition of Fisheries Management

Fisheries management is defined as "the integrated process of information gathering, analysis, planning, consultation, decision-making, allocation of resources, and formulation and implementation, with enforcement as necessary, of regulations or rules which govern fisheries activities to ensure the continued productivity of the resources and the accomplishment of other fisheries objectives" (Cochrane, 2002).

The FAO Technical Guidelines on Fisheries Management (1997) describe a management plan as a formal or informal arrangement between a fisheries management authority and stakeholders. This process includes considerations of:

- Biological factors.
- Ecological and environmental factors.
- Technological factors.
- Social and cultural factors.
- Economic factors.
- Constraints imposed by other parties.

References

Cochrane, K.L. 2002. A fishery's manager's guidebook. Management measures and their application. FAO Technical Paper 424, FAO, Rome.

FAO. 1997. Fisheries Management. Technical Guidelines for Responsible Fisheries, 4: 82 p.

Restrepo, V.R., Hoenig, J.M., Powers, J.E., Baird, J.W., Turner, S.C. 1992. A simple simulation approach to risk and cost analysis, with applications to swordfish and cod fisheries. Fishery Bulletin 90: 736-748.

Chapter 4

Importance of Biosecurity in Shrimp Culture

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Introduction

Biosecurity refers to the practice of preventing the introduction of specific pathogens into broodstock facilities, hatcheries and farms, The primary objective of biosecurity measures is to prevent disease outbreaks that can devastate aquaculture operations. In shrimp farming, biosecurity encompasses a range of practices designed to minimize the risk of pathogen introduction and subsequent spread. Effective biosecurity protocols are essential to maintaining healthy shrimp populations and ensuring the sustainability of shrimp farming operations.

Despite the critical importance of biosecurity, many shrimp producers pay only limited attention to routine biosecurity practices at their hatcheries and farms. This lack of attention is often due to either a lack of knowledge about biosecurity protocols or a misconception that the costs associated with implementing these measures will outweigh the potential benefits. Educating shrimp producers on the importance and long-term benefits of biosecurity, as well as providing practical and cost-effective solutions, is crucial for the advancement and sustainability of the shrimp farming industry.

Concept of Biosecurity

In recent years, the concept of biosecurity has seemingly lost relevance among many shrimp producers in certain farming regions. This trend is concerning, especially given the emergence of major new diseases that have started to impact the industry, alongside the persistent presence of various older diseases. To combat these threats, the implementation of robust biosecurity protocols is essential. This process demands higher levels of awareness and discipline among all hatchery and farm personnel. It also requires a strong and sustained commitment from management to ensure these protocols are effectively put into practice. Educating all stakeholders about the critical importance of biosecurity and demonstrating the long-term benefits of such measures are vital steps in safeguarding the future of the shrimp farming industry.

Shrimp culture production cycle

To ensure a successful shrimp culture production cycle, several critical components must be maintained

Clean Water: The quality of water used in shrimp farming is paramount. It must be free from contaminants and pathogens to promote healthy shrimp growth and prevent disease outbreaks.

Clean Rearing Facilities: Rearing facilities, including tanks and ponds, must be thoroughly cleaned and disinfected regularly. This practice minimizes the risk of pathogen buildup and ensures a healthy environment for the shrimp.

Clean Feed: The feed provided to shrimp must be free from contaminants and pathogens. Using high-quality, clean feed helps in maintaining the overall health of the shrimp and prevents the introduction of diseases.

Hygienic Protocols: Implementing strict hygienic protocols for all personnel and equipment is crucial. This includes regular handwashing, disinfecting tools and equipment, and wearing protective clothing to prevent the spread of pathogens.

Dry Out and Break Cycle: Incorporating a dry out and break cycle into the production process helps to disrupt the life cycles of pathogens. Periodically drying out and resting the rearing facilities can significantly reduce the risk of disease outbreaks.

By adhering to these essential components, shrimp producers can create a more secure and productive farming environment, ultimately leading to healthier shrimp and more sustainable production cycles.

Broodstock

Biosecurity in shrimp aquaculture starts with clean, certified broodstock, supported by disease surveillance and facility. Specific Pathogen Free (SPF) broodstock are periodically tested to ensure they are free of specific diseases. New broodstock, regardless of source, must be quarantined upon arrival and kept separate until their health status is confirmed. These measures prevent the introduction of diseases into existing stocks, maintaining the overall biosecurity and health of shrimp populations. By implementing rigorous quarantine and health certification protocols, shrimp farms can reduce disease risks and enhance the sustainability of their operations.

Sampling Standard

Type of sample	Source of sample	Frequency	Quantity of sample	Parameter
Maturation	Broodstocks	every time when receive broodstocks	2% /Lot	IHHNV, WSSV, TSV, Microsporidia
	Squid (new receiving)	every lot	1 sample/Lot	IHHNV, WSSV, TSV, Microsporidia
	Nauplius	everyday	1 sample/recycle system	IHHNV, TSV, WSSV, Microsporidia
	PL from Sentinel tank	1 time/2 week	10 PL/tank	WSSV
	Moribund shrimp (Weak shrimp)	every time	all samples	WSSV & EHP
Nursery	Fry for check first pass (release product)	1 time/crop	10% of nauplius stocking tank	WSSV, IHHNV
		1 time/crop	100% of nauplius stocking tank	Microsporidia
Polychaete	Polychaete worm	PLW -tank no.	1 sample/tank	WSSV, IHHNV, TSV, Microsporidia
	Nectochaete	Nec-tank no.	1 sample/tank	IHHNV, TSV
Fry after packing	Post test sample	every 10 days	1 sample/customer	Microsporidia, VPA

Common requirement for a farm Biosecurity

- Regularly maintain bird and crab fencing to prevent the entry of potential disease carriers.
- Ensure daily hand and foot washing with 100 ppm $KMnO_4$, changing the solution every day to maintain its effectiveness.
- Assign specific ponds to feed boys to minimize cross-contamination.
- Separate main pumping operations to ensure focused and controlled management.
- Designate electricians to specific sections and require them to wear gumboots to prevent contamination.
- Allow only authorized personnel in farming zones to maintain a controlled environment.
- Restrict outside vehicle movement within the farming zone, permitting only farm vehicles to reduce contamination risks.
- Limit the entry of external laborers to prevent the introduction of pathogens.
- Regularly inspect for potential disease carriers, such as pests, and take steps to collect, treat, or eliminate them to prevent disease spread.
- Frequently check shrimp health using PCR tests to ensure early detection of diseases.
- Regularly sample water from main creeks, treatment areas, and culture ponds to monitor and maintain water quality.
- Maintain open communication with nearby farms to stay informed about their activities and potential risks. This coordination helps in managing and mitigating shared risks effectively.

By adhering to the biosecurity maintenance protocols, shrimp farming operations can effectively minimize the risk of disease outbreaks and ensure the health and productivity of their shrimp populations.

Roots of Biosecurity

Biosecurity in shrimp farming begins with ensuring high-quality postlarvae in hatcheries, free of pathogens. This foundational step is essential for the overall success of shrimp farms. Managing shrimp health in production facilities relies on a multi-faceted approach such as prevention through pathogen exclusion, controlling pathogen resources, and implementing best management practices to foster a healthy, stress-free environment for shrimp.

Farm design and Construction

Effective shrimp farm designs prioritize biosecurity by employing modular systems where seawater undergoes thorough treatment in reservoir ponds before entering culture ponds. Water passes through multiple treatment stages to ensure purification, with all inlets and outlets securely sealed to prevent leaks and unauthorized access. High-density polyethylene or concrete pond liners enhance biosecurity by containing pathogens. Installing crab fences and bird scare lines further reduces viral carrier entry. A central drain system supports optimal culture capacity and efficient water management. These design principles are critical for mitigating disease risks, maximizing production efficiency, and sustaining responsible shrimp farming practices.

Pond water management

In shrimp culture, stocking density and energy use in ponds should be carefully calculated based on pond construction and system specifications. Effective aeration strategies must maintain consistent dissolved oxygen levels, operating continuously day and night while managing energy costs. Removing accumulated pond bottom sludge through central drain pipe siphoning from day 40 to 50 helps increase pond carrying capacity. Siphoning should occur two to three times weekly for up to two hours each session, adapting schedules based on pond management practices. These practices optimize pond conditions, supporting healthy shrimp growth and efficient aquaculture operations.

Human and equipment control

Effective biosecurity includes strict control of human traffic and equipment use, as these can carry viruses. This applies to pond operators and technicians. Each pond should have dedicated water sampling equipment. If equipment like cast nets must be shared, thorough sterilization before and after use is crucial. Designated operators should handle samples and equipment to minimize disease transmission risks.

Quarantine

During a viral outbreak in shrimp ponds, strict quarantine protocols are essential to prevent spread. Suspected ponds should be immediately quarantined with secure closure of inlet and outlet gates. If a virus is confirmed, chlorinate the pond at a higher dosage promptly, prioritizing immediate action over waiting for PCR results. Dispose of dead shrimp by burning or burying them, halt aeration without removing equipment, and let pond water stand for seven days before discharge. Control human traffic in quarantined areas, suspend shrimp and environmental samplings, and assign a dedicated team to enforce quarantine measures to contain the outbreak effectively.

Biosecurity layers

Biosecurity in shrimp farming should be seen as a multi-layered defence system rather than a single barrier. It involves implementing various physical, chemical, and biological measures to protect shrimp from diseases. In the event of disease outbreak, farmers have options to mitigate its effects, prevent its spread, and eventually eliminate it. Key measures include using specific pathogen-free (SPF) shrimp stocks, constructing physical barriers, quarantining incoming stocks, treating water and sediment, minimizing water exchange, sterilizing equipment, and practicing hygiene protocols. A second layer focuses on enhancing shrimp immunity through specific pathogen-resistant breeds and use of immunostimulants. While the effectiveness of these immunological methods is still being researched, caution is advised in their application. Effective biosecurity planning integrates these measures to safeguard shrimp health, whether preventing disease entry or managing outbreaks effectively within shrimp farming operations.

Criteria of defining Biosecurity measures

When defining biosecurity measures, three key criteria must guide the evaluation process. Measures should be scientifically justified, focusing on pathogen control rather than general hygiene practices. They should also be practical, integrating seamlessly into routine farming operations without hindrance. Staff engagement is crucial for effective implementation. Finally, measures must be economically viable, striking a balance between costs and benefits to ensure sustainability and feasibility in shrimp farming operations. By adhering to these principles, biosecurity protocols can effectively mitigate disease risks while supporting efficient and responsible aquaculture practices.

Transmission of pathogens

Understanding the transmission of shrimp pathogens is crucial for effective biosecurity. Pathogens can spread through horizontal transmission between shrimp via direct contact, contaminated food, water, or feces ingestion. Vertical transmission occurs from broodstock to offspring, either inside eggs or through surface contamination from infected ovaries or sperm. Systemic pathogens like white spot syndrome virus and yellow head virus are suspected to transmit per ovum. Cleaning and disinfecting eggs can break this transmission pathway for such pathogens. Effective biosecurity measures should address both horizontal and vertical transmission routes to prevent disease outbreaks and maintain shrimp health in aquaculture settings.

Risk identification

Risk identification forms the foundation for developing effective mitigation strategies in shrimp farming. Risks can be categorized into External and Internal Biosecurity, where interactions with people, vehicles, equipment, and surfaces pose significant risks. Contact with water and pond soil carries lower risks comparatively. Mitigation measures should prioritize cleaning and disinfection procedures, integrated into standard operating procedures for routine application. Harvest operations are particularly high-risk, involving large volumes of shrimp and water in contact with multiple surfaces. Strong detergent cleaning and thorough soaking of equipment and vehicle surfaces at harvest sites are crucial to minimize disease transmission and maintain biosecurity in shrimp aquaculture.

External Biosecurity

External biosecurity focuses on preventing pathogen introduction into shrimp facilities. The initial step involves identifying potential sources of pathogens, including shrimp for stocking, new broodstock, wild crustaceans in incoming water, feed, water, birds, insects, vehicles, equipment, people, and effluents from processing plants. Once these sources are identified, specific procedures to mitigate risks must be developed and implemented. These measures are crucial for safeguarding shrimp health and preventing disease outbreaks, emphasizing proactive management of external factors that could compromise biosecurity in aquaculture operations.

Internal Biosecurity

In internal biosecurity, the primary step is identifying potential pathways for pathogen dissemination and establishing procedures to mitigate risks. When assessing the risk of pathogen spread, two main parameters are crucial. Firstly, the likelihood of items such as equipment, clothing, or shoes carrying infectious viral particles. Secondly, the potential for these viral particles to reach a susceptible host. Effective internal biosecurity measures focus on minimizing these pathways through stringent cleaning and disinfection protocols, controlling movement within facilities, and ensuring strict hygiene practices among personnel. By addressing both parameters, shrimp farms can significantly reduce the risk of disease transmission and maintain a healthy environment for their stocks.

SPF and biosecurity

Biosecurity is integral to the success of Specific Pathogen-Free (SPF) shrimp stocks in aquaculture. It involves understanding and rigorously implementing measures to maximize the genetic potential of selectively bred SPF shrimp. Key components include knowledge of relevant diseases and pathogens, reliable diagnostic methods, and the use of disease-free shrimp stocks. Environmental controls prevent pathogen introduction and spread, supported by robust culture and management practices. Monitoring programs are essential to detect and mitigate infections, while contingency plans for disease containment, eradication, and disinfection are crucial during outbreaks. By adhering to these biosecurity principles, shrimp farms can safeguard SPF stocks, optimize productivity, and sustainably manage disease risks in aquaculture operations.

Disease control

To implement an effective facility-wide biosecurity plan in shrimp farming, several disease control measures should be implemented across all production phases. These include rigorous filtration and disinfection of source water and effluent to prevent pathogen entry and exit. Using verified pathogen-free stocks and feed sources, along with employing bio-secure production systems, helps minimize disease risks. Operationally, restricting public access and controlling the movement of animals, personnel, and equipment within the facility is critical to preventing disease occurrence and spread.

Implementing a proactive disease-monitoring program is essential. This program can detect infections early, preventing their spread and documenting health status over time to maintain effective stock control. By integrating these measures, shrimp farms can enhance biosecurity, reduce disease risks, and maintain sustainable production practices in aquaculture.

Maturation and hatchery operations

In maturation and hatchery operations of shrimp farming, implementing an effective biosecurity plan involves identifying critical control points and optimizing workflow to minimize infection risks. Key measures include controlling facility entrances to prevent environmental pathogen transfer and using robust water treatment methods to maintain a pathogen-free rearing environment.

Critical areas include verifying incoming broodstock for SPF status and using pathogen-screened feeds sourced from reliable SPF suppliers. Disinfecting eggs and nauplii, regular cleaning of equipment and supplies (including air and water lines), and quality control of live feeds (such as algae and artemia) are essential practices. Bacteria and fungi are primary concerns, and implementing regular dry-out periods and the "all in, all out" strategy between production runs can effectively mitigate disease outbreaks.

By focusing on these biosecurity measures, shrimp hatcheries can enhance disease prevention, maintain health standards, and ensure sustainable production practices in aquaculture.

Grow-out operations

In shrimp grow-out operations, the design of the farm plays a critical role in implementing an effective biosecurity plan. Factors such as site location relative to neighboring farms, canal design for managing source water and effluents, compartmentalization of ponds, and the type of culture system (outdoor, enclosed, minimal water exchange, recirculating) significantly influence biosecurity strategies. The key management strategies include implementing seawater filtration and disinfection procedures to prevent pathogen introduction, ensuring high-quality post larvae through quality-assurance programs, and stocking larger juveniles for improved survival and faster growth. Managers must also monitor potential disease triggers such as abrupt changes in water quality, extreme salinity, temperature or pH variations, low dissolved oxygen levels, high stocking densities, toxic compounds, suspended solids, unstable phytoplankton blooms, food shortages, excessive handling, and environmental diseases. By integrating these measures, shrimp farms can mitigate disease risks, optimize production efficiency, and maintain sustainable practices in aquaculture operations. Effective biosecurity planning and management are essential for ensuring the health and productivity of shrimp stocks throughout the grow-out phase.

Reliable diagnostic tools for Biosecurity

Reliable diagnostic tools are crucial for effective biosecurity and health management in shrimp farming. These tools are essential for making timely decisions to control or exclude pathogens, thereby ensuring the sustainability of aquaculture operations. Given the rapid and devastating impact of virulent pathogens on shrimp populations, fast diagnostic capabilities are paramount. Practical methods like PCR and dot blot gene probes offer accuracy, sensitivity, and speed, making them ideal for early disease detection. Cost-effectiveness is also critical, as it enables widespread adoption of these diagnostic tools among shrimp producers. By investing in reliable diagnostic technologies, shrimp farms can enhance their ability to monitor shrimp health, respond swiftly to disease outbreaks, and maintain high biosecurity standards. This proactive approach not only minimizes economic losses but also supports the long-term viability and resilience of the shrimp farming industry against emerging health challenges.

Conclusion

Biosecurity is essential for successful shrimp farming, encompassing three levels of defense: exclusion of pathogens, enhancing shrimp immunity, and responding to disease outbreaks. Preventing the presence, growth, and spread of harmful microorganisms is critical. While smaller aquaculture facilities can implement comprehensive biosecurity measures, larger operations face challenges in isolation from their surroundings. Timely and precise pathogen diagnosis strengthens all biosecurity efforts. Early detection and swift containment measures are vital to prevent widespread disease outbreaks, underscoring the importance of proactive biosecurity practices in maintaining productive shrimp-growing operations. Despite significant disease challenges over the years, the shrimp farming industry has advanced technologically and expanded globally. By prioritizing biosecurity measures, shrimp producers can mitigate risks, maintain productivity, and ensure sustainable practices in aquaculture.

References

Bera, K. K., Karmakar, S., Jana, P., Das, S., Purkait, S., Pal, S., & Haque, R. (2018). Biosecurity in aquaculture: an overview. *Aqua International*, *18*(12), 42-46.

Delphino, M. K., Laurin, E., Patanasatienkul, T., Rahardjo, R. B., Hakim, L., Zulfikar, W. G., ... & Thakur, K. (2022). Description of biosecurity practices on shrimp farms in Java, Lampung, and Banyuwangi, Indonesia. *Aquaculture*, *556*, 738277.

Flores, R. C., Corpuz, M. N. C., Tungol, F. E., Villafuerte, A. A., & Antonio, A. S. (2015). Assessment of aquaculture biosecurity measures in Bataan, Philippines. *International Journal of Life Sciences Biotechnology and Pharma Research*, *4*(4), 189.

Hine, M., Adams, S., Arthur, J. R., Bartley, D., Bondad-Reantaso, M. G., Chávez, C., ... & Wardle, R. (2010, September). Improving biosecurity: a necessity for aquaculture sustainability. In *Farming the waters for people and food. Proceedings of the Global Conference on Aquaculture* (pp. 22-25).

Lightner, D. V. (2005). Biosecurity in shrimp farming: pathogen exclusion through use of SPF stock and routine surveillance. *Journal of the World Aquaculture Society*, *36*(3), 229-248.

Lotz, J. M. (1997). Viruses, biosecurity and specific pathogen-free stocks in shrimp aquaculture. *World journal of microbiology and biotechnology*, *13*, 405-413.

Moss, S. M., Moss, D. R., Arce, S. M., Lightner, D. V., & Lotz, J. M. (2012). The role of selective breeding and biosecurity in the prevention of disease in penaeid shrimp aquaculture. *Journal of invertebrate pathology*, *110*(2), 247-250.

Patanasatienkul, T., Gautam, M., Hammell, K. L., Gilang, D., Delphino, M. K., Burnley, H., ... & Thakur, K. K. (2023). Survey of farm management and biosecurity practices on shrimp farms on Java Island, Indonesia. *Frontiers in Aquaculture*, *2*, 1169149.

Pruder, G. D. (2004). Biosecurity: application in aquaculture. *Aquacultural engineering*, *32*(1), 3-10.

Scarfe, A. D., Lee, C. S., & O'Bryen, P. J. (2008). *Aquaculture biosecurity: prevention, control, and eradication of aquatic animal disease*. John Wiley & Sons.

Schuur, A. M. (2003). Evaluation of biosecurity applications for intensive shrimp farming. *Aquacultural Engineering*, *28*(1-2), 3-20.

Subasinghe, R., Alday-Sanz, V., Bondad-Reantaso, M. G., Jie, H., Shinn, A. P., & Sorgeloos, P. (2023). Biosecurity: Reducing the burden of disease. *Journal of the World Aquaculture Society*, *54*(2), 397-426.

Chapter 5

CURRENT TRENDS IN SHRIMP DISEASE MANAGEMENT ALTERNATIVES TO ANTIBIOTICS

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Aquaculture industry shoulders the responsibility of delivering good quality and protein rich seafood free from antibiotic and chemical residues to the world. Shrimp industry with tremendous growth in recent decades is also witnessing problems with increased disease due to the lack of acquired immunity and shrimps are likely to contract the same pathogen again and had seen periods of turbulence. Controlling *Vibrio* in shrimp aquaculture is a big challengeat all levels of farming starting from brood stock maintenance to grow out ponds. *Vibrio* spp. are a ubiquitous set of bacteria that is among the causative factors for diseases such as Vibriosis, AHPND, RMS, White faecal syndrome. Vibrio severity can be identified with the signs and symptoms such as lethargy, reduced feed intake, reddishness, melanisation, necrosis, luminescence etc. Use of antibiotics to control pathogens is not safe and will also lead to multifaceted problems such as antimicrobial resistance. Shrimp farmers combat bacterial pathogens with probiotics as they are the safe and sustainable solution.

Better disease management strategy begins with understanding the interaction in the multitrophic environment of aquaculture system that comprises heterotrophs (heterotrophs: shrimp, shrimp gut microflora, water microflora & zooplankton), autotrophs (autotrophs: phytoplankton, autotrophic / chemotrophic bacteria) and the organic content introduced and generated in the culture system.

Aquaculture system is a live ecosystem in which organic content such as feed are introduced frequently and regularly, cultured species generate faecal load, microalgae thrive and demise periodically accumulating to the organic load and making the ecosystem nutrient rich for the microflora to thrive. When the nutrients are rich in the culture system *Vibrio* beingamong the natural microflora proliferate rapidly and dominate the culture water.

Dominance of *Vibrio* should be prevented right from water preparation. It is to be notedthat *Vibrio* are among heterotrophic part of the system. Hence the probiotic to combat *Vibrio* should also be heterotrophic along with short doubling time. Following every harvest, the ponds should be allowed good interval to dry and should be tilled during preparation following

Good Aquaculture Practices. Proper biosecurity should be installed and followed to prevent diseases. While preparing the pond water for stocking probiotic bacteria can be introduced. Probiotic bacteria thrive and establish in the waters and outcompete *Vibrio*. Keeping *Vibrio* incontrol is very crucial for the cultured species health. As the probiotic bacteria introduced are only a transient population, split dosage with more frequent application ensures more stable population.

Good Aquaculture Practices

- Probiotic application during pond and water preparation
- Biosecurity measures-Crab, bird fencing
- Good quality PL selection
- Appropriate stocking density
- Properly positioned aeration and as per stocking density
- Check tray observation
- Strict and wise feed management
- Periodic water quality monitoring
- Regular water probiotic application
- Periodic soil probiotic application after DOC 40
- Animal health monitoring

Feed management should be smart and strict. Supplementing gut probiotic in feed willenable good gut health. Overfeeding apart from increasing FCR will also contribute to organic load, increase risk of opportunistic pathogens and water management cost. Excessive feed of ameal may accumulate *Vibrio* and may contaminate shrimp on eating those pellets.

Stress is one important factor that favours *Vibrio* in affecting the cultured species.

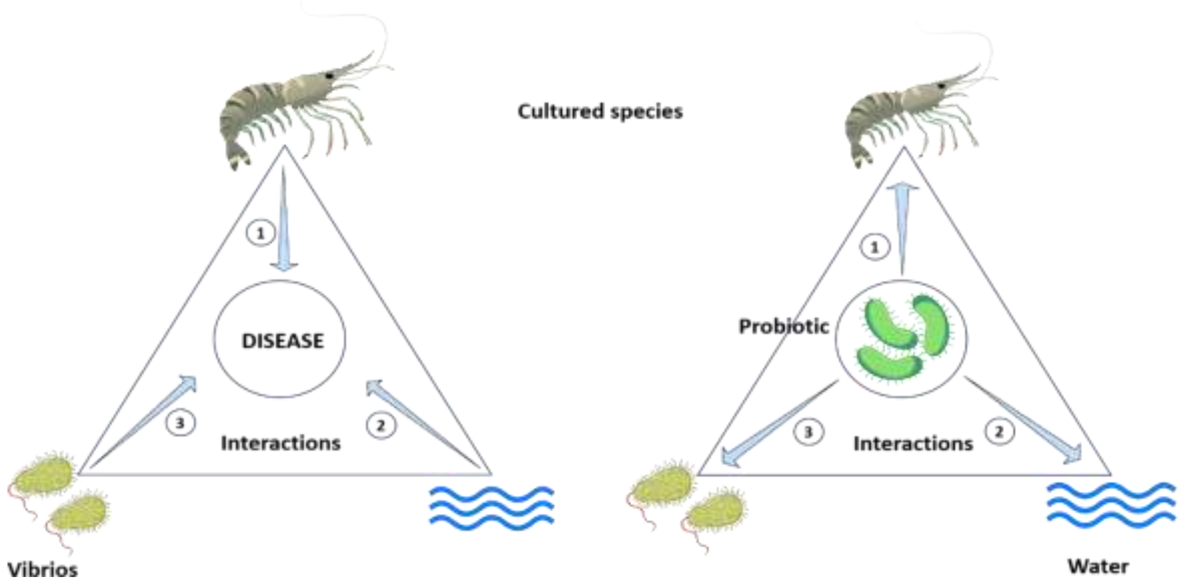
Stressshould be prevented or minimised throughout the culture period. Animals under stressed condition are more prone to get infected. Once a weak animal gets infected it acts as a replicating reservoir for the pathogen. Along with proper pond management sampling should be done periodically to observe the health of the shrimps.

Selective media Thiosulfate-citrate-bile salts-sucrose agar (TCBS agar) screening is theprevalent test used to detect level of *Vibrio* in the aquaculture system. Two kinds of colonies can be observed yellow and green. It is commonly misunderstood that presence of more greencolonies indicates more pathogenic *Vibrio*. The green colour indicates the inability to ferment or utilize sucrose as carbon source. Yellow colonies indicate the species that are able to utilizesucrose. High number of colonies indicate higher load. In high stocking densities the higher *Vibrio* load in the system indicates the higher probability of interaction of *Vibrio* and host (cultured species). Along with the high stocking stress this host-opportunistic pathogen interaction puts the shrimp in risk. Such interaction might lead to disease or add to existing EHP or WSSV and worsen more. This interaction should be kept minimal by enabling a probiotic bacterial population dominate the waters. In case of higher *Vibrio* load in the watersprobiotic bacteria can be given as feed supplement along with water application. Probiotic bacteria restores the favourable conditions in the shrimp gut and water column by eliminatingthe *Vibrios*.

In hatcheries raw water (before treatment) and treated reservoir water should be screened for *Vibrio* using TCBS. Compare and apply probiotic based on the Vibrio load. Artemia accumulate *Vibrio* and this will in turn contaminate larval rearing tanks and also postlarvae gut. Artemia tank water should be manipulated with probiotic bacteria to control *Vibrio*. This will also enrich Artemia with beneficial bacteria. LRT water should be prepared with probiotic bacteria before stocking nauplii. Daily after water exchange probiotic bacteria shouldbe applied to control *Vibrio*.

Probiotic bacteria have good enzymatic activities which supports better digestion in thegut. These bacteria offer better nutrient assimilation to the PL as they feed on probiotic enrichedArtemia. Selected probiotic strains also exhibit good antagonistic activity against Vibrio. Probiotic application in hatchery prevents the colonization of pathogens in the gut of the PL.

Strains of a probiotic product when introduced into the functional environment (such as pond water) should get activated instantaneously and proliferate. Only good manufacturingprocess will ensure this. Proper lyophilisation of the probiotic should be done followed by sterile packing to ensure a good shelf life Parts of the figures featuring in this article were created with SMART – Servier Medical Art, Servier: https://smart.servier.com and Integration and Application Network ian.umces.edu/media-library



1. Deterioration of health
2. Poor environment
3. Pathogen dominance
4. Promotes cultured species health
5. Maintains water quality
6. Keeps pathogen in control

Chapter 6

BIOFLOC BASED COASTAL SHRIMP AQUACULTURE INTENSIFICATION

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Introduction to Biofloc System

Biofloc farming technology (BFT) is a new technology revolution in aquaculture which enhance the water quality through equal distribution of carbon and nitrogen in the system which adds benefit to sustain our ecosystem. This new technology helps to control the pollution due to climate change thus give an upright business insight. Biofloc generates nitrogen cycle by stimulating the growth of microbial heterotrophs and maintain a healthy carbon and nitrogen ratio thus the nitrogenous wastes generated in the system can be maneuvered by the shrimp as feed. In addition to the waste treatment it also bequeaths nutrition to the shrimps or any culturable species. Therefore, biofloc promotes the growth of microorganisms and function both as a bioreactor which control the water quality and a valuable protein food source. Besides these this technology is tailor made for shrimps due to its bottom-dwelling habit and resistance to environmental changes.

Biofloc is entirely a different concept from Recirculating aquaculture system (RAS) methods by avoiding a biofilter which is used to remove the compounds and reduce ammonia toxicity. The usage of formulated feed as the source of nutrients and protein has been applying worldwide. Uneaten or leftover feed are some of the challenges faced by the farm operator which are expensive. Biofloc technology is well known for its ability to reduce feed conversion ratio (FCR) at 1 to 1.5. The amount of feed can be reduced because of increasing culture feasibility or food source from the biofloc. Therefore, the technology helps to improve the understanding of feeding rate or intake rate which is different according to body weight of shrimps to avoid overfeeding. On the other hand, the FCR in RAS systems can be reduced around 1.3 to 1.4 at some time between the culture period. FCR is the amount of feed we used to get 1 kilogram of body weight and usually feed can be up to 60% of the operational cost. Thus, reducing FCR is a good indicator for a feeding strategy to reduce cost operation.

In aquaculture, maintenance of good water quality is a key factor for successful rearing and survival of the stock. Biofloc technology helps to control water quality which is essential for the success of the growing cycles. Daily monitoring of water parameters will ensure the quality of biofloc is at its optimum. Water quality parameter such as ammonia which is one of the most toxic inorganic compounds that are produced in water can only be removed by bacterial activity through conversion into a less toxic compound (nitrate). Dissolved oxygen and solid also should be measured daily to make sure that if there any changes with the water quality, fast actions can be taken to avoid further losses. Applying biofloc technology also has minimal to zero water exchange. Farm operators that have earthen ponds or tanks located near to the sea have the advantage to exchange the water easily. But, the new technology has benefited the farm operator with indoor farming or without excess to seawater.

Biofloc technology helps in disease control and management in the shrimp culture industry. Shrimp are very vulnerable to diseases and can easily infect one another. However, the mechanisms with probiotics which contains bacteria like *Bacillus sp.* will affect the shrimp performance. The probiotics can increase the disease resistance of the shrimp. Beneficial effects are observed by the addition of probiotics by showing a strong immune response of the shrimp toward the pathogens. Therefore, if a pathogen like *Vibrio sp.* present in the water, the shrimp immunity would be able to fight against it.

Microorganisms play a major role in biofloc technology. Phytoplankton, heterotrophic, and nitrifying bacteria have the most important role in biofloc while fungi, ciliate, protozoa, rotifer, copepod, and nematode complement the biofloc community by participating in the food web that includes the cultured animal too. There are few types of bacteria present in biofloc. The heterotrophic bacteria consume organic compounds as a carbon source and convert them into bacterial biomass. Therefore, this community minimizes ammonia accumulation in the water. Photoautotrophs make their food by transforming sunlight into photosynthesis while autotrophic bacteria make their food from inorganic molecules like ammonia and nitrate. There is also a chemoautotrophic bacterial community like nitrifying bacteria that obtain energy through the oxidation of toxic nitrogen compounds. The shrimp grow best under the presence of a diverse community, called the mixotrophic.

A fully indoor farm near the capital has high potential's advantage. The business is directly passed to the end consumer and thus has a short supply chain. The white-leg shrimp (*Litopenaeus vannamei*) has been for 82 DOC for the last batch. The shrimp can be sold as a live product when they are ready to be harvested and actually has a higher price compared to frozen product. The freshness and quality are ensured to achieve consumer satisfaction.

However, only certain animals can live in biofloc water so it is very important to properly choose the species that need to be culture. *Litopenaeus vannamei* or white leg shrimp is cultured because of their special characteristics compared to other species. Vannamei shrimp is an omnivore, which means they eat both animals and plants. As biofloc water consists of algae, protozoa, plankton and bacteria, they are suitable for omnivore animals. Next, the adaptability of vannamei shrimp to high turbidity. Biofloc water is brown and has high turbidity which is caused by the solids from the uneaten feed and faeces and the floc itself. So it is an important characteristic to the animal to adapt. Lastly is the tolerance to low oxygen. The microbial community inside the water also takes up oxygen for respiration and although the algae produce oxygen through photosynthesis, it is still not enough. Therefore, the shrimp need to have a tolerance to low dissolved oxygen which is around 5 ppm. Another animal such as the catfish also can tolerate low oxygen in biofloc which is even lower at 3 ppm.

Biofloc systems can reduce disease outbreak. Disease outbreaks usually happen because of the weak host, bad environment, low water quality and presence of the pathogen. To avoid disease outbreaks, usually, the farm operator should act accordingly to the main factors. In biofloc, the ability of wastes to be converted into less toxic compounds will ensure a stable environment for the shrimp. A variety of beneficial microorganisms will help to eliminate the presence of the bad pathogen. The shrimp or post-larvae that need to be culture must be originally free from disease or specific pathogen-free (SPF) products which can be obtained from the certified hatchery.

The basic process for setting up a biofloc system involves the assimilation, nitrification, and oxidation process. First of all, an adequate amount of feed or urea, and sugar, molasses or flour and a bit of probiotics to enhance the bacterial community is needed to form the floc. Feed or urea is the source of nitrogen for the shrimp, while sugar, molasses, or flour is the source of carbon for microbial activity. It is not necessary to mix everything up but it is important to understand the combination is actually to make carbon to nitrogen ratio. Usually, to set up the floc formation, a minimum carbon to nitrogen ratio of 20:1 is recommended. The difficult part is when to stop the floc formation and the monitoring throughout the culture cycle. The floc formation stage can be observed when normal clear seawater becomes brownish. Next, a microbial community inside the biofloc water needs to be observed frequently. This is crucial before you stock your shrimp for a nursery or grow out. A variety of microbes means that the biofloc water is ready to use. Bio solid generation through Imhoff cone measurement and total suspended solid should also be observed closely.

Shrimp need protein from the formulated feed but the formation of floc in the system can act as the extra feed to the shrimp. All the shrimp waste from the uneaten feed or feces will be recycled back into the water by the microbial community inside the water which is also called the in-situ conversion. However, the biofloc cannot be served as main feed although the shrimp might survive the growth and will be lower and not achieve the desired size during the harvest period. The normal size for *L. vannamei* in the harvesting period is between 20 to 25 g after culturing for 120 days. Longer culturing time might have bigger size shrimp but the cost might increase too.

Advantages and disadvantages of biofloc

The pros of biofloc

The bioflocs themselves are protein-rich and provide fish and shrimp with a good source of vitamins and phosphorous. The proliferation of microbial flocs can improve water quality and immobilise toxic nitrogen. Farmers have also reported that breeding performance of the shrimps reared in biofloc system is considerably higher and thus the greater productivity indicators with the system when compared to conventional aquaculture techniques. Biofloc production can decrease mortality rates, increase larval growth and improve growth rates in the cultured species.

The other key advantage of biofloc technology lies in its improved water and land use rates. Since the system relies on a limited water exchange, the overall environmental impact of production is low. The reduced water inputs decrease pollution and allow for greater biosecurity during production.

The production and carrying capacity are 5 to 10 percent higher than in typical culture systems, with zero water exchange. Shrimp grow larger and reflect FCR rations between 1 to 1.3 and production costs can be 15 to 20 percent lower.

- Eco-friendly culture system
- It reduces environmental impact
- Improves land and water use efficiency
- Limited or zero water exchange
- Higher productivity
- Higher Biosecurity
- Reduces water pollution and the risk of introduction and spread of pathogens
- Cost-effective feed production
- Reduces the utilization of protein-rich feed and also cost of standard feed
- Reduces the pressure on capture fisheries, that means, use of cheaper food fish and trash fish for fish feed formulation

The cons of the system

There’s more to biofloc than meets the eye. The system requires a startup period and yields aren’t always consistent between seasons. Since producers must constantly mix and aerate culture water, energy costs could be higher than expected. In addition to these factors, producers must actively manage biofloc ponds to prevent nitrite accumulation and to keep alkalinity levels remaining within a healthy range. Monitoring animal health and welfare is also key – bioflocs can increase the levels of suspended solids in the water, leaving fish and shrimp susceptible to environmental stress.

Though some reports suggests that the microbial flocs have a probiotic effect on the culture environment and can regulate vibrio activity, this hasn’t been observed in all studies. The researchers note that in some trials, microbial flocs have contained elevated vibrio counts, leaving animal at risk of disease. As it stands now, researchers don’t have a full picture of how individual microbial flocs operate or how to make them proliferate in a predictable way – leaving producers at a disadvantage.

Therefore, Biofloc technology is a new environmental friendly concepts in aquaculture. It is an efficient alternative system as the nutrients can be continuously recycled. The sustainable approach is based on growth of microbial communities with zero to minimal water exchange. The technology may bring higher profit if it is nearer to consumers and the advantages certainly should be explored more.

Chapter 7

SINGLE CELL MICROBIAL PROTEIN FOR SUSTAINABLE SHRIMP AQUACULTURE

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Shrimp culture was started by Mr. Motosaku Fujinaga, a Japanese ichthyologist, also known as the "Father of Shrimp Farming" introduced it for developing techniques for spawning, larval rearing, and grow out. The antioxidants in shrimp are good for our health. These substances can protect our cells against damage. Studies suggest that the antioxidant astaxanthin helps prevent formation of wrinkles and lessens sun damage. Shrimp also has plenty of selenium and is lower in fat and calories than lean beef: Three ounces contains 31 grams of protein, eight grams of total fat, and 3.2 grams of saturated fat. Shrimp are omnivores, which mean that they consume both plants and animals. Despite their small size, shrimp actually have a large range of food options in their diet. Their favourite foods are algae and other plant particles, plankton and even small fish.

The major things required to check for shrimp culture are:

Site selection: The tidal range, water current, and the presence of pollution have to be monitored. If at all the tidal range is less than one meter, then the water management may be very expensive, so pumps would be required. The size and height of the perimeter dike should also be determined to prevent flooding.

Culture tanks: The culture tanks should be covered with a proper net to prevent the shrimps from jumping or moving out.

Culture basin: A culture basin should be placed since it helps in removal of all the suspendedparticles.

Filter for solids and biofilter: This filter helps in reducing the products rich in Nitrogen or the nitrates present and also helps in maintaining the pH.

Single cell protein:

Single cell protein is derived from microorganisms like yeast, bacteria, fungi and algae.SCP is a good source of food for culturing aquatic organisms.

- They are rich in high protein content.
- Rich in Vitamin B12 and Vitamin K.
- Each cell has carbohydrates, protein, lipid and the essential amino acids.
- Nucleic acid has to be eliminated and the protein has to be increased.

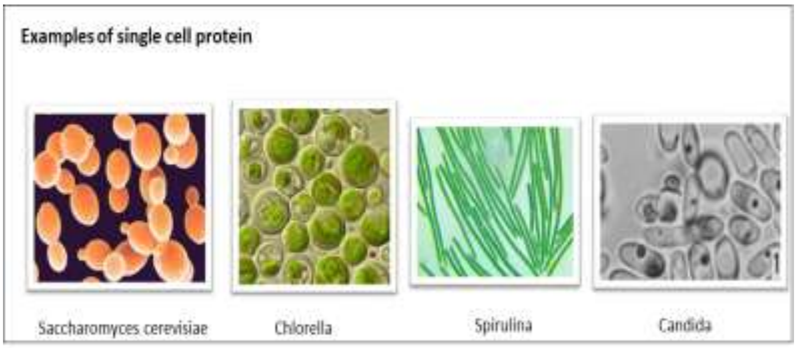
Production of SCP:

1. **Preparation of media-** carbohydrates, polysaccharides which are hydrolysed can be used as the media since starch cannot be taken directly. Food source for microbes to grow is mainly S, P, N. The bacteria would uptake all these for the growth along with this assimilation of carbon source also occur.

2. **Fermentation:** It is a process that helps in breaking down of larger molecules into smaller units by the microbes. For this purpose cell inoculation is done leading to the final production of the product.

3. **Downstream**: The cells are extracted, washed, centrifugation is done and from the broth the cells are dried, cleaned and packaged. Packaging is done by several methods like air dried, crystallized and many more methods.

Bacteria and yeast are the most commonly used microbes and can be derived from sources like gasoil, methane, n-alkenes, methanol etc. These can be cultured easily by residues supplied from industries. Microalgae have very high crude protein content. SCP is also termed as Bio protein or biomass and has amino acids like lysine, methionine and threonine and mostly all the essential amino acids.



Picture Source: Internet

Biofloc fish farming is an environmental friendly aquaculture technique that recycles nutrients and uses them in the culture medium. It is also a kind of waste water treatment that improves water quality by producing single cell microbial proteins. The microbes that are present here have to be isolated, inoculated and then the cultures could be taken and dried for feed.

Gut probiotics usually contain *Lactobacillus* or *Saccharomyces cerevisiae*, nitrifying bacteria, *Streptococci*, *Roseobacter*, and *Bacillus* sp. These bacterial strains work in the shrimp gut by modifying the microbial balance for the benefit of the shrimp thus enhancing immune response.

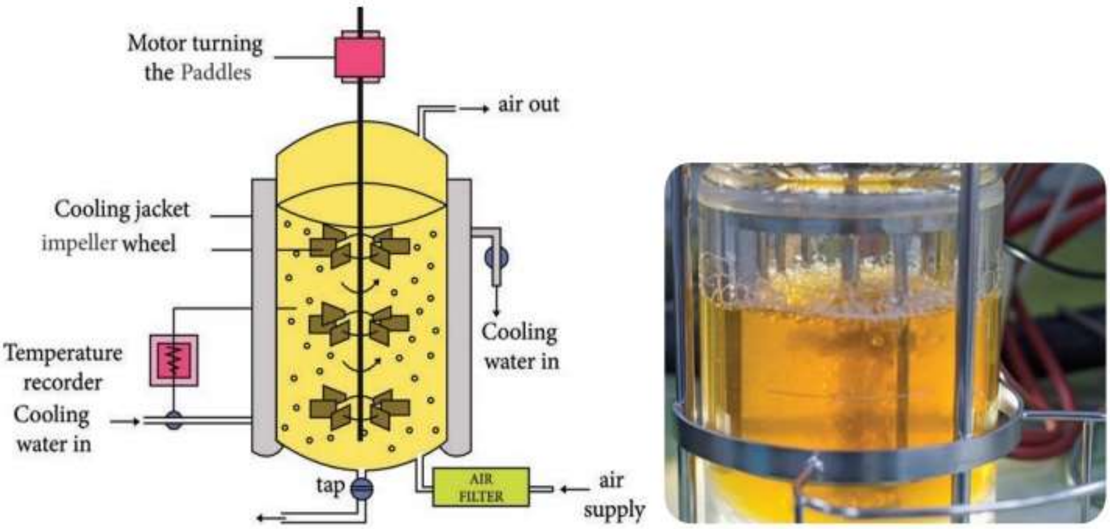


Figure : Design of a fermenter

Limitations:

1. High concentration of nucleic acids.

2. Strong flavour.

3.Could trigger allergic reactions if not cultured properly.

Reference:

Aggelopoulos, T., 2014. Solid state fermentation of food waste mixtures for single cell protein, aroma volatiles and fat production food chem.

Goh, J.X.H., Tan, L.T.H., Law, J.W.F., Khaw, K.Y., Zengin, G., Chan, K.G. and B.H. Goh, 2023. Probiotics: comprehensive exploration of the growth promotion mechanisms in shrimps. *Progress In Microbes & Molecular Biology*, *6*(1).

Jacob-Lopes, E., L.Q. Zepka and M.I. Queiroz (eds.), Microalgal biotechnology, Intech open (2018), pp. 151-175

Muhammad Sharif A., A. Muhammad Hammad Zafar, D. Amja Islam, B. Aqib, B. Muhammad Saeed, R. Mayada Faragc and D. Mahmoud Alagawany, 2021. Single cell protein: sources, mechanism of production, nutritional value and its uses in aquaculture nutrition. Aquaculture 531 (2021) 735885

Ogello, E. O., Outa, N. O., Obiero, K. O., Kyule, D. N., & Munguti, J. M. (2021). The prospects of biofloc technology (BFT) for sustainable aquaculture development. Scientific African, 14, e01053.

Chapter 8

BIOFLOC TECHNOLOGY IN AQUACULTURE: A SUSTAINABLE ALTERNATIVE

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Introduction:

The shrinking land and water resources may not be able to cater the demand for food production for the growing population in the near future. So all food producing sectors need to rely upon intensive farming methods within limited land and use of natural resources like water. The aquaculture upon intensification demands a lot of water to eliminate the effluents from culture system and hence production intensification in aquaculture demands sustainable alternatives. The technologies which are good at recycling and reusing the same water are in high demand these days due to the concern of limited availability of water and space. Recirculatory aquaculture system, biofloc based aquafarming and aquaponics are the promising technologies which are having the potential to recycle and reuse water from the culture units. Of these mentioned technologies, biofloc aquaculture is comparatively cost effective and can be affordable by small and marginal farmers.

The biofloc technology is a sustainable method for maintaining water quality in the aquaculture system through recycling nutrients within culture system. The inorganic metabolites like ammonia, nitrite and nitrate will be utilized for the production of microbial biomass when provided with a suitable carbon : nitrogen ratio. This biomass can be used in situ by cultivated organisms or can be harvested and used as feed ingredients. Microbial aggregates develop in the environment when heterotrophic bacteria colonize due to the introduction of an external carbon source. Heterotrophic bacteria convert inorganic nitrogen into cell biomass and maintain water quality resulting in minimal water exchange and increasing biosecurity in the culture system. This technology has the advantage of reducing the amount of feed needed for fish farming by recycling waste feed and feces into microbial proteins. This process also boosts digestive enzyme production, leading to faster fish growth. The technology is efficient in decreasing feed conversion rates, increasing stocking capacity, and minimizing the risk of disease and negative environmental impacts. The microbial proteins can also serve as an additional source of nutrients for cultivated organisms, providing protein, lipids, minerals and other essential nutrients. The advantages of this technology include possible higher stocking density, high growth rate, reduced feeding and protein

Biofloc technology in India is still in its infancy due to the lack of knowledge and unawareness of its proper maintenance. The technology is scientifically skill oriented and need diligent attention at all levels and the manpower to operate such system need to get trained from established scientific institutions.

Species suitable for biofloc system:

Species should be able to tolerate low water quality with high solids in the BFT system as well as obtain nutrients from the biofloc by filter-feeding. The fish should be able to graze and harvest the suspended flocs, digest and use the nutrient-rich microbial biomass, and convert them into useful animal protein. The species that cannot consume biofloc can still be raised in a biofloc system, which can act as a protective system. The following species are suitable for biofloc systems: Singhi (*Heteropneustes fossilis*), Magur (*Clarias batrachus*), Pabda (*Ompok pabda*), Anabas/Koi (*Anabas testudineus*), Common Carp (*Cyprinus carpio*), Rohu (*Labeo rohita*), Tilapia (*Oreochromis niloticus*), Milkfish (*Chanos chanos*), Pangasius (*Pangasianodon hypophthalmus*), and shellfish like Vannamei (*Litopenaeus vannamei*) and Tiger Shrimp (*Penaeus monodon*).It's important to note that only improved strains of Tilapia are allowed, such as genetically improved farmed Tilapia (GIFT), Monosex Nile Tilapia, and Red Tilapia.

Nutritional composition of biofloc

The nutritional composition of floc varies with environmental conditions, type of carbon source used, Total suspended solid level, the salinity of rearing water, stocking density of fish, light intensity, populations of phytoplankton and bacterial communities, and carbon: nitrogen ratio, etc. The nutrient composition of biofloc ranges from 12-49% protein, 0.5-12.5% lipid, and 13- 46% ash. Biofloc is rich in vitamins such as niacin (vitamin B3), thiamine (vitamin B1), riboflavin (vitamin B2), cobalamin, and tocopherol (vitamin E) and many minerals, especially phosphorus Biofloc contains bioactive compounds such as carotenoids and fat-soluble vitamins, along with other immunostimulants that can trigger the innate immune response in fish.

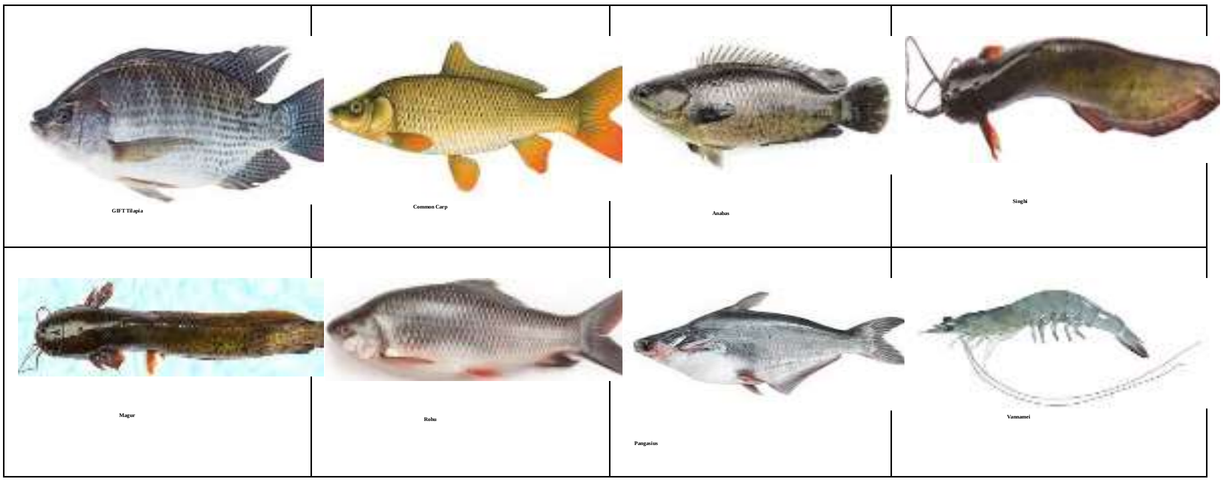


Fig 1: Species suitable for biofloc culture.

Construction of biofloc tank:

The ideal tank size is between 20 to 30 cubic meters with a depth of 1.2 to 1.5 meters. Before the construction, the site needs to be cleared and leveled properly. For constructing the tank, Galvanized Iron sheet/mesh with a minimum weight of 2800 GSM can be used. Construct a drainage system with a 25:1 to 30:1 slope and extend the drainage pipe outside the tank. There should be a water level balancing pipe on the side with a ball valve for draining. The pond liner should be made of PVC coated nylon or HDPE and have a 30cm excess width for tying it on the periphery. Covering the unit with rain shade and shade net to avoid excess rainwater and sunlight. Air pumps or blowers providing 200-240 L per minute are needed for aeration. Surface water must be chlorinated with 20-30 ppm chlorine, dechlorinated by aerating it under sunlight. Groundwater must be tested before use and corrected for alkalinity and pH with Dolomite or quick lime.

Inoculum preparation of biofloc:

Inoculum volume is decided based on the volume of culture system and inoculum: culture volume ratio could be maintained in 1:50-100 (1L of inoculum for 50-100L of culture volume). The required quantity of jaggery to be fermented with little quantity of yeast for 12hr before inoculum preparation. Biofloc inoculums were developed following the methodology of Avnimelech (1999) using 10 mg/l ammonium sulfate, 200 mg/l fermented Jaggery, and 20 g/l of pond soil and incubated for 24hr. Aeration is must in both fermenting jaggery and in inoculum.

Fig 2: Biofloc tanks and drainage system.

Floc development and stocking of fish:

The prepared inoculum should be added to the culture system after the incubation time. It is important to add the ammonium source and carbon source at frequent intervals to maintain a carbon-to-nitrogen ratio of 15:1. Initially, algal growth will prevail, and then the foam formation step indicates the transition phase. It is recommended to stock the fish ten days after adding the inoculum. To control 1 mg/L of ammonia, you need to add 10-20 mg/L carbon. It is important to check ammonia levels daily in the initial days and then every three days later on. To ensure successful biofloc fish farming, it is mandatory to stock quality seed from registered and certified seed hatcheries only. After bringing the seed, rear it for 15-20 days to make it a suitable size for stocking. The preferred seed size for stocking is 4 gm and above. To acclimate the seed packets to the temperature of the tank water, keep them afloat in the tank for 20 minutes. Gradually release the seed by taking in tank water into the packets and slowly releasing it.

Carbon: nitrogen ratio maintenance:

Method 1: The required amount of carbon for the assimilation of ammonia into microbial protein was calculated based on the carbon content of the source and the protein content of the feed. For maintaining C: N ratio at 15:1, 15g of carbon should be added to reduce ammonia nitrogen by 1g. For example, the fish were fed with 3% of the average body weight feed having 30% protein. So, for 1 kg fish biomass, 30 g (9 g protein) of feed is required. However, 16% of the protein in feed was assumed to be converted into nitrogen, and, therefore, with each addition of 30 g feed, 1.4 g of nitrogen will be produced, out of which 75%, i.e., 1.05 g of nitrogen goes into the water. To balance this, the carbon: nitrogen (C: N) ratio was manipulated to 15:1. Thus, for 1.05 g of nitrogen produced in water by 30 g of feed for 1 kg fish, 15.75 g of carbon was required. However, Jaggery contains only ~28.8% carbon against the above assumption. Thus, 54.65 g of fermented Jaggery was added for every 30 g of feed.

Method 2: Carbon: nitrogen ratio can be maintained by measuring the TAN value. For example, the volume of the culture tank is 15000L and the TAN value is 1mgL^{-1}(1mg TAN in 1L of water).

TAN in 15000L water = (TAN * volume of water) = 0.001*15000= 15g.

Carbon: nitrogen ratio (15:1) to be maintained for the biofloc development. So, the amount of carbon source to be added is 15*15= 225g.

Water Quality Management in biofloc system:

Biofloc technology is a method of aquaculture that aims to recycle nutrients by enabling zero water exchange. This process helps to maintain water quality and reduce the amount of nutrients discharged into nearby water bodies. To ensure the success of the biofloc system, it is important to monitor certain water quality parameters such as temperature, dissolved oxygen (DO), pH, salinity, total suspended solids (TSS), total ammoniacal nitrogen (TAN), nitrite-N (NO_2-N), nitrate-N (NO_3-N), alkalinity, and floc volume. The ideal range of water quality parameters for the biofloc culture system is mentioned in Table 1. In a biofloc system, sometimes there is fluctuation in alkalinity. If the alkalinity is less than 100 mgL^{-1}, sodium bicarbonate or calcium carbonate could be added. Lime is added if the pH is less than desirable range and gypsum is added if it is more than desirable range. High TAN value is toxic to fish and leads to mortality of fish. So, the maintenance of TAN value at a desirable level is necessary. Adding a carbon source, minimal or no feed, supplementation of probiotics, and 20-40% water exchange based on TAN value could be the solution if the Tan value is more than 1 mgL^{-1}. Floc volume is one of the important parameters to be considered in biofloc systems. To measure the floc volume, an Imhoff cone is used and the floc is left to settle. Floc volume should be maintained in desirable range. Carbon source need to added if floc volume is less and water exchange or sludge removal is must if the floc volume is high.

Table 1: Water quality parameters and their ideal ranges in the BFT system

Parameters	**Ideal range**
Dissolved oxygen (DO)	>5mgL^{-1}
Temperature (°C)	28–30°C
pH	6.8–8.0
Salinity (ppt)	0 to 30 ppt (Depending on the cultured species)
TAN (NH_3-N) (mgL^{-1})	< 1 mgL^{-1}
Nitrite-N (NO_2-N) (mgL^{-1})	< 4 mgL^{-1}
Nitrate-N (NO_3-N) (mgL^{-1})	Between 0.5–40 mgL^{-1}
Alkalinity (mgL^{-1})	> 100 mgL^{-1}
Floc volume (mgL^{-1})	Shrimp is 5-15 mg/L. For tilapia fingerlings, the recommended range is 5-20 mg/L, while juveniles and adult tilapia require a range of 20-50 mg/L.
Total suspended solids (mgL^{-1})	< 500 mgL^{-1}

Floc in microscope

Floc volume in imhoff cone

Fig 3: Floc observed in microscope and floc volume measured in Imhoff cone.

Disease management:

Biofloc technology is a protective and bio-secure system due to the presence of beneficial heterotrophic bacteria inhibits the growth of pathogens. But improper water quality and floc management can lead to stress in fish, making them susceptible to disease in biofloc systems. Commonly occurred diseases in biofloc system are fin rot (bacterial disease), dropsy, cotton wool disease (fungal disease). Bacterial disease can be controlled by treating with enrofloxacin, oriprim, benzalkonium chloride (BKC) and fungal disease by fluconazole. In addition, supplementation of vitamin C and vitamin B enhances the immune system and relieves the fish stress.

Conclusion:

Biofloc technology is a sustainable method that has several benefits, including low investment costs, minimal land and water use, low feed conversion ratio, and a bio-secure system. This technology can be used to unravel the major problems of salinization and waterlogging in some parts of North India in a sustainable way. It is essential to receive proper training from experts or registered institutions for the success of farms as this technology is based on microbial mechanisms. These actions prevent the misuse of technology and promote sustainability.

Reference:

Avnimelech, Y. 2012. Biofloc Technology. A Practical Guide Book. 2nd ed. Baton Rouge, LA: The World Aquaculture Society.

Crab, R., Defoirdt, T., Bossier, P. and Verstraete, W., 2012. Biofloc technology in aquaculture: beneficial effects and future challenges. Aquaculture, 356, pp.351-356.

https://stock.adobe.com/in/search?k=vannamei+shrimps

https://www.ocean-treasure.com/quality/is-asc-certified-pangasius-a-sustainable-fish/

https://www.fishhobbyist.net/2022/05/get-to-know-more-about-anabas.html

https://cifa.nic.in/sites/default/files/Magur_Pamphlet.pdf

https://cifa.nic.in/sites/default/files/Singhi_Pamphlet.pdf

https://oceanbazzar.com/product/carp-rohu/

https://niasm.icar.gov.in/sites/default/files/pdfs/GIFT_Tilapia_ClimateSmartAquaculture.pdf

https://www.apnikheti.com/en/pn/livestock/freshwater-aquaculture/common-carp

Chapter 9

FUTURE PROSPECTIVE OF SHRIMP AQUACULTURE IN INDIA

K. Manoj Dhanraj & C. Sheeba Anitha Nesakumari

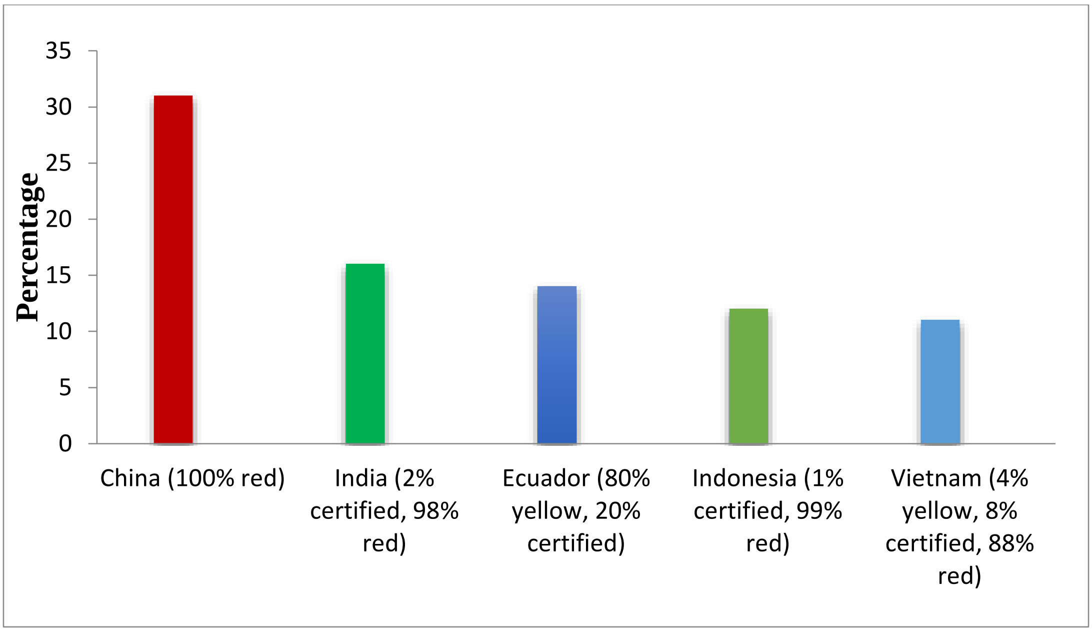
India has a long history of using fisheries and aquaculture to create food for human consumption; the oldest accounts of these methods can be found in the ancient economic texts Kautilya's Arthashastra (321–300 B.C.), which dates back to the time of King Someswara's Manasoltara (1127 A.D.). Approximately 1% of India's GDP comes from the fishing and aquaculture industries, while over 5% comes from the country's agricultural sector. Under the general category of aquaculture, brackishwater aquaculture refers to the thriving farming of shellfish and finfish along the nation's coast and in saline inland areas. Given its substantial contribution to food production, job creation, and economic advantages, the brackishwater aquaculture sector—which is dominated by shrimp farming—is India's aquaculture industry's economic engine.

The shrimp culture sector in India has grown significantly between the 1980s and 2021. In 1983, scientific shrimp farming was initiated due to the increasing demand for shrimp worldwide, government initiatives to encourage seafood exports, and financial contributions from various business organizations to construct farms, hatcheries, and processing facilities. The Indian white shrimp (*Fenneropenaeus indicus*) and the black tiger shrimp (Penaeus monodon) served as its main models.

The farming of Pacific white leg shrimp (*Litopenaeus vannamei*), also known as Specific Pathogen Free (SPF) shrimp, began in Andhra Pradesh in 2008, and it has grown rapidly ever since. The nation carefully introduced the species by enabling a small number of chosen entities to carry out an experimental import and trials. As of right now, broodstock of *L. vannamei* is restricted to importation from authorized sources and must enter the nation quarantined in a facility managed by the government. The government has indicated its interest in allowing entities that can generate broodstock domestically and complete the lifetime of *L. vannamei* within India in a fully contained and highly biosecure facility. Currently, development of broodstock multiplication centers is permitted.

Since SPF *L. vannamei* was introduced, India's shrimp farming industry has grown astronomically. Due to increased *L. Vannamei* stocking densities, a decreased risk of disease, and animal development rates that were on par with or even higher than those of black tiger shrimp up to 20 grams, farms that had previously been cultivating black tiger shrimp saw an increase in productivity. Farmers quickly shifted to SPF *L. vannamei*, and today this species accounts for more than 90% of shrimp production in India.

In 2019, the production of farmed shrimp reached 7.0 lakh tons, of which 87% is shipped to the United States, China, Japan, the European Union, and South East Asia, generating substantial foreign exchange earnings of Rs. 35,000 crores (MPEDA, 2019). The majority of vital inputs, such as seed, feed, and other farm inputs, are produced in Andhra Pradesh and Tamil Nadu and transported to all the shrimp farming states, including the recently emerging inland saline aquaculture areas in Punjab, Haryana, and Rajasthan. The maritime states are home to the allied processing infrastructure. Approximately 12 lakh families rely on this industry both directly and indirectly for their livelihoods through work and money. For shrimp aquaculture to continue in India, the flow of seed, feed, inputs, and output for processing and exportation both within and between states is crucial. Nonetheless, shrimp farming is growing in the northeastern states of Gujarat and Odisha, which are situated north of Andhra Pradesh on the east coast. India produces around one million metric tons of *L. vannamei* annually, making it the second-largest producer in the world. This corresponds to about one in every six of these widely consumed shrimp produced globally. Additionally, they are a major supplier to the United States, making up 38% of all $2.8 billion in warm water shrimp imports in 2022. But today, almost all Indian-farmed whiteleg shrimp are classified as red.



Top countries farming white leg shrimp (Percent of global production)

India's shrimp aquaculture business is shaped by a number of variables that point to a bright future. Here's a thorough analysis of its possibilities going forward:

I. Increasing Need

A number of interconnected variables are driving the increased demand for shrimp in the context of aquaculture, and they all contribute to the growing shrimp industry both domestically and globally. Here's a thorough examination of these elements:

1. A rise in worldwide consumption

Dietary Preferences and Health Trends: Because of its flavor, texture, and adaptability to a variety of culinary styles, shrimp is a popular choice for seafood. The result has been a continuous rise in consumption around the globe. Shrimp is becoming more and more popular among health-conscious consumers due to its high protein level, low fat content, and important nutrients, such as omega-3 fatty acids.

2. Urbanization and Population Growth

Urbanization and Population Growth: The world's population is expanding, especially in emerging nations where the consumption of seafood is rising along with income levels. Greater demand is being seen in urban areas for quick-to-prepare, high-quality food items like shrimp, which are seen as premium in many places.

3. Development of the Economy

Growing Wealth and Middle-Class Expansion: Economic expansion is generating more disposable money in many nations, especially in Asia and Latin America. This, in turn, is driving up the demand for more expensive, premium protein sources like shrimp. Shrimp consumption rises as a result of people's dietary tastes changing as they become more middle class and adopt more varied, high-protein diets.

4. Market Dynamics: Major exports from nations like Vietnam, Thailand, and India include shrimp. Developed markets have a considerable demand for imported shrimp because of their high rates of consumption and preference for high-quality seafood, especially in North America, Europe, and Japan. Shrimp prices are subject to variations in supply and demand. In recent years, rising production costs and supply chain issues have influenced global shrimp prices, but demand remains robust.

5. Trends in Culinary

Gourmet and Ethnic Foods and Product Innovation: The rising demand for shrimp can be attributed to the growing appeal of gourmet and ethnic foods in both developed and emerging nations. Both home cooks and restaurants are using shrimp in a broad range of recipes. Value-added shrimp products, including processed or ready-to-cook shrimp, are among the new goods that are generating attention from consumers and growing market potential.

6. Health and Sustainability Concerns

Nutritional Value and Sustainable Choices:

The health benefits of shrimp, such as its high protein content, low fat content, and the inclusion of vital vitamins and minerals, are becoming more widely acknowledged. This fuels consumer demand from those who are health-conscious. Customers and companies are looking for shrimp that is produced sustainably since environmental challenges are becoming more widely known. Shrimp is increasingly recognized for its health benefits, including high protein content, low fat, and the presence of important vitamins and minerals. This drives demand from health-conscious consumers. With growing awareness of environmental issues, consumers and businesses are seeking sustainably farmed shrimp.

7. Technological Progress

Improvements to the Supply Chain and Production Efficiency:

Shrimp farming is becoming more productive and economical thanks to technological advancements in aquaculture, such as better feed formulations, disease control, and breeding methods. This is helping the sector expand to meet rising demand. Shrimp's increasing market share is partly due to improved cold chain management, traceability, and logistics, which guarantee that shrimp reaches consumers in better condition and more consistently.

8. Government and Industry Support

Policy Support and Industry Initiatives: Numerous countries are putting policies into place to encourage the expansion of aquaculture, which includes shrimp farming, by providing funds for research, infrastructure improvements, and subsidies. The shrimp business is making investments in R&D, marketing, and product quality enhancement to keep up with changing consumer demands

II. Advancement in technology

Technological advancements in shrimp aquaculture have revolutionized the industry, enhancing efficiency, sustainability, and productivity through several key areas:

1. **Selective Breeding and Genetic Improvement**: Advances in selective breeding and genetic research have produced shrimp strains with improved disease resistance, faster growth rates, and better feed conversion ratios.
2. **Disease Management**: Probiotics, prebiotics, vaccines, and immunostimulants are now used to enhance shrimp health, reduce reliance on antibiotics, and manage diseases like White Spot Syndrome Virus (WSSV) and Early Mortality Syndrome (EMS).

3. **Water Quality Management**: Technologies like Recirculating Aquaculture Systems (RAS) and Biofloc Technology help maintain optimal water quality, promote beneficial microbial communities, and reduce environmental impact.
4. **Feeding Technology**: High-quality, balanced feeds and automated feed management systems improve growth rates, reduce waste, and optimize nutrient distribution.
5. **Monitoring and Automation**: Sensors, IoT, and automation systems enable real-time monitoring and control of water parameters, reducing labor costs and enhancing precision in farm operations.
6. **Environmental Management**: Integrated Multi-Trophic Aquaculture (IMTA) and advanced effluent treatment systems reduce environmental impact and improve sustainability by recycling nutrients and managing waste.
7. **Genomic and Biotechnological Tools**: DNA sequencing, molecular markers, and gene editing technologies are used to develop disease-resistant shrimp and improve breeding programs.
8. **Data Analytics and Decision Support**: Big data and AI provide advanced analytics, predictive modeling, and decision-making support to optimize farm management and productivity.
9. **Traceability and Quality Assurance**: Blockchain technology ensures transparency and traceability in the shrimp supply chain, while advanced quality control tools maintain high standards for shrimp products.

Government support is essential to the growth and sustainability of shrimp aquaculture in India. Key initiatives include the Pradhan Mantri Matsya Sampada Yojana (PMMSY), which offers financial aid for infrastructure and technology, and subsidies that lower the cost of setting up and expanding shrimp farms. The government also funds research and development, facilitates training programs, and supports infrastructure development such as aquaculture parks and cold storage facilities. Export promotion efforts, including incentives and quality standards assistance, enhance global competitiveness. Additionally, regulations ensure sustainable practices, while crisis management support, including disaster relief and insurance, helps mitigate risks. Regulatory bodies oversee policy implementation and sector monitoring, ensuring alignment with national objectives. Industry initiatives in shrimp aquaculture are crucial for addressing the challenges and opportunities present in the market. These initiatives focus on improving product quality, meeting consumer preferences, and advancing technological innovations. Shrimp aquaculture in India is set for a bright future, characterized by increased production, improved sustainability, and expanded market reach. By leveraging technological advancements, supportive policies, and a focus on sustainability, India can establish itself as a leading player in the global shrimp industry, driving economic growth and meeting the rising global demand for seafood.

CHAPTER 10

A CASE STUDY OF SHRIMP FARMING ISSUES AND CONTROL MEASURES

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Introduction

Shrimp farming has become a significant sector in global aquaculture, contributing to the livelihoods of millions and meeting the rising demand for seafood. As one of the most traded seafood commodities, shrimp farming plays a crucial role in the economy of many coastal countries. However, despite its importance, shrimp farming is not without its challenges. From disease outbreaks to environmental degradation, shrimp farmers face many issues that can impact their productivity and sustainability. This article delves into the common problems associated with shrimp farming and explores the control measures that can be implemented to address these challenges.

Common Issues in Shrimp Farming

Shrimp farming is a complex process that requires careful management of various factors. The common issues shrimp farmers face include disease outbreaks, environmental degradation, water quality management, feed quality and nutrition, high stocking density, and biosecurity challenges. These issues can lead to significant economic losses and can threaten the sustainability of shrimp farming operations.

a. Disease Outbreaks in Shrimp Farming

One of the most pressing issues in shrimp farming is the occurrence of disease outbreaks. Shrimp are susceptible to a range of diseases, including bacterial, viral, and fungal infections. Some of the most common diseases include White Spot Syndrome Virus (WSSV), Early Mortality Syndrome (EMS), and Vibrio infections. These diseases can spread rapidly in farmed shrimp populations, leading to high mortality rates and significant economic losses.

Impact of Diseases on Shrimp Production

Disease outbreaks can have devastating effects on shrimp farms. Not only do they reduce the overall yield, but they also increase the cost of production due to the need for medical treatments and preventive measures. In some cases, entire farms may be wiped out, leading to severe financial consequences for farmers.

Disease Prevention and Management Strategies

To prevent disease outbreaks, it is essential to implement strict biosecurity measures, including the use of disease-free broodstock, regular monitoring of shrimp health, and maintaining optimal water quality. Vaccination and the use of probiotics are also being explored as potential strategies to enhance disease resistance in shrimp.

b. Environmental Degradation

Shrimp farming has often been criticized for its negative impact on the environment. The destruction of mangroves, pollution of water bodies, and the use of harmful chemicals are some of the environmental issues associated with shrimp farming.

Impact of Shrimp Farming on Ecosystems

The expansion of shrimp farms has led to the destruction of critical coastal ecosystems, particularly mangroves, which play a vital role in protecting coastlines and supporting biodiversity. Additionally, the discharge of untreated effluents from shrimp farms can lead to the pollution of surrounding water bodies, affecting the health of aquatic life and local communities.

Measures to Mitigate Environmental Impact

To reduce the environmental impact of shrimp farming, it is important to adopt sustainable farming practices. These include the use of recirculating aquaculture systems (RAS), integrated multi-trophic aquaculture (IMTA), and organic farming methods. Additionally, restoring and conserving mangrove ecosystems can help mitigate the damage caused by shrimp farming.

c. Water Quality Management

Maintaining optimal water quality is crucial for the health and growth of shrimp. Poor water quality can lead to stress, disease, and reduced growth rates in shrimp, ultimately affecting the productivity of the farm.

Common Water Quality Issues

Some of the common water quality issues in shrimp farming include fluctuations in pH levels, high levels of ammonia and nitrite, and low dissolved oxygen levels. These issues can arise due to overfeeding, inadequate water exchange, and the accumulation of organic waste in the pond.

Techniques to Manage Water Quality Effectively

To manage water quality effectively, farmers can implement regular water testing and monitoring, use aeration systems to maintain adequate oxygen levels, and manage feeding practices to prevent the accumulation of waste. Additionally, the use of biofilters and probiotics can help maintain a healthy microbial balance in the pond.

d. Feed Quality and Nutrition

The quality of feed used in shrimp farming plays a critical role in the health and growth of shrimp. Poor-quality feed can lead to malnutrition, disease, and reduced growth rates, ultimately affecting the profitability of the farm.

Issues Related to Poor Feed Quality

Low-quality feed may lack essential nutrients, be contaminated with harmful substances, or have poor digestibility. This can lead to poor growth performance, increased susceptibility to disease, and higher feed conversion ratios (FCR), which means more feed is required to produce the same amount of shrimp.

Solutions for Improving Feed Quality

To improve feed quality, farmers should source feed from reputable suppliers, ensure that the feed contains all the necessary nutrients, and store it properly to prevent contamination. Additionally, incorporating additives such as probiotics, prebiotics, and enzymes can enhance the nutritional value of the feed and improve shrimp health.

e. High Stocking Density

High stocking density is a common practice in shrimp farming to maximize production. However, it can lead to several issues, including increased stress, higher disease transmission rates, and reduced growth rates.

Risks Associated with High Stocking Density

When shrimp are stocked at high densities, they are more likely to experience stress due to overcrowding. This stress can weaken their immune system, making them more susceptible to diseases. Additionally, high stocking density can lead to poor water quality, as the waste produced by the shrimp accumulates more rapidly.

Impact on Shrimp Health and Growth

High stocking density can negatively impact shrimp health and growth. Shrimp may exhibit slower growth rates, higher mortality, and increased competition for food and space, leading to uneven sizes and lower overall productivity.

Strategies to Manage Stocking Density

To manage stocking density effectively, farmers should consider the carrying capacity of their ponds and avoid overstocking. Regular monitoring of shrimp health and behavior can help detect signs of stress early on, allowing for timely interventions. Additionally, improving water quality management and providing adequate nutrition can help mitigate some of the negative effects of high stocking density.

f. Biosecurity Challenges

Biosecurity is a critical aspect of shrimp farming, as it involves preventing the introduction and spread of diseases. However, maintaining biosecurity can be challenging, especially in areas with high farming intensity and poor infrastructure.

Importance of Biosecurity in Shrimp Farming

Biosecurity measures are essential to protect shrimp farms from the introduction of pathogens and to prevent the spread of diseases within and between farms. This includes controlling access to the farm, using disease-free broodstock, and implementing quarantine procedures for new stock.

Common Biosecurity Threats

Some of the common biosecurity threats in shrimp farming include the introduction of diseases through contaminated water, feed, or equipment, and the movement of people and animals between farms. Additionally, the lack of proper waste management can lead to the spread of pathogens within the farm.

Best Practices for Biosecurity Management

To enhance biosecurity, farmers should implement strict access controls, use protective clothing and disinfectants, and regularly clean and disinfect equipment and facilities. Additionally, isolating new stock and monitoring for signs of disease before integrating them into the main population can help prevent disease outbreaks.

g. Economic Challenges

Shrimp farming is not only challenged by biological and environmental factors but also by economic issues. The cost of managing diseases, improving infrastructure, and complying with regulations can be significant, and market fluctuations can impact the profitability of shrimp farming.

Cost Implications of Shrimp Farming Issues

Addressing the various issues in shrimp farming often requires significant investment. For example, improving biosecurity measures, maintaining water quality, and sourcing high-quality feed can all increase the cost of production. Additionally, disease outbreaks can lead to substantial financial losses due to reduced yields and increased medical expenses.

Market Fluctuations and Their Impact on Farmers

The shrimp market is highly volatile, with prices fluctuating based on supply and demand, global trade policies, and consumer preferences. These fluctuations can make it difficult for farmers to predict their income and plan for the future, leading to financial instability.

Economic Strategies for Sustainability

To improve the economic sustainability of shrimp farming, farmers can diversify their income sources, such as by integrating other forms of aquaculture or agriculture into their operations. Additionally, adopting cost-effective farming practices and improving access to markets through cooperatives or direct sales can help farmers achieve better financial outcomes.

Technological Innovations in Shrimp Farming

Technology plays an increasingly important role in addressing the challenges of shrimp farming. Innovations in areas such as water quality monitoring, disease detection, and feed management are helping farmers improve efficiency and sustainability.

Role of Technology in Addressing Farming Issues

Technological advancements are providing new tools for farmers to monitor and manage their farms more effectively. For example, automated feeding systems can optimize feed distribution, reducing waste and improving growth rates. Additionally, sensors and data analytics can help farmers monitor water quality in real-time, allowing for timely interventions.

Recent Advancements in Shrimp Farming

Recent technological innovations in shrimp farming include the development of advanced water filtration systems, the use of artificial intelligence (AI) for disease detection, and the application of blockchain technology for traceability and transparency in the supply chain.

Future Trends in Shrimp Farming Technology

Looking ahead, the future of shrimp farming technology is likely to involve further integration of AI, automation, and data analytics. These technologies have the potential to revolutionize shrimp farming by making it more efficient, sustainable, and resilient to challenges.

Regulatory and Legal Challenges

Shrimp farming is subject to various regulations and legal requirements, which can vary widely depending on the country and region. Compliance with these regulations is essential but can pose challenges for farmers, especially in terms of cost and complexity.

Overview of Shrimp Farming Regulations

Shrimp farming regulations typically cover areas such as environmental protection, biosecurity, animal welfare, and food safety. These regulations are designed to ensure that shrimp farming is conducted in a sustainable and responsible manner, protecting both the environment and consumers.

Compliance Issues Faced by Farmers

Farmers often face challenges in complying with shrimp farming regulations due to the complexity and cost of meeting the required standards. For example, implementing biosecurity measures, managing effluents, and ensuring traceability can all require significant investment and resources.

Strategies to Navigate Regulatory Challenges

To navigate regulatory challenges, farmers can seek support from industry associations, government agencies, and non-governmental organizations (NGOs) that provide guidance and resources. Additionally, adopting best practices and keeping up-to-date with regulatory changes can help farmers maintain compliance and avoid penalties.

CASE STUDIES

Examining real-world examples of shrimp farming operations can provide valuable insights into the challenges and opportunities in the industry. Case studies of successful and failed ventures can highlight the importance of effective management practices and the need for adaptability in the face of challenges.

Success Stories in Shrimp Farming

Some shrimp farming operations have achieved significant success by adopting innovative practices and focusing on sustainability. For example, farms that have integrated multi-trophic aquaculture (IMTA) systems have been able to reduce environmental impact while improving productivity.

Lessons Learned from Failed Shrimp Farming Ventures

On the other hand, there are also lessons to be learned from shrimp farming ventures that have failed due to issues such as disease outbreaks, poor water quality management, and financial mismanagement. These case studies underscore the importance of proactive planning and risk management.

Sustainable Practices in Shrimp Farming

Sustainability is increasingly becoming a priority in shrimp farming, as consumers, regulators, and industry stakeholders demand more responsible practices. Adopting sustainable practices can not only help protect the environment but also improve the long-term viability of shrimp farming operations.

Importance of Sustainability in Shrimp Farming

Sustainable shrimp farming practices are essential for minimizing the environmental impact of the industry and ensuring that it can continue to meet the growing demand for seafood. These practices also contribute to the well-being of local communities and the overall health of coastal ecosystems.

Practices That Promote Sustainability

Some of the key practices that promote sustainability in shrimp farming include reducing the use of chemicals and antibiotics, improving waste management, conserving water resources, and protecting natural habitats. Additionally, adopting certification schemes such as the Aquaculture Stewardship Council (ASC) can help farmers demonstrate their commitment to sustainability.

Benefits of Adopting Sustainable Practices

By adopting sustainable practices, shrimp farmers can achieve several benefits, including improved access to markets, reduced production costs, and enhanced resilience to environmental and economic challenges. Moreover, sustainable practices can lead to better relationships with local communities and contribute to the overall reputation of the industry.

Conclusion

Shrimp farming is a vital industry that faces numerous challenges, from disease outbreaks to environmental degradation and economic pressures. However, by implementing effective control measures and adopting sustainable practices, farmers can overcome these challenges and ensure the long-term viability of their operations. As the industry continues to evolve, the integration of technology and a focus on sustainability will be key to addressing the issues in shrimp farming and achieving success in the future.