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Editor/Publisher

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Email: info@gwapub.com

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Condolence & Appreciation for the Late

Dr. Dean M. Akiyama

The Future Aquaculture editorial board extends its deepest condolences on the passing of Dr. Dean M. Akiyama, who left us on October 13, 2025.

Dr. Akiyama was more than a respected expert — he was a true pioneer and visionary whose work transformed the landscape of global shrimp aquaculture. Throughout his distinguished career, he built bridges between scientists, industry leaders, and communities, bringing people together with a shared vision of a more sustainable and responsible aquaculture future.

His groundbreaking contributions to shrimp farming and feed development, his tireless advocacy for responsible production, and his generous mentorship inspired generations of researchers, farmers, and professionals around the world. He was known not only for his remarkable scientific achievements but also for his humility, kindness, and unwavering commitment to empowering others.

His passing represents a profound loss to his family, friends, and colleagues — but also to the broader global aquaculture community. Dr. Akiyama's leadership and dedication advanced both scientific understanding and practical applications, leaving behind a legacy that will continue to shape the future of our field for years to come.

On behalf of Future Aquaculture, its readers, and the global aquaculture community, we pay tribute to his extraordinary life and lasting impact. May his legacy of innovation, passion, and integrity continue to inspire our work. We extend our heartfelt sympathies to his family and loved ones during this time of great sorrow.



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Future Aquaculture
Dr. Shahram Dadgar
On behalf of the Editorial Board



Editor-in-Chief

Eng. Ramon M. Kourie

Chief Technical Officer (CTO), Food Security Research Institute (FSRI), South Africa

ramon@futureaquaculture.org

Aquaculture Innovation & Technology: Driving the Future of Sustainable Seafood

Aquaculture has emerged as a cornerstone of global food security, supplying more than half of the world's seafood and growing rapidly each year. Meeting the rising demand requires not only expanding production but also embracing innovative technologies that improve efficiency, sustainability, and resilience across the sector.

Precision and Data-Driven Farming

The integration of artificial intelligence, IoT sensors, and computer vision is revolutionizing modern aquaculture. These tools allow real-time monitoring of water quality, fish health, and feeding patterns, optimizing growth and reducing waste. Predictive analytics and automated feeding systems are increasingly common, enhancing productivity while minimizing environmental impact.

Sustainable Systems and Water Management

Land based Recirculating Aquaculture Systems (RAS) and Biofloc Technology (BFT) facilities offer effective solutions to water scarcity and pollution concerns particularly when built into Integrated Multi-Trophic Aquaculture (IMTA) applications in marine systems as well as Integrated Agriculture-Aquaculture Systems (IAAS) in freshwater food production systems. It will become increasingly essential to improve water productivity and nutrient circularity in farmed food production systems in the coming years in the light of a changing climate, droughts, and changing ocean conditions which impact both food- and seafood security particularly in water scarce regions.

By reusing water and controlling environmental conditions, RAS and BFT reduces ecological footprint, allows precise management of nutrient flows, results in healthier fish and more consistent yields, while the ensuing reduced waste streams facilitates easy integration into IMTA and IAAS contexts enabling exemplary zero-waste-water discharge conditions to be met.

Alternative Feeds and Circular Solutions

Sustainable feed innovation is gaining momentum, with insect protein, microbial meals, and algae-based feeds reducing reliance on wild-caught fish. These alternatives not only conserve marine ecosystems but also support a circular, environmentally conscious aquaculture model.

Offshore and Vertical Expansion

To optimize space and mitigate land constraints, offshore and vertical farming approaches are expanding. Floating cages, modular tanks, and stacked vertical systems allow high-density, controlled production while minimizing land use and local environmental disruption.

Genomics, Selective Breeding, and Biosecurity

Advances in genetics and selective breeding are producing strains with superior growth, disease resistance, and environmental adaptability. Combined with enhanced biosecurity measures, including pathogen detection and automated monitoring, these innovations safeguard fish health and ensure sustainable productivity.

Automation and Robotics

Robotic feeding, underwater drones, and automated inspection systems are transforming daily operations. By reducing manual labor and improving precision in routine tasks, automation increases efficiency and allows farm managers to focus on strategic decision-making.

Conclusion

The convergence of technology and aquaculture is reshaping the industry, making it more sustainable, productive, and resilient. Continued investment in innovation—from precision farming and alternative feeds to genomics and automation—will be essential to meet global seafood demand while protecting our oceans and resources.

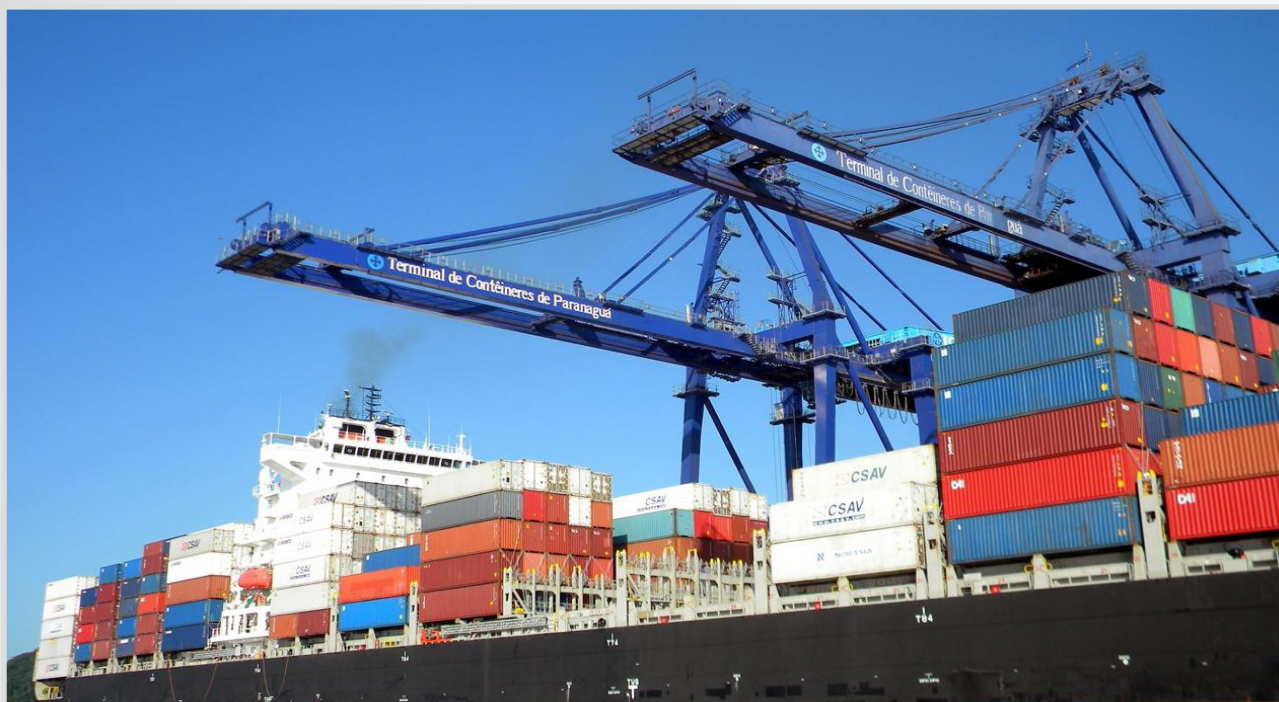




Alejandro Godoy

Seafood consultant and head of Seafood Business Solutions

alejandro@sbs-seafood.com



The Tariff War and Shrimp Trade

Introduction:

The global shrimp industry has become a frontline casualty in the ongoing tariff wars among major seafood-producing and importing nations. As trade barriers rise and retaliatory duties escalate, traditional export flows are being disrupted, reshaping both market access and pricing structures. Producers in Asia and Latin America face shrinking profit margins, while importers in the United States and Europe are forced to reconsider sourcing strategies. Understanding the long-term consequences of these tariff measures is critical for anticipating shifts in the global shrimp economy.

On 1 February 2025 the United States imposed tariffs on seafood imports from several major shrimp-exporting nations. That move reshaped global seafood trade dynamics overnight. The policy aimed to protect domestic interests, yet its effects ripple across producers, importers, retailers, and consumers—creating no clear winner and producing a mix of short-term beneficiaries and long-term losers.

Seafood Tariff rates by country
Mexico — 25%

Ecuador — 15%
Vietnam — 46%
India — 59%
China — 34%
Indonesia — 19%
Bangladesh — 35%
Thailand — 36%

These duties are unusually high for major suppliers and were applied broadly across shrimp product formats, amplifying their market impact.

Shrimp represents roughly 38% of total U.S. seafood consumption, making it the top seafood category by volume and value. U.S. shrimp imports are concentrated among a few countries:

- India – 37% market share (about US\$2.98 billion in imports)
- Indonesia – 19% (about US\$1.55 billion)
- Ecuador – 17% (about US\$1.37 billion)
- Vietnam – 12% (about US\$969 million)
- Thailand – 6% (about US\$455 million)
- Mexico – 3% (about US\$242 million)

- Other countries – 6% combined

If supply from India, Indonesia, Vietnam and Thailand softens, the U.S. would lose access to roughly 64% of its shrimp supply, producing a severe market gap.

Immediate economic winners and losers

Biggest losers are exporting producers in India, Vietnam, Thailand, Bangladesh and others face dramatic revenue loss because tariffs make U.S. shipments far less competitive. Processors can be left with unsold inventory and squeezed margins. U.S. importers and distributors confront higher landed costs, contract strain, and inventory disruption. Many operate on thin margins and fixed-volume commitments.

U.S. consumers face higher retail prices or reduced choice. For budget-sensitive segments, shrimp may become a less frequent purchase or be substituted by other animal proteins.

Regional economies tied to processing and logistics risk job losses and factory slowdowns.

Short-term beneficiaries are some U.S. domestic producers may see improved prices and margins as import competition softens, but domestic production lacks the scale to fully replace imports.

Exporters in non-targeted countries or those able to reroute through third countries can pick up displaced demand.

Alternative markets — China, Europe, and Japan — are absorbing redirected shipments from suppliers like India, cushioning revenue losses.

Strategic responses from industry

Market reallocation: Exporters most affected will accelerate diversification of destination markets and product mixes. India and others are already redirecting shipments to Asia and Europe. These shifts reduce U.S. exposure but increase competition in alternative markets and affect prices there.

Sellers may reformulate exports into product categories, or they may use third-party intermediaries to route product through countries with more favorable treatment. Both



strategies require time, investment, regulatory navigation and risk involved.

Price passthrough and demand response: Importers will attempt to pass tariff costs downstream. Whether consumers absorb higher retail prices; some demand will fall away or move to substitutes, compressing volumes.

Policy and legal action: Tariff measures often spawn disputes, litigation, lobbying, or bilateral negotiations can blunt or reverse impacts over months to years.

Longer-term market implications

The tariff shock accelerates structural change in the shrimp supply chain. Firms that can invest in provenance, traceability, and value-added formats are better positioned to sell into price-insensitive segments.

Premium, traceable, and branded shrimp products are less vulnerable to ad valorem tariffs—consumers pay more for quality and story. This shift opens new space for nearshoring, especially in Mexico and Ecuador as US-friendly suppliers.

Closer logistics ties and nearshoring (sourcing from nearby suppliers like Mexico and Ecuador) can shorten lead times and improve freshness, offering a competitive edge to suppliers who can meet U.S. buyer expectations.

In contrast, commodity-grade exporters face intense pressure to accept lower margins or find new buyers. The rebalancing of flows will likely raise volatility in global shrimp prices.

Conclusion

The tariff war did not produce a single winner. Politically, it signals a protectionist priority; economically, it redistributes pain and gain across borders and value chains. Immediate winners are limited and often temporary; broader losses fall on exporters, importers, and consumers. The market will respond through reallocation, product innovation, and legal and commercial adaptation.

For firms that move quickly to differentiate, improve logistics, and access alternative markets, there are durable opportunities—but those who remain dependent on low-margin, high-volume commodity exports face a difficult adjustment.





Interview with Dr. George Chamberlain President, The Center for Responsible Seafood (TCRS)

Biography:

Dr. George Chamberlain is the President of The Center for Responsible Seafood (TCRS). He previously served as the President of the World Aquaculture Society and founded the Global Seafood Alliance. He has extensive experience in developing innovative technologies for shrimp farming in countries such as Malaysia, Brunei, and Hawaii. His expertise spans research, technology development, and international collaboration, making him a leading voice in promoting responsibility and sustainability in the seafood industry.



Dr. Chamberlain, could you please describe your professional journey in the aquaculture industry and what motivated you to establish TCRS?

I started my aquaculture career in 1975 as an aquaculture graduate student, completed my MS and Ph.D. degrees, and advanced to researcher, instructor, and finally to Extension Aquaculture Specialist. In my role as an Extension Specialist, I began interacting with the commercial aquaculture community through my “Coastal Aquaculture” newsletter, conferences on shrimp and red drum farming, and visits to farms in Asia, Africa, and the Americas.

In 1990, I moved to the corporate world to direct aquaculture programs at Ralston Purina International

and later, Monsanto. That period ushered in more extensive global travel, exposure to a wide variety of commercial aquaculture, and a deep dive into feed ingredients, formulation, and manufacturing. In 1999, I pursued my dream of becoming an aquaculture producer by co-founding and managing an integrated shrimp farm in Malaysia followed by several other shrimp breeding, nutrition, and farming companies with operations in the Americas and Asia. In 2020, I sold my ownership of this company, ultimately known as Kona Bay, to Hendrix Genetics in the Netherlands.

Concurrent with my personal career, I have served several non-profit groups. During 1990 to 1996, I volunteered as a Board member and ultimately as President of the World Aquaculture Society presiding



over the first WAS conference and Seafood Show in Asia. In 1997, I co-founded the Global Seafood Alliance (GSA). During my 25-year term as President, GSA developed the BAP certification program which now certifies nearly 3 million metric tons of farmed and wild seafood per year. In 2022, I retired from GSA to serve as President of a startup non-profit called The Center for Responsible Seafood (TCRS), an organization that advances regenerative seafood production through research and education. TCRS has now established an improver program for smallholder shrimp farms, an online learning center, various research projects on disease management, shrimp and fish welfare, aquaculture engineering, and shark conservation. Beginning in 2023, TCRS launched an annual shrimp farming conference called the Shrimp Summit which has convened events in Ho Chi Minh City, Chennai, and Bali.

What role does TCRS play in promoting responsibility and sustainability in seafood production, and how does it differ from other similar organizations?

I've had the privilege of working with the World Aquaculture Society, an academic organization that provides a valuable platform for researchers to present and discuss their results. I've also worked with the Global Seafood Alliance, a certification organization that generates Best Aquaculture Practices standards. Both are important organizations that provide crucial services, but the role of TCRS is neither academic nor certification. TCRS strives to raise the sustainability bar from simply mitigating impacts to actually improving and restoring ecosystems and communities through regenerative practices that lead to social license. It attempts to continuously improve practices through applied research, education, and collaboration. Collaboration is especially key for a small organization like TCRS. It relies on expertise of leading researchers, support of stakeholders throughout the production chain, and market pull of major buyers. An initial priority is to improve the production efficiency and livelihoods of smallholder shrimp farms and to link them to premier markets by providing credible sustainability assurances.

In recent years, there has been increasing attention on sustainability and responsibility in the seafood sector. In your view, how will these changes shape the future of the industry?

Demand for meat and seafood is projected to double by 2050 in response to increasing population and per capita income. Existing food production systems are already generating nearly a third of carbon emissions, using 70% of freshwater, and impacting biodiversity. The only way to meet demand without generating unacceptable environmental damage is to transform production systems to produce more with less resources. There are countless innovations and advances that are emerging to enable this transformation. The role of TCRS is to accelerate the transfer and adoption of appropriate technologies to aquaculture producers.

Considering your experience in developing innovative technologies, which advancements in shrimp and other aquaculture species do you see as most promising for enhancing industry sustainability?

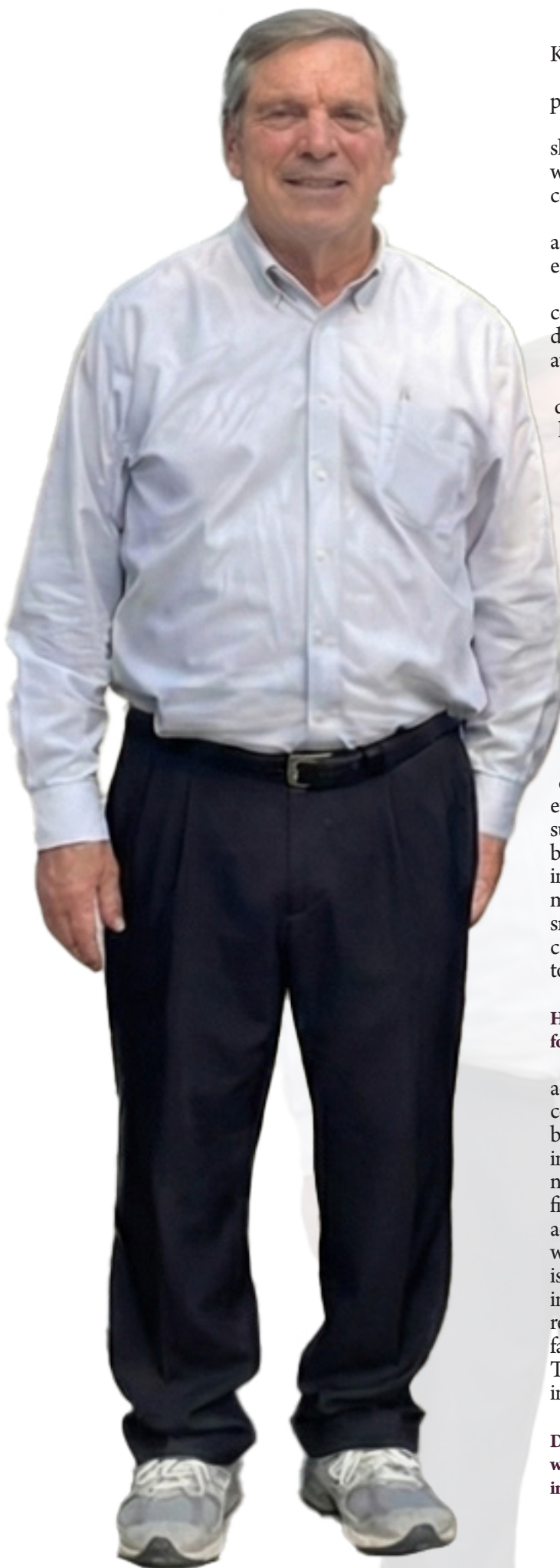
I consider breeding to be the single most impactful aspect of aquaculture production, because it can generate consistent annual performance gains of 10-15% in traits such as growth and disease resistance. Breeding technology is rapidly advancing from mass selection to family selection, marker-assisted selection, genomic selection, and gene editing.

On the production side, a key transformation will be shifting away from flow-through systems that discharge organic wastes into public waters where they degrade water quality and transmit diseases. The opportunity is to adopt water reuse systems that create value from organic wastes through use of bioflocs, fermentation, and carbon sequestration. Organic outputs currently considered as toxic "sludge" can become valuable sources of protein and growth-enhancing micronutrients. A much greater proportion of seafood processing wastes can also be upcycled as valuable human and animal foods.

How does TCRS collaborate with small-scale farmers and producers in developing countries to guide them toward responsible and sustainable practices?

Some smallholder improver programs seek to improve sustainability assurances (environmental, social, food safety, animal welfare) to retailers. This is crucial to provide market access. Other programs seek to improve the efficiency and profitability of farm practices through technology transfer and capacity building. This is crucial to improve the livelihoods of producers. TCRS strives to offer improvements to both the market and the producer.





Key learnings of the program are:

- To engage with major buyers and processors to provide market pull
- To group farms in jurisdictional clusters based on shared water bodies to help align interests in managing water quality and disease and to facilitate cost effective certification using square root sampling of farms
- To use TCRS online learning assets to train local assessors to conduct affordable farm-by-farm surveys of environmental and social compliance
- To collaborate closely with digital technology companies to gain access to IoT production data from digital PL counters, power monitoring systems, and autofeeder from each pond harvest
- To sample disease incidence of farms and water quality of receiving water bodies to enable improved health and zone management
- To consolidate the above data flows into a single database to provide full digital traceability to buyers as well as anonymous production insights to the producers.
- To integrate new technologies for water re-use, waste upcycling, humane slaughter, reduced carbon emissions, and circular economy

Regarding existing challenges in the seafood industry—particularly environmental and social challenges—what measures do you think are necessary to address them effectively?

Perhaps the issue of greatest concern to retailers is social accountability, which refers to such concerns as child labor, forced labor, working conditions, fair wages, etc. Also, very important are environmental concerns such as habitat conservation, carbon emissions, and biodiversity loss. It is no small task to address these issues in countless smallholder farms, in multiple countries with many local languages. The TCRS approach is to enroll smallholder farms into our improver program, begin capacity building, and annually assess their progress toward sustainability compliance.

How do you envision the future of TCRS, and what are your plans for expanding and developing the center's activities globally?

At the start of my career 50 years ago, I worried that aquaculture knowledge gaps might be filled before I could engage. Our knowledge has grown exponentially, but paradoxically, the need for innovation and improvement has never been greater. Now, the urgent need for transformation of food systems drives society to find solutions. There couldn't be a more exciting time for aquaculture innovation and continuous improvement, which is the wheelhouse of TCRS. Our project portfolio is steadily expanding both in number and scope. We intend to continue focusing on the progression to regenerative systems. For example, although smallholder farm improver programs typically end with certification, TCRS intends to continue working on smallholder improvement to progress to regenerative systems.

Dr. George Chamberlain, thank you for sharing your expertise with Future Aquaculture. Your perspectives will provide invaluable guidance and inspiration to our international audience.



TCRS

The Center for
Responsible Seafood

Advancing the Vision of Regenerative Seafood



Technology
Development



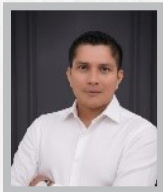
Technology
Transfer



Community
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Market
Acceptance



Vicente Maldonado Sanchez
Spring Genetics
vicente@spring-genetics.com



Feeding techniques to mitigate size variation in Tilapia culture

1. Introduction

Size disparity, or the variation in individual growth rates within a population, is a prevalent challenge in intensive Tilapia aquaculture. This phenomenon can lead to inefficient feed utilization, increased competition, and suboptimal harvest outcomes. Addressing size disparity is crucial for enhancing production efficiency and profitability in tilapia farming systems.

As an aquaculture producer, I have observed that size variability among fish not only affects feed efficiency but also increases operational costs. This experience led me to investigate feeding strategies that can consistently mitigate this issue. With varying sizes, different pricing is required in both the processing plant and sales area, which sparked a strong passion within my team to identify ways to reduce such size disparities.

2. Current Challenges in Tilapia Cultivation

Intensive tilapia farming often results in size disparity due to factors such as:

- **Inconsistent Feeding Practices:** Variations in feeding schedules and quantities can lead to unequal growth among individuals.
- **Environmental Stressors:** Fluctuations in water

quality parameters can adversely affect fish health and growth rates.

- **Genetic Factors:** Inherent genetic variability among individuals can contribute to differences in growth performance.

- **The most common and important factor:** People without DISCIPLINE.

These factors necessitate the implementation of targeted feeding strategies to promote uniform growth and improve overall production efficiency.

3. Feeding Strategies to Reduce Size Disparity

3.1 Phase-Specific Feeding Regimens

Implementing feeding strategies tailored to specific growth phases, peculiar to specific gene lines and breeds, can enhance size uniformity.

Research indicates that adjusting feed composition and quantity during critical growth stages can mitigate size disparity. For instance, studies have shown that varying protein levels and feeding frequencies during different growth phases in Nile tilapia (*Oreochromis niloticus*) can lead to more uniform growth among tilapia populations.

3.2 Increased Feeding Frequency

Increasing the frequency of feeding sessions can

FEEDING TILAPIA FOR ENHANCED SIZE UNIFORMITY



Adopting Phase-Specific Feeding Regimens:
Tailoring feeding practices to specific growth phases can enhance size uniformity.



Increasing Feeding Frequency:
More frequent feeding sessions can improve feed conversion ratios and promote consistent growth.



Integrating Precision Feeding Technologies:
Utilizing automated systems equipped with sensors and computer vision can improve targeted individualized feeding and reduce size disparity.

improve feed conversion ratios and promote more consistent growth. For example, feeding tilapia multiple times per day has been associated with improved growth performance and reduced size variability. This approach ensures that fish receive adequate nutrition throughout the day, minimizing competition and promoting uniform growth.

Contrary to studies suggesting an increase in combined feeding frequency, I have observed an 8–10% decrease in size disparity using a strategy I call the ‘DAD feeding technique: DAD (Distribution, Availability, and most importantly, Discipline). This approach has yielded better results in terms of growth uniformity, reduced coefficient of variation (CV), and more homogeneous harvest sizes.

3.3 Precision Feeding Technologies

The integration of precision feeding technologies, such as automatic feeders equipped with sensors and computer vision systems, allows for individualized feeding based on real-time assessments of fish size and behavior. These technologies enable farmers to deliver precise amounts of feed to each fish, reducing waste and promoting uniform growth. Studies have demonstrated that such systems can significantly enhance production efficiency and reduce size disparity in tilapia farming.

One of the main challenges associated with this technological approach is its cost, which often exceeds the profit margins typically achieved in tilapia farming. This economic constraint may be a key factor limiting producers from adopting and benefiting from precision feeding technologies.

3.4 DAD Feeding Technique

Fish can develop conditioned responses to specific feeding techniques when these methods are consistently applied from early developmental stages. The quantity of feed administered directly affects its accessibility across the entire population within a stocked unit. The illustrations below compare effective versus ineffective

feed distribution patterns.

Feeding frequency should be adjusted according to fish size. During early growth stages (1–40 g), tilapia benefit from frequent feedings—typically 4 to 6 times per day—to support rapid metabolic activity and uniform growth. Once individuals exceed 40 g, feeding frequency can be reduced to three times daily, a regimen that remains effective through to harvest, depending on the desired market size.

Each tilapia farm has its own system, which is unique,

FEED OPTIMIZATION FOR THE THREE PHASES IN TILAPIA CULTURE

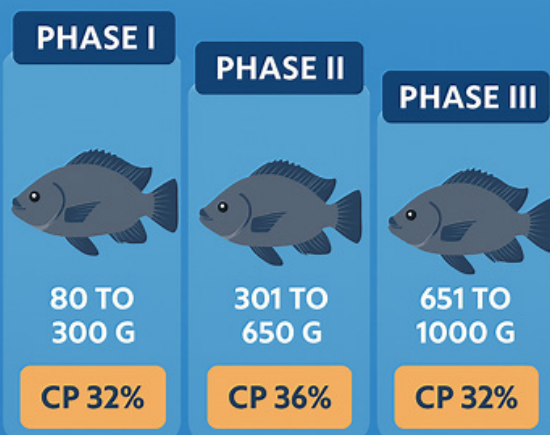




Figure 1. Good feed distribution on the left and bad feed distribution on the right.

but also, when there is a certain water surface area, it must be used properly to deliver feed to all the fish at the same time, in the right amount and distributed correctly (as shown in photo 1 and 2).

Aggressive interactions and superficial injuries (skin and fin wounds) among fish are often attributed to localized feeding practices, where feed is consistently delivered at fixed points. In such scenarios, larger individuals tend to dominate access to feed, displacing smaller conspecifics and increasing the likelihood of physical contact and abrasion. This behavior is illustrated in Photo 3.

4. Comparative Analysis of International Studies

4.1 Brazil

In Brazil, research has focused on optimizing feeding strategies to improve growth uniformity in tilapia. Studies have explored various feeding regimens, including adjustments in protein levels and feeding frequencies, to identify optimal conditions for reducing size disparity.

4.2 Egypt

Egyptian researchers have developed integrated systems combining computer vision and the Internet of Things (IoT) type technologies for precision feeding in tilapia aquaculture. These systems utilize real-time data to

monitor fish size and adjust feeding accordingly, leading to improved growth uniformity and feed efficiency.

4.3 Mexico

In Mexico, studies have examined the impact of feeding strategies on the growth performance of tilapia. Research has highlighted the importance of phase-specific feeding regimens and increased feeding frequencies in promoting uniform growth and reducing size disparity.

5. Conclusions and Recommendations

Addressing size disparity in tilapia aquaculture requires the implementation of targeted feeding strategies. Key recommendations include:

- **Adopting Phase-Specific Feeding Regimens:** Tailoring feeding practices to specific growth phases can enhance size uniformity.
- **Increasing Feeding Frequency:** More frequent feeding sessions can improve feed conversion ratios and promote consistent growth.
- **Integrating Precision Feeding Technologies:** Utilizing automated systems equipped with sensors and computer vision can improve targeted individualized feeding and reduce size disparity.

By implementing these strategies, tilapia producers can



Photo 1 by: Mariana Quiroz



Photo 2 by: Marianela Quiroz

improve growth uniformity, enhance feed efficiency, and increase overall production profitability.

I recommend that producers implement constant monitoring of water quality and adjust feeding strategies according to the specific conditions of their environment, as this may be more effective than following general guidelines. The feeding technique that I will continue to use for many years is implementing the 'DAD' approach — reducing size variation and delivering the greatest possible economic benefit to the farm.

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Photo 3 by: Marianela Quiroz

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Dr. Romi Novriadi^{1,2}

- 1) Lecturer at the Aquaculture Technology Department, Jakarta Technical University of Fisheries
- 2) Secretary General of Indonesian Aquaculture Society
novriadiromi@yahoo.com



Development of economical feed for Pacific White shrimp (*Penaeus vannamei*)

The development of economical feed for *Penaeus vannamei* has become a major focus in modern shrimp aquaculture, as feed represents the largest operational cost—often exceeding 50% of total production expenses. To reduce feed cost without compromising growth and survival, researchers and feed manufacturers are exploring the use of alternative protein sources such as plant-based ingredients (soybean meal, corn gluten, and fermented plant protein) and by-products from agriculture or fisheries (fishmeal replacers, poultry by-product meal, and insect meal). Advances in feed formulation, enzyme supplementation, and nutrient digestibility studies have enabled the reduction of expensive marine ingredients while maintaining feed efficiency and health performance of shrimp.

One alternative ingredient that can be used to replace expensive raw materials or animal protein is Distillers Dried Grains with Soluble (DDGS). Currently, DDGS is increasingly recognized as a promising alternative ingredient for economical feed formulation in *Penaeus vannamei* culture. Derived as a by-product of ethanol production from corn, DDGS contains approximately 25–35% crude protein, 8–12% lipid, and valuable nutrients such as vitamins, minerals, and digestible carbohydrates. Its relatively low cost and consistent

availability make it attractive for partial fishmeal replacement in shrimp feeds. However, the presence of fiber and a variable amino acid balance (notably low lysine and methionine) may limit its inclusion level unless it is properly supplemented with synthetic amino acids or enzyme additives to enhance nutrient utilization.

For this, a strategy is needed to formulate feed by balancing all nutrient requirements, including the availability of limiting amino acids, to ensure optimal growth, feed efficiency, and health while minimizing feed cost and environmental waste. Other than supplementation process, this nutritional balancing process can be achieved by combining DDGS with other alternative raw materials to obtain precise proportions of protein, lipids, carbohydrates, vitamins, and minerals, supporting tissue development, immune function, and energy metabolism. The strategy involves adding several functional additives, such as attractants, enzymes, probiotics, and immunostimulants like protease or nucleotides, to maintain shrimp performance even in low-cost diets.

To determine whether economical feed can be developed by replacing premium raw materials with economical ones, an observation was conducted using DDGS to substitute soybean meal in shrimp feed

Table 1. Ingredient composition and formulation cost of experimental diets containing four graded levels of corn distillers dried grains with solubles (DDGS) for trial controlled and using an open-pond system.

Ingredient (%)	Diet			
	D0	D5	D10	D15
Soybean meal	25.0	22.5	20.0	17.5
Poultry by-product meal	20.3	20.3	20.3	20.3
Fishmeal	8.0	8.0	8.0	8.0
Corn DDGS	0.0	5.0	10.0	15.0
Tuna hydrolysate	2.0	2.0	2.0	2.0
Squid liver powder	6.0	6.0	6.0	6.0
Wheat flour	31.9	29.3	26.8	24.2
Soy lecithin	1.5	1.5	1.5	1.5
Fish oil	1.0	1.0	1.0	1.0
Monocalcium phosphate	1.8	1.8	1.8	1.8
L-lysine	0.00	0.04	0.09	0.14
DL-methionine	0.19	0.18	0.17	0.17
L-threonine	0.08	0.08	0.08	0.09
Mineral premix	1.20	1.20	1.20	1.20
Vitamin premix	0.41	0.41	0.41	0.41
Magnesium sulphate	0.35	0.35	0.35	0.35
Choline chloride	0.20	0.20	0.20	0.20
Antimol	0.12	0.12	0.12	0.12
Formulation cost (IDR/kg)*	10.142	10.037	9.933	9.833

Note: D0 = no inclusion of DDGS; D%5 = 5 inclusion of DDGS; D%10 = 10 inclusion of DDGS; and D%15 = 15 inclusion of DDGS.

formulations with a nutritional balancing strategy. The observation was conducted in a controlled phase using hapa nets installed in commercial ponds specifically for vannamei shrimp production. The feed formulation and growth rates can be seen in Tables 1, 2, and 3.

In the feed formulation (Table 1), supplementation is carried out, especially for the three limiting amino acids — lysine, methionine, and threonine — to rebalance the amino acid profile when soybean meal is substituted with DDGS.



Table 2. Growth, feed intake, feed conversion and feed cost per gain of Pacific white leg shrimp from two separate feeding trials using aquaria tanks. The mean value consists of ten and eight replicates from trial 1 and 2, respectively.

Diet	IBW ¹ (g)	FBW ² (g)	TGC ³	FI ⁴ (g/shrimp)	FCR ⁵	FCG ⁶ (IDR/kg gain)	Survival (%)
Trial 1 period is 52 days							
D0	1.04	10.17	0.077	16.83	1.85	18.783	86.79
D5	1.06	10.90	0.080	16.85	1.72	17.289	89.42
D10	1.03	10.30	0.078	16.81	1.82	18.077	90.17
D15	1.03	10.17	0.078	17.17	1.89	18.541	90.75
PSE ⁹	0.0126	0.2367	0.0011	0.2220	0.0447	445.5	2.3956
<i>p-value</i>	0.2573	0.0856	0.2257	0.5969	0.0525	0.0822	0.5985
Trial 2 period is 84 days							
D0	5.20	18.51	0.035	27.56	2.08	21.056	67.50
D5	5.19	19.29	0.036	28.20	2.00	20.063	70.00
D10	5.17	18.90	0.036	28.91	2.11	21.003	70.75
D15	5.19	19.49	0.037	29.90	2.10	20.684	66.00
PSE	0.0749	0.3741	0.0007	0.8491	0.0707	703.2	6.6299
<i>p-value</i>	0.9919	0.2342	0.3009	0.2251	0.6192	0.7079	0.7253

Research conducted in a controlled and open-pond system has shown that economical feed production for Vannamei shrimp can be achieved with affordable ingredients to replace the expensive ingredients as long as the diet is well formulated and pays attention to digestibility and nutritional balance that meets the nutritional requirements precisely to support optimal growth, health, and feed efficiency. In addition, this research found that DDGS can be used at up to 15% concentration without negatively impacting shrimp growth. Another happy story, as shown in Table 1, feed costs can be reduced by up to 3.05%. Reducing feed

costs as the largest variable cost really helps farmers to increase profits and competitiveness of the products in the (global) market.

The development of economical feed for *Penaeus vannamei* requires a step-by-step strategy that balances cost reduction with nutritional adequacy and growth performance. The first step involves identifying and evaluating alternative protein sources to partially replace expensive ingredients such as soybean meal and other animal protein. Locally available plant proteins (palm kernel meal), agricultural by-products, and novel ingredients like single-cell proteins or insect meals can

Table 3. Growth performance of pacific white shrimp *Penaeus vannamei* (Mean initial weight 1.06±0.01 g) fed experimental diets for 90 d in commercial ponds. Values represent the mean of ten replicates.

Diet code	Final Biomass (g)	FBW (g)	Survival (%)	PWG ⁷ (%)	FCR	TGC	ADG
DO	12089.00 ^b	19.861 ^b	84.55	1769.27 ^b	1.245 ^a	0.0669 ^b	0.214 ^b
D5	12282.00 ^a	20.187 ^a	84.50	1799.95 ^a	1.224 ^b	0.0676 ^a	0.217 ^a
D10	12352.00 ^a	20.252 ^a	84.72	1806.08 ^a	1.219 ^b	0.0677 ^a	0.218 ^a
D15	12074.00 ^b	19.848 ^b	84.49	1768.05 ^b	1.246 ^a	0.0670 ^b	0.214 ^b
<i>p-value</i>	<0.0001	<0.0001	0.9689	<0.0001	<0.0001	<0.0001	<0.0001
PSE ⁹	80.9602	0.0964	0.6572	9.0783	0.0064	0.0002	0.0011

Note: 1 IBW = Initial body weight; 2 FBW = Final body weight; 3 TGC = Thermal growth coefficient; 4 FI = feed intake; 5 FCG = Feed cost gain; 7 PWG = Percentage weight gain; 8 ADG = Average daily growth in gram per day, 9 PSE = Pooled standard error



Figure 1. Visual of experimental feed

be incorporated after assessing their digestibility, amino acid profile, and absence of anti-nutritional factors. The second step is applying the ideal protein concept to ensure amino acid balance while minimizing excessive crude protein inclusion. In the third step, feed additives such as enzymes, probiotics, and organic acids are introduced to enhance nutrient utilization and digestibility, allowing greater flexibility in using low-cost ingredients. The fourth step focuses on improving feed processing conditions, including pellet stability, moisture content,

and particle size, to ensure efficient nutrient delivery and minimize leaching losses. Finally, developed economical feeds will not have a positive impact without proper and precise feeding management. Therefore, adjustments to feed management using economical feeds are necessary to ensure that, while generating profits, the process also avoids negative effects to the environment. By integrating these steps systematically, feed producers can formulate cost-effective diets that maintain shrimp health, growth, and sustainability in intensive culture systems.



Figure 2. Shrimp after 90 days feeding period using an open-pond system

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Dr. Mohamed Alzahaby
Center Laboratory for Aquaculture Research (CLAR), Egypt
Mohamed.alzahaby@arc.sci.eg



Aquaculture in Egypt: Current Status, Strategic Development, and Future Prospects

1. Introduction

Egypt ranks among the top global producers of farmed fish, with aquaculture contributing significantly to national food security and economic development. This paper reviews Egypt's aquaculture production metrics, strategic initiatives, sectoral strengths and weaknesses, and outlines future directions including integrated systems and health strategies. Emphasis is placed on policy frameworks, technological adoption, and sustainability challenges.

Aquaculture has emerged as a cornerstone of Egypt's food production strategy. With a combined output of 2 million tonnes from farmed and wild fisheries, Egypt ranks sixth globally in farmed fish production and leads Africa with 1.5 million tonnes from aquaculture alone. The per capita availability of fish is 25.38 kg/year, with projections indicating full self-sufficiency by 2030 at an estimated production of 3.2 million tonnes.

2. National Aquaculture Development Strategy

Egypt's aquaculture strategy is anchored in the following objectives:

- Achieve 3.2 million tonnes of annual fish production by 2030.
 - Expand aquaculture as a national priority to enhance food security.
 - Extend fishing zones to 200 nautical miles.
 - Promote Integrated Agriculture-Aquaculture Systems (IAAS), particularly in desert regions.
- Government support is channelled through two major programs:
- The National Aquaculture Project.
 - The National Inland Lakes Development Initiative.

3. Sectoral Analysis: SWOT Framework

3.1 Strengths

- Defined legal and institutional frameworks for aquaculture governance.
- Indigenous species (e.g., tilapia, mullet) with strong market acceptance.
- Robust domestic demand and freshwater availability.
- Technological uptake among skilled farmers.

3.2 Weaknesses

- Limited institutional capacity for export promotion

(to the EU), insufficient quality control mechanisms and regulatory oversight and enforcement

- Conflicts over land and water use rights among various stakeholders (tourism, agriculture etc)
- Absence of a national aquatic animal health control system.
- Stock movement regulations and control limits growth opportunities
- Seasonal production variability and inadequate cold chain infrastructure.
- Weak business and marketing support services.
- Currency exchange controls affecting trade.

3.3 Opportunities

- Untapped export potential to the EU for phytosanitary and health certification compliant companies, and untapped export potential to Middle East countries.
- Within country south to north value chain inadequacy leaving untapped market potential (tourism, catering and food service industries)
- Demand stimulation via health-compliant (HACCAP, EU Health Certification etc) aquaculture products.

3.4 Threats

- Disease outbreaks and biosecurity risks.
- Market volatility undermining profitability.
- Climate Challenges: Water scarcity, drought, and extreme heat are pressing concerns, driving the need for climate-smart systems.

4. Inland Lakes Development Program

Key interventions include:

- Mapping and reclaiming lake areas.
- Enhancing water inflows and removing invasive vegetation.
- Establishing environmental monitoring systems.
- Constructing ports, hatcheries, and training centres.

- Strengthening security via water body policing.

Intensive fish ponds in Egypt for the production of Nile tilapia

5. Fish Farm Development Objectives

- Offset deficits in livestock protein through fish farming.
- Utilize marginal lands for aquaculture.
- Promote fish farming in coastal zones.
- Leverage superior feed conversion ratios of fish (1.2–1.6 kg feed/kg fish vs. 2.4–9 kg for other livestock).
- Implement IAAS for nutrient recycling in desert agriculture.
- Support biodiversity through restocking programs.
- Provide affordable protein to low-income populations via fast-growing species (e.g., Nile tilapia, carp).
- Foster rural development and employment, particularly targeting the youth
- Stabilize year-round fish supply to mitigate seasonal shortages by leveraging the advantages of aquaculture.

6. National Aquatic Animal Health Strategy

Egypt's first comprehensive aquaculture health strategy focuses on supporting sustainable development and management of the aquaculture sector, sustainable fisheries production from lakes and coastal waters, and the conservation and restoration of aquatic biodiversity. This provides Egyptian citizens with a necessary source of high-quality protein in sufficient quantities in addition to enhancing the profitability of aquaculture and related projects. The chief aims of the aquatic health strategy include:

- Monitor and prevent transboundary aquatic diseases.
- Enhance farm-level biosecurity and pathogen control.
- Align with international fish health standards.



IPRS System WorldFish Egypt

- Promote ecosystem conservation and stakeholder engagement.
- Develop infrastructure for pathogen surveillance, certification, and quarantining facilities.

The strategy represents a comprehensive roadmap developed for the following purposes:

- Improve knowledge of the current status of aquaculture health and protect Egypt from the risks of transboundary and emerging aquatic animal pathogens.
- Prevent the spread of pathogens between farms.
- Reduce the impact of diseases on aquaculture sustainability, biodiversity conservation, food safety, food security, and the economy.

The strategy was developed according to the following guiding principles to ensure Egypt's international recognition of aquatic animal health at the national level:

- 1) Adherence to international fish health standards.
- 2) Increase Egypt's aquaculture production and enhance its international competitiveness.

3) Protecting the ecosystem and biodiversity.

4) Supporting the need for aquaculture through the private sector.

5) Advocating for principles of transparency, stakeholder engagement, and partnership with the government to develop appropriate bio-security regulations.

6) Advocating for cooperation and coordination among specialists and experts in the field of aquatic animal health.

7) Directing programs and activities to address gaps in Egypt's aquaculture bio-security infrastructure, such as developing a national pathogen list, monitoring pathogens, issuing health certifications, determining the level of protection for state laboratories, and establishing aquatic animal quarantine facilities at designated ports of entry.

7. Flagship Aquaculture Projects

shown in table 1.

Table1

Project Name	Location & Scale	Species & Output
Golyone Project	Kafr El Sheikh, 9000 feddan	25,000 tonnes/year; includes hatchery, feed, processing, and ice plants
Suez Canal Farm	7500 feddan, 4000 ponds	Shrimp, seabream, seabass, meagre
Eldepa Project	72 ponds, 207 feddan	Shrimp; 200 tonnes per 6 months
Elfayroze Project	5331 ponds, 10,000 feddan lake area	Requires investment in wastewater treatment, ice, and packaging facilities

(Note 1 feddan = 4200m²)



Ghalioun, the largest fish farm in the Middle east

Table 2

Egyptian Institution	Key function and responsibility related to aquaculture
Ministry of Agriculture and Land Reclamation (MALR)	Overall management of the sector, setting policy, legislation (decrees, laws, regulations)
Lakes and fish resources protection and development agency (LFRPDA) Low No. 164 for 2021	Licensing of all fish farms and hatcheries and fishers, leasing of land within 200m of lakes, data collection, extension/training, capture of wild fry, designation of suitable aquaculture areas, running of government hatcheries and feed mills
Ministry of Water Resources and Irrigation (MWRI)	Approval for inlet, outlet and quantities of water used
Central Laboratory for Aquaculture Research (CLAR) National Institute of Oceanography and Fisheries (NIOF) and various universities under the Ministry of Higher Education and WorldFish Centre	Aquaculture and Fisheries research and extension and capacity building through training and technical support programs for farmers and fishers

8. Sectoral Challenges

- Site availability constraints and the mapping of available sites for aquaculture development
- Closing biosecurity implementation gaps
- Sustainable feed and technology optimization tuned for Egyptian aquaculture systems
- Coordination between aquaculture and fisheries stakeholders particularly around market access and collaboration
- Governance and licensing inefficiencies. Governance and facilitation of procedures for the establishment and licensing of farms and fishing boats and coordination between the concerned institutions
- Institutional fragmentation across research, marketing, feed, and regulatory domains.
- Adoption of novel and new aquaculture technologies and systems (e.g., IPRS, Biofloc Technology, desert IAAS, IMTA).

9. Conclusion

Egypt's aquaculture sector demonstrates strong growth potential, underpinned by strategic planning, species suitability, and government support. However, realizing its full potential requires addressing systemic weaknesses, enhancing biosecurity, and fostering innovation in integrated systems. Future success will depend on coordinated policy implementation, stakeholder engagement, and investment in infrastructure and health management.

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- World Fish Center. Fish for Africa Innovation Hub (FAIH), Abbassa, Abou-Hammad, Sharkia 44662, EGYPT (<https://worldfishcenter.org/where-we-work/africa/egypt>)





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Mr. Lance Lloyd
Chair, Aquaculture without Frontiers (Australia) Ltd.

A Tide-Turner for Gender, Science, and Global Fisheries – Celebrated by FAO, AwF, and Academia



Dr. Meryl Williams's career is an exceptional testament to leadership, scientific excellence, and an unwavering commitment to **gender equity** in the global aquatic food sector. Spanning over four decades, her impact is felt across continents, from founding international charities to establishing pioneering platforms for women in science. This monumental dedication has culminated in major recognition from the United Nations' FAO and a lasting legacy that continues to inspire and empower.

A Founding Force, An Enduring Guide: Dr. Williams and Aquaculture without Frontiers (AwF)

Dr. Williams's deep commitment to sustainable development and poverty alleviation lies at the very heart of her involvement with **Aquaculture without Frontiers (AwF)**.

- **Original Founder (2004):** She was one of the **original founders of AwF in 2004**, providing the initial vision and intellectual gravitas to launch the global charity. Her involvement was driven by a profound conviction that responsible aquaculture is a potent tool for improving livelihoods and food security in the developing world.
- **Enduring Leadership:** Dr. Williams continues to

serve as an **original board member of AwF (Australia) Ltd. since 2015**, lending her unparalleled strategic insights and ensuring the charity's projects are anchored in scientific rigor, gender inclusion, and measurable community impact.

AwF is immensely proud to have Dr. Williams as a Director, whose life's work perfectly validates and amplifies the charity's core mission of promoting equity and sustainability. She is not merely an advisor, but a living embodiment of the positive change AwF strives to achieve globally.

GAFS and the FAO: A Triumph for Gender Research (2025)

Dr. Williams's most defining institutional achievement in the realm of gender equity is her pivotal role in establishing and nurturing the **Gender in Aquaculture and Fisheries Section (GAFS)** of the Asian Fisheries Society.

- **Pioneering Chair:** Recognizing the glaring need for a dedicated platform, Dr. Williams drove the effort to formalize the group, becoming the **inaugural Chair of GAFS (2017–2022)**. GAFS is globally recognized as the



world's first dedicated gender section within a fishery's professional society.

- **FAO Technical Recognition:** This foundational work culminated in GAFS receiving the prestigious **Food and Agriculture Organization's (FAO) Technical Recognition for Advancing Gender Research in Sustainable Aquatic Food Systems** in **October 2025** in Rome. This monumental award, conferred during FAO's 80th anniversary and the World Food Forum, is a direct validation of the pioneering efforts, guided by Dr. Williams's vision, to:

- o **Influence Global Policy:** GAFS has profoundly influenced global policies and standards, contributing to key documents like the **Shanghai Declaration** (AwF is a proud signatory to this) and high-level submissions to UN bodies, ensuring gender is integral to development agendas.

- o **Empower Women:** It has been instrumental in recognizing women—who comprise roughly half the

sector's workforce—as essential **agents of change** for food security, nutrition, and sustainability, moving beyond viewing them merely as beneficiaries.

This landmark recognition underscores the systemic change Dr. Williams initiated by ensuring gender equity is a core principle of Blue Transformation and sustainable development.

The Zenith of Global Acclaim: FAO Margarita Lizárraga Medal (2024)

Prior to the GAFS collective award, Dr. Williams was individually honoured with the prestigious FAO Margarita Lizárraga Medal in Rome on **8 July 2024**. The medal, which recognizes outstanding contributions to the application of the FAO Code of Conduct for Responsible Fisheries, lauded her as a:

"Tireless, substantive, and globally well-respected advocate for matters of gender, globalization, and development in the fisheries and aquaculture arena... Her inspirational leadership and mentorship... are heralding a new generation of leaders in





gender in fisheries and aquaculture.”

This high-level FAO recognition unequivocally confirms the international significance and profound impact of her decades-long commitment to ethical practices and gender leadership.

Cultivating the Future: The Meryl Williams Fellowship | ACIAR

To ensure her legacy continues to inspire and empower, the **Australian Centre for International Agricultural Research (ACIAR)** established the **Meryl Williams Fellowship (MWF)**, naming it in her honour. This initiative is a core component of ACIAR’s **Gender Equity in Agriculture Research and Development (GEAReD)** program.

- **Purpose:** The MWF is a prestigious, intensive 15-month leadership program designed to empower **female agricultural researchers across the Indo-Pacific**. It aims to enhance their leadership, management,

and scientific communication skills, directly addressing the systemic barriers and personal challenges women face in professional advancement.

- **Transformative Impact:** Fellows, typically mid-career researchers, undertake a comprehensive program that includes executive training, personalized mentorship from both local and international experts, and tailored professional development. This holistic approach builds not only technical skills but also confidence and strategic acumen.

- **Real-world Example:** A Fellow might enter the program as a senior scientist, but emerge as a capable team leader, able to influence policy makers, secure significant research grants, and mentor junior colleagues. They become catalysts for change within their own institutions, challenging gender norms and creating more inclusive research environments. The MWF is a living tribute to Dr. Williams’s vision, transforming research potential into



executive leadership, thereby strengthening global food security and promoting equitable development.

Australian Roots and International Stature: JCU Outstanding Alumnus

Dr. Williams's profound global influence is firmly rooted in her Australian heritage. Her scientific journey began at **James Cook University (JCU)**, where she earned her Bachelor of Science with Honours in 1975. Her subsequent career trajectory, from a fisheries biologist to the **Director General of the WorldFish Center (1994–2004)** – where she refocused its mission on poverty eradication and nutrition – earned her the JCU **Outstanding Alumnus** Award in the College of Science and Engineering in 2010. This prestigious recognition, alongside others like the **IIFET Distinguished Service Award (2024)**, underscores the enduring impact of her foundational education and her ability to translate scientific expertise into global leadership.

Dr. Meryl Williams's career is a powerful narrative of how

scientific dedication, strategic leadership, and an unshakeable commitment to justice can profoundly shape global development. For Aquaculture without Frontiers, she remains an indispensable leader—a visionary whose unwavering focus on disadvantaged communities and the transformative power of women perfectly aligns with and magnifies the organisation's mission. Her legacy is not just one of achievement, but of **empowerment**, ensuring that the future of aquatic food systems is both sustainable and equitable.





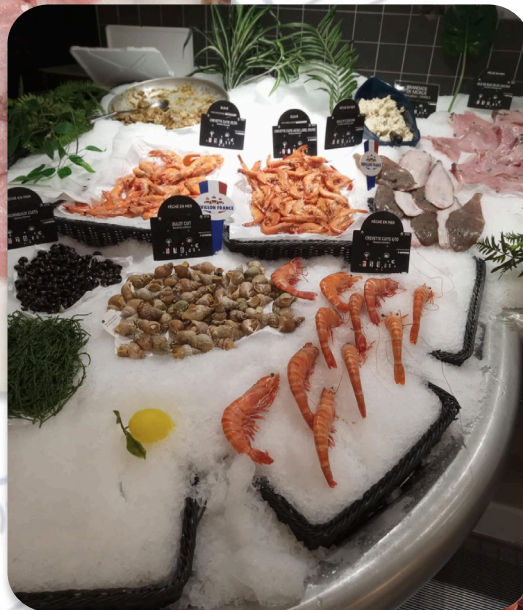
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Why do Consumers Pay Twice for Seafood Sustainability in Australia?

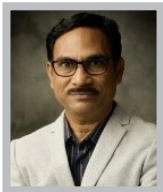
Did you know two-thirds of the seafood we eat in Australia is imported?

How many servings of oily fish a week can cut your risk of dying from heart disease by over a third?

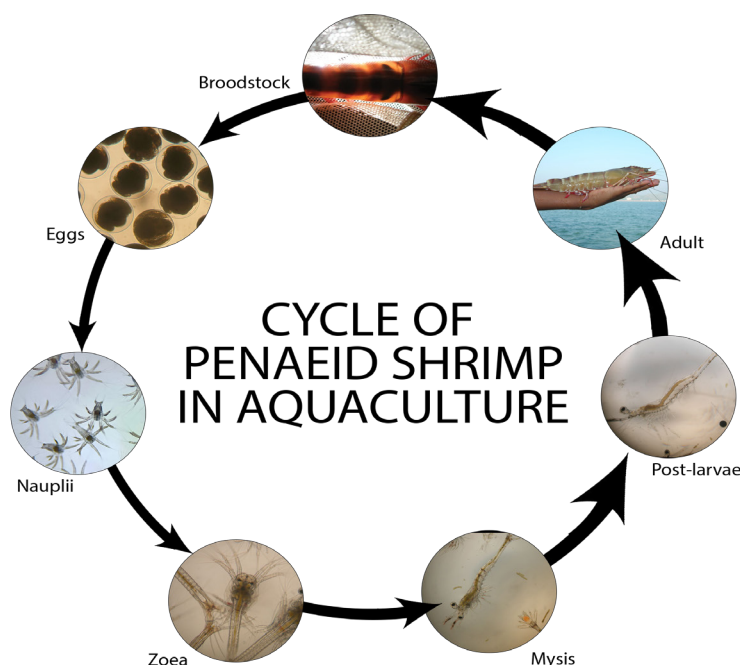
Did you know that commercial seafood bought from a legitimate retailer is considered safe even during a Harmful Algal Bloom (HAB)?



To find out, visit : <https://seafoodconsumers.global/ans.php>



Dr. P V Nageswara Rao
BOS Member, Dept of Zoology & Bio-Technology, AU Avanti SDC, Andhra University, India.
Managing Director, Bluelife Aquaculture Private Limited
sarithanagesh@yahoo.com



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Larval Progression in Penaeid Shrimp Hatchery: A review of challenges and management strategies

The pioneering efforts of Masashi Hudinaga, a Japanese scientist in the successful spawning of penaeid shrimp *Penaeus japonicus* under controlled conditions and their subsequent rearing up to the juvenile stage have paved way for the large-scale hatchery production of seed of penaeid shrimps for aquaculture in the world.

There are two basic hatchery techniques for mass rearing of larvae of penaeid shrimps namely Japanese techniques and Galveston technique. These techniques have been appropriately modified to suit different geographical and climatic conditions and different species of shrimps used for aquaculture. Thus, many gradations between these two techniques have been noticed in different parts of the world. Most of the hatcheries rely on Galveston method in modern world and sometimes combinations of these two techniques have also been used. Rectangular RCC make larval rearing tanks (Fig:1) are of common use in many countries with volume varying between 10-20MT.

Globally, shrimp hatchery performance is variable and strongly dependent on regional hatchery practices, species and prevailing disease pressure. Modern Penaeid hatcheries can routinely achieve good progression

from Nauplius to PL under optimal management, but survival rates vary widely among facilities (many report 40–80% under good practice, while outbreaks or poor management reduce survival dramatically). Major limiting factors include disease outbreaks (*Vibrio*-related vibriosis, AHPND etc.), inconsistent live-feed quality and uneven adoption of closed/zero-exchange systems and biosecurity measures.

In India, hatcheries that use rigorous broodstock screening, strict biosecurity and well managed live-feed and water systems report good survival and uniformity comparable to the best global hatcheries, but a significant fraction of small/medium hatcheries still struggle with disease, water-quality failures, and feed/nutrition gaps.

Shrimp larval progression consists of a distinct series of developmental stages viz., nauplius, protozoea (or zoea), mysis, and then metamorphose to the post larval (PL) stage. Each of these stages play a critical role in hatchery process and is characterized by unique morphological, nutritional, and environmental needs.

Nauplius stage (Fig: 2) is the first larval stage after

hatching out from the egg. It is a non-feeding and relies on yolk reserves within its body for nutrition. The body is unsegmented and somewhat pear-shaped, with three pairs of appendages. Nauplius stage has 5-6 sub stages lasting 1-1.5 days viz., N1, N2N5/N6 that undergoes several molts during this short stage before transform into protozoa. Protozoa (Zoea) stage (Fig: 3), lasting 4-5 days involves a more elongated body structure with a clear cephalothorax, thorax, and abdomen. This stage has three sub stages (Protozoa I, II, III), each marked by progressive development of structures such rostrum, compound eyes, and uropods. A functional digestive tract develops, and the transition from non-feeding to active feeding on microalgae occurs during this period. Protozoa transforms to Mysis stage (Fig: 4) that closely resemble shrimp but swim with their head downwards, the peculiar character. There are three Mysis substages (Mysis I, II & III) lasting for 4-5 days, with each defined by the development of pleopod buds into segmented pleopods. Feeding behavior shifts toward more omnivorous diets, including zooplankton (artemia nauplii or rotifers) in addition to microalgae. With this larval phase ends and metamorphosis takes place to become a miniature adult or Post Larva (Fig: 5).

Larval phase is critical in penaeid shrimp hatcheries because larvae undergo significant changes, requiring specific diets and water quality at each stage to survive and develop. Survival and growth during this planktonic period are heavily influenced by precise feeding and strict biosecurity to prevent disease, making it the most challenging and crucial stage for successful seed production.

Skill, responsibility and dedication of the technical team play a crucial role in hatcheries for successful completion

of the larval phase. Foreseeing of a technical person for the threats about to occur is always a thumb rule for the technical team.

Major drawbacks in larval progression

Disease and microbial outbreaks — *Vibrio* sp. and other opportunistic bacteria cause larval mortalities and slowed down development. AHPND and other bacterial syndromes remain serious threats. Inconsistent live feed quality — Poorly enriched artemia nauplii or collapsed microalgae cultures reduce essential fatty acids and micronutrients, causing stage retardation and low survival. Water quality instability — Rapid swings in DO, ammonia, nitrite, pH or temperature of larviculture water led to stress, poor molting and mortality. Inadequate biosecurity & hatchery hygiene — Cross-contamination between tanks, poor disinfection, and use of untreated water or infected broodstock transmit pathogens. Nutritional imbalances — Suboptimal diets during zoea-mysis-PL transitions impair stage progression, transformation and immune development.

Overview of interventions in addressing the issues

Strict biosecurity & documentation - Broodstock screening, quarantine, cleaning/disinfection protocols, records of tank mortality and treatments have to maintain. Improving water management- Stable DO, temp, salinity and low ammonia/nitrite to be maintained. Gentle aeration and controlled water exchanges are to be adapted. Zero/limited-exchange systems (biofloc where appropriate) can be followed. Live-feed protocols - Standard microalgae production without any contamination, Artemia nauplii enrichment with essential lipids and vitamins, ensure age/size-appropriate feeds. Disease surveillance & rapid response - Routine microbial monitoring (bacterial counts, *Vibrio* screening), PCR for high-risk pathogens, and rapid removal/isolation of affected tanks is mandatory. Nutrition & feed development – Usage of micro encapsulated and micro particulated larval diets along with artemia nauplii helps improving nutrition of larvae.

Larval nutrition and balanced diet for successful larval progression

Nauplius—Rely on yolk;
Zoea- Require microalgae + enriched artemia (or live zooplankton) that supply essential fatty acids (DHA/EPA), sterols, phospholipids and



Figure 1: View of Larval Rearing Unit in a Penaeid Hatchery



Figure 2: Penaeid Nauplius larva

vitamins (A, C, E, B complex).

Mysis- Increasing protein and digestible lipids, careful provision of micro bound or micro diet particles that can ingest. High quality sources of phospholipids and astaxanthin (for molt and stress resistance) help. Well-balanced amino acid profiles (including arginine and methionine) are beneficial. Evidence shows enriched artemia nauplii along with micro-diets will significantly improve metamorphosis.

Effect of nutrition in larval progression

Metamorphosis and molting - Essential lipids (DHA/EPA, phospholipids) and sterols are crucial for successful molts and stage transitions. Deficiencies cause stage retardation (e.g., delayed zoea→mysis). Survival and growth - Adequate micro- and macronutrients reduce mortality and improve size uniformity. Immune competence - Vitamins, antioxidants (vit E, C) and



Figure 3: Penaeid Zoea larva

certain fatty acids support early immune responses, reducing susceptibility to opportunistic infections. Poor nutrition amplifies disease risk and worsens outcomes during bacterial challenges.

Larval syndromes

Zoea-2 syndrome: Is an acute syndrome seen in Penaeid hatcheries, characterized by reduced feeding at the Z2 stage, impaired stage transformation and high mortality. Outbreaks are associated with environmental stress and opportunistic pathogens. White Feces Syndrome (WFS) Is a multi-factorial gastro-intestinal disorder linked to *Enterocytozoon hepatopenaei* (EHP) and opportunistic bacteria causes reduced feed intake, hepatopancreas discoloration, poor growth and elevated mortalities. WFS tends to appear later but can be seeded from hatcheries into grow-out. AHPND - Acute Hepato Pancreatic Necrosis Disease caused by Pir AB toxin-



Figure 4: Penaeid Mysis larva



Figure 5: Penaeid Post larva

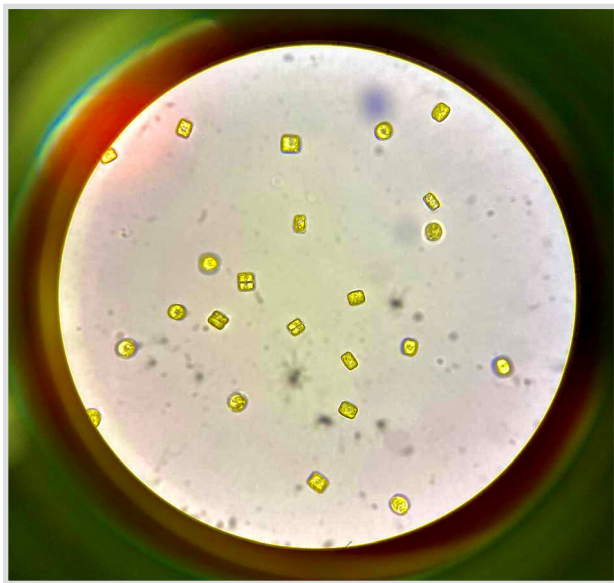


Figure 6: Algal cells

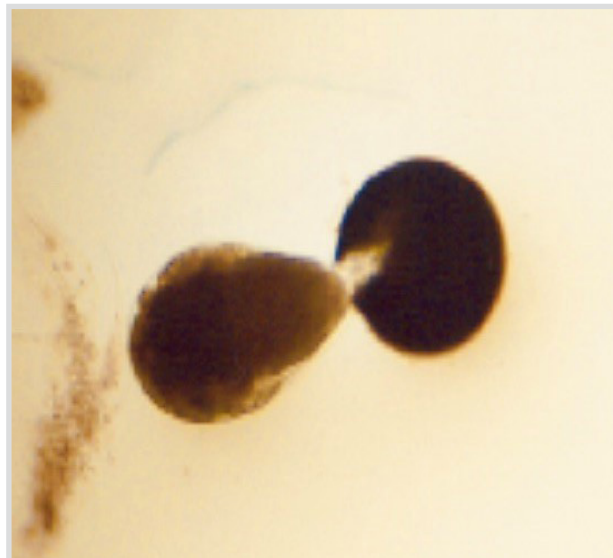


Figure 7: Artemia nauplii

producing *Vibrio*. Rapid mortalities and pale/empty hepatopancreas. AHPND has severely impacted hatchery and farm productivity in several regions.

Precautions to be taken to address syndromes

Source control-Usage of SPF/PS/healthy broodstock, screening broodstock for known pathogens. Preventive biosecurity - Disinfection of seawater intake, UV or ozone treatment wherever feasible, strict zone separation (quarantine / broodstock / larval rooms) are mandatory. Live-feed hygiene - Production of microalgae (Fig: 6) and artemia nauplii (Fig: 7) in controlled systems. Enrichment of artemia nauplii helps in improving nutrition. Early surveillance - Routine PCR/diagnostics for AHPND, EHP and *Vibrio* spp., and daily observation for behavioural/feeding changes (e.g., reduced feeding in Z2) etc., is mandatory. Rapid isolation and disinfection of affected tanks is critical. Nutritional buffering - Usage of stress-reducing supplements (antioxidants, immunostimulants) during known stress windows (e.g., stage transitions, Shifting and Transportation) are key factors for success.

Water management for larval progression

Temperature - Optimal range 30–33°C. Dissolved oxygen (DO) - >6 mg·L⁻¹ in hatchery tanks with adequate, gentle aeration to avoid shear stress. Salinity- 28–35 ppt. Ammonia & nitrite - <0.1ppm. PH - 7.5 to 8.5. Alkalinity -120 to140 ppm.

Quality of water is the heart of the hatchery system and it influences larval progression directly. Ultra filtered or well disinfected sea water to be used in larval rearing. Further the supply water to be analysed microbiologically on routine basis to safeguard the larval rearing system from pathogens. Also, the source sea water drawn from sub-soil or open filter bed laid in the tidal zone of the ocean to be thoroughly monitored for chemistry changes time to time and accordingly amendments to be made in

larval rearing.

Biosecurity in larviculture

Facility zoning and controlled access - Maintaining separate entry and exit zones, use of footbaths, PPE, and entry logs to be mandated. Water treatment - Process of Pre-filtration, sand filters, UV/ozone or chlorination (with dechlorination), and sedimentation to be followed strictly to reduce incoming pathogen load. Disinfection protocols - Validated disinfectants and contact times for tanks, nets, equipment and transport containers to be strictly adhered to. Feed & live-feed control - Protocols to be standardised for production, enrichment and testing of microalgae and artemia. Surveillance & record keeping - Documentation to be followed regarding mortalities, feed intake, growth, water quality and any interventions and routine microbial and pathogen screening (bacterial counts, targeted PCR). Personnel training & SOPs - SOPs to be formulated for all critical operations and regular.

Summary

Larval progression in penaeid shrimp hatchery is a tightly coupled outcome of nutrition, water quality, microbial management and biosecurity. Improving hatchery success requires integrated action i.e., standardized and enriched live-feeds or validated micro-diets, stable water chemistry and aeration, routine pathogen surveillance and immediate containment, and strict biosecurity with good record-keeping. Addressing these elements reduces the incidence of larval syndromes (zoea-2, WFS, AHPND), improves PL quality and increases downstream farm productivity.





Prof. Ioannis T. Karapanagiotidis

Department of Ichthyology & Aquatic Environment, University of Thessaly, Greece

ikarapan@uth.gr



Fish nutrition as a pillar for the sustainable development of future aquaculture

Today, one of the greatest challenges that the global community faces is the need to produce more food to feed an ever-growing human population. However, this must be achieved without degrading the natural environment or depleting its resources.

To this challenge, the aquaculture industry plays a very important role by providing food, and indeed of high nutritional value. World aquaculture annual production reached a new record of 94.4 million tonnes of aquatic animals (FAO 2024), constituting one of the fastest growing food production sectors worldwide and thus contributing to the growing demand for fish and the food security of the global community. Given the stagnation of fisheries production, aquaculture gradually becomes the main supplier of fish products for humans, and thus its contribution to food security is steadily increasing. Future aquaculture needs to produce more fish to meet the growing demand, but this must be achieved by a lower environmental impact. Thus, the sector should continue to

seek and adopt even more responsible practices.

As aquaculture is constantly developing and getting intensified, so does the demand for industrially compound aquafeeds. Today, it is estimated that approximately 55 million tonnes of compound aquafeeds are produced annually (Alltech 2024) and it is predicted that their demand will continue at a high rate in the coming years. The further development of the sector, therefore, will require additional quantities of aquafeeds, and this in turn will require additional quantities of feedstuffs. Until the mid-2000s, fishmeals and fish oils derived from natural fish stocks were the main sources of protein and lipids, respectively, in aquafeeds, especially for carnivorous fish species. The realization that these natural resources are finite, together with their increasing demand and market prices forced the sector to search for alternative feedstuffs that are nutritionally adequate, more economical, widely available and of lower environmental footprint. However, the use of many



of these feedstuffs poses several challenges that must be overcome, such as their nutritional composition not fully matching the dietary requirements of fish, the low scale of their production, their high market price, their unstable quality, the lack of a regulatory framework, and their low acceptability by producers/consumers among others.

Obviously, the most important mitigation is to ensure that fishmeals and fish oils used in aquafeeds come from legal, recorded and regulated fisheries. Today, there is an increasing use of such products, the origin and production of which is certified through various organizations and processes (e.g. Marine Stewardship Council, IFFO RS Global Standard for Responsible Supply, MarineTrust, ASC Feed Standard etc.) in compliance with the FAO Code of Conduct for Responsible Fisheries. At the same time, fishmeals and fish oils sourced from fish and crustacean by-products (derived from the processing of either caught or farmed species) represent an ever-increasing share (34% of fishmeals and 53% of fish oils) of the total fishmeal/fish oil global production, thus reducing wastes and improving the utilization of natural resources (FAO 2024). It is estimated that the quantities of natural fish stocks used for the supply of fishmeals and fish oils have declined to 17 million tonnes from 35 million tonnes back in 1994 (FAO 2024). It should be noted, however, that fish by-products have a lower content of proteins, omega-3 fatty acids and vitamins compared to products obtained from whole fish. Fish protein hydrolysates (FPH) that are produced primarily through enzymatic or chemical hydrolysis of fish by-products are considered a much better option as they are known for their very high palatability and digestibility, bioactivity and functional properties (Bhati & Hayes 2025) and therefore aquaculture sector should further explore their full potential.

Oilseed meals and oils (e.g. soybean, rapeseed, sunflower etc.) were the first alternatives that were used, and today they constitute the main sources of proteins and lipids in aquafeeds, especially for those targeted at grow-out stages, due to their nutritional suitability, ready availability and cheaper price. Thanks to new processing technologies, plant protein concentrates and grain gluten products are now more widely available having a higher nutritional value and improved efficiency than their unprocessed forms. However, the further contribution of plant meals and oils to aquafeeds is limited by their deficiency in specific nutrients (e.g. essential amino acids

such as methionine and lysine) and the presence of anti-nutritional factors (ANFs, such as protease inhibitors, phytic acid, saponins etc.) that reduce their acceptability and digestibility when included at high levels in diets. In addition, their production may have a high environmental footprint, raising concerns about the sustainability of land and water use for their crops (Glencross et al. 2023). In this context, using locally produced feedstuffs may be advantageous for aquaculture as it could lower the costs and emissions of greenhouse gases due to reduced transportation, offer greater control over quality and customization, enhance sustainability through reduced reliance on imported feedstuffs, and offer social benefits by increasing local farmer income.

The use of terrestrial animal by-products derived from monogastric animals, such as poultry byproduct meals meat and bone meals, blood meals, feather meals etc. has been sparked especially after their re-introduction to the European aquafeed chain (EC 56/2013). These feedstuffs generally have a better nutritional value and digestibility compared to plant meals, but still have lower levels of methionine, lysine and threonine compared to fishmeals. Although initially the European aquaculture sector was hesitant in their use due to their past association with bovine spongiform encephalopathy disease, ultimately these raw materials have proven to be safe and efficient sources of protein. Therefore, it is worth further investigating the maximum efficient levels of their inclusion in modern aquafeeds. Their use in aquafeeds contributes to the circular economy and nutrient recycling, thus reducing the environmental footprint of aquaculture (Karapanagiotidis et al. 2019). In this context, an increased production and use of locally produced terrestrial animal by-products could also yield the benefits mentioned earlier. Thus, aquaculture should further strengthen its links with the terrestrial animal sector.

In the last decade, insect proteins (insect meals) have dominated in attracting research and investment interest worldwide because they can be used both as high-quality proteins and as sustainably produced foods and animal feeds. Their environmental footprint is considered low due to the limited land area required, water quantities and lower greenhouse gas emissions compared to other produced feedstuffs (Van Huis & Oonincx 2017). Also, their ability to convert organic wastes, such as discarded fruits and vegetables, into animal protein contributes to a circular economy approach that fits well with many sustainable development goals. From a nutritional point of view, insect meals can contribute to highly digestible and good amino acid profile proteins, although deficient, with some exceptions, in methionine and lysine (Henry et al. 2015). However, beyond their suitability as protein sources, insect meals can also contribute to fish health enhancement as their immunostimulating and antimicrobial properties have been demonstrated (Gasco et al. 2021). As insects are becoming the planet's new farmed animal and the institutional framework for their integration into the human food chain progresses, the industry is growing rapidly. It is currently estimated that approximately 60,000 tonnes of insect products are produced annually and that this production will be further increased in future (IPIFF 2025). The use of insect meals produced from 7 insect species has been permitted in European aquafeeds (EC 893/2017), with meals from the species *Hermetia illucens*

and *Tenebrio molitor* being more readily available on the market. Worldwide, however, there are hundreds of species that are used as food/feed for humans/farmed animals and could potentially be allowed in future for use in European aquafeeds if their suitability in diets is proven, such as *Zophobas morio* (Asimaki et al. 2025) and *Ceratitidis capitata* (CIPROMED Project). Today the aquafeed industry remains hesitant to use insect meals mainly due to their considerably higher price (3000-5000 €/t) compared to fishmeals, but also due to the concerns raised using such “unconventional” raw materials. It is therefore necessary to scale up the production and availability of insect meals, through the development of optimal insect breeding and feeding protocols, the stabilization of their quality, the reduction of their market prices, the further investigation of their suitability in fish diets, the modernization of their institutional framework, as well as better informing producers/consumers in order the aquafeed industry to fully utilize these sustainable raw materials.

Microalgae also constitute very promising aquafeed raw materials, both as sources of single-cell proteins (as dehydrated biomasses), but mainly as rich sources of EPA and DHA fatty acids (as dehydrated biomasses and microalgal oils). Their diverse cultivation in inland/brackish/marine waters, in open and closed bioreactors and in photosynthetic/heterotrophic/mixotrophic systems is known to possess many features of sustainable production (Nagappan et al., 2021) and thus their use in aquafeeds enhances the environmental sustainability of aquaculture. Depending on the species and culture conditions, microalgae can contribute a high level of proteins (up to 70%) with a balanced amino acid profile with substantial amounts of methionine and lysine in some species, and at the same time are rich in antioxidants, pigments and various bioactive compounds with immunostimulating and anti-inflammatory properties. The majority of studies that have been conducted mainly in the last decade agree that the use of microalgae biomasses in aquafeeds supports or even improves the growth performance, immune response and quality of edible fish flesh (Nagappan et al., 2021; Karapanagiotidis et al. 2022). Currently, the cost-effectiveness of microalgae in aquafeeds is currently a challenge due to high production costs, but it has the potential to become cost-competitive as production scales up and technology improves.

The use of macroalgae (e.g. *Laminaria*, *Gracilaria*, *Ulva* spp.) (Hossain et al., 2019) fits better to the nutrition of omnivorous farmed species due to their low protein and high carbohydrate contents. As far as carnivorous species are concerned, the use of macroalgae meals lies more in their application as functional additives to improve health/well-being rather than as main alternative protein sources. Any usefulness would only make sense as cost-effective protein concentrates, but at present such products are only available at a research level. This extensive list of suitable and sustainable alternative to fishmeal proteins includes various unicellular proteins, such as bacteria, fungi and yeast (Wang et al. 2017; Agboola et al. 2021), which are products of high nutritional value and can be produced through waste biodegradation systems (Ledbetter, 2025). However, for these products to become widely available and affordable for aquafeeds, progress in their

biotechnology and, of course, the legalization of their use is required.

Substituting fish oils in aquafeeds is more challenging since EPA and DHA fatty acids that are essential for fish nutrition are difficult to find in nature. Oils from certain microalgae species appear to be the only reliable alternative due to their high EPA-DHA content. Studies show that they can completely replace fish oils in fish feeds and at the same time enhance the lipid value of farmed fish (Karapanagiotidis et al. 2022; Ma & Hu 2024). However, today there is a limited number of commercially available products, available in limited quantities and at high prices. As mentioned earlier, several challenges need to be overcome to make these products widely available and affordable for aquafeeds. Other emerging alternative sources of EPA-DHA that are already commercially available are genetically modified vegetable oils of camelina and rapeseed oil but their application still raises concerns, zooplankton krill oil (*Euphausia superba*) which has a high price, and also the biomass of the yeast *Yarrowia lipolytica* which is available in limited quantities.

In conclusion, the use of various alternative raw materials today has led to more complex dietary formulations that now include a greater number of protein and oil sources that complement each other to create a balanced diet for supporting high growth performance and health/well-being of farmed fish.

This variety of suitable raw materials offers flexibility in formulations and greater resilience to price and quantity fluctuations in the supply chain. On the other hand, it creates the need to incorporate various additional ingredients to supplement specific essential nutrients such as amino acids, fatty acids, vitamins, as well as bioactive compounds, probiotics, prebiotics, immunostimulants, etc. As aquaculture develops and intensifies, it will need even greater quantities of aquafeed raw materials that are nutritionally appropriate, environmentally sustainable and cost-effective. The industry, therefore, should not only intensify its efforts to find innovative raw materials, but also encourage and collaborate in efforts to produce them.

At the same time, we should gain better knowledge about the nutritional requirements of farmed species, which will allow us to formulate more efficient aquafeeds. The industry should further expand its knowledge of nutritional requirements at all growth stages, both of those already being farmed as well as of “new” species, in order to ensure optimal biomass production



and better utilization of feed. The need for a “precision nutrition” approach based not only on the growth stage of fish, but also on the genotype, environmental conditions, immune status, etc. is already being discussed in international forums. Also, the production of numerous and high-quality fish larvae requires the development of improved micro diets and broodstock feeds. At the same time, the sustainability of aquaculture should be based on practices aimed at more efficient feeding of farmed fish in order to limit feed and nutrient losses and reduce the environmental impact. There is room for improvement in feed management practices, mainly through the implementation of more rational feeding levels and balancing the production indicators FCR and SGR, better training and rewarding of staff, as well as modernization and automation of feeding equipment and underwater monitoring of fish populations. Furthermore, the industry must explore how modern technological tools, such as big data modeling, the Internet of Things, and artificial intelligence could benefit it.

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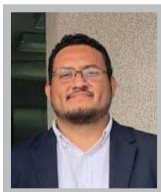
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Eng. Pedro García Hinostro
Research Professor. Experimental aquaculture laboratory,
Instituto Tecnológico de Guaymas (ITG), México.
pedro.gh@guaymas.tecm.mx

"...oyster farming can become a powerful tool for achieving food sovereignty and contributing meaningfully to global sustainable development goals".



Oyster farming: A sustainable alternative for the social sector of aquaculture

Introduction

With a growing population demanding food, there are major challenges to achieving the goal of a world without hunger. Climate change, loss of pollinators, drought, pollution, desertification, reduction of agricultural land, and increased land costs, among others, seem to make the task of feeding 10 billion people by 2050 almost impossible (Bajželj et al., 2014). In the face of these adversities, it is necessary to seek sustainable alternatives for food production. This is where aquaculture, and specifically oyster farming, plays a key role in the production of high-quality protein with a low environmental impact.

Global overview

Worldwide, 88 species of mollusks are cultivated, representing a volume of 17.8 million tons; most of which are bivalves, 11.2 million tons (FAO, 2022). Among oysters, there are around 15 species cultivated commercially worldwide. China, Korea, and Japan are leaders in oyster aquaculture production, with China being the largest producer with a volume of 4.9 MT; *Crassostrea gigas* is the most widely produced species in the world in around 60 countries (Davis, et al. 2021). In terms of volume, *C. angulata*, *C. gigas*, and *C.*

hongkongniensis lead global production (FAO, 2017).

General information on Oyster farming

Farming methods can be summarized into two categories:

-Extensive (direct farming on the seabed): based on the natural settlement of larvae on the seabed, sometimes supplemented with laboratory seeds. There is no protection from predators and little control over farming densities. The advantages are low production and maintenance costs and low labor and input costs.

Intensive: special equipment is used for the growth and containment of the organisms. The investment in equipment is more expensive, but there is better control of growth and predators, intensive methods require a higher initial investment than extensive methods, but they have the advantages of being able to control growth, predators, and the selection of genetically improved seed (polyploidy).

Off-bottom methods:

Oysters are kept in the water column using floating structures, ropes, or suspended cages. This is a common technique in areas with good water circulation and high

natural productivity.

Among the most commonly used variants are:

Long-line: this consists of a floating line held by buoys and anchored at the ends. The oysters are placed on the line in boxes or any other object that can serve as a container (bags, sacks, nestier boxes, etc.), and a float (bags, sacks, nestier boxes, etc.) is attached to them. The line is left at the mercy of the tides.

Bags on tables or racks: a table-like structure is placed on the bottom (usually made of metal, but any material can be used) and the oysters are placed on top of the structure.

Japanese lanterns: cylindrical bags filled with oysters are hung on a floating wooden structure or on a longline.

Cultivation using stakes

This consists of placing stakes or sticks in the intertidal zone, where the larvae naturally attach themselves. It is a traditional technique, popular in Asia and some regions of Latin America. Although it is efficient for capturing natural seed, it requires labor and specific environmental conditions.

Use of recycled materials

Recycled materials can be used in different cultivation systems to reduce investment costs. Among the most commonly used are: vegetable crates, PET bottles used as buoys, vegetable sacks, used 20-liter containers, among others.

Social benefits:

- Oyster farming provides a strategic alternative in areas where fishing is affected by overexploitation and seasonality, contributing to the well-being of coastal communities.

- It can generate jobs and income directly in communities, diversify the economy, and Foster social cohesion among people associated with the sea who have abandoned fishing due to low catches. In addition, oyster farming is an inclusive activity in which people of all ages participate and promotes community participation and gender equality. Many oyster farming groups around the world are led by women.

- Oyster farming has proven to be a driver of social inclusion, especially for women and vulnerable groups. In various communities, women lead the production and marketing of the product, which strengthens their economic autonomy and their participation in family and community decision-making (Diop *et al.*, 2022). Likewise, the development of this activity is associated with improvements in working conditions, access to services, and strengthening of the local social fabric (Naylor *et al.*, 2024).

In addition to the above benefits, oyster farming represents an opportunity for low-income groups who do not have access to income to purchase land. In many countries, concessions are granted for the use of bodies of water for oyster farming.

Environmental benefits

Oyster farming does not require water pumping, which minimizes the use of electricity and the installation of electrical infrastructure. The structures used in farming have a very low impact viz. removable floating structures.

The use of fresh water is minimal, only for cleaning tasks.

No formulated feed is used: Oysters require no formulated feed; as natural filter feeders, they obtain nutrition directly from their environment without affecting aquaculture feed production. As a result, they do not introduce additional nitrogen or phosphorus into cultivation waters and therefore do not contribute to eutrophication. In fact, oyster farms can serve as a valuable management tool in regions facing marine eutrophication challenges.

Carbon sink: as organisms with calcium shells, they are a natural CO₂ sink. Several studies have evaluated the role of oyster farming as a tool for mitigating climate change (Nakayama *et al.*, (2022), Sun *et al.*, (2025), Feng & Yan, (2023)). Chen *et al.*, (2025) demonstrated that oyster farming sequesters 2.39 times more organic carbon than that captured in shells.

Function as an artificial reef: farming structures such as oyster cages act like artificial reefs, creating a diverse ecosystem, supporting biodiversity in the near vicinity while promoting the reproduction of organisms (Tallman & Forrester, 2007).

Integration into IMTA: Oyster farming systems are adaptable and are an essential part of IMTA (integrated multitrophic aquaculture) in reducing nutrients produced in marine fish farming in cages thereby enhancing sustainability (Quental-Ferreira *et al.*, 2019).

Challenges of oyster farming

- **Pollution:** Oyster farming waters are often impacted by human activities. Wastewater contamination can compromise oyster quality to the point of making cultivation unviable—for example, through pathogens such as norovirus. In addition, water and seabed pollution from heavy metals can bioaccumulate in oysters, posing serious risks to human health when consumed. For these reasons, oyster farming

should only be carried out in certified, uncontaminated

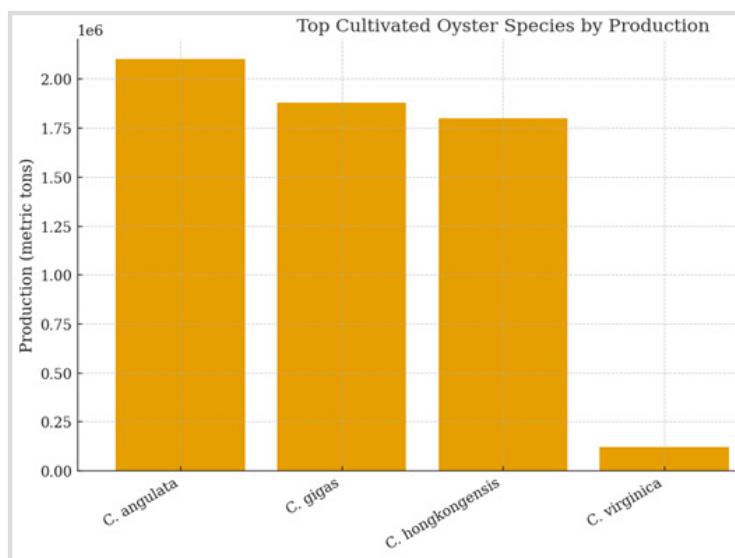


Figure 1.- Main species of oysters produced worldwide.



Figure 2.-Extensive cultivation. Courtesy of COPEMBL A.C.

waters

Ocean acidification: Acidification due to excess CO₂ emissions threatens oyster farming worldwide. Studies show that it affects the fertility, survival, and larval quality of oysters (Boulais *et al.*, 2017). Impacts have been reported in *Crassostrea gigas*, mentioning that exposure to elevated CO₂ and reduced pH altered acid-base regulation, increased the energy cost for maintenance, and reduced tolerance to thermal stress (Lannig *et al.*, 2010).

Given this threat, it is increasingly important to adopt endemic species and diversify oyster production worldwide, rather than relying on exotic species that are less resistant to local conditions.

Harmful algal blooms (HABs): the increase in HABs threatens the oyster industry in different ways: causing the death of oysters by suffocation, contaminating oysters and making them unfit for consumption, reducing growth, and affecting the economy of producers (Rolton *et al.*, 2022, Shumway, 1990).

Pathogens: There are various pathogens that cause mass mortality in oyster farms, some of which are associated with and benefit from rising sea temperatures. The main ones include:

Perkinsus, *vibrio*, *herpesvirus*, among others. The following table provides a summary of the pathogens and their implications (there are others, but this is not



Fig. 3 - Long-line cultivation system in Sinaloa, Mexico. Courtesy of Copembi A.C.

intended to be an exhaustive summary).

Seed availability: The availability of seeds for planting is limited in some areas. In my experience in Mexico, there are few laboratories that produce them, which causes widespread shortages that affect producers. Some laboratories only buy D larvae to fix and sell them; they do not produce them, but import them from countries such as Chile and the USA, which can also introduce biosecurity hazards. It is also necessary to produce endemic species that are adapted to local environmental conditions. For example, in northern Mexico, *C. gigas* can only be cultivated from October to May due to favorable temperate climatic conditions and cannot be produced year-round due to poor heat stress adaptability.

Government support: No activity can thrive without a strong public policy framework to guide and promote it. Active government participation is essential to establish programs that encourage oyster consumption, strengthen production, support the organization of social groups, and ensure effective aquaculture management. Social organization: To successfully engage in oyster farming, communities must organize themselves into cooperatives. Although the activity offers many benefits, there remains limited awareness among the population of its potential as a sustainable and dignified livelihood.

Social organization and education: To participate effectively in oyster farming, communities must organize themselves into cooperatives. While this approach offers many benefits, public awareness of its potential as a sustainable and dignified livelihood remains limited. Therefore, both government support and educational initiatives that highlight the advantages of oyster farming are essential to encourage broader adoption and participation.

Conclusions: Oyster farming stands out as one of the aquaculture activities most closely aligned with the principles of sustainable development. It combines low environmental impact with the ability to act as a natural CO₂ sink, while simultaneously creating employment opportunities in vulnerable coastal communities. Moreover, its accessibility makes it a viable livelihood option for low-income groups. To fully realize this potential, strong government support and regulatory frameworks are essential, alongside efforts to diversify



Fig. 4. Nestier boxes in long line farming. Courtesy of Instituto Tecnológico de Guaymas (ITG).



Fig- 5 Oyster bags in a long-line culture. Courtesy of Santa Maria Seafood Farming.

and expand the production of endemic seed varieties that can thrive in local climates and enable year-round cultivation. By advancing these measures, oyster farming can become a powerful tool for achieving food sovereignty and contributing meaningfully to global sustainable development goals

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Fig. 6 - Cultivation in a bed system in Sinaloa, Mexico. Courtesy of COPEMBI A.C.



Fig. 7-Japanese lanterns on a longline. Source: <https://www.caiqz.shop/>

Table 1. Common pathogens in oyster farming

Causal agent	Symptoms	Affected species	Reference
<i>Perkinsus marinus</i>	High mortality, weight loss, lethargy	<i>Ostrea y Crassostrea spp.</i>	Ford, S. E., & Chintala, (2006)
<i>Haplosporidium nelsoni</i>	Tissue damage, high mortality	<i>Crassostrea virginica</i>	Haskin <i>et al.</i> , (1966)
<i>virus OsHV-1(oyster herpesvirus)</i>	High mortality in juveniles, tissue necrosis	<i>Crassostrea gigas</i>	Renault & Novoa (2004)
<i>vibrio spp.</i>	Green lesions, mortality in juveniles	<i>crassostrea gigas</i>	Garnier <i>et al.</i> , (2007)

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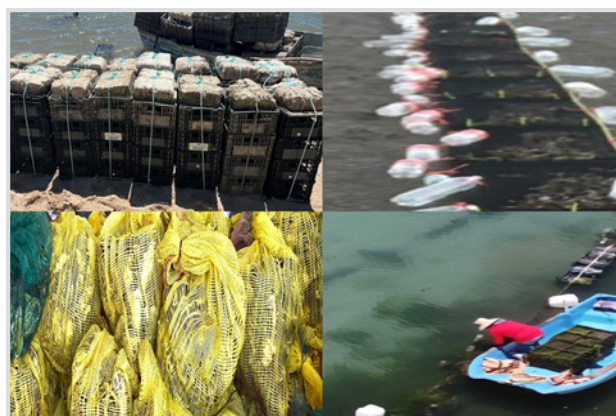


Fig. 9 Recycled materials used in *C. gigas* culture in México, a) vegetables boxes to long-line, b) pet bottles as bouys, c) vegetables bags and d) Gallons used as buoys. Courtesy of ITG and Copembi.



Fig. 10-Women in oyster farming. a) Ahome, Sinaloa, Mexico. Courtesy of Copembi A.C. b) Guaymas, Sonora, Mexico. Courtesy of ITG.

Organic Acids Plus (with Binder)

Technical Data Sheet

INSUAQUA (AQUACULTURE SUPPLIES S.A.) SUSTAINABLE ECOLOGICAL AQUACULTURE Trusted Inputs. Unsurpassed Quality

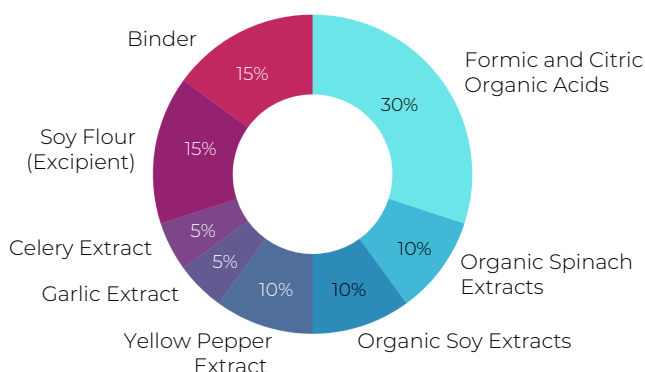
Trusted Inputs.
Unsurpassed Quality.



Organic Acids Plus (with Binder)

Description. It is composed of a combination of organic formic and citric acids. These include the most common, which are carboxylic acids, whose acidity is associated with their carboxyl group (-COOH), and sulfonic acids, which contain the -SO₂OH group, which are relatively stronger acids. Organic Acids Plus can control bacterial proliferation, optimize digestion and absorption processes, and therefore improve the performance of cultured animals.

Composition.



Application

It is recommended to use Organic Acids Plus before problems appear in the culture units. When disease or survival problems are detected, Organic Acids Plus can be used in combination with the bioremediator of your choice.

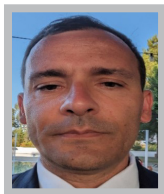
The recommended dose is 3-5 grams per kg of feed. To calculate the necessary amount, first determine the daily feed ration to be supplied, and then the dose of Organic Acids Plus. No additional binder (agglomerant) is needed, as the product already comes with its own.

Benefits of Use

1. It is used as an alternative to antibiotics, as it inhibits the presence of pathogens in the gastrointestinal tract of cultured animals.
2. It presents no contraindications or generates resistance.
3. It has no residual effect that affects traceability.
4. It helps to strengthen the immune system of cultured animals, improving survival.
5. It improves the nutrition and digestive process of cultured animals, which leads to a better feed conversion ratio.

Presentation and Storage

- 20 Kg buckets
- Store in a cool, dry place, under a roof, protected from sun and rain.
- 2 years from the date of manufacture.



Dr. Rui A. Goncalves
PhD in Aquaculture
Expert in Mycotoxin Management
ralexandr3@gmail.com



The Impact of Mycotoxins in Aquaculture: Risks, Realities, and Management Solutions

Aquaculture's Changing Landscape and the Mycotoxin Challenge

Aquaculture is the fastest-growing sector of animal protein production globally, providing a vital source of food and income for millions. As the industry has expanded, so too has the need for sustainable, cost-effective feed solutions. Traditionally, fish meal and fish oil—derived from wild-caught marine species—were the primary protein and lipid sources in aquafeeds. However, concerns over the sustainability and cost of marine ingredients have driven a shift towards plant-based meals, such as soybean, wheat, corn gluten, and rice bran.

While this transition supports environmental and economic goals, it has introduced new challenges. Plant-based ingredients are more susceptible to contamination by mycotoxins—naturally occurring toxic compounds produced by fungi, especially *Fusarium*, *Aspergillus*, and *Penicillium* species. These mycotoxins can enter the feed supply chain at multiple points: during crop growth in the field, post-harvest handling, processing, and storage.

The diversity of farmed aquatic species, each with unique nutritional requirements and varying sensitivities to mycotoxins, further complicates feed formulation. Unlike terrestrial livestock, where regulatory limits for

mycotoxins are well established, aquaculture operates in a legislative vacuum. Most countries lack specific guidelines for mycotoxin levels in aquafeeds, leaving farmers and feed producers to navigate these risks with limited official guidance.

Mycotoxin Occurrence in Aquaculture Feeds

The occurrence of mycotoxins in aquaculture feeds is a growing concern, particularly as the industry increases its reliance on plant-based ingredients. According to Lorusso et al. (2025), a comprehensive survey of aquafeeds and feed ingredients across multiple continents revealed that mycotoxin contamination is both widespread and complex.

The MDPI study found that 94% of aquafeed samples contained at least one mycotoxin, and 80% contained two or more. The most frequently detected mycotoxins were deoxynivalenol (DON), fumonisins (FUM), and zearalenone (ZEN), all primarily produced by *Fusarium* species. Concentration levels of DON often exceeded 500 µg/kg, and fumonisins sometimes surpassed 1,000 µg/kg. Co-occurrence of multiple mycotoxins is common, raising the risk of additive or synergistic toxic effects.

Plant-based ingredients such as maize, wheat, soybean



Mycotoxin prevalence in crops such as soybean, wheat, corn, and rice crops can cause adverse effects in aquatic animals reducing productivity and compromising health and welfare

meal, and by-products like DDGS and corn gluten meal are the main contributors to contamination. This contamination is primarily field-derived, with storage playing a secondary role for aflatoxins and ochratoxin A. Regional differences in contamination patterns reflect variations in climate and agricultural practices, underscoring the need for tailored management strategies.

The Impact of Mycotoxins on Aquatic Species

The adverse effects of mycotoxins on aquatic species have been documented in several studies, including those authored by Rui Gonçalves and colleagues. Controlled feeding trials with *Litopenaeus vannamei* demonstrated that even low doses of DON (0.5 ppm) and FUM (0.6 ppm) can cause significant reductions in final body weight, specific growth rate, and feed conversion ratio. The combination of DON and FUM had a synergistic effect, resulting in a 15% decrease in body weight, 24% decrease in growth rate, and 88% increase in feed conversion ratio compared to controls.

Other studies confirm that rainbow trout, carp, tilapia, and other farmed fish are also sensitive to DON, FUM, and ZEN at levels commonly found in commercial feeds. Effects include reduced feed intake, impaired nutrient utilisation, immunosuppression, and increased susceptibility to disease. Mechanisms of toxicity vary: DON inhibits protein synthesis, FUM disrupts sphingolipid metabolism, and ZEN interferes with reproductive function. Co-occurrence of multiple mycotoxins amplifies these negative outcomes, even when individual concentrations are below established thresholds.

raw materials from reputable suppliers and implementing regular monitoring of both ingredients and finished feeds. Proper storage conditions—dry, ventilated, and protected from pests—are essential to prevent additional contamination. Mold inhibitors can help reduce storage-related mycotoxin formation, but they do not eliminate field-derived toxins.

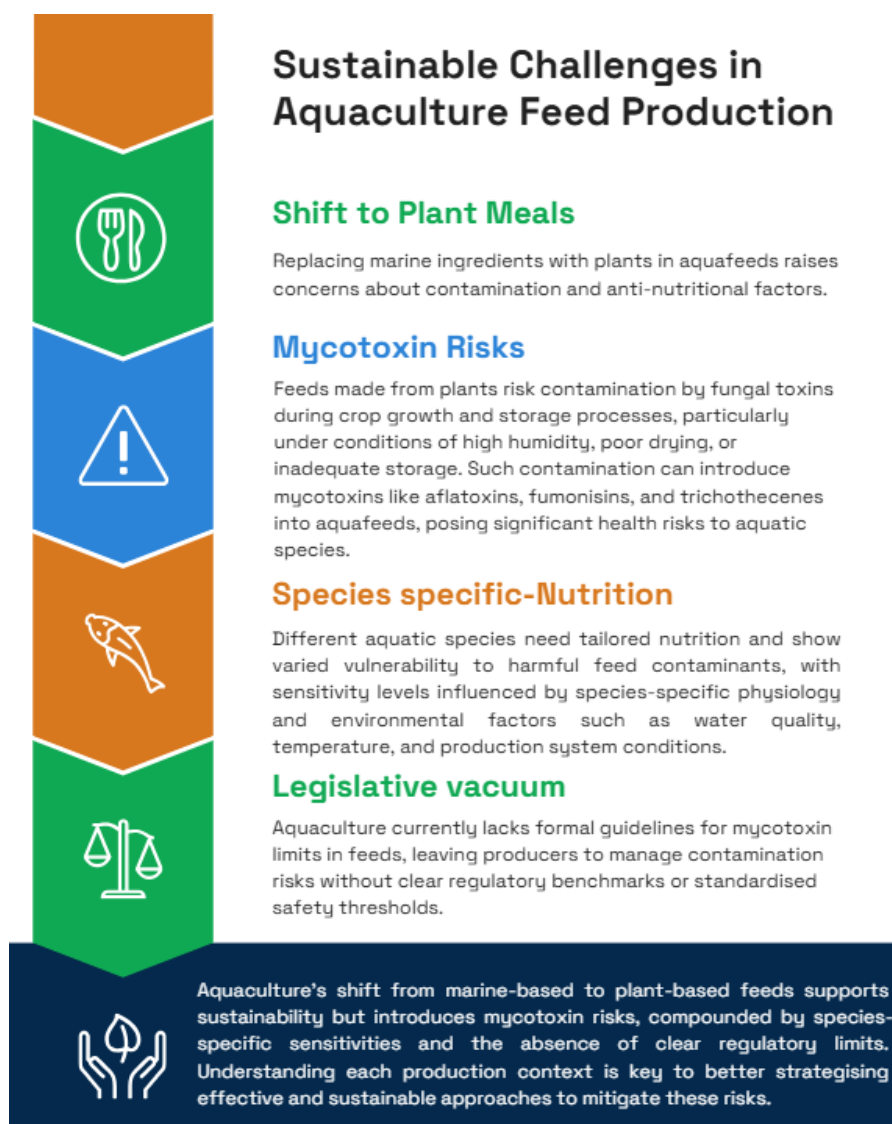
Maintaining optimal conditions during feed production, transportation, and farm storage is critical. Finished feeds should be kept in clean, dry environments, and stock rotation should be practised. Education of farm staff on the risks and signs of mycotoxin contamination is also vital for early detection and intervention.

Binders Technology: Types, Mechanisms, and Efficacy

Binders, or mycotoxin adsorbents, are commonly used to reduce the bioavailability of mycotoxins in the gastrointestinal tract. Clay minerals such as bentonite and montmorillonite are widely used due to their layered structure and high surface area, which enable effective adsorption of aflatoxins. However, their efficacy against *Fusarium* mycotoxins like DON and ZEN is limited because these toxins have molecular structures that do not favor strong binding. When it comes to binders, it is crucial to distinguish between those commercialized for technological purposes (e.g., enhancing formulation physical properties) and those intended for mycotoxin adsorption. While commercial or even technical denominations may appear similar, it is essential to understand whether these adsorbents have been characterized for mycotoxin binding and to assess their potential to carry harmful compounds such as pesticides or heavy metals. The properties of clay minerals reflect the region where they were harvested, meaning their name alone provides no guarantee of

Mycotoxin Management: Good Practices in Ingredient Selection and Feed Handling

Effective mycotoxin management begins with sourcing



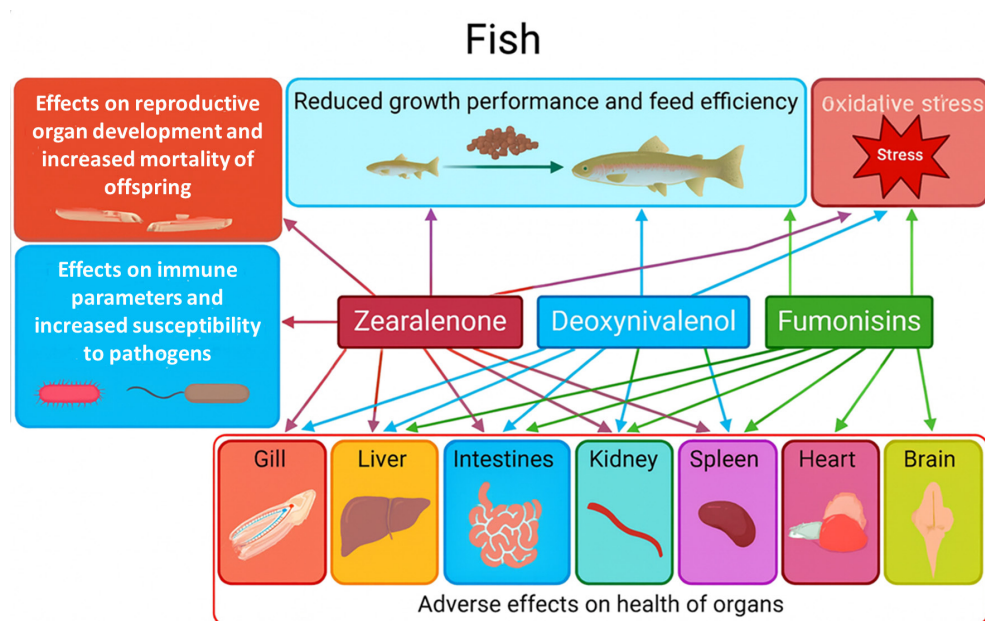
safety or efficacy. Therefore, requesting a supplier to provide full characterization for mycotoxin binding and selectivity (i.e., inability to bind other micronutrients such as vitamins and minerals) is critical. Binders are a very general term, and their selection must be performed with clear criteria and sound knowledge.

Activated carbon offers broad-spectrum adsorption but is costly and may also bind micronutrients, reducing feed quality and potentially originating deficiencies which can indeed lead to nutrition-related diseases and immunosuppression.

Yeast cell wall derivatives, rich in β -glucans and mannans, can bind certain mycotoxins such as zearalenone and ochratoxin A, though their effectiveness varies. Common commercial examples include products based on *Saccharomyces cerevisiae* cell walls, which are widely used in feed additives. These compounds work by providing multiple binding sites for polar and non-polar toxins, but their performance depends on factors such as yeast strain, processing method, and inclusion rate. In addition to adsorption, β -glucans and mannans exhibit immune-modulatory properties, which can support gut health and resilience against stress. However, this dual

functionality requires careful evaluation to ensure that improvements in clinical signs are not simply masking underlying tissue damage caused by mycotoxins. Combining strong adsorption capacity with immune benefits could be advantageous, but it must be validated under practical conditions to guarantee long-term efficacy and safety.

Synthetic polymers represent an emerging approach, engineered for high specificity in mycotoxin binding, but their application in aquaculture remains largely experimental. Examples include cholestyramine, a polymer resin known for binding certain mycotoxins, and synthetic adsorbents based on polyvinylpyrrolidone (PVP) or modified polystyrene matrices designed to target specific toxin structures. These polymers can be tailored to achieve selective adsorption, reducing the risk of nutrient interactions compared to traditional binders. However, challenges such as cost, regulatory approval, and evaluation under aquatic conditions—where water solubility and stability are critical—limit their current use. Future research should focus on optimising polymer formulations for aquatic environments and assessing their long-term safety and efficacy.



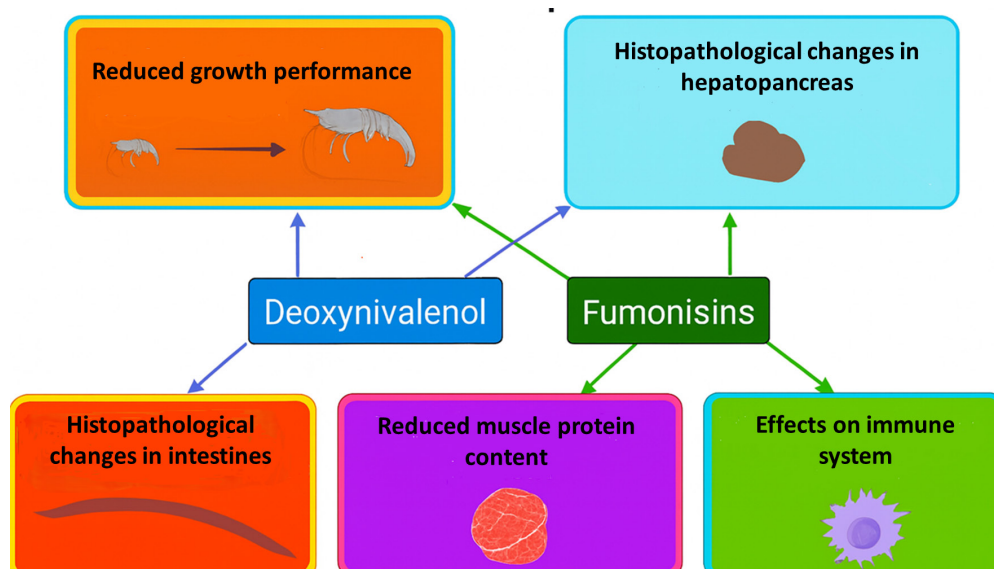
The binding process involves physical adsorption, ion exchange, and hydrogen bonding. Stability of the mycotoxin–binder complex is influenced by gut conditions such as pH and ionic strength. pH stability is particularly critical to ensure that adsorbed mycotoxins are not released during digestion. In aquaculture systems, this becomes even more important because any release of mycotoxins in the intestines or after excretion in faeces can pose significant risks. Mycotoxins are extremely stable and, depending on the species and production system, they can accumulate in rearing environments and be reabsorbed, especially water-soluble toxins. Despite their benefits, binders have limitations, particularly for *Fusarium* toxins, and may interact with nutrients. Regulatory approvals often restrict claims to aflatoxin binding, reflecting these limitations.

Advanced Solutions: A Multi-Layered Strategy

Beyond traditional binders, advanced approaches are

essential to achieve comprehensive mycotoxin control. Enzymatic biotransformation offers a promising solution by irreversibly degrading mycotoxins into non-toxic metabolites, while biological detoxification using bacteria and fungi capable of metabolising mycotoxins is being explored for use as probiotics feed additives. In addition, strategies incorporating immune modulators and antioxidants help mitigate physiological stress caused by mycotoxins. To strengthen resilience, supporting liver and intestinal health through compounds such as artichoke extract, silymarin, curcumin, and other polyphenols can reduce oxidative stress and protect vital organs. The most effective approach combines multiple mechanisms: Adsorption + Enzymatic Degradation + Immune Modulation + Liver/Intestinal Protection, ensuring both toxin removal and long-term health.

These integrated solutions aim to complement traditional binders and deliver broader, sustainable



protection against diverse mycotoxins, particularly in complex systems like aquaculture where environmental recirculation of toxins adds further challenges.

Conclusions and Practical Recommendations

Mycotoxins remain a critical challenge for aquaculture, especially as plant-based feed ingredients become increasingly common. Their impact extends beyond growth performance to organ health, immune function,

and overall system sustainability. Addressing this risk requires a multi-layered strategy rather than reliance on a single solution.

Bottom line: Effective mycotoxin management in aquaculture is not a single intervention but a holistic approach combining prevention, adsorption, detoxification, and physiological support. This integrated strategy will safeguard productivity, animal welfare, and environmental sustainability.

Key Recommendations

Proactive Risk Management



Trusted Suppliers

Source raw materials from trusted suppliers with documented mycotoxin control measures.



Routine Screening

Implement routine screening of feed ingredients and finished feeds for major mycotoxins.



Optimal Storage Conditions

Maintain optimal storage conditions to prevent fungal growth and toxin formation.

Integrated Control Strategies



Well-Characterized Binders

Use well-characterized binders with proven selectivity and stability under gut conditions.



Combined Detoxification

Combine adsorption with enzymatic degradation and biological detoxification to target a broader spectrum of toxins.



Immune Modulators & Protectants

Incorporate immune modulators and organ protectants (e.g., silymarin, artichoke extract, curcumin) to mitigate oxidative stress and support liver and intestinal health.

System-Level Considerations



Prevent Environmental Recirculation

In aquaculture, prevent environmental recirculation of toxins by managing faecal contamination and water quality.



Species-Specific Evaluation

Evaluate binder and detoxifier performance under species-specific conditions, including pH and digestive physiology.



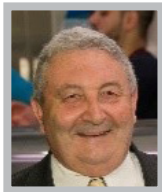
Regulatory Advocacy

Advocate for stronger regulatory frameworks and harmonised standards for mycotoxin control in aquafeeds.



Research & Emerging Solutions

Invest in research on emerging solutions such as synthetic polymers, probiotics, and combined technologies for sustainable long-term protection.



Hon. Professor Roy D. Palmer

Founder - Association of International Seafood Professionals Honorary Life Award - World Aquaculture Society (WAS)

Medal of Honor of the World Gastronomy Institute (WGI)

palmerroyd@gmail.com



The Carp Catastrophe: Australia's \$10 Million Gamble on a Virus to Save its Waterways

The European Carp (*Cyprinus carpio*) has become the most destructive invasive freshwater species in Australia, particularly across the Murray-Darling Basin (MDB). Its unchecked proliferation has precipitated a complex crisis, driving the Australian government toward a radical, irreversible measure: the controlled release of the **Cyprinid herpesvirus 3 (CyHV-3), or the Carp Virus**.

This article examines the carp's destructive history, reviews successful and costly international control efforts, details Australia's controversial virus plan, and proposes complementary, common-sense initiatives that must be adopted to ensure long-term ecological recovery.

The Invasive Success: Why Carp Thrive

The common carp is a hardy, opportunistic fish, originally native to Eurasia and deliberately spread globally for aquaculture since antiquity. In Australia, the dominant pest strain, likely imported from Indonesia, escaped into the wild near Mildura, Victoria, in the 1960s (Koehn, 2004), leading to explosive colonization.

Carp possesses a destructive biological profile that allows them to thrive in stressed environments:

- **Tolerance and Adaptability:** They are exceptionally tolerant of poor water quality, including low oxygen

(hypoxia) and extreme temperatures, allowing them to dominate degraded river systems where native species fail.

- **High Fecundity:** Females are highly prolific, capable of producing up to 1.5 million eggs per spawning season, ensuring rapid population rebound after environmental pressures (Koehn, 2004).

- **Destructive Bottom-Feeding:** Their primary environmental damage comes from "bottom-mouthing"—a feeding behavior that involves sucking up and ejecting riverbed sediment.

The Ecological and Economic Devastation in Australia

The consequences of this invasion in the MDB have been likened to "flipping" the entire ecosystem. Carp are now established in every Australian state and territory except the Northern Territory (Hennecke, 2025).

Environmental Damage

- **Increased Water Turbidity:** The constant stirring of sediment drastically increases water turbidity (cloudiness). This blocks sunlight, leading to the collapse of submerged aquatic vegetation (SAV), which are critical habitats for native fish and insects (Lenard and Kennard,

2016).

- **Algal Blooms:** Carp feeding releases bound nutrients (phosphorus and nitrogen) from sediments into the water column. This nutrient load, combined with the loss of SAV competition, fuels the proliferation of toxic blue-green algae (cyanobacteria) blooms (Zambrano et al., 2006).

- **Native Fish Decline:** Carp directly competes with native species (like Murray Cod) for food. Moreover, dense carp populations often lead to hypoxic (low oxygen) **conditions** when they die and decompose, creating lethal environments for sensitive native fauna (Koehn, 2004).

Socio-Economic Cost

The ecological catastrophe translates to an estimated annual economic and environmental impact of **hundreds of millions of dollars**—conservatively put at **AUD\$200 million per year** (NCCP, 2022). This figure covers increased costs for treating drinking water, accelerated wear on irrigation infrastructure, and lost revenue from tourism.

Despite the pervasive damage, it is acknowledged that a resolute community of recreational fishers, such as the 45,000+ members of “Australian Carp Slayers,” (there may be other groups) enjoys the sport of catching the species.

Lessons from International Carp Management

Australia’s dilemma mirrors crises in other regions, which have developed high-cost, non-biological solutions.

United States: Electric and Commercial Barriers

The U.S. faces a monumental challenge with the rapid spread of Asian Carp (a related species group) toward the Great Lakes. The primary response involves:

- **Infrastructure:** The Army Corps of Engineers maintains costly, continuous underwater electric barriers in the Chicago Sanitary and Ship Canal to physically

block carp migration (U.S. Army Corps of Engineers, 2020).

- **Market-Based Control:** States actively promote commercial harvesting programs, marketing the invasive carp under alternative names like “Silverfin” to incentivize sustained removal for human consumption, animal feed, and other products (U.S. Fish and Wildlife Service, 2019). Note that Australia would need to comply with Australian Fish Names Standard AS5300.

Europe and Canada: Targeted Removal

In Europe, where the common carp originated, management often involves integrated recognition of the carp as a resource and a nuisance.

- **Targeted Exclusion:** Efforts focus on targeted removal by professional fishers and the use of fish screens and barriers on water diversions to protect sensitive, high-value wetland breeding areas from juvenile carp (Fisheries and Oceans Canada, 2017).

These cases show that sustained reduction can be achieved through physical exclusion and commercial pressure, but this requires massive, long-term funding and infrastructure. It also requires political will so perhaps this complexity prompted Australia to seek a biological shortcut.

The Radical Proposal: The National Carp Control Plan (NCCP)

In response to the sheer scale of the MDB infestation, the government has invested in investigating the highly controversial use of the Carp Virus (CyHV-3).

- **The Mandate:** The FRDC was commissioned in July 2016 to manage the National Carp Control Plan (NCCP), originally costing \$10 million (FRDC, 2022). The objective was to research the feasibility of releasing the virus by December 2018.

- **The Agent:** CyHV-3 is a naturally occurring virus that is highly specific to common carp and koi, causing massive mortality rates in infected populations.

- **The Risk of No Return:** The Environmental





Biosecurity Office (DAFF), led by Dr. Bertie Hennecke, now stresses the enormous risk: the carp virus “cannot be removed from waterways once introduced” (Hennecke, 2025). This permanence elevates the need for absolute certainty.

- **The Logistical Nightmare:** A major hurdle is the plan for removing the estimated millions of tonnes of carp carcasses that would result from a successful kill. Failure to manage this decomposition would trigger widespread hypoxic blackwater events, consuming dissolved oxygen and potentially causing mass kills of native fish, completely undermining the environmental goal (NCCP, 2022).

- **Rabbit Precedent:** Scepticism is fuelled by Australia’s history of biological control. While the introduction of the Rabbit Haemorrhagic Disease Virus (RHDV) initially decimated rabbit populations, CSIRO research confirms that resistance in wild rabbit populations has developed, and numbers are now rising again (CSIRO, 2025).

The final decision to deploy the virus requires approval from **all Agriculture Ministers**, pending the completion of a full risk assessment on Australia’s native species. With the Harmful Algal Bloom (HAB) still hanging over South Australia there must, at least, be doubt.

Common-Sense Alternatives to the Virus

Relying solely on a single, irreversible biological agent is fiscally and ecologically irresponsible. A multi-pronged, integrated national management strategy combining environmental remediation with aggressive economic utilization offers a more resilient path forward.

1. Market-Based Utilization and Incentives

The most immediate common-sense initiative is to treat carp as a resource, not just a liability.

- **Re-establish Professional Inland Fisheries:** The Victorian government’s 2002 decision to buy out all remaining commercial inland fishing licenses effectively removed the only sustainable economic pressure on carp populations. Reversing this decision and supporting professional fishers, like Keith Bell, to target the carp biomass (currently restricted by native fish management rules) could remove millions of fish annually.

- **Incentivized Harvest:** Provide subsidies for high-volume commercial harvesting, turning the financial burden of clearing biomass into a market-based funding loop (U.S. Fish and Wildlife Service, 2019).

- **Product Innovation:** Invest in creating high-value carp products, such as:

- **Fish Powder:** Following the model of World Food Prize winner Dr. Shakuntala Thilsted, convert carp and carp waste into high-protein fish powder for use in human consumption which could be used locally or through foreign aid.

- **Soil Amendments:** Emulate Thailand’s rubber industry model by processing carp into bio-extracts and fertilizers, leveraging coordinated private and government action to create a market for their removal. Collaborate with National Farmers Federation, who only this last week complained of shortages.

- **Culinary Acceptance:** Support chefs and processors, like Glen Hill, in rebranding and utilizing carp meat (e.g., carp schnitzel) to reduce the social stigma and drive market demand.

- **Invest in People & Products:** Work with the Seafood Consumers Association to promote Carp both in Australia and overseas through a) training recreational fishers on how to process and cook their Carp catch; b) create a Carp book of recipes with Chef’s Associations; c) develop a book on processing and selling Carp and



d) have competitions relative to ideas, recipes, cooking, etc.

o **Investigate Kamaboko:** Carp could be turned into mince which is extruded into ‘carp sticks’ – these could be breadcrumb/battered and become a new fish protein sensation (<https://www.kamaboko.com/en/>).

2. Environmental Engineering and Native Fish Focus

These actions address the underlying habitat issues that allow carp to flourish.

- **Targeted Exclusion:** Strategically deploy and manage fish screens and locks on dams and weirs to physically prevent large carp from accessing high-value, sensitive wetland breeding sites, protecting native fish nurseries.

- **Flow Management:** Utilize water buyback schemes to create river flows (flood pulses) that favour the breeding cycles of native fish species (such as Murray Cod) while stressing carp populations.

- **Native Fish Enhancement:** Aggressively fund native fish restocking and recruitment into cleaned or protected areas, using native fish populations to out-compete any carp that remain.

3. Transparent Governance and Engagement

The high-risk nature of a viral release demands full transparency.

- **Independent Review:** All Ministers must demand an in-depth, independent study of all potential solutions, including the market-based and engineering options, complete with rigorous benefit-cost analyses, before signing off on the virus.

- **Address Water Use Risk:** The MDB provides irrigation water for export-oriented aquaculture and agriculture. The industry needs clear answers on how they will declare that their water source “may contain a virus” to international customers, which could lead to export bans and business closures. This potential consequence alone mandates exploring alternatives.

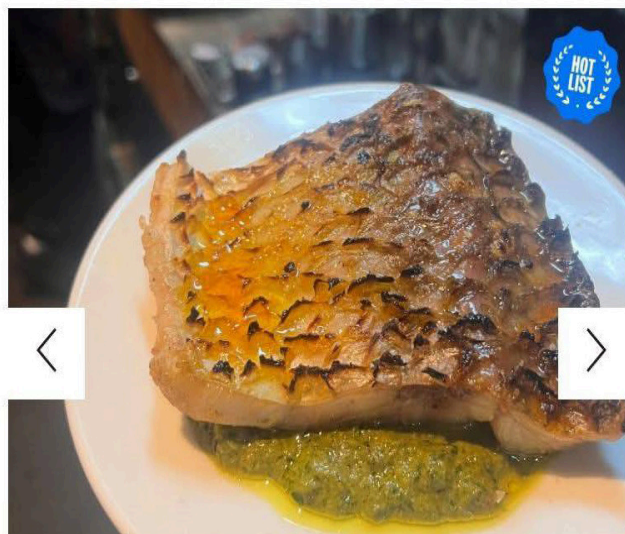
- **Community Involvement:** The decision cannot be made behind closed doors. The public and communities must be engaged—interested parties can email Carp@aff.gov.au to get involved—to ensure broad buy-in for the decades of management that will be required, regardless of the virus’s outcome.

The NCCP is a powerful testament to the severity of the carp catastrophe. However, history and common sense demonstrate that effective pest management requires a resilient, multi-faceted approach. Australia must pivot from viewing the virus as the singular “solution” to viewing it as a potential, high-risk tool that must be buttressed by sustained market pressure and long-term ecosystem restoration.



You Can Keep Your Wagyu, I’m Going Back to Firepop for the “Pest Fish” Dish

This winter-only fish special proves that in the right hands – procured in the right way, by the right people – an overabundant pest can outmatch the best and rarest produce in Australia.



1/3

Firepop's wild-caught carp with double burnt chilli herb salsa

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Joint Organiser:



Organisers:



The Marine Products Export Development Authority



Seafood Exporters Association of India

Technical Partner:



Indian Council of Agricultural Research

With the technical cooperation of:



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Upcoming Aquaculture and Fisheries Conferences and Exhibitions:

AQUACULTURE AMERICA 2026 –

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AQUACULTURE AMERICA 2026 returns to one of the favourite entertainment spots in the world for the only major national aquaculture conference and exposition held in the U.S. The U.S. Aquaculture Society (formerly U.S. Chapter of WAS) joins with National Aquaculture Association and the Aquaculture Suppliers Association to produce the annual Aquaculture America meetings. These sponsors are joined by the annual meetings of Aquacultural Engineering Society, US Trout Farmers Association, and many more associations to make Aquaculture America 2026 the one meeting in the U.S. that you don't want to miss!

Las Vegas offers many attractions and great fun. Aquaculture America 2026 is the place to learn about the latest in aquaculture, see the newest technology in the trade show and have a great time in the many fantastic restaurants, bars and entertainment sites in Las Vegas.



WORLD AQUACULTURE 2026

**Singapore – Singapore –
June 2-5, 2026**



After the successful World Aquaculture Conference and Trade Show held in Singapore in 2022, we have decided to return to Singapore in 2026. World Aquaculture Singapore 2026 will provide an excellent venue for international networking and knowledge exchange among aquaculture practitioners, academics, and commercial companies from the Asia-Pacific region and around the world. Aquaculture is rapidly growing in the Asia-Pacific region and increasingly being integrated into Singapore's food systems, making 2026 the perfect time for the global aquaculture community to focus on Singapore. Fantastic tourist opportunities a gateway to Asia and beyond, Singapore is a cosmopolitan city and a melting pot of diverse cultures. The city is home to a vibrant arts and entertainment scene, lively dining and drinking spots, world-class attractions, and the famous shopping district, Orchard Road. Recently, Singapore was added to the UNESCO recognition list for its iconic hawker culture and the 150-year-old Singapore Botanic Gardens.

AQUACULTURE EUROPE 2026

- Ljubljana Slovenia – Sep. 23 – Oct. 1, 2026

Since 1976, EAS has been bringing people together for the sustainable development of European aquaculture. As we celebrate our 50 birthdays, we look back on key moments and key persons that made EAS what it is today. And we also look forward - continuing to expand our student activities and network and propose benefits for members that are suited to their profile and needs. We will celebrate this milestone throughout the year on social media, and in person at Aquaculture Europe 2026 in Ljubljana, where we invite EAS members to join the celebrations.



Event webpage coming soon on www.aquaeas.org.



Dr. Naga Murali Chalamalasetti
Director at Volta Breems Ltd, Fish & Feeds Ltd, Ghana
chnmurali@gmail.com



A Review on INFOFISH World Tilapia Conference, Bangkok (3rd to 5th Nov, 2025)

Conference Overview

After a long gap, finally INFOFISH World Tilapia Conference was held with the theme: “Innovation, Integration and Profitability in Tilapia Aquaculture: Modernisation for a New Era”.

- **Venue:** Jubilee Prestige Hotel Ratchadapisek (Bangkok, Thailand).
- **Attendance & Scope:** Expected delegates from 30+ countries, industry leaders, government, research, processing/trade sectors.
- **Exhibition & Farm Visit:** A trade exhibition (approx. 20 exhibitors) plus optional onsite farm visit.

A pre-conference meet was conducted on 01-11-25 for a formal meet-and-greet session of presenters and sponsors. In this session, presenters of various sessions were briefed about the house rules, timing, and Q&A handling.

The actual session of the conference started on 2nd Nov with the plenary session and was inaugurated with opening remarks from Acting Director of INFOFISH Ms. Gemma Meermans, Technical Director of USSEC Mr. Lukas Manomaltis, Prof. Kevin Fitzsimmons, and Executive Advisor of Fisheries, DOF, Thailand Dr. Pholphisin Suvanchai.

The plenary session started with a global and regional review of major tilapia-producing regions and markets, with a special address from Mr. Rudolf Hoeffelman, President Director, Regal Springs, Indonesia, followed by Mr. Lukas Manomaltis' presentation on emerging tilapia

producers and markets in SE Asia. A panel discussion was held with Mr. Lukas Manomaltis as moderator where Dr. M. Gulam Hussain from Bangladesh, Mr. Wang Xueguang from China, Mr. Pamudi from Indonesia, Mr. Mohamed Razali from Malaysia, Mr. Florendo Jon from Philippines, Dr. Malasri Kumsri from Thailand, and Mr. Nguyen Hoal Na from Vietnam presented their views and data.

Post-lunch regional sub-sessions were conducted for Latin America and the Caribbean, moderated by Mr. William Griffin of GLOBEFISH, Italy, with Mr. Sergio Zimmermann from Brazil, Mr. Andres Piedrahita from Colombia, and Mr. Francisco Murillo from Mexico.

A sub-session for the Middle East was done with Mr. Hydar M. Alsahtout from Saudi Arabia and Mohamed Razali on Gulf Aquaculture.

A sub-session for Europe and North America was done with Ms. Yobana Bermudez, MD, CONEXEMAR, presenting on Tilapia vs. other white fish in the European market, Ms. Helga Maria on Europe, and Ms. Denise Gurshin on North America.

A sub-session on Oceania was held, moderated by Dr. Geoff Allan, with participants in a panel discussion from Fiji led by Ms. Salote Waqairatu & Mr. Jiosese Talemaimerika, from Papua New Guinea led by Mr. Jacob Wani & Mr. Joshua Noiney, and from Timor-Leste by Dr. Jharendu Pant. Prof. Kevin Fitzsimmons joined this sub-session as guest panelist.

A sub-session for Africa was moderated by Mr. Blessing Mapfumo, who presented on tilapia farming in Africa, followed by a panel discussion with Mohamed Razali on

Ivory Coast, Mr. Francisco Murillo, CEO, Tropo Farms Ghana, and Mr. Nsogbu Wadike, Victory Group, Kenya.

Data regarding production and export from various countries was presented in the above sessions, but some of the data didn't match with ground reality. Especially the figures of production and export presented for India, Colombia, Mexico, Ivory Coast, and Ghana didn't match with the ground reality.

Day 2 started with Session 2 on developments in tilapia genetics and reproduction, moderated by Alejandro Tola Alvarez, Executive Director, GenoMar, Norway, with a panel of experts: Dr. Rajesh Joshi (GENOMAR), Dr. Mathew Hamilton (WorldFish), Dr. Alastair Hamilton (Nam Sai Farms), and Dr. John Buchanan (CEO, Center for Aquaculture Technologies, USA). Presentations from WorldFish and Nam Sai were about genetic selection, whereas GenoMar presented on resilient and resistant species. The presentation from Dr. John Buchanan on gene editing was very impressive and innovative. This was the first innovative presentation in this conference so far.

Session 3 was held on Innovative and Integrative Tilapia Production Technologies, moderated by Mr. Sergio Zimmermann. A keynote presentation on technological innovations regarding efficient and profitable tilapia farming was delivered by Dr. Eduardo Leano, NACA, Thailand, followed by a panel discussion and presentations from Dr. Bui Ngoc Thanh, Dr. Naga Murali, Mr. Warren Andrew Turner, and Kobboon Kaewpila. A presentation on Biofloc technology at commercial level presented by Dr. Naga Murali attracted many participants who still believe Biofloc is an impossible and failed model of aquaculture production systems.

Session 4 was held on Biosecurity and Health Management, moderated by Dr. Eduardo Leano, with presentations from Prof. Andrew Paul Shinn (Global Technical Expert, INVE), Dr. Oliver Decamp (INVE), Dr. Cedric Komar (CEO, ICTYODEV, France), and Mr. Pau Badia Grimalt (FAI Farms, Thailand). This session was about vaccines, immunostimulants, etc.

Session 5 on Advancing Tilapia Nutrition and Feed Technology was moderated by Dr. Dominique P. Bureau, with his keynote presentation on advances in alternative feed ingredients & nutritional supplements, followed by a panel discussion with Dr. Kabir Chowdhury (Maverick Innovation, Bangladesh), Mr. Lukas Manomaltis, and Dr. Emelie Devic (Neofly, New Caledonia). This session focused on replacement of fishmeal by soya, black soldier fly, etc.

Day 3 started with Session 6 on Value Addition and Market Diversification, moderated by Mr. Francisco Murillo, with presentations from Mr. Romain Bracciani (VP, SE Asia, JBL Marel, Thailand), Ms. Pitchaya Chainark

(Director, DOF, Thailand), Mr. Jogier Toppe (Fishery Officer, FAO), and Dr. Stephanie Horn (University of Stirling). A video about JBL Marel and its innovative processing line for tilapia impressed the audience.

Session 7 on Collaboration and Partnership, **Session 8** on Strengthening Investment and Funding, and **Session 9** on Tilapia Welfare and Certification were also conducted on Day 3 with presentations from various speakers, which were just generic and normal presentations.

Overall, the presentations in this conference did not match the theme of the conference *"Innovation, Integration and Profitability in Tilapia Aquaculture: Modernisation for a New Era"*. Hardly two presentations showed innovative technologies. When we look at the production data, almost all countries are stagnant with their tilapia production, and some are even declining. Tilapia is not seen in Thailand street food shops, not seen much on hotel menus, and even the production figures show steep decline. When we visit farms, they have issues with high price of fish feed and low selling price, with low preference shown by consumers. Consumers in Thailand started treating tilapia as cheap fish with a muddy smell. Cage-farmed fish has a slightly better price but still faces high production costs. The same stagnant situation is seen in China, Philippines, Vietnam, and Indonesia too. Declining US imports also show that tilapia is fading away from consumer preference due to various reasons. European markets have no good impression about tilapia due to its cheap imports from China.

Africa seems a rising and emerging market for tilapia production and marketing, but cost of production and selling prices need to be brought down. In countries like Ghana and Ivory Coast, eating tilapia is a luxury as fish is sold for \$3–5/kg in retail markets.

This conference gave more preference to sponsors in presentations and presenting time rather than providing more time to technical sessions and innovative technologies. For me, it was a disappointing conference overall, but I was happy to see INFOFISH Tilapia Conference after a decade.



FAO GLOBEFISH at the 31st Aquaculture Biosecurity Workshop



FAO GLOBEFISH participated in the 31st Aquaculture Biosecurity Workshop, highlighting the latest developments and strategies in aquaculture biosecurity. The session focused on improving disease prevention, management practices, and sustainable aquaculture production, emphasizing the importance of global collaboration, data sharing, and policy support to safeguard aquatic resources and ensure the resilience of the aquaculture sector worldwide.

EU Fish Market 2025 Highlights Pressures and Trends

The 2025 EU Fish Market report reveals a complex and challenging landscape for the sector, marked by fluctuating supply, rising production costs, and shifting consumer preferences. Analysts emphasize the impact of climate change, regulatory changes, and international trade dynamics on both prices and availability of key species. The report also underscores opportunities for innovation, sustainable sourcing, and value-added products as strategies to navigate market pressures and maintain competitiveness across European fisheries and aquaculture industries.



Women-Led Fish Farming Initiative Expands in India

In Chamarajanagar district, 26 women's self-help groups (about 160 members) have completed training and begun fish farming under the Matsya Sanjeevini programme, part of India's Pradhan Mantri Matsya Sampada Yojana. With free fingerlings, technical support, and access to local markets or fisheries board outlets, the women are managing 26 lakes across several taluks and have already released around 200,000 fingerlings. Officials say this initiative not only boosts local fish production but also enhances economic and social empowerment for rural women through shared profits and skills development.



First Regional Aquaculture Academy Launched in Kenya



The aquaculture sector in Kenya is benefiting from the establishment of the first regional Aquaculture Academy, designed to transfer international knowledge and best practices across East Africa. The initiative aims to strengthen sustainable fish farming as a key solution to meet growing protein demand and close the nutritional gap in the region. By enhancing skills, fostering collaboration, and providing region-specific training, the academy is expected to accelerate aquaculture adoption, improve production efficiencies, and support climate-resilient food systems.



Book introduction



Title: Novel Approaches Toward Sustainable Tilapia Aquaculture

Editors:

- Seyed Hossein Hoseinifar (Associate Professor, Department of Fisheries, Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Iran)
- Hien Van Doan (Associate Professor, Department of Animal and Aquatic Sciences, Chiang Mai University, Chiang Mai, Thailand)

Publisher / Year:

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- Year of Publication: 2023 (eBook)
- Edition: 1st edition
- ISBNs: Hardcover ISBN 978 3 031 38320 5; Softcover ISBN 978 3 031 38323 6; eBook ISBN 978 3 031 38321 2

Length: XVI + 262 pages (i.e., 16 pages of front matter plus 262 pages of main content) Format: Available as eBook (PDF/EPUB) and Hardcover/Softcover print.

Summary

This book provides a comprehensive overview of recent research and best practice approaches for sustainable farming of tilapia. It addresses the environmental, health, nutritional, and system design aspects of tilapia

aquaculture in order to support more cost effective, low impact production.

Key content areas include – but are not limited to:

- Current global status of tilapia farming and sustainability concepts.
- Health management in tilapia farming: disease prevention, treatment, biosecurity.
- Effects of feed additives on tilapia reproduction.
- Intestinal microbiota of tilapia: characterization and modulation.
- Use of probiotics, prebiotics, symbiotics in Nile tilapia culture.
- Application of medicinal plants for tilapia aquaculture.
- Alternative protein sources to reduce fish meal consumption in tilapia feed.
- Role of culture systems (including biofloc, recirculating systems, etc.) for sustainable tilapia aquaculture.

Fit for:

- Researchers, academics and policy makers interested in sustainable aquaculture (especially tilapia).
- Extension agents or advanced practitioners looking to incorporate novel, low impact approaches into tilapia farming operations.
- Educators/trainers in aquaculture programs seeking a recent reference book on tilapia sustainability.
- Investors or managers evaluating tilapia production systems with sustainability and innovation focus.



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+91 98497 44984

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